BROOKHAVEN NATIONAL LABORATORY

SPECIFICATIONS

Interdisciplinary Science Building-
Issue for Bid

Building No. 734

Contract No. 160068
Project/Specification No. 11733

Volume 2 – Divisions 20 – 41

April 9, 2010

ESH&Q Risk Level (A3-Minor)

HDR CUH2A

Brookhaven National Laboratory

Interdisciplinary Science Building – (ISB)

Issue for Bid
Technical Specifications

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April 9, 2010

HDR

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Table of Contents

DIVISION 00 - PROCUREMENT AND CONTRACTING REQUIREMENTS

Section	
00 00 01	LIST OF DRAWINGS
00 72 10	GENERAL CONDITIONS
00 73 10	SUPPLEMENTARY CONDITIONS

DIVISION 01 - GENERAL REQUIREMENTS

Section	
01 10 00	SUMMARY OF WORK
01 23 00	ALTERNATES
01 25 13	PRODUCT SUBSTITUTIONS
01 26 13	REQUESTS FOR INFORMATION (RFI)
01 30 00	SUBMITTAL PROCEDURES
01 31 00	CONSTRUCTION PROGRESS DOCUMENTATION
01 31 19	PROJECT MEETINGS
01 32 26	PROGRESS REPORTS
01 35 34	PRODUCT OUTGASSING REQUIREMENTS FOR CLEANROOM CONSTRUCTION
01 35 36	LEED REQUIREMENTS
01 35 38	SUSTAINABLE DESIGN REQUIREMENTS
01 42 11	ABBREVIATIONS - ORGANIZATIONS AND STANDARDS
01 42 13	ABBREVIATIONS FOR UNITS OF MEASURE - ENGLISH SYSTEM OF UNITS (IP)
01 42 19	REFERENCE STANDARDS
01 43 39	MOCK-UPS
01 43 43	COORDINATION DRAWINGS (GC)
01 45 23	TESTS AND INSPECTIONS
01 50 00	TEMPORARY FACILITIES
01 50 13	GENERAL CLEAN ZONE CONSTRUCTION PROCEDURES
01 61 00	ACCEPTABLE MANUFACTURERS AND PRODUCTS
01 65 00	DELIVERY, HANDLING AND STORAGE: MATERIALS AND EQUIPMENT
01 73 29	CUTTING AND PATCHING
01 74 19	CONSTRUCTION WASTE MANAGEMENT
01 74 23	CLEANING
01 77 00	CONTRACT CLOSEOUT (GC)
01 78 23	OPERATION AND MAINTENANCE DATA
01 78 36	WARRANTIES AND GUARANTEES
01 78 39	PROJECT RECORD DOCUMENTS
01 78 43	SPARE PARTS AND MAINTENANCE MATERIALS
01 79 00	SYSTEM DEMONSTRATIONS
01 81 21	INDOOR AIR QUALITY MANAGEMENT (IAQ) DURING CONSTRUCTION
01 81 22	INDOOR AIR QUALITY PROTECTION BEFORE OCCUPANCY
01 91 13	GENERAL BUILDING SYSTEMS COMMISSIONING REQUIREMENTS

DIVISION 02 - EXISTING CONDITIONS

Section	
02 41 00	DEMOLITION
02 42 00	ASBESTOS CEMENT (TRANSITE) PIPE REMOVAL

DIVISION 03 - CONCRETE

Section	
03 08 13	CONCRETE TESTING AND EVALUATION - BNL
03 11 00	CONCRETE FORMWORK
03 20 00	CONCRETE REINFORCING
03 31 00	CONCRETE MATERIALS AND PROPORTIONING
03 31 10	CONCRETE MIXING, PLACING, JOINTING AND CURING
03 33 00	ARCHITECTURAL CAST-IN-PLACE (ACIP) CONCRETE
03 35 00	CONCRETE FINISHING AND REPAIR OF SURFACE DEFECTS

DIVISION 04 - MASONRY

Section	
04 05 05	COLD AND HOT WEATHER MASONRY PROCEDURES
04 05 10	MASONRY CLEANING
04 05 13	PORTLAND CEMENT-LIME (PCL) MORTARS & GROUT
04 05 23	MASONRY ACCESSORIES
04 22 00	CONCRETE MASONRY (CMU)
04 42 03	INDIANA LIMESTONE

DIVISION 05 - METALS

Section	
05 12 10	STRUCTURAL STEEL
05 21 10	STEEL JOISTS
05 31 23	METAL ROOF DECKING
05 45 23	EQUIPMENT SUPPORT SYSTEM
05 50 10	MISCELLANEOUS METAL FABRICATIONS
05 50 13	STEEL STAIRS AND RAILINGS
05 52 16	EXTERIOR METAL RAILINGS
05 60 00	ALUMINUM LOUVER FENCING
05 73 00	CUSTOM METAL RAILINGS

DIVISION 06 - WOOD, PLASTICS, AND COMPOSITES

Section	
06 10 53	CARPENTRY
06 42 16	WOOD PANELING - FLUSH

DIVISION 07 - THERMAL AND MOISTURE PROTECTION

Section	
07 13 26	SELF-ADHERING SHEET MEMBRANE WATERPROOFING
07 21 00	BUILDING INSULATION
07 27 16	SELF-ADHERING AIR BARRIER - VAPOR-RESISTIVE
07 41 13	STRUCTURAL STANDING SEAM METAL ROOF SYSTEM
07 42 13	FOAM-FILLED (INSULATED) METAL WALL PANELS
07 42 16	PREFORMED METAL SIDING
07 42 43	ALUMINUM COMPOSITE MATERIAL (ACM) SYSTEM
07 53 25	FULLY ADHERED EPDM ROOFING (ALTERNATE)
07 54 25	FULLY ADHERED TPO ROOFING
07 62 00	FLASHING AND SHEET METAL
07 72 33	ROOF HATCHES

07 84 00 FIRESTOPPING
07 92 13 EXTERIOR JOINT SEALANTS
07 92 16 INTERIOR JOINT SEALANTS

DIVISION 08 - OPENINGS

Section
08 11 13 HOLLOW METAL (HM) DOORS AND FRAMES
08 14 16 FLUSH WOOD DOORS
08 31 16 ACCESS PANELS AND DOORS
08 33 23 OVERHEAD COILING DOORS (CD)
08 34 73 SOUND CONTROL DOOR ASSEMBLIES
08 42 30 AUTOMATIC CLEANROOM SLIDING DOORS
08 44 13 CURTAIN WALL SYSTEMS (CWS)
08 71 00 DOOR HARDWARE
08 81 02 EXTERIOR GLASS AND GLAZING
08 81 04 INTERIOR GLASS AND GLAZING
08 91 00 ARCHITECTURAL LOUVERS

DIVISION 09 - FINISHES

Section
09 06 10 ROOM FINISH AND COLOR SCHEDULE
09 21 27 EXTERIOR STUD WALL SYSTEM
09 22 16 NON-LOAD BEARING METAL STUD FRAMING
09 29 00 GYPSUM WALLBOARD
09 30 00 TILE
09 51 00 ACOUSTICAL & CEILING TILE MATERIALS (AM)
09 54 24 METAL PLANK CEILINGS
09 60 05 WATER VAPOR EMISSION CONTROL FOR CONCRETE WITH APPLIED FLOORING
09 65 18 SHEET RUBBER FLOORING (SR)
09 65 19 RESILIENT TILE FLOORING (VCT), BASE (RB)
09 65 35 STATIC DISSIPATIVE SHEET RUBBER FLOORING (SDSR)
09 66 16 PRECAST TERRAZZO
09 67 26 SEAMLESS EPOXY FLOORING (SEF)
09 67 81 CONCRETE FLOOR SEALER (CFS-ND)
09 68 13 CARPET TILE (CPTT)
09 77 13 STRETCHED FABRIC PANEL SYSTEM
09 84 13 ACOUSTICAL PANEL SYSTEM
09 91 13 EXTERIOR PAINTING
09 91 23 INTERIOR PAINTING

DIVISION 10 - SPECIALTIES

Section
10 11 00 MARKERBOARDS AND TACKBOARDS
10 14 23 INTERIOR SIGNAGE
10 14 43 PHOTO-LUMINESCENT SIGNAGE
10 21 12 METAL TOILET PARTITIONS
10 21 31 SHOWER CURTAINS
10 28 13 TOILET AND BATH ACCESSORIES
10 44 00 FIRE PROTECTION SPECIALTIES
10 51 13 METAL LOCKERS

DIVISION 11 - EQUIPMENT

Section	
11 13 17	DOCK BUMPERS
11 24 26	HORIZONTAL LIFE LINE SYSTEM FOR FALL ARRESTMENT
11 52 13	PROJECTION SCREENS
11 53 00	LABORATORY EQUIPMENT
11 53 13	FUME HOODS AND EXHAUST DEVICES
11 53 33	LASER SAFETY EQUIPMENT
11 53 43	LABORATORY SERVICE FITTINGS AND FIXTURES

DIVISION 12 - FURNISHINGS

Section	
12 24 14	ROLLER SHADES
12 34 00	FORMALDEHYDE-FREE ARCHITECTURAL CASEWORK (AC)
12 35 53	LABORATORY CASEWORK AND OTHER FURNISHINGS
12 36 65	ENGINEERED QUARTZ FABRICATIONS (EQF)
12 48 13	ENTRANCE MATS (EM)

DIVISION 13 - SPECIAL CONSTRUCTION

Section	
13 34 39	ACOUSTICAL SHIELDED ROOMS
13 48 13	ELECTRO-PNEUMATIC CONTROLLED AIR-SPRING VIBRATION ISOLATION SYSTEM
13 49 57	RADIO FREQUENCY SHIELD ENCLOSURE
13 60 13	SPECIAL CLEAN ZONE REQUIREMENTS
13 60 16	CLEANROOM PROTOCOL
13 60 19	CLEANROOM CERTIFICATION
13 61 16	CLEANROOM PARTITION SYSTEMS (CRPS)
13 62 17	CLEANROOM CEILING SYSTEMS (CRCS)
13 63 13	CLEANROOM RAISED ACCESS FLOORING (CRAF)

DIVISION 14 - CONVEYING EQUIPMENT

Section	
14 21 23	MACHINE ROOM-LESS ELECTRIC TRACTION ELEVATOR - PASSENGER
14 24 43	HYDRAULIC ELEVATORS - SERVICE
14 43 21	SCISSORS LIFT

DIVISION 20 - MECHANICAL GENERAL REQUIREMENTS

Section	
20 05 00	GENERAL MECHANICAL REQUIREMENTS
20 05 19	PIPING SPECIALTIES
20 05 23	MANUAL VALVES
20 05 29	PENETRATIONS AND SUPPORTS
20 05 50	VIBRATION ISOLATION OF MECHANICAL SYSTEMS
20 05 53	MECHANICAL IDENTIFICATION SYSTEMS
20 07 00	PIPE, DUCT AND EQUIPMENT INSULATION
20 08 00	TESTING AND BALANCING
20 11 00	PIPE AND FITTINGS
20 12 00	WELDING PRESSURE PIPING

DIVISION 21 - FIRE SUPPRESSION

Section	
21 10 00	FIRE PROTECTION SYSTEMS

DIVISION 22 - PLUMBING

Section	
22 10 16	PLUMBING PIPING
22 11 00	WATER DISTRIBUTION SYSTEM
22 11 23	PLUMBING PUMPS
22 11 26	PACKAGED DOMESTIC-WATER PRESSURE-BOOSTER SYSTEM
22 13 00	SANITARY SEWERS
22 14 00	STORM DRAINAGE SYSTEM
22 14 10	PRECAST CONCRETE UTILITY STRUCTURES
22 33 00	DOMESTIC WATER HEATERS
22 42 00	PLUMBING FIXTURES
22 60 80	HIGH PURITY PLASTIC PIPING SYSTEMS
22 61 13	LABORATORY AIR SYSTEM
22 62 13	PROCESS VACUUM SYSTEMS
22 63 13	SPECIALTY GAS SYSTEMS
22 63 21	LIQUID NITROGEN PIPING SYSTEM
22 66 00	WASTE TRANSFER
22 67 19	PROCESS PIPING SYSTEMS
22 67 21	DEIONIZED WATER SYSTEM
22 67 23	PROCESS COOLING WATER SYSTEM

DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING

Section	
23 21 13	HYDRONIC PIPING SYSTEMS
23 21 23	HVAC PUMPS
23 22 00	STEAM DISTRIBUTION SYSTEM
23 31 13	AIR DISTRIBUTION SYSTEM
23 35 00	EXHAUST AND VENTILATING FANS
23 36 00	AIR TERMINAL UNITS AND AIR VALVES
23 57 00	HEAT EXCHANGERS AND CONVERTERS
23 73 13	PACKAGED AIR HANDLING UNITS
23 73 43	CUSTOM PACKAGED AIR HANDLING UNIT, CLEANROOMS
23 82 39	HYDRONIC HEATING AND COOLING TERMINAL UNITS
23 82 43	ELECTRIC HEATERS
23 84 13	HUMIDIFIERS
23 90 00	MECHANICAL SYSTEMS COMMISSIONING

DIVISION 25 - INTEGRATED AUTOMATION

Section	
25 22 00	LABORATORY AIR FLOW CONTROL SYSTEM
25 23 00	ADJUSTABLE FREQUENCY DRIVES
25 50 00	BUILDING MANAGEMENT AND CONTROL SYSTEM

DIVISION 26 - ELECTRICAL

Section	
26 00 10	ELECTRICAL GENERAL REQUIREMENTS
26 00 11	WIRING EQUIPMENT FURNISHED BY OTHERS
26 05 13	MEDIUM VOLTAGE CABLE
26 05 19	LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
26 05 26	GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
26 05 33	CONDUITS
26 05 34	BOXES
26 05 35	SURFACE METAL RACEWAYS AND WIREWAYS
26 05 43	UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS
26 05 48	VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS
26 05 73	SHORT-CIRCUIT/COORDINATION/ARC FLASH STUDY
26 09 13	POWER MONITORING AND CONTROL
26 09 43	LOW VOLTAGE LIGHTING CONTROL SYSTEM
26 11 16	SECONDARY UNIT SUBSTATIONS
26 12 19	LOW VOLTAGE DISTRIBUTION TRANSFORMERS
26 23 00	LOW VOLTAGE SWITCHGEAR
26 24 13	SWITCHBOARDS
26 24 16	PANELBOARDS
26 24 19	MOTOR CONTROL EQUIPMENT
26 27 26	WIRING DEVICES
26 28 00	OVERCURRENT PROTECTIVE DEVICES
26 28 16	ENCLOSED SAFETY SWITCHES
26 32 13	DIESEL ENGINE DRIVEN GENERATOR SETS
26 36 23	AUTOMATIC TRANSFER SWITCHES
26 41 13	LIGHTNING PROTECTION SYSTEM
26 43 13	TRANSIENT VOLTAGE SUPPRESSION FOR LOW VOLTAGE EQUIPMENT
26 51 13	BUILDING LIGHTING
26 56 00	SITE LIGHTING
26 70 00	LASER ENTRYWAY CONTROL SYSTEM
26 80 00	ELECTRICAL SYSTEMS COMMISSIONING

DIVISION 27 - COMMUNICATIONS

Section	
27 05 28	TELEPHONE CONDUIT SYSTEMS
27 05 32	TELECOMMUNICATIONS CABLING

DIVISION 28 - ELECTRONIC SAFETY AND SECURITY

Section	
28 05 00	BASIC ELECTRONIC SECURITY REQUIREMENT
28 05 19	SECURITY DEVICES
28 31 00	FIRE ALARM SYSTEM

DIVISION 31 - EARTHWORK

Section	
31 10 00	SITE CLEARING
31 22 00	SITE EXCAVATION AND ROUGH GRADING
31 22 19	TOPSOILING AND FINISHED GRADING
31 23 00	BUILDING EXCAVATION, FILLING, AND BACKFILLING

31 23 33 TRENCHING, BACKILLING, AND COMPACTING FOR UTILITIES
31 23 50 HIGH PRESSURE STEAM AND CONDENSATE SYSTEMS (30 TO 150 PSIG)
31 23 60 UNDERGROUND CHILLED WATER SYSTEMS
31 23 70 EXTERIOR COMPRESSED AIR DISTRIBUTION
31 25 00 SOIL EROSION AND SEDIMENT CONTROL
31 27 00 BIORETENTION

DIVISION 32 - EXTERIOR IMPROVEMENTS

Section
32 12 16 ASPHALTIC CONCRETE PAVING
32 13 13 CONCRETE PAVING AND CURBS
32 14 13 PRECAST CONCRETE PAVERS
32 14 15 PERVIOUS CONCRETE PAVING
32 31 13 CHAIN LINK FENCE AND GATES
32 92 19 SEEDING
32 92 22 WILDFLOWER SEEDING
32 93 13 PLANTS AND PLANTING

DIVISION 41 - MATERIAL PROCESSING AND HANDLING EQUIPMENT

Section
41 22 00 HOISTS, TROLLEYS, AND MONORAILS

APPENDIX – ISB FINAL DESIGN GEOTECHNICAL REPORT

DIVISION 20

MECHANICAL GENERAL REQUIREMENTS

SECTION 20 05 00
GENERAL MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. Products:
      a. Access doors, panels, and frames.
      b. Covers for exposed vertical piping.
      c. Equipment guards.
      d. Motors and controls.
      e. Rain hoods and counter flashings.
      f. Penetrations.
      g. Structural steel for supports.

B. Drawings use and interpretation:
   1. Drawings are diagrammatic and indicate general arrangement of systems and equipment, except when specifically dimensioned or detailed.
   2. For exact locations of building elements, refer to dimensioned architectural/structural drawings.
   3. Field measurements take precedence over dimensioned drawings.
   4. Piping and ductwork plans are intended to indicate size, capacity, approximate location, direction and general relationship of one work phase to another, but not exact detail or arrangement.

C. Installation of systems and equipment:
   1. Installation is subject to clarification as indicated in reviewed Shop and Field Coordination Drawings:
      a. Generally, lay out piping requiring gravity drainage first; then lay out large pipe mains, ductwork and electrical conduit.
      b. This procedure is intended to promote orderly installation, but not to establish trade precedence.
      c. Dimensions indicated are limiting dimensions.
      d. Do not use equipment exceeding dimensions indicated on detail drawings or arrangements that reduce required clearances or exceed specified maximum dimensions.
      e. In mechanical equipment room corridors and aisle ways, maintain clear head room between floor and underside of ducts, pipes, and equipment to allow for future replacing of equipment and major components (e.g., coils, fans, heat exchangers, pumps).

D. Description of systems: Provide materials resulting, upon completion, in functioning systems in compliance with performance requirements specified, and modifications resulting from reviewed Shop and Field Coordination Drawings.

1.2 QUALITY ASSURANCE

A. Perform work in accordance with following codes and standards:
   1. Mechanical Code of New York State.
   2. Energy Conservation Construction Code of New York State.
   3. Plumbing Code of New York State.
   4. American Gas Association.
   5. National Electrical Code 2002 Edition.

6. National Fire Protection Association.
7. Authorities having jurisdiction.

1.3 PROTECTION

A. Provide covering and shielding for all stored on-site or installed equipment to protect from damage.

B. Repair, restore and replace damaged items.

C. Protect nameplates on motors, pumps and similar equipment.

D. Protect plumbing fixtures and brass or chromium plated trim, valves and piping from damage.

E. Keep dirt and debris out of pipes and ducts by capping or plugging open ends:
   1. Keep plug or cap in place until final connections are made.

1.4 JOB CONDITIONS

A. Cause as little interference or interruption of existing utilities and services as possible:
   1. Schedule work which will cause interference or interruption in advance with BNL, Construction Manager, Architect, authorities having jurisdiction, and affected contractors.

B. Keep roads clear of materials and debris.

C. Examine Contract Documents to determine how other work will affect execution of mechanical work.

D. Examine site and become familiar with existing local conditions affecting work.

E. Determine and verify locations of existing utilities on or near site.

F. Make arrangements for and pay for necessary permits, licenses, and inspections.

G. Record drawings:
   1. Keep a complete set of mechanical drawings in job site office for indicating actual installation of mechanical systems and equipment.
   2. Use this set of drawings for no other purpose.
   3. Where material, equipment, or system components are installed differently from that indicated, indicate such differences clearly and neatly.
   4. At project completion, submit record set of drawings in accordance with Division 1.

H. Operation and maintenance data: See Division 1.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Motors:
      a. Base:
         1) Reliance Electric.
      b. Optional:
         1) Baldor.
         2) Century Electronics; E-Plus.
         3) General Electric; Energy Saver.
         4) Westinghouse Motor.

B. Use only prime quality, new materials, apparatus and equipment.

2.2 ACCESS DOORS, PANELS, AND FRAMES

A. Access doors, panels and frames: See Section 08 31 16:

1. Provide where indicated on Drawings.
2. Where not indicated on Drawings, provide access panels and/or doors at walls, and inaccessible ceilings as required to permit access to equipment, devices and piping requiring service, adjustment, or inspection.
3. Size:
   a. As required to allow access, inspection, service, and removal of items served.
   b. Minimum 18 x 18 IN.

2.3 COVERS FOR EXPOSED VERTICAL PIPING

A. Covers for exposed vertical piping:
   1. 18 GA stainless steel (type 302) with No.4 finish.
   2. Fasten seams and joints with stainless steel pop rivets.

2.4 EQUIPMENT GUARDS

A. Equipment guards:
   1. Use suitable structural frames with minimum 12 GA, 3/4 IN galvanized mesh, or expanded metal mesh.
   2. Attach to equipment by removable clips and bolts with wing nuts, or other approved connectors.
   3. At belts, provide opening for measuring RPMs. End of shaft shall be protected from accidental contact.
   4. Provide at belts, couplings, moving machinery and equipment in accordance with OSHA.
   5. Design for easy access to belts and other items requiring replacement.

2.5 MOTORS AND CONTROLS

A. Motors:
   1. Provide motors indicated in Division 23.
   2. Motors shall be ball or roller bearing type, high efficiency type, and have starting and running characteristics consistent with torque and speed requirements of driven machine:
      a. All motors 25 HP and larger shall have greasable bearings.
   3. Motor efficiency:
      a. NEMA Standard MG1-12.53a.
      b. Indicate full load efficiency on each nameplate.
      c. Minimum motor efficiency to comply with ASHRAE 90.1-2001, Table 10.2.
   4. Use motors rated in accordance with NEMA performance standards to carry full nameplate load continuously at maximum temperature rise of 40 degC above ambient with service factor of 1.15.
   5. Motor powers as scheduled.
   6. Do not allow power requirements of driven machine to exceed nominal nameplate rating of motor furnished.
   7. Do not include service factor when selecting motor power.
   8. Motors 1/2 HP and over: 460/3/60.
   9. Motors less than 1/2 HP: 115/1/60.
   10. Provide for items which require electric drive.
   11. Motors for certain pieces of equipment will be controlled by adjustable frequency drives (AFD's). These motors shall be designed for inverter-duty, have 1600 volt insulation for 460 V motors and double shielded bearings:
       a. Meet NEMA MG1-31.
       b. Provide grounding system for protection from static and AFD induced currents.
   12. Where equipment with motors will be driven by adjustable frequency drives (AFD's), provide motors that are compatible with AFD's.

1. If air handlers must be used during construction, filtration media with a Minimum Efficiency Reporting Value of 8 in accordance with ASHRAE 52.2-1999 must be provided at each return register.
2. Replace all filtration media immediately prior to occupancy. Filtration media shall have a Minimum Efficiency Reporting Value of 13 in accordance with ASHRAE 52.2-1999.
3. After construction ends and prior to occupancy, conduct a minimum of two-week building flush-out utilizing 100% outside air.
4. After the flush-out, replace all AHU filter media in accordance with the requirements of Section 23 73 29.

3.10 ADJUST AND CLEAN

A. Inspect equipment and put in satisfactory working order.

B. Clean exposed and concealed items: See Cleaning (Section 01 74 23):
1. Clean air surfaces of coils, fans (including fan wheels and motors), air handler plenums and air filter frames.
2. Clean floor drains, cleanouts, and plumbing fixtures.
3. Clean specialties such as traps and strainers and equipment surfaces such as pumps, motors, boilers, chillers, etc.
4. Clean finned elements of fin tube radiation with compressed air.
5. Clean piping of tags, debris and other construction materials before insulating or painting.
6. Wipe all ducts and air plenums clean inside.

3.11 COMMISSIONING

A. See Section 23 90 00.

END OF SECTION

SECTION 20 05 19
PIPING SPECIALTIES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. Products:
      a. Pressure gauges.
      b. System drains.
      c. Thermometer wells and test gauge connections.
      d. Thermometers (non mercury type).
      e. Wye strainers for steam and hydronic systems.

1.2 QUALITY ASSURANCE

A. Comply with UL, ANSI, ASME or ASTM Standards.

1.3 SUBMITTALS

A. Product data:
   1. Pressure gauges.
   2. Thermometers.
   3. Wye strainers.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Pressure gauges:
      a. Base:
         1) Trerice.
      b. Optional:
         1) Weiss Instruments.
         2) Marsh Instrument.
         3) US Gauge.
         4) Weksler Instruments.
         5) Weston and Ernst.
         6) Orange Research, Inc.
   2. Thermometers:
      a. Base:
         1) Trend Instruments.
      b. Optional:
         1) Weiss Instruments.
   3. Wye strainers:
      a. Base:
         1) Armstrong International.
      b. Optional:
         1) Spirax Sarco.
         2) Keckley, OC.
         3) Metraflex.
         4) Mueller Steam Specialty.

5) Spence Engineering.
6) Victaulic of America.

2.2 PRESSURE GAUGES

A. Pressure gauges:
1. Steam systems and water systems operating above 150 degF:
   a. Case and twist ring: 4-1/2 IN diameter, anodized aluminum.
   b. Socket: brass.
   c. Bourdon tube: Phosphor bronze.
   d. Movement: Bushed Brass Rotary.
   e. Dial: White aluminum, black markings.
   f. Pointer: Black or red anodized aluminum, slotted adjustable.
   g. Window: Glass.
   h. Siphon and gauge cock (low pressure steam): chrome plated brass.
   i. Siphon and needle valve (medium and high pressure steam): chrome plated brass.
   j. Accuracy: 1.0% full scale, ASME B40.1 Grade 1A.
   k. Range: Operating pressure to occur in middle half (25 % to 75%) of the full scale range of the fluid being measured.
   l. Connections: 1/4 IN or 1/2 IN NPT.
2. Compressed air systems and water systems operating below 150 degF:
   a. Case and Ring: 4-1/2 IN diameter, liquid filled, type 304 stainless steel case with polished stainless steel bayonet ring.
   b. Fill liquid: Glycerin.
   c. Socket: Brass with push-in restrictor.
   d. Bourdon tube: Phosphor Bronze.
   e. Movement: Brass rotary type with bushings.
   f. Dial: White aluminum with black markings.
   g. Pointer: Black or red anodized aluminum, adjustable.
   h. Window: Clear acrylic.
   i. Snubber and gauge cock: Chrome plated brass.
   j. Accuracy: 1.0% full scale, ASME B40.1 Grade 1A.
   k. Range: Refer to pressure range schedule except as follows:
      1) Pump suction gauges for open piping systems where elevation difference between pump center line and liquid level of open system is less than 50 feet: Compound type, indicating at least -100 kPa to 210 kPa 30 IN Hg to 30 PSIG.
      2) Fuel oil pump suction: Compound type, indicating .
   l. Connections: 1/4 IN or 1/2 IN NPT.
3. Deionized water system:
   a. Features similar to above, except all wetted parts (tube and socket) to be 316 stainless steel.

4. Pressure gauge range schedule:

	Range PSIG	Fig. Interval PSIG	Inter. Graduations PSIG
Chilled Water	0-150	10	1
Glycol water	0-100	10	1
Heating hot water	0-100	10	1
Fire	0-400	50	5
Cond. pump discharge	0-100	10	1
LP Steam	0-60	5	1
MP Steam	0-100	5	1
HP Steam	0-300	25	5
Flash tank	0-60	5	1
Domestic hot water	0-100	10	1
Domestic cold water	0-100	10	1
Process cooling and secondary chilled water	0-150	10	1
RO or Deionized Water	0-150	10	1

B. Trerice 600. Trerice 700 for deionized water (4-in dial).

C. Differential Pressure Gauges:
1. 4-1/2 IN dial, surface or flush type, whiteface, black numerals, black pointers, brass body, teflon seals, shatterproof glass.
2. Minimum 150 psig static pressure.
3. Piston sensor.
4. ± 2-1/2 % accurate over entire range.
5. Select range such that differential operating point is approximately 50% of full range.
6. Ashcroft 1092 gauge cock and 1106 pulsation damper.
7. Orange Research, Inc.

2.3 SYSTEM DRAINS

A. Valved drains (nonpotable water):
1. Piping 2 IN and smaller:
   a. 1/2 IN V-13 with male hose-thread outlet and brass cap.
   b. Hose bibb with male hose-thread outlet and brass cap.
2. Piping 2-1/2 IN and larger:
   a. 1-1/2 IN V-13 or V-14 ball valve with 1-1/2 IN fire hose adapter and cap.
3. RO or Deionized water piping:
   a. Piping 3 IN and smaller:
      1) 1/2 IN V-67 with SS hose-thread outlet and cap.
   b. Piping 3-1/2 IN and larger:
      1) 1-1/2 IN V-67 with SS hose-thread outlet and cap.

B. Valved drains (potable water):
1. 1/2 IN V-13 with plugged outlet.

C. On nonpotable systems, label system drains as nonpotable.

D. Valve standards: See section 20 05 23.

2.4 THERMOMETER WELLS (SOCKETS) AND TEST GAUGE CONNECTIONS

A. Temperature sensing wells (sockets) and test gauge connections:
1. Brass or stainless steel.
2. Provide extension necks for insulated piping.

2.5 THERMOMETERS

A. Digital Thermometers:
   1. Case: High-impact ABS.
   2. Display: 1/2 IN LCD digits.
   3. Sensor: Glass passivated thermistor.
   4. Ambient Operating conditions: -30 degF to 140 degF.
   5. Accuracy 1% of reading or 1 degF.
   6. Resolution: 0.1 degF between –20 degF and 200 degF.
   7. Recalibration: Through case potentiometer adjustment.
   8. Lux rating: 10 Lux (one foot candle).
   9. Update span: 10 seconds.
   10. Range: -50 degF to 300 degF.
   11. Ambient temperature error: Zero.
   12. Maximum ambient humidity: 100 percent.
   13. Power: Solar.

2.6 WYE STRAINERS FOR STEAM AND HYDRONIC SYSTEMS

A. Wye strainers.
   1. Screwed or flanged.
   2. Body:
      a. 2 IN and smaller:
         1) Cast bronze, ASTM B62, screwed ends.
      b. 2-1/2 IN and larger:
         1) Cast iron, flanged ends.
         2) Coating: Rust inhibiting.
      c. Deionized water:
         1) Stainless steel body and screens, flanged or butt welded connections.
   3. Working pressure, non shock: 150 PSIG.
   4. Strainers in high pressure steam lines shall be 300 psig flange rating.
   5. Screens:
      a. Water: Bronze, monel or stainless steel.
         1) 2 IN and less: 3/64 IN perforations.
         2) 2-1/2 IN and larger: 1/8 IN perforations.
      b. Steam: Stainless steel or brass.
         1) 3/64 IN perforations.

PART 3 - EXECUTION

3.1 GENERAL

A. Install piping specialties according to manufacturer instructions and as specified.

3.2 PRESSURE GAUGES

A. Install filter type pressure snubbers at pumps.

B. Install siphons on steam gauges.

C. Install brass tee handle cock, or needle valve, and 1/4 IN hard tempered tubing from gauge to pipe connection. Deionized water system shall be constructed from 304 or 316 stainless steel.

D. Install additional brass tee handle cock at gauge for panel mounted gauge.

E. Calibrate and zero gauges at job site.

3.3 SYSTEM DRAINS

A. At low points of piping systems, provide valved drains to allow complete drainage of each system.

B. Neither terminate nor run drains over electrical equipment.

3.4 THERMOMETER WELLS AND TEST GAUGE CONNECTIONS

A. Provide test thermometer well adjacent to each point where a temperature sensing device is required by control specifications and where piping schematics indicate thermometers.

B. Placement and sizing:
   1. For 4 IN piping and larger, place tee in piping to create perpendicular flow-to-stem measurement:
      a. Size stem length based on pipe size as indicated below:
         1) 4 and 5 IN pipe: 3-1/2 IN stem.
         2) 6 and 8 IN pipe: 6 IN stem.
         3) 10 and 12 IN pipe: 9 IN stem.
         4) 14 IN pipe and larger: 12 IN stem.
   2. For piping smaller than 4 IN, place oversize piping well and tee in 90-degree piping turn to create parallel flow-to-stem measurement:
      a. Stem length: 12 IN.
      b. Piping well length: 14 IN.
      c. Size piping well and tee based on pipe size as indicated below:
         1) 1/2 and 3/4 IN pipe: 1-1/4 IN well and tee.
         2) 1 IN pipe: 1-1/2 IN well and tee.
         3) 1-1/4 and 1-1/2 IN pipe: 2 IN well and tee.
         4) 2 IN pipe: 2-1/2 IN well and tee.
         5) 2-1/2 and 3 IN pipe: 4 IN well and tee.

3.5 THERMOMETERS

A. Where temperature control requires a temperature transmitter, a thermometer is not required in same location unless specifically required in equipment specifications.

3.6 WYE STRAINERS

A. Provide wye strainers as indicated in piping-system sections.

B. Connections to suit piping system.

C. Provide blow-down valves:
   1. Strainers 6 IN and larger: 1-1/2 IN blow-down valve:
      a. Pipe blow down to drain.
   2. Strainers 2 to 5 IN: 1 IN blow-down valve with 3/4 IN hose end connection and brass cap.
   3. Strainers 1-1/2 IN and smaller: 1/2 IN blow-down valve with 3/4 IN hose end connection and brass cap.

END OF SECTION

SECTION 20 05 23
MANUAL VALVES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Definitions:
   1. Class: ANSI Class.
   2. SWP: Steam Working Pressure.
   3. WOG: Water/Oil/Gas non-shock working pressure.
   4. WWP: Cold water non-shock working pressure.

1.2 QUALITY ASSURANCE

A. Boiler system valves: ASME Boiler Code Specifications.

B. Fire protection valves: UL listed, NFPA and FM approved.

C. Valves used in flammable liquid or flammable gas systems: UL listed for applicable service.

D. Valves cleaned for oxygen service: CGA Pamphlet G-4.1, Cleaning Equipment for Oxygen Service.

E. Valve bodies, shells and seats: Designed, manufactured, and tested in accordance with the following:
   1. Pressure testing of steel valves: MSS SP-61.
   2. Butterfly valves: MSS SP-67.
   3. Cast iron gate valves, flanged and threaded ends: MSS SP-70.
   4. Cast iron swing check valves, flanged and threaded ends: MSS SP-71.
   5. Cast iron plug valves, flanged and threaded ends: MSS SP-78.
   6. Bronze gate, globe, angle and check valves: MSS SP-80.
   7. Valve pressure testing methods: MSS SP-82.
   8. Cast iron globe and angle valves, flanged and threaded ends: MSS SP-85.
   9. Diaphragm type valves: MSS SP-88.
   10. Resilient seated eccentric cast iron plug valves: MSS SP-108.
   11. Ball valves--threaded, socket-welding, solder joint, grooved, and flared ends: MSS SP-110.

F. Standard Specification for Composition of Bronze or Ounce Metal Castings: ASTM-B62.

G. Standard Specification for Steam or Valve Bronze Castings: ASTM-B61.

H. Iron body valves:
   1. Pressure containing parts: ASTM-A126, Grade-B:
      a. Standard Specification for Gray Iron Castings for valves, flanges and pipe fittings: ASTM-A126, Grade B.
   2. Face to face and end to end dimensions: ANSI/ASME-B16.10.
   3. Use domestic manufactured valves as defined by Buy American Act.

I. Valve stems: ASTM-B371, Alloy C69400; ASTM-B371, Alloy C65100H04 (rolled silicon brass); or other material equally resistant to dezincification.

J. Indicate following information on valves:
   1. Stamped or cast into body:
      a. Manufacturer's name or trademark.
      b. Pressure rating as Class, SWP, WOG, or WWP.
      c. "UL-FM" for UL-FM valves.
   2. Permanently attached to body:

a. Valve's country of origin.

1.3 SUBMITTALS

A. Product data:
1. Valves:
a. In addition to submittal requirements of 01 30 00, submittal shall include the following:
1) For submittals with model numbers not listed in this section, include published cross reference sheet. Indicate association between submitted model number and the listed model number on the cross reference sheet.
2) For each valve submitted indicate in which specification section(s) and in which system(s) the valve will be used.
b. When valve assembly includes components other than the base valve body and handle (e.g., operator, valve box), include data on entire valve assembly.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
1. Angle valves:
a. Base:
1) Nibco.
2) Stockham .
b. Optional:
1) Crane Valves.
2) Hammond Valve.
3) Jenkins Valves.
4) Lunken.
5) Milwaukee Valve.
6) Powell.
7) Walworth.
2. Ball valves:
a. Base:
1) Milwaukee Valve.
2) Nibco.
b. Optional:
1) Apollo.
2) Crane Valves.
3) Hammond Valve.
4) Jamesbury.
5) Jenkins Valves.
6) Stockham.
3. Butterfly valves:
a. Base:
1) DeZurik.
2) Milwaukee Valve.
3) Stockham.
4) Victaulic of America.
b. Optional:
1) CenterLine Inds.
2) Crane Valves.
3) Jamesbury.
4) Hammond Valve.
5) Keystone Valve.

6) Lunken.
7) Mueller Steam Specialty.
8) Nibco.
9) Powell.
10) Walworth.

4. Check valves:
   a. Base:
      1) Apco Valve & Primer.
      2) Nibco.
      3) Stockham Valves & Fittings.
   b. Optional:
      1) Crane Valves.
      2) Hammond Valve.
      3) Kennedy Valve.
      4) Milwaukee Valve.
      5) Mueller Steam Specialty.
      6) Powell.
      7) Victaulic of America.
      8) Viking.
      9) Walworth.
      10) Waterous.
5. Gate Valves:
   a. Base:
      1) Mueller Steam Specialty.
      2) Nibco.
      3) Stockham.
   b. Optional:
      1) Crane Valves.
      2) Hammond Valve.
      3) Jenkins Valves.
      4) Kennedy Valve.
      5) Milwaukee Valve.
      6) Mueller Steam Specialty.
      7) Powell.
      8) Walworth.
6. Globe valves:
   a. Base:
      1) Stockham.
   b. Optional:
      1) Crane Valves.
      2) Hammond Valve.
      3) Jenkins Valves.
      4) Lunken.
      5) Milwaukee Valve.
      6) Nibco.
      7) Powell.
      8) Walworth.
7. Plug valves:
   a. Base:
      1) DeZurik.
      2) Resun Valves.
   b. Optional:
      1) Milliken.
      2) Mueller Steam Specialty.
      3) Rockwell International.
      4) Victaulic of America.

8. Valve boxes and stop boxes:
    a. Base:
        1) Tyler Pipe.
        2) Western.
    b. Optional:
        1) Neenah Foundry.
        2) Vulcan.
        3) Local foundry.
9. Balancing valves (globe style):
    a. Base:
        1) Armstrong (Model CBU, min. 4 turn, drip tight shutoff, flow and pressure measurement points).
    b. Optional:
        1) Wheatley.
        2) Mepco.
        3) Tour and Anderson.

B. Ball valves:
1. Port size: Standard.
2. Ball and stem: 316 Stainless Steel.
3. Blow-out proof stems.
4. Reinforced Teflon seats.
5. Teflon seals.
6. Adjustable packing.
7. 3-piece valves:
    a. May be standard port.
    b. Repairable in line.

C. Butterfly valves:
1. Ninety degree operation.
2. Bi-directional, bubble-tight shut off at full pressure rating (at full differential pressure).
3. 2 IN extended neck.
4. Lugs, where specified, shall be drilled and tapped.
5. Operators:
    a. 2-1/2 to 4 IN: Position lock handle.
    b. 5 IN and larger: gear operator with 4-arm or wheel handle.
6. Iron body:
    a. Seals shall be replaceable without removing valve from line or removing parts other than operator.
7. Bronze:
    a. Blow-out proof stem.
    b. Viton seals.
    c. Pressure rating: 175 PSI WWP, 350 PSI WOG.

D. Chain operators:
1. Provide operators for valves located in mechanical spaces 8 FT or higher above floor.
2. Chain lever or chain sprocket operator with sufficient chain to reach within 5 FT of floor.
3. Remote operator accessories by same manufacturer as valve.
4. Do not provide for Fire Protection valves.

E. Electric Valve Operators:
1. Quarter-turn for use with butterfly valves.
2. Permanently lubricated self-locking gear train.
3. Manual over-ride allows operation of valve with motor rotor locked.
4. Mechanical and electrical travel stops:
    a. Travel stops adjustable without disassembly.

5. Drip-proof enclosure:
    a. Epoxy-coated finish to resist corrosion.
    b. Where operator is located out-of-doors, enclosure shall be weather-proof.
    c. Where operator is located in unconditioned environment, provide internal heater to protect operator from low temperature or condensation.
6. Factory Mutual or UL approval.
7. Visual position indicator.
8. Temperature limit: -20 degF to 140 degF.
9. Output torque: Up to 15,000 lb in.
10. Control box:
    a. For wall or pedestal mounting.
    b. Robust, industrial construction. Enclosure, buttons, and pilot lights shall be NEMA rated drip-proof construction.
    c. Open, Close, and Stop buttons.
    d. Open and Closed pilot lights.
    e. Control box to be mounted in a convenient location not more than 48 IN above finished floor.

F. End styles, general:
1. Compatible with piping systems served.
2. Flanged valves:
    a. Class 125 cast iron: Flat flanges.
    b. Class 250 cast iron: Raised flanges.
    c. Ductile iron: Raised flanges.
3. Valves with solder ends for use in brazed piping systems shall be constructed for brazing.

G. Extended necks and stems:
1. For valves specified with extended necks or stems, provide design that isolates moving valve parts from insulation.
2. For valves specified with extended necks or stems and memory stops, provide design that allows access to memory stop without disturbing insulation.

H. Packing shall not contain asbestos.

I. Plug valves:
1. Eccentric plugs:
    a. Non-lubricated valves with resilient seats shall be suitable for 250 degF service.
    b. Rubber seated eccentric plugs: Bolted stem seals shall permit replacement of packing without removing valve from line or removing parts other than operator.

2.2 VALVES

A. General:
1. Example model numbers may indicate a general series, or may be abbreviated. They may not reflect all features described. Provide valves with described features.
2. Specified requirements are minimums. Valves that meet or exceed specifications may be submitted.

B. V-1: Gate valve, Class 125, bronze body, screwed bonnet, non-rising stem, solid wedge disc, solder. Example: Stockham B-112.

C. V-2: Gate valve, Class 150, bronze body, union bonnet, rising stem, solid wedge disc, threaded. Example: Stockham B-120.

D. V-3: Gate valve, Class 125, cast iron body, bronze trim, bolted bonnet, rising stem, OS&Y, solid wedge disc, flanged. Example: Stockham G-623.

E. V-4: Gate valve, same as V-2 except Class 200. Example: Stockham B-135.

F. V-5: Gate valve, same as V-3 except Class 250. Example: Stockham F-667.

G. V-6: Globe valve, Class 150, bronze body, union bonnet, renewable Teflon disc, solder. Example: Stockham B-24T.

H. V-7: Globe valve, same as V-6 except threaded. Example: Stockham B-22T.

I. V-8: Globe valve, Class 125, cast iron body, bronze trim, bolted bonnet, OS&Y, renewable seat and bronze disc, flanged. Example: Stockham G-512.

J. V-9: Globe valve, Class 200, bronze body, union bonnet, renewable plug type seat and disc, threaded. Example: Stockham B-62.

K. V-10: Globe valve, same as V-8 except Class 250. Example: Stockham F-532.

L. V-11: Ball valve, 150 PSI SWP, 400 PSI WOG bronze body, adjustable memory stop, 3-piece construction, extended stem, solder. Example: Milwaukee BA-350S.

M. V-12: Ball valve, same as V-11 except threaded. Example: Milwaukee BA-300S.

N. V-13: Ball valve, 150 PSI SWP, 400 PSI WOG bronze body, 2-piece construction, extended stem, solder. Example: Milwaukee BA-150S.

O. V-14: Ball valve, same as V-13 except threaded. Example: Milwaukee BA-100S.

P. V-15: Ball valve, 150 PSI SWP, 400 PSI WOG, 29 IN Hg vacuum service, bronze body, 3-piece construction, cleaned and capped for oxygen service, lockable in either the open or closed position, color coded handle to match gas service, braze. Example: Milwaukee BA-350S.

Q. V-16: Ball valve, 150 PSI SWP, 600 PSI WOG, 250 PSI UL listed for flammable liquids and LP gas, bronze body, 2-piece construction, full or standard port, bronze ball, non-lubricated, threaded. Example: Nibco T-580-70-UL & T-585-70-UL.

R. V-17: Angle valve, Class 125, bronze body, screwed bonnet, bronze disc, threaded. Example: Stockham B-216.

S. V-18: Angle valve, Class 125, cast iron body, bolted bonnet, bronze trim, renewable seat and disc, flanged. Example: Nibco F-818-B.

T. V-19: Angle valve, Class 200, bronze body, union bonnet, bronze disc, threaded. Example: Stockham B-237.

U. V-20: Angle valve, Class 250, cast iron body, bronze trim, flanged. Example: Stockham F-541.

V. V-21: Angle valve, automatic stop-check, Class 250, cast iron body, bolted bonnet, renewable disc and seat, flanged. Example: Stockham F-541.

W. V-22: Check valve, in-line pattern, spring-operated double doors, Class 250, cast iron body, renewable bronze doors and Viton-A seal, Inconel springs, stainless steel trim, flat faced wafer. Example: Stockham WG-976.

X. V-23: Check valve, Y-pattern, horizontal swing, Class 150, bronze body, threaded cap, renewable Teflon disc and seat, threaded. Example: Nibco T-433-Y.

Y. V-24: Check valve, Y-pattern, horizontal swing, Class 125, bronze body, threaded cap, renewable bronze disc and seat, solder. Example: Nibco S-413-B.

Z. V-25: Check valve, same as V-23 except Class 125. Example: Nibco T-413-Y.

AA. V-26: Check valve, in-line pattern, spring-operated disc, Class 125, bronze body, renewable Teflon disc and seat, 316 stainless-steel spring, threaded. Example: Nibco T-480-Y.

BB. V-27: Check valve, T-pattern, horizontal lift, Class 150, bronze body, union bonnet, renewable Teflon disc and seat, threaded. Example: Stockham B-322-T.

CC. V-28: Check valve, T-pattern, horizontal swing, Class 125, cast iron body, bolted bonnet, bronze trim, renewable bronze or cast iron disc and seat, flanged. Example: Stockham G-931.

DD. V-29: Check valve, in-line pattern, spring-operated double doors, Class 125 (cast iron body) or Class 150 (steel body), Buna-N or EPDM seal, aluminum bronze or stainless steel doors, 316 stainless steel spring; grooved, threaded, flanged, wafer, or lugged at locations other than equipment; grooved, flanged or lugged if between equipment and its isolation valve. Example: APCO L9000.

EE. V-30: Check valve, silent, in-line pattern, spring-operated disc, Class 125, cast iron body, renewable bronze disc and seat, stainless steel spring, flat faced wafer. Example: Nibco W-910-B.

FF. V-31: Check valve, same as V-23 except Class 200. Example: Nibco T-473-Y.

GG. V-32: Check valve, same as V-28 except Class 250. Example: Stockham F-947.

HH. V-33: Butterfly valve, 200 PSI WWP; 27 IN Hg vacuum; cast or ductile iron body; EPT (EPDM) sleeve; stainless steel stem; aluminum-bronze or stainless steel disc; lugged. Example: Stockham L#-7#2.

II. V-34: Butterfly valve, same as V-33 except wafer. Example: Stockham L#-5#2.

JJ. V-35: Butterfly valve, 200 PSI WWP for 12 IN and smaller, 175 PSI WWP for 14 IN and larger; 27 IN Hg vacuum for all sizes; cast or ductile iron body; EPT (EPDM) seat; stainless steel stem; replaceable forged brass, aluminum-bronze, stainless steel, or EPDM coated ductile iron disc; grooved. Example: Victaulic 300/709.

KK. V-36: Eccentric plug valve, 175 PSI WOG, cast-iron body, bronze or nickel-plated cast-iron plug, Isobutene-Isoprene steam and plug seals, high-temperature plug face, capped drip tap on seat end of valve, memory stop, lever handle, threaded. Example: DeZurik 499S.

LL. V-37: Eccentric plug valve, 175 PSI WWP for 12 IN and smaller, 150 PSI WWP for 14 IN and larger, cast-iron body, Viton filled TFE U-ring seal, Isobutene-Isoprene plug face, memory stop; lever handle for sizes 2-1/2 to 4 IN; gear operator with handwheel actuator for sizes 6 IN and larger; flanged. Example: DeZurik 118F.

MM. V-38: Eccentric plug valve, same as V-36 except flanged, or grooved. Example: DeZurik 499.

NN. V-39: Ball valve, same as V-13 and V-14 except include adjustable memory stop. Example: Milwaukee BA-100S and BA-150S.

OO. V-40: Butterfly valve, 200 PSI WWP, bronze body, adjustable memory stop with visual disc position range of 90 degrees, stainless steel disc and stem, Viton seal, threaded. Example: Milwaukee BB2-100.

PP. V-41: Plug valve, lubricated, 200 PSI WOG, semi-steel, bottom or bolted-top entry, UL listed for application, lubricant compatible with application, short pattern flanged. Example: Resun R-1431.

QQ. V-42: Not used.

RR. V-47, Gate valve with valve box:

1. Gate valve, AWWA-C500, 200 PSI WWP for 12 IN and smaller, 150 PSI for 14 IN and larger, iron body, bronze mounted, bronze or cast-iron double disc, non-rising stem, parallel seat, mechanical joint. Example: Stockham G-743.
2. Valve box: coated cast-iron, 5-1/4 IN shaft, screw type, 3-piece, drop-in lid with cast-in marking indicating service. Example: Tyler 6860.

SS. V-48, Butterfly valve with valve box:
   1. Butterfly valve, AWWA-C504, Class 150, iron body, stainless steel seat, aluminum-bronze or cast iron disc, natural rubber or Buna-N seat, mechanical joint or flanged. Example: DeZurik BAW.
   2. Valve box: coated cast-iron, 5-1/4 IN shaft, screw type, 3-piece, drop-in lid with cast-in marking indicating service. Example: Tyler 6860.

TT. V-49: Gate valve, UL-FM, 175 PSI WWP, bronze body, union or screwed bonnet, solid wedge disc, OS&Y, threaded. Example: Nibco T-104-O.

UU. V-50: Gate valve, UL-FM, 175 PSI WWP, cast iron body, bolted bonnet, resilient or solid wedge, OS&Y, flanged. Example: Stockham G-634.

VV. V-51: Butterfly valve, UL-FM, 175 PSI WWP, ductile iron body, O-Ring seals, aluminum-bronze or ductile-iron disc, stainless steel stem, Buna-N seal, manual geared operator with visual position indicator, lugged. Example: Stockham LD-72UF.

WW. V-52: Gate valve, UL-FM, AWWA C-509, 175 PSI WWP, cast iron body, resilient wedge, non-rise stem, indicator post flange, MJ or flanged. Example: Stockham G-600/601/602.

XX. V-53: Check valve, T-pattern, horizontal swing, UL-FM, 175 PSI WWP, cast iron body, bolted bonnet, bronze trim, renewable bronze or cast-iron disc and seat, flanged. Example: Stockham G-939.

YY. V-54: Check valve, in-line, spring-operated single or double door(s), UL-FM, 200 PSI WWP, cast iron body, renewable bronze door and rubber or EPDM seat, stainless steel spring, wafer or grooved. Example: Stockham WG-990.

ZZ. V-55: Butterfly valve, UL listed, 175 PSI WWP, bronze body, stainless steel stem and disc, Viton seal, threaded. Example: Milwaukee BB2-100.

AAA. V-56: Butterfly valve, same as V-40 except include extended neck, solder. Example: Milwaukee BB2-350.

BBB. V-57: Butterfly valve, same as V-40 except include extended neck, threaded. Example: Milwaukee BB2-100.

CCC. V-58: Not used.

DDD. V-59: Butterfly valve, same as V-55 with tamper switch. Example: Milwaukee BB2-100.

EEE. V-60: Plug valve, lubricated, 125 PSI WOG semi-steel, bottom or bolted-top entry, UL listed for application, lubricant compatible with application, threaded. Example: Resun R-1430.

FFF. V-61: Butterfly valve, UL-FM, 175 PSI WWP, coated cast or ductile iron body, aluminum bronze or ductile iron disk with EPDM coating, manual geared operator with visual position indicator, grooved. Example: Victaulic 708.

GGG. V-62: Butterfly valve, 300 PSI WOG, 27 IN vacuum, bronze body, ductile iron disk with EPDM coating, extended neck, grooved. Example: Victaulic 600.

HHH. V-63: Butterfly valve, Class 150, carbon steel body, RTFE seat, stainless steel shaft, stainless steel disc, TFE packing, wafer. Example: Campbell 1W.

III. V-64: Globe-style balancing valve, Y-pattern design, rated for 300 PSI WWP and 250 degF, cast copper alloy construction, dual pressure/temperature read-out ports, calibrated handwheel with minimum (4) 360 degree adjustment turns and hidden tamper-proof memory stop, threaded or sweat connections and suitable for positive shut-off.

JJJ. V-65: Globe style balancing valve, Y-pattern design, rated for 250 PSI WWP and 250 degF, cast iron body fitted with copper alloy components, dual pressure/temperature read-out ports, calibrated handwheel with minimum (5) 360 degree adjustment turns and hidden tamper-proof memory stop, Class 125 flanged or grooved connections, and suitable for positive shut-off.

KKK. V-66: High performance butterfly valve, Class 150, 316 stainless steel body, RTFE seat, stainless steel shaft, stainless steel disc, TFE packing, wafer. Example: Dezurik BHP.

LLL. V-67: Ball valve, 150 PSI SWP, 1000 PSI WOG 316 stainless steel body, locking handle, 3-piece construction, NPT or socket weld. All wetted parts to be stainless steel. Example: Milwaukee 30SSOF.

MMM. V-68: Plug valve, non-lubricated, 316 stainless steel construction. ANSI 150 LB flanged connections. Pressure rating; 250 PSIG minimum. Bearings shall be sleeve type metal bearings of 316 stainless steel ASTM A743 grade CF8M. Shaft seals shall be multiple v-ring type. Example: Sartell, Series 100.

NNN. V-69: Check valve, stainless steel ASTM A351 CF8M body, cover, disc and hinge arm. 150 LB pressure class, flanged end connections. Gasket and plug seal: PTFE hinge pin, disc nut and plug: Type 304 or 316 stainless steel. Example: Aloyco/Crane, Figure 377.

OOO. V-70: Check valve, in-line pattern spring-operated double doors, Class 150 316 stainless steel body, EPDM seat, 316 stainless steel doors and spring; threaded lug type. Example APCO S-9000L (stainless steel).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to individual sections for specific valve installation requirements.

B. Keep valves clear of pull spaces.

C. Install valves in accessible locations for operation, removal, inspection, and repair of valves and equipment.

D. Install gate and globe valves with stem in vertical upright to horizontal position.

E. Install butterfly valves with stem in horizontal position.

F. Install diaphragm valves to be self draining.

G. Support valves individually to relieve pipe stress and allow equipment removal.

H. Follow manufacturer's recommendation for disassembly of valves for end joining method employed.

I. Provide globe valve in bypass around control valves. Coordinate with Controls Contractor.

J. Provide shut off valve on each side of control valve. Coordinate with Controls Contractor.

END OF SECTION

SECTION 20 05 29
PENETRATIONS AND SUPPORTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. Penetrations.
   2. Pipe hangers and supports.
   3. Pipe and equipment anchors.
   4. Pipe supports at plumbing fixtures.

B. Definitions:
   1. UCSS: Universal Channel Strut System.

1.2 QUALITY ASSURANCE

A. Pipe hanger standards:
   1. Manufacturers Standardization Society (MSS) SP-58, SP-89 and SP-69, as referenced.
   2. ASME/ANSI B31.1.
   3. Coordinate with Section 20 05 50.

1.3 SUBMITTALS

A. Shop drawings:
   1. For pipe larger than 16 IN, show layout of hanger locations and method of support from structure.

B. Product data:
   1. Pipe hangers:
      a. Identify each hanger according to systems, pipe sizes, and orientations on which it will be used.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Pipe hangers:
      a. Base:
         1) B-Line Systems.
      b. Optional:
         1) Grinnell.
         2) Elcen.
   2. Concrete inserts, pre-pour:
      a. Base:
         1) B-Line Systems.
      b. Optional:
         1) Grinnell.
         2) Ackerman - Johnson.
         3) Hilti.
   3. Concrete inserts, post-pour:
      a. Base:
         1) Phillips Drill Co.

b. Optional:
    1) Hilti.
    2) Ackerman - Johnson.
4. Factory-fabricated supports for insulated pipe:
    a. Base:
        1) Pipe Shields.
    b. Optional:
        1) B-Line Systems.
        2) Power Piping.
5. Pipe and equipment anchors:
    a. Base:
        1) Shop fabricated.
    b. Optional:
        1) Field fabricated.
6. Factory-fabricated pipe supports at plumbing fixtures:
    a. Base:
        1) Sioux Chief Manufacturing.
    b. Optional:
        1) B-Line Systems.
        2) Holdrite.
        3) Sumner.
7. Universal channel strut system:
    a. Base:
        1) Unistrut.
    b. Optional:
        1) B-Line Systems.
        2) Grinnel.

2.2 PENETRATIONS

A. Penetrations - general:
    1. For concrete walls, floors, roofs, foundations, footings and grade beams, provide openings sufficiently sized to allow free movement of piping with insulation continuous through sleeve.
    2. Create openings by placing sleeves prior to pouring of concrete or by core drilling after concrete has set.
    3. Opening diameters:
        a. Minimum 3 IN.
        b. Bare pipe: Minimum 1 IN larger than outside diameter of pipe.
        c. Insulated pipe: Minimum 1-1/2 IN larger than outside diameter of insulation.
        d. Diameter suitable for construction tolerances and to receive sealant.
    4. Openings for future work: Same as for this work.

B. Pipe entrance wall sleeve and anchoring:
    1. Provide steel, heavy wall welded or seamless pipe sleeve full circle continuously welded water stop plate.
    2. Provide sleeve full length of wall thickness and protect with a primer coat.
    3. Structurally secure pipe to withstand water hammer force:
        a. Extend exterior piping material into building a minimum of 12 IN.
        b. Provide a mechanical joint on interior end of pipe and mechanical tie in back to adjoining structural (exterior) wall.
    4. Provide "link seal" on pipe at exterior side of sleeve.

C. Sealants:
    1. Seal annular space around piping.
    2. For fire and smoke rated floors and walls, see Section 07 84 00.
    3. For non-rated floors and walls, use mineral or glass fiber insulation.

4. For exterior and foundation walls: Use synthetic rubber seals, "Link-Seal" water proof material or system.

2.3 PIPE HANGERS

A. Pipe hangers - General:
   1. Materials, design and manufacture: MSS SP-58.
   2. Fabrication and installation: MSS SP-89.
   3. Selection and application: MSS SP-69.
   4. Hangers and channels, angles, and supporting steel: Galvanized unless indicated otherwise.
   5. Pipes running parallel may be supported on trapezes.
   6. Hanger rods of continuous thread type: Galvanize after threads are cut.
   7. Galvanize structural steel, angles, rods, channels, and hardware located in boiler, mechanical, and fan rooms and on roofs.
   8. Where grooved couplings are used, place hanger within 2 FT each side of fittings or refer to manufacturer's pipe support and anchorage guide.
   9. Screw threads on hangers and fittings: Conform to Class 2A and 2B of ANSI/ASME-B1.1.

B. Structural and vibration considerations:
   1. Steel or concrete roof/floor system including slabs or roof deck shall be in place and complete before installation of mechanical piping system.
   2. Space hangers so maximum individual hanger load will not exceed values listed in paragraph "Pipe hanger loading".
   3. Do not attach hangers to steel roof deck.
   4. Do not attach hangers to bottom of concrete filled floor deck.
   5. Attach hangers to beams or brackets mounted on building columns, or racks mounted on steel columns mounted on levels one and two.
   6. Coordinate with Section 20 05 50.

C. Pipe hanger spacing:
   1. Locate hangers at each change of direction.
   2. Space hangers at or within following maximum limits:

	Standard Steel		Copper	
Pipe Diameter	Fluid	Vapor	Fluid	Vapor
1/2 – 1-1/4 IN	12 FT	12 FT	6 FT	6 FT
1-1/2 - 2 IN	12 FT	12 FT	10 FT	10 FT
2-1/2 - 3 IN	12 FT	12 FT	10 FT	10 FT
3-1/2 - 4 IN	12 FT	12FT	10 FT	10 FT
5 - 6 IN	12 FT	12 FT	10 FT	10 FT
8 - 14 IN	12 FT	12 FT	10 FT	10 FT
16 IN	12 FT	12 FT		

   3. For pipe larger than 16 IN diameter, see mechanical drawing for location of hanger supports:
      a. If not shown on plans, provide shop drawings for approval showing location of hangers and method of support from structure.
   4. Fire protection piping: See Section 21 10 00.
   5. For cast iron pressure piping, space maximum 12 FT OC:
      a. Provide minimum of one hanger per pipe section close to joint on barrel and at change of direction and branch connections.
   6. For cast iron soil piping, space maximum 10 FT OC:
      a. Provide minimum of one hanger per pipe section close to joint on barrel and at change of direction and branch connections.
   7. For piping materials not covered in this spec, space hangers according to manufacturer's recommendations.

D. Pipe hanger rod loading:
   1. Total hanger rod load (including piping, insulation, and fluid) not exceeding following limits:

Nominal Rod Diameter	Maximum Load
3/8 IN	610 LB
1/2 IN	1130 LB
5/8 IN	1810 LB
3/4 IN	2710 LB

   2. Provide the minimum hanger rod diameters:

Pipe Size (IN)	Diameter (IN)
1/2 to 1-1/4	3/8
1-1/2 to 2	3/8
2-1/2 to 3	1/2
4 to 6	5/8
8 to 12	7/8
14 and over	1
PVC to 3	3/8
PVC over 3	1/2

   3. Do not exceed manufacturer's recommended maximum safe load if smaller than above.

E. Pipe hangers for uninsulated pipe:
   1. Independent hangers: MSS SP-69 type 1, 3, 4, 5, 7, 9, 10, 11, 12, 24, 41, 43, 44, 45, or 46.
      a. Use types 7 and 10 only on pipe sizes 6 IN and smaller.
   2. Hangers used with trapezes:
      a. MSS SP-69 type 24 or 26.
      b. Hanger designed as part of UCSS.
   3. Hangers supporting bare copper pipe:
      a. Copper plated or electro-galvanized hangers. Provide factory-applied felt or plastic padding to eliminate contact between support and copper pipe.

F. Pipe hangers for insulated pipe:
   1. Hangers shall support piping from outside diameter of insulation.
   2. Independent hangers: MSS SP-69 type 1, 3, 7, 9, 10, 41, 43, 44, 45, or 46:
      a. Use types 7 and 10 only on pipe sizes 6 IN and smaller.
   3. Hangers used with trapezes:
      a. Pipe sizes 2 IN and smaller: MSS SP-69 type 26.
      b. Pipe sizes 2-1/2 IN and larger:
         1) MSS SP-69 type 24 or 26.
         2) Hanger designed as part of UCSS.
   4. Pipe sizes 2 IN and smaller: Use hanger with insulation protection shield: MSS SP-69 type 40.
   5. Pipe sizes 2-1/2 IN and larger: Use hanger with factory-fabricated support:
      a. 100 PSI, waterproofed calcium silicate fully encased in sheet metal shield.
         1) Pipe supported on rod hangers: Pipe Shields Models A1000, A2000, A3000, A4000 and A9000.
         2) Pipe supported on flat surfaces: Pipe Shields Models A1000, A2000, A5000, A6000 and A7000.
         3) Pipe supported on pipe rolls: Pipe Shields Models A3000, A4000, A5000, A6000 and A8000.
      b. Extend insulation inserts 1 IN beyond shields on refrigerant and chilled water lines.
      c. For steam piping 8 IN and larger, provide supports with slide bases.
   6. Steam pipe sizes 8 IN and larger: Use MSS SP-69 hanger type 41, 43, 44, 45, or 46 with support indicated for pipe sizes 2-1/2 IN and larger.

7. Provide rigid insulation inserts at all hangers and points of support for insulated piping 1-1/2 IN and larger. Inserts shall be fire retardant treated wood blocks, calcium silicate or other high density insulating material. Insert shall be same thickness as adjoining pipe insulation and shall be provided with vapor barrier jacket. Insulation inserts shall not be less than the following lengths:

Pipe Size (IN)	Insert Length (IN)
1-1/2 to 2-1/2	10
3 to 6	12
8 to 10	16
12 and larger	22

8. A 180 degree galvanized sheet metal shield shall be provided between hangers or supports and the insulation inserts. Shields shall be 16 gauge for pipe sizes up to (but not including) 6 IN and shall be 12 gauge for pipe sizes 6 IN and larger. Shield length shall be as follows:

Pipe Size (IN)	Shield Length (IN)
1/2 to 2-1/2	6
3 to 6	8
8 to 10	12
12 and larger	18

G. Pipe hangers in other situations: See MSS-SP-69.

H. Trapezes:
1. Suspend trapezes from concrete inserts, approved structural clips or beam clamps.
2. Construct trapezes of galvanized angle iron, UCSS channels, or other structural shapes with flat surfaces for point of support.
3. See pipe hanger paragraphs for hanger types allowed with trapezes.

I. Vertical pipe supports and guides:
1. Support vertical pipe runs in pipe chases from the top and every other floor down.
2. Provide pipe guides for lateral movement on alternating floors of pipe supports.

J. Concrete inserts:
1. Pre-pour concrete inserts:
   a. Continuous-slot or individual concrete inserts for use with hangers for piping and equipment exposed in labs and classrooms, and as required.
   b. Provide inserts in time for installation in concrete.
   c. Continuous-slot inserts:
      1) B-Line Figure B22I, B32I, B42I or B52I.
   d. Individual inserts:
      1) Grinnell Figure 282, or 281.
      2) Do not exceed manufacturer's recommended load on insert.
2. Post-pour concrete inserts:
   a. Hard-metal, self-drilling wedging anchors tapped for threaded rods and designed not to depend on lead or wood for holding power.

K. Beam clamps:
1. Pipe size 3 IN and smaller:
   a. MSS SP-69 types 19 or 23.
2. Pipe sizes larger than 3 IN but smaller than 8 IN:
   a. Malleable-iron beam clamp: MSS SP-69 type 30.
   b. Iron beam clamp: B-Line B3055 or equal.
3. Pipe sizes 8 IN and larger:
   a. Forged steel beam clamps: MSS SP-69 type 28 or type 29.
   b. Steel Beam clamps: B-Line B3291 through B3298 or equal.

2.4 PIPE AND EQUIPMENT ANCHORS

A. Pipe anchors:
   1. Provide as indicated and required to permit complete installation of system.
   2. Do not anchor piping to plaster or gypsum wallboard partition walls.
   3. Provide anchoring devices at locations indicated.

B. Anchors: Angle iron and rods with turnbuckles, unless detailed otherwise.

C. Anchors for ductwork, equipment and piping hanger rods:
   1. Post-pour concrete inserts: Hard-metal, self-drilling wedging anchors tapped for threaded rods and designed not to depend on lead or wood for holding power.

D. Anchors for steam piping:
   1. Two-part epoxy adhesive system with 304 stainless steel all treaded fasteners. Performance equal to Hilti HVA or better.
   2. Maximum depth of fastener drilling: 4-1/2 IN.
   3. Size all thread fasteners that 1-1/2 IN protrudes after the baseplate, washers, and nuts are installed.
   4. Provide disc spring washers (Belleville type) at all anchor, expansion joint, guide, and support locations.

E. Size anchors in steam pipes 15 psig and less for 475 degF, above 15 psig 650 degF.

2.5 PIPE SUPPORTS AT PLUMBING FIXTURES

A. Pipe supports at plumbing fixtures:
   1. Fire-treated dimensional lumber.
   2. Factory-fabricated metal brackets:
      a. Plastic grommets/inserts factory fabricated for specific pipe diameters and materials.
   3. Factory-fabricated PVC pipe supports and pipe fasteners:
      a. Fastening method: Stainless-steel bands and screws.
      b. PVC: Fire retardant.

PART 3 - EXECUTION

3.1 GENERAL

A. Install components as indicated and in accordance with manufacturer's instructions and recommendations.

B. Obtain and follow BNL's Physical Facilities Guidelines.

3.2 PENETRATIONS

A. Coordinate locations of openings in structural systems with BNL.

B. Maintain rating of fire and smoke rated construction: See Section 07 84 00.

C. Set sleeves plumb or level, in proper position, tightly fitted into work:
   1. Remove sleeves before installing piping.

3.3 PIPE SUPPORTS AT PLUMBING FIXTURES

A. Pipe supports at plumbing fixtures:
   1. General: Fasten piping to supports within 8 IN of final fixture connection point (valve).
   2. Factory-fabricated brackets:
      a. Fasten brackets to studs with screws.
      b. Galvanized brackets:
         1) Fasten piping to brackets with plastic grommets/inserts.
      c. Copper-clad brackets:

1) Use only with copper piping.
2) Isolate copper-clad brackets from metal studs with insulating tape, felt, or rubber pads.
3) Fasten piping to brackets by soldering or by using plastic grommets/inserts.

3. Factory-fabricated PVC supports:
   a. Fasten brackets to waste piping, fixture carriers, or studs.

3.4 BASE PLATES

A. Ship all steam anchor and expansion joint base plates loose to be field fit and welded.

B. The height of the stand-off to be 1-1/2 IN higher to provide sufficient material for field alignment and adjustment.

END OF SECTION

SECTION 20 05 50
VIBRATION ISOLATION OF MECHANICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide vibration control devices, materials, and related items. Perform all work as indicated on drawings and as specified herein to provide complete vibration isolation systems in proper working order.

1.2 MATERIAL AND EQUIPMENT

A. All vibration isolation mounts shall be supplied by one of the following approved manufacturers:
   1. Amber/Booth Co. (Houston, TX) - A.B.
   2. Korfund Dynamics Corp. (Westbury, NY) - K.D.
   3. Mason Industries Inc. (Hauppauge, NY) - M.I.
   4. Kinetics Noise Control Inc. (Dublin, OH) - K.N.C.
   5. Vibration Mountings & Controls Inc. (Butler, NJ) - V.M.&C.

B. Unless otherwise specified, supply only new equipment, parts and materials.

C. The intent of this specification is to ensure the highest standard of vibration isolation for this project. For this reason, all vibration isolation products and materials shall be furnished by a single manufacturer, who will be responsible for the proper installation and operation of all vibration isolation equipment and systems. The only exception will be internal vibration isolation that is integral with the equipment, such as internal isolators on air handling units.

1.3 REQUESTS FOR CHANGE

A. Any requests for changes to Specifications must be submitted in writing at least ten days prior to offer closing. Approval will be given through a written addendum.

1.4 CONTRACTOR'S GENERAL RESPONSIBILITIES

A. The Contractor shall bring to BNL's attention prior to installation any conflicts which will result in unavoidable contact between the building structure and the isolated equipment, piping, etc., described herein, due to inadequate space, etc. Corrective work necessitated by conflicts after installation shall be at the expense of the responsible Contractor.

B. The Contractor shall bring to BNL's attention prior to installation any discrepancies between the requirements of this specification and field conditions, changes required due to specific equipment selection, etc. Corrective work necessitated by discrepancies after installation shall be at the expense of the responsible Contractor.

1.5 DESIGN CRITERIA

A. Equipment, ductwork, piping and conduit shall not be installed which makes rigid contact with the structure unless it is allowed by this specification.

B. Pipe Anchors and Supports: Piping supports and anchors shall not interfere with free operation of vibration isolation systems. Stiff-leg support of piping supported on Type HS, or Type FSN isolators is not acceptable.

C. Ductwork: Ductwork isolation requirements are based on duct equivalent diameters. For rectangular ductwork, the equivalent diameter is the diameter of duct having the same cross-sectional area.

D. Equipment Isolation Frames and Bases: Frames and bases used to support vibration isolated pumps shall be sized to provide support for pipe elbows.

E. Isolation/Absorption Products: The completed installation must be free of vibration and noise. Systems, equipment, or parts which vibrate or generate vibration unduly, or which generate or emit undue noise while in operation, shall: (1) be adjusted, repaired, or replaced as appropriate to obtain acceptable levels of vibration or noise, or (2) be supported on, or fitted with, suppression or absorption devices, or other means, which effectively prevent the transmission of vibration or noise beyond the offending item.

F. Resilient Wall, Ceiling, and Floor Penetrations: Provide resilient wall and ceiling penetrations for all piping, conduit, ductwork, etc., supported on Type HS or Type FSN isolators. Refer to resilient penetration details on the drawings.

1.6 QUALITY ASSURANCE

A. Coordinate the size, location, and special requirements of vibration isolation equipment and systems with other trades. Coordinate plan dimensions with size of housekeeping pads.

B. Provide vibration isolators of the appropriate sizes, with the proper loading to meet the specified deflection requirements.

C. Provide any incidental materials needed to meet the requirements stated herein, even if not expressly specified or indicated on drawings, without claim for additional payment.

D. Verify correctness of equipment model numbers and conformance of each component with manufacturer's specifications.

E. Should any rotating equipment cause excessive noise or vibration; rebalance, realign, or provide other remedial work required to reduce noise and vibration levels. Excessive is defined as specifications exceeding these specifications or the manufacturer's specifications for the unit in question.

F. Upon completion of the work, BNL or BNL's representative shall inspect the installation and shall inform the installing Contractor of any further work that must be completed. Make all adjustments as directed by the Architect that result from the final inspection. This work shall be done before vibration isolation systems are accepted.

1.7 SUBMITTALS

A. Shop drawings: Prior to ordering any products, submit shop drawings of the items listed below. The shop drawings must be complete when submitted and must be presented in a clear, easily understood form. Incomplete or unclear presentation of shop drawings may be reason for rejection of the submittal:
   1. A complete description of products to be supplied, including product data, dimensions, specifications, and installation instructions.
   2. Detailed selection data for each vibration isolator supporting equipment, including:
      a. The equipment identification mark.
      b. The isolator type.
      c. The actual load.
      d. The static deflection expected under the actual load.
      e. Specified minimum static deflection.
      f. The additional deflection-to-solid under load.
      g. The ratio of spring height under load to spring diameter.
   3. Steel rails, steel base frames, and concrete inertia bases indicating all steel work, reinforcing, vibration isolator mounting attachment method, and location of equipment attachment bolts.
   4. Written approval of the frame design to be used shall be obtained from the equipment manufacturer.
   5. Drawings showing methods for suspension, of support, and guides.

6. Drawings showing methods for isolation of piping, at penetrations of walls, slabs, and beams.
7. Special details necessary to convey complete understanding of the work to be performed.
8. Isolated trapeze hangers within the service galleys.

B. Product data: Not required for BNL review.

C. Samples: None required for BNL review.

D. Project information: Not required for BNL review.

E. Contract closeout information: Not required for BNL review.

F. Equipment field final balance reports.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATION MOUNT TYPES

A. General:
1. Metal parts of vibration-isolation units shall be as follows:
   a. Galvanizing shall meet ASTM Salt Spray Test Standards and Federal Test Standard No. 14:
      1) Housing: Hot-dipped galvanized or fusion epoxy coated.
      2) Hardware (washers, nuts, bolts, etc.): Cadmium plated.
      3) Springs shall be neoprene coated.
2. All isolators installed out-doors shall have base plates with bolt holes for fastening the isolators to the support members.
3. Isolator types are scheduled to establish minimum standards. At the Contractor's option, labor saving accessories can be an integral part of isolators supplied to provide initial lift of equipment to operating height, hold piping at fixed elevations during installation and initial system filling operations, and similar installation advantages. Accessories shall not degrade the vibration isolation system.
4. Static deflection of isolators shall be as provided in SECTION 3 - EXECUTION and as indicated on drawings. All static deflections stated are the minimum acceptable deflection for the mounts under actual load. Isolators selected solely on the basis of rated deflections are not acceptable and will be disapproved.
5. The use of nested springs or of multiple parallel springs within a single mount is not permitted.
6. All metal parts of vibration isolation units installed out-of-doors shall be cold-dip galvanized, cadmium plated, or neoprene coated after fabrication. Galvanizing shall meet ASTM Salt Spray Test Standards.

B. Type FN (Floor Neoprene):
1. Neoprene isolators shall be neoprene-in-shear type with steel reinforced top and base. All metal surfaces shall be covered with neoprene. The top and bottom surfaces shall be ribbed. Bolt holes shall be provided in the base and the top shall have a threaded fastener. The mounts shall include leveling bolts that may be rigidly connected to the equipment.
2. Type FN isolators shall be one of the following products:

Type RVD	A.B.
Type F	K.D.
Type ND	M.I.
Type RD	K.N.C.
Series R/RD	V.M.&C.

C. Type FSN (Floor Spring and Neoprene):
   1. Spring isolators shall be freestanding and laterally stable without any housing. Spring diameter shall be not less than 0.8 of the compressed height of the spring at the rated load. Springs shall have a minimum additional travel-to-solid equal to 50 percent of the rated deflection. Springs shall be so designed that the ratio of horizontal stiffness to vertical stiffness is approximately 1 (one). All mounts shall have leveling bolts.
   2. Either the spring element in the isolator shall be set in a neoprene cup and have a steel washer to distribute the load evenly over the neoprene, or each isolator shall be mounted on a Type DNP (Double Neoprene Pad) isolator. If the DNP isolator is used, provide a rectangular bearing plate of appropriate size to load the pad uniformly within the manufacturer's recommended range.
   3. If the basic spring isolator has a neoprene friction pad on its base and a DNP isolator is to be added to the base, a galvanized steel, stainless steel or aluminum plate shall be used between the friction pad and the DNP isolator. If the isolator is outdoors, the plate shall not be made of galvanized steel. The DNP isolator, separator plate and friction pad shall be permanently adhered to one another and to the bottom of the bearing plate.
   4. If the isolator is to be fastened to the building structure and a Type DNP isolator is used under the bearing plate, neoprene grommets shall be provided for each bolt hole in the base plate. Bolt holes shall be properly sized to allow for grommets. The hold down bolt assembly shall include washers to distribute load evenly over the grommets. Bolts and washers are to be galvanized.
   5. Type FSN isolators shall be one of the following products with the appropriate neoprene pad (if used) selected from Type DNP:

Type SW	A.B.
Type WSL	K.D.
Type SLF	M.I.
Type FDS	K.N.C.
Type AC or AD	V.M.&C.

D. Type PCF (Precompressed Fiberglass):
   1. Precompressed fiberglass blocks shall be made of molded inorganic glass fiber that is individually coated and sealed with an impervious elastomeric membrane. Fiberglass shall be severely overloaded during manufacture to stabilize the material into a product that is permanent and has consistent, predictable dynamic properties.
   2. Type PCF isolators shall be one of the following products.

Type KIP	K.N.C.

E. Type HSN (Hanger Spring and Neoprene):
   1. Vibration isolation hangers shall consist of a free standing and laterally stable steel spring and a neoprene element in series, contained within a steel housing. Spring diameters and hanger housing lower hole sizes shall be large enough to permit the hanger rod to swing through a 30 degree arc before contacting the housing. Spring diameter shall be not less than 0.8 of the compressed height of the spring at the rated load. Spring elements shall have a minimum additional travel-to-solid equal to 50 percent of the rated deflection. The neoprene element shall be designed to have a 0.3 IN minimum static deflection. The deflection of both the spring element and the neoprene element shall be included in determining the overall deflection of Type HSN isolators.
   2. Type HSN isolators shall be one of the following products:

Type BSRA	A.B.
Type VSX-30	K.D.
Type 30N	M.I.
Type SPH or SFH	K.N.C.
Type RSH or RFH	V.M.&.C.

F. Type HN (Hanger Neoprene):
   1. Vibration isolation hangers shall consist of a neoprene-in-shear element contained within a steel housing. A neoprene neck bushing shall be provided where the hanger rod passes through the hanger housing to prevent the rod from contacting the hanger housing. The diameter of the hole n the housing shall be sufficient to permit the hanger rod to swing through a 30 degree arc before contacting the hanger housing.
   2. Type HN isolators shall be one of the following products:

Type BRD-A	A.B.
Type H	K.D.
Type HD	M.I.
Type RH or FH	K.N.C.
Type RHD or RFD	V.M.&.C.

2.2 EQUIPMENT BASES

A. Type BSF (Base - Steel Frame):
   1. Steel base frames shall consist of structural steel sections sized, spaced, and connected to form a rigid base which will not twist, rack, deform, or deflect in any manner which will negatively affect the operation of the supported equipment or the vibration isolation mounts. Frames shall be adequately sized to support basic equipment units and motors plus any associated pipe elbow supports, duct elbow supports, electrical control elements, or other components closely related and requiring resilient support in order to prevent vibration transfer to the building structure. The depth of steel frame bases shall be at least 0.1 times the longest dimension of the base, but not less than 6 IN nor more than 12 IN. The base footprint shall be large enough to provide stability for supported equipment.
   2. Frame bases shall include side mounting brackets for attachment to vibration isolators. Mounting brackets shall be located on the sides of the base that are parallel to the axis of rotation of the supported equipment.
   3. Type BSF bases shall be supplied by the isolator manufacturer and shall be one of the following products:

Type WX	A.B.
Type Steel Base	K.D.
Type WFSL	M.I.
Type SFB or SRB	K.N.C.
Series WFB	V.M.&C.

B. Type BIB (Base - Inertia Base):
   1. Concrete inertia bases shall be formed of stone-aggregate concrete, 150 LBS/FT3 and appropriate steel reinforcing cast between welded or bolted perimeter structural steel channels. Inertia bases shall be built to form a rigid base which will not twist, rack, deform, deflect, or crack in any manner which would negatively affect the operation of the supported equipment or the vibration isolation mounts. Inertia bases shall be adequately sized to support basic equipment units and motors plus any associated pipe elbow supports, duct elbow supports, electrical control elements, or other components closely related and requiring resilient support in order to prevent vibration transfer to the building structure. Inertia base depth shall be at least 0.083 times the longest dimension of the inertia base, but not less than 6 IN nor more that 12 IN. The base footprint shall be large enough to provide stability for supported equipment.
   2. Inertia bases shall include side mounting brackets for attachment to vibration isolators. Mounting brackets shall be located on the sides of the base that are parallel to the axis of rotation of the supported equipment.
   3. The steel frame and reinforcement shall be supplied by the vibration isolator manufacturer. Provide concrete in accordance with requirements of Division 3.
   4. Frame and reinforcement for Type BIB bases shall be one of the following products:

Type CPF	A.B.
Type RCPF	K.D.
Type KSL	M.I.
Type CIB-L or CIB-H	K.N.C.
Series WPF	V.M.&C.

2.3 RESILIENT PENETRATION SLEEVE/SEAL

A. Provide resilient wall and ceiling penetrations for all piping, conduit, ductwork supported on vibration isolators. Refer to resilient penetration details on drawings.

B. Resilient penetration sleeve/seals shall be field-fabricated from a pipe or sheet metal section that is 1 IN larger than the penetrating element in all directions around the element, and shall be used to provide a sleeve through the construction penetrated. The sleeve shall extend 1 IN beyond the penetrated construction on each side. The space between the sleeve and the penetrating element shall be packed with glass fiber or mineral wool to within 1/4 IN of the ends of the sleeve. The remaining 1/4 IN space on each end shall be filled with acoustical sealant to form an airtight seal. The penetrating element shall be able to pass through the sleeve without contacting the sleeve. Alternatively, prefabricated sleeves accomplishing the same result are acceptable.

2.4 RESILIENT LATERAL GUIDES

A. These units shall either be a standard product of the vibration isolation mounting manufacturer, or be custom fabricated from standard components. These units shall incorporate neoprene isolation elements similar to Type FN which are specifically designed to provide resilient lateral bracing of duct or pipe risers:
   1. Resilient lateral guides shall be one of the following products:

Type Custom	A.B.
Type Custom	K.D.
Type ADA	M.I.
Type RGN	K.N.C.
Type MDPA	V.M.&C.

2.5 FLEXIBLE DUCT CONNECTIONS

A. Flexible duct connections shall be made from coated fabric (or loaded vinyl if called for on drawings). The clear space between connected parts shall be a minimum of 3 IN and the connection shall have 1-1/2 IN minimum of slack material. Material width shall be 150 percent of clear dimension in addition to width required for attachment. Flexible duct connections shall result in a loose and highly compliant connection.

2.6 FLEXIBLE PIPE CONNECTIONS

A. Flexible pipe connections shall be fabricated of multiple plys of Kevlar or nylon cord, fabric, and neoprene; and shall be vulcanized so as to become inseparable and homogeneous. Flexible connections shall be formed in a double sphere shape, and shall be able to accept compressive, elongative, transverse, and angular movements:
   1. The flexible connections shall be selected and specially fitted, if necessary, to suit the system temperature, pressure, and fluid type. In addition, suitable flexible connections should be selected which do not require rods or cables to control extension of the connector.
   2. Connectors for pipe sizes 2 IN or smaller shall have threaded female union couplings on each end. Larger sizes shall be fitted with metallic flange couplings.
   3. Flexible pipe connections shall be Mason Industries Type SFDEJ; Metraflex Double Sphere (Type DS); V.M.C. Type VMT.

B. Deionized Water System:
   1. Stainless steel pump connector constructed of 304 stainless steel inner corrugated hose and Type 304 stainless steel outer braid.

2. Plate stainless steel flange connections.
3. Minimum working pressure: 150 PSIG at 70 degF.
4. Flexible connections shall be Metraflex, Model SLP.

2.7 RESTRAINTS

A. Thrust Restraints:
1. Thrust restraints shall consist of a spring element in series with a neoprene pad. The unit shall be designed to have the same deflection due to thrust-generated loads as specified for the isolators supporting the equipment. The spring element shall be contained within a steel frame and be designed so it can be precompressed at the factory to allow for a maximum of 1/4 IN movement during starting or stopping of the equipment. Allowable movement shall be field-adjustable.
2. The assembly shall be furnished complete with rods and angle brackets for attachment to both the equipment and the adjacent fixed structural anchor.
3. The thrust restraints shall be installed on the discharge of the fan so that the restraint rods are in tension. Assemblies that place the rods in compression are not acceptable.
4. The holes in the spring restraint brackets through which the restraint rods pass must be oversized to prevent contact between the brackets and rods.
5. Thrust restraints shall be Mason Industries Type WBI or WBD.

2.8 GROMMETS

A. Grommets shall either be custom made by combining a neoprene washer and sleeve, be Isogrommets as manufactured by MBIS, Inc. (Bedford Heights, Ohio), or be Series W by Barry Controls (Watertown, Mass.). Grommets shall be sized so that they will be loaded within the manufacturer's recommended load range. Grommets shall be specially formed to prevent bolts from directly contacting the isolator base plate.

2.9 ACOUSTICAL SEALANT

A. Sealants for acoustical purposes as described in this Specification shall be silicone or one of the nonsetting sealants indicated below:

Acoustical sealant	D.A.P.
Acoustical sealant	Pecora
Acoustical sealant	Tremco
Acoustical sealant	U.S.G.

B. Coordinate acoustical performance with fire rated assemblies and vibration isolation assemblies, when applicable.

PART 3 - EXECUTION

3.1 APPLICATION

A. General:
1. Refer to SECTION 2 - PRODUCTS of this Specification for vibration isolation devices identified on drawings or specified herein.
2. The static deflection of all isolators specified herein are the minimum acceptable deflections for the mounts under actual load. Isolators selected solely on the basis of rated deflection are not acceptable and will be disapproved.

B. Major Equipment (see schedule under 3.5 H):
1. Types and minimum static deflections of vibration isolation devices for major equipment items shall be as specified hereunder.
2. Provide flexible duct connections at all fan unit intakes, fan unit discharges, and wherever else indicated on drawings.

3. Provide flexible pipe connections at all pipe connections to vibration-isolated equipment and as indicated on drawings.
4. Provide thrust restraints on all floor-mounted fans developing 4 IN WG or more of static pressure, all suspended fans, and wherever else indicated on drawings.

C. Miscellaneous Mechanical Equipment:
1. Miscellaneous pieces of mechanical equipment such as heat exchangers, pressure reducing stations, dryers, water heaters, steam generators, strainers, storage tanks, condensate receiver tanks, flash tanks and expansion tanks which are connected to isolated piping systems shall be vibration-isolated from the building structure by Type NP or Type HN isolators (selected for 2.5 mm static deflection) unless their position in the piping system requires a higher degree of isolation as called for under Pipe Isolation.

3.2 PIPING ISOLATION

A. Pipe support isolation shall follow the guidelines established below:
1. Spring isolators shall be selected for a static deflection, under load, of not less than 1 IN. Use FSN or HS isolators, whichever is applicable to the mounting condition.
2. Where lateral support of pipe risers is required within the limits of isolation specified below, this shall be accomplished by use of resilient lateral supports.
3. Pipes that penetrate the building structure within the limits of isolation specified below shall be isolated from the structure by use of resilient penetration sleeve/seals.
4. Drain piping connected to vibration-isolated equipment shall not contact the building structure or other non-isolated system unless it is resiliently mounted as described above.
5. Piping connected to vibration-isolated equipment shall be installed so that it does not strain or force out of alignment pipe flexes or vibration isolators supporting either the equipment or the piping.
6. Where pipes are racked together, the most stringent isolation requirement, as defined in this specification shall take precedence.
7. Piping, 1 IN diameter or greater, which is connected to vibration isolated equipment shall be isolated from the building structure using spring supports, resilient pipe guides, and resilient penetration sleeves (as applicable) for a distance of 25 FT or 50 pipe diameters, whichever is greater. For equipment greater than 50 HP, pipe support isolators will be selected for a deflection of not less than 2 IN.

3.3 EQUIPMENT BALANCE REQUIREMENTS

A. All rotating equipment shall operate at speeds less than 80 percent of their true critical speed. Equipment shall be balanced according to the recommendations given in the following sections.

B. Equipment components such as motors, pump rotors, fan wheels, shall be factory balanced, both statically and dynamically, to meet the balancing requirements described in Paragraph 3.4.C below.

C. Pumps, compressors, fans, and other rotating equipment not covered in paragraph D below, shall be field tested in accordance with the current edition of ANSI Standard S2.41 by an independent company after installation and under actual operating conditions. Vertical and horizontal vibration of rotating equipment shall not be greater than 0.071 IN/sec RMS, 0.1 IN/sec 0-peak velocity. The vibration shall be measured on the equipment bearing caps when the equipment is mounted on its vibration isolation mounts. If the equipment is mounted on an inertia base, or is skid-mounted, see Paragraph 3.4.F below for installed balancing requirements. A balance report shall be provided for each item of equipment.

D. Factory Balance of Fans. Fans greater than 10 HP including re circulation air fans, makeup air fans, and exhaust fans, rotors shall be whirl-tested to 125 percent operating speed and balanced to ASHRAE standards or better. Fan/motor assemblies mounted on the specified isolation springs (within their cabinets if applicable) shall be dynamically balanced to within 0.025 IN/sec RMS (0.035 IN/sec 0-peak):

1. Balance shall be achieved with the fans operating at rated airflow against the rated static pressure. Measurements shall be taken on the fan bearing caps in three orthogonal directions: parallel to the shaft in the horizontal plane and perpendicular to the shaft in the horizontal and vertical planes. For fans having inertia bases, the allowable vibration shall be reduced by the ratio given below. For fans that use adjustable frequency drives, the balance must be achieved at selected, not less than three, shaft speeds within the normal design range of operation. Balance reports shall be provided for each item of equipment prior to shipment.

E. Field Balance of Fans: The balance of the fans shall be checked following field installation. Adjustments shall be made as necessary to bring them within the specified limits. Balance reports shall be provided for each item of equipment.

F. Inertia Base or Skid-Mounted Equipment Balance: The weight of inertia bases or skids (and of any other components mounted on the same inertia base or skid) will reduce the vibration response when equipment is balanced. Therefore, the balance criteria, as specified in Paragraphs 3.5.C and 3.5.D, shall be multiplied by the following factor for such equipment:

$$\text{Factor} = \frac{W}{WT+W}$$

Where

WT = Inertia weight (base + other components)

W = Weight of the subject equipment

G. Pipes:
1. All pipes shall be isolated from the building structure as follows:
   a. Within mechanical rooms.
   b. Within 50 FT total pipe length of connected vibration-isolated equipment.
   c. All piping that is 4 IN or larger shall be isolated throughout the building.
   d. Piping serving labs mounted on isolated trapeze hangers within the service galleys.
2. Piping shall be isolated from the building structure by means of vibration isolation mounts, resilient pipe guides, and resilient penetration sleeve/seals.
3. Isolators for the first three support points adjacent to connected equipment shall achieve one half the specified static deflection of the isolators supporting the connected equipment. When the required static deflection of these isolators is greater than 0.4 IN, Type FSN or HSN isolators shall be used. When the required static deflection is less than or equal to 0.4 IN, Type FN or HN isolators shall be used. All other pipe support isolators within the specified limits shall be either Type FN or HN achieving at least 0.2 IN static deflection.
4. Where lateral support of pipe risers is required within the specified limits, this shall be accomplished by use of resilient lateral supports.
5. Pipes within the specified limits that penetrate the building construction shall be isolated from the building structure by use of resilient penetration sleeve/seals.
6. Provide flexible pipe connections as called for under Major Equipment above and wherever indicated on drawings.

H. Ductwork:
1. All sheet metal ducts and air plenums that are within mechanical rooms or within a distance of 50 FT total duct length of connected vibration-isolated equipment (whichever is longer) shall be isolated from the building structure by Type FN or HN isolators. All isolators shall achieve 0.10 IN minimum static deflection:
   a. All ducts, air plenums, and air terminal units shall be isolated from the building structure by Type FSN or HSN isolators at 1 IN minimum static deflection.
2. Ducts within the specified limits that penetrate the building construction shall be isolated from the building structure by use of resilient penetration sleeve/seals.

3. Provide flexible duct connections as called for above under Major Equipment and wherever indicated on drawings.

3.4 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT

A. General:
1. Locations of all vibration isolation devices shall be selected for ease of inspection and adjustment as well as for proper operation.
2. Installation of vibration isolation equipment shall be in accordance with the manufacturer's instructions.

B. Isolation Mounts:
1. All vibration isolators shall be aligned squarely above or below mounting points of the supported equipment.
2. Isolators for equipment with bases shall be located on the sides of the bases which are parallel to the equipment shaft unless this is not possible because of physical constraints.
3. Locate isolators to provide stable support for equipment, without excess rocking. Consideration shall be given to the location of the center of gravity of the system and the location and spacing of the isolators. If necessary, a base with suitable footprint shall be provided to maintain stability of supported equipment, whether or not such a base is specifically called for herein.
4. If a housekeeping pad is provided, the isolators shall bear on the housekeeping pad and the isolator base plates shall rest entirely on the pad.
5. Hanger rods for vibration-isolated support shall be connected to structural beams or joists, not the floor slab between beams and joists. Provide suitable intermediate support members as necessary.
6. Vibration isolation hanger elements shall be positioned as high as possible in the hanger rod assembly, but not in contact with the building structure, and so that the hanger housing may rotate a full 360 degrees about the rod axis without contacting any object.
7. Parallel running pipes may be hung together on a trapeze which is isolated from the building. Isolator deflections must be the greatest required by the provisions for pipe isolation for any single pipe on the trapeze. Do not mix isolated and unisolated pipes on the same trapeze.
8. Pipes, ducts and equipment shall not be supported from other pipes, ducts and equipment.
9. Resiliently isolated pipes, ducts and equipment shall not come in rigid contact with the building construction or rigidly supported equipment.
10. The installed and operating heights of equipment vibration-isolated with Type FSNTL isolators shall be identical. Limit stops shall be out of contact during normal operation. Adjust isolators to provide 1/4 IN clearance between the limit stop brackets and the isolator top plate, and between the travel limit nuts and travel limit brackets.
11. Adjust all leveling bolts and hanger rod bolts so that the isolated equipment is level and in proper alignment with connecting ducts or pipes.

C. Bases:
1. No equipment unit shall bear directly on vibration isolators unless its own frame is suitably rigid to span between isolators and such direct support is approved by the equipment manufacturer. This provision shall apply whether or not a base frame is called for on the schedule. In the case that a base frame is required for the unit because of the equipment manufacturer's requirements and is not specifically called for on the equipment schedule, a base frame recommended by the equipment manufacturer shall be provided at no additional expense.
2. Unless otherwise indicated, there is to be a minimum operating clearance of 1 IN between inertia bases or steel frame bases and the floor beneath the equipment. Position isolator mounting brackets and adjust isolators so that the required clearance is maintained. The clearance space shall be checked by the Contractor to ensure that no construction debris has been left to short circuit or restrict the proper operation of the vibration isolation system.

D. Flexible Duct Connections:
   1. Sheet metal ducts and plenum openings shall be aligned with the fan discharge, fan intake, or adjacent duct section prior to installation of the flexible connection, so that the clear length is approximately equal all the way around the perimeter. Flexible duct connections shall not be installed until this provision is met. There shall be no metal-to-metal contact between connected sections, and the fabric shall not be stretched taut.

E. Flexible Pipe Connections:
   1. Provide flexible pipe connections in strict accordance with the manufacturer's instructions.

F. Restraints:
   1. Thrust restraints shall be attached on each side of the fan at the vertical centerline of thrust. The two rods of the thrust restraint shall be parallel to the thrust force. This may require custom brackets or standoffs. The body of the thrust restraint shall not come in contact with the connected elements. Thrust restraints shall be adjusted to constrain equipment movement to the specified limit.

G. Resilient Penetration Sleeve/Seals:
   1. Maintain an airtight seal around the penetrating element and prevent rigid contact between the penetrating element and the building structure. Fit the sleeve tightly to the building construction and seal airtight on both sides of the construction penetrated with acoustical sealant.

H. Vibration isolator schedule:

Equipment Description	Base Type	Isolator Type	Minimum Static Defl. (IN)	Restraint Type	Flexible Pipe Conn.	Note:
Air handling units, floor mounted		PCF	1/4		Yes	1
Fan, centrifugal in AHU, 15 HP to 75 HP	BIB	FSN	2	Thrust		
Fan, centrifugal in AHU, 10 HP	BSF	FSN	2	Thrust		
Fan, centrifugal in AHU, 7-1/2 HP and below	BSF	FSN	1	Thrust		
Fan, inline/tubeaxial, suspended		HSN	1-1/2	Thrust		
Propeller fans		HSN	1-1/2	Thrust		
Pumps, floor mounted, 10 HP and above	BIB	FSN	2		Yes	
Pumps, floor mounted, below 10 HP	BIB	FSN	1		Yes	
Pump, condensate, floor mounted	BIB	FSN	1		Yes	
Tempered water circulating pumps		FSN	1		Yes	
Air conditioning unit, computer room.		FN	1/4		Yes	
Fan coil units, suspended		HN	3/8			
NOTES: 1. Place beneath base rails of AHU to completely support unit.						

END OF SECTION

SECTION 20 05 53
MECHANICAL IDENTIFICATION SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of work:
   1. Piping, valve, duct and equipment identification.

1.2 QUALITY ASSURANCE

A. All piping system identification shall meet requirements of ANSI-A13.1 “Scheme for the Identification of Piping Systems,” and ANSI-Z53.1 “Safety Color Code for Marking Physical Hazards.”

1.3 SUBMITTALS

A. Product data:
   1. Pipe markers.
   2. Valve tags.
   3. Duct markers.
   4. Equipment name plates.
   5. Access panel markers.
   6. Underground marking tape.

B. Contract closeout information:
   1. Letter of transmittal indicating valve charts installed and delivered.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Pipe, valve and equipment markers:
      a. Base:
         1) Seton Name Plate.
      b. Optional:
         1) Brady, WH.
         2) EMED.
         3) Kolbi Industries.
         4) 3M.
         5) Craftmark Identification Systems.
         6) Marking Systems.
         7) Carlton Industries.
   2. Underground marking tape:
      a. Base:
         1) Reef Industries.
      b. Optional:
         1) Seton Name Plate.
         2) EMED.

2.2 PIPE MARKERS

A. Pipe markers: Conform to ANSI-A13.1:
   1. Pressure sensitive vinyl (self-adhesive) material.
   2. Mechanically fastened type: Snap on or strap on:
      a. For dirty greasy, oily pipe where pressure sensitive markers may not perform satisfactorily.
   3. Provide with arrows indicating direction of flow. Where flow is multidirectional, use double headed arrows.
   4. Letter sizes: In accordance with table in Part 3.

2.3 VALVE TAGS

A. Valve tags: Brass or anodized aluminum type:
   1. Brass: Minimum 19 gauge, polished, 1-1/2 IN diameter with following lettering:
      a. Service: 1/4 IN stamped black filled letters.
      b. Valve numbers: 1/2 IN stamped black filled letters.
   2. Aluminum: 2 IN diameter, 0.032 IN thick, with following lettering:
      a. Service: 1/4 IN engraved letters.
      b. Valve numbers: 1/2 IN engraved letters.

B. Valve tag fasteners:
   1. 4 ply 0.018 IN copper or monel wire meter seals, brass "S" hooks or No.16 brass jack chain.

2.4 DUCT MARKERS

A. Duct markers:
   1. 1-1/2 IN black stenciled letters denoting system number (e.g., AHU-1, RF-3, EF-5), type (supply, return, exhaust) and flow direction. See Part 3 for format.

2.5 EQUIPMENT NAME PLATES

A. Equipment name plates:
   1. 1/16 IN rigid plastic, "Setonply", "Emedolite" or bakelite with 4 edges beveled; or engraved aluminum with black enamel background and natural aluminum border and letters:
      a. Two 3/8 IN mounting holes.
      b. Lettering size: Minimum 1/2 IN high.
      c. Fasteners: Commercial quality, rust resisting nuts and bolts with backwashers, self-tapping screws or rivets.

2.6 ACCESS PANEL MARKERS

A. Access panel markers:
   1. Metal tack style: Use on acoustical tile ceilings:
      a. Seton style BCM or ECM.
   2. Engraved plastic style:
      a. 3/4 IN square with center hole for small screw.
      b. Seton style CM75.

2.7 CHART AND DIAGRAM FRAMES

A. Chart and diagram frames:
   1. Extruded aluminum with plexiglass or glass windows.

PART 3 - EXECUTION

3.1 GENERAL

A. Provide systems having temperatures above 120 degF or pressures above 40 PSIG with legends indicating those temperatures and pressures.

3.2 VALVE IDENTIFICATION

A. Seton Name Plate Corp. Style 300-BL, 2” diameter tags on all valves installed. Include on tags respective legend as indicated below, and number as shown on Chart:
   1. HW for hot water valves.
   2. CW for cold water valves.
   3. CDA for clean dry compressed air valves.
   4. VAC for process vacuum valves.
   5. CWS for chilled water supply valves.
   6. CWR for chilled water return valves.
   7. PCHWS for process chilled water supply valves.
   8. PCHWR for process chilled water return valves.
   9. HPS/MPS/LPS for steam valves.
   10. C for condensate valves.
   11. HWS for heating hot water supply valves.
   12. HWR for heating hot water return valves.
   13. GWS for glycol water supply valves.
   14. GWR for glycol water return valves.
   15. EHRWS for exhaust heat recovery water supply valves.
   16. EHRWR for exhaust heat recovery water return valves.
   17. For control valves, i.e., V-1, V-2, etc., indicate service and control valve designation as indicated on Drawings.
   18. DIWS for deionized water supply.
   19. DIWR for deionized water return.
   20. CTWS for cooling tower water supply.
   21. CTWR for cooling tower water return.
   22. ROS for RO water supply.
   23. ROR for RO water return.
   24. LCW for laboratory cold water valves.
   25. LHW for laboratory hot water valves.
   26. UN2 for utility nitrogen valves.
   27. LN2 for liquid nitrogen valves.
   28. TW for tempered water valves.
   29. AR for cylinder argon valves.
   30. ARHE for cylinder argon helium gas mix valves.
   31. HE for cylinder helium gas valves.
   32. H2 for cylinder hydrogen gas valves.
   33. HPN2 for cylinder high purity nitrogen gas valves.
   34. LA for cylinder laboratory compressed air valves.
   35. O2 for cylinder oxygen gas valves.
   36. SG for cylinder specialty gas valves.
   37. MTH for cylinder methane gas valves.
   38. SIL for cylinder silane gas valves.
   39. AMN for cylinder ammonia gas valves.

B. Identify all valves, with appropriate service designation and valve number designation on valve tags:
   1. Tagging of valves at cabinet heaters, fan coil units, air terminal unit reheat coils and plumbing fixture stops are not required.

C. Secure tags to valve handles with Seton Name Plate Corp. Catalog 820 brass “S” hooks. Drill lever handle of ball valves to attach “S” hook.

D. Furnish 4 charts including valve identification number, location (room number, department) and purpose:
   1. Provide and mount as directed, in a suitably glazed frame, a typewritten chart giving valve number, whether valve is N.O. or N.C., location, and function of each valve installed.
   2. Include remaining 3 sets in "Operation and Maintenance Manuals".

3.3 PIPE IDENTIFICATION

A. Legend and Flow Arrows: Seton Name Plate Corp., Setmark System Type SNA for 5 IN and under diameter piping and covering, and Type STR for 6 IN and over diameter piping and covering. Minimum color field lengths, letter heights, field and letter colors, and legends shall be as specified below.

B. Do not identify soil, waste and vent piping.

C. Fire-protection and sprinkler piping:
   1. Painting not required in non-finished areas.
   2. Painting required in finished areas:
      a. Color: Safety Red:
         1) Paint Specification: Section 09 91 23.

D. Locate identification lettering as follows:
   1. Next to each valve and fitting, except on plumbing fixtures and equipment.
   2. At each branch or riser take off.
   3. At each passage through walls, floors and ceilings.
   4. At each pipe passage to underground.
   5. On horizontal pipe runs every 20 FT, at least once in each room and each story traversed by piping system.
   6. Identify piping contents, flow direction, supply and return.
   7. Install that it is readable from access panels and not obscured by other work.

E. Size lettering, marker color fields, and arrows as follows:

Outside Diameter of Pipe or Pipe Covering IN	Length of Color Field (Markers) IN	Size of Letters and Arrows IN
1/2 to 1-1/4	8	1/2
1-1/2 to 2	8	3/4
2-1/2 to 6	12	1-1/4
8 to 10	24	2-1/2
Over 10	32	3-1/2

F. Field and Letter Colors:

System Legends	Field Colors	Letter Colors
Chilled Water Supply, Primary, Secondary and Process	Green	Black
Chilled Water Return, Primary, Secondary and Process	Green	Black
Clean Dry Compressed Air*	Yellow	Black
Domestic Cold Water	Green	Black
Domestic Hot Water	Yellow	Black
Domestic Hot Water Recirculating	Yellow	Black
Glycol Supply (EHRWS)	Green	Black
Glycol Return (EHRWR)	Green	Black
Hot Water Heating Supply	Yellow	Black
Hot Water Heating Return	Yellow	Black
Utility Nitrogen	Yellow	Black
Liquid Nitrogen	Yellow	Black
Deionized Water Supply	Green	Black
Deionized Water Return	Green	Black
Cooling Tower Water Supply	Green	Black
Cooling Tower Water Return	Green	Black
Sanitary	Green	Black
Sanitary Vent	Green	Black
Storm	Green	Black
Sprinkler	Red	White
Standpipe	Red	White
Steam*	Yellow	Black
Steam Condensate**	Yellow	Black
Process Vacuum	Yellow	Black
RO Supply	Green	Black
RO Return	Green	Black
Lab Cold Water	Yellow	Black
Lab Hot Water	Yellow	Black
Lab Hot Water Return	Yellow	Black
Tempered Water	Green	Black
Tempered Water Return	Green	Black
Argon	Yellow	Black
Argon/Helium Mix	Yellow	Black
Helium	Yellow	Black
Hydrogen	Yellow	Black
High Purity Nitrogen	Yellow	Black
Laboratory Air	Yellow	Black
Oxygen	Yellow	Black
Specialty Gas	Yellow	Black
Methane	Yellow	Black
Silane	Yellow	Black
Ammonia	Yellow	Black

* Include Pressure Rating
** Include Temperature Rating

3.4 DUCTWORK IDENTIFICATION

A. Locate duct markers as follows:
   1. At each branch or riser take-off.
   2. Next to equipment.

B. Stencil ductwork or exterior surface of insulation:
   1. Mark ducts as follows:
      a. Supply Air – SA AHU - ## SA SF - ##.
      b. Return Air – RA AHU - ##.
      c. Relief Air – RELA AHU - ##.
      d. Outside Air – OA AHU - ##.
      e. Make-up Air – MA AHU - ##.
      f. General Exhaust – EA EF - ##.
      g. Lab Exhaust – LEA EF - ##.

C. Exhaust duct labels: The duct at the fan discharge of each exhaust system must be labeled as indicated above.

3.5 EQUIPMENT IDENTIFICATION

A. Attach equipment nameplates in conspicuous location, directly on item of equipment or apparatus such as starters, AFD's, pumps, fans, HVAC units and control panels:
   1. Secure nameplates with self-tapping screws, or nuts and bolts.

B. For unsuitable surfaces, such as high temperature or lack of space, use copper or brass rings or chains to attach tags.

C. Identify devices located above ceilings with additional identification:
   1. Use access panel markers (metal tack style) for acoustical tile ceilings, or engraved plastic style, 3/4 IN square, for mounting on panel door; or equipment nameplates.
   2. Coordinate with BNL on identification method and color codes.
   3. Provide markers on all removable ceilings and ceiling access panels to indicate locations of valves, dampers, smoke detectors, etc., and other mechanical items that may need servicing or adjustment. Glue marking tacks in place to prevent their falling out.
   4. Where fire protection devices are located inside ductwork, provide an additional tag on the duct access door identifying device inside:
      a. Identification letter size: 1-1/2 IN high minimum.
   5. Color code access panel markers as follows:
      a. Red: Fire dampers, smoke detectors, sprinkler shutoff valves and duct type smoke detectors:
         1) Notation:
            D - Damper
            V - Valve
            S - Smoke Detector
            H - Heat Detector
      b. Yellow: Steam, radiation, reheat and chilled water valves:
         1) Notation:
            V - Valve
      c. Gold: Automatic and balancing dampers:
         1) Notation:
            V - Valve
            D - Damper
      d. Blue: Gases (valves):
         1) Notation: Type of service.
         2) A - Compressed Air.
         3) N – Nitrogen.

3.6 CONTROL DIAGRAMS AND INSTRUCTIONS

A. Provide HVAC control and systems instructions and diagrams in wall mounted frames:
   1. Mount framed diagrams in conspicuous, easily accessible places in equipment rooms housing appropriate HVAC system.

B. Diagrams and instructions may be reduced in size provided they are easily readable and lettering is not smaller than "elite" type of standard typewriter.

END OF SECTION

SECTION 20 07 00
PIPE, DUCT AND EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of systems:
   1. Pipe insulation, non-flexible and flexible.
   2. Duct insulation, non-flexible and flexible.
   3. Equipment insulation.
   4. Insulation jacketing and prefabricated fitting covers.
   5. Insulation fasteners:
      a. Adhesives, mastics, and caulking.

B. Definitions:
   1. Concealed: Outside surfaces are isolated from room ambient air conditions by physical barrier(s):
      a. Concealed items are typically accessed through suspended ceilings, through access doors, or by cutting and patching.
      b. Listed below are examples of spaces that typically contain concealed items:
         1) Walls.
         2) Partitions.
         3) Chases.
         4) Shafts.
         5) Alley ways.
         6) Ceiling spaces.
   2. Exposed: Outside surfaces are not isolated from room ambient air conditions by physical barrier(s):
      a. Exposed items are typically accessed directly from within a room or space.
      b. Listed below are examples of rooms/spaces that typically contain exposed items:
         1) Mechanical rooms.
         2) Rooms without ceilings.
   3. Exposed to weather: Outside surfaces are not isolated by physical barrier(s) from weather or outside ambient air conditions.
   4. Runouts: Piping not more than 12 FT in length.

1.2 QUALITY ASSURANCE

A. Comply with the following fire and smoke hazard ratings:
   1. Test products by procedure ASTM-E84, NFPA-255 and ANSI/UL-723.
   2. Rating requirements:
      a. Maximum Flame Spread: 25.
      b. Maximum Smoke Developed:
         1) Fiberglass, phenolic, PVC: 50.
         2) Elastomeric: 150.
   3. Properly identify products for flame and smoke ratings.
      a. Shipping cartons may be labeled instead of product.

B. Comply with requirements of the following specifications:
   1. ASTM-C547, "Standard Specification for Mineral Fiber Preformed Pipe Insulation."
   2. ASTM-C533, "Standard Specification for Calcium Silicate Pipe and Block Insulation."
   3. ASTM-C553, "Standard Specification for Mineral Fiber Blanket and Felt Insulation."
   4. ASTM-C585, "Recommended Practice for Inner and Outer Diameters of Rigid Pipe 'Insulation for Nominal Sizes of Pipe and Tubing (NPS System)."

5. ASTM-C612, "Standard Specification for Mineral Fiber Block and Board Thermal Insulation."
6. ASTM-C1136, "Standard Specification for Flexible Low Permeance Vapor Retarders for Thermal Insulation."
7. ASTM-C795, "Thermal Insulation for Use Over Austenitic Stainless Steel."
8. Federal Specification HH-I-558B, "Mineral Fiber Boards, Blankets, Pipe Covering."

1.3 SUBMITTALS

A. Product data:
   1. Pipe insulation.
   2. Ductwork insulation.
   3. Insulation for hot equipment.
   4. Insulation for cold equipment.
   5. Jacketing and prefabricated fitting covers.
   6. Insulation fasteners.

B. LEED Information:
   1. LEED Credits MR 5.1 and 5.2, Regional Materials: For products and materials required to comply with requirements for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.
   2. LEED Credit EQ 4.1, Low-Emitting Materials – Adhesives and Sealants: Manufacturer's product data for construction sealants, including printed statement of VOC content.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Acceptable manufacturers:
   1. Insulation materials:
      a. Base:
         1) As indicated.
      b. Optional:
         1) Owens-Corning Fiberglass.
         2) CertainTeed Insulations.
         3) Knauf Fiber Glass.
         4) Johns-Manville.
         5) Armstrong.
   2. Jacketing:
      a. Base:
         1) As indicated.
      b. Optional:
         1) Brocar Products.
         2) Ceel.
         3) Childers Products.
         4) Johns-Manville.
         5) RPR Metals.
         6) Pabco.
         7) Truebro.
   3. Prefabricated fitting covers:
      a. Base:
         1) As indicated.
      b. Optional:
         1) Ceel.

2) CertainTeed Insulations.
3) Childers Products.
4) Knauf Fiber Glass.
5) Johns-Manville.
6) Proto Corporation.
7) RPR Metals.
8) Pabco.

4. Adhesives, mastics, caulkings, and finishes:
   a. Base:
      1) As indicated.
   b. Optional:
      1) Fuller, HB.
      2) Chicago (CMC).
      3) Childers Products.
      4) Dow Corning.
      5) Johns-Manville.

B. Insulation - General:
1. Do not use material that exceeds specified flame and smoke ratings.
2. Use permanent treatments to jacketings and facings to impart specified fire ratings.
3. Use of water soluble treatments is prohibited.
4. At hangers and bracing.

2.2 PIPE INSULATION, NON-FLEXIBLE

A. Pipe insulation, non-flexible:
1. Material: Preformed commercial-grade fiberglass or phenolic thermal insulation.
2. Designed for application on systems operating at temperatures between 0 and 850 degF.
3. Thermal conductivity at mean temperature:
   a. $k \leq 0.23$, 75 degF.
   b. $k \leq 0.29$, 200 degF.
   c. $k \leq 0.54$, 500 degF.
4. Base products:
   a. Owens-Corning Fiberglas ASJ/SSL-II.
5. Facing:
   a. All service jacket:
      1) Temperature range: -20 to 150 degF.
      2) Provide with integral vapor retarder where indicated in Part Three.
6. Seams, longitudinal: 2 IN self-sealing facing tabs:
   a. Provide adhesive on both contacting surfaces.
   b. Designed to perform without stapling.

2.3 PIPE INSULATION, FLEXIBLE

A. Pipe insulation, flexible:
1. Material: Commercial-grade closed-cell elastomeric thermal insulation.
2. Designed for application on systems operating at temperatures between 40 and 200 degF.
3. Thermal conductivity at mean temperature:
   a. $k \leq 0.27$, 75 degF.
   b. $k \leq 0.276$, 90 degF.
4. Base product: Armstrong Armaflex.
5. Seams, longitudinal: Factory-cut and self-sealing.

2.4 DUCTWORK INSULATION, NON-FLEXIBLE

A. Ductwork insulation, non-flexible:
1. Material: Commercial-grade fiberglass thermal insulation formed with a thermosetting resin into semi-rigid or rigid boards.

2. Designed for application on systems operating at temperatures between 0 and 450 degF.
3. Minimum density:
   a. Semi-rigid: 3.0 PCF.
   b. Rigid: 6.0 PCF.
4. Thermal conductivity at mean temperature:
   a. Semi-rigid:
      1) $k \leq 0.22$, 75 degF.
      2) $k \leq 0.27$, 150 degF.
      3) $k \leq 0.38$, 300 degF.
   b. Rigid:
      1) $k \leq 0.23$, 75 degF.
      2) $k \leq 0.27$, 150 degF.
      3) $k \leq 0.37$, 300 degF.
5. Base product:
   a. Owens-Corning Fiberglas Type 703 and 705 industrial insulation.
6. Facing:
   a. Unfaced, foiled-reinforced-kraft (FRK), or all-service-jacket (ASJ) depending on applications as specified in Part Three:
      1) Temperature range: -20 to 150 degF.

B. High efficiency ductwork insulation: Non-flexible Kooltherm Insulation Products, Koolphen K phenolic foam insulation with ASJ vapor barrier jacket:
   1. Thermal conductivity (k value): Not greater than 0.13.

2.5 DUCTWORK INSULATION, FLEXIBLE

A. Ductwork insulation, flexible:
   1. Material: Commercial-grade fiberglass thermal insulation.
   2. Designed for application on systems operating at temperatures between 40 and 250 degF.
   3. Thermal conductivity at mean temperature:
      a. $k \leq 0.27$, 75 degF.
   4. Base product:
      a. Owens-Corning Fiberglas commercial-grade all-service duct wrap.
   5. Facing: Foiled, reinforced-kraft vapor-retarding.
   6. Seams: 2 IN facing tab.

2.6 INSULATION FOR HOT EQUIPMENT

A. Same as Pipe Insulation, Non-flexible.

2.7 INSULATION FOR COLD EQUIPMENT

A. Insulation for cold equipment:
   1. Material: Commercial-grade elastomeric thermal insulation.
   2. Designed for application with complete adhesive coverage on systems operating at temperatures between -40 and 180 degF.
   3. Thermal conductivity at mean temperature:
      a. $k \leq 0.27$, 75 degF.
      b. $k \leq 0.276$, 90 degF.
   4. Base product: Armstrong Armaflex.

2.8 JACKETING AND PREFABRICATED FITTING COVERS

A. Jacketing and fitting covers, general:
   1. Fitting covers:
      a. Designed to fit over precut insulation inserts.
      b. Designed specifically for fitting being covered:
         1) 2-gore covers are not acceptable.

B. Jacketing and fitting covers, PVC:
   1. High impact: Minimum 0.028 IN thick.
   2. Resistant to bacterial growth, mildew, and corrosion.
   3. Installations exposed to weather:
      a. Resistant to ultra-violet rays.
      b. Designed for direct exposure to weather exposure without painting.
   4. Minimum 1 IN over-lap at joints.
   5. Base manufacturer: Johns-Manville.

C. Jacketing and fitting covers, metal:
   1. Material: As indicated in Part Three.
   2. On cold systems, ducts exposed to weather, and equipment, provide factory moisture barrier.
   3. Attaching method:
      a. 0.020 x 3/8 IN bands on 9 IN centers unless indicated otherwise in Part Three.
      b. Band material: Same as jacketing and covers.
   4. Minimum 2 IN overlap at joints.
   5. Tubular jacketing: Locking longitudinal seams.
   6. Base manufacturer: Childers.

D. Jacketing and fitting covers, vinyl:
   1. Material: Molded closed cell vinyl.
   2. Thermal conductivity at mean temperature:
      a. $k \leq 1.17$, 75 degF.
   3. Attaching method:
      a. Nylon ties.
   4. Factory cut longitudinal seams.
   5. Base manufacturer: Truebro.

2.9 INSULATION FASTENERS

A. Insulation adhesive:
   1. Childers CP-82.
   2. Foster 30-36.
   3. Halstead 77-198.
   4. Adhesive shall have a VOC content of no greater than 80 g/L in accord with SCAQMD Rule #1198.

B. Insulation mastic:
   1. Childers CP-30.
   2. Foster 35-00-GPM.
   3. Mastic shall have a VOC content of no greater than 80 g/L in accord with SCAQMD Rule #1198.

C. Insulation caulking:
   1. Dow No.11.
   2. Caulking and sealants shall have a VOC content of no greater than 250 g/L in accord with SCAQMD Rule #1198.

PART 3 - EXECUTION

3.1 APPLICATION - GENERAL

A. Apply products per manufacturer's recommendations and as specified:
   1. Allow for thermal expansion and contraction.

B. Do not insulate piping until satisfactory completion of required pressure tests.

C. Do not insulate piping until heat tracing cable has been installed. Coordinate with cable installer.

D. In general, do not insulate piping below ground:
   1. Specific exceptions may exist under "Pipe insulation, flexible."

E. Apply insulation to clean, dry surfaces with pipe, duct, and equipment surfaces at room temperature.

F. Butt edges of insulation firmly together, and seal joints with compatible jackets, facings and adhesives as specified.

G. On cold systems and equipment, apply insulation with a continuous, unbroken vapor retarder:
   1. To prevent condensation, provide insulation and vapor seals on hangers, supports, and anchors that are secured directly to cold surfaces.

H. Continue insulation through sleeves and wall and ceiling openings.

I. Insulate fittings, valve bodies, flanges and other pipeline accessories.

J. Insulation at piping supports: Coordinate with Section 20 05 29.

K. Rectangular and flat-oval ductwork exposed to weather:
   1. Apply insulation and jacketing so that top of ductwork has crown that effectively prevents pooling of water:
      a. Minimum crown slope: 1/4 IN/FT.

L. Insulation installed in multiple layers: Stagger joints between layers.

3.2 PIPE INSULATION, NON-FLEXIBLE

A. General:
   1. Provide either type of lap seal at joints:
      a. Self-sealing facing tabs.
      b. 3 IN wide pressure-sensitive joint-sealing tape that matches facing:
         1) Manufacturer: Same as insulation.
   2. Fittings:
      a. On non-serviceable items, use either the built-up system or prefabricated fitting covers.
      b. On serviceable items, use prefabricated fitting covers attached with bands:
         1) Exception: On systems exposed to weather, attach with method described as best by manufacturer.
      c. On exposed fittings, flanges, valves, and pipe terminations, use prefabricated fitting covers:
         1) Example: Mechanical rooms.
      d. Built-up system:
         1) 2 IN and smaller: Finish with mineral fiber cement to thickness of adjoining pipe insulation.
         2) 2-1/2 IN and larger: Insulate with mitered pipe insulation segments or preformed fiberglass fittings. Secure with vinyl faced insulation strapping tape or 20 AWG galvanized annealed wire finished with one coat of mineral fiber cement.
         3) After mineral fiber cement is dry, finish with Glass Fab embedded in 2 coats of Foster 30-36 adhesive.
      e. Prefabricated PVC fitting covers:
         1) All sizes: Install covers over mitered pipe-insulation segments or preformed fiberglass fittings.

B. Provide non-flexible insulation on following piping systems in wall thicknesses indicated:
   1. Hydronic systems:
      a. Cooling coil condensate drains:
         1) All sizes: 1 IN.
      b. Chilled water piping, primary and secondary:
         1) Runouts to 2 IN: 1/2 IN.
         2) 8 IN and smaller: 1 IN.
         3) 10 IN and larger: 1-1/2 IN.

c. Heating water piping (to 200 degF):
   1) Runouts to 2 IN: 1/2 IN.
   2) 2 IN and smaller: 1 IN.
   3) 2-1/2 IN and larger: 1-1/2 IN.
d. Glycol water piping including heat recovery:
   1) Runouts to 2 IN: 1/2 IN.
   2) 2 IN and smaller: 1 IN.
   3) 2-1/2 IN and larger: 1-1/2 IN.
e. Process cooling water, same as chilled water piping.

2. Plumbing systems:
   a. Domestic cold water piping, laboratory cold water piping, chilled water piping for drinking fountains:
      1) 2 IN and smaller: 1/2 IN.
      2) 2-1/2 IN and larger: 1 IN.
   b. Domestic or laboratory hot/recirculating water piping (100-130 degF):
      1) 1-1/4 IN and smaller: 1/2 IN.
      2) 1-1/2 IN and larger: 1 IN.
   c. Domestic or laboratory hot/recirculating water (140-160 degF):
      1) 2 IN and smaller: 1 IN.
      2) Over 2 IN: 1-1/2 IN.
   d. Hot water and waste lines below handicapped accessible lavatories and sinks:
      1) All sizes: 1/2 IN.
      2) Waste lines are hot systems.
   e. Horizontal above grade storm drainage and overflow storm drainage piping within the building (including 24 IN up and down from horizontal and up to underside of roof deck):
      1) All sizes: 1 IN.
      2) These are cold systems.
3. Steam systems:
   a. Steam piping (0-15 PSIG, 201-250 degF):
      1) Runouts to 1-1/2 IN: 1 IN.
      2) 1-1/2 IN and smaller: 1-1/2 IN.
      3) Over 2 IN and over: 2 IN.
   b. Steam piping (15-70 PSIG, 251-316 degF):
      1) Runouts to 2 IN: 1-1/2 IN.
      2) 1 IN and smaller: 2 IN.
      3) 1-1/4 to 4 IN: 2-1/2 IN.
      4) Over 4 IN: 3 IN.
   c. Steam piping (Over 70 PSIG, 316 degF):
      1) Runouts to 2 IN: 1-1/2 IN.
      2) 1 IN and smaller: 2-1/2 IN.
      3) 1-1/4 - 2 IN: 2-1/2 IN.
      4) 2-1/2 - 4 IN: 3 IN.
      5) Over 4 IN: 3-1/2 IN.
   d. Steam condensate, pumped condensate return, condensate vent, blowdown, and exhaust steam (all temperatures) piping:
      1) 1 IN and smaller: 1 IN.
      2) 1-1/4 to 2 IN: 1-1/2 IN.
      3) Over 2 IN: 2 IN.

3.3 PIPE INSULATION, FLEXIBLE

A. General:
   1. Install by slipping insulation over piping.
   2. Do not make longitudinal field cuts.
   3. Seal joints with manufacturer approved adhesive.

4. Do not use flexible pipe insulation on systems with heat tracing cable or temperature maintenance cable.

B. Fittings:
1. Insulate fittings and valve bodies with segments cut from pipe insulation.

C. Provide flexible insulation on following piping systems in wall thicknesses indicated:
1. Hydronic systems:
a. Cooling coil condensate:
1) 2 IN and smaller: 1/2 IN.
b. Chilled water runouts:
1) 2 IN and smaller: 1/2 IN.
2) Included are runouts to fan coil units.
c. Heating water runouts:
1) 2 IN and smaller: 1/2 IN.
2) Included are runouts to fan coil units, unit heaters, finned tube radiation, and terminal units.
2. Plumbing systems:
a. Domestic cold water piping, non-potable cold water piping:
1) 2 IN and smaller: 1/2 IN.
2) Flexible insulation only permitted on branch piping concealed within partition or plumbing chase directly behind fixtures being served.
b. Domestic or laboratory hot/recirculating water piping:
1) 2 IN and smaller: 1/2 IN.
2) Flexible insulation only permitted on branch piping concealed within partition or plumbing chase directly behind fixtures being served.
c. Waste piping from water coolers and drinking fountains to first point of mixing with waste from a different type of fixture:
1) All sizes: 1/2 IN.

3.4 DUCTWORK INSULATION, NON-FLEXIBLE

A. General:
1. Secure insulation to ductwork by impaling over welded-pin or adhesive-pin mechanical fasteners:
a. Secure insulation on mechanical fasteners with speed clips.
b. Space mechanical fasteners to hold insulation securely in place:
1) Maximum spacing: 12 IN centers.
2. Where access is not possible for pin attachment, use adhesive or caulk:
a. Cover entire surface with brush applied adhesive.
b. Apply caulk in continuous bead on 6 IN centers.
3. Seal joints and speed clips with 3 IN wide pressure-sensitive joint-sealing tape that matches facing:
a. Staple corners of tape with outward clinching staples.
4. Cold systems only: Coat staples with mastic.
5. Reinforce edges with metal corner angles.
6. Do not apply insulation over coil and damper access panels.
7. Do not apply insulation over internally lined ductwork: Coordinate with Section 23 31 13.
8. Use FRK facing on concealed ductwork.
9. Use ASJ facing on exposed ductwork.

B. Provide non-flexible insulation on following ductwork in thicknesses indicated:
1. Outside-air ductwork (rectangular):
a. All sizes: 2 IN.
2. Factory-packaged air handling units, mixed-air plenum and ductwork, component housings to fan unit inlet including transition sections and prefilter:
a. All sizes: 2 IN.
3. Relief-air/exhaust-air plenums behind louvers:

a. All sizes: 2 IN.
4. Exhaust duct upstream of fans exposed to weather with ASJ facing, 2 IN.
5. Relief and exhaust air ducts in mechanical rooms between plenum and isolation dampers plus 36 IN.

3.5 DUCTWORK INSULATION, FLEXIBLE

A. General:
1. On ductwork 24 IN wide and less, secure insulation to bottom of ductwork with 4 IN wide bands of brush-applied adhesive on 12 IN centers.
2. On ductwork over 24 IN wide, secure insulation to bottom of ductwork by impaling over welded-pin or adhesive-pin mechanical fasteners:
   a. Secure insulation on mechanical fasteners with speed clips.
   b. Space mechanical fasteners to hold insulation securely in place:
      1) Maximum spacing: 12 IN centers.
   c. Seal speed clips with 3 IN wide pressure-sensitive joint-sealing tape that matches jacket:
      1) Staple corners of tape with outward clinching staples.
      2) Cold systems only: Seal staples with mastic.
3. Provide either type of lap seal at joints:
   a. Seal facing tab over adjoining facing with lap adhesive:
      1) Secure lap with outward clinching staples on 6 IN centers.
   b. Use 3 IN wide pressure-sensitive joint-sealing tape that matches facing:
      1) Secure both sides of tape with outward clinching staples on 6 IN centers.
   c. Cold systems only: Seal staples with mastic.
4. Apply insulation to ductwork from air handling unit housing to ends of duct runs, including diffuser necks and register ducts, and silencers.
5. Do not apply insulation over coil and damper access panels.
6. Do not apply over internally lined ductwork: Coordinate with Section 23 31 13.

B. Provide flexible insulation on following ductwork in thicknesses indicated:
1. Supply-air ductwork (including downstream of terminal units) except where covered by non-flexible insulation:
   a. All sizes: 1-1/2 IN.
2. Return-air ductwork in non-air conditioned areas (including utility shafts):
   a. All sizes: 1-1/2 IN.
   b. Ceiling spaces directly above conditioned spaces are considered conditioned.
3. Silencers in ducts are included.
4. Return-air/relief-air ductwork from relief plenum at louver (or other outside opening) back to relief-air damper plus 36 IN:
   a. All sizes: 1-1/2 IN.

3.6 INSULATION FOR HOT EQUIPMENT

A. General:
1. Secure insulation to bottom of flat surfaces wider than 24 IN by impaling over adhesive-pin mechanical fasteners:
   a. Secure insulation on mechanical fasteners with speed clips.
   b. Space mechanical fasteners to hold insulation securely in place:
      1) Maximum spacing: 12 IN centers.
2. Seal joints and speed clips with 3 IN wide pressure-sensitive joint-sealing tape that matches facing:
   a. Secure both sides of tape with outward clinching staples on 3 IN centers, 1/4 IN from edge.
3. Insulate flanges and fittings as indicated under "Pipe insulation, non-flexible."
4. Reinforce ends and irregular surfaces with Glass Fab embedded in 2 coats of Foster 30-36 adhesive.

B. Provide hot-equipment insulation on following equipment in thicknesses indicated:
   1. Flash tanks: 2 IN.
   2. Heat exchangers: 2 IN.
   3. Steam meters.

C. Provide removable insulation jacket for all devices, like pressure reducing valves, which require service.

3.7 INSULATION FOR COLD EQUIPMENT

A. Apply insulation with manufacturer's approved adhesive:
   1. Completely cover joining surfaces (equipment surfaces, and back and butting edges of insulation).
   2. Apply with 1/8 IN overlay pressure on butt joints.
   3. Apply 2 coats of manufacturer's approved white latex enamel to outside layer.

B. Provide cold-equipment insulation on following equipment in number of layers and total thicknesses indicated:
   1. Chilled water pump casing: 1 layer, 3/4 IN.
   2. Domestic and chilled water meter: 1 layer, 3/4 IN.
   3. All above grade drain bodies which convey rain water: 1 layer, 3/4 IN.
   4. Chilled water expansion tanks: 1 layer, 3/4 IN.
   5. Chilled water air separators: 1 layer, 3/4 IN.
   6. Water-to-water heat exchangers: Layer 3/4 IN.

3.8 JACKETING AND PREFABRICATED FITTING COVERS

A. General:
   1. Stagger jacketing and insulation joints.

B. Systems exposed to weather:
   1. Material:
      a. 0.016 IN smooth aluminum.
   2. Attach with method described as best by manufacturer.
   3. Joints:
      a. Orient joint laps to prevent entry of water.
      b. Seal joints weather tight.

C. Hot equipment:
   1. Material:
      a. 0.016 IN smooth aluminum.
   2. Attach with method described as best by manufacturer.

3.9 HOT WATER AND WASTE LINES EXPOSED BENEATH ACCESSIBLE FIXTURES

A. Hot water and waste lines exposed beneath accessible fixtures, see Section 22 42 00.

END OF SECTION

SECTION 20 08 00
TESTING AND BALANCING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Test, balance and adjust following mechanical systems:
   1. Air distribution systems.
   2. Air handling units and air moving equipment.
   3. Heating hot water systems including pumps.
   4. Chilled water systems including pumps.
   5. RO and Deionized water systems including pumps.
   6. Heating and cooling coils.
   7. Domestic and laboratory hot water systems including pumps.
   8. Tempered water system and pumps.

1.2 QUALITY ASSURANCE

A. Agency qualifications: Independent test and balance agency, member of Associated Air Balance Council (AABC), or National Environmental Balancing Bureau (NEBB):
   1. Work supervised by a certified Testing and Balancing Engineer.
   2. Indicate at least 5 successfully completed projects of similar size and scope.

B. Testing and balancing standards: AABC or NEBB standards and procedures.

1.3 RESPONSIBILITIES OF TESTING AND BALANCING (TAB) AGENCY

A. Review the design documents and recommend additional volume control dampers and balance valves where necessary for proper balancing of the systems. Submit recommendations to the Mechanical Contractor prior to bidding.

B. Schedule work with trades involved.

C. Check, adjust, and balance system components to obtain optimum conditions for function and operation of system.

D. Evaluate operation of systems and advise installer of necessary adjustments and corrective measures.

E. Prepare and submit test reports.

1.4 RESPONSIBILITIES OF MECHANICAL CONTRACTOR

A. Provide a set of sheet metal design and piping design documents to the Testing and Balancing Agency for their review.

B. Start up system and keep in correct operation during balancing operations.

C. Provide necessary adjustments and corrections to systems as directed by Testing and Balancing Agency.

D. Maintain accessibility to test locations and devices requiring adjustment.

E. Provide additional sets of pulleys and belts as required by Testing and Balancing Agency.

F. Provide additional balancing dampers and balance valves as required by the Testing and Balancing Agency at no cost to BNL.

G. Provide a complete set of approved mechanical-equipment shop drawings to Testing and Balancing Agency.

H. Provide a complete set of "As-built" drawings to Testing and Balancing Agency.

1.5 JOB CONDITIONS

A. Balance at time directed by Test Engineer:
   1. If balancing is not done during peak cooling season demonstrate satisfactory balancing during next peak cooling season.

B. Keep dust, dirt and debris to an absolute minimum and reinstall removed ceiling tiles to their original positions at end of each day.

1.6 CORRECTIVE WORK

A. Provide extended warranty of 90 days, after completion of test and balance work, during which time BNL's Representative may, at discretion of BNL's Representative, request recheck or resetting of equipment or system which is not performing satisfactorily. Provide technicians to assist as required in making such tests.

1.7 SUBMITTALS

A. Project information:
   1. Within 60 days of award of contract submit a complete Submission Report including:
      a. A company resume listing its personnel and project experience in air and hydronic balancing.
      b. An inventory and calibration data of instruments and devices in possession of balancing agency whether or not they will be used on this project.
      c. A working agenda that includes procedures for testing and balancing each air and water flow system.
      d. Test and Balance Report Forms and Field Data Sheets that will appear in final report, with design data already filled in.
      e. A written, system-by-system description of measurements, test locations and procedures that will be employed during test and balance.

B. Contract closeout information:
   1. Final test and balance report(s):
      a. Use forms similar to AABC or NEBB latest editions.
      b. Report(s) signed by TAB Engineer.
      c. Floor plans with air terminal units and air devices numbered to match report.

PART 2 - PRODUCTS

2.1 JOB SITE INSPECTIONS

A. Job site inspections:
   1. During construction inspect installation of piping, sheet metal work, temperature controls, flow meters, pressure taps, strainers and other components of HVAC system as specified in contract documents.
   2. Note any deficiencies and submit them, in writing, to BNL and to Test Engineer:
      a. Include these inspection reports in final TAB report.

2.2 FINAL TEST AND BALANCE REPORT

A. Using field data, test forms and procedures outlined in Submission Report, perform and record measurements, and complete final TAB report including:
   1. Preface:
      a. A general discussion of system including any abnormalities and problems encountered.
   2. Instrumentation list:
      a. List of instruments including type, model, manufacturer, serial number and calibration date.

3. System identification:
    a. On each Test and Balance Report Form, number and/ or letter air terminal units, zones, supply, return and exhaust openings and traverse points to correspond to numbers and letters on Field Data Sheets.
4. Air handling equipment:
    a. Manufacturer, model number, and serial number.
    b. Design and manufacturer related data.
    c. Total actual air flow rate by traverse if practical; if not practical, sum of outlets may be used, or a combination of each of these procedures:
        1) For specific systems, such as ones with diversity, see AABC National Standards.
    d. Suction and discharge static pressure of each fan, as applicable.
    e. Outside air and return air total air flow rate.
    f. Actual operating current, voltage, and brake power of each fan motor.
    g. Final RPM of each fan.
    h. Fan and motor sheave manufacturer, model, size, number of grooves and center distance.
    i. Belt size and quantity.
    j. Static pressure controls final operation set points.
5. Pumps:
    a. Manufacturer, size, and serial number.
    b. Design and manufacturer's related data.
    c. Pump operating suction and discharge pressures, and final total dynamic head.
    d. No-flow (pump discharge valve closed) suction and discharge pressures, and corresponding total dynamic head. (This procedure is to determine actual impeller size.)
    e. Rated and actual operating current, voltage and brake power of each pump motor.
    f. Submit pump curve indicating design, operating, and no-flow points of operation.
6. Heat exchangers:
    a. Manufacturer and model number.
    b. Design and manufacturer's related data.
    c. Service and location.
    d. Actual pressure drop and related water flow rate or steam pressure, primary side.
    e. Actual pressure drop and related water flow rate or steam pressure, secondary side.
    f. Primary side entering and leaving temperatures. (Not applicable for steam-to-water heat exchangers.)
    g. Secondary side entering and leaving temperatures.
    h. Temperature control setting.
7. Heating and cooling coils:
    a. Manufacturer.
    b. Design and manufacturer's related data.
    c. Rated and actual water pressure drops through each coil and related water flow rate.
    d. Rated and actual static air pressure drops across each coil.
    e. Entering and leaving water temperatures.
    f. Wet bulb and dry bulb temperatures entering and leaving each cooling coil.
    g. Dry bulb temperatures entering and leaving each heating coil.
    h. Water flow rate from flow stations or steam pressure.
8. Air terminal units, air valves, diffusers, registers and grilles:
    a. Adjust air terminal units to deliver design maximum and minimum air-flow conditions.
    b. Flow rate at each air outlet (diffuser).
    c. Flow rate at each return and exhaust air inlet (register or grille).
9. Room Pressure relationships:
    a. Maintain pressure relationships in rooms that are either positive (supply greater than return/ exhaust) or negative (supply less than return/exhaust).
    b. In the final test and balance report, indicate that these pressure relationships were maintained.

B. Units of measure:
   1. Flow rates:
      a. Air: CFM.
      b. Water: GPM.
   2. Temperatures: DegF.
   3. Pressures:
      a. Air: IN WC.
      b. Steam: PSIG.
      c. Water: PSIG.
   4. Pump heads: FT.
   5. Power: HP.

PART 3 - EXECUTION

3.1 GENERAL

A. Accurately calibrate and maintain test instruments in good working order:
   1. If requested, conduct tests of instruments in presence of Test Engineer.

B. If requested, conduct balancing tests in presence of Test Engineer.

C. Do not begin balancing until system(s) have been substantially completed and are in good working order to permit preliminary measurements of total air or water volumes and system pressures.

D. Proceed with final balancing and adjustments when systems are 95 to 100 percent complete.

E. Record inspections, tests and adjustments.

3.2 AIR BALANCING METHODS

A. Balance each air system that is served by air filters, using artificial static loading of system, to demonstrate, test and obtain system design pressure drop data:
   1. Provide dirty filter pressure drop conditions on system.
   2. Do not use high efficiency filters (75 percent and above) in testing and balancing.
   3. Static pressure losses may be simulated by using wood or sheet steel blanking plates in high efficiency filter racks and housings.
   4. Do not install blanking plates within 2 FT of low efficiency filter unit or rack.

3.3 AIR BALANCE TESTING PROCEDURE

A. Perform tests and balance system in accordance with approved Submission Report.

B. Take readings of airflow stations if installed or make pitot tube traverse of main supply, return and exhaust air ducts:
   1. Obtain flow rates at fans at both maximum and minimum outside air operation.

C. Test and adjust each diffuser, grille, and register served by an air terminal unit to within 10 percent of design requirements.

D. In cooperation with HVAC Controls Contractor, set automatically operated dampers to operate as indicated:
   1. Check controls for proper calibration and list controls requiring adjustment.

3.4 WATER BALANCE TESTING PROCEDURE

A. Complete air balancing before commencing water balancing.

B. Perform test and balance systems in accordance with approved Submission Report.

3.5 OPERATING TEST

A. After systems are balanced, conduct operating test of not less than 8 hours duration to demonstrate to satisfaction of Test Engineer and BNL that system(s) comply with requirements of plans and specifications, and that equipment and controls are functioning properly.

END OF SECTION

SECTION 20 11 00
PIPE AND FITTINGS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. Pressurized piping.
   2. Nonpressurized piping.
   3. RO and Deionized water piping.
   4. Accessories:
      a. Dielectric fittings.
      b. Unions.

1.2 QUALITY ASSURANCE

A. Pipe and fittings: ASME B31.3 for Process Piping; ASME B31.9 for Building Service Piping.

B. Welder qualifications: Certified under requirements of ANSI/ASME-B31.1 Power Piping.

C. Welding pressure piping: Section 20 12 00.

1.3 SUBMITTALS

A. Project information:
   1. Manufacturer of listed products.
   2. Pre-insulated conduit piping system test reports.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Fittings, mechanical groove-end and plain-end pipe:
      a. Base:
         1) Victaulic Company of America.
      b. Optional:
         1) Central Grooved Piping Products.
         2) Star Pipe Products.
         3) Gruvlok.
   2. Dielectric waterway fittings:
      a. Base:
         1) Perfection Corp. Victaulic Company of America.

2.2 PIPE

A. Black steel pipe:
   1. Seamless or welded steel pipe, ASTM-A53, standard weight unless otherwise indicated.
   2. For fire sprinkler service: ASTM-A135 and ASTM-A53, Grade-B, Schedule-40 or Schedule-30 with minimum 0.25 IN wall thickness.

B. Galvanized steel pipe:
   1. Seamless or welded, hot-dipped galvanized steel pipe, ASTM-A53 or ASTM-B36.
   2. Joints:
      a. Threaded.
      b. Welded.
      c. Rolled grooved.

C. Stainless steel pipe:
   1. Welded chromium nickel alloy steel ASTM-A312 or ASTM-A358, Grade-304L. Stainless steel pipe, 10 IN and larger, shall be Schedule 10 unless otherwise indicated. Piping less than 10 IN shall be standard weight.

D. Copper pipe:
   1. Seamless copper tubing, ASTM-B88, Type-K or Type-L as indicated.
   2. Joints:
      a. Soldered: Use ASTM-B32, 95 percent tin, 5 percent antimony solder, or Silvabrite 100.
      b. High temperature soldered: Use 1,000 degF solder.
      c. Roll grooved.

E. Cast iron soil pipe:
   1. ASTM-A74.
   2. Bell and spigot joints: Use oakum and lead, or neoprene gaskets (if allowed by code).
   3. Gaskets: ASTM-C564.

F. No hub cast iron pipe:
   1. CISPI-301 or ASTM-A888.
   2. Mechanical joints conforming to CISPI-310.
   3. Hubless couplings conforming to CISPI-310:
      a. Use stainless steel couplings with neoprene gaskets.
      b. Gaskets: ASTM-C564.
      c. Examples:
         1) Husky: No hub couplings shall have a shield constructed of corrugated 304 stainless steel with a minimum thickness of 0.010 IN. Coupling sizes 1-1/2 through 4 IN shall have four bands and sizes over 4 IN shall have six bands. The worm gear drive clamps shall have a hexagonal head to accept a 5/16 IN socket torque wrench.
         2) Clamp All: No hub couplings shall have a shield constructed of minimum 28 ga. 304 stainless steel. Coupling sizes 1-1/2 through 4 IN shall have two bands and sizes over 4 IN shall have four bands. The worm gear drive clamps shall have a hexagonal head to accept a 5/16 IN socket torque wrench.
         3) Clamps shall be tightened to a minimum of 80 IN/LBS.
         4) Gaskets shall be neoprene rubber meeting the requirements of ASTM C-564 and have sealing rings molded into the gasket.
         5) Couplings shall meet the performance requirements of the FM 1680 class 1.

G. Ductile iron pipe:
   1. Centrifugally cast, ANSI/AWWA-C151/A21.51, bituminous lined and coated.
   2. Joints:
      a. Gasketed mechanical joints: ANSI/AWWA-C111/A21.11:
         1) Gaskets: ANSI/AWWA-C111/A21.11.

H. Cast iron pressure pipe:
   1. ANSI/AWWA-C105/A21.5, lined and coated.
   2. Thickness class: 22:
      a. Exception: When depth of cover exceeds 8 FT, use thickness class 23.
   3. Joints: Use mechanical or push-on joints below grade.
   4. Mechanical or push-on joints for water: ANSI/AWWA-C111/A21.11.

5. Gaskets: Suitably formed of high quality vulcanized rubber, made to exact dimensions, and in form of a solid ring, with durometer hardness of approximately 85; for joint rating of 350 PSI internal liquid pressure, minimum.

I. Shop coating and lining for ductile and cast iron pipe:
   1. Cement lining: ANSI/AWWA-C104/A21.4, except lining thickness may be reduced to 0.5 ANSI specified thickness for "Enameling" coating.
   2. Rust preventative: Non-Ox-Id 558.
   3. Bituminous coating: Manufacturer's standard, minimum 1 mil thick.
   4. Provide interior surfaces of ductile iron and cast iron pipe and fittings with cement lining.
   5. Shop coat flange faces with rust preventative compound.
   6. Shop coat other surfaces of ductile iron and cast iron pipe and fittings with bituminous coating.

2.3 FITTINGS AND COUPLINGS

A. Steel pipe fittings:
   1. Socket welding fittings: ANSI/ASME-B16.11 and ASTM-A234.
   2. Butt welding fittings: ANSI/ASME-B16.9, ANSI/ ASME-B16.25 and ASTM-A105.
   3. Grooved fittings: Square cut, ASTM-A53 steel, or roll grooved, ASTM-A135 with EPDM Grade-E gasket.
   4. Flanged fittings: ANSI/ASME-B16.5 and ASTM-A105 with 1/8” thick full face EPDM gasket.
   5. Flange bolts: ASTM HTSB7.
   6. Gaskets: Spiral wound metallic.

B. Malleable iron pipe fittings:
   1. Threaded fittings: ANSI/ASME-B1.20.1 and ANSI/ASME-B16.3, Class 150.
   2. Threaded couplings: Same as threaded fittings except Class 300.
   3. Grooved couplings: ASTM-A47, coupling segments with EPDM Grade-E gasket.
   4. Galvanized malleable iron couplings: Victaulic; or ITT Grinnell.

C. Cast iron pipe fittings:
   1. Drainage fittings: Coated or galvanized, ASTM-A74.
   2. Threaded fittings: ANSI/ASME-B1.20.1 and ANSI/ASME-B16.4, Class 125.
   3. Threaded drainage fittings: ANSI/ASME-B1.20.1, ANSI/ASME-B16.12 and ASTM-A126.
   4. Flanged: ANSI/ASME-B16.1, Class 125 with 1/8” thick full face EPDM gasket.

D. Copper pipe fittings:
   1. Wrought copper fittings: ANSI/ASME-B16.22.
   2. Cast brass fittings: ANSI-B16.18.
   3. Mechanical groove-end fittings: Factory roll grooved.
   4. Flared tubing fittings: Use only on annealed pipe.
   5. Cast flanged fittings: ANSI/ASME-B16.24, Class 150 with 1/8” thick full face EPDM gasket.
   6. 400 PSI fittings: Heavy wall type, Mueller "Steamline".

E. Stainless steel pipe fittings:
   1. ASTM-A182.
   2. Roll grooved: Stainless steel, Victaulic type.
   3. Butt welding fittings: ANSI/ASME-B16.9.
   4. Socket welding fittings: ANSI/ASME-B16.11.

F. Ductile iron pipe fittings:
   1. ANSI/AWWA-C110/A21.10.
   2. Gasketed mechanical joints: ANSI/AWWA-C111/A21.11.
   3. Laying length (AWWA fittings): Short body dimensions.
   4. Flanged fittings: ANSI/ASME-B16.5 with 1/8” thick full face EPDM gasket.

5. Thickness of iron: Not less than for ductile iron pipe with additional thickness as required for proper reinforcement of branches for tees and crosses.

G. Cast iron pressure pipe fittings:
1. ANSI/ASME-B16.1 and ANSI/AWWA-C111/A21.11 mechanical joint type, suitable for minimum working pressure of 150 PSI plus 100 PSI surge pressures.
2. Laying length:
a. AWWA fittings: Short body dimensions.
b. ANSI mechanical joint fittings: ANSI/AWWA-C110/A21.10.
c. Others: ANSI/ASME-B16.1.
3. Thickness, 6 through 12 IN: Not less than for cast iron pipe with additional thickness as required for proper reinforcement of branches for tees and crosses.

H. Dielectric fittings:
1. General:
a. Standard product for prevention of galvanic corrosion.
2. Dielectric waterway fitting:
a. ASTM-F-492, steel pipe casing with inert, non-corrosive thermoplastic lining (NSF/FDA listed).
b. Threaded X threaded, or threaded X grooved connections.
c. Perfection Corp., "ClearFlow".

I. Mechanical groove-end couplings and fittings:
1. Couplings:
a. Malleable iron, ASTM-A47 or ductile iron, ASTM-A536.
b. Gaskets: EPDM Grade-E conforming to ASTM-D2000 for water services up to 230 degF.
c. Gaskets on plastic piping: ASTM-F477.
d. Bolts and nuts: ASTM-A183:
1) Heat treated plated carbon steel, track-head.
2) Minimum tensile strength: 110,000 PSI.
2. Fittings:
a. Malleable iron, ASTM-A47 or ductile iron, ASTM-A536.
b. Copper:
1) 2 IN to 4 IN: ASTM-B75, C12200.
2) 5 IN to 6 IN: ASTM-B584, CDA 844 (81-3-7-9).

J. Unions:
1. Same type, pressure rating and material as piping.
2. Flanges: Raised face type of same type, pressure rating and material as piping.
3. Unions in copper pipe:
a. 2 IN and smaller: Use wrought copper solder joint copper to copper unions.
b. 2-1/2 IN and larger: Use brass flange unions.

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with ANSI/ASME-B31.9 for pressure piping installations:
1. Install piping without "bull-head" fittings.

B. Flush out water piping systems with clean water prior to adding treatment.

C. Make connections to components in piping systems with minimum 3-elbow swing joints to allow for movement:
1. Movement includes but not limited to expansion, contraction, seismic, and equipment vibration isolation.

3.2 PIPING

A. Install piping parallel to building walls at such heights as not to obstruct portion of window, doorway, stairway, or passageway:
   1. Where interference develops in field, offset or reroute piping as required to clear such interferences.
   2. Consult Drawings for exact location of pipe spaces, ceiling heights, door and window openings or other architectural details and report discrepancies to BNL, before installing piping.

B. Pitch piping to drain:
   1. Minimum pitch of 1 IN in 100 FT (except drainage piping).
   2. Make piping and equipment drainable.
   3. Accomplish pipe drainage using drain valves located on equipment and fixtures or separate drains.
   4. Drains: See Section 20 05 19.

C. Factory cut and thread nipples from seamless stock:
   1. Use nipples of same material as pipe with which they are used.
   2. Do not use close nipples except where such use is unavoidable.
   3. Use Schedule-80 seamless pipe for close nipples and nipples of pipes 3/8 IN or smaller.

D. Provide backing and sleeves required in walls or floors for setting of fixtures or equipment.

E. Where transition occurs from sweated fittings (as at connection to fixture supplies, etc.), provide rigid anchorage so that no strain will be placed upon tubing.

3.3 JOINTS

A. Threaded joints:
   1. Cut piping carefully, ream, thread and work into place without springing.
   2. Use PTFE pipe joint tape meeting MIL-T-27730A (ASG).
   3. Pipe joint compound is not to be used.

B. Use dielectric waterway fittings for connections between dissimilar metals.

C. Flanged joints:
   1. Take care to ensure that there is no restraint on opposite end of pipe or fittings which would prevent uniform gasket compression or cause unnecessary stress in flanges.
   2. Keep one flange free to move in any direction while flange bolts are being tightened.
   3. Do not pack or assemble bell and spigot joints affected by flanged joints until such flanged joints have been tightened.
   4. Tighten bolts gradually and at a uniform rate, so that gasket compression is uniform over entire area of gasket.

D. Mechanical joints:
   1. Assemble in accordance with instructions and recommendations of pipe manufacturer.
   2. Clean joint surfaces and lubricate with soap solution or water soluble lubricant immediately before joint is assembled.
   3. Groove-end and plain-end joints:
      a. Use mechanical joint system only with pipe meeting joint manufacturer's requirements:
         1) When joint manufacturer's pipe requirements exceed specified requirements, provide pipe that meets joint manufacturer's requirements.
      b. Prepare pipe and install system in accordance with joint manufacturer's instructions and recommendations.

3.4 UNIONS

A. Provide a union between valves, at connection to each fixture, device or item of equipment, and elsewhere as required to facilitate installing, servicing, making up and disconnecting piping:
   1. Install each union to facilitate removal of parts, equipment or fixtures for inspection or cleaning.
   2. Install in a position which will permit device, fixture or part to be removed without disconnecting piping except unions.

B. Install unions as directed by Fluid Controls Institute, (FCI):
   1. Grooved piping systems:
      a. Grooved type couplings may serve as unions.
   2. Make connections between couplings and flanged equipment with slip-on flanges and a grooved nipple, or groove-to-flange adapter.
   3. Welded piping systems:
      a. Where flanged end-service valves are used at equipment connections, flange unions will not be required.
      b. Make connections to flanged valves and equipment using ANSI welding neck or slip on type welding flanges.
      c. Flanged cast iron ells may be used for connections between pumps, strainers, check valves and other flanged equipment.

C. Install dielectric waterway fitting at each piping joint and equipment connection between ferrous and non-ferrous materials.

3.5 PIPING EXPANSION

A. Install piping to allow thermal expansion and contraction without injury to piping, equipment or structure:
   1. Use loops or expansion joints where necessary and where detailed.
   2. Provide pipe guides at loops as necessary.

B. Where screwed piping is used for soil, waste or vent risers, or downspouts, use caulked joints or expansion joints at intervals to allow expansion movement.

3.6 WELDED STEEL PIPING

A. See Section 20 12 00.

3.7 THREADED STEEL PIPING

A. Branch connections to screwed piping may be made with Weld-O-Lets or Thread-O-Lets.

B. Do not weld pipe couplings in place of welding fittings for branch connections.

3.8 DUCTILE IRON AND CAST IRON PRESSURE PIPING

A. Perform cutting without damage to pipe or to cement lining:
   1. Make pipe cuts smooth, straight and at right angles to pipe axis.
   2. Use approved type mechanical pipe cutters.
   3. In locations where use of mechanical cutters would be difficult or impracticable, existing pipe may be cut with diamond point chisels, saws, or other tools which will not cause damaging impact or shock.

B. Use equipment, tools and methods in handling and laying pipe and fittings which prevent damage:
   1. Hooks inserted in ends of pipe shall have broad, well padded contact surfaces.

C. Replace pipe and fittings in which cement lining has been broken or loosened:
   1. Where damaged areas are small and readily accessible, lining may be repaired, if BNL approved.

D. Repair pipe coating which has been damaged before installing pipe.

E. Make connections between below ground piping and above ground piping with a flanged spigot adapter:
   1. Hold spigot piece in place with bolts on 2 sides of flanges between mechanical joint and flange connector.

F. Comply with AWWA-C600 for installation.

3.9 CAST IRON DRAINAGE PIPING

A. Lay underground pipe on undisturbed earth excavated to provide firm bearing on at least 0.333 of pipe circumference for full length, with bell holes cut out:
   1. Where excavation has been carried too deep, place a layer of sand well tamped to bring pipe to proper grade.
   2. Where fill or unsound earth is encountered, place a layer of 2500 PSI concrete to properly bed pipe.

B. Bell and spigot joints:
   1. Install neoprene gaskets in accordance with manufacturer's recommendations.
   2. Caulk tarred oakum well into joint and pour in molten lead continuously around joint, using at least 12 OZ of lead per IN of pipe diameter.
   3. Furnish sufficient lubricant to provide a thin coat on each spigot end.
   4. Use lubricant that is non-toxic, imparts no taste or odor to conveyed liquid, and has no deleterious effect on rubber gasket, with consistency so that it can be easily applied to pipe in hot or cold weather and will adhere to either wet or dry pipe.

C. Threaded joints:
   1. Clean cut, American National taper pipe threads.
   2. Ream pipe ends to full pipe size and remove burrs, chips, cuttings before making up.
   3. Pipe joint cement permitted on male threads only.

3.10 COPPER PIPING

A. Brazed (high temperature soldered) joints:
   1. Take care to avoid annealing of pipe material.
   2. For pipe sizes 2 IN and larger: Use a circular torch such as Circa Torch by Cedarberg Industries, for soldering joints.

B. Use lead-free solder.

C. T-drilling:
   1. Tapped pipe shall be least 1 IN diameter and branch shall be at least 2 pipe sizes smaller.
   2. Braze (high-temperature solder) joints.
   3. Branch pipe shall not protrude into main.

END OF SECTION

SECTION 20 12 00
WELDING PRESSURE PIPING

PART 1 - GENERAL

1.1 REFERENCES

A. The most recent revision of the publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only:
   1. American Petroleum Institute (API):
      a. API STD 1104:
         1) Welding of Pipelines and Related Facilities.
   2. American Society of Mechanical Engineers (ASME):
      a. ASME B31.1:
         1) Power Piping.
      b. ASME BPVC SEC I:
         1) Boiler and Pressure Vessel Code:
            a) Section I Power Boilers.
      c. ASME BPVC SEC II-C:
         1) Boiler and Pressure Vessel Code:
            a) Section II Material Part C – Welding Rods, Electrodes, and Filler Metals.
      d. ASME BPVC SEC V:
         1) Boiler and Pressure Vessel Code:
            a) Section V Nondestructive Examination.
      e. ASME BPVC SEC IX:
         1) Boiler and Pressure Vessel Code:
            a) Section IX Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators.
   3. American Society for Nondestructive Testing (ASNT):
      a. ASNT SNT-TC-1A:
         1) Recommended Practice.
   4. American Welding Society (AWS):
      a. AWS A2.4:
         1) Symbols for Welding, Brazing and Nondestructive Examination.
      b. AWS A3.0:
         1) Welding Terms and Definitions Including Terms for Brazing, Soldering, Thermal Spraying and Thermal Cutting.
      c. AWS D1.1:
         1) Structural Welding Code - Steel.
      d. AWS B2.1:
         1) Specification for Welding Procedure and Performance Qualification.
      e. AWS QC1:
         1) AWS Certification of Welding Inspectors.
      f. ANSI/AWS Z49.1:
         1) Safety in Welding, Cutting and Allied Processes.
      g. 29 CFR 1910:
         1) Occupational Safety and Health Standards.
      h. 29 CFR 1926:
         1) Safety and Health Regulations for Construction.

1.2 SUBMITTALS

A. Submit the following in accordance with Section 01 30 00.
   1. Shop Drawings:
      a. Pressure piping layout that also denotes each field weld location and corresponding number.
   2. Certificates:
      a. Welding procedures qualification.
      b. Nondestructive examination (NDE) procedures.
      c. NDE personnel certification procedures.
      d. Inspector certification.
      e. Submit inspector certification and NDE personnel certification for record.
   3. Welding Logs:
      a. Periodic submittals of completed Welding Acceptance Logs.
   4. Closeout Submittals:
      a. As-builts with weld identifications shown.
      b. Welding Acceptance Logs.
      c. AWS-Certified Inspector Reports.

1.3 QUALITY ASSURANCE

A. Welding Pressure Piping:
   1. Show location, length, and type of welds and indicated nondestructive testing as required.

B. Procedures: Develop and qualify procedures for welding metals included in the work. Do not start welding until welding procedures, welders, and welding operators have been qualified. Perform qualification testing by an approved testing laboratory. Maintain current records of the test results obtained in welding procedure, welding operator/welder performance qualifications, and nondestructive examination (NDE) procedures. These records shall be readily available at the site for examination. Qualify the procedures for making transition welds between different materials or between plates or pipes of different wall thicknesses. Unless otherwise specified, the choice of welding process shall be the responsibility of the Contractor:
   1. Previous Qualifications: Welding procedures, welders, and welding operators previously qualified by test may be accepted for the work without requalification provided that the following conditions are fulfilled:
      a. Copies of welding procedures, procedure qualification test records, and welder and welding operator performance qualification test records are submitted and approved in accordance with the paragraph entitled “Submittals.”
      b. Testing was performed by an approved testing laboratory.
      c. The welding procedures, welders, and welding operators were qualified in accordance with ASME BPVC SEC IX or AWS B2.1; and base materials, filler materials, electrodes, equipment, and processes conformed to the applicable requirements of this specification.
      d. The requirements of paragraph entitled “Welder and Welding Operator Performance Qualification” for renewal of qualification were met, and records showing name of employer and period of employment using the process for which qualified are submitted as evidence of conformance.
   2. Performance: The Contractor shall be responsible for hiring an independent AWS-certified welding inspector to inspect the quality of joint preparation, welding, and examination. Clearly identify and record materials used in the welding operations. The examination and testing defined in this specification are minimum requirements. Provide additional examination and testing as necessary to achieve the quality required. AWS-certified welding inspector, working with PE, shall complete the Welding Acceptance Log entry for each weld inspected (see log form attached to this section) as well as his own Inspection Reports.

C. Welding Procedures Qualification: Qualification of the welding procedures for each group of materials to be welded is required as indicated in the ASME BPVC SEC IX. Record in detail and qualify the "Welding Procedure Specification" for every welding procedure proposed. Qualification for each welding procedure shall conform to the requirements of ANSI Standards and to this specification. The welding procedures shall specify end preparation for welds, including cleaning, alignments, and root openings. Procedures shall specify shielding gas requirements for welding of stainless steel. Preheat, interpass temperature control, and postheat treatment of welds shall be as required by ANSI Piping documents, unless otherwise indicated or specified. Describe the type of backing rings or consumable inserts, if used, and, if they are to be removed, the removal process. Welding procedure qualifications shall be identified individually and referenced on the shop drawings or suitably keyed to the contract drawings.

D. Welder and Welding Operator Performance Qualification: Qualify each welder and welding operator assigned to work covered by this specification by performance tests using equipment, positions, procedures, base metals, and electrodes or bare filler wires from the same specification, classification, or group number that will be encountered on his assignment. Welders or welding operators who make acceptable procedure qualification tests will be considered performance-qualified for the welding procedure used. Determine performance qualification in accordance with ASME BPVC SEC IX, ANSI Piping Standards and as specified.

E. Renewal of Qualification: Requalification of a welder or welding operator shall be required under one or any combination of the following conditions:
   1. When a welder or welding operator has not used the specific welding process for a period of 3 months. The period may be extended to 6 months if the welder has been employed on another welding process.
   2. There is specific reason to question the welder's ability to make welds that will meet the requirements of the specifications.
   3. The welder or welding operator was qualified by an employer other than those firms performing work under this contract and a qualification test has not been taken within the preceding 12 months. Renewal of qualification under this condition need be made on only a single test joint or pipe of any thickness, position, or material to reestablish qualification for any thickness, position, or material for which the welder or welding operator had qualified previously.

F. Special Requirements for Stainless Steel:
   1. Installer shall be responsible to supply and qualify welders, equipment, and materials for scope of work. The qualifications of welding procedures, welders, and welding operators shall be in accordance with the requirements of ASME, Section IX.
   2. Welding shall conform to the following:
      a. Stainless steel lines: Weld using the tungsten insert gas (TIG) arc welding process.
      b. During welding, all gas lines shall be continuously purged with argon and allowed to escape into the atmosphere through a purge restrictor. All lines shall be maintained, under restricted purge or under pressure at all times during installation (purge relief will vent above the plane of pipe). Portable hand held oxygen monitors shall be used on pipe sizes 2-1/2 IN and larger. Monitors are to read ppm level, percentage monitor are not acceptable. Welding and brazing shall be done at less than or equal to 50 ppm oxygen concentrations. Time purging is acceptable on line sizes 2 IN and smaller.
      c. No welding joint can be less than six inches away from the end of the purge line, which will require, in many instances, that an extension be used.
      d. Provide verification of all purge lines at the end of each shift. If only one shift is scheduled, reduce purge to a trickle purge for overnight purging or cap under pressure. Inspect each flow meter for proper flow and verify that source of argon will be sufficient until next shift startup.
      e. Maintain all installation and purging procedures for all pipe runs until installation is complete and accepted by BNL.

f. If the system becomes contaminated due to fabrication techniques, prior to BNL written acceptance, perform a total system re-clean or replacement. All expenses shall be borne by the installer, with no expense to BNL.

G. Qualification of Inspection Personnel: Qualify inspection personnel in accordance with the following requirements:
   1. Inspector Certification: Qualify welding inspectors in accordance with AWS QC1.
   2. Welding Procedures and Qualifications:
      a. Specifications and Test Results: Submit copies of the welding procedure specifications and procedure qualification test results for each type of welding required. Approval of any procedure does not relieve the Contractor of the responsibility for producing acceptable welds. Submit this information on the forms printed in ASME BPVC SEC IX or their equivalent.
      b. Certification: Before assigning welders or welding operators to the work, submit their names, together with certification that each individual is performance qualified as specified. Do not start welding work prior to procedure qualification. The certification shall state the type of welding and positions for which each is qualified, the code and procedure under which each is qualified, date qualified, and the firm and individual certifying the qualification tests.

H. Safety: Conform to ANSI/AWS Z49.1, 29 CFR 1910-SUBPART Q, "Welding, Cutting, and Brazing, "29 CFR 1926-SUBPART J, "Welding and Cutting."

1.4 ENVIRONMENTAL

A. Do not perform welding when the quality of the completed weld could be impaired by the prevailing working or weather conditions. BNL will determine when weather or working conditions are unsuitable for welding.

1.5 DELIVERY AND STORAGE

A. Deliver filler metals, electrodes, fluxes and other welding materials to the site in Manufacturers' original packages and store in a dry place until used. Label and design packages properly to give maximum protection from moisture and to assure safe handling.

PART 2 - PRODUCTS

2.1 WELDING MATERIALS

A. Comply with ASME BPVC SEC II-C. Welding equipment, electrodes, welding wire, and fluxes shall be capable of producing satisfactory welds when used by a qualified welder or welding operator using qualified welding procedures.

B. Weld-O-Lets and Thread-O-Lets:
   1. Scribe and cut openings in main pipes for welded branches accurately taking care to remove plug and cuttings from main pipe.
   2. Full weld fillet welds for full depth of fillet, with additional beads to form well rounded connection as recommended by Weld-O-Let manufacturer:
      a. Partially filled fillets not acceptable.

PART 3 - EXECUTION

3.1 WELDING

A. Do not deviate from applicable codes, approved procedures and approved shop drawings without prior written approval from BNL. Material or components with welds made off the site will not be accepted if the welding does not conform to the requirements of this specification unless otherwise specified.

3.2 WELDING OPERATORS

A. Perform welding in accordance with qualified procedures using qualified welders and welding operators.

3.3 SUPPORTS

A. Welding of hangers, supports, and plates to structural members shall conform to AWS D1.1.

3.4 EXAMINATIONS AND TESTS

A. Visual examinations shall be performed by the Contractor's independent inspector to detect surface and internal discontinuities in completed welds. Employ the services of a qualified commercial inspection or testing laboratory. Visually examine the welds. Radiographic examination may be required as indicated in Tables I and II attached to this section. Random NDE testing applies to ASME B31.1 piping unless specified otherwise. When examination and testing indicates defects in a weld joint, a qualified welder shall repair the weld in accordance with the paragraph entitled "Corrections and Repairs" of this section:
   1. Random NDE Testing: When radiographic examination is required, BNL will do the radiographic examination of the welds to be examined. If random testing reveals that a weld fails to meet minimum quality requirements, defective welds shall be repaired. If any of the additional welds examined also fail to meet the quality requirements, the entire group of welds shall be rejected. Remove and re-weld rejected welds. All costs associated with re-welding, retesting and delays shall be incurred by the Contractor.
   2. Visual Examination: Visually examine welds as follows:
      a. Before welding, check for compliance with requirements for joint preparation, placement of backing rings or consumable inserts, alignment and fit-up, and cleanliness.
      b. During welding, check for conformance to the qualified welding procedure.
      c. After welding, check for cracks, contour and finish, bead reinforcement, undercutting, overlap, and size of fillet welds.
   3. Nondestructive Examination: NDE shall be in accordance with written procedures. Procedures for radiographic tests and methods shall conform to ASME BPVC SEC V.
   4. Examination and Tests: Examination and tests will conform to paragraphs "Visual Examination" and "Nondestructive Examination" of this section. When destructive tests are made, qualified welders or welding operators shall make repairs using welding procedures which will develop the full strength of the members cut. Welding shall be subject to examination and tests in the mill, shop and field.

B. Stainless Steel:
   1. Completed welds shall be subject to inspection wherever practical.
   2. Welds will be inspected, visually by BNL. Visual weld inspections shall be in accordance with AWS QC 1. Any weld falling below the AWS QC 1 standard and deemed unacceptable by BNL from a visual inspection, shall be repaired or cut out. At the request of BNL, in the event any welder-operator consistently produces unsatisfactory productions welds, he (she) shall be refrained from welding and re-qualified, per Section IX of the ASME Boiler and Pressure Vessel Code. Repair and removal of welds or the re-qualification of welder-operators shall be done at the expense of the installer and not BNL.
   3. Weld Rejection Criteria:

a. No visible tacks on the ID or OD of the weld.
b. No undercut or profile defect causing the wall thickness to fall below that of the parent metal.
c. Concavity / Convexity exceeds 10 percent of the tube/pipe wall thickness.
d. Penetration and bead width must be uniform throughout the entire weld, plus or minus 0.008 IN.
e. Bead meander must not exceed 25 percent of the bead width.
f. There should be no unusual inclusion or porosity when viewed with the unaided eye.
g. Misalignment exceeds 10 percent of the wall thickness.

4. Upon request of BNL, remove a random piece of installed work, sufficient to establish the quality of materials and workmanship. If the piece shows evidence of weld rejection as stated above, BNL may require testing of additional samples. If the additional samples are acceptable, BNL will pay for the direct labor and materials required for the cutting out and restoration of these sample. If they are not acceptable, the cost shall be paid by the installer.

3.5 ACCEPTANCE STANDARDS

A. Visual: The following indications are unacceptable:
1. Cracks, external surface.
2. Undercut, external surface.
3. Weld reinforcement:
   a. ASME B31.1, 1989, conform to Table 127A.2:

Reinforcement of Girth and Longitudinal Butt Welds

	Maximum Thickness of Reinforcement for Design Temperature (inches)		
Thickness of Base Metal (inches)	Greater than 750 °F	350 °F – 750 °F	Less than 350 °F
Up to 1/8, incl.	1/16	3/32	3/16
Over 1/8 to 3/16, incl.	1/16	1/8	3/16
Over 3/16 to 1/2, incl.	1/16	5/32	3/16
Over 1/2 to 1, incl.	3/32	3/16	3/16
Over 1 to 2, incl.	1/8	1/4	1/4
Over 2	5/32	The greater of 1/4 IN or 1/8 times the width of the weld in inches.	

NOTES:
- For double welded butt joints, this limitation on reinforcement given above shall apply separately to both inside and outside surfaces of the joint.
- For single welded butt joints, the reinforcement limits given above shall apply to the outside surface of the joint only.
- The thickness of weld reinforcement shall be based on the thickness of the thinner of the materials being joined.
- The weld reinforcement thicknesses shall be determined from the higher of the abutting surfaces involved.
- Weld reinforcement may be removed is so desired.

4. Lack of fusion on surface.
5. Incomplete penetration (applies only when inside surface is readily accessible).
6. Convexity of fillet weld surface greater than 10 percent of longest leg plus 0.03 IN.
7. Concavity in groove welds.
8. Concavity in fillet welds greater than 1/16 IN.
9. Fillet weld size less than indicated or greater than 1-1/4 times the minimum specified fillet leg length.

B. Radiography: Welds that are shown by radiography to have any of the following discontinuities are unacceptable:

1. Any type of crack or zone of incomplete fusion or penetration.
2. Any other elongated indication which has a length greater than:
   a. 1/4 IN for *t* up to 3/4 IN, inclusive.
   b. 1/3 *t* for *t* from 3/4 IN to 2-1/4 IN, inclusive.
   c. 3/4 IN for *t* over 2-1/4 IN where *t* is the thickness of the thinner portion of the weld. ("*t*" pertains to the thickness of the weld being examined. If a weld joins two members having different thickness at the weld, "*t*" is the thinner of these two thicknesses.)
3. Any group of indications in line that have an aggregate length greater than t in a length of 12t, except where the distance between the successive indications exceeds 6L where L is the longest indication in the group.
4. Porosity in excess of that shown acceptable in Appendix A-250, Acceptance Standard for Radiographically Determined Rounded Indications in Welds, ASME BPVC SEC I.

3.6 CORRECTIONS AND REPAIRS

A. Remove defects and replace welds as specified in ANSI Piping Standards, unless otherwise specified. Repair defects discovered between weld passes before additional weld material is deposited. Wherever a defect is removed, and repair by welding is not required, the affected area shall be blended into the surrounding surface eliminating sharp notches, crevices, or corners. After defect removal is complete and before re-welding, re-examine the area by the same test methods which first revealed the defect to ensure that the defect has been eliminated. After rewelding, reexamine the repaired area by the same test methods originally used for that area. For repairs to base material, the minimum examination shall be the same as required for butt welds. Indication of a defect shall be regarded as a defect unless re-evaluation by NDE or by surface conditioning shows that no unacceptable indications are present. The use of foreign material to mask, fill in, seal, or disguise welding defects will not be permitted.

END OF SECTION

Welding Acceptance Log

Weld No._____

Procedure	**Date**
Fit-up	
Root Pass	
Cover pass	
Performed By/Approved By	**Initials**
Welder	
Contractor's Inspector	
EP Construction Inspector	

Weld No._____

Procedure	**Date**
Fit-up	
Root Pass	
Cover pass	
Performed By/Approved By	**Initials**
Welder	
Contractor's Inspector	
EP Construction Inspector	

Weld No._____

Procedure	**Date**
Fit-up	
Root Pass	
Cover pass	
Performed By/Approved By	**Initials**
Welder	
Contractor's Inspector	
EP Construction Inspector	

Weld No._____

Procedure	**Date**
Fit-up	
Root Pass	
Cover pass	
Performed By/Approved By	**Initials**
Welder	
Contractor's Inspector	
EP Construction Inspector	

Weld No._____

Procedure	**Date**
Fit-up	
Root Pass	
Cover pass	
Performed By/Approved By	**Initials**
Welder	
Contractor's Inspector	
EP Construction Inspector	

Weld No._____

Procedure	**Date**
Fit-up	
Root Pass	
Cover pass	
Performed By/Approved By	**Initials**
Welder	
Contractor's Inspector	
EP Construction Inspector	

DIVISION 21

FIRE SUPPRESSION

SECTION 21 10 00
FIRE PROTECTION SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Fire protection systems:
   1. Descriptions:
      a. Water based:
         1) Dry-pipe sprinkler system.
         2) Dry-pipe/pre-action (double-interlocked) sprinkler system.
         3) Standpipe-and-hose system.
         4) Wet-pipe sprinkler system.
   2. Products:
      a. Pipe, fittings, and supports.
      b. Air pressure maintenance devices.
      c. Alarm and signal devices.
      d. Backflow protection devices.
      e. Dedicated compressed air systems.
      f. Fire department connections.
      g. Fire department valves.
      h. Fire system valves.
      i. Manual valves.
      j. System accessories.
      k. Sprinklers.
      l. Flexible sprinkler hose fittings.

1.2 QUALITY ASSURANCE

A. Quality assurance, general:
   1. Provide complete fire protection systems as described in the Contract Documents and according to criteria of authority (ies) having jurisdiction (AHJ) and the BNL Fire Department:
      a. Where system requirements as described in the Contract Documents exceed those of the AHJ, meet requirements of both.
      b. Where discrepancies exist among the AHJ, and Contract Documents, the most stringent requirements shall take precedence.
   2. Do not downsize piping indicated to serve future areas.

B. Authorities Having Jurisdiction:
   1. Code Enforcement Agencies.
   2. BNL Fire Department.
   3. Suffolk County Water Authority.

C. Referenced Criteria:
   1. Latest edition of referenced criteria applies unless an earlier edition is specifically indicated by the BNL Fire Department.
   2. National Fire Protection Association (NFPA).
   3. Underwriter's Laboratories (UL).
   4. Factory Mutual Engineering Commission (FM).

D. Installer qualifications:
   1. Fire Protection Installer shall be licensed, and shall provide evidence of the successful completion of at least five projects of equal or greater size and complexity.

2. Use workmen skilled in this trade.
3. Provide documentation that welders, and welding operators are certified in accordance with American Welding Society Standard AWS D10.9.
4. Installation of the following items/systems shall be done by authorized representatives of respective manufacturers:
    a. Fire system valves.

E. Piping and Fittings: Section 20 11 00.

1.3 SYSTEM DESCRIPTION

A. Design requirements:
1. Design fire sprinkler and suppression systems.
    a. Design shall be stamped with valid seal of a licensed professional engineer.
    b. Obtain water supply fire flow test prior to designing systems.
        1) Preliminary Flow test information provided by BNL via water flow modeling of a hydrant at mid span of existing 10 inch main along Rochester Avenue between Brookhaven Avenue and Bell Avenue.
    c. Compare flow test results to those listed below, and use lowest pressure of the two to design systems.
        1) Static pressure: 55 PSIG
        2) Residual pressure: 20 PSIG.
        3) Flow: 6,638 GPM.
    d. Design systems using adjusted water supply curve:
        1) Adjust the flow test water supply curve to correspond with the low hydraulic grade line as provided by the water supplier.
    e. Designs shall include a minimum safety allowance of 10 PSIG below the adjusted water supply curve.
    f. Systems shall be hydraulically designed using readily available calculation software in accordance with NFPA 13.

1.4 SUBMITTALS

A. Shop drawings:
1. Submit detailed data and complete layout of fire protection systems approved by authorities having jurisdiction and prepared in accordance with the requirements for Working Plans described in applicable NFPA standards:
    a. Include calculations prepared in accordance with the requirements for Hydraulic Calculations described in applicable NFPA standards.

B. Product data:
1. Backflow protection devices.
2. Dry-pipe sprinkler system.
3. Standpipe-and-hose system.
4. Wet-pipe sprinkler system.

C. Contract closeout information:
1. Letter stating spare parts have been delivered.
2. Operating and maintenance data.
3. BNL instruction report.
4. Test reports:
    a. Certification that tests as indicated in FIELD QUALITY CONTROL (Part 3) have been successfully completed and approved by authorities having jurisdiction.

D. As-Built Sprinkler Drawings: At completion of work submit a set of original "As-Built" drawings showing sprinkler station in detail, sprinkler head and hanger locations, and entire sprinkler piping system both old and new construction as it exists.

1.5 JOB CONDITIONS

A. Arrange and pay for permits, fees and inspections required.

1.6 RELATED SECTIONS

A. Refer to related Sections under Division 20 – Mechanical General Requirements.

PART 2 - PRODUCTS

2.1 MATERIALS - GENERAL

A. Acceptable manufacturers:
   1. Alarm and signal devices:
      a. Base:
         1) Viking.
      b. Optional:
         1) Federal Signal.
         2) Fire-Lite Alarms/Notifier.
         3) Potter Electric Signal.
         4) Potter Roemer.
         5) Simplex Access Controls.
         6) United Electric Controls.
   2. Alarm-test device:
      a. Base:
         1) Viking.
      b. Optional:
         1) Grinnell.
         2) Victaulic of America.
         3) AGF Manufacturing Inc.
   3. Backflow protection devices:
      a. Base:
         1) Cla-Val.
      b. Optional:
         1) Febco.
         2) Hersey Measurement.
         3) Watts Control Valves.
         4) Wilkins Regulator.
         5) Ames Co./Fluid Controls Systems.
   4. Fire department connections, fire department valves, fire hose cabinets, and hydrants:
      a. Base:
         1) Elkhart Brass.
      b. Optional:
         1) Croker West.
         2) Grinnell.
         3) JL Industries.
         4) Larsen's Manufacturing.
         5) Potter Roemer.
         6) Seco.
         7) Waterous.
   5. Fire protection systems, water-based:
      a. Base:
         1) Viking.
      b. Optional:
         1) Firematic Sprinkler Devices.
         2) Globe Fire Sprinkler.

3) Potter Roemer.
4) Star Sprinkler.
5) Victaulic

6. Sprinklers:
   a. Base:
      1) Reliable Automatic Sprinkler.
   b. Optional:
      1) Firematic Sprinkler Devices.
      2) Globe Fire Sprinkler.
      3) Viking.
      4) Star Sprinkler.
      5) Victaulic Company.
7. Flexible sprinkler hose fittings
   a. Base:
      1) Victaulic Company, AquaFlex.
   b. Optional:
   c. Flexhead Industries, Inc.

B. Submit other pipe materials, joining methods, and equipment not specified, but accepted by applicable NFPA standards and approved by authority(ies) having jurisdiction.

C. Use only new material of first class construction, designed and guaranteed to perform service required.

D. Provide fully operational systems.

2.2 PIPE, FITTINGS, AND SUPPORTS

A. Pipe and fittings - General:
   1. Meet or exceed applicable NFPA standards and Section 20 11 00.
   2. Working pressure: Not less than 175 PSI.
   3. The following are not permitted:
      a. Lightwall and Schedule 5 pipe.
      b. Plain end, pressure fit type fittings.
      c. Hole cut mechanical tee fittings.
   4. Fittings: galvanized where galvanized piping is used.
   5. Corrosion Resistance Ratio (CRR) of all pipe used: less than one.

B. Above ground sprinkler pipe normally containing water:
   1. Examples: Wet-pipe fire protection systems.
   2. Black steel, 1-1/2 IN and smaller, Schedule-40 meeting ASTM-A53, 2 IN and larger Schedule 10 meeting ASTM-A153:
      a. Threaded joints for 1-1/2 IN and smaller.
      b. Welded joints for 2 IN and larger.
      c. Mechanical joints for 2 IN and larger:
         1) Rolled groove type.
         2) Mechanical locking (push-on) type.
   3. Seamless copper tubing:
      a. High temperature soldered joints.

C. Aboveground standpipe and hose systems:
   1. Schedule 40 black steel, conforming to ASTM-A53.
   2. Fittings:
      a. 4 IN and Under: 125 LB standard class cast iron screwed, conforming to ANSI-B16.4, or 150 lb. class malleable iron screwed, conforming to ANSI-B16.3.
      b. 5 IN and Over: Standard weight carbon steel butt-welding, conforming to ASTM-A234 Grade WPB and ANSI-B16.9.
   3. Mechanical grooved pipe couplings and fittings as specified below may be used in lieu of, or in combination with, welding and screwed fittings.

a. Mechanical Grooved Pipe Couplings:
   1) 2 IN thru 12 IN: Victaulic Company, Style 75.
   2) Coupling Housing Clamps: Victaulic Company, malleable iron fabricated in two (2) parts, conforming to ASTM-A47 Grade 32510.
   3) Coupling Bolts: Victaulic Company, oval neck track type, conforming to ASTM-A183.
   4) Coupling Gaskets: Victaulic Company, Grade H molded synthetic rubber, conforming to ASTM-D2000.
b. Mechanical Grooved Pipe Fittings: Victaulic Company, malleable iron full-flow type, conforming to ASTM-A47 Grade 32510.
c. Unions: Grinnell Figure 463, 150 LB class bronze-to-iron ground joint, conforming to ANSI-B2.1.
d. Flanges:
   1) Welded and Threaded Steel Piping: 150 LB class carbon steel, conforming to ASTM-A105 and ANSI-B16.5. Figure numbers are Tube Turn's.
      a) Welding Neck Flanges: Figure 30.
      b) Slip-On Flanges: Figure 50.
      c) Threaded Flanges: Figure 60.
      d) Blind Flanges: Figure 70.
   2) Grooved End Steel Piping: Victaulic Company, Style 74 Vic-Flange, 150 LB class malleable iron, conforming to ASTM-A47 Grade 32510. Gaskets shall be as recommended by flange manufacturer.
e. Elbolets and Thredolets: Bonney Forge, carbon steel, 3000 LB class, conforming to ASTM-A105 Grade II.
f. Weldolets: Bonney Forge, carbon steel, extra strong class butt welding end connection, conforming to ASTM-A105 Grade II.

D. Above ground pipe normally containing air:
   1. Examples: Dry-pipe, and dry-pipe/pre-action fire protection systems; piping for alarm and sensing devices.
   2. Galvanized steel, Schedule-40:
      a. Threaded joints.
      b. Welded joints.
      c. Mechanical joints:
         1) Cut or rolled groove type.
         2) Mechanical locking (push-on) type.
   3. Seamless copper tubing:
      a. High temperature soldered joints.
   4. Brass pipe, Schedule-40 (only for valve trim):
      a. Threaded.

E. Pipe, below ground:
   1. Same as outside utility fire protection piping.

F. Fittings:
   1. Threaded:
      a. Black cast iron, Class 150.
      b. Black malleable iron.
      c. Galvanized malleable iron.
   2. Flanged:
      a. Threaded Steel Pipe: 150 LB carbon steel, conforming to ASTM-A105 and ANSI-B16.5. "Grinnell" Figure 1931.
      b. Grooved End Steel Pipe: Victaulic Company, style 741 "Vic-Flange Adapter", 150 LB class malleable iron conforming to ASTM A47 Grade 32510. Gasket shall be as recommended by flange manufacturer.
      c. Blind Flanges: "Grinnel" Figure 1961
      d. Galvanized malleable iron.

e. Gaskets: Full face of 1/8 IN minimum red sheet rubber.
f. Flange bolts: ANSI-B18.2 :
1) Hexagon head machine bolts with heavy semi-finished hexagon head nuts, cadmium plated.

3. Welded:
a. Black steel, standard weights.
b. Elbolets and Threadolets: Bonney Forge, carbon steel, 3000 LB class, conforming to ASTM-A105 Grade II.
c. Weldolets: Bonney Forge, carbon steel, extra strong class butt welding end connection, conforming to ASTM-A105 Grade II.

4. Mechanical GROOVED: Victaulic Company, malleable iron full-flow type, conforming to ASTM-A47 grade 32150 painted with alkyd enamel:
a. 2 IN thru 6 IN: Victaulic Company, "Firelock" rigid coupling style 005
b. 8 IN thru 12 IN: Victaulic Company, "Zero-flex" rigid coupling style 07.
c. Coupling Housing Clamps: Victaulic Company, malleable iron fabricated in two (2) parts, conforming to ASTM-A47 Grade 32150.
d. Coupling Bolts: Victaulic Company, oval neck track type conforming to ASTM-A183.
e. Coupling gasket material: Victaulic Company, Grade E molded synthetic rubber, conforming to ASTM D2000.
f. UL listed.
g. Approved by FM, NFPA-13, and NFPA-14.

5. Unions: Grinnell Figure 463, 150 LB class bronze-to-iron ground joint, conforming to ANSI-B2.1.

6. High temperature soldered:
a. Wrought copper.
b. Cast bronze.

G. Pipe supports:
1. All-purpose type, UL listed and FM approved.
2. Manufacture: Comply with Section 20 05 29.
3. Supports, hanger rods, inserts and clamps acceptable to NFPA.

2.3 ALARM AND SIGNAL DEVICES

A. Alarm and signal devices, general:
1. UL listed and FM approved.
2. Coordinate electrical requirements with electrical installer.

B. Alarm devices:
1. Alarm pressure switch:
a. Shall signal Fire Alarm System Control Panel upon sensing change of pressure in fire system valve.
1) Switch shall automatically reset when pressure returns to normal.
b. Service: Normal.

2. Local alarm devices:
a. General:
1) Provide local alarm on systems of sufficient size as indicated in NFPA-13.
2) Use alarm bell and visible light alarm on electrically operated supplemental fire detection (valve release) systems.
3) Use water motor gong on hydraulically or pneumatically operated supplemental fire detection (valve release) systems.
4) Devices shall be weatherproof.
b. Alarm bell, electric:
1) Shall provide audible alarm signal upon activation of fire protection system.
2) 10 IN weatherproof bell.
3) Provide backer plate to prevent birds and insects from entering inside of bell housing.

c. Visible light alarm:
   1) Semi-flush, 24 volt DC.
   2) Tamper-resistant white lexan lens, with "FIRE" imprinted in red.
   3) Light shall be mountable on either ceiling or wall.

C. Signal devices:
1. Valve tamper switch:
   a. Shall signal Fire Alarm System Control Panel upon valve movement.
   b. Potter Electric Signal Co. Type PIVS-B supervisory switch, 1/2" NPT, and single pole double throw contacts.
2. Waterflow detector:
   a. Shall signal Fire Alarm System Control Panel when water flows in system.
   b. Vane type flow switch with retard mechanism or manual adjustment to prevent false alarm.
   c. 175 PSI rated.
   d. Suitable for working pressure of 150 PSI with sensitivity adjusting screw.
3. Pressure supervising switch:
   a. Shall signal Fire Alarm System Control Panel upon drop in air pressure:
      1) Adjustable low-pressure setting.

2.4 BACKFLOW PROTECTION DEVICES

A. General:
1. Provide on water supply at location indicated on drawings to prevent contamination of potable water system.
2. Corrosion resistant materials.
3. Totally rebuildable.
4. Flanged ends.
5. Rating: Water at 175 PSI working pressure and between 33 to 110 degF.
6. Provide OS&Y inlet and outlet isolation valves.
7. Provide four test cocks.
   a. Provide No. 1 test cock on inlet valve.
8. Approved by Suffolk County Water Authority and authority(ies) having jurisdiction.
9. UL listed and FM approved.

B. Reduced-pressure principle backflow preventer (BFP):
1. Two check valves, test cocks, pressure differential relief valve, isolation valves and accessories assembled as an integral unit, horizontally mounted.
2. Threaded ends: 2 IN and smaller.
3. Flanged ends: 2-1/2 IN and larger.
4. Provide drain line from relief to drain outdoors or if not possible to appropriately sized floor drain.
5. Isolation valves:
   a. 2-1/2 IN and larger:
      1) Non-rising stem.
      2) OS&Y.
   b. Provide No. 1 test cock on inlet valve.

2.5 FIRE ALARM SYSTEM CONTROL PANEL

A. Fire alarm system control panel: Provided under Electrical Specification Divisions.

2.6 FIRE PROTECTION SYSTEMS, WATER-BASED

A. Supplemental fire detection (valve release) system:
1. Detection system shall be part of UL listed and FM approved fire protection system.
2. Provide hydraulically, pneumatically, or electrically actuated supplemental fire detection system as indicated in system description.
   a. Hydraulically actuated system:

1) Do not use where system may be subject to freezing.
b. Pneumatically actuated system:
1) When subject to freezing, provide desiccant dried air (with dew point lower than coldest expected ambient temperature).
2) Connect dry air to system where air will not pass over or through standing water as it pressurizes piping system.
3) When pressurizing system with air, do not exceed flow capacity of dryer: Prefill with dry nitrogen if faster fill is desired.
c. Electrically actuated system:
1) May be used with any fire protection system.
3. Support supplemental detection system piping/wiring separately from sprinkler piping.
4. Devices for hydraulically or pneumatically actuated supplemental detection systems:
a. Sprinkler with temperature setting lower than normal system sprinklers.
b. Thermostatic device that causes fire valve to operate when space temperature rises faster than 15 degF per minute.
c. Combination of sprinkler and thermostatic devices.

B. Dry-pipe fire protection sprinkler system:
1. Description: Automatic system shall employ closed sprinklers attached to a piping system filled with pressurized air and connected to an accelerated dry-pipe valve that is opened by actuation of a sprinkler which relieves air pressure in the system:
a. Normal operation:
1) Actuation of sprinkler relieves air pressure opening dry-pipe valve and allowing water to flow through actuated sprinkler.
2) Water flow through dry-pipe valve sends signal to Fire Alarm System Control Panel, and sounds local alarm.
b. Failure operation:
1) Failure of sprinkler relieves air pressure which opens dry-pipe valve allowing water to flow through failed sprinkler.
2) Water flow through dry-pipe valve sends signal to Fire Alarm System Control Panel, and sounds local alarm.
2. Air source:
a. Obtain air from building compressed air system through air maintenance device.
b. Provide backup dedicated compressed air system with air maintenance device.

C. Standpipe-and-hose fire protection system:
1. Class I:
a. Standpipes, fire department connections, and fire department valves.

D. Wet-pipe fire protection sprinkler system:
1. Description: Automatic system shall employ closed sprinklers attached to a piping system filled with pressurized water.
a. Normal operation:
1) Actuation of sprinkler allows water to flow through actuated sprinkler.
2) Waterflow in zone sends signal to Fire Alarm System Control Panel.
b. Failure of sprinkler allows water to flow through sprinkler.
1) Waterflow in zone sends signal to Fire Alarm System Control Panel.

E. Air pressure maintenance device:
1. UL listed and FM approved.
2. Designed to maintain air pressure in fire protection systems.
3. Types:
a. Restricted orifice.
b. Pressure reducing valve (PRV):
1) Integral back check.
4. Compatible with type of air source specified.
5. Provides continuous, regulated air supply to system:

a. Restrict flow of supply air so that it does not interfere with actuation of system.
b. Field adjustable outlet pressure: 5-75 PSIG.

6. Provide strainer and valved bypass.
7. Provide dedicated air pressure maintenance device for each separately pressurized portion of each system:
   a. Where two or more devices are served from the same air source, use PRV type devices.

F. Dedicated compressed air systems:
1. Air compressor:
   a. UL listed and FM approved.
   b. Dedicated to fire protection service.
   c. Mount pump and motor on common base plate with coupling and guard.
   d. Provide for mounting on wall, floor, or pipe.
   e. Capacity: Capable of restoring normal air pressure in system within 20 minutes.
   f. Field adjustable cut-in and cut-out pressure switch.
   g. Motor electrical data:
      1) Minimum 1/2 Hp.
      2) 460V, 3 ph, 60 Hz.
2. Air compressor accessories:
   a. Inlet silencer and filter.
   b. Discharge air and water separator, with relief valve, gauge glass and ball float valve.
   c. Discharge check valve, isolation valve, and pressure gauge.
   d. Pressure switch: HIGH/LOW operation.
   e. Mounting hardware.
   f. Piping and fittings.
   g. Drip leg with drain valve to collect condensate, and keep it away from compressor.
   h. Desiccant dryer:
      1) Provide dryer when compressed air will be in piping exposed to freezing.
3. Use a single compressor for each sprinkler system.

2.7 FIRE DEPARTMENT CONNECTIONS

A. Fire Department connections:
1. Components and assemblies UL listed and FM approved.
2. Minimum 175 PSI non-shock cold-water working pressure.
3. Inlet threads for connections to fit BNL fire department standards.

B. Fire department (siamese) connections:
1. Outside type.
2. Inlet:
   a. Quantity:
      1) Two.
   b. Size:
      1) 2-1/2 IN.
   c. Fittings:
      1) Brass snoots, brass pin-lug swivels, brass pin-lug plugs, chains, and gaskets.
3. Outlet:
   a. Quantity:
      1) One.
   b. Size:
      1) 4 IN.
4. Finish:
   a. Chrome plated.
5. Raised lettering:
   a. "AUTOSPKR STANDPIPE".
6. Connection style:
   a. Flush, wall-mounted, and drop clappers.

b. Free-standing, brass sleeve, brass escutcheon plate, and drop clappers.

2.8 FIRE DEPARTMENT VALVES

A. Fire department valves, general:
1. Components and assemblies UL listed and FM approved.
2. Valves: Minimum 175 PSI non-shock cold-water working pressure.
3. Outlet threads shall match local fire department standards.

B. Fire department valves:
1. General:
a. 2-1/2 x 2-1/2 IN valve.
b. Cap and chain.
c. Pattern: Straight or angle.
2. FDV, Fire department valve without cabinet:
a. Finish: Polished brass.

2.9 FIRE SYSTEM VALVES

A. Fire system valves, General:
1. UL listed and FM approved.
2. Body: Ductile or cast iron.
3. Pressure rating: 175 PSI non-shock cold-water working pressure.
4. 2 IN and smaller: Threaded.
5. 2-1/2 IN and larger: Flanged or grooved.
6. Trim to meet NFPA requirements.
7. Trim to meet performance as indicated in descriptions of fire protection systems.

B. Deluge valve:
1. Cast bronze clapper, clamp ring, and valve seat.
2. Teflon coated valve seat.
3. Neoprene diaphragm and seat rubber.
4. Stainless steel seat-rubber retaining ring.
5. Locks open upon actuation.
6. Trim for priming, connecting alarms, testing alarms, draining system, preventing water logging, and reading water pressures.
7. Where used in pre-action systems, provide additional trim for connecting air supply and reading air pressure.
8. Provide release controls for supplemental fire detection system.
9. Provide release controls for manual-actuation station when station is indicated in system description.

C. Dry pipe valves:
1. Cast bronze clapper, clamp ring, and valve seat.
2. Teflon coated valve seat.
3. Neoprene diaphragm and rubber seat.
4. Stainless steel seat-rubber retaining ring.
5. Locks open upon actuation.
6. Trim for priming, connecting alarms, testing alarms, draining system, preventing water logging, reading air and water pressures, and connecting air supply.

2.10 MANUAL VALVES

A. Isolation valves:
1. Gate valves:
a. 2 IN and smaller: V-49.
b. 2-1/2 IN and larger: V-50.
2. Butterfly valves:
a. 2 IN and smaller: V-55.

b. 2-1/2 IN and larger: V-51.

3. Butterfly valves with tamper switches:
   a. 2-1/2 IN and smaller: V-59.
   b. 3 IN and larger: V-61.

B. Check valves 2-1/2 IN and larger: V-53 or V-54.

C. Grade-type post indicator valve assembly:
   1. Valve: V-52.
   2. Post: UL listed and FM approved indicator post to fit V-52.

D. Outside valve boxes:
   1. 3 piece cast iron, extension type, 5-1/4 IN shaft, 5-1/4 IN drop lid, screw or slip type.
   2. Screw type lid: Tyler 6860 with No.6 bell base.
   3. Slip type lid: Tyler 6865 with No.8 bell base.
   4. Mark lids with WATER cast in metal.

E. Automatic ball drip valve:
   1. 1/2 IN straight or angle cast-brass ball drip shall close against pressure:
      a. When pressure drops, valve shall open to drain pipe.

2.11 SPRINKLERS

A. Sprinklers - general:
   1. Provide UL listed sprinklers of style and type required for service indicated.
   2. Orifice: Sprinklers in systems sized from pipe schedules shall have 1/2 IN nominal orifices.
   3. Finish of exposed parts: As indicated.

B. Sprinkler types: Metallic fusible link or glass bulb.

C. Sprinkler styles:
   1. Upright:
      a. Finish: Standard bronze.
   2. Pendant:
      a. Finish: Standard bronze.
   3. Pendant with escutcheon:
      a. Finish: Chrome.
   4. Recessed pendant:
      a. Deflector: 1 to 1-1/2 IN below finished ceiling.
      b. Escutcheon: Two-piece with 1/2 IN adjustment.
      c. Removal of escutcheon and ceiling tile shall not disturb sprinkler or drop assembly.
      d. Finish: Chrome.
   5. Flush pendant:
      a. Escutcheon: 1/2 IN adjustment.
      b. Finish: Chrome.
   6. Concealed pendant:
      a. Ceiling plate flush with finished ceiling.
      b. Housing: 1/2 IN adjustment.
      c. Finish: White.
   7. Horizontal sidewall:
      a. Finish: Chrome.
   8. Dry pendant:
      a. For coverage of exterior area from interior wet-pipe system.
      b. For systems with piping that is subject to freezing.
      c. Finish: Chrome.

2.12 FLEXIBLE SPRINKLER HOSE FITTINGS

A. Hose fittings – general:

1. Hose fitting shall be stainless steel for use in connecting sprinkler heads in commercial suspended ceilings. A bracket attaches to the ceiling grid for supporting the hose.

B. Hose fittings shall be braided stainless steel, hose fittings and accessories shall be FM 1637 approved.

2.13 SYSTEM ACCESSORIES

A. Alarm-test device:
   1. Optional replacement for alarm test loop.
   2. Single device or unit that provides visual verification of waterflow in a fire sprinkler system and allows for draining of all or a portion of that system.
   3. Contains sight glass, inspector test valve, auxiliary drain valve and test orifice.
   4. UL listed and FM approved.

B. Pressure gauges: See Section 20 05 19:
   1. UL listed and FM approved.

C. Spare parts:
   1. Tools:
      a. Furnish one emergency rubber ball shutoff on long handle to be used for temporary closing of sprinkler after fire has been extinguished.
      b. Furnish testing apparatus capable of producing the heat or impulse necessary to operate supplemental fire detection systems in manner recommended by manufacturer of detection system.
   2. Sprinkler cabinet, Wall mounted:
      a. Provide spare sprinklers of each type and sprinkler wrench for each type in quantities required by NFPA-13.

D. Sprinkler guards:
   1. UL listed.
   2. Heavy duty welded wire.
   3. Red baked enamel finish.

E. Signs, Tags and Charts:
   1. Signs: Seton name Plate Corp.
      a. For Control Valves: Seton Style SPA.
      b. For Drain and Test Valves: Seton Style SPB.
      c. Signs shall include, but not be limited to the following:
         1) MAIN DRAIN, DRAIN, AUXILIARY DRAIN, OPEN SPRINKLER DRAIN, INSPECTOR'S TEST, TEST VALVE, ALARM TEST VALVE, WATER MOTOR LINE AND OPEN SPRINKLER CONTROL.
      d. Tags: Seton Name Plate Corp. Style 250-BL-1-1/2, round brass stamped with black filled designated numbers. Secure tags to valves with brass "S" hooks, or Seton tool check holders.
      e. Charts: Furnish two (2) typewritten charts of all tagged valves. Charts shall contain the following information: Valve designated number, location, function, and whether valve is N.O. or N.C. Chart shall be plastic coated on both sides, mounted in a wooden frame. Mount one (1) copy on wall next to sprinkler station as designated by P.E. Contact P.E. for sample chart. Heading of chart shall be entitled:

SPRINKLER SYSTEM VALVE SCHEDULE

BLDG. NO._____

PART 3 - EXECUTION

3.1 GENERAL

A. Coordinate with other trades to ensure adequate space for equipment and piping placement.

B. Review plans, specifications and shop drawings of other trades to coordinate work.

C. Do not begin installation until after AHJ approvals have been submitted to Architect.

D. Test systems in accordance with System Standards, manufacturers' instructions, and applicable NFPA publications.

E. Install systems in accordance with System Description, manufacturers' instructions, and approved shop drawings:
   1. Modifications to system design or arrangement after approval of drawings may only be made after receiving written approval of Architect and authority(ies) having jurisdiction.
   2. Such modifications do not include minor relocations in piping or sprinkler placement.
   3. Make revisions in accordance with NFPA.

F. Firestop penetrations in accordance with Section 20 05 29.

G. Field quality control: Give advance notice and arrange for field tests and inspections by authority(ies) having jurisdiction.

3.2 PIPING, SPRINKLERS, AND SUPPORTS

A. Piping - general:
   1. Install sprinkler piping within first 6 IN of space under floor construction:
      a. Where conditions of construction require piping installation at a lower elevation, route piping to avoid interference with work of other trades.
   2. Avoid interconnecting standpipes through sprinkler system piping.
   3. Offset, crossover and otherwise route piping to install system in available space:
      a. Not every offset is indicated.
   4. Provide chrome plated escutcheon plates at pipe penetrations of ceilings, floors, and walls.
   5. When risers are concealed, provide wall flange at each FDV and within cabinets.
   6. Pitch branch lines, cross mains, feed mains and risers to drains. Pitch down not less than 1/16 in 10 feet to main drain valve.
   7. Paint fire sprinkler piping in accordance with Section 09 91 23.
   8. Flush outside fire-main piping prior to connecting to inside system.

B. Sprinklers - general:
   1. Install sprinklers to provide and maintain minimum 18 IN clear between bottom of deflector and top of storage, files, shelving, and cabinets.
   2. Standard-application temperature rating:
      a. Sprinkler type:
         1) Glass bulb: 155 degF.
         2) Fusible link: 165 degF.
      b. Where non-standard applications exist, use higher rating:
         1) Use sprinklers rated at least 50 degF higher than anticipated ambient temperature.
   3. Install sprinklers furnished with gas cylinder cabinets supplied by others. Coordinate sprinkler flow and pressure requirements with system design and pipe sizing.

C. Supports: Install in accordance with NFPA-13 and NFPA-14.

D. Testing - general:
   1. Test sprinkler and standpipe piping, including outside supplies, under hydrostatic pressure of 200 PSI for 2 hours:
      a. Prove system tight to satisfaction of Architect.
      b. Inside piping shall indicate no leakage.
      c. Leakage in underground piping shall be in accordance with NFPA-24.

E. Piping and sprinkler applications by room types:
   1. Areas subject to freezing:
      a. Sprinkler styles: Upright or dry pendant:
         1) Temperature rating: As required for room type.
      b. Provide sprinkler guards on pendant sprinklers.
   2. Electrical rooms/closets:
      a. Sprinkler styles: Upright, pendant, or horizontal sidewall (standard or extended coverage).
      b. Provide sprinkler guards.
   3. Elevator machine rooms:
      a. Provide shielding to protect electrical elevator equipment from sprinkler system discharge:
         1) Coordinate with elevator installer.
         2) Coordinate with authority(ies) having jurisdiction.
      b. Sprinkler styles: Upright, pendant, or horizontal sidewall (standard or extended coverage):
         1) Glass bulb temperature rating: 200 degF.
         2) Fusible link temperature rating: 220 degF.
      c. Provide sprinkler guards.
   4. Finished rooms (rooms with ceilings):
      a. Sprinkler styles:
         1) Recessed pendant.
         2) Concealed pendant.
         3) Horizontal sidewall, standard or extended coverage.
      b. Where ceiling is being replaced in existing areas, relocate existing sprinklers to coordinate with new ceiling layout.
      c. Where ceiling exists in area subject to freezing, comply with requirements for areas subject to freezing.
      d. Locate sprinklers to coordinate with ceiling layout:
         1) Locate sprinklers centered in ceiling tile and in center of metal strip in linear metal ceilings, if such location makes added sprinklers necessary, provide added sprinklers as required to meet code.
   5. Mechanical equipment rooms:
      a. Sprinkler styles: Upright, pendant, or horizontal sidewall (standard or extended coverage):
         1) Glass bulb temperature rating: 200 degF.
         2) Fusible link temperature rating: 220 degF.
      b. Provide sprinkler guards.
   6. Storage rooms:
      a. Glass bulb temperature rating: 286 degF.
      b. Fusible link temperature rating: 286 degF.
   7. Substations:
      a. Sprinkler styles: Upright, pendant, or horizontal sidewall (standard or extended coverage):
         1) Glass bulb temperature rating: 200 degF.
         2) Fusible link temperature rating: 220 degF.
      b. Provide sprinkler guards.
   8. Telephone/Communication rooms/closets:
      a. Sprinkler styles: Upright, pendant, or horizontal sidewall (standard or extended coverage).
      b. Provide sprinkler guards.
   9. Unfinished rooms (rooms without ceilings):
      a. Sprinkler styles: Upright, pendant, or horizontal sidewall (standard or extended coverage).

3.3 ALARM AND SIGNAL DEVICES

A. Where multi-zone, wet-pipe fire protection sprinkler systems exist, provide waterflow detector at each zone take off immediately after isolation valve.

B. Install valve tamper switch on each isolation valve indicated below:
   1. Valves at bases of standpipes.
   2. Valves at fire system valves.
   3. Valves across water meters and backflow protection devices.
   4. Sprinkler-zone valves.
   5. Post indicator valves.

3.4 FIRE PROTECTION SYSTEMS

A. Factory trained Engineer shall supervise installation of fire protection systems.

B. On combination sprinkler and standpipe-and-hose systems, do not interconnect standpipes through sprinkler piping.

C. Factory trained Engineer shall provide following services:
   1. Supervise installation of fire protection systems.
   2. Instruct BNL Fire Department personnel in systems operations.

D. Test completed alarm systems including control and signal circuits wired by Electrical installer:
   1. Coordinate with electrical.
   2. Complete testing prior to substantial completion.

3.5 FIRE DEPARTMENT CONNECTIONS, FIRE DEPARTMENT VALVES, AND FIRE HOSE CABINETS

A. Install fire department connections and fire department valves at height required by authority having jurisdiction:
   1. Position valve to allow 12 IN spanner wrench clearance for connecting hoses.

3.6 MANUAL VALVES

A. Provide isolation valves at following locations:
   1. Bases of standpipes.
   2. Fire system valves.
   3. Suction and discharge of fire pump:
      a. Suction isolation valve must be OS&Y type.
      b. Discharge isolation valve must be indicating type.
   4. Flow test system:
      a. Inlet to hose valve manifold.
      b. Inlet and outlet of flow meter.
   5. On combination sprinkler and standpipe-and-hose systems, provide isolation valve at each sprinkler-zone take off from standpipes.

B. Provide check valves at following locations:
   1. Outlet of fire pump: In-line, spring-actuated check.
   2. Fire department connection.

C. Install indicator posts approximately 3 FT above grade.

D. Provide automatic ball drip at low points:
   1. Piping between outside fire department connection and check valve.
   2. Piping between outside fire department connection and pump test header shutoff valve.

E. Provide valve boxes at each underground valve (except PIV's).

3.7 SYSTEM ACCESSORIES

A. Alarm test loops:
   1. Provide after each waterflow detector.
   2. Alarm test loop consists of two parallel branches:
      a. First branch: Inspector's test branch shall contain a shutoff valve and a restricting orifice imitating the flow through the smallest sprinkler on the system. Provide means for inspector to observe water flow (e.g., drain water within sight of valve or provide sight glass).
      b. Second branch: Drain branch shall contain shutoff valve.
      c. Alarm test loop sizing criteria:
         1) Riser or Main is 2 IN or smaller: 3/4 to 2 IN.
         2) Riser or main is 2-1/2 to 3-1/2 IN: 1-1/4 to 2 IN.
         3) Riser or main is 4 IN or larger: 2 IN.
   3. Extend loops to nearest floor drain or mop sink:
      a. Loops may be terminated outside when approved by authority having jurisdiction.
   4. Label valves and outlets.

B. Drains:
   1. Permit complete draining of systems without disconnection of piping.
   2. Drain consists of dirt leg, valve, and piping.
   3. Extend drain piping to nearest floor drain or mop sink.
   4. Required locations:
      a. At low points of systems.
      b. At alarm test loops.
      c. At fire system valves.
      d. At bases of risers and standpipes:
         1) 1-1/2 IN hose threads that match local fire department threads may be provided instead of extending piping.
   5. Size drain valve and piping according to alarm test loop sizing criteria in this section.
   6. At offsets, plugs may be substituted for drains when approved by authority having jurisdiction.

C. Pressure gauges:
   1. Provide at following locations:
      a. At service entrance to building.
      b. At top of each standpipe.
      c. At inlet and outlet of pressure reducing valves.
      d. At top of each sprinkler riser.
      e. At alarm test loops.
      f. At other indicated locations.
   2. Provide shutoff valve and drain for each gauge.

D. Sprinkler cabinets:
      a. Install in Mechanical room adjacent to Fire Water service.

E. Signs:
   1. Hang signs from valves and piping with brass chains.
   2. Provide an identification sign under water motor alarm as illustrated in Figure A-4-6.1.1, NFPA 13.

3.8 ELECTRICAL WIRING

A. Provide following:
   1. Wiring diagrams for devices.
   2. Supplemental fire detection systems and their wiring.
   3. Wiring not specified but required to provide an operating system.

B. Electrical Installer will provide the following:

1. Alarm and signal device wiring:
    a. Tamper switches: Supervised wiring to Fire Alarm System Control Panel.
    b. Waterflow detectors: Supervised wiring to Fire Alarm System Control Panel.
    c. Alarm pressure switches: Supervised wiring to Fire Alarm System Control Panel.
    d. Pressure supervising switches: Supervised wiring to Fire Alarm System Control Panel.
    e. Supervised wiring from waterflow detector to outside alarm bell.
2. Supplemental fire detection systems:
    a. Supervised wiring to Fire Alarm System Control Panel.

END OF SECTION

DIVISION 22

PLUMBING

SECTION 22 10 16
PLUMBING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of systems:
   1. Systems:
      a. Cold, hot, and circulating domestic water piping systems within building and to 5 FT outside building wall.
      b. Drainage piping systems:
         1) Soil, waste, vent, indirect, and storm piping within building and to 5 FT outside building wall.
         2) Acid resistant waste, and acid vent within building and 5 FT outside building wall.
      c. Pressure drainage piping.
      d. Exposed piping in finished areas.
   2. Products:
      a. Backflow protection devices.
      b. Cleanouts.
      c. Drains:
         1) Air-gap fittings.
         2) Floor drains.
         3) Funnels.
         4) Roof drains.
      d. Flashings.
      e. Traps.
      f. Valves:
         1) Automatic trap primer valves.
         2) Backwater valves.
         3) Balancing valves, constant flow control.
         4) Check valves.
         5) Manual valves, potable water.
         6) Manual valves, waste-water.
         7) Pressure reducing valves.
      g. Water-hammer arresters.
      h. Water meters.

B. Definitions:
   1. Caulked: Tamped lead and oakum joint.
   2. Drainage piping: Soil, waste, vent, acid waste, acid vent, indirect, and storm piping.
   3. Brazing: High-temperature soldering.
   4. Pressure drainage piping: Branch piping from discharge of sump pump or sewage ejector to connection with gravity drainage piping.

1.2 QUALITY ASSURANCE

A. Pipe and fittings standards: See Section 20 11 00.

B. Fire Protection Systems: See Section 21 10 00.

C. Valve standards: See Section 20 05 23 (for valves labeled "V-__").

D. American Water Works Association Standard AWWA-C601: Sterilization Standard.

E. Plumbing and Drainage Institute Standard WH201: Water-hammer arrester standard.

F. Plumbing and Drainage Institute Standard G10: Grease interceptor standard..

G. American Society for Sanitary Engineering Standard ASSE 1001: Pipe Applied Atmospheric Type Vacuum Breakers.

H. American Society for Sanitary Engineering Standard ASSE 1013: Reduced Pressure Principle Backflow Preventers and Reduced Pressure Fire Protection Principle Backflow Preventers.

I. Standard: American Society for Sanitary Engineering Standard ASSE 1020: Pressure Vacuum Breaker Assembly.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Piping layout drawings at 1/4 IN/FT scale.

B. Product Data:
   1. Include sufficient information to verify compliance with specifications:
      a. Backflow protection devices.
      b. Drains.
      c. Valves.
      d. Water hammer arresters.
      e. Water meters.

C. Contract Closeout Information:
   1. Pressure test reports.
   2. Disinfection test report.
   3. Operating and maintenance data.
   4. Certificate of local utility approval of backflow preventer and water meter.

1.4 RELATED SECTIONS

A. Refer to related Sections under Division 20 – Mechanical General Requirements.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Backflow protection device (Reduced-pressure principle):
      a. Base:
         1) Cla-Val.
      b. Optional:
         1) Watts Regulator.
         2) Febco.
         3) Hersey Measurement.
         4) Wilkins Regulator.
   2. Backflow protection device (Vacuum breakers):
      a. Base:
         1) Watts Regulator.
      b. Optional:
         1) Febco.
         2) Wilkins Regulator.
   3. Cleanouts and Drains:
      a. Base:
         1) Wade Division/Tyler Pipe.
      b. Optional:
         1) Watts Drainage - Ancon.
         2) Josam Company.

3) JONESPEC Plumbing Products.
4) Jay R. Smith Manufacturing Co.
5) Zurn Industries, Inc.

4. Valves (Automatic trap primer):
   a. Base:
      1) Precision Plumbing Products.
   b. Optional:
      1) Jay R. Smith Manufacturing Co.
      2) Wade Division/Tyler Pipe.
5. Valves (Backwater):
   a. Base:
      1) Josam Company.
   b. Optional:
      1) Jay R. Smith Manufacturing Co.
      2) Watts Drainage-Ancon, Inc.
6. Valves (Constant flow control balancing valves):
   a. Base:
      1) Griswold Controls COMBO.
   b. Optional:
      1) Flow Design Inc. - Autoflow.
      2) Preso.
7. Valves (Pressure reducing):
   a. Base:
      1) Cla-Val.
   b. Optional:
      1) Watts Regulator.
      2) Fisher.
      3) Wilkins Regulator.
8. Water-hammer arresters:
   a. Base:
      1) Wade Division/Tyler Pipe.
   b. Optional:
      1) Jay R. Smith Manufacturing Co.
      2) Josam Company.
      3) Zurn Industries, Inc.
9. Water meters:
   a. Base:
      1) Hersey Measurement.
   b. Optional:
      1) Badger Meter.
      2) Sensus Technologies.

2.2 PIPE AND FITTINGS

A. Domestic water piping:
   1. Domestic water piping at service entrance (from 1 FT inside building to 5 FT outside): Same as indicated for outside utilities.
   2. 2 IN and smaller after service entrance:
      a. Above grade:
         1) Copper, type L, with solder joints, and wrought copper or cast brass fittings.
      b. Below grade:
         1) Copper, type K soft, with brazed joints and wrought copper or cast brass fittings.
         2) Where below-grade run of piping is shorter than 50 FT, below-grade joints are not acceptable.
   3. 2-1/2 IN and larger after service entrance:
      a. Non-softened cold water:

1) Copper, type L, with roll-groove joints and wrought copper or cast brass fittings.
b. Hot water and soft water:
1) Copper, type L, with roll-groove joints and wrought copper or cast brass fittings.

B. Drainage piping (soil, waste, vent, indirect, and storm):
1. Above grade:
a. Cast-iron, hubless pipe, fittings, bituminous coated and lined and elastomeric sealing sleeves with stainless-steel or cast iron clamps, as allowed by code.
2. Below grade:
a. 2 IN diameter or larger.
b. Cast-iron, hubbed pipe and fittings, bituminous coated and lined with elastomeric push joints, as allowed by code.

C. Drainage piping (Acid resistant):
1. Above grade:
a. Acid resistant flame retardant polypropylene DWV pipe and fittings as allowed by code:
1) Non-concealed joints and fixture connections: Mechanical joint type.
2) All other joints electro-resistance fusion joints.
2. Below grade:
a. Acid resistant polypropylene DWV pipe and fittings:
1) Electro-resistance fusion joints.

D. Pressure drainage piping:
1. Galvanized steel, cast-iron drainage fittings with threaded joints.

E. Exposed piping in finished areas:
1. Stainless steel, chrome or nickel plated brass to wall or floor.
2. Piping 2 IN and larger may be provided with chrome or nickel plated brass sleeves to cover pipe and fittings:
a. See Section 20 05 00.

F. Trap primer pipe between primer device and drain:
1. Above grade: Copper, type L, with solder joints, and wrought copper or cast brass fittings.
2. Below grade: Copper, type K soft, with solder joints, and wrought copper or cast brass fittings.

2.3 BACKFLOW PROTECTION DEVICES

A. Backflow protection devices, general:
1. Approved by local Public Utilities Bureau and the state Environmental Protection Agency.

B. Reduced-pressure principle backflow preventer (BFP):
1. Two check valves, test cocks, pressure differential relief valve, isolation valves and accessories assembled as an integral unit, horizontally mounted. Tested and certified in conformance with ASSE Standard No. 1013.
2. Threaded ends: 2 IN and smaller.
3. Flanged ends: 2-1/2 IN and larger.
4. Provide 3/4 IN drain line from relief to floor drain, floor sink, mop sink, or service sink.
5. Isolation valves:
a. 2 IN and smaller: Ball valve.
b. 2-1/2 IN and larger:
1) Non-rising stem.
2) OS&Y.
c. Provide No. 1 test cock on inlet valve.
6. Size BFP's to have a pressure loss less than 14 PSI at flows indicated below (refer to plans for pipe sizes):
a. 1/2 IN pipe: 2.2 GPM.
b. 3/4 IN pipe: 6 GPM.

c. 1 IN pipe: 13 GPM.
d. 1-1/4 IN pipe: 22 GPM.
e. 1-1/2 IN pipe: 35 GPM.
f. 2 IN pipe: 75 GPM.
g. 2-1/2 IN pipe: 125 GPM.
h. 3 IN pipe: 170 GPM.
i. 4 IN pipe: 315 GPM.
j. 6 IN pipe: 720 GPM.
k. 8 IN pipe: 1250 GPM.

C. Pressure type vacuum breakers (PTVB):
1. Designed to protect against back-siphonage in continuous-pressure piping systems. Tested and certified in conformance with ASSE Standard No. 1020.
2. Bronze body and lightweight internal floats designed to eliminate spillage.
3. Provide isolation ball valve on inlet and outlet of PTVB.
4. Provide outlet connection on VB compatible with equipment/fixture being served.
5. Mount bottom of VB at least 12 IN above the flood-level rim of the equipment/fixture being served.
6. Provide test cocks.
7. Match VB size to pipe size indicated on plans.

D. Atmospheric vacuum breakers (VB):
1. Bronze body and lightweight internal float designed to eliminate spillage. Tested and certified in conformance with ASSE Standard No. 1001.
2. Provide isolation valve immediately upstream of VB.
3. Provide outlet connection on VB compatible with equipment/fixture being served.
4. Mount bottom of VB at least 6 IN above the flood-level rim of the equipment/fixture being served.
5. Match VB size to pipe size indicated on plans.

2.4 CLEANOUTS

A. Cleanouts, general:
1. Provide flashing collars and clamps for CO bodies being installed in floors with finishes installed over waterproofing.
   a. Coordinate with Division 09 and Room-Finish installers.
2. Dimensions are nominal.
3. Body material (unless indicated otherwise): Coated cast iron.
4. Cleanout plugs:
   a. Extra-heavy, threaded, tapered, brass plug with solid hexagonal nut.
   b. Comply with Plumbing Code.
   c. Provide with American Standard pipe threads.
5. Cleanouts on lines completely accessible from within pipe chases do not require covers.
6. Cleanouts in exposed piping in equipment rooms do not require special covers.

B. Interior, floor-mounted cleanouts:
1. Extra-heavy, flanged, cast-iron ferrule, tapped for cleanout plug with spigot or inside-caulk outlet.

C. Example:
1. Two-piece, threaded, adjustable housing.
   a. ANSI load class: Light duty, unless noted otherwise.
   b. Example: Wade 6000.
2. Top and cover as specified below by floor finish.
   a. Resilient tile and sheet finish: Round flange top with scoriated cover.
   b. Ceramic tile finish: Square flange top with scoriated cover.
   c. Poured finish: Round, wide-flange top with scoriated cover.
   d. Carpet finish: Round top with standard top tapped for carpet-marker bolt.

e. Terrazzo finish: Round top with recessed-for-terrazzo cover.
f. Quarry tile finish: Square, heavy-duty top with heavy-duty scoriated cover.
g. Concrete finish (unfinished areas):
1) Heavy, round frame; satin-bronze, scoriated tractor top.
2) ANSI load class: Heavy duty.
3) Example: Wade 6000Z.

D. Cleanouts in vertical piping:
1. Tapped cleanout tee.
2. Extra-heavy, threaded, brass plug with solid hexagonal nut.

E. Cleanouts in hubs of combination wye and eighth bends or wyes.
1. Tapped spigot.
2. Extra-heavy, threaded, brass plug with solid hexagonal nut.

F. Cleanouts at ends of hubless combination wye and 1/8th bends or wyes.
1. Blind plug.

G. Covers over cleanouts in concealed vertical piping:
1. Square, nickel-bronze frame with secured, smooth, stainless-steel access cover.
2. 6 x 6 IN for pipe sizes 4 IN and less.
3. 9 x 9 for pipe sizes 5 IN and larger.
4. Example: Wade W-8480-S.

2.5 DRAINS

A. Drains, general:
1. Provide flashing clamps with seepage openings for drain bodies with flashing collars being installed in floors with finishes installed over waterproofing.
a. Coordinate with Division 09 and Room-Finish installers.
2. Provide underdeck clamps for drain bodies except those installed in slabs on grade.

B. Air-gap fittings:
1. Inlet: Female IPS or collar with set screw.
2. Outlet: Spigot or IPS.
3. Material: Cast-iron or bronze.
4. Minimum air-gap area: 2 times inlet area.
5. Examples: Jay R. Smith 3950 series.

C. Downspout nozzles:
1. DSN-1:
a. Cast bronze nozzle with rough bronze finish and flange for securing nozzle to wall.
b. Example: Jay R. Smith 1770.

D. Floor drains:
1. General:
a. Dimensions are nominal.
b. Provide trap-primer taps where trap primer valves are required: See paragraph on trap primer valves.
c. Material (unless indicated otherwise): Coated cast iron.
2. D-4:
a. 12 IN diameter flashing collar.
b. Adjustable top.
c. 8 IN diameter, removable, non-tilt tractor grate.
d. Cast iron strainer.
e. Example: Wade 1340TD

E. Floor sinks:
1. General:
a. Dimensions are nominal.

b. Provide trap-primer taps where trap primer valves are required: See paragraph on trap primer valves.
c. Material (unless indicated otherwise): Coated cast iron.
d. Provide flashing collars.

2. D-3:
a. Dimensions: 12 x 12 x 6 IN floor sink with square top.
b. Material of construction: 304 stainless steel.
c. Stainless-steel sediment basket and optional dome bottom strainer, same grade as body.
d. Grate:
1) Removable, full size, medium duty anti-tilt type.
2) Material of construction: stainless-steel, same grade as body.
3) Size: 10 IN square.
e. Example: Jay R. Smith 9697.

F. Funnels:
1. Material: Match to associated grate, strainer, or P-trap.
2. Secure to grates and strainers with screws.
3. 6 IN diameter, 4 IN tall.
4. 8 x 3 IN oval, 4 IN tall.

G. Roof drains:
1. General:
a. Dimensions are nominal.
b. Material (unless indicated otherwise): Coated cast iron.
c. Provide deck clamps.
d. Provide bearing pan/sump receiver (where occurs at steel decks).

2. D-1:
a. Flashing collar diameter: 16 to 19 IN.
b. Flashing clamp with gravel stop.
c. Mushroom dome: coated cast iron.
d. Mushroom dome height: 5 IN.
e. Mushroom dome diameter: 11 to 14 IN.
f. Provide bearing pan/sump receiver.
g. Provide solid or adjustable extension to allow for insulation thickness between concrete deck and waterproof membrane.
1) Coordinate extension height with roof insulator.
h. Example: Wade 3000.

3. D-2 (overflow drain):
a. Flashing collar diameter: 16 to 19 IN.
b. Flashing clamp with integral 2 IN tall water dam.
c. Mushroom dome: coated cast iron.
d. Mushroom dome height: 5 IN.
e. Mushroom dome diameter: 11 to 14 IN.
f. Provide bearing pan/sump receiver.
g. Provide solid extension to allow for insulation thickness.
1) Coordinate extension height with roof insulator.
h. Example: Wade 3000SD.

4. D-7:
a. 6 IN round flashing collar.
b. Nickel bronze flashing clamp ring.
c. Provide Bearing pan.
d. 4-1/4 IN diameter, 4-1/2 IN tall, removable, bronze, dome strainer, painted cast iron body with threaded outlet.
e. Example: Wade 3240B47.

2.6 DRIP PANS OVER CRITICAL AREAS

A. Drip pans:
   1. Field- or shop-fabricated: See detail.

2.7 FLASHINGS

A. On floors above grade, allow for flashings provided by others at penetrations in floors with finishes installed over waterproofing.
   1. Coordinate with Division 09 and Room-Finish installers.

2.8 TRAPS

A. Traps, general:
   1. Cast brass or cast iron, one piece pattern, 3 IN minimum seal.
   2. Same material, coating, and finish as piping system into which they are installed except traps 2 IN NPS and under, not buried in earth, shall be cast brass with union and cleanout.
   3. Place trap cleanouts in accessible locations.

B. Provide deep-seal traps for drain bodies in ventilation housings: Traps need to maintain seal against static pressure in fan housing.

C. Traps for drains with buried outlet: Cast iron P-traps, unless otherwise indicated.

2.9 VALVES

A. Automatic trap primer valves.
   1. General:
      a. Rebuildable.
      b. Integral vacuum breaker on drain branch.
      c. Connections: Soldered or threaded.
      d. Provide trap primers as indicated on plans.
   2. Automatic trap primer valve:
      a. Serves single drain.
      b. 1/2 IN bronze.
      c. Designed to be installed in the supply line to an individual fixture with branch extended to drain.
      d. Examples: Wade 2400, Smith 2699.
   3. Automatic trap primer valve:
      a. Serves one to four drains.
      b. 1/2 IN brass.
      c. Integral backflow preventer.
      d. Designed to be installed at end of dead-end line with continuation to drain.
         1) Activated by 5 PSI drop or more in main.
      e. Automatically adjusts to line pressures between 35 and 75 PSIG.
      f. Example: Precision Plumbing Products Prime-Rite.
   4. Automatic trap primer valve:
      a. Serves one to eight drains.
      b. Body: Polypropylene.
      c. Internal parts: Stainless steel, monel metal.
      d. Integral backflow preventer.
      e. Designed to be installed at end of dead-end line with continuation to drain.
         1) Activated by 3 PSI drop or more in main.
      f. Automatically adjusts to line pressures between 35 and 75 PSIG.
      g. Example: Precision Plumbing Products Oregon #1.
   5. Trap primer distribution reservoir.
      a. Copper reservoir with brass fittings and clear plastic inspection cover.
         1) Feeds up to four traps through separate lines.
         2) Provide mounting brackets.

b. Example: Precision Plumbing Products.

B. Backwater valves:
1. Coated cast iron body.
2. Hubbed inlet.
3. Offset spigot outlet.
4. Gasketed and bolted cover.
5. Removable, automatic bronze valve seat and flapper that hangs open during periods of non-operation.
6. Example: JayR. Smith 7012.

C. Balancing valves, constant flow control:
1. Factory calibrated, direct acting, automatic pressure compensating.
2. Control flow rates within 5 percent of flow rating over operating pressure differential range:
   a. Set flow rating according to pipe sizes indicated on plans:
      1) 1/2 IN: 1.0 GPM.
      2) 3/4 IN: 2.5 GPM.
      3) 1 IN: 6 GPM.
      4) 1-1/4 IN: 9 GPM.
3. Pressure differential range:
   a. 1-14 PSID.
4. Threaded-brass or copper-sweat body with stainless-steel internal parts.
5. Provide a metal identification tag with chain for each installed valve:
   a. Identify zone or location, valve model number, flow rate, direction of flow, and differential pressure range.
6. Provide with integral unions to allow field exchange of internal components without removing valve body from pipeline.
7. Provide manual valve upstream and downstream of each valve.

D. Check valves:
1. 2 IN and smaller: V-24 or V-25.
2. 2-1/2 IN and larger: V-28 or V-29.

E. Manual valves, potable-water:
1. 2 IN and less: V-13 or V-14.
2. 2-1/2 to 4 IN:
3. 6 IN and larger:
   a. V-34 or V-35 or V-62.
   b. Totally enclosed gear operator and wheel handle.
   c. At equipment and at service entrance:
      1) Use lug type valves, V-33.
      2) Use groove-end type valves, V-62.
4. Balancing cocks:
   a. Constant flow control balancing valves.

F. Manual valves, waste-water:
1. Drainage piping shut off: V-37.
2. Pressure drainage piping:
   a. Shut off: V-2.
   b. Check: V-28.

G. Pressure reducing valves:
1. Use pilot-operated or direct-acting PRV based on pipe size indicated on plans.
   a. 2 IN and smaller: direct-acting.
   b. 3 IN and larger: pilot-operated.
2. Direct-acting PRV:
   a. Bronze bodied, diaphragm and spring type valve with integral thermal bypass and removable, stainless-steel strainer.

b. Pressure adjustment range: 15 to 75 PSIG.
c. Size PRV's to have a maximum fall-off pressure of 15 PSIG at flows indicated below (refer to plans for pipe sizes):
1) 1/2 IN pipe: 2.2 GPM.
2) 3/4 IN pipe: 6 GPM.
3) 1 IN pipe: 13 GPM.
4) 1-1/4 IN pipe: 22 GPM.
5) 1-1/2 IN pipe: 35 GPM.
6) 2 IN pipe: 75 GPM.

3. Pilot-operated PRV:
a. Hydraulically operated, pilot controlled diaphragm type valve:
1) Pilot control: Direct-acting, adjustable, spring-loaded, normally open.
b. Single removable seat and resilient disc.
c. Fixed orifice in control system.
d. Pressure rating: 125 class.
e. Temperature rating: 180 degF.
f. Valve body: Cast iron ASTM-A48.
g. Stainless-steel trim.
h. Provide thermal relief if PRV is installed on cold-water side of water heater.
i. Adjustment range: 15 to 75 PSI.
j. Pipe size indicated on plans: 3 IN:
1) Min PRV flow rate: 15 GPM.
2) Normal maximum flow rate: 150 GPM.
3) Maximum intermittent flow rate: 260 GPM.
k. Pipe size indicated on plans: 4 IN:
1) Min PRV flow rate: 30 GPM.
2) Normal maximum flow rate: 310 GPM.
3) Maximum intermittent flow rate: 475 GPM.
l. Pipe size indicated on plans: 6 IN:
1) Min PRV flow rate: 50 GPM.
2) Normal maximum flow rate: 720 GPM.
3) Maximum intermittent flow rate: 1000 GPM.
m. Pipe size indicated on plans: 8 IN:
1) Min PRV flow rate: 115 GPM.
2) Normal maximum flow rate: 1250 GPM.
3) Maximum intermittent flow rate: 1870 GPM.
n. Pipe size indicated on plans: 10 IN:
1) Min PRV flow rate: 200 GPM.
2) Normal maximum flow rate: 1965 GPM.
3) Maximum intermittent flow rate: 2950 GPM.

2.10 WATER-HAMMER ARRESTERS

A. Water-hammer arresters:
1. Engineered, and certified in accordance with Plumbing and Drainage Institute (PDI) Standard WH-201.
2. Type and construction:
a. Bellows type and constructed entirely of stainless steel.
b. Piston type is not acceptable.

B. Water-hammer arrestors shall be bellows type and constructed entirely of stainless steel.

2.11 WATER METERS

A. Water meters, general:
1. Use threaded fittings on meters 2 IN and less in size.
2. Use flanged connections on meters 2-1/2 IN and larger.

3. Provide valve on each side of meter.
4. Provide meters that can be remotely read by building's energy management system:
   a. Coordinate with Control Provider.

B. Private water meters:
1. As shown on drawings.
2. Provide vertical-shaft turbine meters on main water supply to building and on cold water supply to laboratory water system and make-up water lines to HVAC and Plumbing equipment.
3. Match size to pipe size indicated on drawings.

PART 3 - EXECUTION

3.1 GENERAL

A. General:
1. Install piping as indicated and to provide fixtures and items of equipment with proper drainage, vent, and water connections as required by governing codes.
2. Hold piping as close to structure as possible to maintain maximum head room.
3. Run piping concealed wherever possible.
4. Under no circumstances reduce pipe size indicated without written consent of Architect.
5. Size branches to individual fixtures as scheduled.
6. Consult the following before roughing in piping:
   a. Manufacturer's data.
   b. Large-scale Architectural, and Mechanical Drawings of rooms containing equipment and plumbing fixtures.
7. Stub piping through wall directly behind item being served (e.g., equipment, plumbing fixtures, vending machines):
   a. Cap and protect until such time as installation is performed.
   b. Exception: Upon approval of Architect, piping mains and/or branches may be run in lab benches, in built-in counters, and in cabinet work.
8. Plug or cap piping immediately after installation.
9. Install chromed escutcheons on finished-area sides of pipe penetrations:
   a. Secure escutcheons so they make contact with floor, wall, or ceiling.
10. Install equipment in accordance with manufacturer's instructions.
11. Connect equipment furnished by BNL or other divisions in accordance with Section 20 05 00.
12. Install piping supports, sleeves, and seals as indicated in Section 20 05 29.

3.2 DOMESTIC WATER PIPING SYSTEMS

A. General:
1. Install plumbing without cross- or inter-connections between potable and non-potable lines.
2. Provide unvalved system drains on trapped portions of systems: See Section 20 05 19.
3. Provide thermometers and pressure gauges where indicated on drawings: See Section 20 05 19.

B. Service entrance installation through floor:
1. Provide reaction anchorage at buried elbow where water service turns up below the floor.
2. Terminate top of exterior piping material with flange connection:
   a. Tie flange back to buried elbow with tie rods of same diameter as flange bolts.
   b. Permanently protect below-grade tie rods against corrosion.
   c. Provide minimum of one tie rod for each two flange bolt holes.

C. Backflow protection devices:
1. Provide at following locations:
   a. At fixtures and equipment as indicated and required by Code.

b. Were specified in Section 22 42 00: Plumbing Fixtures.
c. Where specified in Section 22 60 80: High Purity Water Systems.
2. Pipe drain from reduced pressure principle backflow preventers to drain or mop sink.
3. Install vacuum breakers over mop sink or over drain in unfinished area.

D. Balance hot water circulation system.

E. Provide manual isolation valves at following locations:
1. To isolate groups of fixtures and equipment on branch runouts from piping mains.
2. On each branch serving a rest room.
3. On inlet and outlet of each equipment.
4. On each branch to hose bibb or wall hydrant.
5. At main feed points to domestic water pipe risers.
6. As indicated and as required to adequately service parts of systems and equipment.

F. Wire isolation valves on emergency showers open and tag "Do Not Close".

G. Provide water-hammer arresters on hot and cold water lines in accordance with PDI Standard WH-201 sizing and placement data; the Contractor shall be responsible for sizing of water hammer arrestors in accordance with this standard.

H. Testing of domestic water system:
1. Upon completion of system or a section of system, test piping hydrostatically to pressure not less than 50 percent in excess of pipe's working pressure, but in no case less than 150 PSI:
a. System shall hold pressure for 24 hours.
2. Repair leaks or replace defective pipe disclosed by tests.
3. Repeat tests until piping indicates tight.

I. Sterilization of domestic water system:
1. Sterilize system as indicated or in accordance with AWWA-C652 or CS186.
2. Thoroughly flush potable water systems.
3. After flushing, introduce chlorine or chlorine compound into system with dosage sufficient to give an initial residual chlorine content of 50 PPM.
4. Collect samples from various taps and fixtures throughout buildings during introduction of chlorine to assure uniform distribution.
5. Open and close valves several times.
6. After a 24 hour contact period, flush traces of heavily chlorinated water from systems.
7. After flushing is complete, indicate effectiveness of disinfection by submitting laboratory reports of bacteriological tests on samples taken from system.
8. If unsatisfactory results are obtained, repeat disinfection process until satisfactory.
9. Do not put system into service until tests are approved by Plumbing Inspector.

3.3 DRAINAGE PIPING SYSTEMS

A. General:
1. Changes of direction and junctions: Make with wye fittings and eighth bends:
a. Use sanitary tee fittings in vertical pipe only:
1) Sanitary crosses not allowed.
2. Provide P-trap for each direct waste-pipe connection to equipment.
3. Trap fixtures as required by governing code.
4. For ice makers, provide either of the indirect drain options listed below:
a. Floor sink.
b. Dedicated, under-counter P-trap.
5. Provide air gaps at indirect drains.

B. Slopes:
1. Install horizontal soil, waste, and storm lines with following slopes:
a. 3 IN and smaller pipes:
1) 1/4 IN/FT.
b. 4 IN and larger pipes:

1) 1/8 IN/FT.

c. Slopes indicated on plans override those indicated here.

C. Vents:

1. Run vent stacks parallel to soil and waste stacks to receive branch vents from fixtures:
   a. Each vent stack shall originate from a soil or waste stack at its base.
2. To permit proper flashing, offset through-the-roof piping away from walls on roof before passing through roof.
3. Carry vent stacks 4 IN and larger full size through roof.
4. Install vent lines so they will drain and not trap water.
5. Where possible combine soil, waste or vent stacks before passing through roof to minimize roof openings.
6. Where minimum vent-through-roof size is larger than vent size, provide increaser minimum of 12 IN below roof line:
   a. Minimum vent-through-roof size:
      1) 4 IN.
7. Extend vent stacks at least 12 IN above roofing.

D. Acid resistant waste and vent piping:

1. Install piping system free of stresses and in accordance with manufacturer's recommendations.
2. Provide accessories as indicated or required for complete connections.
3. Laboratory sinks furnished by other divisions:
   a. See fixture S-1 in Section 22 42 00.
   b. Make final connections.

E. Provide cleanouts on drainage piping as indicated below and on plans:

1. Locations:
   a. At dead ends.
   b. At changes of direction greater than 45 degrees.
   c. At junction of building drain and building sewer.
   d. 36 IN to 48 IN above finished floor in vertical piping that connects to horizontal soil, waste, or storm piping immediately below in ceiling space or under grade.
   e. As test tee to receive test plugs in each riser at least every other floor.
   f. At maximum 50 FT intervals in horizontal 4 IN and smaller drains.
   g. At maximum 100 FT intervals in horizontal, 5 IN and larger drains.
2. Sizes:
   a. 4 IN diameter and smaller piping: Match pipe size.
   b. 5 IN diameter and larger piping: Not less than 4 IN.
3. Where cleanouts occur in concealed spaces, provide with extensions to wall or to floor above:
   a. Make extensions using long sweep ells or wye and eighth bends.
4. Where cleanouts are indicated in ceiling spaces above critical areas, extend cleanouts through floor above.
5. Install carpet-marker bolts after carpet installation.

F. Install piping and drains to allow for flashings provided under Roofing System section:

1. Coordinate with Roofing installer.

G. Floor drains and floor sinks:

1. At locations with waterproofing: Set top of flashing collar 1/2 IN below level of waterproofing.
2. At locations without waterproofing: Place drain integrally with poured concrete. Set top of drain flush with finished floor.
3. Set over P-traps.

H. Drains in plenums: Indirectly waste plenum drains to receptor outside of plenum.

I. Backwater valves:

1. Install valves in 30 IN diameter RCP basin.
2. Provide light-duty frame and solid cover with lift hole:
   a. Set cover at grade level.
   b. Neenah R-6450 or optional manufacturer.
3. Set RCP on 6 IN thick, WWF-reinforced, 42 IN diameter concrete pad with 12 IN diameter center hole.
4. Set pad on 12 IN of granular fill.
5. Set valve bottom 4 IN above top of concrete pad.

J. Testing of drainage piping systems:
   1. Do not insulate, conceal, or install furring around pipe until it has been tested to satisfaction of BNL and Plumbing Inspector:
      a. If inspection or test indicates defects, replace such defective work or material and repeat inspection and tests.
   2. Test piping at completion of installation of each stack or section of piping:
      a. Fill system with water to highest point and check joints and fittings for leaks.
      b. Eliminate leaks before proceeding with work or concealing piping.
      c. Minimum test height: 10 FT.
      d. Make repairs to piping with new material.
      e. Peening and chiseling of holes or screwed joints is not allowed.

END OF SECTION

SECTION 22 11 00
WATER DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Compaction density test:
   1. See Section 31 23 33, TRENCHING, BACKFILLING AND COMPACTING FOR UTILITIES.

B. Reference: NFPA 24.

1.2 SUBMITTALS

A. Project information:
   1. Manufacturer's certification for materials.

B. LEED Information:
   1. LEED Credit MR 4.1 [4.2], Recycled Content: Manufacturer’s product data for products with recycled content indicating amount of post-consumer and post-industrial recycled content
   2. LEED Credit MR 5.1, Local/Regional Materials: Manufacturer’s certification indicating final point of assembly for products and materials located within 500 miles of Project site. Include manufacturer’s name, address and phone number.

1.3 JOB CONDITIONS

A. Verify location of existing utilities and structures and underground utilities.

B. Protect existing utilities and structures and replace if damaged.

C. Repair if damaged by this work.

D. Lengths indicated on drawings are for information only.

E. Furnish lengths as required.

F. Verification of existing utilities and structures:
   1. Plans indicate existing utilities as indicated on site survey.
   2. Verify accuracy, location and depth of each utility prior to trenching or tunneling.
   3. If pipe adjustment is necessary due to location of other utilities, secure approval from LT.

G. Revisions to Contract Drawings:
   1. If it becomes necessary to change location of lines due to building construction, secure prior written approval from LT.
   2. If Contractor initiated, make approved changes without added cost to BNL.

H. Do not change pipe sizes without securing prior written approval from LT.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Water mains:

1. Ductile iron pipe and fittings, ANSI/AWWA-C151/A21.51, ANSI/AWWA-C105/A21.5, ANSI/AWWA-C111/A21.11, and ANSI/AWWA-C110/A21.10, thickness Class 2, or heavier, bituminous coated, cement mortar lined in accordance with ANSI/ AWWA-C104/A21.4.

B. Service lines 3 IN and smaller: ASTM-B88 copper tubing type "K" hard drawn, with solder type bronze fittings.

C. Valves: AWWA C500, gate type, with mechanical joint ends or as otherwise may be necessary; cast iron body, bronze mounted, parallel seat, double disk, non-rising stem, open left (counter clockwise), working pressure 200 PSI; valves from a single manufacturer.

D. Valve boxes: Roadway type, cast iron, 2 section, adjustable screw type, proper length and base size for depths required; word "water" cast in cover; compatible with valves.

E. Fire hydrants:
1. AWWA C502, dry barrel type designed for 150 PSI working pressure.
2. Valve opening at least 5 IN in diameter.
3. 6 IN bell connection.
4. Two 2-1/2 IN hose connections.
5. One 4-1/2 IN pumper connection.
6. Outlets: American National Standard fire hose coupling threads.
7. Working parts: Bronze.
8. Latest stock pattern produced by manufacturer.
9. Opening counterclockwise.
10. Hydrant bonnets and hose valve outlet caps shall be painted light blue to conform with NFPA 291 Standard. Hydrant barrels to be painted yellow (color to match BNL Standard).

F. Corporation and service stops: Bronze with flange joint coupling, threads on inlet end conforming to AWWA C800; tested to minimum hydraulic pressure of 200 PSI.

G. Buttresses:
1. Portland cement concrete, 6 bag mix.
2. Minimum 28 day compressive strength: 3,000 PSI.

H. Backfill material:
1. See Section 31 23 33.

PART 3 - EXECUTION

3.1 TRENCH EXCAVATION AND PREPARATION FOR PIPE LAYING

A. See Section 31 23 33.

3.2 CLEANING PIPES

A. Thoroughly clean pipes and fittings before laying.

B. Keep clean until acceptance of Work.

C. Thoroughly clean inside of every pipe and fitting just before lowering into trench, to remove foreign matter.

D. Carefully lower into trench in manner to exclude foreign matter while jointing to other pipe.

E. At close of each work day, or during period when job is not being actively pursued, tightly seal pipe ends with an expansion type stopper or other approved type of watertight seal so that no foreign substance or water may enter line.

F. Keep seal in place until pipe laying is again resumed.

G. Under no circumstances use pipe that has been contaminated inside with petroleum products or other liquid that will soak into cement lining or soften bituminous lining.

H. In event that foreign matter or water enters pipe that has already been laid, immediately cease work and lay no more pipe until contamination has been removed to satisfaction of LT.

3.3 LAYING PIPE

A. Use only proper and suitable tools and appliances for safe and convenient handling and laying of pipes and fittings.

B. Carefully place pipe, fittings and valves into trench.

C. Do not dump or roll pipe or fittings into trench.

D. Do not allow pipe or fitting to drop against pipe or fitting already in trench.

E. Take care to prevent damage to pipe lining and coating.

F. Repair lining or coating damaged to satisfaction of LT.

G. Install pipe so ends of pipe abut and there is no shoulder or unevenness inside main.

H. Take special care to insure that pipes are well bedded on a solid foundation.

I. Repair defects due to settlement at Contractor's expense.

J. Dig bell holes large enough to insure proper jointing.

K. Do not allow pipe to rest on rock.

L. Whenever a pipe or fitting requires cutting, perform work in a satisfactory manner with tools which leave smooth right angle cuts without damaging lining or pipe.

M. Make such cuts at no added cost to BNL.

N. Do not spring joints to effect a change in direction unless directed to do so by LT.

O. Secure pipe, fittings and valves in place on concrete foundation, thrust blocks or by strapping, as indicated.

P. Where foundation or thrust blocks are not indicated, secure pipe, fittings and valves in place as directed by LT.

3.4 PERMISSIBLE DEFLECTION AT JOINTS

A. Wherever it is necessary to deflect pipe from a straight line, either in vertical or horizontal plane, amount of deflection allowed shall not exceed that required for satisfactory calking or assembly of joint.

B. Make such necessary deflection in accordance with values and tolerances established by pipe manufacturer.

3.5 JOINTS

A. Ductile Iron mechanical joint pipe:
   1. Rubber gasket, cast iron gland ring and T bolts with hex nuts.
   2. Before joint is made, insure that outside of spigot and inside of bell are entirely free of oil, tar and greasy substances to insure to tight bond.
   3. Make joint in accordance with manufacturers instructions.
   4. Tighten bolts with a torque wrench set between 50 and 60 LB.

B. Ductile Iron push on joint pipe:
   1. Circular rubber gasket which fits into specially designed bell or socket end of pipe and a specially prepared lubricant.
   2. Make joints in following manner:

a. Thoroughly clean gasket seat and gasket.
b. Wipe with a cloth and apply thin film of lubricant to inside surface of gasket which will come into contact with entering pipe.
c. Use only lubricant furnished with pipe.
d. In no case use mineral oil or petroleum base lubes.
e. Thoroughly clean plain end of pipe to be jointed and start it into socket so it is in contact with gasket.
f. Apply a thin film of lubricant to outside of plain end for about 1 IN back from end.
g. Complete joint by exerting sufficient force on entering pipe so that it's plain end is moved past gasket until it makes contact with socket base.
h. Method, which does not harm pipe, may be used to hone pipe.

3.6 FITTINGS AND VALVES

A. Place fittings, gate and air valves, blowoff connections and valves, valve and blow off vaults, air valve manholes and valve boxes along water mains as indicated or where designated by LT.

B. Place in accordance with requirements as provided elsewhere in these specifications.

C. Set fittings and valves and join to pipe in manner specified for cleaning, laying and jointing pipe.

D. Where valves are placed on end of a pipe line place a cast iron plug secure in exposed bell before backfilling.

E. Provide valve box for every nut operated valve and grease case enclosed operating mechanism valve.

F. Carefully place valve box at right angle to main.

G. Do not allow valve box to transmit shock or stress to valve; center it plumb over wrench nut of valve, with box cover flush with surface of finished pavement, or set to elevation indicated.

H. Rest flange at bottom of top section on planks which extend 8 IN into solid ground on trench sides.

I. Take care in tamping backfill around valve to keep box in place and firmly supported to preclude settlement.

J. Remove and reset boxes found out of place or not firmly supported at no added cost to BNL.

K. Determine whether valve or valves are in proper working order before and after installation.

L. If not, notify BNL and replace.

3.7 HYDRANTS

A. Install hydrants in accordance with AWWA C600 or C603, as applicable, except as modified herein.

B. Set operating nut not over 4 FT above finish grade.

C. Thoroughly compact backfill around hydrants to grade.

D. Make hydrant available for beneficial use.

E. Set hydrant on slab of stone or concrete, minimum 4 IN thick and 15 x 15 IN.

3.8 CONNECTION TO EXISTING WATER SYSTEM

A. Make connections to water system as indicated.

B. Make connections at such hours, determined by LT, to cause least disturbance of water supply to existing consumers.

C. Notify BNL at least 3 days in advance of time Contractor desires to make connections.

D. Make no connections without LT's prior approval.

E. Include expense of making connections in bid price.

3.9 ARTIFICIAL FOUNDATION

A. When directed, lay pipe upon an artificial foundation, consisting of gravel, sills, wedges, plank or timber, or of concrete, sized and placed as directed by LT.

B. Include necessary excavation for such construction.

3.10 TESTING WATER MAINS

A. Test completed water mains for leakage.

B. Test sections as directed or approved by LT.

C. Maximum allowable leakage not exceeding 1.0 GAL/1000 FT of pipe per hour for 16 IN pipe when tested at 150 PSI.

D. Fill length of water main under test with water and bring to test pressure of 150 PSI.

E. Operate valves in test section during test.

F. After valves have been tested and deficiencies corrected; fill length of main under test with water, taking care to eliminate air from line.

G. Raise pressure to test pressure by means of compressed air.

H. Maintain at test pressure for at least 2 HR.

I. At end of test period, again fill pipe with water from either measured receptacle or an accurately calibrated meter and determine leakage.

J. Repair every leak which BNL deems important, and every section of line in which leakage exceeds maximum allowable amount, whether or not trench has been filled.

K. Replace every pipe, fitting, valve, etc., which gives evidence under test of being defective.

L. If line indicates excessive leakage during any phase of test, retest line after correction of defects.

M. Continue correcting defects until leaks exceeding allowable leakage have been remedied.

N. Repair leaks and defects or otherwise remedy at no added expense to BNL and to complete satisfaction of LT, at whatever time that they become apparent.

3.11 STERILIZATION OF WATER MAINS

A. Sterilize water mains as specified and directed.

B. Perform sterilization by either of following methods:
   1. By introducing a chlorine gas/water mixture by means of a solution/feed chlorinating device.
   2. By introducing a mixture of calcium hypochlorite (comparable to commercial products known as HTH or Perchloron) and water.

C. Prior to beginning of sterilizing operations, submit for LT's approval, schedule listing details of procedure to be followed.

D. Before beginning sterilization, remove dirt and foreign matter from mains by a thorough flushing with clean water.

E. Introduce water slowly and introduce sterilant through corporation cocks at rate 1 LB chlorine gas/2400 GAL of water, or at rate of 1 LB calcium hypochlorite (measured in a dry state prior to preparation of slurry) per 1,680 GAL of water.

F. After sterilizing agent has been in pipe minimum of 3 HR, take samples and analyze.

G. If less than 5 mg/L residual chlorine is indicated, drain pipe and repeat treatment.

H. If more than 5 mg/L residual is indicated, drain lines to waste and refill with clear water.

I. Take care to prevent contamination of sterilized pipe.

3.12 BACKFILLING AND COMPACTION

A. See Section 31 23 33.

3.13 MAINTENANCE DURING WARRANTY PERIOD

A. If prior to expiration of warranty period, broken pipes or defects are found in mains or in their appurtenances, remove and replace with proper material and workmanship, at no added cost to LT.

B. Carefully examine materials for defects prior to placing; do not place defective material.

END OF SECTION

SECTION 22 11 23
PLUMBING PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of systems:
   1. Circulating pumps.
   2. Storm Liftstation
   3. Sanitary Liftstation.
   4. Sump pumps.

1.2 QUALITY ASSURANCE

A. Pipe and fittings standards: See Section 20 11 00.

B. Manual-valve and check-valve standards: See Section 20 05 23 (for valves labeled "V-__").

1.3 SUBMITTALS

A. Product data:
   1. Circulating pumps:
      a. Include pump curves with point of operation indicated.
   2. Storm liftstation:
      a. Include pump curves with point of operation indicated.
   3. Sanitary liftstation:
      a. Include pump curves with point of operation indicated.
   4. Sump pumps:
      a. Include pump curves with point of operation indicated.

B. Contract closeout information:
   1. Operating and maintenance data.
   2. BNL instruction reports.

PART 2 - PRODUCTS

2.1 GENERAL

A. Pumps, general:
   1. Motors: Section 20 05 00.
   2. Motor data: As scheduled on drawings.
   3. Pump capacities: As scheduled on drawings.
   4. Provide disconnects.
   5. Provide starters for 3-phase motors.
   6. Basins: As specified and as detailed on drawings.

B. Vibration isolation:
   1. Provide in accordance with Section 20 05 50.

2.2 CIRCULATING PUMPS

A. Circulating pumps:
   1. In-line centrifugal.
   2. Pump casing and impeller: Bronze, designed for domestic water circulating.
   3. Fractional-horsepower pumps: Seal-less.

2.3 STORM LIFTSTATION PUMPS

A. Rail-mounted, duplex, submersible sump pumps:
   1. General:
      a. Each pump: Liftable out of basin along guide rails by chain or cable.
      b. When lowered into place, pump automatically realigns with and seals against permanently mounted discharge elbow at bottom of basin.
      c. Personnel can service pumps and controls without entering basin.
   2. Pumps:
      a. Permanently wet pit installation.
      b. Cast-iron housings and impeller.
      c. Stainless-steel shaft.
      d. Provide discharge elbow and lift chain/cable.
         1) Lift chain: Hot-dipped galvanized carbon steel.
         2) Stainless-steel cable.
         3) Chain/cable lifting capacity shall be at least 1.5 times the weight of the pump.
      e. Stainless-steel trim.
   3. Controls, wall or basin-cover mounted:
      a. Float-operated non-mercury type switches.
      b. High-water alarm:
         1) Able to integrate with building's energy management system.
         2) Coordinate with Control Contractor.
      c. Automatic alternation to sequence pump operation and to cause both pumps to operate if one pump cannot handle load.
      d. Common trouble alarm integrated with building management system.
   4. Basin:
      a. Prefabricated reinforced fiberglass made with commercial grade polyester resin and glass fibers, include a 0.010 to 0.020 IN resin rich inner surface layer. Minimum wall and floor thickness of 1/2 IN. Provide with reinforcing rings, anti-floatation and anchoring flanges, inlet and outlet sizes: As indicated on plans. Meeting ASTM D3753.
      b. Provide gas-tight, water-tight aluminum basin cover (minimum 1/4 IN thick) and quick opening hinged manway access door(s).
      c. Coordinate pump mounting brackets and inserts which need to be pre-installed in basin.
      d. Test basin for no leaks at 5 psig air pressure.
   5. Warranty: 18 months from start up.

2.4 SANITARY LIFTSTATION PUMPS

A. Rail-mounted, duplex, submersible sump pumps:
   1. General:
      a. Each pump: Liftable out of basin along guide rails by chain or cable.
      b. When lowered into place, pump automatically realigns with and seals against permanently mounted discharge elbow at bottom of basin.
      c. Personnel can service pumps and controls without entering basin.
   2. Pumps:
      a. Permanently wet pit installation.
      b. Cast-iron housings and impeller.
      c. Stainless-steel shaft.
      d. Provide discharge elbow and lift chain/cable:
         1) Lift chain: Hot-dipped galvanized carbon steel.
         2) Stainless-steel cable.
         3) Chain/cable lifting capacity shall be at least 1.5 times the weight of the pump.
      e. Stainless-steel trim.
   3. Controls, wall or basin-cover mounted:
      a. Float-operated non-mercury type switches.
      b. High-water alarm:

1) Able to integrate with building's energy management system.
2) Coordinate with Control Contractor.

c. Automatic alternation to sequence pump operation and to cause both pumps to operate if one pump cannot handle load.

d. Common trouble alarm integrated with building management system.

4. Basin:

a. Prefabricated reinforced fiberglass made with commercial grade polyester resin and glass fibers, include a 0.010 to 0.020 inch resin rich inner surface layer. Minimum wall and floor thickness of ½-inch. Provide with reinforcing rings, anti-floatation and anchoring flanges, inlet and outlet sizes: As indicated on plans. Meeting ASTM-D3753.

b. Provide gas-tight, water-tight aluminum basin cover (minimum 1/4 IN thick) and quick opening hinged manway access door(s).

c. Coordinate pump mounting brackets and inserts which need to be pre-installed in basin.

d. Test basin for no leaks at 5 psig air pressure.

5. Warranty: 18 months from start up.

2.5 SUBMERSIBLE, SIMPLEX SUMP PUMPS (IN ELEVATOR PITS)

A. Pump housing: Cast iron ASTM-A48.

B. Impeller: Cast iron, ASTM-A48, Class 30.

C. Motor shaft: Stainless steel.

D. Permanently lubricated sealed bearings.

E. Double mechanical seal on motor shaft.

F. Provide with differential non-mercury type float switch and oil minder switch with sufficient cable length to reach control panel.

G. Basins:

1. Size: As detailed on Structural drawings.
2. Inlet and outlet sizes: As indicated on drawings.

PART 3 - EXECUTION

3.1 GENERAL

A. General:

1. Install as indicated and in accordance with manufacturer's instructions and recommendations.
2. Sump pumps with gas-tight covers: Extend vent independently through roof.
3. Provide galvanized guide rails for rail-mounted pumps.
4. Seal all piping, conduit and wiring penetrations into basin to be liquid tight.

B. Furnish piping, isolation valves, check valves, and fittings not included as a part of equipment as recommended by manufacturer:

1. Provide manual isolation valves at following locations.

a. On inlet and outlet of each circulating pump.

b. On outlet of each sump pump.

c. On outlet of each storm and sanitary liftstation sump pump.

d. As indicated and as required to adequately service parts of systems and equipment.

2. Provide check valve at outlet of each pump.
3. See Section 22 10 16 for valve requirements.

END OF SECTION

SECTION 22 11 26

PACKAGED DOMESTIC-WATER PRESSURE-BOOSTER SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. Booster pumps.
      a. Adjustable speed system.

1.2 QUALITY ASSURANCE

A. References:
   1. Hydraulic Institute.
   2. NEMA - National Electrical Manufacturers Associations.
   3. UL - Underwriters Laboratories.
   4. NEC - National Electric Code.

B. Packaged-system manufacturer's requirements:
   1. UL listed as control panel manufacturer.
   2. Written and operational Quality Assurance program.
   3. Minimum 10 years experience in manufacturing and application of pumping systems.
   4. Accepting full responsibility for proper pressures and flows in the entire system.

C. Factory tests:
   1. Hydrostatically test assembled pumping systems to 200 PSIG for a minimum of one hour.
   2. Test control system, and simulate sequences and alarms.
   3. Wire-to-water efficiency test:
      a. Perform test at 25, 50, 75 and 100 percent of system-design flow.
   4. Prior to shipment, provide written report to Engineer:
      a. Include following for each of above system-design flows:
         1) System total dynamic heads.
         2) KW's.
         3) Wire-to-water efficiencies.
      b. Report certified by a registered professional engineer.

1.3 SUBMITTALS

A. Shop drawings:
   1. Packaged domestic-water pressure-booster system:
      a. System arrangement and dimension drawings.

B. Product data:
   1. Packaged domestic-water pressure-booster system:
      a. System design information sheet.
      b. Description of system operation.
      c. Pump material and construction drawing.
      d. Pump curves indicating design points.
      e. Control wiring diagram.
      f. Catalog information on valves, strainers, and control components.

C. Contract closeout information:
   1. Operating and maintenance data:
      a. System design information sheet.
      b. Description of system operation.
      c. Packaged system dimension and general arrangement drawing.

d. Electrical power and control wiring diagram.
e. Bill of material.
f. Pump operation and maintenance instructions.
g. Special electrical component operation instructions.

2. Factory-test reports.

1.4 DELIVERY OF EQUIPMENT

A. Configure system to be deliverable and installable through passages and doorways as indicated on Architectural drawings:
1. Factory disassemble systems for shipping and field assembly.
2. Provide assembly instructions.

B. Remove drain plugs from equipment where possibility of freeze damage may exist.

C. Comply with manufacturer's instructions for rigging, unloading, and transporting equipment.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
1. Packaged domestic-water pressure-booster system:
a. Base: Canariis.
b. Optional:
1) Armstrong Pumps.
2) Aurora Pump.
3) Tigerflow.
4) Syncroflow.
2. Pumps:
a. Base: Aurora Pump.
b. Optional:
1) Allis-Chalmers, ITT.
2) Armstrong Pumps.
3) Goulds Pumps.
4) Bell & Gossett, ITT.
5) PACO Pumps.
6) Peerless Pump.
7) Taco.

2.2 PACKAGED SYSTEM, GENERAL

A. Packaged system, general:
1. Provide components factory assembled, piped, and wired. Include the following:
a. Electrical control panel.
b. Pumps.
c. Motors: Section 20 05 00.
d. Piping, fittings, and valves: Section 22 10 16.
e. Piping specialties: Section 20 05 19:
1) Pressure gauges.
2) Unions.
3) System drains.
f. Mechanical sound, vibration & seismic control: Section 20 05 50:
1) Vibration base with isolators.
2) Flexible connectors.
2. Provide one suction and one discharge pipe connection, and one electrical power connection.

3. If package needs to be broken down to allow transportation to installed location, construct it to be broken down modularly:
    a. Modular construction:
        1) Field reconnections must be by unions, flanges, bolts, screws, and electrical plugs.
        2) Reconnection requiring cutting, welding, soldering, multiple connections to screw terminals, is not allowed.
4. Assemble package so ample room exists within the package for servicing of components.

B. Electrical control panel, general:
1. UL listed.
2. NEMA 1 enclosure.
3. Single door interlocked disconnect switch with individual circuit breakers.
4. Hand-off-auto switches for each pump.
5. Control circuit transformer with protected primary and secondary.
6. Power on light.
7. Run light for each pump, and contact for remote output.
8. Elapsed run-time meter for each pump.
9. Low-suction cutout with alarm and contact for remote output.
10. Pump failure alarm light, reset pushbutton, and contact for remote output.

C. Pumps:
1. Type:
    a. Centrifugal:
        1) Base-mounted end suction with backout design.
    b. Flex-coupled.
    c. Bronze-fitted.
    d. Single-stage, double-suction.
2. Construction:
    a. Cast-iron casing, casing wear rings, bronze impeller, shaft sleeve, mechanical seal.
    b. Maximum pump casing pressure: 230 PSIG.
    c. Designed so that pump can be serviced without moving motor and without disconnecting piping.
3. Performance:
    a. Each pump shall perform as scheduled and as specified.
    b. Pumps shall not overload at any point on the pump curves.
4. Capacity: As scheduled.

D. Piping, fittings, manual valves, and piping specialties, general:
1. Epoxy phenolic lined steel piping and fittings.
2. Provide isolation valves on suction and discharge from each pump.
3. Provide spring-loaded check valve on discharge from each pump.
4. Supports:
    a. See Section 20 05 29.
    b. Provide supports for the following:
        1) Suction header.
        2) Suction and discharge piping on each pump.
        3) Discharge header.
    c. Support piping independently of pump connections.
    d. Arrange pipe supports to permit field installation of insulation: Section 20 07 00.
5. Pressure gauges mounted in control enclosure for indication of suction and discharge pressures.
6. Shut-off valves on control sensing lines and gauges.

2.3 ADJUSTABLE SPEED PACKAGED SYSTEM

A. Adjustable speed packaged system, general: In addition to general packaged system requirements, provide the following:
1. Additional control panel features.

2. Adjustable frequency drives.
3. Isolation transformers.

B. Electrical control panel:
1. Designed to start and stop pumps and modulate speed to meet system demands.
2. Monitor system pressure at remote transmitters and send 4-20 mA DC signals via a pair of wires to a receiver/controller in control cubicle.
3. Receiver/controller: Field programmable:
   a. Direct digital type.
   b. Data entry in engineering units by keypad.
   c. PID control: Capacity to select signal that has deviated farthest from setpoint from up to 10 transmitters.
4. Start pumps on a drop in system pressure and stop after an adjustable minimum run time:
   a. Provide no-flow probe to control lead pump shutdown.
5. Start pumps manually and adjust speed automatically or manually using H-O-A switch and manual speed potentiometer for each VFD.
6. Control sequence enclosure:
   a. High and low system pressure alarms and contacts for remote outputs.
   b. Lead pump selector switch and manual alternation.
   c. Pump sequencing logic.
   d. Transient snubbers on inductive loads in panel.
   e. Receiver/controller.
   f. Interface controls for adjustable frequency drives.
7. Provide signal isolating buffers on internal and external 4-20mA circuits where utilized by more than 2 devices.
8. Remote pressure transmitters:
   a. Self-contained, variable capacitance type.
   b. Install transmitter(s) in following locations:
      1) Cold-water main in mechanical room.

C. Adjustable frequency drives: See Section 25 23 00.

2.4 DEMONSTRATION

A. System manufacturer or manufacturer’s representative: Provide start-up and adjustment service for packaged pumping system.

B. System manufacturer or manufacturer’s representative: Provide a minimum 4 hours of training for the BNL's personnel on the operation and maintenance of the packaged pumping system.

C. System manufacturer: Have factory trained authorized service agency located within 35 miles of project site.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install pressure booster system in accordance with manufacturer's recommendations and instructions.

B. Align pump and motor shafts to within manufacturer's recommended tolerances prior to system start-up.

C. Pipe drain lines to floor drain.

D. Provide wiring between pressure transmitters and receiver/controller, (adjustable speed system only).

END OF SECTION

SECTION 22 13 00
SANITARY SEWERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Definitions:
   1. Engineer: Soils Engineer employed by BNL, empowered to conduct inspections and make approvals.
   2. Unsuitable material: Debris and/or soil material judged unsuitable by Engineer for support of slabs or other site improvements.

1.2 QUALITY ASSURANCE

A. See Section 31 23 33 for soil testing and compaction requirements.

B. Compaction density test:
   1. Standard Proctor, ASTM-D698.

C. BNL will hire an independent soils laboratory to conduct in place moisture and density tests:
   1. Contractor pay for retests of material not passing initial tests.

1.3 JOB CONDITIONS

A. Verify locations of existing and new underground utilities and coordinate installation with all other utility installers.

B. Verification of existing utilities and structures:
   1. Plans indicate existing utilities indicated on site survey.
   2. Verify accuracy, location and depth of each utility prior to trenching or tunneling.
   3. If pipe adjustment is necessary due to location of other utilities, secure approval from Architect.

C. Protect existing structures and utilities from damage:
   1. Repair if damaged by this work.

D. Lengths indicated on drawings are for information only:
   1. Furnish lengths as required.

E. Perform no pipe work in fill areas until embankment or fill has been completed to at least 2 FT above top of pipe and has been properly compacted.

F. Revisions to Contract Drawings:
   1. If it becomes necessary to change location of sanitary lines due to building construction, secure prior written approval from Architect.
   2. If Contractor initiated, make approved changes without added cost to BNL.

G. Do not change pipe sizes without securing prior written approval from Architect.

H. Site utility installer and building plumbing installer shall interface work 5 FT outside face of building:
   1. Building plumbing installer shall provide necessary materials (adaptors).

1.4 SUBMITTALS

A. Shop drawings:
   1. Precast manhole drawings showing size and type of structure base.

B. Product data:
   1. Manufacturer catalog cuts and literature for pipe, manholes, manhole frame and covers and cleanouts.

C. Project information:
   1. Manufacturer's certification for materials.

1.5 EXTRA WORK

A. Removal and replacement of unsuitable material will be paid for as extra work:
   1. Notify BNL's agent in time to have Engineer measure and record quantity removed.
   2. Recorded quantity will be basis for payment.
   3. Include unit price per cubic yard on Bid Form.

B. Rock excavation will be paid for as extra work:
   1. Notify BNL's agent in time to have Engineer measure and record quantity removed.
   2. Recorded quantity will be basis for payment.
   3. Include unit price on Bid Form.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Ductile iron pipe and fittings:
   1. Pipe:
      a. Ductile iron pressure pipe; Class 52, bituminous coated outside; AWWA C151/ANSI A21.51.
      b. Lining: Bituminous; AWWA C104/ANSI A21.4.
   2. Joints: Push on type; AWWA C110/ANSI A21.10.
   3. Fittings: Cast iron; AWWA C110/ANSI A21.10.

B. Concrete materials:
   1. Comply with requirements of Division 03 "Concrete." Minimum compressive strength 4000 psi at 14 days.

C. Cleanout covers: ASTM-A48, cast iron with machined bearing surfaces.

PART 3 - EXECUTION

3.1 EXCAVATION, BACKFILL AND COMPACTION

A. Refer to Section 31 23 33, TRENCHING, BACKFILLING AND COMPACTING FOR UTILITIES.

3.2 INSTALLATION OF PIPE

A. Lay pipelines on uniform grades between inverts.

B. Locate structures as indicated and construct lines between them.

C. Lay pipe upgrade beginning at lower end with bell ends of pipe upstream.

D. Provide proper facilities for lowering pipe into trench.

E. Do not lay pipe in water.

F. Do not lay pipe when trench condition or weather is unsuitable for such work.

G. Remove sections of pipe already placed found to be out of alignment, defective or damaged.

H. Relay or replace without additional cost to BNL.

I. Bedding:
   1. Lay pipe directly on shaped subgrade.
   2. No blocking permitted.
   3. Form a continuous bearing with a minimum width of bearing equal to 0.6 of outside diameter of pipe, for full length of pipe, except for portion excavated for joint.

3.3 CLEANOUT STRUCTURES

A. Construct cleanout risers of 6 IN pipe laid on angle on undisturbed natural ground.

B. Tamp backfill around and above pipe in layers not exceeding 8 IN depth so that no settlement occurs.

C. Lay base of cleanout on concrete block.

3.4 WYE BRANCHES

A. Install where sewer connections are indicated or required.

B. Cutting into piping for connections not permitted except as approved by Architect.

3.5 BUILDING CONNECTIONS

A. Building connections shall include lines to and connection with building waste drainage piping at a point approximately 5 FT outside building, unless otherwise indicated. Where building drain piping is not installed, terminate building connections approximately 5 FT from site of building and plug pipe end.

3.6 LEAKAGE TESTS

A. Test lines for leakage by low pressure air testing or exfiltration tests, as appropriate:
   1. Low pressure air testing ASTM-C828.
   2. Exfiltration test: Fill line to be tested with water so that a head of at least 2 FT is provided above both water table and top of pipe at upper end of pipeline to be tested. Allow filled line to stand until pipe has reached its maximum absorption, but not less than 4 hours. After absorption, head shall be re-established. Amount of water required to maintain this water level during a 2-hour test period shall be measured.
   3. Leakage as measured shall not exceed 250 gallons per inch diameter per mile of pipeline per day.
   4. When leakage exceeds maximum amount specified, satisfactory correction shall be made and retesting accomplished.

END OF SECTION

SECTION 22 14 00
STORM DRAINAGE SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. Definitions:
   1. Engineer: Soils Engineer employed by BNL, empowered to conduct inspections and make approvals.
   2. Unsuitable material: Debris and/or soil material judged unsuitable by Engineer for support of slabs or other site improvements.

1.2 EXTRA WORK

A. Removal and replacement of unsuitable material below design elevations will be paid for as extra work:
   1. Notify BNL's agent in time to have Engineer measure and record quantity removed.
   2. Recorded quantity will be basis for payment.
   3. Include unit price on Bid Form.

1.3 QUALITY ASSURANCE

A. Storm drainage standards: State of New York, Department of Transportation, "Standard Specifications for Road and Bridge Construction," as amended to date.

B. Should conflicts arise between standard specifications of government agencies mentioned herein and Contract Documents, the more stringent shall govern.

C. Compaction density test:
   1. Standard Proctor, ASTM-D698.

D. BNL will hire an independent soils laboratory to conduct in place moisture and density tests.
   1. Contractor to pay for retests of material failing initial tests.

1.4 SUBMITTALS

A. Shop drawings:
   1. Manhole, inlet and headwall coordination drawings (enlarged plans and sections/elevations) indicating at a minimum the following:
      a. Size and type of structure.
      b. Incoming/outgoing pipe sizes and locations with invert elevations of each.
      c. Rim elevation of structure.
   2. Detention grate assembly drawings and installation details.
   3. Inlet grates with locking device or security bolts.
   4. Manhole frame and cover with locking device and removable key.

B. Product data:
   1. Manufacturer's literature for all materials.

C. Project information:
   1. Manufacturer's certification for materials.

1.5 JOB CONDITIONS

A. Verify locations of existing and new underground utilities:
   1. Coordinate installation with all utility installers.

B. Protect existing structures and utilities from damage.

1. Repair if damaged by this work.

C. Lengths indicated on drawings are for information only:
   1. Furnish lengths as required.

D. Perform no pipe work in fill areas until embankment or fill has been completed to at least 2 FT above top of pipe and has been properly compacted.

E. Verification of existing utilities and structures:
   1. Plans indicate existing utilities as indicated on site survey.
   2. Verify accuracy, location and depth of each utility prior to trenching or tunneling.
   3. If pipe adjustment is necessary due to location of other utilities, secure approval from Architect.

F. Revisions to Contract Drawings.
   1. If it becomes necessary to change location of storm drainage lines due to building construction, secure prior written approval from Architect.
   2. If Contractor initiated, make approved changes without added cost to BNL.

G. Do not change pipe sizes without securing prior written approval from Architect.

H. Building plumbing installer and site utility installer to interface work 5 FT outside face of buildings:
   1. Building plumbing installer to provide necessary materials (adapters).

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Pipe and fittings: Manufacturer who has produced pipe successfully used, for at least 5 years.
   2. Pipe joint sealing compound:
      a. Base:
         1) K T Snyder.

B. Reinforced concrete pipe (RCP):
   1. Pipe and fittings: ASTM-C76, Classes III wall B.
   2. Joints:
      a. Compression type: Removable rubber gasket, ASTM-C443.
      b. Install in accordance with manufacturer's recommendations.
   3. Sizes: As indicated.

C. Ductile iron pipe (DIP):
   1. Centrifugally cast, ANSI/AWWA-C151/A21.51, ASTM-A377, lined and coated, Class 22 or higher.
   2. Joints: Bell and spigot with mechanical or push-on joints.
   3. Gaskets: AWWA C111.

D. Salvaged ductile iron pipe:
   1. From ISB site prep chilled water relocation.
   2. Gaskets: AWWA C111, compatible with salvaged piping.

E. Pipe underdrain (UD):
   1. Pipe and fittings:
      a. Polyvinyl-chloride: ASTM-F949.
      b. Polyethylene: ASTM-D3350, AASHTO M294, and AASHTO M252.
      c. Extruded with smooth interior and corrugated exterior.
      d. Manufacturer:

1) PVC: A-2000 perforated pipe by Contech Construction Products, Middletown, Ohio.
2) Polyethylene: Hi-Q by Hancor, Findlay, Ohio or N-12 by Advanced Drainage Systems, Columbus, Ohio.

2. Joints:
   a. PVC: Compression type, ASTM-D3212, with single rubber gasket, ASTM-F477.
   b. Polyethylene: Corrugated coupler.
3. Perforations: Perforated holes or slotted per criteria of AASHTO M252.
4. Filter fabric: Typar 3401 or Mirafi 140N.
5. Granular material from 6 IN below pipe to 6 IN above top of pipe:
   a. Size: 3/4 to 1/4 IN.
6. Pipe sizes: As indicated.
7. Install in accordance with manufacturer's recommendations and as detailed.

F. PVC piping:
   1. 4 IN – 6 IN ASTM-D2665 or ASTM-D3034, Schedule 40.
   2. 4 IN – 15 IN ASTM-D3034-SDR 35
   3. Joinsts ASTM-D3034-SDR 35, elastomeric gasket.

G. Cleanouts:
   1. Provide as detailed.
   2. For 4 IN pipe: 4 IN cleanouts.
   3. For 6 IN and larger pipe: 6 IN cleanouts.

H. Manhole frame and cover:

I. Granular bedding material for non-perforated plastic pipe:
   1. Free draining sands and gravel or crushed rock:
      a. Size: No.4 sieve to 100 mesh.

J. Backfill material:
   1. As approved by Engineer.
   2. Free of rock, cobbles, roots, sod, organic matter, and frozen material.
   3. Moisture content at time of placement:
      a. 3 percent plus/minus of optimum moisture content.
      b. Wet dry material, as required.
      c. Dry wet material, as required or:
      d. Furnish off site material at no additional cost to BNL.

PART 3 - EXECUTION

3.1 EXCAVATION, BACKFILL AND COMPACTION

A. Excavate trenches to depth indicated on plans and necessary to accommodate work.

B. Keep trenches free of water.

C. Form bell holes in trench so only barrel of pipe is firmly supported by shaped subgrade.

D. For concrete pipe, compact backfill under and around pipe up to 24 IN above top of pipe in lifts not exceeding 8 IN loose thickness.

E. For plastic pipe, compact granular bedding material under and around pipe up to 6 IN above top of pipe.

F. Compact evenly on both sides of pipe to top of excavation or to a depth such that pipe will not be injured by subsequent compaction used to achieve required density.

G. Backfill and compact remainder of trench in 8 IN lifts to specified density.

H. Exercise care in backfilling operations to avoid displacing pipe joints either horizontally or vertically and to avoid breaking pipe.

I. Do not water flush for consolidation.

J. Compact trench backfill in areas under paved roads, parking areas, sidewalks and other structures, to minimum 95 percent of specified density.

K. In locations where trench is not under paving or structures, compact backfill to minimum 90 percent of specified density.

L. Remove materials which cannot be compacted as specified.

M. Replace with suitable material and compact.

3.2 INSTALLATION OF PIPE

A. Lay pipelines on uniform grades between inverts.

B. Locate structures as indicated and construct lines between them.

C. Lay pipe upgrade beginning at lower end.

D. Provide proper facilities for lowering pipe into trench.

E. Do not lay pipe in water.

F. Do not lay pipe when trench conditions or weather is unsuitable for such work.

G. Remove sections of pipe already placed found to be out of alignment, defective or damaged.

H. Relay or replace without additional cost to BNL.

I. Bedding for nonplastic pipe:
   1. Lay pipe directly on shaped subgrade.
   2. No blocking permitted.
   3. Form a continuous bearing with a minimum width of bearing equal to 0.6 of outside diameter of pipe, for full length of pipe, except for portion excavated for joint.

J. Bedding for plastic pipe (PVC and PE):
   1. Excavate 6 IN below bottom of pipe.
   2. Install granular bedding material below pipe.
   3. Backfill with bedding material and compact under and around pipe up to 6 IN above top of pipe.

3.3 FIELD QUALITY CONTROL

A. Check each line with a light.

B. Each line indicate a good light circle throughout its length.

C. Should these tests indicate line to be defective, remove defective portions and replace.

D. Retest.

END OF SECTION

SECTION 22 14 10
PRECAST CONCRETE UTILITY STRUCTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Precast concrete manhole structures and appurtenant items:
      a. Sanitary sewer manholes and appurtenances.

B. Related Sections include but are not necessarily limited to:
   1. General Conditions Governing All Contracts.
   2. Section 31 23 33 - Trenching, Backfilling, and Compacting for Utilities.
   3. Section 22 14 00 - Storm Drainage System
   4. Section 22 13 00 - Sanitary Sewers
   5. Section 03 20 00 - Reinforcement.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Society for Testing and Materials (ASTM):
      a. A48, Standard Specification for Gray Iron Castings.
      b. C150, Standard Specification for Portland Cement.
      c. C478, Precast Reinforced Concrete Manhole Sections.
      d. D4022, Coal Tar Roof Cement.
   2. Occupational, Health and Safety Administration (OSHA).

1.3 SUBMITTALS

A. Shop Drawings:
   1. See General Conditions Governing All Contracts, Article 4 - Contractor's Shop Drawings, Integrated Drawings, Sleeve and Penetration Drawings, and Record Drawings.
   2. Product technical data including:
      a. Acknowledgement that products submitted meet requirements of standards referenced.
      b. Manufacturer's installation instructions.
   3. Fabrication and/or layout drawings:
      a. Include detailed diagrams of manholes showing typical components and dimensions.
      b. Itemize, on separate schedule, sectional breakdown of each manhole structure with all components and refer to drawing identification number or notation.
      c. Indicate knockout elevations for all piping entering each manhole.

B. LEED Information:
   1. LEED Credit MR 4.1, Recycled Content: Manufacturer’s product data for products with recycled content indicating amount of post-consumer and post-industrial recycled content
   2. LEED Credit MR 5.1, Local/Regional Materials: Manufacturer’s certification indicating final point of assembly for products and materials located within 500 miles of Project site. Include manufacturer’s name, address and phone number.

PART 2 - PRODUCTS

2.1 SANITARY SEWER MANHOLE STRUCTURE COMPONENTS

A. Manhole Components:
   1. Reinforcement: ASTM C478.

2. Minimum wall thickness: 5 IN.
3. Minimum base thickness: 12 IN.
4. Provide the following components for each manhole structure:
   a. Base precast with integral bottom section or cast-in-place.
   b. Precast bottom section(s).
   c. Precast barrel section(s).
   d. Precast eccentric transition section.
   e. Precast adjuster ring(s).
   f. Rubber gaskets for joints between manhole riser sections and top sections: ASTM C443.
   g. Resilient connectors for joints between manhole and entering or leaving pipes: ASTM-C923.
5. Unless dimensioned or specifically noted on Drawings, provide manhole section with minimum 48 IN inside dimensions.

B. Nonpressure Type Frames and Cover:
1. Frames and covers: ASTM-A48 cast iron with minimum tensile strength of 30,000 PSI and machined horizontal and vertical bearing surfaces, non-rocking type.
2. Use only cast or ductile iron of best quality, free from imperfections and blow holes.
3. Furnish frame and cover of heavy-duty construction a minimum total weight of 450 LBS.
4. Machine all horizontal surfaces.
5. Furnish unit with lids as detailed on the Drawings. Letter covers "SEWER" for all sanitary collection system manholes, and "STORM" for storm sewer systems manholes.
6. Ensure minimum clear opening of 24 IN DIA.

C. Manhole steps: ASTM-A48, cast iron epoxy coated, nonslip surface, designed to support a concentrated load of 500 LBS. Minimum tread length 12 IN and minimum tread width 1 IN.

D. Ladders: Use in lieu of steps for manholes over 12 FT in depth:
1. Ladders: ANSI-A14.3 steel fixed-rail type.
2. Ladders and accessories shall be galvanized.
3. Rungs: Solid-section rods, fitted into punched holes in rails, welded, and ground smooth, spaced out 12 IN.
4. All splices and connections shall have a smooth transition with original members without projections that are sharp or more extensive than required for joint strength.
5. Rails shall be fitted with brackets at 5 FT intervals for anchorage to structure.

E. Joint Treatment:
1. Joints of precast sections:
   a. Black mastic compound: ASTM D4022.

F. Sanitary Sewer Manhole Concrete:
1. Provide all sanitary manholes constructed with Portland ASTM C150, Type I or II cement with a tricalcium aluminate content not to exceed 8 percent.
2. Mix aggregate shall be a minimum of 50 percent crushed limestone.
3. Provide 3000 psi non-shrink grout.

G. Cleanout covers: ASTM-A48, cast iron with machined bearing surfaces.

PART 3 - EXECUTION

3.1 MANHOLE CONSTRUCTION

A. General:
1. Construct cast-in-place concrete base slabs.
2. Make inverts with a semi-circular bottom conforming to the inside contour of the adjacent sewer sections.

B. Build each manhole to dimensions shown on plans and at such elevation that pipe sections built into wall of manhole will be true extensions of line of pipe.

C. Seal all pipe penetrations in manhole. Form pipe openings smooth and well shaped. After installation, seal cracks with, non shrink grout. After grout cures, wire brush smooth and apply two coats emulsified fibered asphalt compound to minimum wet thickness of 1/8 IN to ensure complete seal.

D. Set and adjust frame and cover to match finished pavement or finished grade elevation using precast adjuster rings.

END OF SECTION

SECTION 22 33 00
DOMESTIC WATER HEATERS

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Factory testing: Subject tank and elements to hydrostatic test pressure, 150 percent in excess of working pressure. Certify that components are free of leaks.

B. Manufacturing standard: ASME Pressure Vessel Code.

1.2 SUBMITTALS

A. Product data:
   1. Water heaters.

B. Contract closeout information:
   1. Operating and maintenance data.
   2. BNL instruction report.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Steam-heated semi-instantaneous water heater:
      a. Base:
         1) Patterson-Kelley.
      b. Optional:
         1) Aerco.
         2) Adamson.
         3) RECO.
   2. Temperature/pressure relief valves:
      a. Base:
         1) Watts.
      b. Optional:
         1) A W Cash.
         2) Wilkins.

B. High-temperature limits shall prevent delivery of water that is hotter than that selected for delivery from heater.

C. Concrete linings shall comply with MIL-T-12295.

D. Unless indicated otherwise, water pressure drop through heater shall not exceed 10 PSI.

2.2 STEAM-HEATED SEMI-INSTANTANEOUS WATER HEATER

A. Steam-heated semi-instantaneous water heater:
   1. Factory-assembled, packaged commercial water heater with heater section, controls, and other components as indicated.
   2. Completely factory assemble water heater so that installation involves only setting, leveling, anchoring, and connection of piping and electrical services.
   3. Designed for potable water service.
   4. Capable of being disassembled and heater section removed without breaking domestic water connections.

5. Easy access to heater tubes without moving heater from installed position.
6. Factory fabricated steel supports.
7. Provide manufacturer's standard enamel finish.

B. Scheduled information:
1. Entering water temperature.
2. Leaving water temperature.
3. Recovery capacity.
4. Steam pressure.
5. Power: BTUH.

C. Tank:
1. Labeled ASME Code construction for not less than 150 PSI working pressure.
2. Shell: Copper silicon or carbon steel with copper lining.
3. Insulation: Minimum 1-1/2 IN thick fiberglass complying with ASHRAE 90.1.
4. Steel outer jacket with manufacturer's standard finish.

D. Heater section:
1. Removable.
2. Copper tubes.
3. Steam chamber: Cast iron.
4. Provide leak-indicating, double-wall isolation between steam and water.

E. Controls:
1. Control leaving water temperature within 5 degF of selected temperature.
2. Adjustable leaving water temperature range: 110-180 degF.
3. High-temperature limit with adjustable set point.
4. Pneumatic temperature control valve with temperature controller.

F. Other components:
1. Temperature/pressure relief valve.
2. Leaving water temperature gauge.
3. Steam pressure gauge.
4. Steam strainer.
5. Condensate orifice or F & T trap.
6. Circulating pump:
a. 110V, fractional horsepower, wired for continuous operation:
1) Provide manual starter.
b. Bronze with copper piping, fittings, and isolation valves.

2.3 TEMPERATURE/PRESSURE RELIEF VALVES

A. Temperature/pressure relief valves:
1. AGA and ASME-approved, tight-shutoff, self-closing, bronze-bodied.
2. Threaded inlet and outlet.
3. Test lever.
4. Capacity: Same power as water heater. See schedule.
5. Relief setting: 210 degF/150 PSIG unless otherwise required by code.

PART 3 - EXECUTION

3.1 GENERAL

A. Install units in accordance with manufacturer's instructions.

B. Install units to allow complete access for servicing including removal of heater sections.

C. Set thermostat so heater will deliver scheduled leaving water temperature.

3.2 STEAM-HEATED WATER HEATERS

A. Pipe steam condensate to receiver so that it flows by gravity. Provide additional steel channel stands if additional height is required.

3.3 PARALLEL PIPING MANIFOLD

A. Pipe groups of heaters serving the same system in parallel:
   1. Provide equal-distance water-piping manifolds so that pressure drops through each heater branch are identical:
      a. Equal-distance manifolds:
         1) Cold-water manifold: Developed distances are equal between each heater's cold-water inlet and common tee that splits cold-water flow to heaters.
         2) Hot-water manifold: Developed distances are equal between each heater's hot-water outlet and common tee that combines the hot-water flow from heaters.
         3) Hot-water recirculation manifold: Developed distances are equal between each heater's cold-water inlet and common tee that splits recirculation-water flow to heaters.
      b. Equal developed distances include equal quantities of fittings and valves.
      c. Connect heaters' inlets and outlets to straight-through ports of common tees. Tees' branch ports are the common ports.

END OF SECTION

SECTION 22 42 00
PLUMBING FIXTURES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Definitions:
   1. Aerator: Device that mixes room air with faucet's water stream.
   2. Ledge-mounted faucet: Faucet with body mounted on top of faucet ledge and covered by faucet housing or single escutcheon.
   3. Bottom-mounted faucet: Faucet with body mounted beneath faucet ledge; each penetration is covered by single escutcheon.
   4. Semi-cast: Fittings, return bends, and nuts are cast brass. Waste arms and wall bends are tubular.

1.2 QUALITY ASSURANCE

A. Manual-valve standards: See Section 20 05 23 (for valves labeled "V-__").

B. Design and Installation standards:
   1. ANSI Z358.1: Standard for Emergency Eyewash and Shower Equipment.
   2. ASSE 1016: Individual Thermostatic Pressure Balancing, and Combination Pressure Balancing and Thermostatic Control Valves for Individual Fixture Fittings.
   3. ASSE 1017: Temperature Actuated Mixing Valves for Hot Water Distribution Systems.

C. Accessibility:
   1. Manufacturing standards:
      a. Americans with Disabilities Act (Public Law 101-336).
      b. ANSI-A117.1, current edition.
   2. Installing standards:
      a. Americans with Disabilities Act (Public Law 101-336).
      b. ANSI-A117.1, current edition.
      c. Local authorities.
      d. State authorities.

1.3 SUBMITTALS

A. Product Data:
   1. Assemble submittals by mark number. Include sufficient information to verify compliance with descriptions. Where model numbers differ from descriptions, submit to meet description requirements:
      a. Drinking fountains.
      b. Electric water coolers.
      c. Hose bibbs.
      d. Hose reels.
      e. Lavatories.
      f. Mixing valves.
      g. Showers.
      h. Sinks.
      i. Standpipe and supply boxes.
      j. Urinals.
      k. Wall hydrants.
      l. Water closets.
      m. Undersink protective covers.

B. Contract Closeout Information:
   1. Operating and maintenance data.

PART 2 - PRODUCTS

2.1 MATERIALS - GENERAL

A. Acceptable manufacturers:
   1. Electric water coolers and drinking fountains:
      a. Base:
         1) Halsey-Taylor.
      b. Optional:
         1) Elkay Manufacturing.
         2) Haws Corporation.
         3) EBCO Manufacturing (Oasis).
         4) Sunroc.
   2. Faucets (Sensor operated):
      a. Base:
         1) Sloan Valve.
      b. Optional:
         1) Chicago Faucet.
         2) Hydrotek.
   3. Faucets (Single-lever mixing):
      a. Base:
         1) American Standard Plumbing.
      b. Optional:
         1) Chicago Faucet.
         2) T&S Brass & Bronze Works.
   4. Faucets (Two-handled):
      a. Base:
         1) American Standard Plumbing.
      b. Optional:
         1) Chicago Faucet.
         2) T&S Brass & Bronze Works.
   5. Fixtures (Enameled cast iron):
      a. Base:
         1) Kohler.
      b. Optional:
         1) American Standard.
         2) Crane Plumbing.
         3) Eljer Plumbingware.
   6. Fixtures (Molded stone, precast terrazzo, fiberglass-reinforced polyester):
      a. Base:
         1) Fiat.
      b. Optional:
         1) Creative Industries Terrazzo Products.
         2) Standard Elsemere.
         3) Stern and Williams.
         4) Swan.
         5) Mustee & Sons, EL.
   7. Fixtures (Stainless steel):
      a. Base:
         1) Elkay Manufacturing.
      b. Optional:
         1) Just Manufacturing.

2) Advance Tabco.

8. Fixtures (Vitreous china):
   a. Base:
      1) American Standard Plumbing.
   b. Optional:
      1) Eljer Plumbingware.
      2) Kohler.
9. Fixture carriers:
   a. Base:
      1) Wade.
   b. Optional:
      1) Watts/Ancon.
      2) Jonespec.
      3) Josam.
      4) J R Smith.
      5) Zurn Industries.
10. Flow control devices:
   a. Base:
      1) Same as installed faucet or shower head.
   b. Optional:
      1) American Standard Plumbing.
      2) Chicago Faucet
      3) Crane Plumbing.
      4) Coyne & Delany.
      5) Delta Commercial.
      6) Eljer Plumbingware.
      7) Hydrotek.
      8) Kohler.
      9) Omni.
      10) Sloan Valve.
      11) T&S Brass & Bronze Works.
11. Flushometer valves:
   a. Base:
      1) Sloan Valve.
   b. Optional:
      1) Coyne & Delany.
      2) Zurn Industries.
12. Hose bibbs:
   a. Base:
      1) Chicago Faucet.
   b. Optional:
      1) Acorn Engineering.
      2) Delta Commercial.
      3) Crane Plumbing.
      4) Croker West.
      5) Sloan Valve.
      6) Speakman.
      7) T&S Brass & Bronze Works.
      8) Woodford Manufacturing.
13. Mixing valves (Pressure-balanced):
   a. Base:
      1) Symmons.
   b. Optional:
      1) Chicago Faucet.
      2) Leonard Valve.
14. Mixing valves (Thermostatic):

a. Base:
    1) Symmons.
b. Optional:
    1) Lawler Manufacturing.
    2) Leonard Valve.
    3) Powers.

15. Mixing valves (Tempering):
    a. Base:
        1) Powers.
    b. Optioinal:
        1) Watts.
        2) Leonard.
16. Shower drains:
    a. Base:
        1) Wade.
    b. Optional:
        1) Watts-Ancon.
        2) Jonespec.
        3) Josam.
        4) J R Smith.
        5) Zurn Industries.
17. Standpipe and supply boxes:
    a. Base:
        1) Acorn Engineering.
    b. Optional:
        1) Amsco.
        2) Bradley.
        3) Guy Manufacturing.
18. Trim:
    a. Base:
        1) McGuire Manufacturing.
    b. Optional:
        1) American Standard Plumbing.
        2) Brass-Craft Manufacturing.
        3) Chicago Faucet.
        4) Crane Plumbing.
        5) Dearborn.
        6) Eljer Plumbingware.
        7) Elkay Manufacturing.
        8) Just Manufacturing.
        9) Kohler.
        10) T&S Brass & Bronze Works.
19. Wall hydrants:
    a. Base:
        1) Wade.
    b. Optional:
        1) Watts-Ancon.
        2) Jonespec.
        3) Josam.
        4) J R Smith.
        5) Woodford Manufacturing.
        6) Zurn Industries.
20. Water closet seats:
    a. Base:
        1) Beneke.
    b. Optional:

1) Bemis.
2) Centoco.
3) Olsonite.

21. Undersink Protective Covers:
    a. Base:
        1) Truebro.
    b. Optional:
        1) McGuire.
        2) TCI Products.
        3) Brocar Products.

B. Construct or equip fixtures with air gap or anti-siphon devices to prevent siphoning non-potable water into potable water supply system.

C. Piping exposed in finished areas (including fittings and trim): See Section 22 10 16.

D. Dimensions:
    1. Dimensions are nominal.
    2. Multiple dimensions:
        a. First dimension: Side-to-side.
        b. Second dimension: Front-to-back.
        c. Third dimension: Top-to-bottom.

E. Manufacture accessible fixture assemblies to meet requirements of accessibility manufacturing standards (see Quality Assurance article in Part 1 of this section).

F. Faucets, general (Following general conditions apply unless detailed otherwise in specific descriptions):
    1. Renewable cartridges with integral seats (or renewable seats and stems).
    2. Materials: Brass, bronze, copper, stainless steel, ceramic. (Plastic components are not acceptable.)
    3. Finish: Polished chrome.
    4. Gooseneck spouts: Discharge at least 5 IN above rim of fixture.
    5. Electric, sensor-operated faucets:
        a. Mount transformer and control panel in concealed but accessible location.
        b. Coordinate with Electrical and Casework contractors.
        c. If mixing valve is not included in faucet description, provide a tempering, under-counter mixing valve. Mechanical mixing valves shall not be used.

G. Flow control devices, general:
    1. Provide flow control devices with indicated maximum flow rates on listed fixtures:
        a. Lavatory, public:
            1) Metering: 0.25 gallons per metering cycle.
            2) Non-metering: 0.5 GPM.
            3) All locations shall be considered public, except as specifically identified above for private.
        b. Sinks: 1.5 GPM at 60 psi
        c. Showers: 1.5 GPM at 80 psi.
    2. Material: Brass.
    3. Finish: Chrome.
    4. Accomplish controlled flow without aeration of water stream. Aerators are not acceptable unless specifically identified in the faucet description.
    5. Flow control devices shall be disinfectable.

H. Lavatory fixtures, general (Following general conditions apply unless detailed otherwise in specific descriptions):
    1. Vitreous-china and enameled, cast-iron fixtures:
        a. Color: White.
        b. Overflows: Integral.

2. Stainless-steel fixtures:
    a. Finish: Soft satin.
    b. Type: 302 (18-8) or 304 (18-8).
    c. Thickness: 20 GA, minimum.
    d. Sound deadening that covers complete underside of bowl.
3. Provide integral faucet ledge with holes:
    a. Coordinate hole quantities, locations, and centerings with faucet types indicated in fixture descriptions.
    b. Provide exact number of holes necessary. Use of faucet hole covers is not acceptable.

I. Mixing valves, general (Following general conditions apply unless detailed otherwise in specific descriptions):
1. Materials: Brass, bronze, copper, stainless steel, ceramic:
    a. Thermostatic mixing valves: Thermostat may contain plastic parts.
    b. Escutcheon may be pot metal.
2. Finish of exposed surfaces: Polished chrome.
3. Hot/cold color coding.
4. Coordinate number of ports with trim indicated in fixture descriptions:
    a. Four-port valves:
        1) If diverter spout is indicated in fixture description, provide built-in choke.
        2) If external diverter valve is indicated in fixture description, provide without choke.
5. Tempering type mixing valve:
    a. ASSE 1016 Type: T/P.
    b. Integral checks and service stops on inlets.
    c. Inlet screens: stainless steel.
    d. Adjustment: adjustable locking type.
    e. Connections: 3/8 IN.
    f. Example: Powers model e480.
6. Pressure-balanced mixing valves:
    a. Renewable stainless-steel piston with brass seat.
    b. Integral checks and service stops on inlets.
    c. Temperature control with built-in shut off; opens from cold to hot.
    d. Single lever handle.
    e. Adjustable, temperature-limit stops.
    f. "OFF-COLD-HOT" marking in block type letters (minimum 7/32 IN high).
7. Thermostatic mixing valves:
    a. ASSE 1017 compliant.
    b. Renewable thermostatic and pressure-balance elements.
    c. Compensates for changes in both temperature and pressure.
    d. Integral checks and service stops.
    e. Temperature control with built-in shut off; opens from cold to hot.
    f. Single lever handle.
    g. Adjustable, temperature-limit stops.
    h. "OFF-COLD-HOT" marking in block type letters (minimum 7/32 IN high).

J. Mixing valve trim, general:
1. Cabinets:
    a. Stainless steel construction.
    b. Hinged doors:
        1) Removable when in the open position.
        2) Hinge on side.
    c. Size cabinets to hold valve and accessories as required in each description.
2. Thermometers:
    a. 3-1/2 IN dial.
    b. Hermetically sealed.
    c. Bimetal element.

d. Range: 0 to 140 degF.
e. Construction: Welded stainless steel.
f. White-faced, three-color dial.

3. Vacuum breakers and valves:
   a. See "Faucets, general" in Article 2.01.

K. P-traps and continuous wastes, semi-cast:
1. P-trap, semi-cast:
   a. 1-1/4 or 1-1/2 IN NPS cast-brass return bend with clean out.
   b. 17 GA x 1-1/4 or 1-1/2 IN OD copper tube tailpiece.
   c. Nuts: Cast brass.
2. Continuous waste, semi-cast:
   a. 1-1/2 IN NPS cast-brass tee.
   b. 17 GA x 1-1/2 IN OD copper tube tailpieces.
   c. Nuts: Cast brass.

L. Shower heads, general (Following general conditions apply unless detailed otherwise in specific descriptions):
1. Nozzle designed to prohibit liming and clogging.
2. Body:
   a. Material: Brass.
      1) Hand-held shower-head body may be plastic.
   b. Finish: Chrome.
      1) Hand-held shower-head body may be white.
3. Internal components:
   a. Foul resistant.

M. Sink fixtures, general (Following general conditions apply unless detailed otherwise in specific descriptions):
1. Vitreous china: White.
2. Stainless steel:
   a. Finish: Soft satin.
   b. Type: 302 (18-8) or 304 (18-8).
   c. Sound deadening that covers complete undersides of each bowl, unless noted otherwise.
   d. Thickness:
      1) Sink depth less than or equal to 10 IN: 18 GA, minimum.
      2) Sink depth greater than 10 IN: 16 GA, minimum.
3. Molded stone and terrazzo:
   a. Marble chips in reinforced Portland cement:
      1) 7-day compressive strength: 3000 PSI.
      2) Exposed surfaces: Ground smooth, grouted and sealed to resist staining.
   b. Drain body opening: Integrally cast.
   c. Color: As selected from manufacturer's standard line by Architect.
4. Enameled cast-iron:
   a. Color: White.
5. Counter-top sinks: Self-rimming.
6. Provide integral faucet ledge with holes:
   a. Coordinate hole quantities, locations, and centerings with the following:
      1) Faucets and trim indicated in fixture descriptions.
      2) Hot-water dispensers.
      3) High-purity water faucets.
   b. Provide exact number of holes necessary. Use of faucet hole covers is not acceptable.

2.2 ELECTRIC WATER COOLERS

A. Electric water coolers, general (Following general conditions apply unless detailed otherwise in specific descriptions):
1. Self contained, refrigeration units:

a. Capacity based on 90 degF room temperature, 80 degF inlet-water temperature, and 50 degF drinking-water temperature.
b. Air cooled condensing units:
1) 115V.
2) Hermetically sealed compressor.
2. Bubbler drain-pan: Stainless steel.
3. Stainless steel: Type 304 with satin finish.
4. Chrome-plated, brass bubbler:
a. Bubbler guard may be plastic and need not be chrome-plated.
5. Stream regulator(s) mounted inside cabinet or in bubbler. Regulator shall maintain constant stream height while line pressure varies between 30 and 90 PSI.
6. Certified lead free as defined by the Safe Drinking Water Act.

B. P-5, Accessible (forward facing), dual-level:
1. Fixture:
a. Brushed stainless steel, remote refrigeration unit, dual level extensions with oval receptors, access panel cover, rounded corners, rounded edges, designed to eliminate splashing and standing waste water. Provide self-closing, semi-circular push bars with full 180 degree activation. Minimum capacity: 8 GPH:
1) Halsey Taylor OVL-II SEBP.
2. Trim:
a. Supply: Chrome plated brass, quarter turn ball valve, 1/2 IN threaded by 3/8 IN OD, soft-copper tube, stops, CSA certified to 200 psig:
1) McGuire Model BV02.
b. P-trap: Chrome or satin, 1-1/4 IN (or 1-1/2 IN) semi-cast with cleanout, with 17 GA x 1-1/4 IN (or 17 GA x 1-1/2 IN) OD copper-tube trap arm.
3. Remote Chiller:
a. Remote chiller capable of delivering 9.6 GPH of 50 deg. F chilled water at 90 deg F ambient air temperature and 80 deg. F inlet water temperature in compliance with UL and ARI Standard 1010. Rust resistant heavy gauge galvanized steel cabinet with removable service panels. Provide optional wall mounting shelf. Hermetically sealed compressor using R134A refrigerant. Adjustable +/-5 deg F thermostat. Certified lead free as defined by the Safe Drinking Water Act. 115V, 60 Hz, single phase power.

2.3 EMERGENCY FIXTURES

A. Emergency combination shower/eyewash or eyewash units are furnished by Division 12:
1. Mixing Valves: In compliance with current editions of ANSI standard Z358.1 (American National Standard for Emergency Eyewash and Shower equipment) and ASSE standard 1016 (American Society for Sanitary Engineering).

B. TWMV-1, Mixing Valve, thermostatic:
1. Cabinet mounted valve, example: Leonard TM-850ststl-exp-view.
2. Operating parameters:
a. Flow control range: 3-64 GPM.
b. Minimum flow at 30 PSI: 20GPM.
c. Minimum flow at maximum pressure drop of 10 PSIG: 29 GPM.
d. Output temperature range: 60-90 degF:
1) Maintain output temperature range to a minimum flow of 3 GPM.
e. HW supply temperature: 90 degF.
f. Supply pressure range: 40-80 PSIG.
g. Mixing valve bypass: cold water by-pass if valve should fail.
3. Cabinet: exposed stainless steel; door with view port, hinge and lock.

2.4 FIXTURE CARRIERS

A. Fixture carriers:
1. Application:

a. This paragraph describes carriers for wall-hung valves and wall-hung fixtures except water closets. See Water Closet article for closet carriers.

2. Carriers consist of uprights, floor anchors, and fixture supports:
   a. Fixture-support types are concealed-arm, exposed-arm, hanger-plate, and clinical-service-sink.
   b. Include associated hardware.
3. Materials:
   a. Coated cast iron.
   b. Steel.
4. Weight of construction: Institutional.
5. Uprights: Rectangular structural steel.
6. Floor anchors:
   a. Non-adjustable cast-iron floor anchors bolted to uprights; or steel-plate floor anchors integrally welded to uprights.
   b. 4-hole anchoring to floor.
7. Concealed-arm fixture supports:
   a. Header couplings:
      1) Vertically adjustable with horizontally adjustable cross tie.
      2) Integral pipe sleeves.
   b. Secure arms to pipe sleeves with threaded or set-screw connections.
   c. Hardware for vitreous-china fixtures:
      1) Leveling screws for four corners of fixture.
      2) Non-slip devices to lock fixture into place on arms.
   d. Hardware for cast-iron fixtures:
      1) Threaded eye bolts with leveling hardware.
   e. For flat-slab fixtures requiring set out from wall, provide 2 IN chromed wall escutcheons.
8. Hanger-plate fixture supports:
   a. Bolted attachment to uprights.
   b. Drilled/slotted to match fixture.
   c. Hardware for attaching fixture.
   d. Provide in adequate size and quantity to anchor fixture at every anchoring point on the fixture.
9. Service-sink fixture supports:
   a. Two heavy-duty hanger plates, one with cast-iron waste-outlet coupling.
   b. Hardware for attaching fixture and waste piping.
10. Match lengths, mounting locations, and sizes to fixture requirements.

2.5 HOSE BIBBS

A. Hose bibb, general (Following general conditions apply unless detailed otherwise in specific descriptions):
   1. Material: Brass.
   2. Finish: As indicated.

B. HB-1, polished brass hose bibb with vacuum breaker:
   1. Fixture:
      a. 1/2 IN IPS male inlet, adjustable / removable wall flange, lever handle, 3/4 IN garden hose outlet:
         1) Model: T&S Brass B-0718.
      b. Vacuum breaker: Garden hose vacuum breaker, 3/4 in female garden hose inlet & male outlet:
         1) Model: T&S Brass B-0972.

2.6 LAVATORIES

A. See Article 2.01 MATERIALS – GENERAL.

B. P-3, Lavatory, oval, under counter mounted, stainless steel:
   1. Fixture:
      a. 17.5 x 12.5 IN oval, under counter, stainless steel, with overflow assembly:
         1) Just Manufacturing UOIF-1521.
   2. Faucet:
      a. Electric sensor-operated, ledge-mounted, 4 IN centerset faucet, integral spout, faucet-mounted sensor:
         1) Sloan ETF-600.
      b. Mixing valve:
         1) Provide thermostatic mixing valve with checkstops.
         2) Valve shall be mounted under lavatory.
         3) Provide chrome plated copper tubing for all exposed piping.
   3. Trim:
      a. Supplies: Chrome plated brass quarter turn ball valve stops, 13 1/2 IN sweat with 5 IN extension by 3/8 IN OD, soft-copper tube, , escutcheons, CSA certified to 200 psig:
         1) McGuire Model BV170.
      b. Grid drain: Chrome 1-1/4 IN cast-brass with 17 GA x 1-1/4 IN OD copper-tube tailpiece:
         1) McGuire Model 155A.
      c. P-trap: Chrome or satin, 1-1/4 IN (or 1-1/2 IN) semi-cast with cleanout, with 17 GA x 1-1/4 IN (or 17 GA x 1-1/2 IN) OD copper-tube trap arm:
         1) McGuire Model 8902.

C. P-3A, Lavatory, oval, under counter mounted, stainless steel, accessible:
   1. Fixture:
      a. 17.5 x 12.5 IN oval, under counter, stainless steel, with overflow assembly:
         1) Just Manufacturing UOIF-ADA-1521.
   2. Faucet:
      a. Electric sensor-operated, ledge-mounted, 4 IN centerset faucet, integral spout, faucet-mounted sensor:
         1) Sloan ETF-600.
      b. Mixing valve:
         1) Provide thermostatic mixing valve with checkstops.
         2) Valve shall be mounted under lavatory.
         3) Provide chrome plated copper tubing for all exposed piping.
   3. Trim:
      a. Supplies: Chrome plated brass quarter turn ball valve stops, 13 1/2 IN sweat with 5 IN extension by 3/8 IN OD, soft-copper tube,, escutcheons, CSA certified to 200 psig:
         1) McGuire Model BV170.
      b. Grid drain: Chrome 1-1/4 IN cast-brass with 17 GA x 1-1/4 IN OD copper-tube tailpiece:
         1) McGuire Model 155A.
      c. P-trap: Chrome or satin, 1-1/4 IN (or 1-1/2 IN) semi-cast with cleanout, with 17 GA x 1-1/4 IN (or 17 GA x 1-1/2 IN) OD copper-tube trap arm:
         1) McGuire Model 8902.

2.7 MIXING VALVES

A. See Article 2.01 MATERIALS – GENERAL.

B. EMV-1. Electronic Mixing valve:
   1. Exposed valve with cabinet:
      a. Armstrong RADA EMC-123.
   2. Capacity: 75 gpm maximum with no minimum system draw-off requirement.
   3. Components:
      a. 12V DC electronic temperature controllers.

b. Inlet and return check valves.
c. Pressure gauges (Refer to Specification 15120 for requirements).
d. Inlet, system blend and return line thermometers.
e. Isolation valves.
f. 110 V UL-listed transformer enclosed in a NEMA 4X enclosure.
g. Low Voltage control wiring with protective conduit.
h. Circulating pump rated at design flow and pressures as scheduled on drawings.
i. System control module.

4. Temperature Controller: non-thermostatic featuring integrated circuit board technology.
5. Package:
   a. All required installation components shall be supplied pre-plumbed and pressure-tested, mounted to an enameled steel frame terminating in five standard union connections for hot and cold supply in, blended water to the system, and system and water heater return lines.
   b. Electronic control box shall be supplied pre-wired, terminating at a knockout for Romex or BX cable connector.
   c. Mounting restrictions:
      1) Valve package with cabinet to fit within 42 wide recessed wall space. Refer to drawings for location and additional restrictions.
      2) Cabinet: Flush-mounted with lockable, hinged door.
6. Operating requirements:
   a. Recirculated water control within plus or minus 2 degF with minimal recirculation of 4 2 gpm.
   b. Control of blended water drawn from the system at a point of use within plus or minus 2 degF.
   c. Minimum of 2 degF recirculation system temperature loss required for effective loop control.
   d. Visual operation “set” and “actual” temperature display for effective commissioning, adjustment and system monitoring.
   e. Visual signal by display to show “error” mode or “out of range” system failure, coupled with output for audible alarm and/or downstream solenoid valve relay.
   f. Integral two-way data port for PC and BMCS interface.
   g. Automatic shutoff of hot water flow in the event of a power failure.
7. Standards compliance:
   a. Temperature controllers compliant with:
      1) ASSE Standard 1017.
      2) CSA B125.
8. Building Automation System Interface components:
   a. Integral 4-20 ma output connection for Mixing Unit temperature transmission to BMCS.
   b. Integral 4-20 ma output connection for Mixing Unit remote set point adjustment via BMCS.
   c. Unit Control Module to Mixing Unit (interface cable provided).
   d. Unit Control Module to BMCS (wiring to BMCS by Section 25 50 00).
   e. Additional temperature transmitter for downstream mixed water temperature transmission to BMCS (wiring by Section 25 50 00).
   f. Image file containing EMC system graphic template.

2.8 SHOWERS

A. See Article 2.01 MATERIALS – GENERAL.

B. Shower fixtures (pre-cast terrazzo), general:
   1. Terrazzo: marble chips in Portland cement:
      a. 7-day compressive strength: 3000 PSI.
      b. Reinforcing: 4 x 4 IN galvanized steel mesh.
      c. Exposed surfaces: ground smooth, grouted and sealed to resist staining.

d. Size and shape as indicated on architectural drawings.
e. Color: As selected from manufacturer's standard line by Architect.
f. Slip-resistant surface.

2. Drain body: Integrally cast stainless steel or chrome-plated brass. Provide for elastomeric or minimum 1-1/2 IN deep lead/oakum connection.
3. Strainer: removable stainless steel.
4. Tiling flange, integrally cast:
   a. Coordinate with ceramic-tile work.
   b. Provide at sides where ceramic tile walls abut receptor: Coordinate with Division 09.

C. P-6, Shower, ceramic-tile, accessible:
1. Fixture:
   a. Drain body for ceramic-tile shower base. Material: Coated cast iron. 250 mm 10 IN diameter flashing collar. Reversible flashing clamp with seepage openings and tapped opening for strainer body. Threaded strainer body. 150 mm 6 IN square, secured, satin nickel bronze, removable strainer. Provide flashing around drain:
      1) Wade W-1100G.
2. Mixing valve and trim:
   a. Pressure-balanced, flush-mounted valve with lever handle. Shower-head assembly: 760 mm 30 IN slide bar with adjustable shower-head mount; standard, hand-held shower head; 1.500 m 5 FT, flexible, metal-clad hose; supply elbow with wall flange; in-line vacuum breaker:
      1) Symmons S-96-300.

2.9 SINKS

A. See Article 2.01 MATERIALS – GENERAL.

B. P-7, Single bowl, wrist blades and gooseneck, accessible:
1. Fixture:
   a. 19 x 19 x 5.5 IN, counter-top, stainless-steel, single-bowl, 3-1/2 IN outlet:
      1) Elkay Lustertone LRAD-1919.
2. Faucet:
   a. Bottom-mounted, 8 IN spread, two 4 IN wristblades, 5 IN diameter fixed gooseneck:
      1) American Standard Plumbing Heritage 6832.000.
3. Trim:
   a. Supplies: Chrome plated brass quarter turn ball valve stops, 1/2 IN sweat with 5 IN extension by 3/8 IN OD, soft-copper tube, escutcheons, CSA certified to 200 psig:
      1) McGuire Model BV170.
   b. Chrome plated brass grid drain for 3-1/2 IN outlet with 17 GA x 1-1/2 IN OD copper-tube tailpiece:
      1) McGuire Model 152N.
   c. P-trap: Chrome or satin, 1-1/2 IN) semi-cast with cleanout, with 17 GA x 1-1/2 IN OD copper-tube trap arm:
      1) McGuire Model 8912.

2.10 SINKS, CUP

A. CS-1, Cup Sink, oval:
1. Fixture:
   a. Furnished by others.
2. Faucet:
   a. Furnished by others.
3. Trim:
   a. DN40 1-1/2 IN tailpiece and P-trap of specified material for acid waste piping (see Section 22 10 16).
   b. Supplies: Chrome plated brass, 1/2 IN threaded to 3/8 IN compression, quarter turn ball valve, CSA certified to 200 psig. McGuire BV02.

2.11 SINKS, LABORATORY

A. L-"X":
   1. Fixture:
      a. Furnished by others.
   2. Faucet:
      a. Furnished by others.
   3. Trim:
      a. DN40 1-1/2 IN tailpiece and P-trap of specified material for acid waste piping (see Section 22 10 16).
      b. Supplies: Chrome plated brass, ½ IN threaded to 3/8 IN compression, quarter turn ball valve, CSA certified to 200 psig. McGuire BV02.

2.12 SINKS, MOP

A. See Article 2.01 MATERIALS – GENERAL.

B. P-4:
   1. Fixture:
      a. One-piece, molded-stone, floor-mounted basin, 3 IN brass or stainless-steel drain body, removable dome strainer, vinyl or stainless-steel bumper guards on sides not adjacent to wall:
         1) Fiat MSB-3624, 600 x 900 mm24x36 IN.
   2. Faucet:
      a. Wall-mounted, combination service-sink fitting, two handles, fixed spout, integral vacuum breaker, 3/4 IN hose threads, adjustable wall brace, pail hook, flanged female adjustable arms with integral stops:
         1) Chicago Faucet 897.

2.13 SPARE PARTS

A. Provide two of each type of renewable cartridge, stem, and seat.

2.14 URINALS

A. See Article 2.01 MATERIALS - GENERAL

B. Urinal fixtures, general (Following general conditions apply unless detailed otherwise in specific descriptions):
   1. Fixture material: White vitreous china.
   2. Spud material: Brass.
   3. Floor-mounted fixtures: Provide bolt caps with retainers for exposed bolts.
   4. Nominal flush volume: 0.125 GPF.

C. P-2, Urinal, Sensor Operated, 120-volt:
   1. Fixture:
      a. Wall-hung, Ultra High Efficiency, DN20 3/4 IN top spud, 50 mm 2 IN outlet, elongated rim, integral trap, flushing rim:
         1) American Standard Plumbing Washbrook FloWise 6590.525.
      b. Fixture carrier: Hanger-plate type:
         1) Jay R. Smith Model 0637.
   2. Flushometer valve:
      a. Chrome finished brass, 300 mm 12 IN tall, 120 volt, sensor-operated diaphragm type with manual override feature, integral vacuum breaker, flush connection and spud coupling for 3/4 IN top spud, screwdriver back-check angle stop. Equipped with solenoid and sensor unit, wall cover plate for electrical gang box with tamper proof screws. Match flush volume to fixture requirements. Provide 120VAC/24VAC 50VA transformer:
         1) Sloan Optima Royal 186-0.13-ES-S TMO.

D. P-2A, Accessible Urinal, Sensor Operated, 120-volt:
   1. Fixture:
      a. Wall-hung, siphon jet, DN20 3/4 IN top spud, 50 mm 2 IN outlet, elongated rim, integral trap, flushing rim:
         1) American Standard Plumbing Allbrook 6541.132.
      b. Fixture carrier: Hanger-plate type:
         1) Jay R. Smith Model 0637.
   2. Flushometer valve:
      a. Chrome finished brass, 300 mm 12 IN tall, 120 volt, sensor-operated diaphragm type with manual override feature, integral vacuum breaker, flush connection and spud coupling for 3/4 IN top spud, screwdriver back-check angle stop. Equipped with solenoid and sensor unit, wall cover plate for electrical gang box with tamper proof screws. Match flush volume to fixture requirements. Provide 120 VAC/24VAC 50 VA transformer:
         1) Sloan Optima Royal 186-0.13-ES-S TMO.

2.15 WATER CLOSETS

A. See Article 2.01 MATERIALS – GENERAL.

B. Fixture carriers for wall hung water closets:
   1. Carriers consist of drainage fitting, faceplate, foot supports, closet coupling, and associated hardware.
   2. Style:
      a. Adjustable:
         1) Capable of being installed to accept accessible and standard-height closets at each carrier by adjusting only the face-plate position.
      b. Floor anchored.
   3. Material: Coated cast iron.
   4. Weight of construction: Institutional.
   5. Extension:
      a. When distance between carrier and closet exceeds manufacturer's recommended distance, provide longer closet coupling, longer fixture studs, and additional foot supports.
   6. Provide anchor foot assembly for single carriers.
   7. Closet couplings: Cast iron.
   8. Hardware:
      a. Provide hardware to assemble carrier and to mount fixture to carrier.
      b. Match hardware to fixture requirements.
   9. Finish on exposed parts: Chrome unless indicated otherwise in fixture description.

C. Water-closet fixtures, general (Following general conditions apply unless detailed otherwise in specific descriptions):
   1. Wall-hung closets: Provide fixture carriers.
   2. Bowls: Elongated.
   3. Color: White.
   4. Fixture material: Vitreous china.
   5. Spud material: Brass.
   6. Spud size: 1-1/2 IN.
   7. Nominal flush volume: 1.28 GPF.

D. Water-closet seats, general:
   1. Solid plastic.
   2. Color: Black.
   3. Resistant to scratching, stains, chemicals, and cleaning agents.
   4. Elongated-bowl style.
   5. Stainless-steel hinge pins, bolts, and hardware.
   6. Check hinges.

7. Integrally molded bumpers.

E. P-1, Public wall-hung, Sensor operated, 120-volt:
1. Fixture:
a. Wall-hung, siphon jet, top spud:
1) American Standard Plumbing Afwall FloWise 3351.128.
2. Flushometer valve:
a. Chrome finished brass, 12 IN tall, 120 volt, sensor-operated diaphragm type with manual override feature, integral vacuum breaker, flush connection and spud coupling for 1-1/2 IN top spud, 1 IN screwdriver back-check angle stop with tamper proof screws. Match flush volume to fixture requirements. Provide 120 VAC/24VAC 50 VA transformer:
1) Sloan Optima Royal 111-1.28-ES-S TMO.
3. Seat:
a. Open-front seat without cover:
1) Beneke Model 523 SS.

F. P-1A, Public wall-hung, Sensor operated, 120-volt, accessible:
1. Fixture:
a. Wall-hung, siphon jet, top spud:
1) American Standard Plumbing Afwall FloWise 3351.128.
2. Flushometer valve:
a. Chrome finished brass, 12 IN tall, 120 volt, sensor-operated diaphragm type with manual override feature, integral vacuum breaker, flush connection and spud coupling for 1-1/2 IN top spud, 1 IN screwdriver back-check angle stop with tamper proof screws. Match flush volume to fixture requirements. Provide 120 VAC/24VAC 50 VA transformer:
1) Sloan Optima Royal 111-1.28-ES-S TMO.
3. Seat:
a. Open-front seat without cover:
1) Beneke Model 523 SS.

2.16 UNDERSINK PROTECTIVE COVERS

A. Undersink protective covers, vinyl:
1. Material: Molded closed cell vinyl.
2. Minimum thermal conductivity at mean temperature:
a. $k \leq 1.17$, 75 degF.
3. Attachment method: Reusable snap clips or seamless pre-wrapped.
4. Service: Provide lock-lid access covers or openings for service of angle valves and cleanouts.

PART 3 - EXECUTION

3.1 GENERAL

A. Install fixtures in first class manner with proper connections to water, drainage and vent systems.

B. Install fixtures at manufacturer's suggested height unless noted otherwise.

C. Install fixtures in accordance with manufacturers' instructions.

D. See that proper grounds are set to form a secure base and an absolutely rigid setting for each fixture.

E. Provide guards and boxing as may be required to protect fixtures against damage from operations of other trades during construction.

F. Where pipes penetrate walls, floors, or ceilings, conceal penetrations with chrome escutcheons or stainless-steel plates.

G. Connect exposed traps and supply pipes for fixtures and equipment to rough piping systems at wall, unless otherwise specified.

H. Where plumbing fixtures abut to walls, floors, and countertops, seal with silicone-type sealant: See Section 07 92 16.

I. On flushometer valves with pipe supports, mount pipe support to wall two-thirds of flush-valve height above fixture spud.

J. Provide undersink protective covers on water supply and waste lines exposed beneath accessible fixtures.

3.2 FIXTURE CARRIER LEVELING

A. Level fixture carriers by shimming floor anchors with steel washers of varying thicknesses.

3.3 ACCESSIBLE FIXTURES

A. Install accessible fixture assemblies to meet requirements of accessibility installing standards (see Quality Assurance article in Part 1 of this section).

3.4 WATER-CLOSET FIXTURE CARRIERS

A. Install each carrier to accept accessible and standard-height water-closet installations so that future change from one height to the other can be accomplished by adjusting only the position of the face plate.

3.5 ADJUST AND CLEAN

A. Valves with adjustable temperature-limit stop: Adjust stop to deliver maximum 110 degF.

B. Remove dirt from fixtures, fittings and traps.

C. Secure escutcheons against wall.

END OF SECTION

SECTION 22 60 80
HIGH PURITY PLASTIC PIPING SYSTEMS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This Section includes requirements for procurement, fabrication, installation, and testing of high purity plastic piping systems:
   1. RO water distribution piping systems.
   2. DI water piping distribution piping systems.
   3. Connections to RO or DI equipment furnished by others, as indicated on the Drawings.

1.2 RELATED WORK

A. Refer to other Mechanical Specification Divisions in Division 20 for general mechanical requirements.

B. Refer to other Mechanical Specification Divisions in Division 20:
   1. Pipe hangers and supports.
   2. Piping identification.

1.3 SUBMITTALS

A. Shop Drawings.

B. Product Data:
   1. Submit valve cut-sheets indicating materials of construction, testing, and quality assurance procedures.
   2. Submit copies of valve ordering schedule for approval before ordering valves.
   3. Submit manufacturer's preshipment cleaning procedures for pipe, fittings, and valves for review and approval prior to ordering. Identify chemicals to be used in the cleaning procedures. Describe cleaning procedures in detail. Cleaning procedures shall comply with or exceed specified requirements.
   4. Submit a definitive plan for the provision of a temporary clean room facility to be used on the site for prefabrication of sections of piping system in preparation for installation. Submit a definitive plan for the provision of a temporary clean, dry and well maintained facility to be used on the site for prefabrication of piping spools in preparation for installation. This facility must have controlled environments of a minimum 55 degF to maximum 85 degF ambient temperatures.
   5. Submit Installation Quality Control and Field Quality Assurance procedures for review and approval by BNL prior to start of piping system fabrication.

1.4 QUALITY ASSURANCE

A. Follow requirements of ASME B31.3 Process Piping Code.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Pipe:
   1. GF Plastic Systems.
   2. Asahi.

B. Fittings:
   1. GF Plastic Systems.
   2. Asahi – extended legs on 2 IN and smaller.

C. Unions:
   1. GF Plastic Systems.
   2. Asahi.

D. Gaskets:
   1. RO Gaskets: EPDM.

E. Valves - Diaphragm:
   1. GF Plastic Systems.
   2. Asahi.

F. Valves - Zero Dead Leg one piece molded for PVDF Piping Systems:
   1. GF Plastic Systems.
   2. Asahi.

G. Valves - Check:
   1. GF Plastic Systems.
   2. Asahi.

H. Valves – Sample:
   1. GF Plastic Systems – 3/8 IN Type 525 Sample valve (PVDF systems).
   2. Asahi.

I. Valves – Pressure Relief:
   1. GF Plastic Systems.
   2. Asahi.
   3. Plast-O-Matic – RVT 000 V PF.

J. Regulators – Pressure:
   1. GF Plastic Systems.
   2. Asahi.

K. Gauge Isolators - PVDF:
   1. GF Plastic Systems - Type 523.
   2. Asahi.

L. Flow Meters – In-line type polypropylene or PVDF tube ends, polysulphone tube, PVDF float, EPDM O-rings, maximum working temperature 150 degrees F:
   1. GF Plastic Systems Type 801.
   2. Asahi.

2.2 PIPING, FITTINGS AND VALVES

A. General:
   1. RO water distribution is to be polypropylene (PP) material. 4-inch and smaller: 10 bar (150 psi) rated pipe and fittings.
   2. DI water distribution system is to be polyvinylidene fluoride (PVDF) material. 4-inch and smaller: 16 bar (232 psi) rated pipe and fittings.
   3. Purchase semiconductor grade prepared piping, fittings, and valves from the manufacturer. Materials shall be initially manufacturer cleaned, capped or sealed in a bag, and enclosed in a container to prevent contamination during shipment, and are to remain in “clean container” until fused into the system.

B. Piping:
   1. RO Water Distribution Fittings, and Valves: Fabricated of non-toxic virgin non-contaminating, natural unpigmented polypropylene, copolymer Type 2, sanitary type SDR 11 pipe.

2. DI Water Distribution Fittings, and Valves: Fabricated of virgin Solef®, a pure polyvinylidene fluoride (PVDF) homopolymer manufactured by Solvay & Cie S.A. of a type which will not introduce contamination into the ultra high purity water. Specifically, use raw materials in product manufacturing free of chemical additives, fillers, property enhancers and reinforcements, such as antioxidants, antistatic agents, colorants, flame retardants, heat stabilizers, lubricants, mold release agents, pigments, plasticizers, processing aids, ultraviolet stabilizers, and viscosity depressants. Internal surfaces shall comply with the following:
   a. Not more than 5 pores per 1300 sq. cm with no pore larger than 5 microns across.
   b. No visible flow lines in the interior.
   c. Nonfragmenting and smooth shouldered pores.
   d. Glass-like finish.

C. Piping, Fittings, and Valve Joints: Radiant heat (IR) butt-fusion, DI water distribution to be also Bead and Crevice Free (BCF) process in strict accordance with manufacturer's recommendations.

D. Valves Up to 2 inches:
   1. DI Water Distribution; PP body with EPDM diaphragm, butt-fused, with a position indicator
   2. DI Water Distribution; PVDF body with Teflon® diaphragm, butt-fused, with a position indicator.

E. Check Valves: Stainless Steel check valves shall be fully opening with external spring or arm.

2.3 CLEANING

A. General: Perform no operations other than those explicitly stated herein without the approval of BNL.

B. Chemicals: Low mobile ion and low particulate grade.

C. Nitrogen:
   1. Provide zero gas grade certified THC as CH_4 <0.5 ppm, 99.998 percent minimum purity.
   2. Alternatively, gas phase nitrogen drawn from a liquid nitrogen dewar can be used. The gaseous nitrogen so obtained shall be medical grade. Provide certification of compliance to BNL for each and every dewar.
   3. Filter gaseous nitrogen at the point-of-use, which is defined as being a maximum of 10 feet of interconnect piping between the filter outlet and the component being cleaned. Provide a Type 316L stainless steel filter housing assembly with a 0.2 micron absolute membrane filter cartridge.

D. Deionized Water:
   1. Rinse components with deionized water having a resistivity at point-of-use of not less than 10 megohm/centimeter. Provide an available continuous recording of water resistivity at point-of-use for review by BNL. Provide instrument calibration records to BNL.
   2. Filter DI water to 0.1 micron at the point-of-use, which is defined as being a maximum of 10 feet of interconnect piping between the filter outlet and the component being cleaned.
   3. Filters: Pall or Millipore filter housings with 316L stainless steel assemblies having an electropolished 10 microinch interior finish and an all Teflon® PFA or all metal membrane, membrane support, core, end caps, and seals. This filter unit may be used for water temperatures up to 80 degrees C (176 degrees F).
   4. Pipe: Fabricated of nonparticulating nonoutgassing material such as Perfluoro Alkoxy Fluorocarbon (PFA) and used for connecting the various gases to the distribution system for installation, cleaning, purging, and testing operations. Rubber will not be acceptable. Pipe selected requires BNL approval. Prior to use, rinse pipe with hot DI water and dry with nitrogen.

5. Draw samples of DI water at point of use at 24-hour intervals for determination of "viable organism count." Prepare 2 cultures from each of the samples taken using Millipore total count growth media and incubate for 48 hours at 28 degrees C. Stain cultures and count at 5X magnification.
6. Total viable organism count shall not exceed 10 per 100 milliliters for any sample assayed. If culture count exceeds 10 for any 1 sample from any sample interval, immediately discontinue use of said source of DI water. Do not use water source any further until quality is restored to specified level. Microbiological assay methodology is subject to review and approval by BNL.

E. Cleaning Materials and Equipment:
1. Suits: Full clean room garment, with separate head and foot covers, and tight-fitting at wrists.
2. Gloves: Powder-free, low-extractable, and high-strength design and manufacture, compatible with chemicals used. Design to provide flexibility, fit and strength, with cuffs of a reverse-taper design to insure a secure fit over clean room garment. Replace immediately if gloves become damaged or dirty.
3. Clean room lint-free wipes.
4. Polyurethane pipe sized pigs.
5. Soft nylon bottle type pipe brushes, stainless steel wire wound.
6. Nitrogen.
7. Clean workbenches.
8. Clean pipe caps.
9. Clean polyethylene bags.
10. PVC tape or tie wraps.
11. Polyethylene tubing.

F. Piping Inspection Procedure:
1. Immediately upon use at the site, visually inspect each and every length of pipe to assure the interior is free of stains, discoloration, oils, residue, impurities, damaged ends, warping, cracks and signs of mishandling. Mark rejected pipe with a red tag and immediately remove from the job site.
2. Store accepted pipe, fittings, and valves in their bagged condition in a separate, clean, well-maintained room. Use racks and bins to keep material organized and off floor.

G. Cleaning of contaminated Pipe, Fittings, and Valves: Installer shall be responsible for the cleanliness integrity of the system as specified. Cleaning is only required on contaminated materials. Cleaning shall be as follows:
1. Rinse the pipe with filtered high purity DI. Use filtered DI water once only and discard:
   a. If approved by BNL, on-site DI water may be available to the installer for rinsing PVDF piping spools.
   b. Prior to connecting to an existing DI water source for rinse up the installer must submit temporary piping schematics to BNL QAR / Contamination Control for final approval.
   c. The cost of materials and labor for temporary rinse stations shall be borne by the installer.
2. Dry the pipe filtered Nitrogen to remove residual moisture.
3. Immediately seal pipe ends with clean plastic caps.
4. Cover pipe ends with small polyethylene bags and secure with PVC tape. Do not allow tape to adhere to the pipe, only the bag.

2.4 PACKAGING AND SHIPPING AT MANUFACTURER

A. Pipe:
1. Immediately following the drying step, securely bag the ends of each pipe length in 6 mil polyethylene bags and place a hard plastic cap over polyethylene bagged ends.
2. Package piping in heat-sealed polyethylene bags to maintain purity, finish, and ovality. Securely package the bagged piping for shipment to the site. Do not use cardboard boxes or loose packing materials such as Styrofoam pieces for packing of piping.

3. All piping shall be properly supported to prevent ovality problems during shipping.

B. Fittings: Supplied by the manufacturer in a cleaned condition in accordance with the approved procedures. Immediately upon completion of cleaning operation double package each fitting separately in heat-sealed polyethylene bags.

C. Valves: Supplied by the manufacturer in a cleaned condition in accordance with approved procedures and individually packaged in heat-sealed polyethylene bags for shipment.

PART 3 - EXECUTION

3.1 FACILITIES

A. Perform subassembly fabrication operations in a separate, temporary facility located either in installer's on-site shop or within the building. As a minimum, the facility must be a clean, dry and well-maintained area. A controlled 55 degF (min) to 85 degF (max) ambient environment is required for fabrication.

3.2 COMPONENTS

A. Upon delivery to the site, store valves, fittings, and pipe in a clean, dry, well-maintained environment. Store material in the original shipping containers. Open containers only as components are used.

3.3 TOOLS AND EQUIPMENT

A. Provide clean, dedicated tools for piping system fabrication and installation, keep separate from other tools, and use exclusively for working on the piping system.

B. Clean tools at the start of each shift with IPA/DI water solution, and dry with pure, filtered nitrogen.

3.4 WORKMANSHIP

A. In addition to approved procedures and provisions stipulated in the installer's "Field Quality Assurance Program," the following procedures shall apply:
   1. Conduct qualification tests for the fusion equipment and the fusion operators prior to the start of system fabrication. Conduct tests with the fusion system manufacturer's (e.g. George-Fisher / Asahi IR-Fusion Testing Representative for IR-Butt fusion operator qualifications), representative present and subject to approval by the manufacturer and BNL.
   2. Submit a duplicate of the manufacturer's published operating instructions for the use of the radiant heat butt fusion equipment to BNL for review and approval.
   3. A sample radiant heat butt-fusion joint shall be made up by each fitter for each pipe diameter to be used, for both vertical and horizontal weld orientations. Submit sample joints to BNL for inspection prior to the start of the project. The BNL shall compare the joint quality with high-quality welds produced by manufacturer.
   4. The BNL reserves the right to suspend fusion operations via Construction Management for noncompliance with specified procedures or standards.
   5. BNL reserves the right to request the removal of any system joints deemed substandard or otherwise unacceptable. The acceptable IR weld criteria shall be:
      a. Uniform double beads on pipe OD. The complete absence of one bead (half) or the other, no matter how slight is cause for rejection.
      b. Weld will have no offset or joint misalignment greater than 10 percent of pipe wall.
      c. No angular deviation, due to misalignment.
      d. No visible inclusions or voids within the parallel lines of the wall thickness.
      e. The mid-point of the double bead shall never be less than or compromise the wall thickness.
      f. The pipe or fitting exteriors must show no evidence of slippage in the clamps or the fusion machine. This condition is not acceptable regardless of bead formation.

6. Random field samples will be checked by BNL for excessive and/or thin wall anomalies. Refer to PVDF Permissible Variation / Physical Dimensions Chart for tolerances.
7. The installing/IR-Operator shall perform 100% inspections on all personally made fusion joints.
8. BNL shall inspect and sign off 100% of all PVDF/PP IR-Fused joints.

3.5 PROCEDURES

A. Do not locate or use flux plastic primer/cement compounds near the piping system work area.

B. Fitters and helpers involved with the fabrication and installation of the piping system shall wear non-soiled apparel and clean latex gloves at all times.

C. Valves and fittings shall be used immediately upon being individually unpacked. No further attempt at cleaning shall be made.

D. Protect piping system components from contamination at all times. Replace any system component contaminated during fabrication and installation with a new, clean item. Do not attempt to re-clean contaminated components in the field unless authorized by BNL.

E. Maintain valves, fittings, and pipe under clean, dry, dust-free conditions to the greatest extent possible when the internal aspects of the components are exposed to the environment.

F. Immediately process each lot of pipe arriving at the site as follows:
   1. BNL shall randomly inspect samples of pipe. Acceptance of each lot by BNL is required prior to utilization of pipe.

PVDF Permissible Variation / Physical Dimensions Chart

Nominal Sizes Standard / Metric		Outside Diameter	Nominal Wall Thickness	Wall Thickness Tolerance
½ IN	20 mm	0.787	0.0745	+ 0.12 / - 0
¾ IN	25 mm	0.987	0.0745	+ 0.12 / - 0
1 IN	32 mm	1.260	0.0945	+ 0.12 / - 0
1 ¼ IN	40 mm	1.575	0.0945	+ 0.12 / - 0
1 ½ IN	50 mm	1.969	0.118	+ 0.12 / - 0
2 IN	63 mm	2.480	0.118	+ 0.12 / - 0
2 ½ IN	75 mm	2.953	0.142	+ 0.16 / - 0
3 IN	90 mm	3.543	0.169	+ 0.20 / - 0
4 IN	110 mm	4.331	0.209	+ 0.24 / - 0
5 IN	140 mm	5.512	0.174	+ 0.24 / - 0
6 IN	160 mm	6.300	0.193	+ 0.28 / - 0
8 IN	200 mm	7.874	0.244	+ 0.32 / - 0
9 IN	225 mm	8.858	0.275	+ 0.36 / - 0

   2. The taking of pipe samples shall comply with the procedures as specified in Part 2. It is essential that the sampling procedures in no way compromise the cleanliness of the pipe.

3.6 FABRICATION

A. Pay strict attention to progress of assembly to ensure that system ends and components are not left exposed to the environment when work is not in progress.

B. Prior to joining long runs or subassemblies together in final location environment (e.g. when two separate pipe runs meet for final connection), the surrounding ambient environment must be under temperature control at 70 degrees F, plus or minus 5 degrees F. Prior to final connections, the HVAC system should be in operation for ambient temperature control. If HVAC is still under construction, final connections must be postponed until such, or installer may submit for BNL approval, a definitive plan for ambient temperature control up to the time of normal HVAC operations.

C. Whenever field fabrication / installation is required in non-controlled / non-protected areas, the installer is required to protect the area of the fusion joint from adverse weather conditions. The permitted material and equipment ambient temperature range for IR-Fusion joining is between 50 F and 90 F. Outside this range, suitable action shall be taken to ensure that these conditions are maintained. Materials shall be at surrounding ambient temperatures prior to IR-fusion welding.

D. Cleanrooms and areas of strong air currents are of particular importance for IR-Welding. Due to the non-contact heating method of the fusing system, any stray air current can interfere with the radiant heat transfer process. Therefore, air currents must be addressed by the installer, i.e:
   1. Shield the IR welder to prevent any drafts from interfering with the IR heater plate.
   2. Place approved tape over the clamping halves to prevent air from entering the small gaps between the two halves.
   3. Close off holes in the IR end caps since the holes may allow enough air infiltration to interfere with the weld.
   4. Whenever possible, move the IR welder away from direct air currents prior to IR welding.
   5. All fittings and pipe ends must be covered prior to IR welding. Note: This applies to all ambient conditions.

E. Piping shall be set on hangers/racks to adjust to the ambient temperature environment prior to final field joining of long runs or subassemblies.

F. For weld traceability provide a fusion log on each fused joint noting joint number, date, and operators' name. Logs shall be turned over to BNL at the end of the project for project archiving.

G. A thermal transfer printed label shall be placed beside the actual joint on the pipe / fitting and/or valve. Labels shall be made of white polyester and acrylic adhesive type material. Labels shall be High Purity labels for cleanroom and standard quality for non-cleanroom applications. HP labels must resist against: high temp (140 C/ 280F), 95% humidity, IPA cleaning agents and UV-rays. The IR fusion machine must interface with a printer to create a unique number identifying the IR machine, date, joint number, process status, plus designation for operator and QA/QC signatures. This information shall be recorded on each label.

H. The installing tradesman shall inspect all PVDF materials prior to installation. Using a white light source, materials shall be inspected for OD & ID surface imperfections, i.e. pits, scratches, stains, residues and discoloration. Surface or sub-surface anomalies within 1/4" of the fusion ends and/or any deficiency which compromises the wall thickness or integrity of the material shall be rejected and removed from the job-site. PVDF material anomalies discovered in the field by the installer and/or BNL; shall be recorded in a report generated by the installer and transmitted to BNL.

3.7 JOINTS

A. Radiant Heat Butt /Fusion: Make up in strict accordance with manufacturer's instructions.

B. Threaded: Use only at equipment connections. Make up with PTFE tape using no more than 2 wraps, beginning at large end of threads, wrapping toward small end, leaving 2 end threads exposed. Sealant material other than 100% pure PTFE tape will not be acceptable. Use Fluoroware 100 percent pure PFTE teflon tape or an approved equal.

C. Joints on long straight runs of piping may be flanged at no less than 40 foot intervals in buildings and tunnels.

3.8 VALVES - MAINS, SUBMAINS, BRANCH, SAMPLING AND VENTS

A. Locate valves and in-line piping specialties to be readily accessible for operation and maintenance. Provide unions, flanges, or flaretek hose connections at equipment and work station connections or at other in-line locations requiring maintenance as indicated on the Drawings.

B. Provide Millipore or GF Plastics sampling valves as indicted on the Drawings. Sampling valve protection may be required. Use PVDF Zero Dead Leg (ZDL) style socket x 3/8 FPT style valve for all sampling ports for DI systems.

C. Install piping system to prevent or minimize high points which may prevent complete system venting. Where high points are unavoidable, use PVDF Zero Dead Leg (ZDL) style socket x 3/8 FPT style valve for venting.

D. Provide one of the following methods to limit dead leg lengths on branch mains and equipment branch lines:
   1. Install zero dead-leg valves.
   2. Install in-line valves to limit dead leg length to a maximum of six (6) internal pipe diameters.

E. All zero dead-leg valves (up to 4 inch x 2 inch) shall have a full size +GF+ union IR-welded directly downstream of the valve (male union half next to valve). Reducers shall be placed downstream of unions for desired line size requirements.

F. All zero dead-leg valves designated for future tool-hookup and/or branch-line capped for futures shall have male union halves IR-welded directly downstream of the valve. A white ¼" polymer blank insert shall be placed between the male/female union body halves and hand tightened. The union shall then be double poly-bagged and taped with cleanroom approved tape for contamination control. Minimize tape contact with PVDF tube, fittings, and valve assemblies.

G. Within the fusion area, the component and tube to be jointed shall have the same wall thickness with a maximum permissible wall displacement of 10%.

3.9 HANGERS

A. Securely support piping with cushioning to prevent swaying and vibration, allowing the pipe to move when thermal expansion and contraction occurs. Install supports at no greater than the following intervals:

Maximum Support Spacing for Hangers	
Nominal Pipe Size (inches)	Max. Spacing (feet)
1/2, 3/4 and 1	3.0
1-1/2 and 2	4.0
3 and 4	4.0
6	7.0
8 and larger	7.5

B. The above spacing requirements are based on piping carrying fluid at 68 degF operating temperature, where, due to operating conditions, manufacturers support spacing dimensions are less than those listed above, manufacturer's requirements take precedence. As an alternate, provide continuous vee channel support with vee bottom clevis hangers at 10 ft spacing.

C. Where pipe is installed outdoors or where temperature changes may occur, supports shall be fabricated and installed to allow for pipe movement due to thermal expansion, allowing supports to act as guides rather than attaching the pipe rigidly at each hanger.

D. Unless noted otherwise, thermal growth for plastic pipe is 1 inch per 10 degrees F temperature change per 100 feet. Evaluate the system for the requirement for and location of expansion loops, anchor points, and pre-stressing of piping in conjunction with the manufacturers recommendation and BNL. Locate any takeoff valves and branch lines, so that there is no interference when these lines move due to thermal expansion.

E. Install piping in strict accordance with manufacturer's recommendations.

3.10 FINAL TEST PROCEDURES

A. Pipe System:
   1. Test fluid:
      a. RO piping shall be RO water filtered to 0.2 micron absolute for all process lines.
      b. DI piping shall be semiconductor grade deionized water filtered to 0.2 micron absolute for all process lines.
   2. Pressure test piping hydrostatically.
   3. Fill the piping system with water, opening all valves and ports to purge system of air.
   4. For piping systems apply 125 psi pressure water using a hydro pump for 4 hours. Bring piping system to pressure in 25% increments, allowing the system to stablize. Note leaks if any, release pressure, and remove water by purging with specification-grade nitrogen.
   5. Take special care when repairing leaks. Remove fragments and particulate matter produced during joint preparation. Repair leaks, resume test.
   6. Recharge piping system and maintain 125 psi test pressure for a period of 4 hours with no decay.
   7. Tests shall be witnessed by BNL.
   8. Check system to assure compliance with flow requirements.
   9. Check all controls and alarms to assure proper operation.
   10. Unless a constant recirculation can be achieved through the piping system or piping segment that is being pressure tested, open valves and ports, drain and blow dry the system using filtered Nitrogen upon completion of the pressure test(s). At the completion of all pressure tests on the system, proceed with the sterilization of the system. Disinfection shall be witnessed by BNL.
   11. At the completion of the disinfection procedure, proceed with Final Purity Testing.

B. Final Purity Testing shall be carried out by the installer and witnessed by BNL. Testing methodology shall be in accordance with this section.

C. Taking Samples:
   1. Flush sample ports for a minimum of 10 minutes before taking samples.
   2. Following each port flush, rinse sample containers with 4 times container volume of sample to be tested.
   3. Avoid contact with the container neck when filling containers and drawing test samples.

D. Sample Stations Locations:
   1. Inlet & outlet of the water purification equipment.
   2. Mid-stream in the supply and return pipe system.
   3. As indicated on the Drawings.

E. Contractor shall run the following tests on each sample at weekly intervals over 30 days for compliance with purity specification:
   1. Conduct resistance test on site. All sample stations shall meet 18 megohm-cm at 25 degrees C. Instrument shall provide a direct readout in megohm-cm at 25 degrees C using a flow-through cell.

2. Draw 3 samples of DI water at points noted above for determination of "viable organism count." Prepare 2 cultures from each of the 3 samples taken in Millipore total count growth media and incubate for 48 hours at 28 degrees C. Stain cultures and count at 5X magnification.
3. Total organic carbon (TOC) using an Anatel TOC analyzer, Model A-1000.
4. Particulate testing using on-line particle counter.
5. Total silica ($Si0_2$) per Scientific Instruments CFA 1000.
6. Sodium (Na) per ASTM-D3561 or Ion Chromatography.

3.11 STERILIZATION

A. Conduct sterilization process after water purification system and end use equipment are operational and the piping system has been pressure and leak tested. Do not install Ion Exchange resin, filters and RO membrane elements, and other chemically sensitive equipment until after sterilization is complete.

B. Consult with BNL to schedule sterilization date.

C. Give the BNL at least a 4 day notice that sterilization will be done.

D. Lock out automatic and manual electric circuits, and shut and tag out feed valves to the system. Remove or isolate all sensitive instrumentation.

E. Persons performing this operation must use proper PPE as outlined in the chemical's Material Safety Data Sheet (MSDS).

F. Do not work alone. Work in pairs!

G. The following safety equipment must also be available: Scott air packs, ladders, exhaust fan, safety harness, life line, domestic water, hose for washdown, and a backup person with a radio, if required.

H. Pump 500 ppm Paraoxyacetic acid into the DI supply line to the polish system and downstream distribution/recirculation loop for 4 hours.

I. Open and close outlets and sample ports each hour for 2 minutes.

J. At the end of the 4-hour recirculated period contact BNL to determine proper drain/disposal method. When draining the system, the disinfection solution may need to be diluted with domestic water.

K. Open valves, unlock electric currents, and flush with semiconductor grade deionized water filtered to 0.2 microns absolute until the disinfection solution is below detection upon sampling.

L. Follow ASTM-F60 to determine the bacterial population. This analysis requires the use of a Millipore MHBG03700 bacteriological filter disk with incubation of 24 hours using Pseudomonas specific isolation agar. Bacterial population of the outlet water shall not exceed that of the water entering the system.

M. Install ion exchange resin, filters, and RO membranes, furnished by others.

N. Rinse or flush newly installed system components and system piping with semiconductor grade DI water filtered to 0.015 micron, absolute.

O. Continue rinsing until accepted by BNL.

P. At the completion of the sterilization process, place the semiconductor grade deionized water on line with equipment in operation and with the distribution piping system in recirculation mode.

3.12 QUALITY ASSURANCE FOR DI WATER

A. Semiconductor grade deionized water shall meet or exceed the following:

Parameter	Value	Procedure
Resistivity	18.2 Megohm-cm @ 25°C, min.	ASTM-D1125
Bacteria	<1 CFU/1000 ml	ASTM-F60
Particles (> 0.2 µ)	<55 /liter, max.	PMS On-line particle counter
Total Organic Carbon	< 5.0 ppb, max.	Anatel A-1000 on-line
Silica (dissolved)	<3.0 ppb, max.	Scientific Instruments CFA 1000
Sodium	< 0.02 ppb, max.	Ionic and metallic species to be determined by IC, ICPMS, AA
Chloride	< 0.04 ppb, max.	ASTM-D512 or ion chromatography
Boron	<10 ppb	Ion chromatography

B. Test samples shall be taken and tested by BNL.

C. Installer shall be held responsible to meet deionized water quality specifications. Additional sterilization and testing procedures necessary to meet quality specification criteria shall be provided by the installer at no additional cost to BNL.

END OF SECTION

SECTION 22 61 13
LABORATORY AIR SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section includes the equipment requirements for the clean dry compressed air (CDA) systemfor the laboratories. Compressed air is supplied from the BNL Site Compressed Air system:
   1. Air receiver and accessories.
   2. Dewpoint monitor.
   3. Air distribution piping.
   4. Pressure reducing valves.
   5. Air filters.

B. Refer to the Drawings for work covered by these specifications.

1.2 QUALITY ASSURANCE

A. The laboratory air system components shall provide instrument quality compressed air, in accordance with ANSI ISA 7.0.01 Quality Standard for Instrument Air.

1.3 RELATED WORK

A. Refer to other Mechanical Specification Divisions for general and special mechanical requirements.

B. Work of other Mechanical Specification Divisions:
   1. Welding and brazing requirements.
   2. Plumbing systems.
   3. Pipe hangers and supports.
   4. Piping and equipment identification.
   5. Process piping systems.

1.4 SUBMITTALS

A. Product Data:
   1. Provide data for receiver, dewpoint monitor, pressure reducing valves, piping, fittings and valves.
   2. Performance data.
   3. Physical dimensions and weight data.
   4. Piping diagrams, and field connections.
   5. Electrical and controls wiring data, and field connections.

B. Contract Closeout Information:
   1. Operating and maintenance data.
   2. BNL instruction report.
   3. Warranty.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Air receivers:

a. Base: Hanson Tank.
b. Optional:
1) Silvan Industries.
2) Manchester Tank.

2. Air dewpoint monitor:
a. Base:
1) Van Air Systems.
b. Optional:
1) EdgeTech Moisture and Humidity System.
2) Pneumatic Products.
3) Deltech.
4) Gardner Denver.

3. Pressure reducing valves:
a. Base: Arrow Pneumatics.
b. Optional:
1) Hankinson Corp.
2) Ingersoll Rand.
3) Watts Fluid Air.

4. Air filters:
a. Base: Arrow Pneumatics.
b. Optional:
1) Hankinson Corp.
2) Ingersoll Rand.
3) Watts Fluid Air.

2.2 AIR RECEIVER

A. Provide steel air receiver(s) as shown on the drawings.

B. Receivers shall be suitable for a maximum working pressure of 150 PSIG, and shall be furnished with ASME stamp and certification papers.

C. Floor mounted receivers shall be provided with steel support legs or skirt, designed for bottom of tank 12 IN above floor, and suitable for the applicable seismic zone.

D. Receivers shall be internally lined with a combination epoxy and polyamide-type resin; Plasite 7133 or approved equal. Receiver exterior shall be sandblasted, primed and painted with a coat of machinery enamel.

E. Provide the following accessories:
1. Manway.
2. Flanged inlet and outlet nozzles.
3. NPT drain nozzle:
a. Include an automatic electric stainless steel condensate drain valve assembly with timer (ASCO CDVA, 1/2 IN, 120V, 60 Hz or equal) for each receiver.
4. NPT relief valve nozzle:
a. Include an ASME pressure relief valve on each receiver, capable of relieving the total system rated capacity at the set pressure of 175 PSIG.
5. NPT pressure gauge nozzle:
a. Include a pressure gauge, with isolation valve, with 0-200 PSIG range.
6. Sight glass.
7. Lifting lugs.
8. Nozzle gaskets (EPDM).

F. Nameplates: Each receiver shall be supplied with a 316L stainless steel equipment identification label mounted on a raised flat surface permanently attached to the receiver.

G. Spare parts: Provide one spare gasket for all manways and nozzles.

2.3 DEWPOINT MONITOR

A. Self contained unit, complete with interconnecting control wiring. The unit shall be packaged ready for mounting with a single sensor installed in piping, single point communication connection and single-point electrical power connection.

2.4 PIPING SYSTEM

A. For skid piping and valve requirements, refer to specification section 22 67 19.

2.5 PRESSURE REGULATING VALVES

A. Regulators shall be inline type with regulated pressure range of 5 to 125 PSIG and be provided with adjusting screw, tamper proof cap, integral pressure gauge.

2.6 PARTICULATE FILTERS

A. Filters shall be inline type coated aluminum body with threaded ends, metal bowl, sight glass, manual drain valve, Buna-N seal, differential pressure gauge, 1 micron absolute pleated fiber element. Rated for 250 psig maximum pressure. Size based upon a 1 psig clean pressure differential at 100 psig.

2.7 PRESSURE GAUGES

A. Pressure Gauges: Weksler Royal Gauge Type AA14Y, phosphor bronze bourdon tube material, 0 to 160 psig dial range, 20 psi figure intervals, 1/4 IN diameter bottom connection, with level handle cock Type A12.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. General: Install equipment as indicated on the drawings, and in strict accordance with the manufacturers written instructions.

B. Install equipment on 4 inch high concrete pad.

END OF SECTION

SECTION 22 62 13
PROCESS VACUUM SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section includes the equipment requirements for the Process Vacuum (PV) system:
   1. Packaged vacuum skids.
   2. Vacuum receiver.

B. Refer to the Drawings for work covered by these specifications.

1.2 QUALITY ASSURANCE

A. All process vacuum system components shall be furnished by a single supplier.

1.3 RELATED WORK

A. Refer to other Mechanical Specification Divisions for general and special mechanical requirements.

B. Work of other Mechanical Specification Divisions:
   1. Welding and brazing requirements.
   2. Insulation.
   3. Plumbing systems.
   4. Pipe hangers and supports.
   5. Piping and equipment identification.
   6. Process piping systems.

1.4 SUBMITTALS

A. Product Data:
   1. Performance data.
   2. Physical dimensions and weight data.
   3. Vibration and acoustical data.
   4. Piping diagrams, and field connections.
   5. Electrical and controls wiring data, and field connections.

B. Contract Closeout Information:
   1. Operating and maintenance data.
   2. BNL instruction report.
   3. Warranty.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Process vacuum skids – oil-less claw:
      a. Base:
         1) Busch.
      b. Optional:
         1) BeaconMedaes.
         2) Rietschle.

2. Vacuum receivers:
   a. Base:
      1) Hanson Tank.
   b. Optional:
      1) Silvan Industries.
      2) Manchester Tank.
3. Vacuum gauges:
   a. Base:
      1) Weksler.
   b. Optional:
      1) Ashcroft.
      2) Trerice.
      3) Weiss.

2.2 PACKAGED PROCESS VACUUM SYSTEM – OIL-LESS CLAW

A. General: Furnish a packaged system consisting of vacuum pump(s), receiver, controls, and all necessary accessories factory assembled and piped, requiring only a single-point connection of electrical, and drain piping to begin operation.

B. Vacuum pumps:
   1. Oil-less Claw type, sealed oil lubricated, air cooled.
   2. Rating: deliver scheduled capacity at site elevation above sea level.
   3. Mount pumps on horizontal tank with vibration isolation supports.
   4. Provide initial charge of lubricating oil.

C. Receivers:
   1. Horizontal, ASME code stamped and rated for full vacuum to 200 PSIG.
   2. Provide vacuum gauge and transmitter on receiver.
   3. Provide automatic “block-and-bleed” drain.

D. Controls:
   1. Provide integral control system to start and stop lead vacuum pump to maintain system set point vacuum. Lag pump shall start if lead pump fails to maintain vacuum.
   2. Lead pump shall be time alternated.
   3. Provide NEMA 4 enclosure, transformers, motor starters, motor overload and short circuit protection devices, pump hand-auto-off control switches and indicating lights and other devices required for system operation. Power and control sections shall be appropriately separated.
   4. Provide outputs to BNL’s building management system for system pressure and vacuum pump fault.
   5. Provide run time meter for each pump with panel-mounted display.

E. Factory wiring of all components to motor starters and control panels is required and shall be in accordance with Division 16 requirements.

2.3 VACUUM RECEIVER

A. Provide horizontal steel vacuum receiver(s) as shown on the drawings.

B. Receiver shall be suitable for a full vacuum to 200 PSIG working pressure, and shall be furnished with ASME stamp and certification papers.

C. Receiver shall be provided with steel support legs for floor mount, designed for bottom of tank 6 IN above floor, and suitable for the applicable seismic zone.

D. Receiver shall be internally lined with a combination epoxy and polyamide-type resin; Plasite 7133 or approved equal. Vessel exterior shall be sandblasted, primed and painted with a coat of machinery enamel.

E. Provide receiver with the following accessories:
   1. Manway.
   2. Flanged inlet and outlet nozzles.
   3. NPT drain nozzles.
   4. NPT pressure relief valve nozzle.
   5. NPT vacuum gauge nozzle:
      a. Include a vacuum gauge, with isolation valve, with -30-0 INHG range.
   6. Lifting lugs.
   7. Nozzle gaskets (EPDM).

F. Nameplates: Each receiver shall be supplied with a 316L stainless steel equipment identification label mounted on a raised flat surface permanently attached to the receiver.

G. Spare parts: Provide one spare gasket for all manways and nozzles.

2.4 PIPING SYSTEM

A. For skid piping and valve requirements, refer to specification section 22 67 19.

2.5 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

2.6 VACUUM GAUGES

A. Vacuum Gauges: Weksler Royal Gauge Type AA14Y, phosphor bronze bourdon tube material, 4-1/2 IN dia. white dial, 30 IN - 0-15 psig dial range, 5 IN and 3 psi figure intervals, 1/4 IN diameter bottom connection, with lever handle cock Type A12.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. General: Install equipment as indicated on the drawings, and in strict accordance with the manufacturers written instructions.

B. Install equipment on vibration isolation bases where specified elsewhere in the construction documents.

C. Install vacuum pump exhaust piping with drip leg and drain valve, terminate to a safe location outside the building.

3.2 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

END OF SECTION

SECTION 22 63 13
SPECIALTY GAS SYSTEMS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This Section covers materials, installation, and testing of specialty gas systems.

B. Specialty gas systems include these cylinder or dewar source systems:
   1. Argon (Ar).
   2. High Purity Nitrogen (HPN2).
   3. Carbon Dioxide (CO2).
   4. Carbon Monoxide (CO).
   5. Helium (He).
   6. Argon/Helium Mixture (ArHe).
   7. Silane (SiH4).
   8. Hydrogen (H2).
   9. Ammonia (NH3).
   10. Methane (CH4).
   11. Oxygen (O2).
   12. Specialty Gas (SG) – BNL defined.
   13. Laboratory Compressed Air (LA) – From cylinder.

C. Scope includes:
   1. Gas panels.
   2. Specialty gas piping and valves.

1.2 RELATED WORK

A. Refer to Mechanical Specification Divisions under Division 20 for the following:
   1. Pipe hangers and supports.
   2. Piping and equipment identification.
   3. Laboratory equipment.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Equipment drawings, showing materials of construction, features, and installation details.
   2. Submit piping system routing drawings and details prior to any material installation.

B. Product Data:
   1. Valve cut-sheets indicating materials of construction, leak rates, surface finish, testing and quality assurance procedures prior to ordering valves. Comprehensive reliability data (leak rate vs. service time) shall be provided.
   2. Manufacturer's preshipment cleaning and packaging procedures for tube, fittings, and valves, along with samples thereof, prior to ordering. Identify chemicals to be used in the cleaning procedures. Describe cleaning procedures in detail. Cleaning procedures shall comply with or exceed specified requirements.
   3. Catalog information pertaining to automatic tube butt-welding system proposed for use.
   4. A definitive plan for the provision of a temporary clean room facility to be used on the site for prefabrication of sections of piping system in preparation for installation.
   5. Installation Quality Control and Field Quality Assurance procedures for review and approval by BNL prior to start of piping system fabrication.

C. Contract Closeout Information:
   1. Operations/Maintenance Manuals:
      a. Submit for BNL's use, complete operating and maintenance manuals that describe proper operating procedures, maintenance and replacement schedules, component parts list, and closest factory representative for components and service.

1.4 PACKING AND SHIPPING REQUIREMENTS

A. All products must be delivered with appropriate manufacturer's quality assurance documentation stating, materials composition; mill test reports; certification of conformance report; testing and compliance with leak rate specifications.

B. Gas panels, valve manifold boxes, regulators, and gauges shall be cleaned, packed, and shipped per manufacturer's standard procedures.

C. Piping:
   1. Piping ends shall be sealed with 1.75 mil Aclar 33C wrap and low residue clean room tape under purged Nitrogen or Argon, then protected with hard plastic end cap.
   2. Piping shall be double bagged in heat sealed 6-mil polyethylene bags.
   3. Pipe shall be properly supported to prevent ovality and distortion problems while being shipped.

D. Fittings: Immediately double package upon completion of cleaning operation each fitting separately in heat-sealed polyethylene bags purged with 0.01 um absolute filtered Nitrogen or Argon.

E. Valves: Supplied by the manufacturer in a cleaned condition in accordance with approved procedures and individually double packaged in heat-sealed polyethylene bags purged with 0.01 um absolute filtered Nitrogen or Argon for shipment.

1.5 QUALITY ASSURANCE

A. Follow requirements of ASME B31.3 Process Piping Code.

PART 2 - PRODUCTS

2.1 INERT GAS PANELS – AUTOMATIC SWITCHOVER

A. Acceptable manufacturers:
   1. Base:
      a. Matheson - SwitchPro.
   2. Optional.
      a. Air Products.
      b. Praxair.

B. The inert gas panel design is based on a self-contained, manifold package consisting of a sheet metal panel with all piping and fittings, flex hoses, filters, sensing devices, purifiers, and mounting hardware for safe automatic delivery of non-hazardous gases to the process use points.

C. The inert gas panel assemblies are designed for cylinder gas pressure regulation and control of 2 inert gas cylinders, one in use and one in standby.

D. The assemblies are designed for isolation of gas cylinders for cylinder changeover and new cylinder purge.

E. Inert gas panels shall have provisions for auto-switchover to the standby gas cylinder, allowing continuous, uninterrupted delivery of gas.

F. Piping:
   1. Refer to tubing and device requirements in this specification section.

2. All piping, piping manifolds, and piping components shall meet the following as a minimum:
    a. The final outlet isolation valve shall have a 1/2 IN female VCR fitting on its outlet side.

G. Control system:
1. Controllers: The inert gas panel controllers shall be of modular design allowing for easy maintenance and modification, including the following:
    a. Stand-alone capabilities to allow independent operation without the gas management system.
    b. History of events retention during loss of communication with the gas management system and automatic upload of process data when communications are restored.
    c. Easily removed or replaced for maintenance.
    d. Configurable from the gas management system and locally at the controller.
    e. Remote interface capabilities for communications link to gas management system.
    f. Local lockout of non-emergency remote control functions.
    g. User programmable parameters.
2. The inert gas panel controllers shall activate automatic shutdown on the following conditions:
    a. Overpressure downstream of regulator (regulator diaphragm failure).
    b. Excess gas flow.
    c. Detection of seismic activity per local, state and federal regulations.
3. The inert gas panels shall activate local audible/visual alarms on the following conditions:
    a. Low process cylinder pressure or weight.
    b. Low purge cylinder pressure.
    c. Auto shutdown/remote shutdown.
4. The inert gas panel controllers shall be fail safe by interrupting gas supply and closing all supply valves in the event of loss of electrical power or pneumatic pressure.
5. Each inert gas panel controller shall include:
    a. Independent alarm and shutdown capability through hardwired systems from external control signals.
    b. Externally mounted emergency stop buttons.

H. Electrical:
1. Inert gas panels shall be designed to operate on 120 VAC.
2. Provide RFI protection and/or shielding from RF interference a distance of one foot from the controllers from sources listed below:
    a. Two-way radio (walkie-talkie) transmission: 900 MHz, up to 4 watts energy output.
    b. Orbital Welding Equipment: 1 to 10 MHz, up to 25 kV voltage output.
3. Single grounding point shall be provided per equipment.

I. Instrumentation:
1. All wetted instrument elements shall be cleaned for high purity gas service, prior to installation. CFC based cleaners are not allowed.
2. All pressure transducers shall be gauge type. Pressure transducers shall be provided to monitor the following points as a minimum:
    a. Process gas; high pressure side.
    b. Process gas; delivery pressure.
    c. Vacuum pressure side.

2.2 INERT GAS PANELS – SINGLE CYLINDER

A. Acceptable manufacturers:
1. Base:
    a. Matheson – PAN-5100.
2. Optional:
    a. Air Products.
    b. Praxair.

B. The inert gas panel design is based on a self-contained, manifold package consisting of a sheet metal panel with all piping and fittings, flex hoses, filters, sensing devices, purifiers, and mounting hardware for safe automatic delivery of non-hazardous gases to the process use points.

C. The inert gas panel assemblies are designed for cylinder gas pressure regulation and control of 1 inert gas cylinder.

D. Piping:
   1. Refer to tubing and device requirements in this specification section.
   2. All piping, piping manifolds, and piping components shall meet the following as a minimum:
      a. The final outlet isolation valve shall have a 1/2 IN female VCR fitting on its outlet side.

E. Electrical:
   1. Single grounding point shall be provided per equipment.

F. Instrumentation:
   1. All wetted instrument elements shall be cleaned for high purity gas service, prior to installation. CFC based cleaners are not allowed.

2.3 PRESSURE REGULATOR

A. Acceptable manufacturers:
   1. Base:
      a. Tescom.
   2. Optional:
      a. APTech.

B. All internal surfaces shall be 316L stainless steel electropolished to a 10 Ra average finish. Connection shall be VCR with pure nickel seal welded to the regular body by the manufacturer.

C. Regulator shall be constructed of 316L stainless steel body, Kel-F81, valve seat, 316 stainless steel diaphragm, stem, and seal disc.

D. Operating temperature minus 40 degF to plus 140 degF with a maximum rated inlet pressure of 3,500 psig and outlet pressure as required by process tool. Regulator shall incorporate an adjustable stop allowing a maximum outlet pressure to be limited to any valve between the maximum rated valve and 50 percent of the maximum valve.

E. All regulators shall be 100 percent inboard leak tested and certified to $1x10^{-9}$ am cc/sec. using helium.

F. Two pressure gauges shall be provided, 1 upstream and 1 downstream connected directly to regulator.

2.4 PRESSURE GAUGES

A. Acceptable manufacturers:
   1. Base: Matheson

B. Provide 2 IN dial face, mirror backed gauge with 316L stainless steel bourdon tubes, stainless steel movement, and VCR female gland connection with pure nickel gasket.

C. Mounting connection shall be bottom mounted.

D. Gauges shall be factory cleaned as stated herein and certified to meet a helium test $1x10^{-9}$ am cc/sec.

2.5 HIGH PURITY TUBING

A. Acceptable manufacturers:
   1. Base:
      a. Cardinal – Tech 100.

2. Optional:
   a. Valex – 401.
   b. Advanced Micro Finish.

B. Carrier tubing:
1. Seamless, 316L stainless steel, ASTM-A213, ASTM-A269, ASTM-A632, hydrogen bright annealed having a controlled inside diameter electropolished finish with a maximum roughness not to exceed 10 Ra average and a hardness of Rb 60 to Rb 80, with 5 percent maximum allowable chromium carbide, and 0.005 to 0.010 maximum sulfur content.
2. Provide piping within a given size with the same heat number. Provide certification and test method used as part of tubing submittal.
3. Seamless piping shall conform to the following:

			Permissible Variation		
Size (Inches)	ASTM No.	Wall Thickness	Diameter (Inches)	Ovality (Inches)	Wall Thickness (%)
1/2	A632	0.035	+0.004/-0.000	N/A	10%
3/8	A632	0.035	+0.004/-0.000	N/A	10%
1/2	A269	0.049	+/-0.005	+/-0.010	10%
3/4	A269	0.065	+/-0.004	+/-0.010	+20%-0%
1	A269	0.065	+/-0.006	+/-0.010	+20%-0%
2	A629	0.065	+/-0.008	+/-0.010	+22%-0%
2-1/2	A269	0.065	+/-0.008	+/-0.010	+22%-0%
3	A269	0.065	+/-0.008	+/-0.010	+22%-0%

C. Containment tubing:
1. Provide containment tubing where indicated on the drawings, of same material and finish as carrier tubing. Size containment tubing as indicated on the Drawings.

D. Fittings:
1. Tees: Fabricated by using 316L stainless steel pipe stock with after fabrication dimensions and tolerances compatible with orbital welding equipment.
2. Elbows: Manufactured, long radius type with wall thickness and heat number the same as piping.
3. Field bending is allowed on 1/4 IN and 3/8 IN size piping with minimum 10x-tube diameter radius bends. Coaxial 1/4 IN carrier tubing may be bent with less than 10x – 1/2 IN benders if pre-approved by the Owner.
4. All piping and fittings must comply (fit and function) with standard sizes, wall thickness, components, and weld methodology.

2.6 HIGH PURITY VALVES

A. Acceptable manufacturers:
1. Mains and branches valves:
   a. Base:
      1) SAES/Parker.
   b. Optional:
      1) Carten.
      2) Nupro.
2. Gas cabinets/purge panel valves:
   a. Base:
      1) Nupro.
   b. Optional:
      1) Parker.
      2) Veriflo.
      3) APTech.

B. Valves:
   1. Packless bellows or diaphragm type rated at 150 PSI minimum, provided with 316L stainless steel bodies, Kel-F seats, integral purge ports upstream and downstream of seat with VCR fitting caps, stainless steel bellows or diaphragm.
   2. Manufacturer shall use 60 degC hot DI water to clean for ultra high purity gas valves and ship to site in sealed, unopened, double polyethylene bags.
   3. Valve tube extensions shall be of the same heat number as piping material. Provide valves with the extensions sufficiently long to allow orbital welding with the following weld heads.

C.

Pipe Size	Head Size
1/4 IN through 1/2 IN	3/4 IN (AMI 750)
3/4 IN through 1-1/2 IN	1-1/2 IN (AMI 1500)
2 IN through 2-1/2 IN	2-1/2 IN (AMI 2500)
3 IN	4 IN (AML 4000)

D. Leak test: For the outboard and across the seat test, pressure to 150 psi with helium. There shall be no detectable helium with the contents of the bag using a helium detection device. Valves shall be tested for compliance with a leak rate not exceeding $1x10^{-9}$ atm.cm^3/sec. across the seat.

E. Finish: Gas wetted surfaces shall be the same as for tubing.

F. Quality assurance: Delivered to Project with appropriate manufacturer's quality assurance documentation stating testing and compliances with leak rate specifications. Submit test and cleaning methodology to Owner and Engineer for review prior to shipment of valves. Traceability by heat lot of tube extensions will be required.

2.7 CLEANED-FOR-OXYGEN-SERVICE TUBING

A. Acceptable manufacturers:
   1. Tubing and butt weld fittings:
      a. Base:
         1) Cardinal.
      b. Optional:
         1) Valex.
         2) Advanced Micro Finish.
   2. Weld fittings from machined stock:
      a. Base:
         1) Microfit by Swagelok.
      b. Optional:
         1) Minibutt Weld by Parker.
         2) Mini Butt Weld (E series) by HTC.
   3. Compression fittings:
      a. Base:
         1) Swagelok by Swagelok.
      b. Optional:
         1) Let-Lok by HTC.
         2) A-Lok by Parker.
   4. Face seal fittings (used for purge assemblies and purge ports):
      a. Base:
         1) VCR by Swagelok.
      b. Optional:
         1) Vacuseal by Parker Hannifin.
         2) Face seal by HTC (E series greater than or equal to 1/2" OD, U series for others).

B. Carrier tubing:
   1. All tube shall be produced from ASTM Grade TP 316L (UNS S31603) stainless steel raw material. Tubing sized smaller than 1/2 IN shall be seamless; 1/2 IN and larger may be seamless or welded seam.

2. Tubing shall be bright annealed at the producing mill in a dry hydrogen atmosphere (dew point <40 degrees Celsius) or vacuum annealed (10 micron HG) to a Rockwell 90 Rb maximum hardness.
3. Elemental sulfur content shall be in the range of 0.005 to 0.017 percent.
4. Interior surface finish shall have a minimum 180-grit finish or less than 30 Ra.
5. "Clean-for-oxygen service" shall mean tubing free of visible contamination, which includes visible stains, discoloration, and pitting. The cleaning process shall meet NFPA 99, CGA 4.1, and ASTM G-93-88.
6. Provide piping within a given size with the same heat number. Provide certification and test method used as part of tubing submittal.
7. Seamless piping shall conform to the following:

			Permissible Variation		
Size (Inches)	ASTM No.	Wall Thickness	Diameter (Inches)	Ovality (Inches)	Wall Thickness (%)
1/2	A632	0.035	+0.004/-0.000	N/A	10%
3/8	A632	0.035	+0.004/-0.000	N/A	10%
1/2	A269	0.049	+/-0.005	+/-0.010	10%
3/4	A269	0.065	+/-0.004	+/-0.010	+20%-0%
1	A269	0.065	+/-0.006	+/-0.010	+20%-0%
2	A629	0.065	+/-0.008	+/-0.010	+22%-0%
2-1/2	A269	0.065	+/-0.008	+/-0.010	+22%-0%
3	A269	0.065	+/-0.008	+/-0.010	+22%-0%

C. Fittings:
1. All fittings and components shall be equal in all respects to tubing specified above. This includes, but is not limited to, quality, properties, cleanliness, packaging, shipping, inspection, and quality assurance.
2. Tees: Compression “Swagelok” stainless steel fittings with silver plated front ferrule. Alternatively, tees may be fabricated by the drawn or pulled tee method, or using milling equipment to notch or drill the joining parts.
3. Elbows: Compression “Swagelok” stainless steel fittings with silver plated front ferrule. Alternately, manufactured long radius type with wall thickness and heat number the same as piping, or field bending of elbows is allowed with minimum 10x-tube diameter radius bends.
4. Welding: TIG welding method. Welds shall be flush and contain no pits or crevices. A smooth radii shall be present at the connection on both the ID and OD surfaces after final finishing. No undercutting of the external weld bead shall be allowed. Concavity of the external weld bead in excess of 10 percent of the wall thickness is not permitted. Wall thickness variations from the nominal value shall not exceed plus or minus 10 percent.
5. All manufactured components shall be cleaned after manufacturing and shall meet NFPA 99, CGA 4.1, and ASTM G-93-88.

2.8 CLEANED-FOR-OXYGEN-SERVICE VALVES

A. Acceptable manufacturers:
1. Mains and branches valves:
   a. Base:
      1) Whitey.
   b. Optional:
      1) Evans.
      2) PBM.
      3) SAES/Parker.

B. Valves:
   1. Three piece ball type rated at 150 PSI minimum, provided with 316L stainless steel body and ball, reinforced PTFE seats, integral purge ports upstream and downstream of seat with VCR fitting caps. Stainless steel Swagelok mechanical fitting on valve outlet with cap.
   2. Manufacturer shall use 60 degC hot DI water to clean for ultra high purity gas valves and ship to site in sealed, unopened, double polyethylene bags.

C. Leak test: For the outboard and across the seat test, pressure to 150 psi with helium. There shall be no detectable helium with the contents of the bag using a helium detection device. Valves shall be tested for compliance with a leak rate not exceeding $1x10^{-9}$ atm.cm^3/sec. across the seat.

D. Finish: Gas wetted surfaces shall be the same as for tubing.

E. Quality assurance: Delivered to Project with appropriate manufacturer's quality assurance documentation stating testing and compliances with leak rate specifications. Submit test and cleaning methodology to BNL and Engineer for review prior to shipment of valves. Traceability by heat lot of tube extensions will be required.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install specialty gas equipment and devices where indicated on the Drawings and in accordance with the manufacturer's instructions.

B. Provide onsite testing, adjustment and demonstration of all installed equipment as required for complete and satisfactory operation.

C. Testing and adjustments shall be made by a factory certified technician, per certification procedure approved by BNL's representative.

3.2 QUALITY ASSURANCE

A. BNL has the option to provide its own and/or retain an independent third party Quality Assurance Representative (QAR) to monitor and inspect the installation of all process piping systems.

B. BNL's General Responsibilities:
   1. Verify that all required examinations and testing have been completed and to inspect the piping and installation to the extent necessary to be satisfied that it conforms to all applicable examination requirements of applicable codes, engineering design and specifications.
   2. Have access to any place where work concerned with the piping installation is being performed. This includes manufacture, fabrication, assembly, erection, examination, and testing of the piping. BNL shall have the right to audit any examination, to review all certifications and records necessary to satisfy applicable codes, design and BNL specifications.
   3. Maintain daily Quality Control Logs of work in progress, plus discrepancies.
   4. Establish tracking, (paper document & PC based) for systems installation progress, analytical testing and systems buyoff.
   5. Verify purge gas pressure and flow at the source and runs.
   6. Assure that only approved materials are installed.
   7. Observe installation methods and technologies to assure conformance to the manufacturer's installation instructions and project specifications.
   8. Monitor cleanliness conditions of work area and tools.
   9. Observe worker's daily performance.
   10. Inspect and sign-off orbital weld joints.

C. BNL's QAR has the right to select tube joints, which may be removed from installed systems or fabrication for random quality check inspections.

D. BNL's QAR is authorized to stop work, via the General Construction Manager, when nonconforming work is observed or results of testing indicate improper installation.

E. If BNL's QAR selects work for removal or testing which is subsequently found to be acceptable to BNL, BNL shall bear all costs associated with the removal, cleaning, re-cleaning, testing, re-testing, and installation of the removed or tested work. However, if the work is subsequently found to be unacceptable to BNL per Design, Local Codes, manufacturer's installation requirements and/or specifications, the installer shall bear all said costs.

F. Daily Quality Control Provisions: (Piping Installer):
   1. Workers are to check in with signature.
   2. Provide a suitable caged material authorization point. Unused materials are to be returned daily.
   3. Maintain a daily log.

3.3 QUALITY ASSURANCE OF RECEIVED MATERIALS

A. Upon receiving any high purity process piping components, a visual inspection of the packaging shall be made to ensure all parts are double bagged and/or nitrogen purged and free from defects:
   1. Any parts having defective packaging shall be removed from inventory, and the part tagged DEFECTIVE. Tag and remove rejected material(s) from the approved materials area.
   2. A visual inspection shall be made on the components themselves after the packaging is removed to verify no contamination, discoloration, incomplete electropolishing, or any other cosmetic defects are detected on the part prior to installation.

B. Piping Samples: 6 inches long, taken from actual piping to be used for the Project, for each diameter involved and subjected to specified electropolishing/cleaning procedure. Randomly cut samples from 5 pieces or 10 percent, whichever is greater, of random tubing lengths of approximately 20'-0" for examination. As a minimum, for 10 percent of the material being inspected, a sample coupon shall be taken from the middle section for inspection. The lot shall be accepted if there are zero unacceptable samples from a given lot based upon surface anomalies, ovality and wall thickness. If there is one rejection in a lot, another 10 percent will be sampled and any further rejections will result in rejection of the lot.

C. Fitting Acceptance: After fabrication, randomly select 5 pieces or 10 percent (whichever is greater) of fittings from the lot for examination. The lot shall be accepted if there are zero unacceptable samples from a given lot. If there is one rejection in a lot, another 10 percent shall be sampled and any further rejections will result in rejection of the lot.

3.4 WELDING EQUIPMENT AND TOOLS

A. Provide welding equipment and supplies which are needed to perform the work including but not necessarily limited to: power supply, properly sized welding heads, remote controls, collets, voltage regulators, surge suppressers and tack welders.

B. Properly maintain and care for welding equipment during the construction period.

C. Automatic orbital welders shall be used for all welding. While tubing is under dynamic purge, TIG welders may be used for skin tacking on tubing 3/4 IN and larger. Welders shall be certified for TIG as for orbital welding, per Paragraph 3.6 of this Section. All TIG tack welds must be 100 percent consumed by the orbital weld.

D. Provide new, unused tubing cutters and wheels, de-burring tools, facing tool bits, for UHP piping system fabrication and installation, keep separate from other tools, and label or tag for "UHP SS PIPING ONLY".

E. At the start of each shift and as needed, clean tools and facilitating materials; i.e. tubing cutters and wheels, de-burring, facing, collets, bits, tape measure blades, purge PFA hose(s) and purge / facing hose connections, e.g. Teflon® / nylon ferrules. This includes any tool and/or facilitation component that has direct contact with UHP tube, fittings or UHP components. Clean with a mixture of 70 percent DI and 30 percent IPA and dry with filtered Argon or Nitrogen.

3.5 CLEANED-FOR-OXYGEN-SERVICE FACILITIES

A. All prefabrication work (including cutting, facing, bending, and welding) shall be performed in a Class 100,000 Clean Area and free from normal construction traffic. While cleaning may not be required after cutting, all possible care shall be taken to ensure spool piece remains free from contamination.

B. If a fabrication piece becomes contaminated, the QAR may require the piece to be cleaned using DI water.

C. The Clean Area shall be divided into two areas:
   1. "Prep area" for receiving and cutting tube for either subassembly work or direct installation in the tubing system in the field.
   2. "Subassembly area" for welding subassemblies of tube, valves, fittings, gauges, etc., for installation in the field. This area shall also be used for rinsing and cleaning of cutoff tube segments.

D. The Clean Area areas shall be equipped with pass-through windows with two sets of windows, one exterior and one interior, to permit transfer of materials with minimum impact to the air quality in the Clean Area.

E. All personnel entering the Clean Area shall only enter through the prep area (an emergency exit door shall be provided in the subassembly area). "Sticky" mats shall be used outside the main entrance. Immediately upon entering the Clean Area, all personnel shall don gloves, hair nets, and facial hair nets.

F. Provide filtered nitrogen (from a cryogenic source), high-purity, welding grade argon, and DI water.

G. Provide coordination with the Contractor for domestic water and power connection locations.

H. The Clean Area shall be of sufficient size to permit welding a fitting or valve on to the end of a 20 foot length of tube. The exhaust end of the tube may extend into the prep area during the weld operation in the subassembly area.

3.6 SHOP OR FIELD FABRICATION

A. Tubing used for connecting the various gases to the gas distribution system for welding, purging, and testing operations, and all purge, weld, test valves, lines, manifolds, etc. to be of the same quality as the system being constructed:
   1. For continuous field purging of installed runs and finished subassemblies, use electropolished SS tubing from the purge source valve to the .01um metal sintered filtered purge port connection. For shop or field spool fabrication, installer may use pre-cleaned PFA tubing with a filter at spool point of connection, however, PFA tubing cannot be longer than 20ft. in length. When not in use, purge lines must be capped under flow, or maintain a 5 cfh trickle/dynamic argon purge.

B. In addition to approved procedures and provisions stipulated in BNL approved, installer’s "Field Quality Assurance Program" the following shall apply:
   1. Conduct qualification tests for the welding equipment and the welding operators prior to the start of system fabrication. All testing is subject to approval by BNL's QAR.
   2. Submit a duplicate of the manufacturer's published operating instructions for the use of the welding equipment to BNL's QAR for review and approval. Submit equipment weld-ability sample joints, for all sizes, to BNL's QAR/QC for inspection prior to fabrication.

3. Each welder shall be qualified by the installer's QC with BNL's field QAR present. The orbital butt-welding equipment and operator shall perform operations and qualifications in accordance with the approved equipment manufacturer's published information and written procedures. An approved weld joint shall be made by each welder for each material and wall thickness to be welded.
4. Each welder shall coupon in with two coupons at the beginning of each shift and coupon out at the end of each shift. In addition, replacement of weld heads, modification of weld heads, welder maintenance, or power interruptions will require a re-coupon. Starting and ending coupons must support all welds performed during the shift. The operator shall cut the coupons a minimum of 3/8-inches from the weld center to allow good visual inspection of the tube I.D. and heat-affected zone. At the time of coupon in or out, the coupon(s) heat number and purge flows must match the material being fabricated and/or installed. All coupons shall be logged with coupon number.
5. Each weld machine shall have a daily log sheet to verify machine setup, daily weld-head calibration, correct purge setup and coupon inspections. Logs shall be on cleanroom approved paper while working in a cleanroom environment. The welder and installer's QC must inspect and sign-off the log daily. Random inspection signoffs will be done by BNL. Copies of logs shall be transmitted to BNL's QAR for project archiving.
6. For installer and BNL QC viewing, weld coupons shall be dated and left with the weld machine. Store coupons in a protective poly-bag for the duration of the project.
7. All ink markings when measuring, cutting, bending, etc. must be removed from material prior to welding and/or installation.
8. Provide weld map of each system showing machine, welder, and weld head numbers. Update weld maps at the end of each shift.
9. Rejected Weld Criteria. Criteria for rejection of a weld are as follows:
    a. No visible Heli-arc tacks on the tube ID or OD after orbital welding.
    b. No undercut or profile defect causing the wall thickness to fall below that of the parent metal.
    c. Concavity / Convexity exceeds 10 percent of the tube wall thickness.
    d. Penetration and bead width must be uniform throughout the entire weld, plus or minus 0.008 in.
    e. Bead meander must not exceed 25 percent of the bead width.
    f. There should be no unusual inclusion or porosity when viewed with the unaided eye.
    g. Misalignment exceeds 10 percent of the wall thickness.
    h. Tube OD color should be at a minimum.
    i. Tube I.D. color (haloing in heat effected area) should be at a minimum, no color is preferable.
10. BNL's QAR reserves the right to suspend welding operations, for noncompliance with specified BNL approved procedures or standards.
11. BNL's QAR reserves the right to request removal of any system welds deemed substandard or otherwise unacceptable. If, after removal, the weld proves to be substandard, installer will pay for replacements. If the weld is acceptable, BNL will pay for replacement. Orbital weld inspections shall be based upon the above criteria.
12. For field bent tubing, if there is any kind of deformation of the tubing during bending, discard the bender immediately and replace the tubing.
13. Only one VCR gasket is to be used at one time VCR gaskets shall not be reused. Tighten VCR connection per manufacture recommendations.
14. VCR clamps shall be used on all valves and/or components that are not base-mounted and directly connected to each another.
15. Any VCR connected line or spool that transfers radial torque to valves and/or components shall have VCR clamps.
16. Support all UHP SS piping with plastic molded cush-clamps or approved equal. Support and hanger requirements shall be per Mechanical Specification Divisions.

C. Provide QC personnel to perform required inspections, testing and documentation while adequately monitoring all shop and field activities. Inspections shall include minimum bore scoping of 90 percent of tubing sections. BNL may provide full-time quality assurance representative(s) (QAR) relative to installation of the UHP piping system. QAR services shall be the responsibility of BNL.

D. Upon acceptance of components and after having opened the package, maintain a minimal 5CFH Argon purge, or while under dynamic purge, seal the ends using plugs or caps until just prior to installation. Plugs and caps shall be either compression type with a PFA, Nylon ferrule or VCR on tubing up to and including 1 inch.

E. Maintain a continuous 0.01um metal sintered filtered Grade 6 Argon gas purge, minimum 99.9 percent pure with verification from the Argon supplier, on piping system segments during cutting, facing, fabrication and installation. Purging based upon time and flow is acceptable up to 1-1/2 IN OD piping. For pipe greater than 1-1/2 IN, a portable hand held oxygen monitor reading ppm level is required. Purge O2 readings shall not exceed 10 ppm prior to welding.

F. For field QC verification, O2 monitors shall have copies of manufacturer's calibration requirements along with calibration log sheet(s) noting the calibration date, including the name of calibrator. Log and OEM sheets shall remain with the O2 monitor(s) at all times. Logs will be turned over to BNL for project archiving.

G. Cut and face pipe using orbital cutter and facing tools, keeping pipe under purge during cutting and facing operations to keep pipe clean of any metal particles. Keep tools sharp and replace before "mushrooming" occurs.

H. Welding:
   1. Place a clean flow restrictor over the end of a piping segment for purging.
   2. A purge-base standard for line sizes 1/4 IN up to 1-1/2 IN OD; a minimum flow of 10 CFH for two minutes, per 1/8 inch diameter, per 20 feet length is required.
   3. 4 IN and larger diameter tube or pipe will require a non-shedding purge diffuser for adequate ID gas coverage.
   4. For accelerated purging, thus decreasing purge time requirements; increase the CFH on line sizes 1/4 IN up to 1-1/2 IN to the following:

*Based upon 20 ft. linear footage

Tube O.D Diameter	Tube I.D. Flowrate	Purge Time
.250	15 CFH	2 Min.
.375	15 CFH	2.5 Min.
.500	20 CFH	3 Min.
.750	20 CFH	3.5 Min.
1.00	20 CFH	4 Min.
1.50	20 CFH	6 Min.

Purge Restrictor Size:

Tube O.D. Diameter	Orifice Size
3/8 IN and smaller	1/8 IN
1/2 IN up to 1-1/12”	1/4 IN
2 IN	3/8 IN
4 IN to 6 IN	1/2 IN
8 IN and larger	3/4 IN

5. Once installation of a piping segment has begun, continue the inner Argon gas purge without interruption. As a minimum, adhere to the following purge requirements:
   a. Whenever possible, utilize systems in-line isolation valve purge ports for continuous purging.
   b. It is important to consider the piping system layout when establishing the purge. The best method is to establish the purge at the source and fabricate the piping from this point to the point of use. Establishing the purge at one location also minimizes disturbances in the purge system.
   c. For system overnight and/or weekend purging and for work left over from one shift to another, a plug or cap with no greater than 1/8 in. OD opening shall be placed over the purge restrictor with a minimum 10CFH continuous flow, or provide isolation valve and cap with piping sections maintained under positive pressure.
   d. Make certain that purge exhaust flows are sufficiently vented to prevent build-up of inert gas in areas of possible gas entrapments, e.g. low elevation containment pit/basement and/or confined space areas. Since these gases are considered to be an asphyxiant, in certain cases, inert gases my need to be vented outside of building. For all areas in question, contact BNL for review and approval.
   e. Whenever possible, use isolation valve purge ports for continuous and shock purging. If ports aren't available, for line sizes 1-1/2 IN and larger, weld-on purge caps are required. For smaller sizes, compression purge caps can be used.
   f. For continuous pipe runs 2 IN or larger, with vertical heights of 2ft. or greater, "shock purge" horizontal runs prior to installing vertical transition piping spool(s).
   g. To prevent component failures due to metal shavings etc., prior to the installation of components and/or valves, a shock purge must first be done on the line the valve or component is installing to.
6. Provide flow meter to monitor all purges.

3.7 INSTALLATION OF FITTINGS, VALVES, AND COMPONENTS:

A. All components and fittings shall be installed by trained personnel using clean techniques and welding practices consistent with the tubing installation procedures described in this Specification.

B. Compression Fittings: Compression fittings are not permitted in the cleaned-for-oxygen-service gas systems, except for capping the unused ends of smaller valves and the sealing of outer containment lines, if shown on the Drawings.

C. Mechanical Joint Fittings:
   1. Mechanical joint fittings in Hydrogen systems are only allowed inside a vented and monitored Valve Manifold Box, or on connection to the Hydrogen Tank in an exterior, and open to atmosphere gas pad location.
   2. Mechanical fittings may only be used for connection of gauges, sensors, purge ports, etc., that require frequent removal and/or replacement for calibration or service. Except for gauges and purge ports, the location and intended use of all mechanical fittings shall be submitted and approved by the Contractor prior to purchase. Mechanical fittings shall be precleaned for cleaned-for-oxygen service and sealed in nitrogen-purged plastic bags prior to shipment.
   3. Protect gland faces from damage when making trial connections by using unplated nickel gaskets to verify piping configurations. Never touch the surfaces of the glands or the gaskets.
   4. Make sure faces of sealing surfaces are clean and that no visible signs of contamination are present. If contamination exists, remove with a Alpha-Wipe and then blow off with purge gas.
   5. Make all necessary rotational alignments prior to tightening finger tight. Do not permit the faces of the sealing surfaces or the gasket to rotate during the tightening process.
   6. Finger tight must be achieved, so gently wiggle the fitting or tubing alignment while continuing to ensure finger tightness.

7. Gland surfaces must be parallel and tubing axis must be in line when making up final connections. It is very important that both sides of the connection have good centerline (axial) alignment before the connection is made.
8. Bulkhead Joints: Fittings for pass-through of the tubing into an enclosure or equipment housing shall be a mechanical bulkhead compression union, 316 stainless steel, bored-through, nylon-ferruled compression fittings of the size appropriate to the outside diameter of the process gas tubing. The tubing shall pass directly through the fitting with no connections or welds. Alternatively, a VCR bulkhead fitting may be used.

D. Manual Valves:
1. Valves shall be located to allow space to operate the valve handle and connect to purge ports after installation in the field.
2. Valves shall be installed using clean techniques and welding practices consistent with this document.
3. All valves shall be cycled five times after being welded to pipe segment, while in the subassembly area, and while under purge. Cycling shall be the process of gently turning to the full open position and then back to the full closed position.
4. Caps on valve extensions for future connection shall be welded for pipe diameters greater than or equal to 3/4 inch and Swagelok compression fittings with silver-plated stainless front ferrules (factory degreased and cleanroom packaged) for pipe diameters less than 3/4 inch. This only applies to systems which are going to be extended within 1 month, otherwise they shall be welded. Purge and fill end cavity with argon after installing caps.

3.8 GROSS LEAK TEST – (PRESSURIZATION TEST)

A. A gross leak test shall be performed by the Installer on all new or repaired process piping installations.

B. Prior to beginning the gross leak testing, the Contractor, Installer, and BNL shall complete a walk-through of the entire system to verify that the drawings and diagrams have been followed for the fabrication and installation of said lines. During the walk-through, verify craftsmanship (plumb / square / uniformity), as well as verifying that pipe supports, pipe labeling and analytical tags are in place.

C. Use 0.01 um metal sintered filtered and regulated Argon for pressurization of the piping systems.

D. Maintain the system at static pressure of 150-psig minimum, (200-psig maximum) for a period not less than 24 hours.

E. Test pressure gauges to be non-particulating, mirrored background with 1psi graduation.

F. Any loss of pressure (- 1psig) indicates a leak in the piping system.

G. Locate the leak(s) using approved Helium Leak Detector and approved leak detection procedures, repair the leak, re-pressurize the line, and restart the check.

Note: Do not use liquid for leak detection.

H. If there is no pressure loss, allow the test to remain for 24 hours from the first initial reading. The results of any checks that are made must be documented. All testing to be witnessed and signed-off by BNL. Test documentation shall be turned over to BNL for project archiving.

I. When outer containment piping is installed in the piping system, provide gross leak testing as stated above on all containment piping.

J. Upon completion of the Gross Leak test procedure, recharge the line to 10 psi with 0.01 um metal sintered filtered and regulated Argon, then close all valves starting at the farthest point from the Argon source. When the line is sealed, maintain the system in this condition until the Shock Purge process is performed.

K. If UHP Specialty Gas lines (single or coaxial) are designated as spare lines for future use, if lines are not connected to isolation valves per design, but terminate outside of exhausted valve boxes, cabinets and/or inert panels. Install permanent end of line UHP valves with UHP 0 to 30psi pressure gauges for 10psi inert static pressure monitoring. Valves with gauges shall be placed on spare lines within the gas bunker areas.

3.9 SHOCK PURGE

A. A shock purge (sometimes referred to as a pulse purge) shall be performed by the Installer on all new or repaired process piping installations using approved purge procedures.

B. The purge shall consist of a minimum 100 psi, 10-cycle (one minute per cycle) purge flow, starting from the valve closest to the source and proceeding downstream through mains, branch lines, and equipment isolation valves.

C. Use 0.01 um metal sintered filtered and regulated Argon for purging of the piping systems.

D. The Argon must not come from an existing house or bulk gas system source, unless approved by BNL.

E. On lines sizes 1-1/2 in. and larger: Midway through the system's shock purging 10-cycle sequence, piping walls must be moderately tapped, using a non-destructive / non-dimpling type rubber mallet. Line tapping is required throughout the entire line system.

F. Never allow the purge pressure to drop below 5 psig or reach atmospheric pressure when cycle purging line.

G. Upon completion of the shock purge cycling, and before turning the line over for acceptance testing, recharge the line to 10 psig with .01um filtered Grade 6 Argon, closing all valves starting at the farthest point from the Argon source. When the line is sealed, maintain the system in this pressure condition until Acceptance Testing is performed.

H. Prior to any testing, hang white, cleanroom approved, “Gas line Installation and Qualification Tags”.

I. Tag Placement:
   1. All end-of-mains / branches and equipment isolation valves.
   2. All gas lines prior to entering exhausted gas box or equipment enclosures.
   3. All gas lines exiting component / valve exhausted gas box enclosures.
   4. All gas lines prior to inert manifold panels and lines exiting inert panels.
   5. All source gas lines exiting a gas cabinet.

J. Tag Format:
   1. White lettering on black background:

GAS LINE INSTALLATION
AND QUALIFICATION TAG
Line Number: _____
Installed By: _____
Date: _____
Gross Leak Tested by: _____
Date: _____
Shock Purged by: _____
Date: _____
Helium Leak Checked by: _____
Date: _____
Particle Checked by: _____
Purity Tested by: _____
Date: _____
*** Please Do Not Remove***
White lettering on red background.

2. Fill out tags with a Black Sanford Sharpie pen:
   a. Note: The installer(s) performing the tasks to sign-off applicable tag sections as installation or testing is completed.

3.10 PIPING SYSTEM IDENTIFICATION

A. Colors will be used to identify the characteristic hazards of the contents.

B. Labeling to be completed by the end of every workday.

C. BNL will provide specific line numbering for all specialty gases. Numbering will denote source supply and all distribution transitions. Specific line-number label placement shall be adjacent to legend pipe labels and arrows.

D. Labeling is to be consistent with Mechanical Specification Divisions.

E. Labeling Legend(s) shall be provided by BNL.

3.11 ANALYTICAL TESTING AND CERTIFICATION

A. Testing Steps: All new or repaired process piping shall be tested by BNL before the materials or work can be accepted as certified and/or placed into service. BNL shall test and qualify in the following sequence:
   1. Particulate Testing.
   2. Helium Leak Testing.
   3. Purity Testing.

B. Final analytical testing will be performed by an BNL supplied testing organization independent of the installer.

C. Certification is performed by recording test data and completing required documentation when tested materials pass each testing step.

D. Prior to beginning analytical testing and certification steps, BNL will verify that piping and components have been gross leak checked, shock purged, and the Gas Line Installation and Qualification Tag has been filled in correctly.

E. BNL's OAR must observe all tests.

3.12 PARTICULATE TEST

A. Approved particulate test shall be performed by BNL before the materials or work can be accepted as certified.

B. Prior to beginning particulate testing BNL will verify that piping and components have been gross leak checked, shock purged, and the Gas Line Installation and Qualification Tags in place.

C. Particle Testing – Minimum General Requirements:
   1. The particle test of the gas line must cycle a volume of gas through the line and measure the amount of particles in that volume. The test cycle consists of charging the line to line pressure no less than 30 PSI and then discharging the line through an approved laser gas particle counter.

D. Particle Testing – Minimum Documentation Requirements:
   1. Document the particle counts that accumulate during the cycle purge and stabilization period.
   2. All particle documents including counts from components that fail the particle testing specifications shall be transmitted to BNL for review.

E. For a line or component to meet qualification requirements, particle must be less than 10 counts at .2um per purge cycle for minimum 5 consecutive sample intervals.

F. If a component fails to qualify after the maximum 20 sample intervals, cycle purge the component and re-perform the particle testing. If the component fails to qualify the second attempt schedule time for replacement of the component.

G. If a line fails, cycle purge the line. If a line fails to qualify after the second attempt, the line shall be tested in segments to isolate the failure. The segment shall then be repaired / replaced. Particle testing shall resume on that line as well as for the entire system (combined segments).

H. BNL shall have the right to be present and witness the particulate testing operation.

I. If a particle count reveals that a sampled point does not comply with specifications, BNL will retest said point. If a second testing of that point also indicated noncompliance, BNL shall determine the extent of the segment in the system to be removed and replaced as a result of noncompliance. The installer shall be held responsible for all costs incurred in performance of corrective action taken, including costs associated with re-testing of the system until acceptable. No waiving of testing allowed.

J. Upon successful completion of the particle test procedure, recharge the line to 10 psi with Argon, closing all valves starting at the farthest point from the Argon source. When the line is sealed, maintain the system in this pressure condition until the Helium Leak Testing is to be performed.

K. Confirm all testing data has been recorded accurately and complete required certification documentation.

3.13 HELIUM LEAK TEST – CARRIER TUBING

A. An approved Helium leak test shall be performed by BNL before the materials or work can be accepted as certified. Testing includes double containment lines.

B. Prior to beginning Helium Leak testing, BNL will verify that piping and components have passed the analytical particle test, and the Gas Line Installation and Qualification Tag has been filled correctly.

C. Use 0.01 um metal sintered filtered and regulated Helium for pressurization of the piping system between 90 - 100 psig.

D. The piping system must hold static pressure for a period not less than 24 hours after initial pressurization. Any loss of pressure indicates a leak in the piping system.

E. Locate all leaks using an approved Helium Leak Detector, and approved helium leak detection procedures.

   Note: Do not use liquid for leak detection.

F. The installer must repair all leaks. If lines require cutting, insertions and re-welding, the line must again be shock purged and all testing repeated.

G. Upon successful completion of the Helium Leak Testing, recharge the line to 10 psi with 0.01 um metal sintered filtered and regulated Argon; closing all valves, starting at the farthest point from the Argon source. When the line is sealed, maintain the system in this condition until the Purity Test is to be performed.

H. Confirm all testing data has been recorded accurately. Complete required testing/certification documentation and transmit to BNL.

3.14 PURITY TEST - CARRIER TUBING

A. An approved purity test shall be performed by BNL before the materials or work can be accepted as certified.

B. Prior to beginning Purity testing; BNL will verify that piping and components have passed all prior testing and the Gas Line Installation and Qualification Tags have been filled in correctly.

C. Perform flow purge to evacuate all Helium from source to point of use using 0.01 micron filtered and regulated Nitrogen or Argon.

D. Test equipment to be used for analytical purity testing must be approved for use.

E. Moisture, 02, CO, CO2, CH4: System outlet gas impurities for each constituent shall increase by not more than 20 ppb over the source gas measurement to meet test acceptance specifications. The source gas is targeted at 20 ppb impurities.

F. If a gas analysis reveals that a sampled point does not comply with specifications, in the following paragraph, shock purge and retest said point. If a second testing of that point also indicates noncompliance, BNL shall determine the extent of the system to be replaced as a result of noncompliance. The procedures to be followed for such remedial action shall be in strict accordance with these specifications. The installer shall be held responsible for all costs incurred in performance of corrective action taken, due to non-compliant piping segments including costs associated with re-testing of the system until acceptable.

G. Purity Level acceptance for UHP Process Piping:

1. O2 <40 PPB MAX w/ delta relative to source <20 PPB
2. H2O <40 PPB MAX w/ delta relative to source <20 PPB
3. CO <40 PPB MAX w/ delta relative to source <20 PPB
4. CO2 <40 PPB MAX w/ delta relative to source <20 PPB
5. THC <10 PPB MAX

H. Upon successful completion of the Purity Test, recharge the line to 10 psi with 0.01 micron filtered and regulated Nitrogen or Argon. Close all valves starting at the farthest point from the Nitrogen or Argon source. When the line is sealed, maintain the system in this condition until the line is to be put into operational service.

I. Confirm all testing data has been recorded accurately and complete required certification documentation.

3.15 LEAVE-BEHINDS

A. BNL is willing to negotiate purchase of equipment at conclusion of construction based on pre-arranged terms. Clean all welding equipment and hand tools used during construction, assure good operating condition, and then turn over to BNL.

END OF SECTION

SECTION 22 63 21
LIQUID NITROGEN PIPING SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of work includes the furnishing of labor and material to provide a complete and operable liquid nitrogen piping system to supply a dewar filling station from a bulk liquid tank.

B. Scope of Work shall include:
   1. Storage tank(s).
   2. Ambient vaporizer(s).
   3. Vacuum-jacketed liquid nitrogen piping system(s).
   4. Phase separator(s).
   5. Dewar filling station(s).

1.2 QUALITY ASSURANCE

A. Installer qualifications: Manufacturer, of reputable, established organization regularly engaged in supply and servicing liquid nitrogen piping systems, including providing engineering services.

B. All liquid nitrogen system components shall be furnished by a single supplier.

C. All materials used in the system shall be compatible with the cryogenic service requirements.

D. The system shall be designed to minimize heat gain to the liquid nitrogen and the volume of nitrogen vaporized.

E. Seismic design criteria: See Section 20 05 00.

1.3 RELATED WORK

A. Work by Others shall include:
   1. Liquid nitrogen storage tank(s) shall be supplied and installed by Air Products.
   2. Ambient vaporizer(s) and switching unit shall be supplied and installed by Air Products.
   3. Gaseous pressure control manifold shall be supplied and installed by Air Products.

B. Refer to other Mechanical Specification Divisions for:
   1. General mechanical requirements.
   2. Pipe hangers and supports.
   3. Piping identification.

C. Refer to Electrical Specification Divisions for electrical requirements.

1.4 SUBMITTALS

A. Shop Drawings:
   1. Tank layout, including foundation support drawings and details.
   2. Piping schematics.
   3. Liquid nitrogen piping layout at 1/4 inch scale.

B. Product Data:
   1. Storage tank.
   2. Vaporizer, including performance data.
   3. Pipe and fittings.
   4. Valves.
   5. Accessories and gauges.
   6. Phase separator.

7. Dewar filling stations.

C. Contract Closeout Information:
   1. Test reports.
   2. Operating and maintenance data.
   3. Local service office and response time for service.

1.5 DELIVERY, STORAGE, AND HANDLING

A. The Manufacturer shall be solely responsible for the adequacy of the preparation for shipment provisions employed with respect to materials and application.

B. Equipment and components shall be completely free of water prior to any shipment preparation.

C. Adequate protection shall be provided against mechanical damage and atmospheric corrosion in transit.

D. All instruments and valves, including auxiliary systems, must be securely mounted and/or supported to eliminate damage during shipment, and storage.

E. Supports and rigging connections shall be provided to prevent damage during lifting or unloading.

F. Protection of Piping Connections:
   1. All flange faces shall be protected by securely fastened blind flanges to prevent damage and contamination during shipment.
   2. Threaded connections shall be provided with a pipe plug of the same material as the connections. Plugs shall have a hex head. Only 100% Teflon tape shall be used as thread sealant.
   3. Opened ends of tubes and pipe shall be capped (taping alone is not adequate) for protection, and double wrapped to minimize contamination.

G. Piping connections between factory-fabricated vacuum jacketed piping spools shall be match marked to agree with the manufacturer's submitted piping plan drawings.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable Manufacturers:
   1. Storage tanks:
      a. Base:
         1) Chart / MVE.
      b. Optional:
         1) Taylor-Wharton.
   2. Ambient vaporizers:
      a. Base:
         1) Chart / MVE.
      b. Optional:
         1) Thermax.
   3. Piping system and components:
      a. Base:
         1) Chart / MVE.

B. Components used in the liquid nitrogen distribution system shall be products of a single manufacturer and shall be marketed collectively as a system. Materials used in the system shall be compatible with the low temperature service requirements.

C. Field fabrication of major components, or acquisition and use of components from multiple manufacturers is not acceptable.

2.2 STORAGE TANKS

A. Provide liquid nitrogen storage tanks as indicated on the drawings.

B. Tanks shall be designed to 250 PSIG Maximum Allowable Working Pressure in accordance with ASME Code.

C. Tanks shall be complete with the following accessories:
   1. Fill, liquid outlet, and vapor outlet connections and piping.
   2. Pressure building coil.
   3. Economizer.
   4. Pressure safety relief valves.
   5. Outer vessel vacuum readout.
   6. Pressure and level indicators.

2.3 AMBIENT VAPORIZERS

A. Provide ambient vaporizers as indicated on the drawings.

B. Vaporizers shall be sized to deliver the 2140 SCFH continuous flow for 10 day period before freezing.

C. Vaporizers shall be complete with the following:
   1. 450 PSIG Maximum Allowable Working Pressure in accordance with ASME Code.
   2. All aluminum construction.
   3. Inlet and outlet connections.
   4. Supports.
   5. Automatic switchover controls, for multiple vaporizers, with adjustable timed period.
   6. Standard industrial gas service pressure control manifold.

2.4 FLEXIBLE STATIC PIPING SYSTEM

A. General:
   1. Provide a complete flexible static vacuum-jacketed piping system as indicated on the drawings, including pipe, fittings, valves, and accessories.

B. Double Wall Pipe:
   1. Two concentric, corrugated stainless steel tubes, separated by a Teflon spacer.
   2. The spacer shall be in the form of a ribbon, twisted on its own axis, and wrapped in a helical configuration in the annular space between the two tubes.
   3. The exterior surface of the outer tube shall be coated with a braided outer cover.
   4. The annular space shall be evacuated and sealed at the factory.

C. Valves and accessories:
   1. All valves and accessories shall be suitable for use with the other system components and shall be products of the system manufacturer.

2.5 RIGID STATIC PIPING SYSTEM

A. General:
   1. Provide a complete rigid static vacuum-jacketed piping system as indicated on the drawings, including pipe, fittings, valves, and accessories.

B. Pipe and Fittings:
   1. Inner carrier:
      a. The design and manufacturing of the vacuum insulated pipe shall be in accordance with ANSI B31.3 - Chemical Plant and Petroleum Refining Piping and latest applicable addenda for 150 PSI.
      b. Material shall be "INVAR 36" or 304 stainless steel, ASTM-A312 pipe, welded or seamless.
      c. Flow rate and size shall be as Indicated on Drawings.

d. Pipe ends shall be bayonet joints for joining spools and as specified on Drawings at use point(s).

2. Vacuum jacket:
   a. The vacuum jacket shall be designed in accordance with the ASME Code for Unfired Pressure Vessel, Section VIII for an internal vacuum and external atmospheric pressure with the assembly at ambient temperature.
   b. Material shall be 304 stainless steel, ASTM-A312 welded pipe.
   c. Expansion joints (NOTE: Only required when stainless steel inner carrier is used). Shall be installed in the inner pipe of each spool as required to compensate for the differential rates of expansion and contraction between the inner carrier and jacket pipe:
      1) Material: Type 304 stainless steel with Type 304 stainless steel ends for butt welding.
      2) Design: Normal movement with minimum design as follows:
         a) External pressure: 20 PSI with internal vacuum.
         b) Internal pressure: 35 PSI.
         c) Cycle life: 5000 cycles.
3. Spacers:
   a. The inner carrier shall be supported within the jacket by a support system designed to absorb thermal loads on the inner pipe when partially or completely filled with product, to minimize heat leakage, withstand loadings (a, b, and c below) during shipping and loading, and (d) during and after installation:
      1) Three "g" load applied vertically downward.
      2) Three "g" load applied vertically upward.
      3) Two "g" load applied horizontally, longitudinally, or laterally combined with one "g" load vertically downward.
      4) When inner liner is filled with Trichlorethylene, meet uniform building code for Zone 3 seismic requirement or higher. Coordinate with seismic requirements.
4. Laminar Radiation Shielding:
   a. The inner line shall be "super insulated" with a minimum of fifteen alternate layers of aluminum foil and Dexter glass fiber paper.
5. Chemical Gettering System:
   a. Each spool shall have molecular sieve and a hydrogen converter installed in the vacuum annullus for the purpose of removing the majority of vacuum contaminants released by outgassing. The quantity of sorption pumping materials required for each spool section shall be determined by the manufacturer.
6. Evacuation Port:
   a. Each spool shall be equipped with a combination evacuation/relief valve port complete with a Hastings DV-6R vacuum transducer for monitoring the vacuum level without breaking into the vacuum annulus:
      1) Location shall be in an approved location or approximately centered on each spool with consideration to personnel safety, accessibility, and non-interference with other equipment.
7. Manufacturing:
   a. Shall be accomplished through the use of certified welders. Welder's certification to be submitted upon request.
8. Evacuation:
   a. Heat shall be applied during pumping to accelerate outgassing. Minimum temperature shall be 200 degF. Spools to be sealed at less than 10 microns.
   b. Means shall be employed on the vacuum pumping system to prevent oil from backstreaming into the spool vacuum space.

C. Valves and accessories:
   1. All valves and accessories shall be suitable for use with the other system components and shall be products of the system manufacturer.

2.6 PIPING FITTINGS

A. The available fittings shall include, but not be limited to, bayonet connections, elbows, crosses, tees, and end terminations.

B. All fittings shall be of dimensions commensurate with the piping to which attached and shall possess the same vacuum insulating qualities.

C. End terminations shall be suitable for the designated individual application, and shall include an end with proper thermal isolation.

D. Where appropriate for dynamic piping system, the end terminations shall have a pump-out port for the maintenance of vacuum.

E. Where appropriate for dynamic piping system, bayonet connections shall contain connections on each vacuum port to which a metal jumper hose can be attached to permit the dynamic vacuum to be continuous around the fitting.

2.7 VALVES

A. All valves shall be suitable for use with the other system components.

B. Manual liquid nitrogen shut-off: Stainless steel, 145 PSI maximum operating pressure, non-rising stem, vacuum jacketed, bayonet connections, manual operation.

C. Automatic liquid nitrogen shut-off: Stainless steel, 145 PSI maximum operating pressure, non-rising stem, vacuum jacketed, bayonet connections, pneumatic operation, solenoid actuated, 115 Volt, 60 Hz.

D. Vacuum shut-off, for dynamic piping system: Brass, 1/4 turn, Teflon seals, Viton o-ring stem seal, integral annullus relief valve, two plugged DN6 female NPT taps, VF-25 flanged end connections.

E. High vacuum solenoid, for dynamic piping system: Brass, continuous duty normally closed solenoid actuator, Viton o-ring seals, 115 Volt, 60 Hz.

F. Back pressure regulating: Stainless steel and brass globe valve assembly, Teflon seats, vacuum jacketed, bayonet connections (liquid nitrogen), VF-25 flanged connections (vacuum).

G. Relief: Stainless steel, NPT end connections.

2.8 PIPING ACCESSORIES

A. All accessories shall be suitable for use with the other system components.

B. Provide pressure gauges suitable for cryogenic service, with a range of 0-200 PSIG. Provide a gauge at each liquid nitrogen supply valve.

C. Provide in-line mechanical float type venting devices, with vent heater, at all high points of the liquid nitrogen piping system, to keep the piping system continuously wetted with liquid nitrogen.

D. Provide safety relief valves in each segment of liquid nitrogen piping that can be isolated by shutoff valves. Select and size safety relief valves in accordance with ASME Code for piping and components being protected.

E. Provide gas trap assemblies at each liquid nitrogen point of use and end of line, to reduce the liquid losses when the liquid nitrogen is not flowing.

2.9 PHASE SEPARATORS

A. The phase separator shall be a horizontal, vacuum insulated dewar type vessel fabricated of stainless steel and shall include an inlet bayonet connection, an automatic valve, an inlet relief valve, a reservoir relief valve, a vacuum zone valve, and a vent terminating in a male bayonet connection.

B. Provide vacuum pump with digital vacuum readout meter for each phase separator.

C. Separator shall be designed to vent gaseous vapor at the top of the separator to the atmosphere at a pressure of approximately 1 atmosphere.

D. Maximum liquid nitrogen inlet pressure: 150 PSI (10.34 BAR).

E. Outlets:
   1. Phase separator shall have eight (8) liquid outlet connections.
   2. Liquid nitrogen shall be dispensable by gravity from the bottom of the separator through the inner tube of the triple wall pipe to the end termination at the point of use. The pressure in this portion of the system shall be approximately equal to the hydrostatic head from the phase separator to the point of use.

F. Controls:
   1. Phase separator shall be provided with a complete and functional control system.
   2. System shall control supply of liquid nitrogen to the phase separator with a pneumatically operated valve governed by a solenoid valve. The solenoid valve shall respond to electrical signals from a sensor probe in the phase separator to maintain the liquid level at essentially atmospheric pressure.

2.10 AUTOMATIC DEWAR FILLING STATIONS

A. Provide an automatic liquid nitrogen dewar filling station(s) as indicated on the drawings, for standard (160 – 240 LITER) dewars.

B. The dewar filling station shall provide fully automatic fail-safe operation, suitable for outdoor installation. The filling station shall incorporate solid state electronics, maximum fill timer, safety relief valves, vent check valve, vent interlock, strainer, and dual solenoid valves suitable for cryogenic service.

C. A security key switch shall be included to limit access to authorized users and to permit operation in a "Manual" mode.

D. The fill station shall be provided with an emergency machine off (EMO) switch.

E. The dewar filling station shall be fabricated with a stainless steel exterior case, and shall have a weather tight electrical enclosure (NEMA 4X, CE compliant).

F. The dewar filling station shall operate between 15 – 125 PSIG operating pressures, and with single-phase 115V, 3A, 60 HZ power supply.

G. The dewar filling station shall be supplied with two 1/2 IN ID x 4 FT long non-vacuum insulated flex hoses, and suitable brackets for wall mounting.

H. Basis of design: Cryotech, ADF-10.3 or equal Chart, LO LOSS Fill Station.

PART 3 - EXECUTION

3.1 FABRICATION

A. Minimize the quantity of connections by making the sections of piping as long as practical while maintaining functionality.

B. To the greatest extent possible, achieve corners by bending the pipe. The arc of the bend shall not be less than the minimum bend radii specified by the piping manufacturer.

C. Design the installation such that the pressure of the liquid nitrogen supply shall not exceed 130 PSI.

3.2 TANK AND VAPORIZER

A. Install the storage tanks and vaporizers in accordance with the manufacturer’s instructions.

B. Provide common tank fill connection assembly with fill piping to each tank, as indicated on the drawings.

3.3 PIPING

A. Install the complete system in accordance with the Contract Documents, and the requirements of the system manufacturer.

3.4 PHASE SEPARATOR

A. Install in accordance with the manufacturers written installation instructions. Install in a level condition. Do not install with obstructions within 3 FT of the exhaust vent.

B. Install an end trap and bypass ahead of each end termination to permit liquid and gas to return to the phase separator through the annular space between the inner two tubes of the triple wall pipe.

C. Route vent piping to the outside, or as indicated on the drawings.

3.5 DEWAR FILLING STATION

A. Install in accordance with the manufacturers written installation instructions.

B. Provide all hoses and interconnecting liquid and vent piping between Bulk Tank and Filling Station.

3.6 VALVES

A. Install high vacuum solenoid valves in the upright position.

B. Install an annulus relief valve on the system side of the vacuum connection.

C. Install a vacuum ball valve on the system side of each annulus relief valve.

D. Install relief valves so discharge is to a safe location away from personnel.

3.7 SUPPORTS

A. Provide supports in quantities and types required by the piping system manufacturer.

3.8 TESTING

A. Prior to shipment to the site, factory cold-test the complete system vacuum integrity using liquid nitrogen. Manufacturers shall perform pressure tests on storage tank, vaporizer and phase separator.

B. BNL's Representative shall be provided the opportunity to witness any factory testing. Provide BNL at least 2 weeks advance notice of any factory testing.

C. Vacuum Retention Test (Static System Only):
   1. Each spool shall be tested over a two day period with the spool isolated from the pump at ambient temperature. The pressure in the annual space shall be measured every 24 hours and recorded. Spools will be acceptable if:
      a. There is a pressure rise of eight microns or less. A pressure greater than eight microns will require one additional day of vacuum retention. The line shall be considered acceptable if the third day's reading indicated the vacuum is stable.
      b. The maximum stabilized pressure before shipping is 35 microns. (Consult factory for seven day or greater retention).

D. Pressure test all piping after installation in accordance with ASME B31.3 Code.

END OF SECTION

SECTION 22 66 00
WASTE TRANSFER

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This Section includes the following:
   1. Process waste piping, services, and accessories. Rough piping and final connections to all equipment (other than process tools) whether furnished in this Section or not.
   2. Sleeves and supports, cutting, patching and framing of openings, and flashing of wall penetrations for work under this Section.
   3. Systems and equipment:
      a. Laboratory Waste (LW).
   4. Laboratory Waste System will collect drainage from the following systems:
      a. Cleanroom tools and support equipment.
      b. Emergency Safety Shower/Eyewash.
      c. Laboratory drains.

1.2 RELATED WORK

A. Refer to other Mechanical Specification Divisions for the following:
   1. Waste piping.
   2. Process piping.
   3. Plumbing systems.
   4. General and special mechanical requirements.
   5. Pipe hangers and supports.
   6. Piping and equipment identification.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Detailed shop drawings for each equipment item.
   2. For components such as pumps submit complete detailed drawings giving all dimensions, connections, weights, electrical motor data and performance data (such as pump curves and computerized selection sheets) specifically for the required duty.
   3. Submittals shall be approved by BNL's Representative before any purchase is made.

B. Product Data:
   1. Catalog cut sheets for equipment items.
   2. For piping and valves, submit list of suppliers with make and model number for materials, and manufacturer's printed data and illustrations of manufactured items identifying each size furnished.
   3. Submittals shall be approved by BNL's Representative before any purchase is made.

1.4 OPERATION AND MAINTENANCE MANUALS

A. Include the following:
   1. All items covered under submittals.

1.5 FINAL DOCUMENTS

A. Operation and maintenance manuals.

B. Warranties.

C. Manufacturer's certification of proper installation and function of equipment.

PART 2 - PRODUCTS

2.1 PIPE MATERIALS

A. Gravity industrial waste piping shall be flame retardant polypropylene, Schedule 40, Type 1 conforming to ASTM-D4101. Material shall be flame retardant with maximum average flame spread of zero seconds and a maximum extent of burning of 13 mm, in accordance with ASTM-D635. Fittings shall be flame retardant polypropylene.

B. Fittings shall be designed for electronic resistance socket fusion to mating piping. Connections between for above-grade piping polypropylene pipe and matched fittings shall be made using electronic resistance socket fusion joint.

C. Application:
   1. Gravity lab drains.
   2. Gravity drains in cleanroom subfab.

D. Piping below grade shall be same material as specified in Section 2.1.A. except not flame retardant. Fittings shall be polypropylene with an integral heavy gauge, nickel/chrome electrical resistance wire molded in place in the fitting body. Connections between pipe and fittings shall be electro resistance fusion weld.

2.2 ACCEPTABLE COMPONENT SUPPLIERS

A. Polypropylene Piping and Fittings:
   1. Enfield:
      a. Fusion Joint (above & below grade).
      b. Mechanical Joint (above grade piping in casework).
   2. George Fischer:
      a. Fuseal MJ (above grade piping in casework).
      b. Fuseal II (above & below grade).
   3. Orion.
   4. Zurn.

2.3 VALVES

A. Gravity Industrial Waste.
   1. 2“ and Smaller: GF true-union ball type, polypropylene material to match piping, resilient seats, and Viton O-rings.
   2. 2-1/2" and Larger: GF 38 Series or Asahi 75 Series, polypropylene body, stainless steel threaded lug style butterfly, 316 SS stem and PVDF disk with Viton liner. “Tandem” type butterfly valves shall be Asahi 75 series.

2.4 OTHER COMPONENTS

A. Acid Resistant Floor Drains and Cleanouts: Fabricated type 304 stainless steel:
   1. Jay R. Smith.
   2. Josam.
   3. Zurn.

B. Lab sink outlets and traps:
   1. GF Fuseal.
   2. Enfield
   3. Orion.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide all rigging, transportation, on and off loading personnel, etc., for all equipment furnished under this Contract.

B. Install and connect all equipment and components to provide a complete operating system.

C. Provide 2 days start-up and personnel training time.

D. Sleeves shall be installed where non-metallic drain piping passes through masonry, concrete, or any fire separation.

E. Exterior wall penetrations and roof openings shall be made watertight using approved flashing materials and/or sealants.

F. The grade of horizontal gravity drainage piping is to be minimum 1/4 IN per foot (2 percent) uniform slope for 3 IN and smaller piping. For 4 IN and larger piping a slope of 1/8 IN per foot (1 percent) is be used. Vent lines are to slope toward drain at a slope of 1/16 IN per foot (1/2 perccent).

G. Install piping parallel to building surfaces with a minimum of fittings.

H. Pipe the discharge of each relief valve, backflow preventer, and similar device to floor sink, floor drain, exterior or other acceptable location, except in attics and ceiling spaces.

I. Piping subject to expansion or contraction shall be installed with anchors and expansion loops or joints as required. Provide adequate anchors and guides to prevent misalignment.

J. Use DWV elbows, wyes, etc. or combination of fittings to equal drainage patterns as specified for each system.

K. Install non-conductive material between dissimilar materials.

L. Install unions or flanges at all connections to equipment, on both sides of control valves, and elsewhere as required to facilitate maintenance.

M. Install single piece chrome plated escutcheons on less than two inch pipe penetrations through walls or ceilings that are exposed to view and are in “finished rooms” (i.e. offices). Do not use split escutcheons.

N. Arrange piping and hangers to allow for expansion, contraction and structural settlement. Do not install piping in contact with the building structure. Hanger spacing shall be per piping manufacturer's specifications.

O. Install flexible connectors only where absolutely necessary.

P. Core drilling: Do not core drill unless specifically reviewed and approved by the Structural Engineer in writing. Drill holes 1 IN larger than O.D. of pipe for pipe less than four inches diameter, and 2” larger than O.D. of pipe greater than four inches diameter. Where pipes pass through sleeves or core drilled holes, recommend backer rod and fill outer 1/2 IN depth of the annular space with sealer. Penetration sealants and caulking are to satisfy the requirements of the building code.

Q. Label all piping valves in accordance with Mechanical Specification Divisions.

R. Air vent piping shall be compatible with adjoining materials.

S. For buried pipe, provide detection using a magnetic anomaly detector or other means to trace.

3.2 PIPING

A. General:
   1. Where different pipe materials interconnect, provide appropriate manufactured adapters or flanged connections with Teflon gasket, torque to manufacturer's specifications.
   2. Locate all hand operated vertical valves which require daily or more frequent operation, at a height not more than 7 FT-0 IN above floor.
   3. Stubs: Install valves where indicated on the drawings and elsewhere to facilitate pipe cleaning, venting, drainage, flushing or testing.
   4. Label all piping in accordance with Mechanical Specification Divisions.
   5. For gravity process drain piping, install cleanouts (bi-directional vent T's) at end of mains and laterals, every 50 feet on horizontal runs, and at every 135-degree change in direction. The flanged T's shall be out of the waste stream, and labeled or tagged as cleanouts to differentiate from futures.

B. Plastic: Install all plastic piping systems in strict accordance with pipe manufacturer's recommendations, including preparation of pipe and fittings for jointing, selection of solvent and primer, and curing and installation. Prior to fabricating system, demonstrate, in the presence of BNL, the proposed field method of making joints.

C. Tanks will be cleaned by installer before the tank is put in service.

3.3 PIPE PRESSURE TEST

A. Test all piping as noted below, with no leaks or loss in pressure. Repair or replace defective piping and re-test until tests are accomplished successfully. Any failures on test will require restart and complete time testing after repair.

Test System	Test Pressure	Test Medium	Test Time
Gravity Drains	10 ft.	water	4 hours

B. Any leaks found shall be repaired in the following manner:
   1. Plastic joint - Remove/Reinstall per manufacturer's instructions.

END OF SECTION

SECTION 22 67 19
PROCESS PIPING SYSTEMS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This Section includes the following:
   1. Process piping, services and accessories. Rough piping and final connections to all equipment (other than process tools) whether furnished under this Section or not.
   2. Sleeves and supports; cutting, patching and framing of openings; and flashing of wall penetrations for work under this Section.

B. Systems and accessories:
   1. Process Cooling Water (PCW).
   2. Process Vacuum (PV).
   3. Utility Nitrogen (UN2).
   4. Clean Dry Air (CDA).

1.2 RELATED WORK

A. Refer to other Mechanical Specification Divisions for general and special mechanical requirements.

B. Work of other Mechanical Specification Divisions:
   1. Welding and brazing requirements.
   2. Piping specialties.
   3. Insulation.
   4. Plumbing systems.
   5. Pipe hangers and supports.
   6. Piping and equipment identification.

1.3 SUBMITTALS

A. Shop Drawings:
   1. For components such as heat exchangers, pumps, tanks, submit complete detailed drawings giving all dimensions, connections, weights, electrical motor data and performance data (such as pump curves and computerized selection sheets) specifically for the required duty.
   2. For vacuum systems, submit detailed shop drawings including wiring and piping diagrams with flows, pressures, temperatures, controls and points of connection for all services clearly identified, plus detailed motor data including make, model, rpm, insulation class, FLA, RLA, and NEMA eff.
   3. Submittals shall be approved by the Owner's representative before any purchase is made.

B. Product Data:
   1. For piping and valves, submit list of suppliers with make and model number for materials, and manufacturer's printed data and illustrations of manufactured items identifying each size furnished.
   2. Submittals shall be approved by BNL's representative before any purchase is made.

C. Contract Closeout Information:
   1. Operating and maintenance data for items requiring operational instructions or periodic maintenance such as: air vents, constant flow control valves, pressure relief valves, water flow measurement devices, etc.

1.4 QUALITY ASSURANCE

A. Follow requirements of ASME B31.3 Process Piping Code.

PART 2 - PRODUCTS

2.1 PIPE MATERIALS

A. Process Cooling Water (PCW):
   1. 4 IN and Smaller (in Mechanical Room 150 only): Schedule 80, Chlorinated Poly Vinyl Chloride (CPVC) plain ends per ASTM-F441 with CPVC Schedule 80 solvent welded socket type fittings per ASTM-F439:
      a. Solvent cement per ASTM-F493 with primer as recommended by manufacturer. Note; plastic piping is not to be installed above production areas or equipment (see below).
      b. Joining Materials and Methods: Solvent welding, using solvent and methods per manufacturer's recommended procedures.
   2. 4 IN and Smaller: Schedule 10S, 304L or 316L seam-welded stainless steel:
      a. Joining Materials and Methods: All orbital or gas tungsten arc welded, with flanges at valves and equipment connections using expanded PTFE, non-ink embossed "Gore-Tex" cut sheet gaskets; 1/8 inch thick.
      b. Fittings will be factory made with radius bends. Pulled Tee may be used if authorized by the Owner in advance of installation (sample will be required).
   3. Small diameter tool connection (3/4 inch and smaller) can be routed in 304L or 316L stainless steel tubing with Swagelok or Parker A-Lok SS fittings or approved hose and clamped, barbed fitting system:
      a. Threaded or compression type (Swagelok or Parker A-Lok) connections shall be kept to a minimum, regardless of size. Threaded connections shall be made with 100 percent pure PTFE tape only.
      b. Changes in direction shall be made with radius bends in the tubing or hoses unless the specific job conditions do not allow it.
   4. All CPVC pipe and fittings shall meet flame spread of 25 or less and smoke development of 50 or less per ASTM-E84A.

B. Process Vacuum (PV) and Vacuum Pump Exhaust:
   1. 4 IN and Smaller: Type L hard drawn seamless copper tubing per ASTM-B88 with wrought copper solder cup fittings per ANSI B16.22.
   2. Joining Materials and Methods: Solder with grade HB lead-free solder (lead content not more than 0.1 percent); ASTM B32, ANSI/AWS A5.8. J. W. Harris, Bridgit.

C. Utility Nitrogen (UN2) and Clean Dry Air (CDA):
   1. General: Pipe and fittings cleaned for oxygen service or equal, per CGA pamphlet G-4.1. Use tubing filled with nitrogen purge and pipe ends capped. The interior surface shall be uniform, bright, smooth finish with particulate matter of no more than 0.038 g/in2 (as called for in ASTM-B280 specification).
   2. 4 IN and Smaller: Type L hard-drawn copper tubing, plain ends certified to ASTM-B819 specifications with brazed solder-type wrought copper (castings not allowed) fittings per ANSI Standard B16.22:
      a. Copper Tubing Joining Materials: AWS – BcuP-5 Classification, "Silverflow-15" or approved equal.
      b. Brazing Copper Pipe to Brass Flanges: Flux is acceptable only if written permission is given to the installer by BNL before each respective project. A condition of the approval is that each joint be bench brazed, and inspected (and approved) prior to installation. Approved brazing procedures are described under the Execution section in this specification. Approved flux products include Stay-Silv, Stay-Brite, and Stay-Clean.

2.2 VALVES

A. Process Cooling Water (PCW):
   1. 2 IN and Smaller:
      a. For CPVC applications: George Fischer #346, CPVC true union ball valve with EPDM seats.
      b. For CPVC applications: George Fischer #360 true-union ball check type, CPVC material to match piping, resilient seats, and EPDM O-rings.
      c. For stainless steel applications: Jordan Valve Steriflow Series Mark 90 three piece ball valve CF8M body with tube ends, PTFE seat, packing and cavity filler.
   2. 2-1/2 IN and Larger:
      a. Amri "Cosmia", Mueller Series 56, Grinnell Series 8000 or Keystone Series 222 butterfly valve, lug body with drill and tap, EPDM seat with stainless disc and stem. All butterfly valves shall be rated for 150 PSI dead-end service in both directions, and bi-directional:
         1) Metal seated valves shall be Keystone "K-Lok" 362, with stainless steel seat.
      b. Stockham Series 15-SRF swing check valve, TFE seals with stainless body and trim.
   3. Pressure Regulator: Direct acting, setscrew adjustment, stainless steel body and trim, flanged end connections. Jordan Valve Mark 60/61 Series.
   4. Pressure Relief: Stainless steel body, stainless steel trim; EPDM, Viton or Teflon seals, direct-pressure actuated. Relief device shall comply with the requirements of the ASME boiler and pressure vessel code for relief devices. Crosby Series 900.

B. Process Vacuum (PV):
   1. 2 IN and Smaller:
      a. George Fischer #346 true-union ball type, CPVC material to match piping, resilient seats, and Viton O-rings.
      b. George Fischer #360 true-union ball check type, CPVC material to match piping, resilient seats, and Viton O-rings.

C. Utility Nitrogen (UN2) and Laboratory Air (LA):
   1. 2 IN and Smaller: Non-lubricated, bronze body, Teflon® seats and seal, stainless steel ball, two piece, full port ball valve with threaded ends and lockable handle. Apollo No. 77-100 or BNL approved equal.
   2. 2-1/2 IN and Larger: Amri "Cosmia", Mueller Series 56, Grinnell Series 8000 or Keystone Series 222 butterfly valve. Ductile iron body, lug style drilled and tapped, EPDM seat with stainless disc and stem. All butterfly valves shall be rated for 150 PSI dead-end service in both directions, and bi-directional.
   3. Pressure Regulator: Direct acting, setscrew adjustment, stainless steel body and trim, flanged end connections. Jordan Valve Mark 60/61 Series.
   4. Pressure Relief: Stainless steel body, stainless steel trim; EPDM, Viton or Teflon seals, direct-pressure actuated. Relief device shall comply with the requirements of the ASME boiler and pressure vessel code for relief devices. Crosby Series 800.

2.3 PIPING ACCESSORIES

A. All inline piping accessories, devices and specialty items shall be constructed from materials suitable for use with the other system components, and the system it serves.

B. For piping specialties, refer to specification section 20 05 19. Additional requirements shall be as noted below, and shall govern:
   1. System drains for hydronic systems:
      a. Provide with all stainless steel construction, including wetted materials.
   2. Wye strainer, for Process Cooling Water (PCW) system:
      a. Provide with all stainless steel construction, including wetted materials.

C. Flexible pipe connectors (FPC) for pumps, refer to specification section 20 05 50:
   1. Provide with EPDM elastomers.

D. Air vents for hydronic systems, refer to manual air vents in specification section 23 21 13:
   1. Provide with all stainless steel construction, including wetted materials.

E. Vacuum breaker, for Process Cooling Water (PCW) system:
   1. Vacuum breaker shall be designed for continuous exposure to a pressurized system, and shall be normally-closed to prevent system emissions.
   2. Vacuum breaker shall be constructed completely of stainless steel material.
   3. Suitable for 100 PSI working pressure and 75 degF maximum temperature.
   4. Vacuum breaker shall begin to break a vacuum at 2 IN water (0.15 IN mercury).
   5. Basis of design: Spirax Sarco VB21.

2.4 INDICATING DEVICES

A. For piping specialties, refer to specification section 20 05 19. Additional requirements shall be as noted below, and shall govern:
   1. Pressure gauges:
      a. Provide with all stainless steel construction, including wetted materials.
      b. Provide stainless steel body, PTFE (Teflon®) diaphragm seals for gauges mounted in plastic piping.
   2. Thermometers:
      a. Provide with stainless steel wetted materials and thermowells.

B. Rotameters, for Process Cooling Water (PCW) system:
   1. Vertical tube type, PVC body with socket end connections, polysulfone tube, PVDF float, FPM (Viton®) O-rings.
   2. Provide scales calibrated in GPM as indicated on the drawings.
   3. Basis of design: +GF+ George Fischer “Industrial”.

PART 3 - EXECUTION

3.1 PIPING

A. General:
   1. Where different pipe materials interconnect, provide appropriate manufactured adapters or flanged connections with using expanded PTFE, non-ink embossed “Gore-Tex” cut sheet gaskets; 1/8 IN thick. Teflon® gasket. Torque to manufacturer’s specifications.
   2. Locate all hand operated vertical valves which require daily or more frequent operation, at a height not more than 7 FT-0 IN above floor.
   3. Stubs: Install valves where indicated on the drawings and elsewhere to facilitate pipe cleaning, venting, drainage, flushing or testing.
   4. Label all piping in accordance with Mechanical Specifications Divisions.

B. Plastic: Install all plastic piping systems in strict accordance with pipe manufacturer's recommendations, including preparation of pipe and fittings for jointing, curing and installation. Prior to fabricating system, demonstrate in the presence of BNL, the proposed field method of making joints:
   1. Acceptable Primer/Cement Types and Applications:

Application:	Primer	Cement
PVC to PVC	IPS Weld-on P-70-C	IPS Weld-on 711-G
CPVC to CPVC	IPS Weld-on P-70-C	IPS Weld-on 714-G
CPVC to CPVC (orange)	Extinguishsure F-903	IPS Weld-on 714-O

Note: For pipe sizes greater than 12 IN use Primer and Cement as per IPS Weld-on manufacture recommendations.

C. Copper: Cut copper piping with wheel cutter. Debur all cut ends and blow out chips with nitrogen.

3.2 VALVES

A. Pipe risers:
   1. Provide isolation valves at main feed points to risers.
   2. Provide isolation valves at branch take-offs from risers.

B. Hydronic systems:
   1. Install pressure relief valves on heat exchangers' piping between exchanger and isolation valves.
   2. Provide drain piping at pressure relief valves and valves with test levers:
      a. Extend piping to within 6 IN of floor.
   3. System drains:
      a. At low points of piping systems, provide valved drains to allow complete drainage of each system.
   4. Air vents, manual:
      a. Vents shall prevent air binding in systems.
      b. Provide vent valves at trapped high points of closed piping systems.
   5. Provide vacuum breakers on closed piping systems where shown. Install per manufacturers recommendations.

3.3 COPPER AND STAINLESS PIPE INSTALLATION

A. Installation: All materials and installation work shall conform to all applicable codes and regulations. All work shall be done in a competent manner using the latest techniques of the trade:
   1. Thread Fitting / Connections:
      a. Only 100 percent pure PTFE Teflon® tape is acceptable for all Process Piping Systems.
   2. Copper:
      a. Installer is responsible to supply qualified brazers, equipment, and materials for scope of work.
      b. Brazing shall conform to the following:
         1) Copper lines shall be brazed using an oxygen-fuel flame.
         2) For all copper lines, all joints will be brazed with AWS – BcuP – 5 Classification; Silverflow – 15 or BNL approved equal.
         3) During brazing all gas lines must be continuously purged with 0.1 micron absolute filtered nitrogen gas, which shall be allowed to escape into the atmosphere through a purge restrictor. Purge relief vent will be positioned above the plane of the pipe. Open ends will be closed and spool piece stored at ambient temperature until installed. Portable hand held oxygen monitors will be used on pipe sizes 2-1/2 IN and larger. Monitors are to read in parts per million (ppm) level, percentage monitors are not acceptable. Welding and brazing will be done at less than or equal to 50ppm oxygen concentrations. For Sizes 2” and down, timed purging is acceptable.

*Based upon 20ft. linear footage.

Tube O.D Diameter	Tube I.D. Flowrate	Purge Time
0.250	15 CFH	2 Min.
0.375	15 CFH	2.5 Min.
0.500	20 CFH	3 Min.
0.750	20 CFH	3.5 Min.
1.00	20 CFH	4 Min.
1.50	20 CFH	6 Min.
2.00	20 CFH	8 Min.

Purge Restrictor Size:

Tube O.D. Diameter	Orifice Size
3/8 IN and smaller	1/8 IN
1/2 IN up to 1-1/2 IN	1/4 IN
2 IN	3/8 IN
4 IN to 6 IN	1/2 IN
8 IN and larger	3/4 IN

4) No brazed joint can be less than 12 IN away from the end of the purge line, which will require, in many instances, that an extension be used.
5) Verification of all purge lines at the end of each shift. If project only has one shift, reduce purge to a trickle purge for overnight purging or capped under pressure. Inspect each flow meter for proper flow and verify that source of nitrogen will be sufficient until next shift startup.
6) Maintain installation and purge procedures, for all pipe runs, until installation is complete and accepted by BNL.
7) All joints which show evidence of overheating, cracking, poor penetration, or other defects of fit-up or workmanship, shall be replaced at installer's expense.
8) If the system becomes contaminated due to fabrication techniques, prior to BNL's written acceptance, perform a total system re-clean or replacement. All expenses shall be borne by the installer, with no expense to BNL.
9) No more than 60 feet of pipe should be assembled in line prior to brazing.
10) Pipes shall be cut with ends squared and true to size. Only clean tubing cutters with sharp cutting wheels shall be used. Hacksaws or similar type cutting tools shall not be used. All burrs must be removed.
11) When cool, wire brush all fittings.

3. Stainless Steel:
   a. Installer shall be responsible to supply and qualify welders, equipment, and materials for scope of work. The qualifications of welding procedures, welders, and welding operators shall be in accordance with the requirements of ASME, Section IX.
   b. Welding shall conform to the following:
      1) Stainless steel lines: Tac-welding using the tungsten inert gas (TIG) arc welding process. Stainless steel tubing shall be orbital welded.
      2) During welding, all gas lines shall be continuously purged with argon and allowed to escape into the atmosphere through a purge restrictor. All lines shall be maintained under restricted purge or under pressure at all times during installation (purge relief will vent above the plane of pipe). Portable hand held oxygen monitors shall be used on pipe sizes 2-1/2 IN and larger. Monitors are to read ppm level, percentage monitors are not acceptable. Welding and brazing shall be done at less than or equal to 50 ppm oxygen concentrations. Time purging is acceptable on line sizes 2 IN and smaller.
      3) No welded joint can be less than six inches away from the end of the purge line, which will require, in many instances, that an extension be used.
      4) Provide verification of all purge lines at the end of each shift. If only one shift is scheduled, reduce purge to a trickle purge for overnight purging or cap under pressure. Inspect each flow meter for proper flow and verify that source of argon will be sufficient until next shift startup.
      5) Maintain all installation and purging procedures for all pipe runs until installation is complete and accepted by BNL.
      6) If the system becomes contaminated due to fabrication techniques, prior to BNL's written acceptance, perform a total system re-clean or replacement. All expenses shall be borne by the installer, with no expense to BNL.

B. Inspection: All material and workmanship shall be subject to inspection and examination by BNL:
   1. Copper:
      a. Upon request of BNL, remove a random piece of installed work, sufficient to establish the quality of materials and workmanship. If the piece shows evidence of oxidation or contamination, BNL may require testing of additional samples. If the additional samples are acceptable, BNL will pay for the direct labor and materials required for the cutting out and restoration of these samples. If they are not acceptable, the cost shall be paid by the installer.
   2. Stainless Steel:
      a. Completed welds shall be subject to inspection wherever practical.
      b. Welds will be inspected, visually by BNL. Visual weld inspections shall be in accordance with AWS QC 1. Any weld falling below the AWS QC 1 standard and deemed unacceptable by BNL from a visual inspection, shall be repaired or cut out. At the request of BNL, in the event any welder-operator consistently produces unsatisfactory productions welds, he (she) shall be refrained from welding and re-qualified, per Section IX of the ASME Boiler and Pressure Vessel Code. Repair and removal of welds or the re-qualification of welder-operators shall be done at the expense of the installer and not BNL.
      c. Orbital Weld Rejection Criteria:
         1) No visible tacks on the ID or OD of the weld.
         2) No undercut or profile defect causing the wall thickness to fall below that of the parent metal.
         3) Concavity / Convexity exceeds 10 percent of the tube/pipe wall thickness.
         4) Penetration and bead width must be uniform throughout the entire weld, plus or minus 0.008 in.
         5) Bead meander must not exceed 25 percent of the bead width.
         6) There should be no unusual inclusion or porosity when viewed with the unaided eye.
         7) Misalignment exceeds 10 percent of the wall thickness.
         8) Tube O.D. color should be at a minimum.
         9) Tube I.D. color (haloing in heat effected area) should be at a minimum, no color is preferable.
      d. Upon request of BNL, remove a random piece of installed work, sufficient to establish the quality of materials and workmanship. If the piece shows evidence of weld rejection as stated above, BNL may require testing of additional samples. If the additional samples are acceptable, BNL will pay for the direct labor and materials required for the cutting out and restoration of these samples. If they are not acceptable, the cost shall be paid by the installer.

   3. Pipe shall be hung in accordance with manufacturer's recommendations to avoid damage to the pipe. Proper support spacing is required in order to avoid sagging of the material. Support spacing is temperature dependent and shall be based on manufacturer's recommendations.
   4. Hangers shall be supplied or specified by the pipe manufacturer. U-bolt hangers are not allowed due to pin point loading effects.

C. Inspection: Prior to pressure testing, the system shall be examined for the following items:
   1. Pipe shall be completed per drawing layout with all pipe and valve supports in place.
   2. Pipe, valves and equipment shall be supported as specified, without any concentrated loads on the system.
   3. Pipe shall be in good condition, void of any cracks, gouges or deformation:
      a. Pipe flanges shall be properly aligned. All flange bolts should be checked for correct torque by the installer.
      b. All joints should be reviewed for appropriate welding technique.
      c. Socket joints to have two beads on the end of the fitting and on the outside of the pipe in contact. Refer to manufacturer's instructions for weld bead inspection

d. Butt joints should have two beads 360° around the joint. Refer to manufacturer's instructions for specific weld bead inspection.

D. Pressure Test:
1. Test fluid should be compressed air with quality level set by Quality Control Engineer. In all cases test must be done hydrostatically.
2. Begin pressurizing the system in increments of 10 PSI. Bring the system up to 100 PSI and hold. Allow the system to hold pressure for a minimum of two hours and up to a recommended 12 hours. Check pressure gauge after one hour. Due to natural creep effects on plastic piping the pressure will have decreased. If drop is less than 10% pump the pressure back up. At this time the system may be fully pressurized to desired test pressure.
3. If after one hour the pressure has decreased more than 10%, consider the test a failure. Note the 10% value may need to be greater for larger systems, or systems experiencing significant thermal changes.

3.4 SYSTEMS PRESSURE TESTING

A. Test all piping as noted below. Piping shall meet test conditions with no leaks or loss in pressure. Repair or replace defective piping until tests are accomplished successfully. The use of oil pumped air or nitrogen is expressly forbidden. All nitrogen used for testing and purging operations shall be from a cryogenic source. Re-testing following piping repairs shall be performed for full specified time period.

System	Test Pressure	Test Medium	Test Time
Process & Closed Loop Cooling Water	150 PSIG	Water	4 hours
Utility Nitrogen & Laboratory Air	150 PSIG	Nitrogen	24 hours

Note: Plastic piping may be pre-tested with 5 psi nitrogen prior to final Hydro-Testing.

B. Any leaks found in copper or plastic piping systems shall be repaired in the following manner:
1. Brazed joint – Remove/replace fitting and re-braze new joints.
2. Plastic joint – Remove and install new fitting.

3.5 INSULATION

A. Refer to Mechanical Specification Divisions for materials and installation requirements.

END OF SECTION

SECTION 22 67 21
DEIONIZED WATER SYSTEM

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This section includes the equipment requirements for the Reverse Osmosis (RO) and Deionized (DI) water systems:
   1. Water softeners.
   2. Dechlorination filters.
   3. Reverse osmosis (RO) systems.
   4. RO water storage tanks.
   5. Repressurization pumps.
   6. Deionized (DI) mixed beds.
   7. Ultraviolet (UV) sterilizers.
   8. Final filters.

B. The RO and DI systems Vendor shall be responsible for the design, procurement, fabrication, and delivery of skid assemblies, equipment, valving, controls and all loose shipped materials required for a complete, operating system. Installation of equipment and interconnecting piping, wiring, and controls will be by the Mechanical and Electrical Contractors under the supervision of the RO and DI systems Vendor.

C. The Vendor shall provide assistance in system commissioning, as specified herein.

D. Refer to the Drawings for work covered by these specifications.

1.2 QUALITY ASSURANCE

A. Installer qualifications: Manufacturer, of reputable, established organization regularly engaged in supply and servicing high purity water systems, including providing engineering services.

B. All RO or DI system components shall be furnished by a single supplier.

1.3 RELATED WORK

A. Work by Others: The Vendor is responsible for fabrication, procurement, and delivery of all components of the RODI system except as specified herein. Installation responsibilities by others shall include:
   1. Installation of Vendor-furnished equipment.
   2. Furnish and installation of interconnecting piping and valves between Vendor-furnished skids and/or Vendor-furnished equipment, based on fabrication drawings provided by the Vendor.
   3. Furnish and installation of power and control wiring to Vendor furnished control panels and skid-mounted disconnects for feeds to skid-mounted equipment, based on wiring schematics provided by the Vendor.
   4. Wiring of Building Management and Control System (BMCS) inputs from Vendor-furnished control panel or devices to the BMCS system I/O cabinet(s).
   5. Furnish and installation of the RODI water distribution piping.
   6. Furnish and installation of off-site regenerate mixed bed ion exchangers.

B. Work of other Mechanical Specifications:
   1. General and special mechanical requirements.
   2. Plumbing systems.
   3. Pipe hangers and supports.
   4. Piping and equipment identification.

5. High purity water piping system.

C. Refer to Electrical specifications for electrical requirements:
   1. Electrical work.
   2. Variable frequency controllers.
   3. Medium voltage cables.
   4. Motor starters and motor control centers.

D. Refer to Integrated Automation Division for instrumentation and controls requirements:

1.4 SUBMITTALS

A. Shop Drawings:
   1. Process flow schematic of the proposed system, showing all equipment and accessories, major flow piping, sizes, flow rates, stream conditions, and field connections.
   2. P&ID of the proposed system, with all equipment, accessories, piping, meters and gauges, instrumentation and control devices, and major control loops..
   3. Equipment and component layout.
   4. Drawings for interconnecting piping systems.

B. Product Data:
   1. Performance data, including pump curves.
   2. Physical dimensions and weight data.
   3. Vibration and acoustical data.
   4. Piping diagrams, and field connections.
   5. Detailed list of all required utilities and estimated rates of peak and average consumption.
   6. Electrical and controls wiring data, and field connections.
   7. Detailed electrical power requirements, including in-rush current, recommended fuse size, locked rotor and full load amperes.
   8. Wiring diagrams showing terminations for all interconnecting power and control wiring between panels and skids, including wiring to devices that are field installed.
   9. Panel layouts.
   10. Annotated catalog cut sheets of all proposed controls and instrumentation.
   11. Project specific Sequence of Operations (SOO).
   12. Seismic calculations.
   13. Installation procedures.

C. Contract Closeout Information:
   1. Operating and maintenance data.
   2. Instrumentation and controls data.
   3. BNL instruction report.
   4. Warranty.
   5. Test reports.

1.5 DESIGN CRITERIA

A. The RO water system shall be designed to circulate water supply to the facility at 20 PSIG supply pressure at the system outlet, and shall provide for 1 GPM of water make up.

B. The DI water system shall be designed to circulate water supply to the facility at 20 PSIG supply pressure at the system outlet, and shall provide for 1 GPM of water make up

C. The RO water system shall be designed to the following make up water conditions (supplied from the domestic water system). Vendor shall be responsible for verification of make up water characteristics:.

1. Temperature (degF)	55 – 86 range, 75 typical
2. Pressure (psig), min	50
3. pH (pH units)	7.2 – 9.0 range, 7.8 typical
4. Hardness (mg/l as $CaCO_3$)	69 – 290 range, 190 typical
5. Silica (mg/l as $Si0_2$)	9 – 32 range, 14 typical

6. Chlorine (mg/l as Cl) 37 – 280 range, 164 typical
7. Alkalinity (mg/l as $CaCO_3$) 56 – 210 range, 130 typical
8. Conductivity (micro-siemens/cm) 801 – 1660 range, 1254 typical
9. Magnesium (mg/l as $Mg/CaCO_3$) 16 – 44 range, 22 typical
10. Total Dissolved Solids (mg/l) 180 – 780 range, 560 typical

D. The DI system shall be designed to get makeup water from the RO system.

E. System performance criteria (product RO water quality) shall meet ASTM Type III as follows:
1. Resisitivity, min.= 4.0 megohm @ 25 deg.C
2. Conductivity, max. = 0.25 micromhos/cm @ 25 deg.C
3. pH, units = Not Applicable at 25°C
4. Total Organic Carbon, max.= 200 ug/l
5. Sodium, max. = 10 ug/l
6. Chloride, max. = 10 ug/l
7. Total Silica, max. = 500 ug/l

F. System performance criteria (product DI water quality) shall meet Semiconductor Type E-2 as follows:

Parameter	Value	Procedure
Resistivity	18.2 Megohm-cm @ 25°C, min.	ASTM-D1125
Bacteria	<1 CFU/1000 ml	ASTM-F60
Particles (> 0.2 µ)	<55 /liter, max.	PMS On-line particle counter
Total Organic Carbon	< 5.0 ppb, max.	Anatel A-1000 on-line
Silica (dissolved)	<3.0 ppb, max.	Scientific Instruments CFA 1000
Sodium	< 0.02 ppb, max.	Ionic and metallic species to be determined by IC, ICPMS, AA
Chloride	< 0.04 ppb, max.	ASTM-D512 or ion chromatography
Boron	<10 ppb	Ion chromatography

G. Piping system velocities shall be limited to the following:
1. Supply Main and Laterals 3 FPS min., 5 FPS max.
2. Return Laterals and Main 3 FPS min, 5 FPS max.

H. The RO and DI water storage tank capacities, sizes, and connections shall be as indicated on the drawings. The vertical tank shall have a top which is capable of withstanding an external uniformly distributed loading of 25 pounds per square foot, or a concentrated weight of 250 pounds.

1.6 AVAILABLE FACILITY UTILITIES

A. The following utilities are available for the RO and DI water system:
1. Clean Dry (instrument grade) Air:
   a. Pressure 80 PSIG
2. Utility Nitrogen (utility grade):
   a. Pressure 80 PSIG
3. Electric Power:
   a. Feed Voltage 480 V, 3-phase, 4-wire
   b. Frequency 60 Hz
   c. Control voltage 24 V
   d. Max fluctuation ± 5% for connected loads

B. Local UPS capacity shall be provided by the Vendor for all RO and/or DI system controls and instrumentation.

1.7 REGULATORY REQUIREMENTS

A. Seismic design of equipment, piping, and conduit supports and restraints shall meet or exceed the latest edition of the International Building Code for the project's jurisdiction. Submit four sets of wet-stamped calculations by registered civil or structural engineer in the state where the project is located.

1.8 FACTORY TESTING

A. Vendor shall perform factory testing of all factory-assembled components and skid assemblies prior to shipment and certification shall be furnished.

B. The piping subassemblies shall be hydraulically leak tested as specified herein.

C. BNL shall be notified at least 5 working days in advance of all factory testing so that he may be present to observe the factory testing.

D. RO and DI Water Tank Testing:
   1. Tank shall be tested and inspected by the Vendor at the point of manufacture with written documentation of the test results supplied to BNL. Tests shall include, but are not limited to the following:
      a. At the rated tank pressure, hydrostatic test for 24 hours duration to detect leakage shall be performed by the Vendor. Any leakage or weeping is unacceptable.
      b. Compliance check of tank and accessory dimension per the Drawings shall be performed by the Vendor.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Preparation for Shipment:
   1. Each skid or equipment item shall be suitably prepared for the shipment in a manner requiring minimum re-assembly prior to operation.
   2. The Vendor shall be solely responsible for the adequacy of the preparation for shipment provisions employed with respect to materials and application.
   3. All flange faces shall be protected by securely fastened Schedule 80 PVC blind flanges and full-faced red colored NBR gaskets on all vessel nozzles and face piping flange faces to prevent damage and contamination during shipment.
   4. Equipment and components shall be completely free of water prior to any shipment preparation.
   5. Adequate protection shall be provided against mechanical damage and atmospheric corrosion in transit.
   6. The following shall be shipped to prevent freezing and exposure to temperature extremes in excess of manufacturer's recommendations:
      a. RO membranes.
      b. Ion exchange resin.
   7. All instruments and valves, including auxiliary systems, must be securely mounted and/or supported to eliminate damage during shipment, and storage.
   8. Supports and rigging connections shall be provided to prevent damage during lifting or unloading.
   9. Threaded connections shall be provided with a pipe plug of the same material as the connections. Plugs shall have a hex head. Only 100% Teflon tape shall be used as thread sealant.
   10. Opened ends of tubes and pipe shall be capped (taping alone is not adequate) for protection, and double wrapped to minimize contamination.
   11. All equipment shall be packed, securely anchored (frame mounted when required) and weather protected. Separate, loose, or spare parts shall be boxed and each part individually protected as required. Each individual container shall be marked both inside and outside with the equipment number and service for which the parts are intended.
   12. Each container shall also include a complete Bill of Materials identifying each part. In some instances, such as instruments, specific tagging shall be required.

13. Piping connections to skids or field-installed equipment shall be match marked to agree with Vendor's submitted connection table.

B. UV Sterilizer Cleaning and Packing:
   1. After unit assembly and final manufacturers proof testing each UV sterilizer shall be wiped clean and dried using nitrogen gas prior to packaging for shipment.
   2. After cleaning and nitrogen gas drying, completely assembled UV equipment shall have inlet and outlet connections capped with suitable blind flanges and red silicon gaskets, be double layer packaged in plastic and wood crated for shipment.

C. RO Skid:
   1. RO skids shall be shipped to the job site complete with handling support and/or spreader bars to facilitate, if required, handling rigging and placement without damage to the RO skid, vessels, and/or piping.
   2. RO skid may be fabricated into separate mated support skids to facilitate shipment, rigging and installation. The Vendor's drawings shall clearly indicate skid connections.

D. RO and DI Water Tank Shipment:
   1. Prior to inspection and loading, all dirt and extraneous materials shall be removed from the tank interior. All exterior surface markings, special coatings, or contaminants shall be removed prior to shipment.

E. RO and DI Water Tank Packing and Loading:
   1. Tank shipped in the horizontal position shall be mounted on padded cradles at least 6 in. wide for up to 8 foot diameter and 12 in. wide for larger diameter tanks. Cradle padding will contact each tank along at least 20 percent of the exterior circumference. At least 4 in. of high density foam rubber, 2 in. of Styrofoam padding will be used to protect tanks. All tank end blocking used to prevent shifting of tank during transit shall be padded and bear only upon the knuckle radius of flat or dished heads.
   2. Flange faces shall be protected from damage by a closed-cell foam gasket and a securely fastened plywood covering.
   3. Pipe, tubing, fittings, baskets, bolts, or any other small miscellaneous parts and accessories shall be padded and packaged in a crate or box and shipped with the tank.
   4. Additional protection, such as battens, end wrapping, or other interior fastening may be necessary to ensure that the tanks are not damaged during shipment.
   5. Exterior fittings, such as nozzles and tie-down lugs, will be padded and prevented from contacting other tanks and accessories in the same shipment.
   6. Tank that is shipped on an open trailer shall be fully wrapped with plastic and completely covered with tarps to prevent contamination of the exterior and interior of the tank from road contamination and diesel soot/fumes.
   7. The tank manufacturer will obtain a Certified Weight of the tank prior to delivery. This certified weight will be used by the riggers in determining the proper methods for rigging the tank during unloading and installation. Estimated weights or calculated weights will not be acceptable.

F. Equipment, including the RO and DI Water tanks, shall be inspected upon delivery at the project site prior to unloading, for damage. Any damage occurring during shipment shall be the responsibility of the Vendor.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. RO and DI water system:
      a. Base:
         1) Agape Water Solutions.

b. Optional:
   1) Siemens Water Technologies.
   2) GE Water Technologies.
   3) Pure H2O Technologies

B. The RO and DI systems shall consist of completely new systems, as specified herein and as indicated on the drawings.

C. System shall be designed and guaranteed by the Vendor to produce water to meet the specifications in this section.

D. All components of the system shall be designed with maximum water quality, conservation and reuse in mind.

E. Equipment Packages:
   1. Mounting Skids: Each equipment skid shall include a structural steel base such that there is an even distribution of the equipment weight on the floor and, when fully loaded, there will be no distortion or unequal stresses upon equipment or face piping. Skid piping, valving, and instrumentation shall be completely supported from structural frame or vessel to prevent distortion from the vertical and horizontal planes. Upon arrival at the jobsite, skid piping shall be level with the vertical and horizontal planes over the skid length.
   2. The surface finish of the vessels, skids, pipe supports, and other ferrous metallic surfaces shall be primed with rust-inhibitive primer compatible with the paint, and painted with polyamide epoxy.
   3. Skid framing fabricated from I-beam or channel steel shall have anchor bolt holes drilled through both flanges of the structural member to allow anchor holes in the floor to be drilled vertically with the skid in place. Anchoring tabs shall be welded to skids with bases fabricated from hollow structural section. In all cases, there shall be a minimum of 18 inches vertical clearance above the anchor holes to allow for floor drilling. Where this is not possible, it shall be explicitly noted and reasons given.
   4. Pump bases and equipment skid frames shall be designed to allow the base or frame to be filled with grout after the equipment has been set.
   5. All equipment shall be mounted sufficiently high above skid frames to allow adequate clearance to all service points when the skid frames are filled with grout. When a spring-isolated inertia base is required, provide a base designed for concrete fill and spring isolation. Spring isolators shall be provided by the installation subcontractor. Concrete shall be provided by the installation subcontractor. Subcontractor to coordinate with installation subcontractor on spring clip design.
   6. Where applicable, a local control panels shall be provided installed on each skid. The panel rating shall be NEMA 4 minimum or equivalent. All instruments installed on the skid shall be wired to terminal blocks installed in the panel.

F. General:
   1. In no case shall sound levels exceed 85 dB measured 3 feet from the sound source as defined by SEMI S2-91 standards or equivalent. If equipment generates sound levels in excess of this, the vendor shall provide sound insulation to attenuate the sound to less than the specified level.
   2. Equipment and piping labeling shall be located in a manner such that it is easily visible and accessible to operators during normal operation of the equipment. Control components identification shall match the labels and identifiers shown on the P&IDs.
   3. Instrumentation and controls shall be mounted in a manner so as to be easily visible and accessible to the operators for use, calibration, maintenance, and replacement. The top of the highest instrument on local control panels shall be less than or equal to 6.5 feet above finished floor. The minimum height of local control mounted instruments shall be 42 inches above finished floor.
   4. All conduit, mechanical, and process piping shall be supported from epoxy-coated Unistrut or structural steel. FRP or PVC channel framing can be used for nonstandard applications. Galvanized metal and threaded rod are not allowed.

5. For all motors, provide local locking disconnects.

G. Piping:
1. Piping configurations shall not block maintenance access, and shall not block operator viewing of vessel sight glasses and instrumentation.
2. Equipment and skid piping shall be designed and fittings shall be selected to minimize System "dead legs". A dead leg is defined as minimum of four pipe diameters of stagnant liquid which occurs when a valve is closed.
3. Instrument air tubing on equipment and skids shall be flame-retardant polyethylene.
4. Instrument and sample ports shall be located to avoid breakage by operators. Susceptible ports shall be protected by a mechanical plate or other external mechanical shield.
5. Resistivity, conductivity, and pH probes shall be installed in accordance with manufacturer's instructions and in such a manner to ensure the probes are continuously wetted when equipment is taken off line and drained.
6. Manual valve centerlines located more than 7 feet above the finished floor shall be equipped with chain wheel operators. Chains shall be sized such that the bottom of the chain hangs four to five feet above finished floor.
7. The hand wheel on gear operated manual valves shall be at least 6 inches in diameter.
8. The use of thread lubricants and sealants for the construction of the RODI system is prohibited at all times. Teflon tape that is impregnated with metals, or dyed with coloring is prohibited at all times. Only the use of pure, unpigmented (white), teflon tape on threads is acceptable.

H. Nameplates:
1. Attach a permanent stainless steel or self-adhesive chemically resistant plastic equipment identification label to each component. The label shall state the following minimum information:
   a. Equipment name and service.
   b. Equipment identification number.
   c. Name of manufacturer.
   d. Manufacturer serial number.
   e. Date of manufacture.
   f. Purchase order number.
   g. Nominal capacity.
   h. Design temperature and pressure.
2. The nameplate shall be clear coated to prevent chemical corrosion.

I. Extra Stock:
1. For each filter component, provide one full set of sacrificial filter cartridges for start up, and one full set of spare filter cartridges.
2. Salt for brine tank: Furnish for a minimum of four (4) times original load.

2.2 WATER SOFTENER

A. Water softening system: Vertical pressure type ion exchanger system with regenerating equipment, complete with components required to insure proper operation.

B. The water softening system shall consist of one softener tank. During normal operation, the tank will have a normal service flowrate. During regeneration, the tank will be offline.

C. Softener tank: Fiberglass reinforced molded thermoplastic inner shell with dished heads, equipped with reinforced openings for piping connections:
1. Provide hand hole at top and bottom and tank supports of structural steel.
2. ASME Code rated at 150 PSI working pressure.

D. Internal distribution: Design underdrain system to uniformly collect softened water as well as distribute backwash laterally across entire bed:
1. Header-lateral construction with minimum of 2 plastic strainers per 1 SF of bed area.
2. Furnish gravel sub-fill only, not extending above strainers.

E. Upper distribution system: Header-lateral manifold type arranged for uniform distribution of both brine solution and raw waste, as well as collection of backwash:
   1. Construct both upper and lower distributors of an approved non-corrosive material.

F. Ion exchange resin: High capacity sulfonated polystyrene type requiring no chemicals other than sodium chloride to obtain specified capacity.

G. Controls:
   1. The softener tank shall be provided with a water volume initiated 5 cycle fully automatic regeneration, managed by a solid state electronic controller featuring:
      a. Fully programmable cycle times.
      b. Service and standby modes.
      c. Water volume totalizer and flow rate displays.
      d. System status indicator lights.
      e. Provisions for additional auxiliary outputs.
   2. Provide controls interface compatible with the facility control system. Provide output for connection of common trouble alarm to BNL control system.

H. Provide pressure gauges with sample cocks on inlet and outlet of each tank.

I. Regenerating tank: Rigid, molded polyethylene, or welded steel with flat bottom with bitumastic coating inside and rust inhibiting primer on exterior:
   1. Fresh make-up water shall flow downward through solid salt controlled by float valve in salt storage tank.
   2. Filter brine through 5 IN layer of graded gravel and collect by suitable collector.
   3. Provide automatic valve to control amount of brine draw.
   4. Furnish with 6 IN support legs.
   5. Provide necessary valves, educator and piping.
   6. Size: Large enough for a minimum of four (4) regenerations at full salting.

J. Provide water testing kit to make chemical tests necessary for controlling operation and adjustments of brine dosage.

K. Size and capacity as shown on drawings.

2.3 PREFILTER

A. Low velocity multi-media filter with stratified filter media designed to remove turbidity, suspended solids and heavy sediments.

B. Vessel: Welded, industrial grade, cold rolled carbon steel with dished head:
   1. Construct and stamp in accordance with ASME Code, Section VIII and U-1 (Unfired Pressure Vessels). Design vessel for a maximum operating pressure of not less than 125 psig and test hydrostatic pressure of not less than 150 psig. Sideshell height shall be designed to allow for a minimum of 50 percent expansion of filter media during backwash cycle.
   2. Filter bed media components; top layer of 1.0-1.2 MM anthracite (SP=1.5); second layer of 0.4-0.5 MM flint sand (SP=2.6); third layer of 0.35-0.45 MM garnet (SP=4.0) all of which rests upon a coarse gravel underbedding to ensure even flow distribution. Filtered water collector and backwash water distributor shall be a fine-slotted self-cleaning stainless steel or plastic manifolds with slots sized to prevent passage of filter media. Ship filter bed media separately.
   3. Furnish vessel with O-Ring seals at openings, inlet, outlet, backwash outlet, manway, top loading port, backwash sight glass, drain valves, inlet and outlet pressure gauges with isolating valves, self-adjusting flow control valves (backwash, slow rinse and fast rinse), 14-day calendar clock and controls necessary for automatic regeneration.
   4. Exterior Finish: Epoxy enamel.
   5. Interior finish: Minimum 30 mil thick monolithic, inert, non-leaching virgin polyethylene, permanently bonded by heat fusion.

C. Vessel Internal Piping and Fittings: PVC, Schedule 80.

D. Size and capacity as shown on drawings.

2.4 CARBON FILTER

A. The carbon filter shall be granular activated carbon (GAC) required in the pretreatment/makeup water system for removal of residual chlorine and the reduction of nonpolar organics (TOC) from the city inlet water.

B. The filter system shall consist of a carbon filter. During normal operation, the activated carbon filter will have a normal service flowrate. During backwash, the filter will be offline.

C. The activated carbon filter shall produce water having a residual chlorine concentration of less than 0.1 ppm when operated at the normal service conditions.

D. The activated carbon filter shall be designed for a carbon loading rate of 2 gpm per cubic foot.

E. Filter vessel: Fiberglass reinforced molded thermoplastic inner shell with dished heads, equipped with reinforced openings for piping connections:
   1. Provide hand hole at top and bottom and tank supports of structural steel.
   2. ASME Code rated at 150 PSI working pressure.

F. Distribution system: Header-lateral manifold type arranged for uniform distribution, as well as collection of backwash.
   1. Construct both upper and lower distributors of an approved non-corrosive material.

G. Controls:
   1. The filter vessel shall be provided with a water volume initiated 5 cycle fully automatic regeneration, managed by a solid state electronic controller featuring:
      a. Fully programmable cycle times.
      b. Service and standby modes.
      c. Water volume totalizer and flow rate displays.
      d. System status indicator lights.
      e. Provisions for additional auxiliary outputs.
   2. Provide controls interface compatible with the facility control system. Provide output for connection of common trouble alarm to BNL control system.

H. Provide pressure gauges with sample cocks on inlet and outlet of each tank.

I. Size and capacity as shown on drawings.

2.5 REVERSE OSMOSIS (RO) SYSTEMS

A. Design Criteria: The reverse osmosis unit shall be designed to comply with the specified performance requirements. The Vendor shall recommend the hydraulic array most closely approximating optimum performance at the lowest applied system drive pressure.

B. The reverse osmosis unit shall be supplied complete with membrane elements (not installed), pressure vessels, interconnecting piping and valves, instrumentation and controls, sample taps, pressure gauges, pump control, control panel, and support structure.

C. Feed pumps:
   1. Pump shall be an integral unit consisting of an ANSI B73.1 316 stainless steel vertical multistage centrifugal pump and motor.
   2. Pump shall be non-contaminating and designed for the high purity service intended.
   3. Single external mechanical seal model shall have silicon carbide/silicon carbide surfaces, and stainless steel metallic parts. Elastomers shall be viton.
   4. All pumps shall be sized such that the impeller required at the given maximum flow and head is midrange of the impellers available in the casing provided. Motor horsepower shall be sized to prevent motor overloading at reduced system head.
   5. Operating point shall not be to the right of the maximum efficiency on the pump curve.

6. Motor enclosures shall be TEFC. Motors shall be inverter duty rated, suitable for adjustable frequency drive operation, and 460 V, 60 Hz service.
7. No oils or grease shall be used during assembly of the volute and impeller.
8. Motors shall have a high-current motor protection switch. All RO pumps will have controlled-voltage starters or adjustable frequency drives provided by others.
9. Pumps shall be mounted on the top or side of the membrane skid, and shall be easily removable.
10. Basis of Design: ITT-Goulds SSV.

D. Vessels/tubes:
1. The RO vessels shall be filament-wound FRP.
2. The vessels shall be designed, fabricated, and tested in accordance with ASME standards.
3. Vessel exterior finish shall be a white pigmented gel coat.

E. Membrane elements:
1. Membranes shall arrive on site in the original manufacturer's packaging. Performance test data on the membranes shall be available for any membrane required to be wet packed.
2. Furnish EPDM or Viton o-rings, gaskets, and seals. Furnish interconnectors and any other hardware required for a complete system.

F. Piping and valves:
1. All valving shall be within 6 feet of the finished floor. Isolation valves shall be provided across each pump and each vessel array.
2. CAM-LOC connections (Victaulic connections in high pressure piping) shall be provided across each vessel bank within an array for membrane cleaning.
3. Sample taps shall be provided on the product line from each vessel.

G. Controls: Solid state electronic controller.
1. Flow, temperature, resistivity, and pressure transmitters and indicators shall be supplied as required for a complete and operating system
2. Flow elements and indicators are required on the feed, product, recycle and reject streams. Includes percent recovery and rejection.
3. Temperature elements and indicators are required on the feed streams.
4. Resistivity elements and indicators are required on the feed and product streams.
5. Pressure transmitters and indicators are required on the pre-filter, pump discharge, product and reject streams.
6. Provide controls interface compatible with the facility control system.

H. Size and capacity as shown on drawings.

2.6 RO AND DI WATER STORAGE TANKS

A. A water storage tanks shall be provided to allow retention time for product water distribution for each system.

B. Tanks shall be manufactured of linear, rotationally molded polyethylene with extra heavy wall construction.

C. Fabrication:
1. The tanks shall be vertical with cone bottoms and straight sides.
2. The tanks shall be provided with at least four lifting lugs evenly spaced and incorporated into the straight sides. Lifting lugs shall be of manufacturer's design, using 304 stainless steel material.
3. Cone-bottomed tanks shall be mounted on polypropylene or steel stand and basket assemblies with hold-down lugs. The hold-down lugs shall be made of 304 stainless steel.
4. Support stands and frames for conical bottom, horizontal and rectangular tanks must be reinforced to minimize bulging.
5. Support stands and frames shall be manufactured from polypropylene or carbon steel. Design shall be able to support the tank and tank contents having a specific gravity of 1.9.

6. Flanged nozzles, plate-gusseted nozzles, and bottom-drain nozzles shall be provided as required. All fittings shall be molded or seamlessly welded – gasketed bulk head fittings are not allowed. Flange diameters and drillings shall meet ANSI B16.4 150-pound standard. Compression molded, PVC long shank, double nut, high torque design flanges are acceptable. Nozzle bolt holes shall straddle natural tank center lines.
7. Manways shall be provided with all necessary gaskets, non-corrosive bolts, and covers.
8. Tank restraint system shall be supplied and the design for same certified by a structural engineer registered in the state where the project is located. Detailed instructions for installation shall be provided, along with all necessary hardware including anchor bolts. All components of the restraint system shall be stainless steel.
9. The final locations of nozzles and accessories shall be subject to change until shop drawing approval.

D. Accessories:
1. Water loop return spray ball fitting. Spray Systems 27500 or equal.
2. Hydrophobic PTFE submicron vent filter. Siemens FCVPTO6S1 or equal.
3. Non-intrusive level controls. Flowline Switch-Tek / Point or equal.
4. Tank repair kit containing all of the necessary components for small repairs.
5. Gaskets shall be Viton.
6. All flanges shall be covered with blind flanges and Viton gaskets bolted securely in place. However, the tank will be shipped in a manner that allows the tank to "breathe".

E. Finishes:
1. The tank support and basket assemblies shall be painted with corrosion-resistant epoxy paint.
2. The tank finish shall be natural polyethylene.

F. Basis of Design: Terracon, model CXC, see drawings for capacities.

2.7 REPRESSURIZATION PUMPS

A. Each pump shall be an integral unit consisting of an ANSI B73.1 316 stainless steel vertical multistage centrifugal pump and motor.

B. Pump shall be non-contaminating and designed for the high purity service intended.

C. Single external mechanical seal model shall have silicon carbide/silicon carbide surfaces, and stainless steel metallic parts. Elastomers shall be FPM (Viton®).

D. All pumps shall be sized such that the impeller required at the given maximum flow and head is midrange of the impellers available in the casing provided. Motor horsepower shall be sized to prevent motor overloading at reduced system head.

E. Operating point shall not be to the right of the maximum efficiency on the pump curve.

F. Motor enclosures shall be TEFC. Motors shall be inverter duty rated, suitable for adjustable frequency drive operation, and 460 V, 60 Hz service.

G. No oils or grease shall be used during assembly of the volute and impeller.

H. Each pump shall be supplied with matched adjustable frequency drives (AFD), provided by the Vendor. AFDs will be in accordance with Specification Section 25 23 00.

I. Basis of Design: ITT-Goulds SSV Series, with Aquavar drive, size and capacity as shown on drawings.

2.8 DEIONIZED (DI) MIXED BEDS

A. Mixed bed ion exchange vessels shall be Service Deionization (SDI) type, with quick connect fittings on inlet and outlet to facilitate removal for off-site regeneration. SDI vessels shall be BNL furnished and BNL installed.

B. Resin furnished shall be suitable for use in polish mixed bed deionizer application and for the intended application. The Vendor shall confirm with resin manufacturer the best vessel design to support the resin's unique characteristics.

C. The Vendor shall provide BNL with the mixed bed ion exchange requirements, and recommendations of local SDI companies providing off-site ion regeneration vessel supply and service.

D. Equipment – vessels:
   1. Each vessels volume shall be 3.6 cubic feet.
   2. Vessels shall be filament wound FRP, ASME code rated at 150 PSI working pressure.
   3. Underbed construction shall be dished false bottom with electropolished 316L stainless steel slotted well screen strainer inserts and tailpipes.

E. Internal distributors and collectors:
   1. The inlet distributor shall be of an electropolished 316L stainless steel high-flow header/splash-plate design.
   2. An adjustable directional spray nozzle system, with header and laterals, shall be provided for sluicing the resin from the sides and the bottom of the tank. No more than ½ liter of resin shall be left in the service vessel after each resin transfer. Nozzles shall have well screen inserts to prevent movement of resin back into the header during normal service when a constant purge will flow out of the vessel.
   3. Well screen bayonet-style nozzles shall be provided for the bottom nitrogen inlet and the drain-down connections.
   4. All internal hardware shall be electropolished 316L stainless steel.

F. Resin trap:
   1. Resin trap shall have electropolished 316L stainless steel well screen with acrylic cylinder sandwiched between line flanges. Resin trap shall be in-line type with a resin flush port.

G. Acceptable manufacturers: Siemens/USFilter, GE Water, or equal, size and capacity as shown on drawings.

2.9 ULTRAVIOLET (UV) STERILIZERS

A. Design:
   1. For Bacteria destruction the ultraviolet light wavelength shall be 254 nm.
   2. The UV dosage shall be at least 40,000 mws/cm^2 at 254 nm after 9,000 hours of operation time.

B. General: As a minimum, ultraviolet sterilizers shall each have the following:
   1. Single medium-pressure mercury vapor lamp in a quartz tube with electrical connections at both ends.
   2. Single quartz sleeve to isolate the lamp tube from the product water.
   3. UV monitor for continuous indication of UV lamp intensity.
   4. High temperature switch for automatic lamp shutoff protection.
   5. Clear labeling of each UV housing to indicate the lamp wavelength.
   6. Clear labeling of each UV control panel to indicate unit service (e.g. Polish Loop Sterilizer), housing equipment number and electrical source.
   7. An integral power-stepping function to maintain constant UV dosage during life of the UV lamp.
   8. UV sterilizers shall be designed to allow BNL to change the sterilizer purpose (operating wavelength) by changing out no more than the UV lamp and the quartz sleeve.
   9. All wetted elastomers for the UV units shall be ozone-compatible. Solid Teflon gaskets shall not be used.

C. Construction:
   1. House high intensity ultraviolet lamps in recessed, specially fused quartz sleeves, with ozone-compatible (viton) seals, to isolate the lamp tube from the product water.

2. Wetted surfaces of the UV sterilizer chamber and other components shall be 316L stainless steel that is electropolished for a sanitary finish of less than 15 Ra microinches (36 Ra on welds). All stainless steel welds shall be full penetration and purged with inert gas, and weld radii shall be ground smooth prior to electropolish.
3. Quartz sleeves shall be watertight to allow lamp changeout without draining the chamber.
4. Inlet and outlet piping connections to the UV sterilizers shall be electropolished 316L stainless steel with a 50 Ra maximum surface roughness. As a minimum, stainless steel piping shall be used from the flanged UV sterilizer connection up to the flanged end of the inlet or outlet butterfly valve. A light trap, of at least one stainless steel 90 degree elbow and 2 feet of pipe shall be provided at each connection.
5. Rate sterilizers at 150 PSI and test to 180 PSI.
6. Fabricate the ultraviolet chamber with a helical baffle for proper water passage through the unit for maximum germicidal and organic destruct efficiency, with a minimum 3X flow potential.
7. Electrical supply shall be single phase 120V, 60 HZ.

D. Power Panels:
1. The sterilizer power panels shall be controlled and powered, and at a minimum, provide local indication of the following:
   a. Lamp ON/OFF status.
   b. Lamp intensity.
   c. Lamp run time.
   d. Alarm status lights.
   e. HAND/OFF/AUTO hand switches for lamp operation.
   f. Provide integral waterstop in conduit between the quartz sleeve and the power panel.
2. The UV sterilizers shall be configured such that, if power to the UV sterilizer is interrupted or lost, the UV sterilizers automatically restart once the power source is regained.

E. Controls: Provide each sterilizer with a NEMA 4X stainless steel status display panel, optical sensor, intensity meter, lamp status indicator, temperature safety controls, and running time meter:
1. Provide controls interface compatible with the facility control system. Provide output for connection of common trouble alarm to BNL control system.

F. Basis of Design: Aquafine SL or CSL series, size and capacity as shown on drawings.

2.10 FINAL FILTERS

A. High purity cartridge filter housings and elements for DI water final filtration.

B. Filter housings:
1. Housing shall be designed and manufactured in accordance with ASME Code Section VIII, Division I.
2. All filter housings shall be pressure tested in accordance with ASME pressure vessel code.
3. Filter housings shall be of passivated 316L stainless steel construction. Elastomers shall be viton.
4. Housings shall have a flanged side inlet and a flanged bottom outlet.
5. The filter housing vent connection shall be a ¼-inch FNPT fitting located at the top of the dome lid.
6. All flanges shall be welded to the housing surface such that the flange face surface is parallel to the normal tangent at the point of connection within 1 degree (1/32 inch per 12 inches).
7. The axis of any flange or connection shall be located with a bilateral tolerance of 1 degree around the perimeter of the housing relative to the axis of an opposing flange or connection.
8. For vessel heads greater than 10 pounds, provide spring assisted or manual screw jack type of head lifting system.
9. All filter housings shall be designed in a manner which minimizes the dead space above the cartridges (no domed top plates).

10. The support rods and hold-down plate shall be designed to allow filter elements from multiple high-purity cartridge manufacturers.

C. Filter elements:
   1. Filter elements shall be high surface area filter cartridges, constructed of pleated glass microfiber media and polypropylene core, providing absolute particle retention and long on-stream life cycles.
   2. Materials of construction shall provide a wide chemical compatibility, with no leachables or extractables, for intended service.
   3. Final-filters shall have a rating of 0.2 micron absolute.

D. Basis of Design: Millipore Corp., Size and capacity as shown on drawings

2.11 INSTRUMENTATION

A. The Vendor shall supply all control devices required for a complete and operating system, including (but not limited to) the following:
   1. Conductivity monitor:
      a. Transmitter:
         1) 4 line back-lit display.
         2) UL listed and CE compliant approvals, with NEMA 4X and IP 65 enclosure.
         3) Power supply shall be 115V AC, 5 A.
         4) Output shall be 4-20 mA.
         5) Ambient operating environment shall be -10 to 50 degC, 0-95% relative humidity.
         6) Measurement shall be 0.02 to 2000 uS/cm, with an accuracy of +/- 0.5%.
      b. Probe:
         1) 3/4 IN MNPT match probe, with patch cord as required.
      c. Basis of Design: Thornton.

2.12 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

PART 3 - EXECUTION

3.1 INSTALLATION REQUIREMENTS – GENERAL

A. Vendor shall furnish onsite factory trained permanent employees as necessary to fully inspect the received equipment and supervise the entire installation of the RO and DI systems (in accordance with all written Vendor instructions and specifications). Final acceptance of the RO and DI systems shall be subject to satisfactory completion of the performance specifications detailed herein. Vendor's onsite employees shall supervise and document in real time any adjustments necessary and required for satisfactory operation.

B. Vendor's Responsibility and Services:
   1. The Vendor's employee(s) shall be prepared as necessary to assist the Mechanical and Electrical Contractors during installation and to provide written certification that the equipment has been installed as specified and in accordance with Vendor's requirements.
   2. The Vendor's employee(s) shall provide the initial start up of equipment in the presence of the Commissioning Authority and BNL:
      a. Provide a pre-start check of all piping, valves, control devices, control panels, and equipment.
      b. Perform final calibrations and adjust equipment and controls for operation at the specified design conditions.
      c. Provide a record of all start-up events noting problems and their resolution.
      d. Provide a record of all set points for operational controls and devices.

e. Review the functional operating sequence associated with programmed PLC software and correct to comply with O&M manual documentation requirements and update the Vendor generated sequence of operations submitted before equipment shipment.

3. Upon the completion of equipment startup, provide up to 40 hours of instructional time with BNL's personnel to review the operations and maintenance manuals and perform each step necessary for start up, shut down, troubleshooting, and routine maintenance. The instructional times shall be scheduled through BNL.
4. Upon completion of all inspection, start up, testing, check out, and validation procedures, the Vendor shall submit written notice to the Commissioning Authority and BNL that the RO and DI systems areis ready for use by BNL.

3.2 EQUIPMENT

A. Vendor shall furnish equipment installation instructions in the form of drawings and written instruction as part of the Operation and Maintenance Manuals. Installation of factory-assembled equipment skids, loose equipment, interconnecting piping and accessories, control panels, interconnecting wiring, and instrumentation shall be by the Mechanical and Electrical Contractors under the Vendor's supervision.

B. Mechanical and Electrical Contractors shall be responsible for installation of equipment base pads for equipment skids, pumps, vessels, panels, etc. Typical base pad details are provided on the Drawings.

3.3 TANK INSTALLATION

A. After inspection and acceptance by BNL, the RO and DI tanks shall be unloaded, stored and subsequently installed by the installer. Tanks shall be stored on a smooth, padded (as described for shipping) surface until installation. Care will be taken during storage to prevent flexing of the nozzles, brackets, or lugs and impacts and rolling.

B. The Mechanical Contractor shall verify field conditions prior to installation.

C. The Mechanical Contractor shall install the tank per the manufacturer's written instructions, this specification, and the drawings.

D. Prior to final placement of tanks, the Mechanical Contractor shall submit tank installation drawings to BNL for approval of tank location, elevation, and orientation.

E. Prior to placing into service, all interior surfaces including nozzle interiors and manway cover of the tank shall be wiped down with isopropanol using a lint-free cloth and rinsed with deionized water. After rinsing and drying, all openings shall be capped and sealed with clean rigid materials to prevent contamination of the tank.

3.4 FILTER INSTALLATION

A. Filter elements: The sacrificial and operational filter element sets shall be installed in the filter housings by the RO and DI water systems Vendor.

B. All filter elements shall be shipped to the job site in the filter manufacturer's original, unopened shipping containers by the vendor just prior to installation in the filter housings.

3.5 INSTRUMENTATION AND CONTROLS INSTALLATION

A. Electrical Contractor shall install, connect, and calibrate field-mounted instrumentation and control devices in accordance with the drawings provided by the Vendor.

B. Panels and wiring shall be installed in accordance with applicable sections in Special Construction Divisions and Electrical Divisions.

C. Vendor shall be responsible for installation, startup, debugging, and demonstration of PLC program software.

3.6 SYSTEMS PRESSURE TESTING

A. Test RO and DI systems equipment and piping in accordance with applicable sections of this specification and Mechanical Specifications, when directed by BNL.

END OF SECTION

SECTION 22 67 23
PROCESS COOLING WATER SYSTEM

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Standards:
   1. ANSI/ASME B73.1 - Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process.
   2. ASME B31.9 – Building Services Piping.

1.2 RELATED WORK

A. Refer to other Mechanical and Plumbing Specification Divisions for general and special mechanical requirements.

B. Work of other Mechanical Specification Divisions:
   1. Welding and brazing requirements.
   2. Insulation.
   3. Plumbing systems.
   4. Pipe hangers and supports.
   5. Piping and equipment identification.
   6. Process piping systems.

1.3 SUBMITTALS

A. Product Data:
   1. Performance data, and pump curves.
   2. Physical dimensions and weight data.
   3. Vibration and acoustical data.
   4. Piping diagrams, and field connections.
   5. Electrical and controls wiring data, and field connections.

B. Contract Closeout Information:
   1. Operating and maintenance data.
   2. BNL instruction report.
   3. Warranty.

1.4 DESIGN CRITERIA

A. The process cooling water system will be designed to circulate chilled water to the facility at 50 PSIG supply pressure at a temperature of 60 degF at the system supply outlet. The return water temperature will be 70 degF.

B. The system will operate by monitoring the supply and return water temperatures and will maintain the 60 deg. F supply water temperature. The circulating pumps will be controlled by adjustable frequency drives to maintain the end of loop pressure setpoint of 50 PSIG.

C. The system will be adjusted to have a 1/4 GPM continuous makeup of fresh water. There will also be a side stream of water through the mixed beds to maintain the process cooling water quality.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Pumps:
      a. Base:
         1) Goulds.
      b. Optional:
         1) Durco.
         2) Peerless Pump.
   2. Pump mechanical seals:
      a. Optional:
         1) Five Star.
         2) Crane.
         3) Garlock.
         4) Durametallic.
         5) American Seal Technology (AST).
   3. Pump packing:
      a. Optional:
         1) Garlock.
         2) Chesterton.
         3) Crane.
   4. Pump couplings:
      a. Optional;
         1) TB Woods.
         2) Dodge.
         3) Koppers.
         4) Omni Flex.
   5. Heat exchangers:
      a. Base:
         1) Alfa Laval Thermal.
      b. Optional:
         1) Tranter.
         2) Bell & Gossett ITT.
   6. Water cartridge filters:
      a. Base:
         1) Pall.
      b. Optional:
         1) Filterite.
         2) PTI Advanced Filtration.
   7. Ultraviolet sterilizers:
      a. Base:
         1) Trojan Technologies.
      b. Optional:
         1) Aquafine Corp.
         2) Aquionics.
   8. Air Separator:
      a. Base:
         1) Amtrol Engineered Products
      b. Optional:
         1) Bell & Gossett.
         2) Taco.
   9. Expansion tank:
      a. Base:
         1) Amtrol Engineered Products

b. Optional:
   1) Bell & Gossett.
   2) Taco.

10. Deionized Mixed Beds:
    a. Base:
       1) Siemens Water Technologies.
    b. Optional:
       1) GE Water Technologies.
       2) Agape Water Solutions.

2.2 PUMPS

A. Pumps shall be base mounted end-suction horizontal, and shall comply with the requirements of ANSI B73.1, Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process.

B. Pumps shall have wetted metallic parts using passivated type 316L stainless steel. Provide FPM (Viton®) elastomers and wetted seal components of type 316 stainless steel.

C. Pumps shall operate at 1800 RPM or less, unless pressure requirements necessitate higher speed.

D. Pumps with suctions and discharge connections greater than or equal to 2 IN shall have non-threaded, flanged connections that conform to ANSI standards.

E. Bearing material shall be recommended and guaranteed by pump manufacturer. Life of anti-friction ball or roller bearings shall be calculated in accordance with ANSI/AFBMA 9, Load Rating and Fatigue Life for Ball Bearings, or ANSI/AFBMA 11, Load Rating and Fatigue Life for Roller Bearings, and guaranteed for a minimum life of 50,000 hours at rated conditions.

F. Impellers shall be balanced in accordance with International Organization for Standardization (ISO) G6.3.

G. Pumps shall have spacer-type shaft couplings unless otherwise specified.

H. Shafts:
   1. Only solids shafts are allowed.
   2. Dynamic shaft deflection at the impeller centerline under maximum load shall not exceed 0.0002 IN at the face of the mechanical seal.
   3. Shaft run out at the face of the mechanical seal and at the impeller shall not exceed 0.002 IN.
   4. Run out at the face of the stuffing box (or seal chamber) shall not exceed 0.002 IN.
   5. Stuffing box (or seal chamber) register run out shall not exceed 0.002 IN.

I. Shaft sealing:
   1. Pumps shall be equipped with mechanical seals.
   2. Gland plates shall have at least four bolts.

J. Pumps shall be provided with the following:
   1. Lifting lugs for pumps weighing over 100 pounds.
   2. Tapped, plugged suction, and discharge pressure gauge connections.
   3. Case drains.

K. Pump motor drives:
   1. Motors shall be premium efficiency, rated for inverter duty use with adjustable frequency drives. See section 20 05 00.
   2. See section 25 23 00 for adjustable frequency drives (AFD).

2.3 AIR SEPARATORS

A. Air separators shall be cyclone action/centrifugal type, with system strainer.

B. Separators chosen shall be rated by the manufacturer for a capacity equal to or greater than the service where they are to be installed.

C. Separator vessels shall be type 304 stainless steel, or internally and externally epoxy-coated carbon steel for corrosion resistance. ASME code stamped for 125 PSIG at 350 degF.

D. Separator vessel shall be provided with flanged inlet and outlet connections, top vent connection to direct accumulated air, and bottom blowdown connection to facilitate routine cleaning.

E. Separator shall be provided with support brackets for suspended mount or skirt for floor mount, where applicable to facilitate installation.

2.4 EXPANSION TANKS

A. Tanks shall be welded carbon steel, ASME code stamped for 125 PSIG at 240 degF, with heavy duty butyl rubber bladder.

B. Accessories: Provide valved pressure gauge and air-charging fitting (1/4-inch NPT), tank drain, furnished flanged handhold for bladder removal.

C. Tank shall be provided with steel legs for floor mount or support brackets for wall mount, where applicable to facilitate installation.

2.5 PLATE AND FRAME HEAT EXCHANGERS

A. Exchangers shall be gasketed plate design with individually removable channel plates, epoxy coated steel frame and pressure plates at each end of the unit, and corrosion resistant steel carrying bars capable of at least 50 percent extension capacity.

B. ASME construction and stamped for 125 PSIG working pressure and 275 degF design temperature.

C. Plate material shall be type 316 stainless steel with clip-on EPDM gaskets.

D. Nozzles for hot side liquid shall be type 316 stainless steel.

E. Design for counter flow use, with inlet/outlet nozzles for each service on the same side of the unit.

F. Where indicated on the drawings, furnish removable and reusable insulation for the plate and frame heat exchanger. The insulation shall be 2 inch thick poltisocyanurate board with an inner aluminum liner and outer skin.

2.6 WATER CARTRIDGE FILTERS

A. Filter elements:
   1. Filter elements shall be constructed of chemical resistant polypropylene medium and core. No binder resin shall be used. Filter gaskets shall be EPDM.
   2. Filter elements shall have a 100% removal rating at 10 microns absolute.
   3. Filter elements shall be double open-ended configuration, and the length shall be as required for the housing installation.

B. Filter housing:
   1. Filter housing shall be constructed of type 316 stainless steel shell, tube sheet, and connections. Housing gaskets shall be EPDM.
   2. Filter housing shall be designed and constructed in accordance with ASME codes, and stamped for 200 PSIG at 300 degF.
   3. Inlet and outlet connections shall be 150 LB flanged. Drain and vent connections shall be NPT threaded half coupling.
   4. Filter housing shall be provided with steel legs for floor mount, and with lifting davits.
   5. Filter housing provided with inlet/outlet pressure taps and differential pressure meter.

C. Make-up water filters:
   1. All of the system makeup water supplies shall be provided with water filters.
   2. Filter housing and element shall be constructed of polypropylene, with buna-n gaskets.
   3. Filter elements shall have a nominal removal rating at 25 microns absolute.

4. Filter assembly (housing and element) shall be selected for a maximum pressure drop of 5 PSI at design flow rate. A differential pressure meter shall be provided with the housing cap.
5. Filter housings shall be designed and constructed for 90 PSIG at 100 degF.
6. Basis of Design: Pentek Big Blue housing, DGD element.

2.7 ULTRAVIOLET STERILIZER

A. Design:
   1. For TOC destruction the ultraviolet light wavelength shall be 185 nm.
   2. The UV dosage shall be at least 90,000 mws/cm^2 at 254 nm after 9,000 hours of operation time.

B. Construction:
   1. House high intensity ultraviolet lamps in recessed, specially fused quartz sleeves, with ozone-compatible (viton) seals, to isolate the lamp tube from the product water.
   2. Use pickled, passivated, and electropolished (40 Ra) type 316 stainless steel for wetted materials other than quartz tubes, fine finish 304 stainless steel for other structural metal parts, and ozone-compatible (viton) for O-ring seal and flat gaskets.
   3. Rate sterilizers at 150 PSI and test to 180 PSI.
   4. Fabricate the ultraviolet chamber with a helical baffle for proper water passage through the unit for maximum germicidal and organic destruct efficiency, with a minimum 3X flow potential.
   5. Provide flanged inlet and outlet piping connections, perpendicular to the quartz tubes. A light trap, of at least one type 304 stainless steel 90 degree elbow, 2 FEET of type 304 stainless steel pipe and flange, shall be provided at each connection.
   6. Electrical supply shall be single phase 120V, 60 HZ.

C. Controls: Provide each sterilizer with a NEMA 4X stainless steel status display panel, optical sensor, intensity meter, lamp status indicator, temperature safety controls, and running time meter:
   1. Provide controls interface compatible with the facility control system. Provide output for connection of common trouble alarm to BNL control system.

2.8 DEIONIZED (DI) MIXED BEDS

A. Mixed bed ion exchange vessels shall be Service Deionization (SDI) type, with quick connect fittings on inlet and outlet to facilitate removal for off-site regeneration. SDI vessels shall be BNL furnished and BNL installed.

B. Resin furnished shall be suitable for use in polish mixed bed deionizer application and for the intended application. The Vendor shall confirm with resin manufacturer the best vessel design to support the resin's unique characteristics.

C. The Vendor shall provide BNL with the mixed bed ion exchange requirements, and recommendations of local SDI companies providing off-site ion regeneration vessel supply and service.

D. Equipment – vessels:
   1. Each vessels volume shall be 3.6 cubic feet.
   2. Vessels shall be filament wound FRP, ASME code rated at 150 PSI working pressure.
   3. Underbed construction shall be dished false bottom with electropolished 316L stainless steel slotted well screen strainer inserts and tailpipes.

E. Internal distributors and collectors:
   1. The inlet distributor shall be of an electropolished 316L stainless steel high-flow header/splash-plate design.

2. An adjustable directional spray nozzle system, with header and laterals, shall be provided for sluicing the resin from the sides and the bottom of the tank. No more than ½ liter of resin shall be left in the service vessel after each resin transfer. Nozzles shall have well screen inserts to prevent movement of resin back into the header during normal service when a constant purge will flow out of the vessel.
3. Well screen bayonet-style nozzles shall be provided for the bottom nitrogen inlet and the drain-down connections.
4. All internal hardware shall be electropolished 316L stainless steel.

F. Resin trap:
1. Resin trap shall have electropolished 316L stainless steel well screen with acrylic cylinder sandwiched between line flanges. Resin trap shall be in-line type with a resin flush port.

G. Acceptable manufacturers: Siemens/USFilter, GE Water, or equal, size and capacity as shown on drawings.

2.9 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

2.10 CONTROLS

A. Provide controls interface compatible with the facility control system see Section 25 50 00 Building Management and Control System. Provide output for connection of common trouble alarm to BNL control system.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. General: Install equipment as indicated on the drawings, and in strict accordance with the manufacturers written instructions.

B. Install equipment on vibration isolation bases where specified elsewhere in the construction documents.

C. Inline suspended equipment (i.e. air separators) shall be installed with adequate support such that the connected piping shall not support any of the equipment weight.

3.2 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

END OF SECTION

DIVISION 23

HEATING, VENTILATING, AND AIR CONDITIONING

SECTION 23 21 13
HYDRONIC PIPING SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of systems:
   1. Systems:
      a. Chilled water piping.
      b. Coil header piping.
      c. Condensate and cooling coil drain piping.
      d. Heating water piping.
      e. Glycol water piping.
      f. Make-up water piping.
      g. Water treatment system piping.
      h. Glycol and glycol feed system.
   2. Products:
      a. Air vents.
      b. Expansion tanks.
      c. Flow switch wells.
      d. Pressure and temperature test stations, combination.
      e. Strainers.
      f. Valves.
      g. Water flow measurement devices.

B. Work installed but not furnished:
   1. Automatic valves: Furnished in Section 25 50 00:
      a. Provide fittings and reducers required for installation of automatic valves.

1.2 QUALITY ASSURANCE

A. Piping: ASTM labeled for rating specified.

B. Piping standards: Section 20 11 00.

C. Manual valve standards: Section 20 05 23 (for valves with "V" prefix).

1.3 SUBMITTALS

A. Shop drawings:
   1. Piping layouts at 1/4 IN/FT scale.

B. Product data:
   1. Air vents.
   2. Expansion tanks.
   3. Pressure and temperature test stations, combination.
   4. Strainers.
   5. Valves, manual.
   6. Valves, pressure reducing.
   7. Valves, pressure relief.
   8. Valves, triple duty.
   9. Valves, constant flow control.
   10. Water flow measurement devices.
   11. Water treatment system.
   12. Glycol water make-up system.

C. Contract closeout information:
   1. Operating and maintenance data.
   2. Field test reports.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Air vents, manual:
      a. Base:
         1) Crane Valves.
      b. Optional:
         1) Jenkins.
         2) Johnston.
         3) OIC.
         4) Powell.
         5) Stockham Valves & Fittings.
         6) Walworth.
   2. Expansion tanks:
      a. Base:
         1) Bell & Gossett, ITT.
      b. Optional:
         1) Thrush.
         2) Armstrong Pumps.
         3) Taco.
         4) Amtrol.
   3. Pressure/temperature test stations, combination (P/T plug):
      a. Base:
         1) Peterson Equipment Company (Pete's plug).
      b. Optional:
         1) Sisco P/T Plugs & Flex Connectors.
         2) Super Seal.
         3) Fairfax.
   4. Strainers, in-line wye strainer and valve combination:
      a. Base:
         1) Griswold Controls.
      b. Optional:
         1) Autoflow.
   5. Strainers, single-basket and tee:
      a. Base:
         1) Hoffman Specialty, ITT.
      b. Optional:
         1) Armstrong International.
         2) Gustin-Bacon.
         3) Keckley, OC.
         4) Metraflex.
         5) Mueller Steam Specialty.
         6) Spence Engineering.
         7) Spirax Sarco Type AT.
         8) Tate.
         9) Victaulic of America.
   6. Strainers, duplex basket:
      a. Base:
         1) Hayward.

b. Optional:
    1) Kraissl.
7. Valves, pressure reducing (water and glycol):
    a. Base:
        1) Bell & Gossett, ITT.
    b. Optional:
        1) Watts Control Valves.
        2) Armstrong Pumps.
        3) Conbraco.
        4) Taco.
        5) Thrush.
8. Valves, pressure relief (water and glycol):
    a. Base:
        1) Bell & Gossett, ITT.
    b. Optional:
        1) Farris.
        2) Armstrong Pumps.
        3) Taco.
        4) Teledyne Farris Engineering.
        5) Thrush.
9. Valves, triple duty:
    a. Base:
        1) Bell & Gossett, ITT.
    b. Optional:
        1) Gustin-Bacon.
        2) Victaulic of America.
        3) Armstrong.
10. Valves, constant flow control:
    a. Base:
        1) FDI Flow Design, Inc.
    b. Optional:
        1) Griswold Controls.
        2) Presco.
11. Water flow measurement devices:
    a. Base:
        1) Barco USA.
    b. Optional:
        1) Data Industrial.
        2) Dynasonics.
        3) Gerand Engineering.
        4) Victaulic of America.
12. Water treatment system cleaning chemicals:
    a. Base:
        1) Oakite Products.
    b. Optional:
        1) Mitco.
        2) Diversey Water Technologies.
    c. Deionized water system:
        1) Citranox, acid cleaner and detergent.
13. Water treatment system chemical feeders:
    a. Base:
        1) Nalco.
    b. Optional:
        1) Mitco.
        2) Calgon-Vestal.
        3) Diversey Water Technologies.

14. Glycol water make-up system:
    a. Base:
        1) Nalco.
    b. Optional:
        1) Mitco.
        2) Calgon.
15. Glycol water:
    a. Base:
        1) Dow Chemical Co.
    b. Optional:
        1) Olin Corporation.
        2) Ashland Chemical Co.

2.2 PIPE AND FITTINGS

A. Chilled water piping:
    1. Copper, type L, with soldered joints, and wrought copper or cast brass fitting; or T-drilled with brazed joints:
        a. Mechanical groove-end fittings and couplings may be used for sizes 3 IN and larger.
        b. Pipes 2 IN and less ProPress System by Ridge Tool Company is acceptable.
    2. Black steel, Schedule 40:
        a. 2 IN and smaller: Threaded joints, with cast iron or malleable iron threaded fittings.
        b. 2-1/2 IN and larger: Welded joints.
        c. Grooved couplings and fittings may be used for chilled water and process chilled water piping.
    3. Inside fan plenums (and piping from coil connections to piping headers inside and outside of plenums):
        a. Copper, type L, with soldered joints, and wrought copper or cast brass fittings.
        b. Black steel, with grooved couplings and fittings.
        c. Galvanized steel, with grooved couplings and fittings.

B. Coil header piping:
    1. Fabricate of black steel pipe with weld-o-lets for tees.
    2. Copper, type L, with soldered joints, and wrought copper or cast brass fittings.
    3. T-drilled Type L copper with brazed joints.
    4. For pipes 2 IN and less, ProPress System by Ridge Tool Company is acceptable.

C. Condensate and cooling-coil-drain piping:
    1. Copper, type M or L, and soldered joints.
    2. Galvanized steel with cast iron drainage type fittings.

D. Glycol-water piping:
    1. Black steel, with welded joints:
        a. For 2-1/2 IN and larger: Use forged butt welding fittings.
        b. For 2 IN and less: Use socket welding fittings, 2000 or 3000 PSI class.
        c. Threaded pipes and nipples may be used at equipment connections.
        d. Weld-o-let or thread-o-let type of fittings may be used in lieu or tees for branch connections, provided main is one size larger than takeoff:
            1) Couplings or half couplings are not acceptable except for non-flow connections such as thermometers or gauges.
        e. Grooved type couplings and fittings may be used for glycol-water piping.
    2. T-drilled Type L copper with brazed joints.

E. Heating water piping, above grade:
   1. Copper, type L, with soldered joints, and wrought copper or cast brass fittings; or T-drilled with brazed joints:
      a. Mechanical groove-end couplings and fittings may be used for sizes 3 IN and larger.
      b. For pipes 2 IN and less, ProPress System by Ridge Tool Company is acceptable.
   2. Black steel, with welded joints:
      a. For 2-1/2 IN and larger: Use butt welding fittings.
      b. For 2 IN and less: Use socket welding fittings, 2000 PSI class, or cast iron threaded fittings.
      c. Weld-o-let or thread-o-let type fittings may be used in lieu of tees for branch connections, provided main is one size larger than takeoff. Couplings or half couplings are not acceptable except for non-flow connections such as thermometers or gauges.
      d. Grooved type couplings and fittings may be used for heating water piping.

F. Make-up water piping:
   1. Same as system served.

G. Water treatment system piping:
   1. Same as system served.

2.3 AIR VENTS

A. Air vents, manual:
   1. Vent valves: 1/4 IN 125 PSI globe angle valve with XH nipple connecting to pipe.
   2. Deionized water air vents shall be all stainless steel construction.

2.4 EXPANSION TANKS

A. Tanks, expansion (air-elimination system):
   1. Pre-pressurized diaphragm type.
   2. Size: As scheduled.
   3. Rated pressure: 125 PSIG.
   4. Rated operating temperature: 240 degF, minimum.
   5. Precharge pressure: Same as scheduled minimum operating pressure.
   6. Bladder: Heavy duty butyl, removable for inspection.
   7. ASME constructed and stamped.

2.5 FLOW SWITCH WELLS

A. Flow switch wells:
   1. Install 1 IN thread-o-let for flow switch installation.
   2. Provide 1 IN nipple and cap.

2.6 PRESSURE AND TEMPERATURE TEST STATIONS, COMBINATION

A. Pressure/temperature test station, combination:
   1. Station to receive either a 1/8 IN OD temperature or pressure probe.
   2. Fitting: Solid brass, 1/4 IN NPT, with 2 valve cores of neoprene (maximum 200 degF at 500 PSI) or Nordel (maximum 275 degF at 500 PSI).
   3. Provide extension at locations with pipe insulation. Extension length shall match or exceed insulation thickness.
   4. Provide with color coded and marked cap with gasket, rated at 1000 PSI at 140 degF.

B. Pressure and temperature test kit:
   1. Range: 0-100 PSI, 0-230 FT WG.
   2. 1/8 IN OD probe and 5 IN stem pocket testing thermometers:
      a. Provide 1 for chilled water: 25-125 degF.
      b. Provide 1 50-500 degF for hot water.
   3. No. 500 gauge adapter with 1/8 IN OD probe.
   4. Protective carrying case.

2.7 STRAINERS

A. Strainers, in-line wye strainer and valve combination:
   1. One piece configuration consisting of O-ring union, P/T plug, blow down and ball valve with handle.
   2. Strainer valves 1-1/4 IN and smaller: Limit passage of particles larger than 500 microns.
   3. Strainer valves 1-1/2 IN and larger: Limit passage of particles 1000 microns and larger.
   4. Bronze body construction with threaded or sweat connections:
      a. Internal parts: Brass and stainless steel.
   5. Provide valves with unions to allow field exchange of internal components without removing valve body from pipeline.
   6. Provide metal ID taps permanently marked to show direction of flow, strainer mesh and model number.

B. Strainers, single-basket type:
   1. Screwed or flanged.
   2. Body: Cast iron, flanged ends, bolted access cover.
   3. Coating: Rust inhibiting.
   4. Working pressure, non shock: 150 PSIG.
   5. Screens: Bronze, monel or stainless steel:
      a. 2 IN and less: 3/64 IN perforations.
      b. 2-1/2 IN and larger: 1/8 IN perforations.

C. Strainer, tee-pattern type:
   1. Grooved ends.
   2. Body: One-piece ductile iron casting conforming to ASTM-A536 or malleable iron conforming to ASTM-A47.
   3. Coating: Rust inhibiting.
   4. Working pressure rating: 300 PSI.
   5. Basket screen: 304 stainless steel 0.041 IN wire in a woven No.6 mesh wire screen with 0.126 IN opening.
   6. Vertical down flow or horizontal flow.
   7. Cleaning access through blank end cap.

D. Strainers, wye:
   1. See Section 20 05 19, Piping Specialties.

E. Strainers, duplex:
   1. Ductile iron construction, 125 LB flange connections.
   2. Basket perforations shall be 3/64 IN for chilled water applications and cooling tower water applications.
   3. Perforated stainless steel basket.
   4. PTFE or EPDM seals.
   5. With integral drain and vent valves.

2.8 VALVES

A. Constant flow control valves:
   1. Factory calibrated, direct acting, automatic pressure compensating:
   2. Control flow rates within 4 percent of flow rating over operating pressure differential range.
      a. Set flow rating to match the maximum flow required by device served.
   3. Pressure differential range:
      a. 2-32 PSID.
   4. Threaded-brass or copper-sweat body with stainless-steel internal parts.
   5. Provide a metal identification tag with chain for each installed valve:
      a. Identify valve model number, rated GPM, direction of flow, and differential pressure range.

6. Provide with integral unions and integral ball valve. Y configuration to allow field exchange of flow cartridge without removing valve body from pipeline.
7. Provide as indicated.
8. Pressure and temperature taps.
9. For flow rates, see drawings.

B. Manual valves:
1. Angle valves:
   a. 2 IN and smaller: V-17.
   b. 2-1/2 IN and larger: V-18.
2. Balancing valves:
   a. 2 IN and smaller: V-64.
   b. 2-1/2 IN to 6 IN: V-65.
   c. 8 IN and larger:
      1) Plug valve: V-37 with memory stop.
      2) Provide venturi waterflow measuring device.
   d. Ball type balancing valves/circuit setters shall not be used.
3. Isolation valves (Ball valves):
   a. 2 IN and smaller: V-13 or V-14.
4. Isolation valves (Butterfly valves):
   a. 2 IN and smaller: not used.
   b. 2-1/2 IN and larger: V-34 or V-35.
5. Check valves, pump discharge:
   a. 2 IN and smaller: V-25 or V-26.
   b. 2-1/2 IN and larger: V-28, V-29, or V-30.
6. Check valves, other:
   a. 2 IN and smaller: V-25.
   b. 2-1/2 IN and larger: V-28 or V-29.
7. Isolation valves (Gate valves):
   a. 2 IN and smaller: not used.
   b. 2-1/2 IN and larger: V-3.
8. Globe valves:
   a. 2 IN and smaller: V-6 or V-7.
   b. 2-1/2 IN and larger: V-8.
9. Plug valves:
   a. 2 IN and smaller: V-36.
   b. 2-1/2 IN and larger: V-37.

C. Electric valve operators:
1. Provide electric valve operators on CWS valve at chilled water entrance.
2. Valves are to be operable from the building control system.

D. Pressure reducing valves:
1. Water type, diaphragm operated with low inlet pressure check valve and built-in strainer.
2. Construction:
   a. Body: Brass.
   b. Diaphragm: EPT.
   c. Check valve: Rubber.
   d. Seat: Brass.
   e. Stem: Brass with Buna N insert.
   f. Strainer: Brass.
3. Maximum working pressure: 100 PSIG.
4. Adjustable pressure range: 25-60 PSIG.

E. Pressure relief valves:
1. ASME-approved, tight-shutoff, self-closing.
2. 2-1/2 IN and less: Screwed.

3. 3 IN and larger: Flanged.
4. Ten percent over pressure.
5. Test lever.
6. Capacity: Same BTUH as equipment served. See schedules.
7. Relief setting: 125 PSIG unless indicated otherwise.

F. Triple-duty valves:
1. Non-slam check valve with spring-loaded disc.
2. Calibrated adjustment feature to regulate pump discharge flow and shut-off.
3. Cast iron body.
4. 175 PSIG working pressure, 300 degF operating temperature.
5. Valves capable of being repacked under full line pressure.

2.9 WATER FLOW MEASUREMENT DEVICES

A. Differential water pressure meter for Venturi flow measuring devices:
1. Wall mounted type with 6 IN round dial, 270 degree indication.
2. Range: 0-100 IN WG or 0-50 IN as required.
3. Meter assembly rated at 250 PSI and 250 degF.
4. Arrange tubing for multi-station measurement or provide direct reading single station meter where indicated.
5. For multi-station measurement, use four measuring devices maximum.

B. Venturi waterflow measuring device:
1. Accuracy: Plus/minus 1 percent at design flow.
2. Maximum pressure drop: 0.8 FT.
3. Provide safety shut-off valves, sensing taps, nipples and quick connection couplings.
4. Identify with metal tag on chain indicating:
   a. Size.
   b. Location.
   c. GPM.
   d. Meter reading for GPM indicated.
5. Sizes 1/2 IN through 2 IN brass, screwed.
6. Sizes 2-1/2 IN and over steel, flanged or butt welded.

2.10 WATER TREATMENT SYSTEM

A. Water-treatment-system cleaning chemicals:
1. Alkaline:
   a. Oakite 62, 162, 24, 77.
2. Acid:
   a. Oakite 32.

B. Water-treatment-system chemical feeders:
1. Pot type feeders constructed for operating pressure of 150 PSI.
2. Capacity of feeders: 3 GAL minimum.

2.11 AUTOMATIC AIR SEPARATOR/ELIMINATOR

A. Combination air separator and air eliminator in a single unit:
1. ASME “UM” Coded.
2. Body and Cover: Cast Iron.
3. Working Temperature: 240 degF.
4. Working Pressure: 2 to 150 PSIG.
5. Flow Range: 0 to 8 GPM.
6. Prevents air from entering system in vacuum conditions.
7. Amtrol Model No. 721 for heating water and chilled water.
8. Wessel Model SPA 10S-SS for deionized water.

2.12 GLYCOL-WATER MAKE-UP SYSTEM

A. Glycol-water make-up storage tank:
   1. Self-supporting polyethylene, minimum 4 mm thickness, with removable cover or black steel with 4 mm polyethylene insert.
   2. Capacity shall be 50 gallon with approximate diameter of 24 IN and height of 36 IN.
   3. Reinforced threaded pipe connections shall be provided for all connections.
   4. Provide identification for tank indicating name of the contents.

B. Glycol-water make-up pump:
   1. Bronze fitted, self-priming, high head type suitable for pumping a 25 percent to 50 percent glycol-water solution in intermittent service.
   2. Provided with a mechanical shaft seal.
   3. Flange connected to a NEMA Type C motor.
   4. Capacity: 1.5 GPM at 100 PSIG.
   5. Built-in or external relief valve set for design head of the pump, as indicated on drawings.

C. Glycol-water pressure control:
   1. Stainless steel diaphragm, positive snap-acting SPST switch mechanism, rated 10 amps, 120 volts AC.
   2. General purpose (NEMA 1) enclosure.
   3. Rated for pressure to 150 PSIG
   4. Provide first low pressure switch to make circuit on low water pressure. It shall cycle make-up pump to maintain pressure in glycol-water circuit.
   5. Provide second low pressure switch to make circuit on lower water pressure. It shall send signal for low pressure alarm.

D. Back pressure regulating valve:
   1. Spring loaded, diaphragm actuated type with bronze or steel body, stainless steel trim.
   2. Capacity to relieve 100 percent of pump flow with an allowable rise in the regulated pressure of 10 PSIG above the setpoint.
   3. Setpoint shall be above system PRV setting.

E. Low glycol water level control:
   1. Steel or cast iron float housing, stainless steel float.
   2. Positive snap-acting SPST switch mechanism, rated 10 amps, 120 volts AC, in General Purpose (NEMA 1) enclosure.
   3. Rated for pressure to 150 PSIG.
   4. Make alarm circuit on low water level.

2.13 GLYCOL-WATER

A. Industrially inhibited propylene glycol, phosphate-based:
   1. Fluid must pass ASTM-D1384.
   2. Provide free annual analysis by fluid manufacturer.
   3. Corrosion inhibitors formulated for HVAC systems to keep pipes free of corrosion without fouling.
   4. Dow Chemical Company: Dowfrost.

2.14 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

PART 3 - EXECUTION

3.1 GENERAL

A. Excavation and backfilling: Section 31 23 33.

B. Install in accordance with Section 20 11 00 and Section 20 05 00.

C. Connect equipment.

D. Painting: Section 09 91 23.

3.2 PIPE AND FITTINGS

A. Threaded joints in glycol-water piping:
   1. Remove pipe cutting oil from threads by scrubbing in Portland cement.
   2. Coat dry threads with "Permatex" pipe compound prior to assembly.

B. Do not insulate or conceal piping until testing is completed.

3.3 AIR VENTS

A. Air vents, manual:
   1. Vents shall prevent air binding in systems.
   2. Pipe discharge of vent to a location where air and water may be collected in a bucket.
   3. Locations:
      a. Provide at trapped high points of closed cooling and heating piping systems.
      b. Provide at coil headers in air handling units unless an automatic air vent is indicated at that location on equipment or piping schematic drawings.

3.4 STRAINERS

A. Provide full line size strainers ahead of control valves (motor operated), regulating valves, pumps, and as indicated.

B. Provide strainer types as indicated:
   1. Chilled water: Dual basket, single-basket, tee, or wye type.
   2. Heating water: Single-basket, tee, or wye type.

C. Connections to suit piping.

D. Provide blow-down valves:
   1. Strainers 6 IN and larger: 1-1/2 IN blow-down valve:
      a. Pipe blow down to drain.
   2. Strainers 2 to 5 IN: 1 IN blow-down valve with 3/4 IN hose end connection.
   3. Strainers 1-1/2 IN and smaller: 1/2 IN blow-down valve with 3/4 IN hose end connection.

3.5 VALVES

A. Heating and cooling pipe risers:
   1. Provide isolation valves at main feed points to risers.
   2. Provide isolation valves at branch take-offs from risers.

B. Install pressure relief valves on heat exchangers' piping between exchanger and isolation valves.

C. Provide drain piping at pressure relief valves and valves with test levers:
   1. Extend piping to within 6 IN of floor.

D. Provide system drains: See Section 20 05 19.

E. Provide 3-valve manifold for each differential pressure sensor:
   1. Coordinate locations and quantities of sensors with Controls Contractor.

F. Constant flow control:
   1. Install as recommended by Manufacturers.
   2. Allow space for replacement of parts.

3.6 WATER FLOW MEASUREMENT DEVICES

A. Provide as indicated.

3.7 WATER TREATMENT SYSTEM

A. Mount chemical feeder as indicated:
   1. Chilled water system.
   2. Heating water system.

3.8 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

3.9 TESTING

A. Test piping upon completion of a section or of entire system:
   1. Test hydrostatically to pressure not less than 50 percent in excess of maximum pressure to which pipe will ordinarily be subjected, but in no case less than 150 PSI.
   2. Repair or replace leaks or defective pipe disclosed by tests.
   3. Repeat tests until piping indicates tight.

3.10 CLEANING OF HYDRONIC PIPING SYSTEMS

A. Do not valve in or operate system pumps until after system has been cleaned.

B. At system completion, make temporary connection to domestic water system, and flush system until clear water is visible from drain connection:
   1. Drain system after flushing.

C. At project completion, clean systems:
   1. Thoroughly flush system with a recommended hot solution (160-180 degF) of alkaline cleaning chemical to remove oil and grease that may be present:
      a. Thorough flushing includes eliminating air from system.
      b. Drain systems, and rinse completely with clean water.
   2. Add water and acid solution, and circulate through systems as recommended by manufacturer to remove rust and scale:
      a. Circulate solution through systems at a minimum velocity of 10 FPS.
      b. Drain systems, and rinse completely with clean water:
         1) Rinse system at a minimum velocity of 10 FPS.
   3. Check drain water for pH level.
   4. If drain water is acidic, neutralize system by thoroughly reflushing with alkaline-type material as indicated above.

D. After cleaning is complete, and just before start-up, clean strainers and replace filter cartridges.

3.11 START-UP

A. After cleaning is complete, and water pH is acceptable to manufacturer of water treatment chemicals, add manufacturer-recommended amount of chemicals to systems.

B. For glycol-water systems, add sufficient propylene glycol to provide 40% percent by volume of glycol to water mixture.

C. Provide monthly testing for the first six months after start-up to verify that the correct chemical concentrations are present in each system.

END OF SECTION

SECTION 23 21 23
HVAC PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. Single suction pumps.

1.2 QUALITY ASSURANCE

A. Standards:
   1. Hydraulic Institute Standards: HI1983, 14TH Edition.
   2. Hydraulic Institute Engineering Data Handbook: HI979, First Edition.

1.3 SUBMITTALS

A. Product data:
   1. Pumps:
      a. Include curves.
      b. Factory vibration test reports.

B. Contract closeout information:
   1. Operating and maintenance data.
   2. Letter stating extra material has been delivered.
   3. Field vibration test reports.

1.4 WARRANTY

A. Provide a one (1) year warranty from date of acceptance by BNL for items furnished that shall cover the following:
   1. Faulty or inadequate product design.
   2. Improper assembly or erection.
   3. Defective workmanship and materials.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Single suction, heating and cooling water pumps:
      a. Base:
         1) Berkeley Pumps.
      b. Optional:
         1) Allis-Chalmers, ITT.
         2) Armstrong Pumps.
         3) Aurora Pump.
         4) Taco.
         5) PACO Pumps.
         6) Peerless Pump.
         7) Weil Pump.
   2. Flexible pump couplings:
      a. Base:
         1) Dodge Regupol; "Para-flex".

2) Wood's "Sure-flex".

2.2 SINGLE SUCTION PUMPS – HEATING WATER

A. Pumps, heating water: Centrifugal, single stage, single suction, horizontal type, with vertically split casing, end suction and top vertical discharge with electric motor drive.
   1. Capacity: As scheduled, with continuously dropping head capacity curve from zero to maximum flow.
   2. Motor coupling: Close coupled, or flexible coupled as indicated.
   3. Provide coupling guard for flexible couplings.
   4. Mount pump and drive on common base.
   5. Base: Cast iron or steel plate with raised lip and drain connections.

B. Pumps, single suction centrifugal:
   1. Case: Cast iron, 125 LB ANSI standard flanged connections, hydrostatically tested at minimum 150 PSIG.
   2. Fit case with vent and drain valve.
   3. Impeller: Bronze, enclosed type with volute vent plug.
   4. Shaft: Forged alloy steel.
   5. Shaft sleeves: Stainless steel.
   6. Mechanical seal: Ceramic on carbon.
   7. Bearings: Grease lubricated, ball or roller type.

C. Pump motor drives: Constant speed, squirrel cage induction, 40 degC, drip-proof, AC, ball bearing, non-overloading. Rated to operate with AFD where indicated.
   1. Nameplate horsepower ratings: Not less than maximum required pump input brake horsepower at pump capacities from zero to maximum.
   2. See Section 20 05 00.

D. Pump couplings, flexible: Dodge Para-Flex.
   1. Taper-Lock bushings keyed to shaft.

2.3 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

PART 3 - EXECUTION

3.1 GENERAL

A. Install pumps according to manufacturer's recommendations and as indicated. For base mounted pumps, provide concrete inertia pad and spring isolators.

3.2 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

3.3 VIBRATION TESTS

A. Each pump, 5 HP and above, shall be dynamically balanced in the factory and run tested with pump and motor fully assembled. Maximum pump vibration shall not exceed 2 mm per second rms. Vibration shall be measured in all directions at pump base. Vibration shall be measured at all frequencies at 1/3 octave bands. After installation, factory trained technicians shall re-test and verify in the field that the pumps meet the specified vibration criteria.

END OF SECTION

SECTION 23 22 00
STEAM DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. Pressure reducing valves.
   2. Safety valves.
   3. Steam and steam condensate valves.
   4. Specialties.
   5. Pipe and fittings.
   6. Condensate pumps and receiver.

B. Work installed but not furnished:
   1. Automatic valves: Furnished in Section 25 50 00:
      a. Provide necessary fittings and reducers.

1.2 QUALITY ASSURANCE

A. Manual valve standards: Section 20 05 23 (for valves labeled "V-__").

B. Piping standards: Section 20 11 00.

1.3 SUBMITTALS

A. Shop drawings:
   1. Piping layouts at 1/4 IN/FT scale.

B. Product data:
   1. Pressure reducing valves.
   2. Safety valves.
   3. Steam valves.
   4. Steam condensate return valves.
   5. Traps.
   6. Condensate pumps/receivers.

C. Contract closeout information:
   1. Operating and maintenance data.
   2. Test reports.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Pressure reducing valves (pilot operated):
      a. Base:
         1) Spence.
   2. Safety valves, steam:
      a. Base:
         1) Spence.

b. Optional:
    1) Farris (Division of Curtis-Wright Flow Control).
    2) Watts.
    3) Consolidated.
    4) Dresser, Inc.
3. Steam traps:
    a. Base:
        1) Spirax Sarco.
    b. Optional:
        1) Illinois.
        2) Armstrong International.
        3) Hoffman Specialty.
        4) Mepco.
4. Condensate pumps/receiver:
    a. Base:
        1) Domestic Pump ITT.
    b. Optional:
        1) Dunham-Bush.
        2) Nash Engineering Co.
        3) Roth.
        4) Spirax Sarco.
5. Blowdown separators:
    a. Base:
        1) Pennsylvania Separator Co.
    b. Optional:
        1) Adamson Co., Inc.
        2) Cleaver Brooks.
6. Pressure powered pump:
    a. Base:
        1) Spirax Sarco.
    b. Optional:
        1) Armstrong International.
        2) Bell & Gossett, ITT.
7. Flash tank:
    a. Base:
        1) Spirax Sarco.
    b. Optional:
        1) Pennsylvania Separator Co.
        2) Adamson

2.2 PRESSURE REDUCING VALVES

A. Pressure reducing valves - general:
    1. Flow capacity and pressure range: As indicated.
    2. Provide wye strainer on inlet side of each valve.
    3. Provide noise diffuser to limit rated sound level to 85 dBA at a distance of 3 FT from the valve.
    4. Follow pressure reducing valve manufacturer installation instructions when erecting pressure reducing station.
    5. Pressure reducing valve shall be Spence Type E.
    6. Pressure regulator pilot shall be Spence Type D for reduction from 125 psig to 60 psig and Spence Type D5 for reduction from 60 psig to 15 psig.

B. Pressure reducing valves (1/2 – 4 IN): Pilot actuated diaphragm operated type:
    1. Cast iron body with raised face flanged end connections.
    2. Stainless steel seats and trim.
    3. Body rating: Class 250.

4. Cast iron pilot with stainless steel trim.

C. Pressure reducing valves (over 4 IN): Pilot actuated diaphragm operated type:
1. Cast iron body, raised face flanged end connections.
2. Class 250B per ANSI/ASME-B16.1.
3. Shutoff classification: ANSI/FCI Class V.
4. Main valve shall be single seated.
5. Trim: Hardened stainless steel.
6. Pilot shall be externally mounted to regulator body.

2.3 SAFETY VALVES

A. Safety valves, steam:
1. Sizes 3 IN and less: Threaded or flanged ends:
   a. Dresser, Inc. Consolidated Type 1511.
2. For capacities over 3 IN use multiple valves.
3. Valve sizing: Sized for 10 percent overpressure with a minimum of 5 PSIG overpressure on pressure reducing valve setting.
4. ASME rated stainless steel seat & disc.
5. Valves to have test levers.
6. Safety valve discharge elbow: Spence Model DPE.
7. Exhaust heads: Wright Austin Model 40 EHC.

2.4 STEAM VALVES TO 30 PSIG

A. Isolation valves (gate valves):
1. 2 IN and smaller: V-2.
2. 2-1/2 IN and larger: V-3.

B. Check valves, vacuum breaker, (2 IN and smaller): V-23.

C. Check valves, other:
1. 1-1/2 IN and smaller: V-25.
2. 2 IN and larger: V-22 or V-28.

2.5 STEAM AND CONDENSATE VALVES OVER 30 PSIG

A. Shutoff and Blowdown Valves:
1. 2 IN and Under: Bonney Forge – RP&C Gate Valve, Figure EF57D, Class 800, forged steel body, socket weld connections, “D” trim (13Cr/HF).
2. 2-1/2 IN and Over (steam inside building, all condensate applications): Crane Figure 47XUF, 150 LB class, raised face flanged gate valve, carbon steel body, bolted bonnet, outside screw and yoke, one piece flexible wedge disc.

B. Bypass Valves:
1. 2 IN and Under: Bonney Forge – RP&C Gate Valve, Figure EF57D, Class 800, forged steel body, socket weld connections, “D” trim (13Cr/HF).

C. Check Valves:
1. 2 IN and Under: Bonney Forge – RP&C Check Valve, Figure F95D, spring loaded ball check valve, Class 800, forged steel body, socket weld connections, “D” trim (13Cr/HF).
2. 2-1/2 IN and Over: Crane Figure 147X, 150 LB class, cast steel swing check, flanged ends.

2.6 STEAM CONDENSATE RETURN VALVES TO 30 PSIG

A. Isolation valves (ball valves):
1. 2 IN and smaller: V-13 or V-14.

B. Isolation valves (gate valves):
1. 2-1/2 IN and larger: V-3.

C. Check valves:
   1. 2 IN and smaller: V-25.
   2. 2-1/2 IN and larger: V-28 or V-29.

2.7 SPECIALTIES

A. Steam traps - general:
   1. Sizes: As indicated, minimum; increase size if required to meet capacity requirements.
   2. Provide dirt pocket and wye strainer full size of trap opening.
   3. Provide shut-off valve and union on each inlet.
   4. Provide check and gate valve in discharge, at each lift leg.

B. Steam traps, low pressure (15 PSIG and less):
   1. Equipment traps: Use F & T type rated at 15 PSI working pressure. Each trap shall be sized using 1/2 PSI pressure drop and 2 times scheduled flow rate of equipment. Where two traps are shown on a single piece of equipment (e.g. heat exchanger), each trap shall be sized for 100% redundancy.
   2. End of main traps: Use F & T type. Trap sizes shall be as indicated on plans. If size is not indicated, the minimum trap size shall be 3/4 IN. The minimum capacities for each size of trap shall be as follows (based on 1/2 PSI differential):

Trap Size	Capacity
3/4 IN	550 lb/hr
1 IN	700 lb/hr
1-1/4 IN	950 lb/hr
1-1/2 IN	2100 lb/hr
2 IN	4000 lb/hr

C. Steam traps, medium and high pressure (over 15 PSIG):
   1. Steam Trap Assembly: Trap shall be Yarway Series 712 inline renewable tilting disc-type thermodynamic trap with chrome-moly body in ASME SA-182 GR.F-11 and stainless steel trim. End connections shall be ANSI Class 600 socket welded. Trap shall have an integral strainer with stainless steel screen, and integral blow-off valve.
   2. Equipment traps (16-30 PSIG): Sized using 2 PSI pressure drop and 2 times scheduled flow rate of the equipment.
   3. Equipment traps (over 30 PSIG): Sized using 1/2 of the maximum pressure differential across the trap and 3 times scheduled flow rate of the equipment.
   4. End of main traps: Trap size: as indicated on plans. If size is not indicated, the minimum trap size shall be 3/4 IN. The minimum capacities for each size of trap shall be as follows (based on 2 PSI differential):

Trap Size	Capacity
3/4 IN	1140 lb/hr
1 IN	2300 lb/hr
1-1/4 IN	3700 lb/hr
1-1/2 IN	5400 lb/hr
2 IN	10900 lb/hr

D. Steam traps on equipment: Provide traps and cooling legs, 18 IN deep minimum:
   1. Connect trap line to cooling leg 6 IN from bottom.
   2. Provide cap.
   3. Install trap above floor (elevate equipment if necessary).

E. Flash tank: Centrifugal design with stainless steel striking plate at point of inlet impingement with surfaces and baffles slanting for quick drainage and no pockets for condensate accumulation:

1. Inlets and outlets as indicated.
2. Cemline Corporation.

F. Strainers: See Section 20 05 19.

G. Supports, sleeves and seals: See Section 20 05 29.

H. Flashings: See Section 20 05 00.

I. Thermometers: See Section 20 05 19.

J. Pressure gauges:
1. Weksler Type AA14C, 1/4 IN bottom connection, white dial, numerals range of 0 to 160 psig with 20 PSIG figure intervals, with Type A03B siphon, and Type A10 tee handle cock.

2.8 PIPE AND FITTINGS 30 PSIG AND OVER

A. Pipe:
1. 2 IN and smaller (steam): Schedule 80 black steel, conforming to ASTM-A106 Grade B, seamless.
2. 2-1/2 IN and larger, (steam): Schedule 40 black steel, conforming to ASTM-A53 Grade B, seamless.
3. All condensate pipe regardless of size: Schedule 80 black steel, conforming to ASTM-A106 Grade B, seamless.

B. Fittings:
1. 2 IN and smaller: 3000 LB socket weld.
2. 2-1/2 IN and larger: Seamless standard class carbon steel butt welding, conforming to ASTM-A234 Grade WPB and ANSI-B16.9.

C. Unions (1/2 IN – 2 IN): 2000 LB carbon steel, socket weld, ground joint, integral seats, conforming to ASTM A105.

D. Flanges: 150 LB class carbon steel, raised face, conforming to ASTM-A105 and ANSI-B16.5. Figure numbers are Tube Turn's:
1. 1/2 IN – 2 IN: Schedule 80 bore, socket weld.
2. 3 IN and larger:
   a. Welding Neck Flanges: Figure 30.
   b. Slip-On Flanges: Figure 50.
   c. Blind Flanges: Figure 70.
3. Gaskets: Ring-type, 150 LB class:
   a. For steam and condensate systems: Flexitallic 304 Stainless Steel, 1/8 IN thick, spiral wound.
4. Bolts:
   a. HPS and HPC: Alloy steel stud bolts, conforming to ASTM-A193, Grade B7.

E. Elbolets and Thredolets: Bonney Forge, carbon steel, 3000 LB class, conforming to ASTM-A105 Grade II.

F. Weldolets: Bonney Forge, carbon steel, extra strong class butt welding end connection, conforming to ASTM-A105 Grade II.

2.9 PIPE AND FITTINGS LESS THAN 30 PSIG

A. Steam and steam vent piping: Black steel (Schedule 40), seamless piping:
1. 2-1/2 IN and larger: Use welded joints, with malleable steel fittings.
2. 2 IN and smaller: Use threaded or welded joints with malleable steel (3000 PSI) fittings.

B. Steam condensate and pumped condensate piping: Black steel (Schedule-80), seamless piping:
   1. 2-1/2 IN and larger: Use welded joints, with malleable steel fittings.
   2. 2 IN and smaller: Use threaded joints or welded joints with malleable steel (3000 PSI) fittings.

C. Relief vent pipe and fittings: Same as steam piping.

D. Flanges: 150 LB class carbon steel, raised face, conforming to ASTM-A105 and ANSI-B16.5. Figure numbers are Tube Turn's:
   1. 1/2 IN – 2 IN: Schedule 80 bore, socket weld.
   2. 3 IN and larger:
      a. Welding Neck Flanges: Figure 30.
      b. Slip-On Flanges: Figure 50.
      c. Blind Flanges: Figure 70.
   3. Gaskets: Ring-type, 150 LB class:
      a. For steam and condensate systems: Flexitallic 304 Stainless Steel, 1/8 IN thick, spiral wound.
   4. Bolts:
      a. All except HPS and HPC: Steel, square headed machine, or full threaded stud bolts, conforming to ASTM-A307 Grade B and ANSI-B1.1 coarse thread series Class 2A fit.

E. Elbolets and Thredolets: Bonney Forge, carbon steel, 3000 LB class, conforming to ASTM-A105 Grade II.

F. Weldolets: Bonney Forge, carbon steel, extra strong class butt welding end connection, conforming to ASTM-A105 Grade II.

2.10 CONDENSATE PUMPS/RECEIVER

A. Condensate pumps/receiver, above ground: Duplex, factory assembled, with pumps, receiver, and controls for above floor mounting:
   1. Capacity: As scheduled.
   2. Pump: Vertical submerged centrifugal or turbine type suitable for operation with 210 degF condensate:
      a. Bronze impeller, renewable liners and stainless steel shafts.
      b. Flanged mounted on receiver and close coupled to vertical motor.
      c. Provide wafer type shutoff valves between receiver and pumps to isolate each pump for maintenance or replacement while system continues to operate.
   3. Motor: See Section 20 05 00:
      a. Non-overloading at working pressure up to design pressure.
      b. Provide magnetic starters for 3-phase motors.
   4. Float switches: Heavy duty 2-pole with seamless copper float and stainless steel rod.
   5. Receiver: Cast iron, with inlet, vent and overflow connections.
   6. Controls: Contained in a unit mounted NEMA II control cabinet with hinged door:
      a. Two combination magnetic starters with circuit breakers and cover interlock.
      b. Manual sequence control switches.
      c. Manual select lead pump.
      d. Each pump control circuit to be independent of the other.
      e. Alternator: Provide simultaneous operation under peak load conditions; and operate second pump automatically, should active pump or its controls fail.
      f. Provide control circuit transformer for each circuit.
   7. Provide inlet strainer with vertical self-cleaning bronze screen and large dirt pocket mounted on receiver.

2.11 PRESSURE POWERED PUMP

A. Steam, low profile pressure powered pump:
   1. Body construction: Cast 316 iron.

2. Provide pump with float operated snap acting mechanism with no internal seals or packing, stainless steel trim, and hardened stainless steel mechanism bearing components with single piece motive inlet valve.
3. Provide pump with cycle counter to monitor volume of liquid being pumped and sight glass to monitor operation.
4. Size: 1-1/2 IN Spirax Sarco, Model PPEC.

2.12 FLASH TANK

A. Flash tank, steam:
1. Construction: Mild steel.
2. Maximum operating pressure: 150 psig.
3. Maximum operating temperature: 450 degF.
4. Size: 16 IN diameter x 48 IN high.

PART 3 - EXECUTION

3.1 PIPING - GENERAL

A. Install in accordance with Section 20 11 00 and Section 20 05 00.

B. Provide drain piping from safety valves and valves that have test levers to floor drain.

3.2 STRAINERS

A. Provide full line size wye strainers ahead of steam control valves (motor operated), steam traps, regulating valves, pumps, and where indicated:
1. See Piping Specialties: Section 20 05 19.

3.3 JOINTS

A. Joints shall be socket welded, butt welded, and flanged.

3.4 INSTALLATION

A. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, 3/4” ball valve, and short 3/4 IN threaded nipple and cap.

B. Install branch connections to supply mains using 45 degree fittings in main with take-off out of the top of the main. Use of 90 degree tee fittings is permissible, where use of 45 degree fittings is not practical. Where the length of a branch take-off is less than 10 feet, pitch branch line down toward main, 1/2 IN per foot.

C. Make reductions in pipe sizes using eccentric reducer fittings installed with the level side down.

3.5 SLOPES

A. Slope of Pipes: Down in direction of flow 1 IN in 40 FT-0 IN, unless otherwise specified or indicated on Drawings.

3.6 TESTING

A. Allow no piping to be insulated, concealed, or furred-in until it has been tested to satisfaction of Engineer.

B. Upon completion of a section or of entire piping systems, test pipes as follows:
1. Steam and Condensate Systems (Vacuum to 30 psig):
   a. Test medium temperature shall not exceed 100 degF.
   b. Test system hydrostatically at 75 psig.
   c. Isolate system from source of pressure, and allow system to stand for four (4) hours during which time no drop in pressure shall occur.

2. Steam and Condensate Systems (30 to 150 psig):
   a. Test medium temperature shall not exceed 100 degF.
   b. Test system hydrostatically at 225 psig.
   c. Isolate system from source of pressure, and allow system to stand for four (4) hours during which time no drop in pressure shall occur.

C. Repair leaks and replace defective pipe disclosed by tests and repeat tests until no drop in pressure.

3.7 CLEANING

A. Cleaning of steam supply piping: Before steam supply system is placed in service either for temporary or permanent use, clean and flush as follows:
   1. For temporary use where additional piping will be added to system as construction proceeds, flush piping by "blowing down" with steam.
   2. At completion of project after piping is complete, flush piping by "blowing down" with steam until visual inspection indicates system cleaned. During "blow down" period: Waste condensate to sewer.
   3. After "blow down" period is complete, thoroughly clean strainers and traps.

B. Cleaning of condensate return piping: Before steam condensate return system is placed in service either for temporary or permanent use, clean and flush as follows:
   1. For temporary use where additional piping will be added to system as construction proceeds, and before strainers, traps, equipment, etc., are installed, flush piping by "blowing down" with steam.
   2. At completion of project after piping is complete, and steam supply mains are "Blown Down", flush steam condensate return piping by "blowing down" with steam until visual inspection indicates system cleaned.
   3. Prior to "blowing down" system remove strainers and traps from system and bypass equipment connected to system.
   4. During "blow down" period: Waste condensate to building sewer.
   5. After "blow down" period, clean strainers and traps and reinstall in piping system. Reconnect equipment previously bypassed.
   6. For steam traps and all equipment, follow manufacturer’s installation recommendations.

END OF SECTION

1. 1/2 IN – 2 IN: Schedule 80 bore, socket weld.
2. 3 IN and larger:
   a. Welding Neck Flanges: Figure 30.
   b. Slip-On Flanges: Figure 50.
   c. Blind Flanges: Figure 70.
3. Gaskets: Ring-type, 150 LB class.
   a. For steam and condensate systems: Flexitallic 304 Stainless Steel, 1/8 IN thick, spiral wound.
4. Bolts:
   a. All except HPS and HPC: Steel, square headed machine, or full threaded stud bolts, conforming to ASTM-A307 Grade B and ANSI-B1.1 coarse thread series Class 2A fit.

E. Elbolets and Thredolets: Bonney Forge, carbon steel, 3000 LB class, conforming to ASTM-A105 Grade II.

F. Weldolets: Bonney Forge, carbon steel, extra strong class butt welding end connection, conforming to ASTM-A105 Grade II.

2.10 CONDENSATE PUMPS/RECEIVER

A. Condensate pumps/receiver, above ground: Duplex, factory assembled, with pumps, receiver, and controls for above floor mounting.
   1. Capacity: As scheduled.
   2. Pump: Vertical submerged centrifugal or turbine type suitable for operation with 210 degF condensate.
      a. Bronze impeller, renewable liners and stainless steel shafts.
      b. Flanged mounted on receiver and close coupled to vertical motor.
      c. Provide wafer type shutoff valves between receiver and pumps to isolate each pump for maintenance or replacement while system continues to operate.
   3. Motor: See Section 20 05 00.
      a. Non-overloading at working pressure up to design pressure.
      b. Provide magnetic starters for 3-phase motors.
   4. Float switches: Heavy duty 2-pole with seamless copper float and stainless steel rod.
   5. Receiver: Cast iron, with inlet, vent and overflow connections.
   6. Controls: Contained in a unit mounted NEMA II control cabinet with hinged door.
      a. Two combination magnetic starters with circuit breakers and cover interlock.
      b. Manual sequence control switches.
      c. Manual select lead pump.
      d. Each pump control circuit to be independent of the other.
      e. Alternator: Provide simultaneous operation under peak load conditions; and operate second pump automatically, should active pump or its controls fail.
      f. Provide control circuit transformer for each circuit.
   7. Provide inlet strainer with vertical self-cleaning bronze screen and large dirt pocket mounted on receiver.

2.11 PRESSURE POWERED PUMP

A. Steam, low profile pressure powered pump:
   1. Body construction: Cast 316 iron.
   2. Provide pump with float operated snap acting mechanism with no internal seals or packing, stainless steel trim, and hardened stainless steel mechanism bearing components with single piece motive inlet valve.
   3. Provide pump with cycle counter to monitor volume of liquid being pumped and sight glass to monitor operation.
   4. Size: 1-1/2 IN Spirax Sarco, Model PPEC.

2.12 FLASH TANK

A. Flash tank, steam:
   1. Construction: Mild steel.
   2. Maximum operating pressure: 150 psig.
   3. Maximum operating temperature: 500 degF.
   4. Size: 6 IN diameter x 39 IN high.

PART 3 - EXECUTION

3.1 PIPING - GENERAL

A. Install in accordance with Section 20 11 00 and Section 20 05 00.

B. Provide drain piping from safety valves and valves that have test levers to floor drain.

3.2 STRAINERS

A. Provide full line size wye strainers ahead of steam control valves (motor operated), steam traps, regulating valves, pumps, and where indicated.
   1. See Piping Specialties: Section 20 05 19.

3.3 JOINTS

A. Joints shall be socket welded, butt welded, and flanged.

3.4 INSTALLATION

A. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, 3/4” ball valve, and short 3/4 IN threaded nipple and cap.

B. Install branch connections to supply mains using 45 degree fittings in main with take-off out of the top of the main. Use of 90 degree tee fittings is permissible, where use of 45 degree fittings is not practical. Where the length of a branch take-off is less than 10 feet, pitch branch line down toward main, 1/2 IN per foot.

C. Make reductions in pipe sizes using eccentric reducer fittings installed with the level side down.

3.5 SLOPES

A. Slope of Pipes: Down in direction of flow 1 IN in 40 FT-0 IN, unless otherwise specified or indicated on Drawings.

3.6 TESTING

A. Allow no piping to be insulated, concealed, or furred-in until it has been tested to satisfaction of Engineer.

B. Upon completion of a section or of entire piping systems, test pipes as follows.
   1. Steam and Condensate Systems (Vacuum to 30 psig):
      a. Test medium temperature shall not exceed 100 degF.
      b. Test system hydrostatically at 75 psig.
      c. Isolate system from source of pressure, and allow system to stand for four (4) hours during which time no drop in pressure shall occur.
   2. Steam and Condensate Systems (30 to 150 psig):
      a. Test medium temperature shall not exceed 100 degF.
      b. Test system hydrostatically at 225 psig.
      c. Isolate system from source of pressure, and allow system to stand for four (4) hours during which time no drop in pressure shall occur.

C. Repair leaks and replace defective pipe disclosed by tests and repeat tests until no drop in pressure.

3.7 CLEANING

A. Cleaning of steam supply piping: Before steam supply system is placed in service either for temporary or permanent use, clean and flush as follows:
   1. For temporary use where additional piping will be added to system as construction proceeds, flush piping by "blowing down" with steam.
   2. At completion of project after piping is complete, flush piping by "blowing down" with steam until visual inspection indicates system cleaned. During "blow down" period: Waste condensate to sewer.
   3. After "blow down" period is complete, thoroughly clean strainers and traps.

B. Cleaning of condensate return piping: Before steam condensate return system is placed in service either for temporary or permanent use, clean and flush as follows:
   1. For temporary use where additional piping will be added to system as construction proceeds, and before strainers, traps, equipment, etc., are installed, flush piping by "blowing down" with steam.
   2. At completion of project after piping is complete, and steam supply mains are "Blown Down", flush steam condensate return piping by "blowing down" with steam until visual inspection indicates system cleaned.
   3. Prior to "blowing down" system remove strainers and traps from system and bypass equipment connected to system.
   4. During "blow down" period: Waste condensate to building sewer.
   5. After "blow down" period, clean strainers and traps and reinstall in piping system. Reconnect equipment previously bypassed.
   6. For steam traps and all equipment, follow manufacturer’s installation recommendations.

END OF SECTION

SECTION 23 31 13
AIR DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. High and low pressure ductwork, fittings and accessories.
   2. Manual dampers.
   3. Fire and smoke dampers.
   4. Backdraft and barametric dampers.
   5. Fireproof duct covering.
   6. Diffusers, registers and grilles.
   7. Sound attenuators.
   8. Louver blank-off plates.
   9. Duct access doors.
   10. Control dampers less actuators:
      a. Actuators for control dampers: See Section 25 50 00.

B. Work installed but not furnished:
   1. Automatic dampers: Furnished under Section 25 50 00.
   2. Airflow measuring stations: Furnished under Section 25 50 00.

C. Definitions:
   1. Low and high pressure ductwork: See Part 2.2 of this section.
   2. Gage:
      a. Steel sheet and wire: U S Standard Gage.
      b. Aluminum sheet: Browne & Sharpe Gage.
      c. Steel wire: Washburn and Moen Gage.
   3. Concealed insulated surfaces: Piping, ductwork and equipment in walls, partitions, floors, pipe chases, pipe shafts, duct shafts and above suspended ceilings.
   4. Exposed insulated surfaces: Piping, ductwork and equipment located in mechanical rooms, tunnels and rooms without suspended ceilings.

D. Location of diffusers, registers and grilles are indicated on Architectural reflected ceiling plans.

E. Drawings indicate tentative arrangement of partitions, diffusers and lights:
   1. Final location of diffusers, registers and grilles: Architectural reflected ceiling plans.

F. Control dampers installed in air handling units: delivered to air handling unit manufacturer and factory mounted in unit. Actuators shall be field mounted under Section 25 50 00.

1.2 QUALITY ASSURANCE

A. Design and installation standards:
   1. ASHRAE Handbook - HVAC Systems and Equipment: Current chapter on duct construction.
   2. ADC Standard 1062: GRD-84, Test Code for Grilles, Registers and Diffusers.
   3. ADC Test Code FD 72-R1, Flexible Air Duct Test Code.
   4. AMCA Standard 210, Test Code for Air Moving Devices.
   5. ASHRAE Standard 70-72, Method of Testing for Rating the air flow performance of outlets and inlets.
   6. NFPA-90A, Standard for the Installation of Air Conditioning and Ventilating Systems, current edition.
   7. SMACNA HVAC Duct Construction Standard - Metal and Flexible, Current Edition.

B. Fire and smoke rating test standards: ASTM-E84, NFPA-255 and ANSI/UL-723.

C. Duct sizes indicated are internal sizes.

1.3 SUBMITTALS

A. Shop drawings:
   1. Ductwork layout at 1/4 IN to 1 FT scale.

B. Product data:
   1. Ductwork and fittings, high pressure.
   2. Dampers, nonrated.
   3. Dampers, fire.
   4. Dampers, smoke.
   5. Diffusers, registers and grilles.
   6. Sound Attenuators.

C. Contract closeout information:
   1. Operating and maintenance data.
   2. Test reports.

PART 2 - PRODUCTS

2.1 MATERIALS - GENERAL

A. Acceptable manufacturers:
   1. Flat oval and round spiral ductwork, high pressure:
      a. Base:
         1) United McGill Airflow Corporation.
      b. Optional:
         1) Semco Incorporated.
         2) Sheet Metal Connectors, Inc.
         3) Eastern Sheet Metal, Inc.
   2. Factory fabricated duct connection systems:
      a. Base:
         1) Ductmate Industries.
      b. Optional:
         1) Nexus.
         2) Ward Industries, Inc.
   3. Sealants:
      a. Base:
         1) Hardcast.
      b. Optional:
         1) Hardcast.
         2) United McGill Airflow Corporation.
         3) Foster (Division of HB Fuller).
   4. Turning vanes:
      a. Base:
         1) Aerodyne Controls.
      b. Optional:
         1) Airsan.
         2) Tuttle & Bailey.
         3) Titus.
         4) VentProducts.
   5. Flexible fan connections:
      a. Base:
         1) Ventfabrics.

b. Optional:
    1) Duro-Dyne.
    2) Elgin.
6. Flexible duct, preinsulated:
    a. Base:
        1) Atco.
    b. Optional:
        1) Flexible Technologies, Thermaflex.
        2) Hart and Cooley.
7. Flexible ducts, uninsulated:
    a. Base:
        1) United McGill Corp.
    b. Optional:
        1) ATCO Rubber Products, Inc.
        2) Or approved equal.
8. Fireproof duct covering:
    a. Base:
        1) Pabco.
        2) Thermal Ceramics.
    b. Optional:
        1) Flexible Technologies, Thermaflex.
        2) 3M.
9. Access Doors, low and high pressure:
    a. Base:
        1) Ductmate.
    b. Optional:
        1) Ward Industries.
        2) United McGill Airflow Corporation.
10. Dampers(manual, backdraft, barametric):
    a. Base:
        1) Ruskin Manufacturing.
    b. Optional:
        1) Arrow.
        2) Louvers and Dampers, Inc.
        3) American Warming & Ventilating.
        4) Air Balance.
        5) Cesco Products.
11. Fire and smoke dampers:
    a. Base:
        1) Ruskin Manufacturing.
    b. Optional:
        1) Air Balance.
        2) Greenheck.
        3) Nailor-Hart Industries, Inc.
        4) Prefco Products.
        5) Safe-Air of Illinois.
        6) CESCO products.
12. Diffusers, registers and grilles:
    a. Base:
        1) Titus.
    b. Optional:
        1) Carnes.
        2) Anemostat Air Products.
        3) Tuttle & Bailey.
        4) Krueger.
        5) Price.

13. Sound Attenuators:
    a. Base:
        1) Vibro-Acoustics.
    b. Optional:
        1) AeroSonics.
        2) Dynasonics.
        3) Rink Sound Control.
        4) Semco Incorporated.
        5) TranSonics.
        6) United McGill Airflow Corporation.
14. Pressure relief doors:
    a. Base:
        1) Ruskin.
    b. Optional:
        1) Kees.

B. Sheet metal:
    1. Galvanized steel (G90): ASTM-A653/A653M.
    2. Stainless steel: ASTM-A167.

C. Duct sealer: NFPA rating of "Non-Combustible":
    1. Flame spread rating: 25 or lower, in dry condition.
    2. Smoke developed rating: 50 or lower, in dry condition.
    3. Resistant to water and water vapors.
    4. Pressure rupture rating: 16 IN WG , minimum.
    5. Durkee-Atwood Permatite Class I Duct Sealer; Hardcast Iron Grip 601 and Duct Seal 321; or United McGill Sheet Metal Uni-Mastic 181 Duct Sealer and United Duct Sealer.

D. Solder: ASTM-B23, Grade-50B.

E. Duct sealing tape: NFPA rating of "Non-Combustible":
    1. Flame spread rating: 25 or lower, in dry condition.
    2. Smoke developed rating: 50 or lower, in dry condition.
    3. Adhesive: Specifically compounded for maximum adhesion to galvanized and stainless steel.
    4. Durkee-Atwood Permatite Class I Insta-Seal; Hardcast Aluma-Grip 701 and Flange Grip 1902; or United McGill Sheet Metal Uni-Cast tape.

F. RTV foam: UL listed room temperature vulcanized silicone rubber foam.

2.2 DUCTWORK

A. Ductwork - general:
    1. Maintain full areas and suitable shapes at every point.
    2. Shapes may be changed to fit unusual space conditions:
        a. Cross sectional area to be maintained.
        b. Modifications increasing system pressure drop require BNL approval.
        c. Modifications increasing aspect ratio beyond 5:1 require BNL approval.
    3. Provide necessary transitions and offsets to complete systems.
    4. All systems shall be constructed of G90 galvanized steel, except as follows:
        a. Laboratory and cleanroom exhaust branch ducts from fume hoods to horizontal duct mains and canopy hoods: 316 stainless steel.

B. Ductwork, low pressure, sheet metal:
    1. Construct in accordance with SMACNA HVAC Duct Construction Standard as follows:
        a. Rectangular duct: Table 1-6, 3 IN WG static pressure, positive or negative.
        b. Rectangular duct: Table 1-7, 4 IN WG static pressure, positive or negative.
        c. Round duct: Table 3-2A, 4 IN WG static pressure, positive or negative.
    2. Low pressure ductwork, 3 IN WG static pressure includes:

a. Outside air ductwork.
b. Return air ductwork, unless otherwise noted.
c. All general exhaust ductwork.
d. All supply ductwork serving FCU'S.

3. Low pressure ductwork, 4 IN WG static pressure includes:
   a. Relief ductwork.
   b. All supply ductwork downstream of air terminal units.
4. Transverse joints, rectangular:
   a. Ducts with longest side 36 IN and longer:
      1) Use factory fabricated flanged duct connection systems (e.g. Ductmate 35/25 slide on systems).
      2) Non-proprietary SMACNA defined T-22 or T-24 flanged connections
      3) Seal transverse flanged duct connections with pressure sensitive, high density, closed cell, neoprene or polyurethane tape gasket.
   b. Ducts with longest side shorter than 35 IN:
      1) Flanged duct connection systems as defined above are optional.
      2) Refer to SMACNA HVAC Duct Construction Standard for proper duct construction.
5. Longitudinal seam: Use Pittsburgh lock seam only.
6. Seal low pressure ducts to Seal Class A requirements.
7. Runouts to diffusers, register and grilles: Insulated flexible ducts may be used:
   a. Exception: Flexible ducts may not pass through smoke or fire rated walls, floors or ceilings.
   b. Flexible duct length: 6 FT maximum.
   c. Minimum turning radius:
      1) As recommended by manufacturer.
      2) Do not kink, bend or restrict free area of duct as to generate additional pressure drop or noise.

C. Ductwork located outside, exposed to weather:
   1. Construct using flanged duct connection systems.
   2. Seal flanged ends with pressure sensitive, high density, closed cell, neoprene or polyurethane tape gasket.
   3. Use continuous cleat seals on top joints of ducts.

D. Ductwork, high pressure:
   1. Construct in accordance with SMACNA HVAC Duct Construction Standard as follows:
      a. Rectangular duct: Table 1-8, 6 IN WG static pressure, positive or negative.
      b. Round duct: Table 3-2A, 10 IN WG static pressure.
   2. High pressure ductwork includes:
      a. Supply ductwork serving AHU from air handling unit discharge to connection with air valves/terminal units.
      b. All exhaust ductwork serving laboratories and clean rooms.
   3. Runouts to air terminal units: Rigid or flexible ductwork.
      a. Exceptions:
         1) Flexible ducts may not pass through smoke or fire rated walls, floors or ceilings.
         2) Flexible ducts shall not be used for connections to air terminal units for exhaust or return systems.
      b. Flexible duct length: 4 FT minimum, 6 FT maximum.
      c. Minimum turning radius:
         1) As recommended by manufacturer. Do not kink, bend or restrict free area of duct as to generate additional pressure drop or noise.
         2) Ninety degree bends are not allowed.
   4. Seal high pressure duct to seal Class A requirements.

E. Duct hangers and supports: In accordance with following:
   1. High and low pressure ductwork (sheet metal): SMACNA HVAC Duct Construction Standard, Section IV.

F. Duct fittings and joints on low pressure systems:
   1. Radius elbows without vanes: Radius ratio (R/W) of 1.5 and greater.
   2. Radius elbows with vanes: Radius ratio (R/W) less than 1.5; use where space limitations occur:
      a. R/W = 0.75 to 1.0: Provide 3 vanes in elbow.
      b. R/W = 1.0 to 1.25: Provide 2 vanes in elbow.
      c. R/W = 1.25 to 1.5: Provide 1 vane in elbow.
      d. Provide vane spacing per Figure 2-3, SMACNA HVAC Duct Construction Standards.
   3. Where square elbows are indicated or required, provide with turning vanes.
   4. Connections to diffusers, grilles and registers: Fitted securely to necks or collars provided behind diffuser, grille, or register face area.
   5. Branch connections:
      a. Round: Factory built short cone or bellmouth type. Air scoops are not acceptable.
      b. Rectangular: 45 degree entry type or radius elbow.
   6. Provide necessary transition pieces and duct collars to make connections to ductwork from neck sizes scheduled or indicated on drawings.
   7. Where building walls, floor and ceilings form portions of duct or plenum, provide gasketed angles or channels at junction points, securely bolted to building structure.

G. Duct fittings and joints on high pressure systems:
   1. Elbows 3-8 IN diameter: Die stamped, for minimum air friction loss, with continuous corrosion resistance welds.
   2. Elbows over 8 IN diameter: Welded segment type, not less than 5 pieces for 90 degree elbows, and not less than 3 pieces for 45 degree elbows, using corrosion resistant welds.
   3. Tees: "Low loss, short cone type", unless specifically detailed otherwise for space limitations.
   4. "Y's" 45 degree type. 60 degree type may be used if space conditions dictate.
   5. Install "Y's" as indicated.
   6. Where tees are indicated, "Y's" may be substituted if space is available.
   7. "Y's": Straight sided type (no cone).
   8. Takeoffs from air handling unit plenums: Standard Bellmouth fittings:
      a. Construct in accordance with SMACNA HVAC Duct Construction Standards.
   9. "Y" takeoffs from horizontal ceiling mounted ducts to serve boxes: May be straight sided, shop fabricated type by accurately cutting and welding "Y's" into spiral ducts without use of fittings.

H. Turning vanes: For square elbows:
   1. Velocities up to 2500 FPM: Single vane, runner Type 2, 2 IN vane radius and 1.5 IN vane spacing, minimum 24 GA:
      a. For widths over 36 IN install vanes in 2 or more sections or use tie rods to limit unbraced vane length.
   2. Where inlet and outlet dimensions of elbows are not equal, set 2 or more sections at 45 degrees angle to give optimum turning.

I. Partitions and blank-off plates:
   1. Where used as part of an air handling unit, construct of 14 GA sheet metal with 1-1/2 IN standing seams.
   2. Partitions 8 FT long or less: Provide additional bracing of 1-1/2 x 1/4 IN angles spaced 2 FT on center.
   3. Partitions over 8 FT long: Provide additional bracing of 2 x 1/4 IN angles spaced 2 FT on center.

J. Flexible fan and duct connections:
   1. Material: Neoprene double coated closely woven glass fabric flexible connections.

2. Fasten fabric to sheet metal duct work and to fan collar extension with 3/16 IN rivets spaced not more than 5 IN OC.
3. Locate in inlet and outlet of fans, as close to fan as possible.
4. Provide at ducts crossing building expansion joints and as indicated on drawings.
5. Connections shall not be under tension.
6. Provide minimum separation distance of 1 IN across the connection.

K. Flexible ducts, preinsulated:
1. Low pressure construction:
   a. Liner: Steel wire helix encapsulated within a double lamination of polyester.
   b. Insulation: 1 IN x 3/4LB/CF fiberglass insulation, minimum resistance of R-4.2.
   c. Insulation: 1 IN x 3/4 LB/CF fiberglass insulation, minimum resistance of R-6. Jacket: Bi-directional metalized polyester.
2. High pressure supply construction:
   a. Insulation: 1 IN x 3/4 LB/CF fiberglass insulation, minimum resistance of R-4.2.
   b. Jacket: Bi-directional metalized polyester.

L. Flexible ducts, uninsulated:
1. Provide for all connections to HEPA filter diffusers and where indicated.
2. Medium pressure construction:
   a. Heavy gauge corrugated aluminum.
   b. Aluminized mylar, wire reinforced and fabric type not permitted.
3. Rated working pressure:
   a. Medium pressure duct: Positive 8 IN minimum.
4. Fire resistant, self extinguishing, UL Standard 181, Class 1 with flame spread of 25 or less and smoke development not to exceed 50.
5. Medium pressure connections:
   a. Secure duct to collar or sleeve with duct sealer and number and type of fasteners as required in SMACNA HVAC Duct Construction Standards.
6. Duct sealer: E Moore Co., Tuff-bond No. 12; or Benjamin Foster No. 30-02.
7. Turn radius: Not less than R/D equal to 1.0.
8. Provide flexible duct supports in accordance with Figure 3-9 and 3-10, SMACNA HVAC Duct Construction Standards.

M. Access doors:
1. Provide at fire dampers, smoke dampers, smoke detectors, duct mounted automatic dampers, pressure and temperature sensors, air plenums behind louvers and at other locations as required. Access doors shall be positioned to permit easy visual inspection and to allow maintenance and resetting of the device served. Increase duct dimensions at devices when necessary to accommodate required access. Wherever possible, access doors shall be installed above accessible lay-in ceilings. Where access doors are installed above gypboard ceilings or within shafts, provide access panels per Section 20 05 00.
2. Low and high pressure ductwork:
   a. Construction: Access doors shall be removable, double wall construction with 1 IN thick fiberglass insulation, closed cell neoprene gasket and attachment bolts, to provide an air tight seal up to static pressures of 20 IN WG.
   b. Sizes shall be as follows:
      1) For ducts 18 IN and under, the minimum door size shall be 10 IN X 6 IN.
      2) For ducts 19 IN to 24 IN, the minimum door size shall be 16 IN X 12 IN.
      3) For ducts over 24 IN the minimum door size shall be 24 IN X 18 IN.

2.3 DAMPERS

A. Dampers - general:
1. Sizes and types: As indicated.
2. Locate as indicated.
3. Factory built and assembled dampers.

B. Dampers, control:
   1. Furnish under Section 25 50 00.
   2. Install as specified in this section.

C. Dampers, manual (rectangle and square):
   1. Opposed blade type, fitted with shank bolts, marked for direction (open/closed).
   2. Provide for double socket wrenches to fit square shank and locking hex nut.
   3. Construction: Heavy black iron frames, flat or angle iron, with blades of 16 GA galvanized steel, equipped with brass pin running on stainless steel pivot for vertical axis.

D. Damper, manual (round):
   1. Butterfly type with circular blade mounted to shaft.
   2. Frame: Minimum 14 GA galvanized steel channel.
   3. Blade: Minimum 16 GA galvanized steel.
   4. Axle: 1/2 IN diameter.
   5. Bearings: Self-lubricating nylon or stainless steel sleeve.

E. Dampers, backdraft, low pressure:
   1. Counterbalanced, gravity operated.
   2. Fabricate of aluminum.
   3. Blades: Provided with common linkage rod and felt seals.

F. Dampers, barametric, low pressure:
   1. Counterbalanced, static pressure operated.
   2. Counterweight adjustable to hold damper blades closed until specified static pressure is reached.
   3. Fabricate of aluminum.
   4. Blades: Provided with common linkage rod and felt seals.

2.4 FIRE DAMPERS

A. Fire dampers - general:
   1. UL labeled, 1.5 Hour rated (unless otherwise indicated).
   2. Fire dampers shall have 165 degF fusible link.
   3. Fire dampers shall be dynamic type.
   4. Provide as indicated and as required by NFPA and local regulations.
   5. Provide with mounting angles and sleeves.
   6. For curtain-type fire dampers, blades must be out of air stream (Type B fire damper).

B. Fire dampers in low pressure ducts:
   1. Provide curtain type damper, Ruskin Model DIBD2:
      a. Rated up to 2375 FPM at 4 IN WG for vertical mounted applications.
      b. Rated up to 2520 FPM at 4 IN WG for horizontal mounted applications.

C. Fire dampers in high pressure ducts:
   1. For vertical mounted applications: curtain type damper, Ruskin Model DIBDX2:
      a. Rated up to 4550 FPM at 8 IN WG.
   2. For horizontal mounted applications: curtain type damper, Ruskin Model DIBD2:
      a. Rated up to 2520 FPM at 4 IN WG.

2.5 SMOKE DAMPERS

A. Smoke dampers - general:
   1. UL classified as a leakage rated damper for use in smoke control systems under UL555S, latest edition, and bear a UL label attesting to same.
   2. Suitable for velocity and pressure of system.
   3. Jamb seals: Stainless steel flexible metal compression type.
   4. Provide in ductwork adjacent to smoke partition (not in wall) with actuator in accessible location and visible for inspection.
   5. Actuator shall not be inside of duct.

6. Provide dampers and actuators as a single entity which meets all applicable UL555 and UL555S qualifications for both dampers and actuators as a rated assembly.
7. Frame: 16 GA galvanized steel, minimum.
8. Loss through wide open damper:
   a. Not more than 0.15 IN WG at 3000 FPM face velocity for high pressure.
   b. Not more than 0.15 IN WG at 2000 FPM face velocity for low pressure.
9. Provide factory supplied caulked sleeve.
10. Provide smoke dampers as indicated.

B. Smoke dampers, low pressure:
1. Parallel blade type with blades hinged together for operation in unison and bearings arranged for automatic operation.
2. UL555S Leakage Rating: Class I (4 CFM/ SF at 1 IN WG):
   a. Ruskin Model SD37.
3. Blades: Single or double thickness type:
   a. Single thickness type: 16 GA steel, minimum.
   b. Double thickness type: 18 GA steel.
4. Blade width: Not more than 6 IN.
5. Single blade dampers may be used for up to 8 IN wide blade, or up to 12 IN round.

C. Smoke dampers, square or rectangular, high pressure:
1. Parallel or opposed blade type with linkage for automatic operation.
2. UL555S Leakage Rating: Class I (8 CFM/ SF at 4 IN WG):
   a. Ruskin Model SD60 or SD50.
3. On round or flat oval ductwork:
   a. Provide dampers in an enclosure with round or oval connections on each side.

D. Smoke dampers, round or flat oval, high pressure:
1. Single blade type with encompassed blade edge seal.
2. UL555S Leakage Rating: Class I (8 CFM/ SF at 4 IN WG):
   a. Ruskin Model SDRS25.

E. Damper actuator (operator): Electric type, factory installed:
1. Two-position type.
2. 120 VAC.
3. Spring return fail closed.
4. UL listed at 250 degF.

2.6 COMBINATION FIRE-SMOKE DAMPERS

A. Fire-smoke dampers, combination - general:
1. UL classified as a Leakage Rated damper under UL555S, latest edition, bearing a UL label attesting to same.
2. UL555 fire rating: 1.5 Hour.
3. Suitable for velocity and pressure of system.
4. Compressible metal jamb seals.
5. Actuator installed per UL requirements, in accessible location and visible for inspection.
6. Actuator shall not be inside duct.
7. Provide dampers and actuators as a single entity which meets all applicable UL555 and UL555S qualifications for both dampers and actuators as a rated assembly.
8. Frame: 16 GA galvanized steel, minimum.
9. Loss through wide open damper based on AMCA Test Figure 5.3:
   a. 12 IN x 12 IN duct size: Not more than 1.25 IN WG at 3000 FPM face velocity.
   b. 24 IN x 24 IN duct size: Not more than 0.45 IN WG at 3000 FPM face velocity.
   c. 36 IN x 36 IN duct size: Not more than 0.3 IN WG at 3000 FPM face velocity.
10. Provide factory supplied caulked sleeve.
11. Provide fire-smoke dampers as indicated.

B. Fire-smoke dampers, combination, low pressure:
   1. Parallel blade type with blades hinged together for operation in unison and bearings arranged for automatic operation.
   2. May be used in lieu of separate fire and smoke dampers.
   3. UL555S Leakage Rating: Class I (4 CFM/SF at 1 IN WG):
      a. Ruskin FSD37.
   4. Fusible link: 165 degF melting point.

C. Fire-smoke damper, combination, high pressure:
   1. Parallel blade type.
   2. May be used in lieu of separate fire and smoke dampers.
   3. UL555S Leakage Rating: Class I (8 CFM/ SF at 4 IN WG):
      a. Ruskin Model FSD60 .
   4. Fusible link: 165 degF melting point.

D. Damper actuator (operator): Electric type, factory installed:
   1. Two-position type.
   2. 120 VAC.
   3. Spring return fail closed.
   4. UL listed at 250 degF.

2.7 DIFFUSERS, REGISTERS AND GRILLES

A. Diffusers, ceiling:
   1. Square type.
   2. Size, type and manufacturer: As scheduled.
   3. Finish of steel units: Factory applied, baked or electrocoated enamel; color as selected by Architect/Engineer or as indicated.
   4. Provide necessary screws, duct collars, transitions and air pattern deflectors.
   5. Provide opposed blade dampers where indicated.

B. Diffusers, radial throw type:
   1. Size, type and manufacturer: As scheduled.
   2. Provide with steel housing with hinged face to allow filters to be replaced from within the room without requiring access to the ceiling.
   3. Diffusers: Capable of 180 degree radial throw pattern.
   4. Provide gasket material around frame body on frame face of air seal.
   5. Finish: Baked, white epoxy finish.

C. Air grilles and registers:
   1. Size, type and manufacturer: As scheduled.
   2. Finish of steel units: Factory applied, baked or electrocoated enamel; color as selected by Architect/Engineer or as indicated.
   3. Provide necessary screws, duct collars and transitions.
   4. Provide opposed blade dampers in registers where indicated.

D. Diffusers and grilles, linear slot type:
   1. Size, type and manufacturer: As scheduled on drawings.
   2. Adjustable pattern controller (on supply units only) capable of 180 degree air pattern adjustment and volume control. All adjustments accessible from the face of the diffuser.
   3. Extruded aluminum or steel ceiling linear diffuser.

2.8 SOUND ATTENUATORS

A. Sound Attenuators:
   1. Prefabricated, straight through design.
   2. Airflow pressure drop and noise reduction (NR) values as indicated on drawings.
   3. Size and shape as indicated on drawings.
   4. Outer casing: 22 GA, minimum, galvanized steel.

5. Interior partitions or splitters: 24 GA, minimum, perforated galvanized steel.
6. Aluminum construction: At least 50 percent thicker than steel specified.
7. Use straight through air passages.
8. Use airtight construction:
   a. Make unit leakproof when subjected to differential air pressure of 8 IN WG between outside and inside.
   b. Weld lock joints or seams or fill with mastic.

B. Sound attenuators, noise reduction (NR) rating:
   1. Tests made in such manner as to eliminate end reflections, beaming or directivity, flanking, standing waves, and room absorptions.
   2. Test method may be either "in-duct with anechoic termination" or "reverberant rooms with tunnel between".
   3. Size of units tested: Not smaller than 24 IN x 24 IN rectangular or 24 IN round outside, with full size connections.
   4. Submit corroborative report of tests made in nationally recognized, qualified, independent testing laboratory approved by AMCA for airflow determinations.

C. Sound attenuators, airflow pressure drop rating:
   1. Do not exceed pressure drop at specified airflow(s).
   2. Base rating on results of tests made in manner to provide reliable data.
   3. Basic setup: Standard code method as adopted by AMCA for testing fans.

D. Sound attenuators, acoustical fill:
   1. Inert, vermin and moisture proof, inorganic glass or mineral fiber.
   2. Pack behind partitions or splitters under not less than 5 percent compression to provide "spring" and avoid settling.
   3. Fill containment: totally encapsulated and sealed with a polymer film. Separate fill material from perforated baffle by a non-combustible, erosion resistant, acoustical stand-off. Refer to schedule for applicability.

2.9 HEPA FILTER MODULES

A. HEPA Filter Modules:
   1. Ducted filters shall be anodized extruded aluminum housing with 12" diameter duct collar connection. Furnish a baffle plate to permit uniform air distribution inside the module. The support lip shall be a continuous part of the extruded aluminum frame. HEPA filters as manufactured by American Air Filter or Camfil.
   2. Filter Assembly:
      a. Factory built and assembled.
      b. Removable ceiling filter module to be replaceable from room side.
      c. Filter assembly hermetically sealed.
   3. Filter:
      a. Extended surface, 99.99 percent efficient certified on 3 micron particles. Tested and constructed accordance with IES-RP-CC-001 for Type C HEPA Filters:
         1) 4 IN deep mini-pleated, American Air Filter Model TM4 disposable type. Or equal by manufacturers listed under “MATERIALS” in Part 2 of this section.
         2) Nominal resistance at rated air flow: Not greater than 0.25 IN WG at 70 f.p.m. usable face velocity.
         3) UL rated, Class 1.
         4) Provide 5% extra stock.
   4. Filter module:
      a. Aluminum perimeter and internal channels with welded corners. American Air Filter Model TM4 with 14 IN inlet. Module shall be 7 IN high to house the 4 IN deep filter.
      b. Perimeter edge for gasket sealing system.
      c. Filter sizes to fit modular ceiling system as indicated herein.
      d. Module to include perforated diffusion damper, UL-900, perforated 12 IN inlet disc, Class 1 housing, filter, white filter face guard.

5. Acceptable manufacturer:
   a. Base:
      1) American Air Filter.
   b. Optional:
      1) Cambridge.
      2) Camfil Farr.

PART 3 - EXECUTION

3.1 GENERAL

A. Install and coordinate systems and components.

B. Install air flow measuring stations furnished with Section 25 50 00 in accordance with manufacturer's installation instructions and as specified.

3.2 INSTALLATION OF DUCTWORK

A. Install generally as indicated.

B. Conceal ductwork in finished spaces unless indicated otherwise.

C. Do not install ductwork in or allow to enter or pass through electrical rooms, elevator machine rooms, or spaces housing switchboards, panelboards or distribution boards, except ductwork that serves electrical rooms, elevator machine rooms, or spaces.

D. Exercise special care to provide tight fitting well fabricated, well braced ductwork systems.

E. Field assemble rectangular or round ductwork as follows:
   1. Use duct joint sealer applied slip joints.
   2. Use Ductmate Spiralmate or Ovalmate systems.
   3. Isolate dissimilar metals with elastomeric sealant tape or fiber gaskets, and gaskets and washers for bolts.
   4. Install TDC flanged duct connection systems in accordance with SMACNA construction standards.

F. In high pressure round ductwork, do not use 2 piece mitered 90 degree elbows with or without vanes.

G. Fabricate duct connections for openings, fans, and other devices.

H. Where ducts pass thru fire rated and smoke rated construction, maintain rating indicated:
   1. Where fire dampers are not used, seal around duct with firestopping.
   2. See Section 07 84 00 for materials.

I. Do not bend or otherwise restrict the free area of flexible ductwork.

J. Install air terminal units for easy access from floors and from above ceiling platforms:
   1. Obtain BNL’s approval prior to proceeding with installation of air terminal units.

3.3 INSTALLATION OF FIRE AND SMOKE DAMPERS

A. Install in accordance with manufacturer's instructions and UL requirements:
   1. See Section 07 84 00.

B. Provide typical, prototype installation to include wall mounted dampers for the different wall constructions. Obtain approval of BNL's Fire Protection Authority before proceeding with the remainder of the damper installations. Submit certificate of approval to BNL's Physical Facilities prior to installation of any other fire and smoke dampers.

3.4 PERFORMANCE TESTS

A. BNL's representative to perform random visual examination of each duct section.

B. BNL to employ the services of a qualified testing agency.

C. When testing indicates that ductwork does not meet leakage class 6 as defined in SMACNA HVAC Systems Duct Design Manual for Seal Class A, discretionary judgement by BNL and the BNL will be used to determine the extent of work rejected due to failed leak tests.

D. All work rejected must have joints disassembled and remade as required to pass leakage testing at no additional cost to BNL.

3.5 CLEANING

A. At substantial completion, clean work installed under this section. Wipe ducts clean inside.

3.6 EQUIPMENT DEMONSTRATION

A. At substantial completion, inspect and test, and operate satisfactorily, in presence of BNL and representative of BNL, operation of each piece of equipment and its accessories.

B. If inspection or test indicates defects, replace defective work or material.

C. Repeat inspections and tests until defects are eliminated.

END OF SECTION

SECTION 23 35 00
EXHAUST AND VENTILATING FANS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. In-line centrifugal fans.
   2. Propeller fans.
   3. Roof exhaust fans.
   4. Cabinet exhaust fans.
   5. Mixed-flow exhaust fans.

B. Abbreviations:
   1. AMCA: Air Moving and Conditioning Association.
   2. ADC: Air Diffusion Council.
   3. ASHRAE: American Society of Heating, Refrigeration and Air Conditioning Engineers.

1.2 QUALITY ASSURANCE

A. Standards:
   1. ADC Standard 1062R2, Air Diffusing Equipment Test Code.
   2. AMCA Standard 210, Test Code for Air Moving Devices.
   3. ASHRAE Standard 70, Method of Testing for Rating the air flow performance of outlets and inlets.
   4. NFPA-90A, Standard for the Installation of Air Conditioning and Ventilating Systems, 1980 edition.

1.3 SUBMITTALS

A. Product data:
   1. In-line centrifugal fans.
      a. Performance data.
      b. Physical dimensions.
      c. Fan curves.
      d. Sound data.
   2. Propeller fans.
      a. Performance data.
      b. Physical dimensions.
      c. Fan curves.
      d. Sound data.
   3. Roof exhaust fans.
      a. Performance data.
      b. Physical dimensions.
      c. Fan curves.
      d. Sound data.
   4. Mixed-flow exhaust fans.
      a. Performance data.
      b. Physical dimensions.
      c. Fan curves.
      d. Sound data.

B. Contract closeout information:
   1. Operating and maintenance data.
   2. BNL instruction report.

1.4 WARRANTY

A. Provide a one (1) year warranty from date of acceptance by BNL for items furnished that shall cover the following:
   1. Faulty or inadequate product design.
   2. Improper assembly or erection.
   3. Defective workmanship and materials.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Fans (General):
      a. Members of AMCA.
   2. In-line centrifugal fans.
      a. Base: See schedule.
      b. Optional:
         1) Barry Blower.
         2) Cook, Loren.
         3) Penn Ventilator.
         4) Twin City Fan & Blower.
         5) Acme Engineering and Manufacturing.
   3. Propeller fans:
      a. Base: See schedule.
      b. Optional:
         1) Carnes.
         2) Acme Engineering and Manufacturing.
         3) Cook, Loren.
         4) Hartzell Fan.
         5) ILG Industries.
         6) New York Blower.
         7) Peerless-Winsmith.
         8) Penn Ventilator.
         9) Jenn-Air.
   4. Roof exhaust fans:
      a. Base: See schedule.
      b. Optional:
         1) Carnes.
         2) Acme Engineering and Manufacturing.
         3) Aerovent, TCF.
         4) Cook, Loren.
         5) Jenn Industries.
         6) Penn Ventilator.
   5. Mixed-flow exhaust fans:
      a. Base:
         1) Greenheck.
      b. Optional:
         1) Strobic Air..
   6. V-belt drives:
      a. Base:
      b. Optional:
         1) Fairbanks Morse Engine.
         2) Gates.
         3) Reliance Electric.

B. Fans - General:
   1. Performance ratings: Based on laboratory tests conducted in accordance with latest edition of ASHRAE/AMCA Standard Test Codes.
   2. Ratings: As indicated.
   3. Arrangement and drive: As indicated.
   4. Provide removable belt guard.
   5. Drive sheaves:
      a. Cast iron, split tapered bushings dynamically balanced at factory.
      b. Provide wide range variable speed adjustable sheaves to be used for balancing systems.
      c. Provide final fixed pitch drive sheaves for proper RPM determined during balancing process.
   6. Fans 5 HP and less: Provide with adjustable sheaves.
   7. Finish: Applied enamel.

C. Bearings: Extra heavy duty self-aligning ball, roller, or sleeve type, grease lubricated.

D. Motors and control: As specified in Section 20 05 00.

E. Housings:
   1. Constructed of steel scroll and side sheets conforming to standard gauges of National Association of Fan Manufacturers.
   2. Continuously welded construction.
   3. Mount in heavy steel supports on both sides.
   4. For outdoor installation provide hinged weather hood that will cover both drive and motor.

F. Drives:
   1. Single or multiple belts as required to develop full horsepower of driving motor with service factor of not less than 1.50.
   2. Where more than one belt is used for drive, provide "matched" sets.
      a. Use new belts on final fixed pitch drive sheaves.
   3. Motors on fan drive: Provide with adjustable rail motor mounts of type using screws for tightening of belts.
   4. Bolt motor mounts to fan bases or frames.
   5. For fans suspended from ceilings, belt tightening device may be pivoted type.

G. Belt guards: As specified in Section 20 05 00.

H. Vibration Control
   1. Framework shall be of sufficient rigidity to assure fan and motor meet vibration requirements specified in Section 20 05 50. Fan shaft shall be steel, solid and totally ground and polished. Fan shall be keyed to the shaft and locked in place with set screws. Shaft shall have grounding system for protection from static and AFD induced currents.
   2. Fans shall be dynamically balanced and run tested at the factory as a complete fan assembly (fan wheel, motor, and drive) to achieve maximum fan vibration, measured on fan bearings, of 2 mm per second rms. Fan vibration readings shall be taken in accordance with ANSI S2.19 grade G6.3. Fan shaft shall not exceed 75 percent of its first critical speed at any cataloged rpm.

2.2 IN-LINE CENTRIFUGAL FANS

A. In-line centrifugal fans:
   1. Inlet bell and diffuser section.
   2. Flanged joint connections.
   3. Mounting frame to support drive and to permit mounting of fan on any side except motor side.
   4. Stiffening angles to maintain housing shape.
   5. Air foil blades in diffuser section.
   6. Finished with 2 coats of enamel primer.

B. Fan wheel:
   1. Axial flow, centrifugal type.
   2. Air foil shaped blades.
   3. Statically and dynamically balanced.
   4. Extend fittings for lubricating bearing to exterior of housing.

2.3 PROPELLER FANS

A. Propeller fans, General:
   1. Direct or belt drive, AMCA labeled.
   2. Fan capacity and RPM: As indicated.
   3. Fan blades and hubs: Cast aluminum type, or 2-piece die formed hubs and blades, using welded construction with blades reinforced with gussets or of air foil design and rigidity; designed for low noise operation.
   4. Propeller assembly reinforced to prevent distortion.
   5. Statically and dynamically balanced.
   6. Motor and drive: Isolate from enclosure with vibration isolators (see Section 20 05 50) or rubber-in-shear.
      a. For direct drive fans, resiliently mounted motors may be used.
   7. Motors and drives not located in air-stream: Open drip-proof or TEFC construction.

B. Wall mounted fans:
   1. Suport on heavy metal frames designed for wall opening.
   2. Automatic dampers: See Section 25 50 00.
   3. Provide self acting backdraft dampers for exhaust fans.
   4. Mounting ring or plate: Extended type to provide suitable support for motor.
   5. Speed: Not over 1800 RPM.
   6. Safety guard: Stiff woven wire, or other standard construction.

2.4 ROOF EXHAUST FANS

A. Roof exhaust fans:
   1. Centrifugal, belt driven, curb mounted type, AMCA labelled.
   2. Capacity: As scheduled.
   3. Housing: Extruded or heavy gauge sheet aluminum mounted on rigid support structure.
      a. Wind band, for upward discharge of air, welded to curb cap.
      b. Square base to match roof curb.
   4. Motor and drive: Isolated from exhaust air stream.
      a. Provide overload protection.
      b. Isolate each fan motor and drive from enclosure with vibration isolators.
      c. Provide variable pitch motor pulleys for belt drive fans.
   5. Bearings:
      a. Pillow block ball type minimum L10 life in excess of 100,000 hours.
   6. Fan wheel: Backward curved, dynamically and statically balanced.
   7. Provide factory installed and wired disconnect device outside motor compartment.
   8. Provide factory prefabricated, insulated roof curbs.
      a. Curb height: 12 IN, above finished roof.
      b. Type to suit roof construction and provide water tight enclosure.
      c. Provide sound attenuating galvanized steel or aluminum baffles in curb throat.
      d. Provide level installation, regardless of roof slope.
   9. Provide 1/2 IN mesh birdscreen on outlet.
   10. Provide self acting backdraft damper in curb base.
   11. Factory wired, solid state speed controller, on direct drive fans.

2.5 MIXED-FLOW EXHAUST FANS

A. General:
   1. Provide a direct drive mixed-flow induced dilution fan for the described purpose and duty shown on the plans and as described by this specification. To assure system performance, the fan, plenum section, and roof curb shall be provided by the unit manufacturer and manufactured under their supervision. See fan schedule for performance requirements.
   2. The fans shall have been tested under AMCA 210-85, "Laboratory Methods of Testing Fans for Rating" and shall have been witnessed by an independent agency. Documented aspiration tests shall have been preformed in conjunction with the fan performance testing. Provide documentation of testing along with equipment submittals.
   3. The fans shall be sound tested in accordance with AMCA 300 and shall be UL and CUL listed per UL 705 safety standard. Fans shall meet NFPA-45 criteria.
   4. Fan manufacturer shall furnish a certificate of guarantee stating that the fan, mixing plenum, outlet nozzle, stack extension if any, and all related accessories specified herein have been pre-tested at the factory and that the curves supplied in submittal documentation have been de-rated for any and all system effects created by the accessories.
   5. Start-up shall be provided by a factory certified start-up technician in accordance with the factory start-up procedures. Provide start-up certification along with the "Operation and Maintenance" documentation. Provide O&M documentation to BNL at start-up completion. Technician shall be available to assist the Automatic Temperature Contractor at start-up of the ATC controls.

B. Mixed-flow induced dilution fan(s):
   1. The fan impeller shall be mounted directly to the motor shaft to provide a direct drive arrangement 4 type fan. All motors shall be isolated from the primary exhaust air stream and shall be visible and accessible from the fan exterior for inspection and service.
   2. The mixed-flow impeller shall consist of combination axial/backward curved blades and shall be of welded steel construction. The impeller shall have non-stall and non-overloading performance characteristic with stable operation at any point on its fan curves. Stationary discharge guide vane sections shall be provided to increase fan efficiencies.
   3. The fan shall be dynamically balanced and shall not exceed 0.5 mil peak to peak at the blade pass area when operation at the fan design frequency. Vibration isolation shall be limited to rubber-in-shear pad type isolators and shall be provided by the manufacturer with the fan/plenum.
   4. Fan assemblies shall not require guy wire supports. Any additional supports shall be provided at no cost to BNL.
   5. The fan shall discharge through twin FRP chemical and UV resistant nozzles with passive third central tacks that are capable of generation aspiration.
   6. A steel entrainment windband shall provide secondary induction of outside air. The induction shall take place downstream of the fan impeller and shall not influence BHP or static pressure requirements. The windband shall discharge up to 270% of the design flow rates. The manufacturer shall publish discharge volumes for all fans at specified primary exhaust flow.
   7. A non-ferrous inlet bell shall be provided in order to reduce sparking in the event of a motor bearing failure.
   8. The fan shall be modular construction and capable of being assembled on a conventional roof curb. PTFE gaskets shall be provided at all companion flanged joints. All fastening hardware shall be 316 stainless steel.
   9. A bolted access door shall be provided for impeller inspection on each fan or one per every two fans on a multiple fan plenum.
   10. The fans and accessories shall have an internal drain system to prevent water from entering the building through the duct system.

11. Provide a TEFC Mill & Chemical duty electric motor with a 1.15 service factor and an L-50 bearing life of 200,000 hours. The motor shall have sealed bearings up through a 256T NEMA frame. The motors shall be C-Face and foot mounted. All motors shall comply with efficiencies listed in U.S. Energy Policy Act of 1992. Motors must be rated for use with variable speed drives.
12. A NEMA 3R non-fused disconnect switch shall be provided, mounted and wired to each motor.
13. Coatings - All steel and aluminum surfaces shall be prepared for coating by blasting or chemical etching. Coating will be Epoxy (8-10 mils) for protection against weather, chemical vapors and splashes.

C. Accessories:
1. An inlet mixing plenum shall be provided by the fan manufacturer. Each plenum shall be sized to support the weight and performance requirements of the number of fans listed on the schedule. Multiple fan plenums shall be double wall construction with structural stiffeners or shall be continuously welded, heavy gauge single wall construction.
2. All plenums shall be capable of supporting the fan(s) without guy wires or supports. The plenums shall include hinged access doors and safety screens over primary air inlets. The primary air inlets shall be located as noted on the construction drawings. Coatings shall be the same as specified for the fans. Unless otherwise specified, plenums shall be suitable for mounting on roof curbs.
3. A stainless safety screen shall be supplied over the bottom primary air inlet
4. Bypass dampers shall be provided with all mixing plenums for outside air with primary exhaust. Dampers shall be opposed blade low leakage air foil control dampers with extended shaft for connection to an operator. The dampers shall be all aluminum construction. Heavy duty plastic UV resistant rain hoods shall be provided with each damper. Each damper shall be controlled by an electric 24V operator. The operator shall be provided by the ATC contractor and field mounted.
5. A low leakage isolation damper(s) shall be provided for each fan and be constructed of aluminum air foil extrusions and coated with epoxy. Operators shall be 2 position, spring return and shall be 120V electric. The electric operator shall be factory wired via a transformer to the fan disconnect switch to open when the fan is energized and close via a spring return when de-energized. When the fan ships separate from the plenum, all wiring and conduit shall be factory supplied for easy connection in the field.
6. Vortex breakers shall be provided on all side inlet and multiple fan plenums.
7. A 14 gauge galvanized steel roof curb shall be provided to support the fans/plenums. The curb shall be minimum 14 gauge and canted for rigidity in wind loads. The curb shall be 12 IN high. The curb shall include a rigid fiberglass liner and a wood nailer.

2.6 VIBRATION ISOLATION

A. Vibration isolation: Section 20 05 50.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fans, general:
1. Install in accordance with manufacturer's recommendations and as specified.

B. Air curtain fans:
1. Provide side baffle on each side of door/air curtain installation to prevent bypass of outside air.
2. Wiring between Control Panel and micro switch and between Control Panel and fan motor junction box shall be by Division 26.

3.2 VIBRATION ISOLATION

A. Vibration isolation: Section 20 05 50.

3.3 FAN DYNAMIC BALANCING

A. Experienced, trained mechanics from factory shall dynamically balance all fans in the field after they have been set in place and installation is complete. Balancing shall include the following:
   1. Inspection of fans to determine if damage has occurred during storage or installation and coordinate repair of damages.
   2. Inspection of fan drives including bearing and motor mounts.
   3. Inspection of tensioning of drive belts on adjustable and fixed pitch sheaves.
   4. X-Y dynamic vibration plot on each fan resulting in a properly balanced installation within the vibration specifications above, performed after system has been balanced and final fixed pitch drive sheaves installed.

END OF SECTION

SECTION 23 36 00
AIR TERMINAL UNITS AND AIR VALVES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. Air terminal units.
   2. Air valves.

B. Operators and controllers:
   1. Operators and controllers for air terminal units: Provided in Section 25 50 00.
   2. Operators and controllers for air valves: Provided by air valve manufacturer.

C. Definitions:
   1. Low pressure ductwork: Refer to Section 23 31 13.
   2. High pressure ductwork: Refer to Section 23 31 13.

1.2 QUALITY ASSURANCE

A. Design and installation standards:
   1. ASHRAE Guide and Data Book – Systems and Equipment, current chapter on duct construction.
   2. Air Diffusion Council, ADC Standard 1062R2, Air Diffusing Equipment Test Code.
   3. Air Moving and Conditioning Association, AMCA Standard 210, Test Code for Air Moving Devices.
   4. ASHRAE Standard 70-72, Method of Testing for Rating the Air Flow Performance of Outlets and Inlets.
   5. NFPA-90A, Standard for the Installation of Air Conditioning and Ventilating Systems, current edition.
   6. SMACNA HVAC Duct Construction Standard - Metal and Flexible current edition.
   7. UL Publication No.181, Erosion Test Methods.

1.3 SUBMITTALS

A. Product data:
   1. Air Terminal units.
   2. Air valves.

B. Contract closeout information:
   1. Operating and maintenance data.
   2. BNL instruction report.

1.4 WARRANTY

A. Provide a one (1) year warranty from date of acceptance by BNL for items furnished that shall cover the following:
   1. Faulty or inadequate product design.
   2. Improper assembly or erection.
   3. Defective workmanship and materials.

PART 2 - PRODUCTS

2.1 MATERIALS - GENERAL

A. Acceptable manufacturers:
   1. Air terminal units:
      a. Base:
         1) Titus
      b. Optional:
         1) Price.
         2) Trane.
         3) Krueger.
   2. Air Valves:
      a. Base:
         1) Phoenix.
      b. Optional:
         1) TekAir.
         2) TriaTek.
         3) Flow Safe Inc.

2.2 AIR TERMINAL UNITS

A. Air terminal units - general: Factory assembled.
   1. Configured for pressure independent control.
   2. Capacity: As indicated.
   3. Noise level: As scheduled.
   4. DDC Controllers and Operators: Furnished under Section 25 50 00 but factory installed and wired under this section.
      a. Section 25 50 00 will furnish 120V/24V transformer and power disconnect to power all control devices in the unit.
      b. This contractor shall install and wire all devices at the factory. The air terminal units shall be configured to have a single point 120V connection to power all electrical devices in the unit.
      c. All wiring shall be plenum rated. There shall be no exposed 120 volt terminals in control cabinet.
   5. Acoustical fiberglass liner:
      a. Comply with NFPA-90A for fire resistivity and UL Standard 181 for erosion.
      b. Insulation shall consist of 1 IN thick non-porous foil faced rigid fiberglass insulation secured by full length galvanized steel z-strips which enclose and seal all edges, eliminating tape and adhesives.
   6. Provide multi-point velocity pressure sensors with external pressure taps.
   7. Provide static pressure tube(s).
   8. Valve adjustment: Field adjustable.
   9. Set air terminal units to air flow rates indicated.
   10. Casing leakage: 5 percent, maximum, of nominal rated capacity at 3.0 IN WG internal pressure.

B. Heating coils for air terminal units: ARI certified, continuous plate or spiral fin type, leak tested at 300 PSI.
   1. Capacity: As indicated.
   2. Headers: Copper or brass.
   3. Fins: Aluminum, maximum 8 fins per IN.
   4. Tubes: Copper, arrange for counter-flow of heating water.
   5. Water velocity: 8 FPS maximum with head loss not greater than indicated.
   6. Provide 20 GA galvanized steel casing with slip and drive construction for attachment to metal ductwork.
   7. Provide vent and drain connection at high and low point, respectively, of each coil.

C. Air terminal units, single duct, with or without coils: Constant or variable volume, unit with or without reheat coil, as indicated.
   1. Construction: 22 GA galvanized steel or 0.040 IN aluminum, minimum.
   2. Sound Attenuators: Refer to plans and specification section 20 05 50 for locations and requirements.
   3. Sound Attenuators: Provide where indicated on schedules.

2.3 AIR VALVES

A. Air valves, flow control:
   1. All air valves shall be variable volume control type.
   2. Airflow control device shall be a venturi valve.
   3. Pressure independent over a 0.6 IN WG – 3.0 IN WG drop across valve.
   4. Volume control accurate to plus or minus 5% of airflow over an airflow turndown range of 16 to 1. No minimum entrance or exit duct diameters shall be required to ensure accuracy or pressure independence.
   5. Response time to duct static pressure change less than one second.
   6. 16 gauge aluminum continuous welded seam valve body with corrosion resistant baked phenolic coatings, control device, shaft, shaft support bracket, pivot arm and internal mounting link. The control device shall have a baked on corrosion resistant phenolic coating. The shaft shall have a Teflon coating and all shaft bearing surfaces shall be made of Teflon. The pressure independent springs shall be made of stainless steel.
   7. The airflow device shall have no exposed stainless steel components. The shaft support brackets, pivot arm, internal mounting link, and pressure independent springs shall have a baked-on corrosion resistant phenolic coating. Internal nuts, bolts, and rivets shall be titanium or phenolic coated stainless steel.
   8. Actuator to be factory mounted to the valve.
   9. Closed loop control of airflow by way of flow feedback signal with less than 120 seconds of response time.
   10. Valves shall modulate from minimum to full flow in response to 0-10 vdc input signal.
   11. Valves shall provide 0-10 vdc feedback signal factory calibrated to correspond to valve flow rate.
   12. Valve shall be normally open type.

B. Exhaust sound performance data: As scheduled.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units as indicated and in accordance with manufacturer's recommendations and instructions and as specified.

B. Sizes as scheduled on drawings.

C. Provide adequate access space for the air terminal unit control panel.

END OF SECTION

SECTION 23 57 00
HEAT EXCHANGERS AND CONVERTERS

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Design standards: ASME and Standard of Tubular Exchanger Manufacturers Association.

B. Factory test: Test sheets and tubes at 300 PSI.

1.2 SUBMITTALS

A. Product data.

B. Contract closeout information:
   1. Operating and maintenance data.
   2. BNL instruction report.
   3. Test reports.

1.3 WARRANTY

A. Provide a one (1) year warranty from date of acceptance by BNL for items furnished that shall cover the following:
   1. Faulty or inadequate product design.
   2. Improper assembly or erection.
   3. Defective workmanship and materials.

PART 2 - PRODUCTS

2.1 HEAT EXCHANGERS AND CONVERTERS

A. Acceptable manufacturers:
   1. Heat exchangers, shell and tube:
      a. Base:
         1) Bell & Gossett, ITT.
         2) Taco.
         3) Armstrong.
         4) Patterson-Kelley.
         5) Adamson.

B. Heat exchangers: Instantaneous, shell and U-tube type, heating liquids with steam, with removable tube bundle.
   1. Capacity: As indicated, with steam in shell, water in tubes.
   2. Shell working pressure: 150 PSIG.
   3. Shell: Steel.
   4. Heads: Cast iron.
   5. Tubes: Copper, 3/4 IN OD minimum.
   6. Fouling factor: 0.002 on water and steam sides.
   7. Pressure loss in header coils: As indicated.
   8. Maximum tube velocity: 7.5 FPS.
   9. ASME code construction.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install components in system piping as indicated.

B. Install so that components may be removed without disturbing piping.

END OF SECTION

SECTION 23 73 13
PACKAGED AIR HANDLING UNITS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Abbreviations:
   1. ADC: Air Diffusion Council.
   2. AMCA: Air Moving and Conditioning Association.
   3. ANSI: American National Standards Institute.
   4. ARI: Air-Conditioning and Refrigeration Institute.
   5. ASHRAE: American Society of Heating, Refrigeration and Air Conditioning Engineers.
   6. IES: Institute of Environmental Sciences.

B. This section applies to air handling units AHU-1 to 7 and heat recovery units HRU-1 to 3.

1.2 QUALITY ASSURANCE

A. Standards:
   1. AMCA 99 - Standard Handbook.
   2. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.
   3. AMCA 300 - Test Code for Sound Rating Air Moving Devices.
   4. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices.
   5. AMCA 500 - Test Methods for Louver, Dampers and Shutters.
   6. ANSI/AFBMA-9 - Load Ratings and Fatigue Life for Ball Bearings.
   7. ANSI/UL-900 - Test Performance of Air Filter Units.
   8. ARI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils.
   9. ARI 430 - Standard for Central-Station Air-Handling Units.
   10. ARI 435 - Standard for Application of Central-Station Air Handling Units.
   11. NFPA-90A - Installation of Air Conditioning and Ventilation Systems.
   12. SMACNA - Low Pressure Duct Construction Standards.
   13. Air Handling Units: Product of manufacturer regularly engaged in production of components who issues complete catalog data on total product.

1.3 SUBMITTALS

A. Product Data:
   1. Shop drawings shall indicate assembly, unit dimensions, weight loading, required clearances, construction details and field connection details.
   2. Product data shall indicate dimensions, weights, capacities, ratings, fan performance, motor electrical characteristics and gauges and finishes of materials.
   3. Provide fan curves with specified operating point clearly plotted.
   4. Submit product data of filter media, filter performance data, filter assembly and filter frames.

B. Contract Closeout Information:
   1. Submit operation and maintenance data.
   2. Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists and wiring diagrams.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures and finish.

1.5 ENVIRONMENTAL REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, all filters are in place, bearings lubricated, and fan has been test run under observation.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Indoor air handling units:
   1. Base:
      a. Trane Climate Changer.
   2. Optional:
      a. Carrier - Aero.
      b. McQuay - Vision.
      c. York - Solution.
      d. All listed manufacturers shall meet the dimensions of base manufacturer without affecting the mechanical room layout shown on the contract documents or the ability to service equipment. Manufacturers who do not meet this requirement may be rejected at the discretion of the Engineer.

B. Filters:
   1. Base:
      a. American Air Filter.
   2. Optional:
      a. Flanders.
      b. Cam-Farr.
      c. Eco-Air Products.

2.2 GENERAL DESCRIPTION

A. Fabricate draw-thru type air handling units suitable for the scheduled capacities.

B. Fabricate units with segments as per schedules and drawings.

C. Factory fabricate and test air handling units of sizes, capacities, and configuration as indicated and specified.

D. All internal components specified in the air handling unit schedule shall be factory furnished and installed. Unit(s) shall be completely factory assembled.

E. Units shall ship in one piece where possible. Shipping splits can be provided as required for installation. Lifting lugs will be supplied on each side of the split to facilitate rigging and joining of segments. Units with shipping splits shall be provided with "male" and "female" connection pieces for easy field assembly. Units requiring field installed gasketing must be assembled under supervision by factory trained and employed personnel from the air unit manufacturer.

2.3 CASING: INDOOR AIR HANDLING UNIT

A. The entire unit shall be provided with a full-length, continuous, base rail channel. Base rail channels will be formed of a minimum of 12 gage galvanized steel. The base channel will have a minimum height of 6 IN. All major components shall be supported from the base. Integral lifting lugs shall be provided. Units without a complete and continuous base rail will not be acceptable.

B. The unit shall have a frame construction consisting of cast aluminum corner pieces and galvanized steel vertical and horizontal structural members. The frame shall be constructed to permit complete removal of the wall and roof panels without affecting the structural integrity of the unit.

C. All segments shall be 2 IN double wall and shall be constructed of G90 mill galvanized sheet steel, formed and reinforced to provide a rigid assembly. The exterior casing shall be constructed of a minimum 18 gauge galvanized steel. The interior lining shall be a solid lining of a minimum of 22 gauge galvanized steel except that 22 gauge solid aluminum liner shall be used in the cooling coil and humidifier section.

D. All side panels shall be completely removable for unit access and removal of components.

E. Panels will be removable with a 5/16 IN Hex Wrench. Access panels requiring the removal of sheet metal screws for panel removal will not be acceptable.

F. All panels shall be completely gasketed prior to shipment with a minimum of 1/4 IN thick and 3/4 IN wide closed cell neoprene.

G. All panels shall be insulated with 2 IN-1.5 lb fiberglass insulation. The panel insulation must be a full 2 IN (non-compressed) throughout the entire unit. Units with less than 2 IN of insulation in any part of the walls, floor, roof or drain pan shall not be acceptable. The insulation shall meet the flame and smoke generation requirements of NFPA-90A.

2.4 HEATING AND COOLING COIL SECTIONS

A. All cooling and/or heating coils shall be furnished to meet the performance requirements set forth in the schedule. All coils shall have performance certified in accordance with ARI Standard 410.

B. Coil casings shall be constructed of 16 gauge galvanized steel for heating coils and 16 gauge type 304 stainless steel for cooling coils. Intermediate casing supports of similar construction shall be supplied for finned lengths that exceed 60 IN.

C. The main cooling coil drain pan shall be double sloped to assure positive condensate drainage with connections on one side located adjacent to floor drain. The pan shall be of double wall construction with a stainless steel liner and have a minimum of 2 IN of insulation (uncompressed). The pan shall have a minimum depth (free-board) of 4 IN. Cooling coils with finned height greater than 48 IN shall have a stainless steel intermediate drain pan extending the entire finned length of the coil. The intermediate pans shall have drop tubes to guide condensate to the main drain pan.

D. Extended surface shall be of plate fin design consisting of die-formed, continuous, aluminum fins. The fins shall have fully drawn collars to accurately space fins, and to form a protective sheath for the primary surface. The minimum fin thickness shall be 0.006 IN. The maximum fin spacing shall be 10 FPI.

E. Headers shall be of heavy seamless copper tubing, silver-brazed to tubes. Connections shall be of steel, with male pipe threads, silver-brazed to the headers. A 1/4 IN FPT, plugged, vent or drain tap will be provided on each connection.

F. Coil grommets shall be provided on all coils to completely seal the area between the coil connection and the unit casing. The cooling coil segments shall have a full width, sloped drain pan that extends downstream of the coil to provide sufficient amount of space to contain moisture carryover. The unit design shall not require a drain pan in any downstream section to contain the coil condensate.

G. Water coils shall be drainable and designed to operate at 250 psig design working pressure and up to 300F and shall be tested with 325 psig compressed air under water. Circuiting shall provide free and complete draining and venting when installed in the unit. All vent and drain connections shall be extended to the outside of the unit casing. Water coils shall be circuited for counter flow of air and water. Water velocities shall not exceed 7 feet per second and/or exceed the water pressure drops scheduled. All coils must have same end connections regardless of the number of rows deep. For water coils, the primary surface shall be 5/8 IN O.D. copper tube, staggered in direction of airflow. Tubes shall be mandrel expanded to form fin bond and provide burnished, work-hardened interior surface. The tubes shall have a minimum tube wall thickness of 0.020 IN.

H. Steam distributing coils (1 IN OD) shall be designed for operation at 100 PSIG pressure and a corresponding saturated steam temperature of 338 degF. Coils shall be tested with 315 PSIG compressed air under water. The outer tube shall be 1 IN OD and the inner distribution tube shall be 5/8 IN OD. The coil shall be designed to not trap condensate and the steam shall discharge in the direction of condensate flow. The tubes shall have a minimum tube wall thickness of 0.025 IN and .035 IN thickness at return bends. Minimum fin thickness shall be .0075 IN.

2.5 ACCESS DOORS

A. General:
   1. All access doors shall be double wall.
   2. Thickness and construction: same as wall panels.
   3. Gasket:
      a. Bulb type; 3/8”minimum.
      b. Provide around entire door perimeter.
   4. Hinges: industrial type permitting 180 degree door swing.
   5. Arranged to open against unit pressure.
   6. Unless noted otherwise all access doors shall be located on the coil header side of the unit.
   7. Removal of sheet metal screws to accommodate unit access is not acceptable.

B. Provide at the following locations:
   1. Fan section; provide with double pane wire glass viewing window.
   2. Filter section; coil header-side of the unit.
   3. All access sections.
   4. Economizer section; upstream and downstream of return damper.
   5. Air blender section; downstream side.
   6. Humidifier section; downstream side; provide with double pane wire glass viewing window.

2.6 FANS

A. The supply fan segment shall be equipped with a double width double inlet (DWDI) centrifugal type or single width single inlet (SWSI) centrifugal type fan with flat backward inclined (BI) or airfoil (AF) blades.

B. Fan and unit performance shall be rated and certified in accordance with ARI Standard 430. All units that are not ARI Certified shall be witness tested at an independent laboratory to assure performance.

C. All airfoil fans shall bear the AMCA Seal. Airfoil fan performance shall be based on tests made in accordance with AMCA standards 210 and comply with the requirements of the AMCA certified ratings program for air and sound. In addition, all airfoil wheels shall comply with AMCA standard 99-2408-69 and 99-2401-82.

D. After the pre-balanced fan is installed in the air handler, the entire fan assembly shall be run-balanced at the specified speed to insure smooth and trouble-free operation. The run balance shall include filter-in and filter-out balancing in all three (3) planes, on both sides of the fan assembly at the bearings:

1. Fans with adjustable frequency drives shall be balanced for inverter duty operation. The fan will be balanced over the entire range of fan operation (30 percent to 100 percent of RPM). Filter-in measurements shall not exceed 5 mils in the horizontal and vertical planes. Filter-out measurements shall not exceed 7.5 mils in the horizontal, vertical and axial planes.

E. Fan and fan motor shall be internally mounted and isolated on a full width isolator support channel using 1" springs. The fan discharge shall be connected to the fan cabinet using a flexible connection to insure vibration-free operation. The isolator support rail shall be structurally supported from the unit base. Cantilever supports of the isolator support base are unacceptable.

F. Fan arrangement shall be as indicated on drawings.

G. Belt guards: As specified in Section 20 05 00.

2.7 BEARINGS AND DRIVES

A. Fan bearings shall be self-aligning, pillow block or flanged type regreaseable ball bearings and shall be designed for an average life (L50) of at least 200,000 hours. All bearings shall be factory lubricated and equipped with standard hydraulic grease fittings and lube lines extended to the motor side of the fan.

B. Fan drives shall be selected for a 1.5 service factor and anti-static belts shall be furnished. All drives shall be fixed pitch.

C. Fan shafts shall be selected to operate well below the first critical speed and each shaft shall be factory coated after assembly with an anti-corrosion coating.

2.8 SUPPORT RAILS

A. Provide units with factory furnished 6 IN high galvanized steel support railing in quantity and strength to allow sound, vibration free installation.

2.9 ELECTRICAL CHARACTERISTICS AND COMPONENTS

A. Fan motors shall be NEMA design ball bearing type with electrical characteristics and horsepower as specified on the schedule. Motors shall be 1800 RPM, open drip-proof type.

B. All motors shall be in accordance with Section 20 05 00.

C. On units more than 42 IN in height, provide factory mounted, weather resistant, vapor tight, incandescent light fixture in each section having access doors. The fixtures shall be complete with wiring, junction box, glove, aluminum globe guard, receptacle and bulb. The light switch shall be externally mounted on the unit wall.

D. Wire fan motors to a unit mounted disconnect switch. Wiring shall be brought thru a liquid tight, flexible conduit. For units 48 IN and larger in height, disconnect switch shall be mounted external to the unit near fan section access door. For units smaller in height, mount disconnect switch external to unit casing, near fan section access door. Disconnected switches shall be provided as specified in Division 26:
   1. For units with AFD provide auxiliary control interlock switch in disconnect switch.
   2. Switch contact rated for 30 amp, 120 volts.
   3. UL listed.

E. The motor shall be mounted on the same isolation base as the fan. The motor shall be on an adjustable base.

2.10 FILTERS

A. The filter frames shall be constructed of galvanized steel and be built as an integral part of the unit.

B. All filter segments shall be side service with an access door on the drive side of the unit.

C. Flat Filter Segments shall accommodate 4 IN media. Media shall be 30 percent efficient pleated type.

D. High Efficiency Cartridge Filter Segments shall accommodate high efficiency rigid filters of the specified efficiency. Filter frames shall be provided with neoprene gasketing on the leaving air side of the filter for pressure sealing assembly:
   1. Rigid filter media shall be 12 IN deep and the efficiency shall be as scheduled and as determined by ASHRAE Standard 52-76.
   2. Filter media shall be listed Class 2 under U.L. Standard 900.

E. A magnahelic, differential pressure gage shall be factory installed on drive side to measure the pressure drop across each prefilter and high efficiency filter sections.

2.11 CONTROL DAMPERS

A. Control dampers shall be as specified in Section 23 31 13. Where shown in the unit, the control dampers shall be factory mounted. Control damper actuators to be field mounted. Dampers shall be sized for a damper face velocity of 1200 to 1500 FPM based upon supply cfm of air handling unit.

B. Outside and return air dampers shall be parallel blade type arranged horizontally to converge return and outside airstreams in circular mixing pattern.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions. Assemble units by bolting segments together. Isolate fan segment with flexible duct connections.

B. Install in conformance with ARI 435.

C. Provide drive sheaves as listed below:
   1. Provide initial fixed pitch drive sheaves based upon estimated design conditions for initial balancing readings.
   2. Provide final fixed pitch drive sheaves for proper RPM determined during balancing process.

END OF SECTION

SECTION 23 73 43

CUSTOM PACKAGED AIR HANDLING UNIT, CLEANROOMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Abbreviations:
   1. AMCA: Air Moving and Conditioning Association.
   2. ADC: Air Diffusion Council.
   3. ASHRAE: American Society of Heating, Refrigeration, Air Conditioning Engineers.
   4. ARI: Air-Conditioning and Refrigeration Institute.

1.2 QUALITY ASSURANCE

A. Standards:
   1. ADC standard 1062R2, Air Diffusing Equipment Test Code.
   2. AMCA Standard 210, Test Code for Air Moving Devices.
   3. ASHRAE Standard 70-72, Method of Testing for Rating the Air Flow Performance of Outlets and Inlets.
   4. NFPA 90A Standard for the Installation of Air Conditioning and Ventilating Systems, 1989 edition.
   5. ARI Standard 410-72, Forced-Circulation Air-Cooling and Air-Heating Coils.
   6. Federal Standard 209D.
   7. ASHRAE Standard 5276, filters, methods of testing for rating performance.
   8. AMCA Bulletin 300.
   9. IEEE Test Procedure 112A.

1.3 SUBMITTALS

A. Shop drawings:
   1. Dimensioned equipment layout.

B. Product data:
   1. Air handling units.
      a. Equipment features and performance data.
      b. Fan curves at operating conditions and at RPM corresponding to scheduled motor HP.
      c. Coil performance data.
      d. Unit sound power levels.
      e. Vibration tests, certified by manufacturer.

C. Contract closeout information:
   1. Maintenance data.
   2. Instruction report.
   3. On-site vibration retest report, certified by manufacturer.
   4. Manufacturer's recommended spare parts list.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures and finish.

1.5 ENVIRONMENTAL REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, all filters are in place, bearings lubricated, and fan has been test run under observation.

1.6 EXTRA STOCK

A. Air filters:
   1. Provide full compliment of scheduled filters for use during construction. Units are not to be operated during the construction phase without these filters in place.
   2. Provide new set of filters, per the equipment schedule, for test and balance and final turn over of systems to BNL.
   3. Provide an additional two spare sets of filters to be turned over to BNL at project substantial completion.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Custom air handling units:
      a. Base:
         1) Huntair
      b. Optional:
         1) Miller-Picking.
         2) Cleanpak.
         3) Racan-Carrier.
   2. Fans: Plug.
      a. Base:
         1) Huntair
      b. Optional:
         1) York Blower.
         2) Twin City Blower.
   3. Air filters:
      a. Base:
         1) Farr.
      b. Optional:
         1) American Air Filter.
         2) Purolator.
   4. Duct sealer:
      a. Base:
         1) Durkee-Atwood.
      b. Optional:
         1) Hardcast.
         2) Childers.

B. Sheet metal:
   1. Galvanized steel: Hot dipped G-90, ASTM-A653, F.S.QQ-I-716.
   2. Black steel: ASTM-A109, F.S.QQ-S-636.
   3. 2S alloy aluminum: ASTM-B209, F.S.QQ-A-561.
   4. 3S alloy aluminum: ASTM-B209, F.S.QQ-A-359.
   5. Stainless steel: ASTM-A167, F.S.QQ-S-766.

C. Insulation:
   1. Shall meet NFPA-90A smoke and flame spread requirements.

D. Duct sealer: NFPA rating of "Non-Combustible"
   1. Flame spread rating: 25 or lower, in dry condition.
   2. Smoke developed rating: 50 or lower, in dry condition.
   3. Resistant to water and water vapors.
   4. Pressure rupture rating: 16 IN WG.

E. Solder: ASTM-B23, grade 50B or F.S.QQ-S-571, Composition Sn50.

F. Duct sealing tape: NFPA rating of "Non-Combustible"
   1. Flame spread rating: 25 or lower, in dry condition.
   2. Smoke developed rating: 50 or lower, in dry condition.
   3. Adhesive: Specifically compounded for maximum adhesion to galvanized and stainless steel.
   4. Tape shall be compatible with cleanroom construction.

G. Electrical work: Starters, wiring and accessories as specified under Electrical Specification Divisions.

2.2 GENERAL

A. Units shall consist of direct driven fan and motor, cooling coil, drain pan, prefilters, internal vibration isolation, sound attenuation, all enclosed in a finished enclosure. Ship units in sections, as required by method of shipment or installation and rigging.

B. See drawing details for exact configuration of unit components and duct connections.

C. Unit fully factory assembled, packaged, prewired, cleanroom quality unit. Field fabrication of units and their components will not be acceptable.

D. Both interior and exterior surfaces and structural assemblies shall be painted with dry powder polyester paint.

2.3 UNIT BASE

A. Constructed on a heavy duty full perimeter steel base supporting major components. The base shall consist of electrically welded structural members. Internal members shall be properly sized to allow rigging and handling and supporting of the unit from the bottom.

B. After construction the base shall have exterior welds ground smooth, cleaned, primed and painted with an epoxy mastic.

C. Construction shall be suitable to withstand rigors of shipping and rigging.

D. Base shall include properly located lifting brackets for rigging, handling and supporting of the unit from the bottom, minimum 4 per section.

2.4 CASING

A. Exterior wall and top panels shall be minimum 16 ga. sheet steel. Panel joints shall have formed channel sections securely attached with bolts to insure rigidity and air-tight sealing.

B. Double wall construction with 16 ga. sheet steel inner wall. Interior surface shall have totally encapsulated, 2-IN 3-pound double density fiberglass panels with aluminized mylar scrim-reinforced jacket.
   1. Powder coated solid metal interior liner throughout, except cooling coil section.
   2. Cooling coil section liner to be 304 stainless steel.
   3. Caulking applied between liner and interior panel seams to completely seal panel.

C. Provide unit with hinged, access doors to allow access to all interior components. Access door shall have a full perimeter automotive type gasket, stainless steel hinges, and a 12-IN square sealed, double thickness, wired glass inspection window. Provide a minimum of two stainless steel or chrome plated wedge type handle latches operable from both sides. Doors to be a minimum of 24-IN wide, 72-IN high unless unit size prohibits. Door construction and thickness same as casing.

D. Provide outside air duct connection between cooling coil and fan as indicated.

E. Finish: Interior and exterior to be dry powder formulated baked on hybrid epoxy/polyester coating, exhibiting 2H, hardness, 199 percent adhesion, 2000 gram scratch resistance, 29/.8 gram abrasion and 30 IN/LB impact resistance. Color to be manufacturer's standard. The powder must be a minimum 3 mils and not over 5 mils thick and then baked in strict accordance with the manufactures guidelines.

2.5 COOLING COIL

A. General:
   1. Coil capacity, size and type as scheduled.
   2. Seal coils to casing to prevent leakage of air around coils.
   3. Water coils shall be proof tested at 300 PSIG and leak tested at 200 PSIG air pressure under water.
   4. Coils shall be circuited for counterflow operation with supply connection at the bottom and water return at the top.
   5. Certified in accordance with ARI 410.
   6. Provide seamless copper, brass, or cast iron supply and return headers with vent and drain connections extending through casing.
   7. Fluid velocity not to exceed 8 feet per second.
   8. All coils shall be fully drainable.

B. Chilled Water Cooling Coils:
   1. Provide 5/8-IN seamless copper tubes, minimum 0.020 IN thickness, expanded into 0.0075-IN minimum thickness aluminum fins.
   2. 16 gauge 304 stainless steel casing with 16 gauge stainless steel frame for bolting to other sections.
   3. Provide intermediate 0.03 IN minimum thickness stainless steel drain pan for each vertical cooling coil section with downspout to main drain pan. Pan shall extend 2 IN upstream and 6 IN downstream from coil face.
   4. 200 PSIG operating pressure.

C. Drain pans:
   1. Provide under cooling coil as required to catch condensate from cool surfaces. Drain Pan shall have a drain connection as indicated, 3/4-IN minimum. Drain pans shall be fabricated of 304 stainless steel.
   2. Cap unused drain connections.

2.6 FAN ASSEMBLY

A. The supply fans shall consist of multiple, direct driven, arrangement 4 plenum fans constructed per AMCA requirements for the duty specified, (Class I, II, or III). All fans shall be selected to deliver the specified airflow quantity at the specified operating Total Static Pressure and specified fan/motor speed with one fan disabled (N+1). The fans shall be selected to operate at a system Total Static Pressure that does not exceed 90% of the specified fan's peak static pressure producing capability at the specified fan/motor speed. Each fan/motor "cube" shall include an 11 gauge, A60 Galvanized steel intake wall, 14 gauge spun steel inlet funnel, and an 11 gauge G90 Galvanized steel motor support plate and structure. The fan intake wall, inlet funnel, and motor support structure shall be powder coated for superior corrosion resistance. All motors shall be standard pedestal mounted type, TEFC, T-frame motors selected at the specified operating voltage, RPM, and efficiency as specified or as scheduled elsewhere. All motors shall include isolated bearings or shaft grounding. Each fan/motor cartridge shall be dynamically balanced to meet AMCA standard 204-96, category BV-5, to meet or exceed Grade 1.0.

B. Fans shall be provided with acoustical silencers that reduce the bare fan discharge sound power levels by a minimum of 15 db re 10^-12 watts throughout the eight octave bands with center frequencies of 125, 250, 500, 1000, 2000, 4000, and 8000 HZ when compared to the same unit without the silencers. The silencers shall not increase the fan total static pressure, nor shall it increase the airway tunnel length of the Air Handling Unit when compared to the same unit without the silencer array. Silencer insulation shall be flexible open cell melamine tested and certified to meet cleanroom environmental standards.

C. The fan array shall consist of multiple fan and motor ”cubes”, spaced in the air way tunnel cross section to provide a uniform air flow and velocity profile across the entire air way tunnel cross section and components contained therein. Each fan cube shall be individually wired to a control panel containing a redundant VFD’s, as specified elsewhere, for the total connected HP for all fan motors contained in the fan array. Wire sizing shall be determined, and installed, in accordance with applicable NEC standards.

D. Each fan/motor assembly shall be removable through a 30” wide, free area, access door located on the discharge side of the fan wall array..

E. Each fan/motor “cube” will be provided with an individual back-draft damper similar to a Ruskin BD6 Heavy Duty 6063T5 extruded aluminum frame, .125” wall thickness. Frame shall have galvanized steel braces on all corners. Blades shall be minimum .070” wall thickness 6063T5 extruded aluminum. Bearings shall be corrosion resistant long life synthetic. Linkage shall be ½” tie bar with stainless steel pivot pins.

F. Provide a complete electrical and control system required to run the fans including all equipment, material, electrical enclosure, electrical components and electrical labor. Electrical designs shall be in accordance with the NEC, UL 508A, and Local Codes.

G. All motors shall be provided with individual Motor Protection for thermal overload protection. All motor circuit protectors shall be located in main enclosure. If required by design, all motor circuit protectors shall be mounted and located in a remote motor circuit protector panel as needed that is separate from the main enclosure. Motor circuit protector enclosure must be located and mounted at a minimal distance from motors in the fan array.

H. Provide one Variable Frequency Drive for normal operation and a second Variable Frequency Drive for Redundant Backup operation. Provide control wiring and control circuitry to transfer from main VFD to Redundant VFD when main drive has faulted. The Variable Frequency Drives shall be sized accordingly to start and hold all motors in the fan array. Provide short circuit protection for each drive through means of using fuses with fuse blocks or circuit breakers.

I. The Variable Frequency Drives shall be mounted in a dedicated enclosure for connection to single point power. Variable Frequency Drive enclosure shall be provided with a main disconnecting means. Provide appropriate cooling of enclosure.

J. Motor circuit protectors shall be used for each motor. Motor circuit protectors shall be housed and mounted in the VFD enclosure as required. Motor circuit protectors may be mounted in a remote enclosure that is separate from VFD enclosure if design requires. Variable frequency drive enclosure and remote Motor circuit protector enclosure must be mounted at a minimal distance from fan array motors and each other.

K. Provide three phase power distribution wiring and control wiring as required. All three phase power components shall have a rating listed for Short Circuit Current Rating. Provide control wiring and components required for complete operation of the fans. System controls, controls components and control wiring shall include but is not limited to Auto mode or manual mode, CFM control mode, or BMS control mode. Controls and control wiring shall include auto start/stop, manual start stop, life safety shutdown, smoke shutdown, system alarms and VFD alarms. All control wiring shall be included in VFD enclosure provided with system.

L. Provide an AEGIS SGR shaft grounding system for each AC motor to prevent electrical damage to motor bearings and to extend motor life by safely channeling harmful shaft currents to ground.

2.7 FILTER SECTION

A. Filters:
   1. Factory built and assembled.
   2. Capacity, and type as scheduled.
   3. Provide where indicated.
   4. In each filterbank, provide the maximum possible face area of filters to fill the physical size of air handling unit even if filter sizes are not listed in filter schedule.
      a. It is desired to use as many 24-IN by 24-IN face dimension filter sections as feasible. Where necessary, a minimum number of 24-IN by 12-IN filter sections may be used.
      b. Where manufacturer's standard design utilizes other sizes, these are acceptable, but manufacturer shall use as few different sizes as possible.
   5. Average filtration efficiency: As scheduled, when tested in accordance with ASHRAE Test Standard 52.1.

B. Filter (F-2).
   1. Pleated media, disposable panel type.
      a. Non-woven, non-fiberglass synthetic media, continuously bonded to a heavy-duty, corrosion-resistant, expanded metal support grid with a 96% open face area.
      b. Heavy duty beverage board frame with high wet strength.
      c. Grid assembly bonded to all interior surfaces of the frame with solvent-free water based glue.
      d. UL rated, Class 2.

C. Filter racks:
   1. For units 60-IN tall or greater, provide front loading filter racks. Filters individually removable from inside air handling unit.
   2. For units less than 60-IN tall, provide side loading filter racks. Filters removable through access door.
   3. Positive sealing filter frames welded together, structural supports welded to frames and mounted in air handler.
   4. Rack shall be thoroughly caulked and sealed to minimize filter bypass.
   5. Internal blank-offs as required to prevent air bypass around the filters.

2.8 ELECTRICAL

A. Electrical components, conduits, and conductors shall be in accordance with Electrical Specification Divisions.

B. Provide one wall bracket vapor proof light fixture with polycarbonate diffuser and one 120 volt, 26 watt compact fluorescent lamp in each section with access door. All lights shall be factory wired to one or as many as required, 1-hour timer type switch mounted externally on the unit wall. Provide a GFI type utility outlet adjacent to the switch.

2.9 AIR PRESSURE GAUGES

A. Flush mounted magnehelic gauges outside of casing to indicate differential pressure across each filter bank, supply fan, and air handling unit discharge pressure.
   1. Accuracy +/- 2 percent of full scale.
   2. Die cast aluminum housing 4 IN diameter, clear plastic face, with metric scale:
      a. Medium and high efficiency filters, scale: 0-2 IN WG.
      b. Supply fans, select scale as required by fan static pressure. Reading; between 25-75 percent of full scale.
      c. Air handling unit discharge pressure, scale: 0-5 IN WG.

2.10 THERMOMETERS

A. Provide at unit discharge to indicate discharge air temperature.

B. Solar powered industrial type.
   1. High impact ABS.
   2. Display 3/8 IN LCD digits with wide ambient temperature range.
   3. Stem assembly: Full conformance with Fed. Spec GG-T-321D.
   4. Sensor: Glass passivated thermistor.
   5. Lux rating: 10 Lux.

C. Thermometer range: 0-100 degF.

2.11 SOUND ATTENUATION

A. The unit construction shall include silencers as specified in paragraph 2.6 “Fan Assembly”.

B. The sound attenuation device shall not include any materials that will shed particles into the airstream. All insulation must be sealed by aluminized mylar covering or spun olefin. Interior partitions or splitters shall be no less than 24 gauge powder coated perforated steel or aluminum sheets.

C. Maximum generated sound pressure levels of recirculating air handlers at all design flow and pressure conditions shall not exceed Noise Criteria (NC)-55 throughout the occupied clean room areas with all units operating and process equipment off.

D. 30 days following contract award, the successful bidder will be required to submit the results of analyses and a proposal showing how the specified levels will be achieved.

PART 3 - EXECUTION

3.1 FACTORY TEST

A. Units shall be completely factory assembled with all components factory installed. Units shall be inspected and factory run tested to insure structural integrity, acceptable leakage rates, and specified fan performance and conformance to sound and vibration requirements. Coils shall be pressure tested prior to shipment. Units shall be inspected while completely assembled with the fans operating.
   1. Fan vibration readings shall be taken in accordance with ANSI S2.19 grade G6.3. Maximum fan vibration, measured on fan bearings, shall not exceed 2 mm per second rms.
   2. Sound test units as specified in accordance with AMCA Standard 300 or similar test procedures. Sound test one unit in each size.

B. Factory pressure test air handling unit housing at 1.5 times supply fan total static pressure under supervision of manufacturer's service agent. Maximum allowable leakage; 1 percent.

C. 7-day advance notice of tests will be given to BNL and Engineer to allow witnessing of tests.

3.2 DELIVERY, STORAGE AND HANDLING

A. Air handling units shall be shipped fully assembled.

B. All units shall be cleaned after final assembly and testing in accordance with these specifications. After the unit is alcohol-cleaned, wrap in a protective double-layer plastic bag and seal all joints so that the unit can be transported, stored and installed without concern for contamination of the cleaned unit.

C. Each cleaned and bagged unit shall then be strapped on top of a full-sized wood base to allow shipment and handling, without damage to the cabinet. Shipping base and pallet frame shall be suitable for fork lift pickup and moving. BNL’s representative will review the method of packaging and shipment prior to the first shipment.

D. Receive, unload, inspect, store, uncrate and install the units at the job site.

E. Any units arriving at the job site that have not been adequately protected will be rejected by BNL's representative and must be returned to the manufacturer for rework or replacement.

F. The outside of the package or crate shall be adequately marked or tagged to indicate its contents by equipment number and weight.

3.3 INSTALLATION

A. Assemble and install air handling units in accordance with manufacturer's installation drawings and instructions, and as specified.

B. Provide travel expenses for manufacturer's service engineer to instruct contractor personnel on proper installation of units.

C. Install components furnished un-mounted.

D. Touch-up abraded or damaged finish.

3.4 STARTUP

A. Prior to start up, replace filters used during construction.

B. After equipment installation is complete, provide factory trained service engineer, directly in employment of the manufacturer, to inspect the installation and supervise the start up and checkout of the equipment.

END OF SECTION

SECTION 23 82 39
HYDRONIC HEATING AND COOLING TERMINAL UNITS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. Cabinet heaters.
   2. Fan coil units.

B. Work installed but not furnished:
   1. Control valves: Furnished under Section 25 50 00.

1.2 QUALITY ASSURANCE

A. Standards:
   1. Methods of Testing for Rating Fan-Coiled Air Conditioners: ASHRAE-79.
   2. Room Fan-Coil Air Conditioners: ARI-440.
   3. Safety Standards for Fan Coil Units and Room Fan Heater Units: ANSI/UL-883.
   4. Testing and Rating Code for Finned Tube Commercial Radiation: IBR-1966.
   5. Advanced Installation Guide for Hydronic Heating Systems: IBR-250, 2nd Edition.

1.3 SUBMITTALS

A. Product data:
   1. Cabinet heaters.
   2. Fan coil units.

B. Contract closeout information:
   1. Operating and maintenance data.
   2. BNL instruction report.

1.4 WARRANTY

A. Provide a one (1) year warranty from date of acceptance by BNL for items furnished that shall cover the following:
   1. Faulty or inadequate product design.
   2. Improper assembly or erection.
   3. Defective workmanship and materials.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Cabinet heaters:
      a. Base:
         1) Trane.
      b. Optional:
         1) Carrier.
         2) York.
   2. Fan coil units:
      a. Base:
         1) Trane.

b. Optional:
   1) Carrier.
   2) Sterling.
   3) McQuay.
   4) Airtherm.
   5) International Environmental.

2.2 CABINET HEATERS

A. Cabinet heaters, vertical: Vertical cabinet units with finned heating coils, motor driven centrifugal fans and 18 GA galvanized steel chassis with flanged edges.
   1. Capacity: As scheduled.
   2. Type: Vertical cabinet.
   3. Fans: Centrifugal type, forward curved, double width, double inlet, selected for quiet operation. Fan housing of formed galvanized steel.
   4. Motor: Direct drive type with internal thermal overload protection. See Section 20 05 00.
   5. Heating coil: Copper tube mechanically bonded to configurated non-ferrous fins with continuous fin collars and sleeved end supports.
      a. Maximum working pressure 300 PSIG.
      b. Capacity certified in accordance with ARI Standard 441-70.
      c. Leak tested to maximum working pressure.
   6. Filters: Permanent, cleanable aluminum mesh.
   7. Provide motor starters.
   8. UL listed.
   9. Controls: Unit mounted fan speed switch.
   10. Unit sound data to be pre-tested and rated in accordance with ARI Standard 443-70.
   11. Exposed panel:
      a. 16 GA front panel and 18 GA other steel panels.
      b. Heavy density thermal and acoustical insulation inside faced on front panel.
      c. Finish: Baked powder finish in manufacturer's standard color as selected by BNL.

2.3 FAN COIL UNITS

A. Fan coil units, horizontal concealed type: Blow thru type, heating and cooling or cooling only, as scheduled, motor driven centrifugal fans, filters and drain pan.
   1. Capacity: As scheduled.
   2. Fans: Double width, double inlet, forward curved, centrifugal type with heavy gauge galvanized steel housing.
   3. Motors: Direct-drive type with internal thermal overload protection. See Section 20 05 00.
   4. Heating and cooling coils: Copper tube mechanically bonded to configurated non-ferrous fins with continuous fin collars and sleeved end supports.
      a. Maximum working pressure 300 PSIG.
      b. Capacity certified in accordance with ARI Standard 441-70.
      c. Leak tested to maximum working pressure.
   5. Filters: Permanent, cleanable aluminum mesh.
   6. Drain pans: Galvanized steel with molded polystyrene foam insulating liner or noncorrosive ABS. Solderless drain connection.
   7. Provide motor starters.
   8. UL listed.
   9. Controls: Three-speed controller with integral "on-off" switch.
   10. Unit sound data to be pre-tested and rated in accordance with ARI Standard 443-70.

B. Piping package:
   1. Provide all units with piping package complete with the following for each coil:
      a. Stop valves.
      b. Balancing valve.
      c. Manual air vent.

d. Electric 24 volt, 2-position, 2-way automatic control valve.

C. Fan coil units, vertical: Top discharge units with finned heating and cooling coils, motor driven centrifugal fans and 18 GA galvanized steel chassis with flanged edges.
1. Capacity: As scheduled.
2. Type: Floor cabinet model.
3. Fans: Centrifugal type, forward curved, double width, double inlet, selected for quiet operation. Fan housing of formed galvanized steel.
4. Motor: Direct drive type with internal thermal overload protection. See Section 20 05 00.
5. Heating and cooling coils: Copper tube mechanically bonded to configurated non-ferrous fins with continuous fin collars and sleeved end supports.
   a. Maximum working pressure 300 PSIG.
   b. Capacity certified in accordance with ARI Standard 441-70.
   c. Leak tested to maximum working pressure.
6. Filters: Permanent, cleanable aluminum mesh.
7. Drain pans: Galvanized steel with solderless drain connections and molded polystyrene foam insulating liner.
   a. Auxiliary drain pan: Located under control valve.
   b. Provide condensate pump to handle condensate from both drain pans where indicated.
8. Provide motor starters.
9. UL listed.
10. Controls: Unit mounted 3-speed switch.
11. Unit sound data to be pre-tested and rated in accordance with ARI Standard 443-70.
12. Cabinet enclosure:
   a. 18 GA steel panels.
   b. Heavy density thermal and acoustical insulation inside faced on front panel.
   c. Hinged access door.
   d. Double deflection discharge grille.
   e. Finish: Factory applied rustproofing and baked enamel in manufacturer's standard color as selected by BNL.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as indicated and in accordance with manufacturer's recommendations and instructions.

END OF SECTION

SECTION 23 82 43
ELECTRIC HEATERS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Product data:
   1. Electric heaters:
      a. Catalog cuts.
      b. Wiring diagrams.
      c. Performance data.

B. Contract closeout information:
   1. Operating and maintenance data.
   2. BNL instruction report.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Electric unit heaters:
      a. Base:
         1) Trane.
      b. Optional:
         1) Modine.
         2) Q-Mark.
         3) Markel.
         4) Reznor.

2.2 ELECTRIC UNIT HEATERS

A. Coils of size, type, and capacity as scheduled.

B. Unit heater shall be draw-thru design to provide uniform temperature across heater element and forced air cooling of motor with ambient air.

C. Heater elements shall be corrosion protected, steel tubular sheath elements with elements brazed to fins for maximum strength and heat transfer. Contactor, where required, shall provide disconnecting line break. Provide automatic reset thermal cutouts to protect from over-temperature.

D. All motors shall have permanently lubricated bearings, built-in thermal protection and shall be enclosed. Separate motor supply circuit shall not be required.

E. All units to have single supply circuit with fuses as required by NEC for element and motor protection.

F. Fans shall be aluminum, directly connected to the fan motor. All units shall have a thermal fan delay switch to prevent blowing of unheated air and to remove residual heat from heater cabinet by recirculating ambient air until temperature drops to 90 degF for maximum energy savings. All metal surfaces of the cabinet shall be phosphetized and protect by an oven baked polyester paint finish.

G. Brackets shall be furnished for wall or ceiling mounting as required by location of heater shown on drawings.

H. Individually adjustable louvers shall be furnished to direct discharge air as desired.

I. Other options provided shall include:
   1. 24V Control (where not standard).
   2. Interlocking, Non-fused Disconnect Switch.
   3. Manual Reset Thermal Cutout (in addition to automatic).
   4. SCR (Solid State Modulating Control).
   5. NEMA-12 Terminal Box Enclosure.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct heaters as indicated and in accordance with manufacturer's recommendations and instructions.

B. Provide wiring diagrams and supervise installation, wiring and control wiring of units.

END OF SECTION

SECTION 23 84 13
HUMIDIFIERS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Product data.

B. Contract closeout information:
   1. Operating and maintenance data.
   2. BNL instruction report.
   3. Manufacturer's approval of all installations.

1.2 WARRANTY

A. Provide a one (1) year warranty from date of acceptance by BNL for items furnished that shall cover the following:
   1. Faulty or inadequate product design.
   2. Improper assembly or erection.
   3. Defective workmanship and materials.

PART 2 - PRODUCTS

2.1 HUMIDIFIERS

A. Acceptable manufacturers:
   1. Steam grid humidifiers:
      a. Base:
         1) Dri-Steem.
      b. Optional:
         1) Pure Steam.
         2) Hygromatik, Spirax Sarco.
         3) Herrmidifier.

B. Humidifiers: Steam grid type used for plant steam:
   1. Control and humidistat as specified in Section 25 50 00.
   2. The stainless steel steam control valve shall be able to control steam flow from maximum to minimum rangeability of 30:1. Provide 2 pneumatic valves.
   3. A steam separating chamber with baffles and mesh packing shall be provided to remove moisture particles larger than 3 microns.
   4. The steam distribution manifold shall be designed for fast absorption. All vapor shall be fully absorbed by the air stream within 1.5 feet of the manifold at the design operating condition of the system based on air temperature, velocity and relative humidity.
   5. Y-strainers and steam traps. Trap manifold grid and steam separator separately when required by design.
   6. Capacity and performance as scheduled.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as indicated and in accordance with manufacturer's recommendations and instructions.

B. Condensate discharge from humidifier is atmospheric. Provide adequate height between condensate discharge and condensate return pumps for proper drainage. Verify installation with humidifier manufacturer.

END OF SECTION

SECTION 23 90 00
MECHANICAL SYSTEMS COMMISSIONING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section includes specification of Division 25 subcontractors' responsibilities in the commissioning process.

B. The systems to be commissioned are listed in Section 01 91 13.

C. Commissioning is a systematic process of ensuring that all building systems perform interactively according to the design intent, basis of design, construction documents, and BNL's system operational needs. The commissioning process coordinates system documentation, equipment startup, control system calibration, testing and balancing, performance testing, and operator training.

D. BNL has retained the services of a commissioning agent that will assist in the startup and documentation of the mechanical and control systems. They shall be referred to as the test engineer for this section of specifications.

E. It is not intended that all trades stand by and be present during check out if their involvement is not required to operate or check out the equipment. The trade responsible for the equipment shall be present to operate their equipment. Problems related to other trades shall be addressed via a commissioning punch list.

1.2 RELATED WORK

A. Related Documents: Refer to the following sections for related work:
   1. Construction Drawings and general provisions of the contract, including general and supplementary conditions, and Division 1 specification sections, apply to this section.
   2. Section 01 91 13 – Building Commissioning.
   3. Section 20 08 00 – Testing and Balancing.
   4. Section 26 80 00 – Electrical Systems Commissioning.

1.3 COMMISSIONING RESPONSIBILITIES

A. General: The commissioning responsibilities applicable to each of the mechanical, controls and TAB subcontractors of Divisions 20 through 25 are as follows. All references apply to commissioned equipment only:
   1. Construction and Acceptance Phases:
      a. Attend a commissioning scoping meeting and other meetings necessary to facilitate the commissioning process, as directed by the Test Engineer.
      b. Assist in the development of startup and prefunctional testing procedures. BNL test engineer will create the actual test procedures and fill out the test forms.
      c. Provide support to the Test Engineer, including drawings and equipment performance documentation, for development of functional performance testing procedures. Review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
      d. During the startup and initial checkout process, execute the mechanical-related portions of the prefunctional checklists for all commissioned equipment.
      e. Perform startup and system operational checkout procedures. Test engineer shall witness and document checkout.

f. Provide skilled technicians to execute starting of equipment and to support the Test Engineer in execution of the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving. Assist the Test Engineer in interpreting the monitoring data, as necessary.
g. Correct deficiencies (differences between specified and observed performance) as identified during testing.
h. Prepare Operation and Maintenance manuals according to the contract documents, including clarifying and updating the original sequences of operation to as-built conditions.
i. Prepare red-line as-built drawings for all drawings and final as-builds for contractor-generated coordination drawings.
j. Provide training of BNL's operating personnel as specified in the contract documents.
k. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

2. Warranty Period:
   a. Execute seasonal or deferred functional performance testing, witnessed by the Test Engineer, according to the specifications.
   b. Correct deficiencies and make necessary adjustments to Operations and Maintenance manuals and as-built drawings for applicable issues identified in any seasonal testing.

B. Mechanical Contractor. The responsibilities of the mechanical subcontractor during construction and acceptance phases in addition to those listed in the article 1.3(A) are:
1. Provide startup for all HVAC equipment, except for the Building Management and Control System (BMCS).
2. Assist and cooperate with the TAB contractor to facilitate testing and balancing.
3. Install a P/T plug at each water sensor which is an input point to the control system.
4. List and clearly identify on the as-built drawings the locations of all air-flow stations.
5. Prepare a preliminary schedule for Divisions 20, 22, and 23 pipe and duct system testing, flushing and cleaning, equipment start-up and TAB start and completion. Update the schedule as appropriate.
6. Notify the Contractor and Test Engineer when pipe and duct system testing, flushing, cleaning, startup of each piece of equipment and TAB will occur. Notify the Contractor and Test Engineer, ahead of time, when commissioning activities not yet performed or not yet scheduled will delay construction.

C. Controls Contractor. The commissioning responsibilities of the controls subcontractor during construction and acceptance phases in addition to those listed in 1.3(A) are:
1. Provide an as-built version of the control drawings and sequences of operation in the final controls Operations and Maintenance manual submittal.
2. Assist and cooperate with the TAB contractor to facilitate testing and balancing.
3. Assist and cooperate with the Test Engineer to execute the functional performance testing of the controls system, mechanical equipment, electrical equipment and trend logs as specified in Section 01 91 13.
4. Prepare a written plan indicating in a step-by-step manner, the procedures that will be followed to test, checkout and adjust the control system prior to functional performance testing, according to the process in Section 01 91 13. At minimum, the plan shall include for each type of equipment controlled by the automatic controls:
   a. System name.
   b. List of devices.
   c. Step-by-step procedures for testing each controller after installation, including:
      1) Process of verifying proper hardware and wiring installation.
      2) Process of downloading programs to local controllers and verifying that they are addressed correctly.
      3) Process of performing operational checks of each controlled component.
      4) Plan and process for calibrating valve and damper actuators and all sensors.

5) A description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.

d. A copy of the log and field checkout sheets that will document the process. This log must include a place for initial and final read values during calibration of each point and clearly indicate when a sensor or controller has "passed" and is operating within the contract parameters.

e. A description of the instrumentation required for testing.

f. Indicate what tests on what systems should be completed prior to TAB using the control system for TAB work. Coordinate with the Test Engineer and TAB contractor for this determination.

5. Provide a signed and dated certification to the Contractor and Test Engineer upon completion of the checkout of each controlled device, equipment and system prior to functional testing for each piece of equipment or system, that all system programming is complete as to all respects of the contract documents, except functional testing requirements.

6. Beyond the control points necessary to execute all documented control sequences, provide monitoring, control and virtual points as specified.

7. List and clearly identify on the as-built duct and piping drawings the locations of all static and differential pressure sensors (air, water and building pressure).

D. TAB Contractor. The duties of the TAB subcontractor, in addition to those listed in 1.3(A) of this section, are specified in Section 20 08 00.

E. See also Section 01 91 13.

1.4 SUBMITTALS

A. Division 20 through 25 subcontractors shall provide submittal documentation relative to commissioning as required in this Section and Section 01 91 13.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Division 23 subcontractors shall provide all test equipment necessary to fulfill the testing requirements of this Division.

B. Refer to the Construction Phase Commissioning Plan and Section 01 91 13 for additional Division 23 requirements.

PART 3 - EXECUTION

3.1 STARTUP

A. The mechanical and controls subcontractors shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in Section 01 91 13. Division 23 subcontractors have start-up responsibility and are required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the contract documents. The commissioning procedures and functional performance testing do not relieve or lessen this responsibility or shift that responsibility partially or in whole to the Test Engineer or BNL.

B. Functional performance testing is intended to begin upon completion of a system. Functional performance testing may proceed prior to the completion of systems or sub-systems at the discretion of the Test Engineer. Beginning system testing before full completion does not relieve the subcontractors or the Contractor from fully completing the system, including all prefunctional checklists as soon as possible.

3.2 TEST AND BALANCE (TAB)

A. Testing and balancing shall be in accordance with the requirements in this section and Section 20 08 00.

3.3 FUNCTIONAL PERFORMANCE TESTS

A. Refer to Section 01 91 13 for a list of systems to be commissioned and a description of the process. The Test Engineer will develop the required Functional Performance Test procedures.

B. Subcontractors shall support the Contractor and Test Engineer in execution of the Functional Performance Test procedures as specified herein.

3.4 TEST DOCUMENTATION, NON-CONFORMANCE, AND APPROVALS

A. Refer to Section 01 91 13 for specific details on non-conformance issues relating to startup checklists and prefunctional tests and issues relating to functional performance tests.

3.5 OPERATION AND MAINTENANCE (O&M) MANUALS

A. The following Operation and Maintenance manual requirements do not replace O&M manual documentation requirements elsewhere in these specifications:
   1. Division 20 through 25 subcontractors shall compile and prepare documentation for all equipment and systems covered in Division 20 through 25 and deliver this documentation to the Contractor for inclusion in the O&M manuals, according to this section and Division 1, prior to the training of BNL personnel.
   2. The Test Engineer shall receive a copy of the O&M manuals for review.

B. Special Control System O&M Manual Requirements. In addition to documentation that may be specified elsewhere, the controls subcontractor shall compile and organize at minimum the following data on the control system in labeled 3-ring binders with indexed tabs:
   1. Three copies of the controls training manuals in a separate manual from the O&M manuals.
   2. Operation and Maintenance Manuals containing:
      a. Specific instructions on how to perform and apply all functions, features, modes, etc. mentioned in the controls training sections of this specification and other features of this system. These instructions shall be step-by-step. Indexes and clear tables of contents shall be included. The detailed technical manual for programming and customizing control loops and algorithms shall be included.
      b. Full as-built sequence of operations for each piece of equipment.
      c. Full points list. In addition to the updated points list required in the original submittals (Part 1 of this section), a listing of all rooms shall be provided with the following information for each room:
         1) Floor.
         2) Room number.
         3) Room name.
         4) Air handler unit ID.
         5) Reference drawing number.
         6) Air terminal unit and air valve tag ID.
         7) Heating and/or cooling valve tag ID.
         8) Minimum cfm.
         9) Maximum cfm.
      d. Marking of all system sensors and thermostats on the as-built floor plan and mechanical drawings with their control system designations.
      e. Maintenance instructions, including sensor calibration requirements and methods by sensor type, etc.
      f. Control equipment component submittals, parts lists, etc.
      g. Warranty requirements.
      h. Copies of all checkout tests and calibrations performed by the Contractor (not commissioning tests).

3. The manual shall be organized and subdivided with permanently labeled tabs for each of the following data in the given order:
    a. Sequences of operation.
    b. Control drawings.
    c. Points lists.
    d. Controller / module data.
    e. Thermostats and timers.
    f. Sensors and DP switches.
    g. Valves and valve actuators.
    h. Dampers and damper actuators.
    i. Program setups (software program printouts).
4. Field checkout sheets and trend logs should be provided to the TE for inclusion in the Commissioning Record Book.

C. Special TAB Documentation Requirements. The TAB subcontractor shall compile and submit the following with other documentation that may be specified elsewhere in these specifications:
1. Final report containing an explanation of the methodology, assumptions, test conditions and the results in a clear format with designations of all uncommon abbreviations and column headings.
2. The TAB subcontractor shall mark on the drawings where all traverse and other critical measurements were taken and cross reference the location in the TAB report.

D. Review and Approvals. Review of the commissioning related sections of the O&M manuals shall be made by BNL and by the Test Engineer.

3.6 TRAINING OF BNL PERSONNEL

A. The Contractor shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed. Refer to Section 01 91 13 for additional details.

B. The Test Engineer shall be responsible for overseeing and approving the content and adequacy of the training of BNL personnel for commissioned equipment. Refer to Section 01 91 13 for additional details.

C. Mechanical Subcontractor. The mechanical subcontractor shall have the following training responsibilities:
1. Provide the Contractor with a training plan at least four weeks before the planned training.
2. Provide designated BNL personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of HVAC equipment including, but not limited to, pumps, boilers, furnaces, chillers, heat rejection equipment, air conditioning units, air handling units, fans, terminal units, cooling towers, heat exchangers, controls and water treatment systems, etc.
3. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing subcontractor or manufacturer’s representative.
4. The controls subcontractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.
5. The training sessions shall follow the outline in the Table of Contents of the Operation and Maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
6. Training shall include:
    a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
    b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.

c. Discussion of relevant health and safety issues and concerns.
d. Discussion of warranties and guarantees.
e. Common troubleshooting problems and solutions.
f. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
g. Discussion of any peculiarities of equipment installation or operation.
h. The format and training agenda in The HVAC Commissioning Process, ASHRAE Guideline 1-1989R, 1996 is recommended.

7. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.
8. The mechanical subcontractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.

D. Controls Subcontractor. The controls subcontractor shall have the following training responsibilities:
1. Provide the Contractor with a training plan at least four weeks before the planned training.
2. The controls subcontractor shall provide designated BNL personnel training on the control system in this facility. The intent is to clearly and completely instruct BNL on all the capabilities of the control system.
3. Control systems training shall include:
a. Specific hardware configuration of installed systems in this building and specific instruction for operating the installed system, including HVAC systems, lighting controls and any interface with security and communication systems.
b. Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing setpoints and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.
c. All trending and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically and printing trends. Trainees will actually set-up trends in the presence of the trainer.
d. Every screen shall be completely discussed, allowing time for questions.
e. Use of keypad or plug-in laptop computer at the zone level.
f. Use of remote access to the system via phone lines or networks.
g. Setting up and changing an air terminal unit controller.

END OF SECTION

DIVISION 25

INTEGRATED AUTOMATION

SECTION 25 22 00
LABORATORY AIR FLOW CONTROL SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. A laboratory airflow control system shall be furnished and installed to control the airflow into and out of laboratory rooms. The exhaust flow rate of a laboratory fume hood shall be controlled precisely to maintain a constant average face velocity into the fume hood at either a standard/in-use or standby level based on an operator's presence in front of the fume hood. The laboratory airflow control system shall be capable of operating as a standalone system or as a system integrated with the Building Management System (BMCS).

1.2 ACCEPTABLE MANUFACTURERS

A. The plans and specifications for the laboratory airflow control system are based on systems and equipment manufactured by Phoenix Controls Corporation.

1.3 PREVENTIVE MAINTENANCE

A. The laboratory airflow control system supplier shall provide at no additional cost to the owner during and after the warranty period five years of required preventive maintenance on all airflow sensors (e.g., pitot tube, flow cross, orifice ring, air bar, hot wire, vortex shedder, side wall sensors, etc.) and flow transducers provided under this section. Airflow sensors shall be removed, inspected, and cleaned annually during the five-year period to prevent inaccuracies due to long-term buildup from corrosion, lab tissues, wet or sticky particles, or other materials that foul the sensor. If impractical to remove the airflow sensors, the laboratory airflow control system supplier shall include in the proposal the cost of supplying and installing duct access doors, one for each sensor. The transducer shall be checked and recalibrated annually to ensure long-term accuracy. Note that auto-zero recalibration of transducers is not acceptable as a substitute for annual recalibration.

1.4 WARRANTY PERIOD

A. Warranty shall commence upon the date of shipment and extend for a period of 36 months, whereupon any defects in materials or laboratory airflow control system performance shall be repaired by the supplier at no cost to the Owner.

PART 2 - SYSTEM COMPONENTS

2.1 AIRFLOW CONTROL DEVICE – GENERAL

A. The airflow control device shall be a venturi valve.

B. The valve assembly manufacturer's Quality Management System shall be registered to ISO 9001:2000.

C. The airflow control device shall be pressure independent over its specified differential static pressure operating range. An integral pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change or quantity of airflow controllers on a manifolded system.

D. The airflow control device shall maintain accuracy within ±5% of signal over an airflow turndown range of no less than 16 to 1.

E. No minimum entrance or exit duct diameters shall be required to ensure accuracy and/or pressure independence.

F. The airflow control device shall be constructed of one of the following three types:
   1. **Class A –** The airflow control device for non-corrosive airstreams, such as supply and general exhaust, shall be constructed of 16-gauge aluminum. The device's shaft and shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting link shall be made of aluminum. The pressure independent springs shall be a spring-grade stainless steel. All shaft bearing surfaces shall be made of a Teflon, polyester or PPS (polyphenylene sulfide) composite. Sound attenuating devices used in conjunction with general exhaust or supply airflow control devices shall be constructed using 24 gauge galvanized steel or other suitable material used in standard duct construction. No sound absorptive materials of any kind shall be used.
   2. **Class B –** The airflow control device for corrosive airstreams, such as fume hoods and biosafety cabinets, shall have a baked-on, corrosion-resistant phenolic coating. The device's shaft shall be made of 316 stainless steel with a Teflon coating. The shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting link shall be made of 316 or 303 stainless steel. The pressure independent springs shall be a spring-grade stainless steel. The internal nuts, bolts and rivets shall be stainless steel. All shaft bearing surfaces shall be made of a Teflon or PPS (polyphenylene sulfide) composite.
   3. **Class C –**The airflow control device for highly corrosive airstreams shall be constructed as defined in Paragraph E.2. In addition, these devices shall have no exposed aluminum or stainless steel components. Shaft support brackets, pivot arm, internal mounting link, and pressure independent springs shall have a baked-on, corrosion-resistant phenolic coating in addition to the materials defined in paragraph E.2. The internal nuts, bolts, and rivets shall be titanium or phenolic coated stainless steel. Only devices clearly defined as “high corrosion resistant” on project drawings will require this construction.

G. Actuation:
   1. For electrically actuated VAV operation, an electronic actuator shall be factory mounted to the valve. Loss of main power shall cause the valve to position itself in an appropriate failsafe state. Options for these failsafe states include: normally open-maximum position, normally closed-minimum position and last position. This position shall be maintained constantly without external influence, regardless of external conditions on the valve (within product specifications).
   2. Constant volume valves do not require actuators.
   3. High Speed Electric Actuators requires a response from Minimum to Maximum of 1 second.

H. Certification:
   1. Each airflow control device shall be factory calibrated to the job specific airflows as detailed on the plans and specifications using NIST traceable air stations and instrumentation having a combined accuracy of no more than ±1% of signal over the entire range of measurement. Electronic airflow control devices shall be further calibrated and their accuracy verified to ±5% of signal at a minimum of 48 different airflows across the full operating range of the device.
   2. Each airflow control devices shall be marked with device-specific factory calibration data. At a minimum, it should include the tag number, serial number, model number, eight-point characterization information (for electronic devices), and quality control inspection numbers. All information shall be stored by the manufacturer for use with as-built documentation.

I. Airflow control devices that are not venturi valves and airflow measuring devices (e.g., pitot tube, flow cross, air bar, orifice ring, vortex shedder, etc.) shall only be acceptable, provided these meet all the performance and construction characteristics as stated throughout this specification and:

1. The airflow control device employs transducers manufactured by Rosemount, Bailey, Bristol, or Foxboro. Accuracy shall be no less than ±0.15% of span (to equal ±5% of signal with a 15 to one turndown) over the appropriate full-scale range, including the combined effects of nonlinearity, hysteresis, repeatability, drift over a one-year period, and temperature effect. 316L stainless steel materials shall be provided for all exhaust applications. The use of 304 stainless steel materials shall be provided for all make-up air applications.
2. Airflow sensors shall be of a multi-point averaging type, 304 stainless steel for all supply and general exhaust applications, 316L stainless steel for all fume hood, canopy, snorkel, and biosafety cabinet applications. Single point sensors are not acceptable.
3. Suppliers of airflow control devices or airflow measuring devices requiring minimum duct diameters shall provide revised duct layouts showing the required straight duct runs upstream and downstream of these devices. Coordination drawings reflecting these changes shall be submitted by the supplier of the laboratory airflow control system. In addition, suppliers shall include static pressure loss calculations as part of their submittals. All costs to modify the ductwork, increase fan sizes and horsepower and all associated electrical changes shall be borne by the laboratory airflow control supplier.

2.2 EXHAUST AND SUPPLY AIRFLOW DEVICE CONTROLLER

A. The airflow control device shall be a microprocessor-based design and shall use closed loop control to linearly regulate airflow based on a digital control signal. The device shall generate a digital feedback signal that represents its airflow.

B. The airflow control device shall store its control algorithms in non-volatile, re-writeable memory. The device shall be able to stand-alone or to be networked with other room-level digital airflow control devices using an industry standard protocol.

C. Room-level control functions shall be embedded in and carried out by the airflow device controller using distributed control architecture. Critical control functions shall be implemented locally; no room-level controller shall be required.

D. The airflow control device shall use industry standard 24 Vac power.

E. The airflow control device shall have provisions to connect a notebook PC commissioning tool and every node on the network shall be accessible from any point in the system.

F. The airflow control device shall have built-in integral input/output connections that address fume hood control, temperature control, humidity control occupancy control, emergency control, and non-network sensors switches and control devices. At a minimum, the airflow controller shall have:
   1. Three universal inputs capable of accepting 0 to 10 Vdc, 4 to 20 mA, 0 to 65 K ohms, or Type 2 or Type 3 10 K ohm @ 25 degree C thermistor temperature sensors.
   2. One digital input capable of accepting a dry contact or logic level signal input.
   3. Two analog outputs capable of developing either a 0 to 10 Vdc or 4 to 20 mA linear control signal.
   4. One Form C (SPDT) relay output capable of driving up to 1 A @ 24 Vac/Vdc.

G. The airflow control device shall meet FCC Part 15 Subpart J Class A and be UL916 listed.

2.3 FUME HOOD CONTROL EQUIPMENT

A. Fume hoods shall be variable air volume (VAV) systems. A sash sensor shall be provided to measure the height of each vertically moving fume hood sash. A sash sensor shall also be provided for horizontal overlapping sashes. Control systems employing sidewall-mounted velocity sensors shall be unacceptable.

B. The laboratory airflow control system shall employ individual average face velocity controllers that directly measure the area of the fume hood sash opening and proportionally control the hood's exhaust airflow to maintain a constant face velocity over a minimum range of 20% to 100% of sash travel. The corresponding minimum hood exhaust flow turndown ratio shall be 5 to 1.

C. The hood exhaust airflow control device shall respond to the fume hood sash opening by achieving 90% of its commanded value within one second of the sash reaching 90% of its final position (with no more than 5% overshoot/undershoot) of required airflow. Rate of sash movement shall be from one to one and one-half feet per second.

D. A presence and motion sensor shall be provided to determine an operator's presence in front of a hood by detecting the presence and/or motion of an operator, and to command the laboratory airflow control system from an in-use operating face velocity (e.g., 100 fpm) to a standby face velocity (e.g., 60 fpm) and vice versa:
   1. The sensor shall define a detection zone that extends approximately 20" (50 cm) from the front of the fume hood. If the sensor does not detect presence and/or motion in its detection zone within five seconds, it shall command the system to the user-adjustable standby face velocity. When the sensor detects the presence and/or motion of an operator within the detection zone, it shall command the system to the in-use face velocity within one second.
   2. The sensor shall have a control circuit that adapts to its specific surroundings and adjusts automatically for inanimate objects placed within its detection zone. It shall map the area into memory and, after a period of five minutes, nullify the image of the inanimate object and return to a standby mode. When operators enter and leave the zone, the unit shall adjust automatically between in-use and standby modes. If the inanimate object is moved or taken out of the zone, the unit shall re-map the area automatically.
   3. Wide area motion detectors (on the hood or room level) shall be unacceptable.

E. The airflow at the fume hood shall vary in a linear manner between two adjustable minimum and maximum flow set points to maintain a constant face velocity throughout this range. A minimum volume flow shall be set to assure flow through the fume hood even with the sash totally closed.

F. A fume hood monitor shall be provided to receive the sash sensor output and presence and/or motion signal. This same monitor shall generate an exhaust airflow control signal for the appropriate airflow control device in order to provide a constant average face velocity. Audible and separate visual alarms shall be provided for both flow alarm and emergency exhaust conditions.

G. The laboratory airflow control system shall use volumetric offset control to maintain room pressurization. The system shall maintain proper room pressurization polarity (negative or positive) regardless of any change in room/system conditions, such as the raising and lowering of any or all fume hood sashes or rapid changes in duct static pressure. Systems using differential pressure measurement or velocity measurement to control room pressurization are unacceptable.

H. Air Flow control valve for Fume hoods shall be of Class B construction. Electric actuator shall be high speed with fail safe state of normally open – maximum position. Makeup Air valves and general exhaust valves associated with the fume hood valve, shall be of Class A construction. Electric actuator shall be high speed with fail safe state of last position.

2.4 TWO-POSITION EXHAUST AIRFLOW CONTROL DEVICE

A. The airflow control device shall maintain a factory calibrated fixed maximum and minimum flow set point based on a switched signal via network or manual. The device shall generate a digital feedback signal that represents its airflow. All two-position devices shall be either networked or hard-wired into the room-level network so as to be considered under pressurization control.

B. Airflow control device that serves Canopy hoods shall be of Class A construction with Fail – safe state of last position

2.5 EXHAUST AND SUPPLY AIRFLOW DEVICE CONTROLLER – TRACKING PAIR

A. One controller shall be supplied for both the supply airflow control device and the corresponding exhaust air control device. The controller shall be a microprocessor-based design and use closed-loop control to linearly regulate airflow based on a digital control signal. The device shall generate a digital feedback signal that represents its airflow.

B. Airflow control devices that serve both supply and exhaust shall be of Class A construction.

C. A low-speed electric actuator shall be used to modulate the airflow over the range of the specific valve size. The maximum time to modulate from minimum to maximum flow shall be less than 90 seconds. A UL or CSA listed electronic actuator shall be factory mounted to the valve. The actuator shall have sufficient torque to modulate the airflow against the maximum duct static pressure (within product specifications). Loss of main power shall cause the valve to maintain its last airflow position. This position shall be maintained until power is restored.

2.6 CONSTANT VOLUME AIRFLOW CONTROL DEVICE

A. The airflow control device shall maintain a constant airflow set point. It shall be factory calibrated and set for the desired airflow. It shall also be capable of field adjustment for future changes in desired airflow.

B. Laboratory airflow control systems suppliers not employing constant volume venturi airflow control valves shall provide pneumatic tubing or electrical wiring as required for their devices.

2.7 CONTROL FUNCTIONS

A. The airflow control devices shall utilize peer-to-peer, distributed control architecture to perform room-level control functions. Master-slave control schemes shall not be acceptable. Control functions shall include, at a minimum, pressurization, temperature, humidity control, as well as respond to occupancy and emergency control commands.

B. Pressurization Control:
   1. The laboratory control system shall control supply and auxiliary exhaust airflow devices in order to maintain a volumetric offset (either positive or negative). Offset shall be maintained regardless of any change in flow or static pressure. This offset shall be field adjustable and represents the volume of air, which will enter (or exit) the room from the corridor or adjacent spaces.
   2. The pressurization control algorithm shall sum the flow values of all supply and exhaust airflow devices and command appropriate controlled devices to new set points to maintain the desired offset. The offset shall be adjustable.
   3. The pressurization control algorithm shall consider both networked devices, as well as:
      a. Up to three non-networked devices providing a linear analog flow signal.
      b. Any number of constant volume devices where the total of supply devices and the total of exhaust devices may be factored into the pressurization control algorithm.
   4. Volumetricumetric offset shall be the only acceptable means of controlling room pressurization. Systems that rely on differential pressure as a means of control shall provide documentation to demonstrate that space pressurization can be maintained if fume hood sashes are changed at the same time a door to the space is opened.
   5. The pressurization control algorithm shall support the ability to regulate the distribution of total supply flow across multiple supply airflow control devices in order to optimize air distribution in the space.

C. Temperature Control:
   1. The laboratory control system shall regulate the space temperature through a combination of volumetric thermal override and control of reheat coils and/or auxiliary temperature control devices. The laboratory control system shall support up to four separate temperature zones for each pressurization zone. Each zone shall have provisions for monitoring up to five temperature inputs and calculating a straight-line average to be used for control purposes.

Separate cooling and heating set points shall be writeable from the BMCS, with the option of a local offset adjustment.

2. Temperature control shall be implemented through the use of independent primary cooling and heating control functions, as well as an auxiliary temperature control function, which may be used for either supplemental cooling or heating. Cooling shall be provided as a function of thermal override of conditioned air with both supply and exhaust airflow devices responding simultaneously so as to maintain the desired offset. Heating shall be provided through modulating control of a properly sized reheat coil.
3. The laboratory control system shall also provide the built-in capability for being configured for hot deck/cold deck temperature control.
4. The auxiliary temperature control function shall offer the option of either heating or cooling mode and to operate as either a standalone temperature control loop, or staged to supplement the corresponding primary temperature control loop.

D. Occupancy Control:
1. The laboratory control system shall have the ability to change the minimum ventilation and/or temperature control set points, based on the occupied state, in order to reduce energy consumption when the space is not occupied. The occupancy state may be set by either the BMCS as a scheduled event or through the use of a local occupancy sensor or switch. The laboratory control system shall support a local occupancy override button that allows a user to override the occupancy mode and set the space to be occupied for a predetermined interval. The override interval shall be configurable from one to 1440 minutes. The local occupancy sensor/switch or bypass button shall be given priority over a BMCS command.

E. Fume Hood Control:
1. Airflow devices intended to control the face velocity of a fume hood shall have the ability to interface directly with the fume hood monitoring device. The airflow control device shall:
   a. Accept command inputs to regulate the flow accordingly and make this command value available to the BMCS.
   b. Accept a sash position signal and make this value available to the BMCS.
   c. Accept a Usage Based Control signal to indicate user presence and make this signal available to the BMCS.
   d. Provide a flow feedback signal to the fume hood monitor, which may be used for calculating face velocity or to confirm the airflow device has achieved the proper flow rate and make this value available to the BMCS.
   e. Provide alarm signals to the fume hood monitor in the event the airflow device is unable to achieve the proper flow rate, there is a loss of static pressure indicating improper fan operation, or there is a loss of power to the airflow control device, in order to provide a local alarm indication.
   f. The fume hood airflow control device shall respond to changes in sash position and user presence within one second, in order to provide a constant 80-feet-per-minute face velocity when the fume hood is in use.

F. The laboratory control system shall be segregated into subnets to isolate network communications to ensure room-level control functions and BMCS communications are carried out reliably. Each laboratory space or pressurization zone shall be its own subnet. Commercially available routers shall be used to provide this isolation.

G. The laboratory airflow control system shall support at least 20 networked devices in each pressurized zone.

H. All points shall be available through the interface to the BMCS for trending, archiving, graphics, alarm notification and status reports. Laboratory airflow control system performance (speed, stability and accuracy) shall be unaffected by the quantity of points being monitored, processed or controlled.

I. Refer to the BMCS specification for the required input/output summary for the necessary points to be monitored and/or controlled. All points shall be available to be mapped into the BMCS system.

J. There shall be no reliance on external or building-level control devices to perform room-level control functions. Each laboratory control system shall have the capability of performing fume hood control, pressurization control, temperature control, humidity control, and implement occupancy and emergency mode control schemes.

2.8 INTERFACE TO BUILDING MANAGEMENT SYSTEMS

A. The laboratory airflow control system network shall have the capability of digitally interfacing with the BMCS. The required software interface drivers shall be developed and housed in a dedicated interface device furnished by the laboratory airflow control system supplier.

B. All room-level points shall be available to the BMCS for monitoring or trending. The gateway shall maintain a cache of all points to be read and monitored by the BMCS. The room-level airflow control devices shall update this cache continually.

C. The building-level network shall be a high-speed LonTalk (1.25 Mbps) communications protocol. The building-level network shall support up to 100 subnets or pressurization zones, or 6000 data points.

D. A commercially available interface card shall be provided with the Accel-Way™ gateway in order to connect to the building-level network.

E. A commercially available network interface card shall be provided with the gateway to interface with the BMCS. System shall interface using BACNET over IP protocol.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The automatic temperature controls (ATC) contractor shall install the sash sensors, interface boxes, presence and motion sensor, and fume hood monitor on the fume hood under initial supervision of the laboratory airflow control system supplier. Reel-type sash sensors and their stainless steel cables shall be hidden from view. Bar-type sash sensors shall be affixed to the individual sash panels. Sash interface boxes with interface cards shall be mounted in an accessible location.

B. The ATC contractor shall install all routers and repeaters in an accessible location in or around the designated laboratory room.

C. The ATC shall install an appropriately sized and fused 24 Vac transformer suitable for NEC Class II wiring.

D. All cable shall be furnished and installed by the ATC contractor. The ATC contractor shall terminate and connect all cables as required. The ATC shall utilize cables specifically recommended by the laboratory airflow controls supplier.

E. The mechanical contractor shall install all airflow control devices in the ductwork and shall connect all airflow control valve linkages.

F. The mechanical contractor shall provide and install all reheat coils and transitions.

G. The mechanical contractor shall provide and install insulation as required.

H. Each pressurization zone shall have either a dedicated, single-phase primary circuit or a secondary circuit disconnect.

3.2 SYSTEM START-UP AND TRAINING

A. System start-up shall be provided by a factory-authorized representative of the laboratory airflow control system manufacturer. Start-up shall include calibrating the fume hood monitor and any combination sash sensing equipment, as required. Start-up shall also provide electronic verification of airflow (fume hood exhaust, supply, make-up, general exhaust or return), system programming and integration to BMCS (when applicable).

B. The balancing contractor shall be responsible for final verification and reporting of all airflows.

C. The laboratory airflow control system supplier shall furnish a minimum of eight hours of owner training by factory trained and certified personnel. The training will provide an overview of the job specific airflow control components, verification of initial fume hood monitor calibration, general procedures for verifying airflows of air valves and general troubleshooting procedures.

D. Operation and maintenance manuals, including as-built wiring diagrams and component lists, shall be provided for each training attendee.

END OF SECTION

SECTION 25 23 00
ADJUSTABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of systems:
   1. Adjustable frequency drives, PWM.
   2. Input fused padlockable manual disconnect.
   3. Two (2) contactor manual bypass.
   4. Minimum three (3) percent AC line or DC link reactor.
   5. Adjustable frequency drives are to be furnished under this section. They are to be mounted and wired under Division 26, Electrical.

1.2 QUALITY ASSURANCE

A. Manufacturer shall have a minimum of 7 years in manufacture and operation of PWM drives in size(s) indicated.

B. UL-508C, Standard for Power Conversion Equipment.

C. IEEE Standard 519, latest edition, "Guide for Harmonic Control and Reactive Compensation of Static Power Converters".

D. European Union Electromagnetic Compatibility Directive 89/336/EEC, EN 61800-3 Adjustable Speed Electrical Power Drive Systems, Part 3.

E. Local service representative's qualifications:
   1. Provide and maintain field service personnel authorized by Manufacturer to perform service both in and out of warranty.
   2. Maintain full stock of service parts for all units furnished.
   3. Provide in-depth training in operation of all units.

1.3 SUBMITTALS

A. Shop drawings:
   1. Dimensional drawings.
   2. Power circuit drawings.
   3. Control connection drawings.

B. Product data:
   1. AFD's maximum rated output amps.
   2. AC link and/or DC link reactor data.
   3. CE mark indicating compliance with European Union EMC Directive 89/336/EEC.

C. Contract closeout information:
   1. Operating and maintenance data.
   2. BNL instruction report.
   3. Factory start-up and field test reports.
   4. Warranty.

1.4 WARRANTY

A. Warranty:
   1. 12 months from date of start up, not to exceed 18 months from date of shipment:
      a. Include all parts, labor, travel time and expenses.

PART 2 - PRODUCTS

2.1 ADJUSTABLE FREQUENCY DRIVES - GENERAL

A. Acceptable manufacturers:
   1. Adjustable frequency drives, pulse width modulated:
      a. Base:
         1) Allen Bradley.
      b. Optional:
         1) Asea Brown Boveri (ABB).
      c. No other manufacturers will be accepted.
   2. Fuses:
      a. Base:
         1) Bussmann.
         2) Shawmut.
         3) Reliance Electric.

B. General requirement for adjustable frequency drives:
   1. Adjustable frequency in proportion to output speed.
   2. Adjustable output voltage with constant volts/Hz over a variable torque output range.
   3. Supply full rated current at frequency within a variable torque output range.
   4. Develop full shaft power needed.

C. Adjustable frequency drives shall be checked against each motor's total amperage, and current limiting overload control shall be properly set.

D. Adjustable frequency drives and associated motors shall be compatible without motor deration.

E. Motor noise as a result of AFD: Limited to three dB over across the line operation, measured at three feet from motor's center line.

2.2 ADJUSTABLE FREQUENCY DRIVES (AFD'S)

A. Adjustable frequency drives (AFD): Provide rectifiers to convert three-phase, 60 Hz AC power to DC power and inverters to “invert” DC power back to a variable voltage and variable frequency, three-phase AC power:
   1. Provide input fused disconnect switch or combination circuit breaker and fuse to disconnect drive, bypass and all accessories:
      a. Fuses to be provided by AFD manufacturer.
      b. Provisions for padlock in off position.
   2. AFD shall be rated for 100,000 Amp interrupting capacity (AIC).
   3. Enclosed in NEMA 1 enclosure including accessories, completely assembled and tested; or all components provided in a single factory supplied racking system with components and accessories assembled, wired and factory tested.
   4. In applications where drives are to be mounted out-of-doors, all components shall be mounted within a NEMA 4 enclosure.
   5. Enclosure shall be of such design to assure adequate cooling at full load under ambient conditions to 104 ºF. Provide fan cooling if necessary.
   6. Harmonic mitigation: Minimum 3 percent AC line or DC link reactor mounted within the AFD enclosure.
   7. Drive efficiency: 97 percent of greater at full speed and full load.
   8. Displacement power factor: 0.95 at all speeds and loads.
   9. Switching frequency adjustable over minimum range of 2.0 to 12.0 kHz.

B. Rectifier section: Full wave diode bridge rectifier. Phase controlled rectifiers are unacceptable.

C. DC bus linking rectifier and inverter.

D. Inverter section: Pulse width modulated voltage source inverter (PWM):
   1. Output voltage shall very with frequency using insulated gate bipolar transistors (IGBT). VVI, six-step, current source, SCR, GTO, and bipolar junction transistor (BJT or Darlington pair transistors) drives are not acceptable.

E. Printed circuit boards: Completely tested before being assembled into completed adjustable frequency drive:
   1. Subject adjustable frequency drive to a preliminary functional test, and computerized final test.
   2. Drive input power: Continuously cycled for maximum stress and thermal variation.

F. Environmental operating conditions:
   1. 32 to 104 degF at 4 kHz switching frequency.
   2. 0 to 3300 feet above sea level, less than 95 percent humidity, non-condensing.
   3. Atmosphere: Standard equipment room environment.

G. Additional requirements:
   1. Provide same control interface and connections regardless of horsepower rating.
   2. On loss of input signal:
      a. Display a fault condition.
      b. Maintain last output speed prior to loss of signal.
   3. Utilize digital display (LCD or LED).
   4. Automatically restart after an overcurrent, overvoltage, under-voltage, loss of input signal protective trip or any other fault:
      a. Number of restart attempts and trial time to be programmable.
   5. Capable of starting into a rotating load (forward or reverse) and accelerate or decelerate to setpoint without safety tripping or component damage.
   6. Provide an automatic extended power loss ride-through circuit which will utilize inertia of load to keep drive powered:
      a. Minimum power loss ride-through: One-cycle or extended time.
   7. Control terminal strip: Isolated from line and ground.
   8. Provide prewired 3-position Hand-Off-Auto switch, manual speed adjustment (keypad or potentiometer) and local-remote switch to control AFD:
      a. When in "Hand" position, AFD will be started at the drive location.
      b. When in "Off" position, AFD will be stopped.
      c. When in "Auto" position, AFD will start via an external contact closure.
      d. When local-remote switch is in "Local" position, speed will be controlled by manual speed adjustment.
      e. When local-remote switch is in "Remote" position, speed will be controlled by external speed reference.
      f. Operate local-remote switch independently of HOA switch for maximum flexibility:
         1) Control speed by manual speed adjustment or external speed reference by selecting "Local" or "Remote" regardless of whether HOA is in "Hand" or "Auto" position.

H. Provide following adjustments:
   1. A minimum of 3 critical frequency lockout ranges to prevent adjustable frequency drive from continuously operating at an unstable speed:
      a. Width of each frequency range: Field adjustable.
   2. Two programmable analog inputs: Accept a current or voltage signal for speed reference, or for reference and actual signals for PI controller:
      a. Provide a filter programmable from 0.01 to 10 seconds to remove any oscillation in input signal.
      b. Minimum and maximum values (gain and offset): Adjustable within range of 0-20 mA and 0-10 Volts.
   3. Two programmable analog outputs: Proportional to frequency, motor speed, output voltage, output current, motor torque, motor power, or DC bus voltage.

4. Relay outputs:
    a. Rated for maximum switching current 8 amps at 24 VDC and 0.4 amps at 250 VAC; Maximum voltage 300 VDC and 250 VAC; Continuous current rating 2 amps RMS.
5. Independently adjustable acceleration and deceleration rates (1-600 seconds).
6. Ramp or coast to a stop, as selected by user.
7. Provide DC hold and dynamic braking.

I. Operational information displays:
1. Output Frequency.
2. Motor current.
3. Output voltage.

J. Protection circuits: In case of a protective trip, stop drive and display fault condition. Detect fault on any one or more phases:
1. Overcurrent trip: 200 percent of AFD's variable torque current rating.
2. Overvoltage trip: 130 percent of AFD's rated voltage.
3. Undervoltage trip: 60 percent of AFD's rated voltage.
4. Overtemperature: Plus 158 degF.
5. Ground Fault.
6. Adaptable electronic motor overload protection:
    a. Protect motor based on speed, load curve, and external fan parameter.
    b. Circuits which are not speed dependent are unacceptable.

K. Speed command input:
1. Keypad or manual speed potentiometer.
2. Analog inputs: Each capable of accepting a 0-20 mA 4-20 mA, 0-10 V, 2-10 V signal:
    a. Input: Isolated from ground, and programmable via keypad for different uses.
    b. Provide programmable filter to remove any oscillation of the reference signal.
    c. Filter: Adjustable from 0.01 to 10 seconds.
    d. Able to be inverted, so that minimum reference corresponds to maximum speed, and maximum reference corresponds to minimum speed.
    e. Minimum and maximum values (gain and offset): Adjustable within range of 0-20 mA and 0-10 Volts.

L. Accessories:
1. Interlock terminal strip:
    a. Provide separate terminal strip for connection of freeze, fire, smoke contacts, and external start command.
    b. External interlocks: Remain fully functional whether drive is in Hand, Auto or Bypass.
    c. Interlocks shall be 30 volt maximum. Provide pilot relays where required.
2. All wires to be individually numbered at both ends for ease of troubleshooting.
3. Door interlocked disconnect switch: Padlockable in "Off" position.
4. Door interlocked magnetic circuit breaker: Disconnect all input power from drive and all internally mounted options:
    a. Disconnect handle: Thru-the-door type, padlockable in "Off" position.
5. Bypass manual transfer to line power via three (3) contactors:
    a. Include motor thermal overload and fuse or circuit breaker protection while in bypass operation.
    b. Provide a three position drive/off/bypass selector switch to control bypass drive input and output contactors:
        1) Mechanically and electrically interlock bypass and drive output contactors.
        2) In "Normal" mode, bypass contactor is open while drive input and output contactors are closed.
        3) In "Off" position, all contactors are open.
        4) In "Bypass" position, drive input and output contactors are open, and bypass contactor is closed.

6. Drive output contactor: Open when drive is stopped, isolating motor from drive:
    a. Start/stop signals and safety interlocks: Work in drive and bypass modes.
7. Time delay relay: 0-120 seconds field adjustable.
8. Where AFD is indicated to serve two motors not intended to run simultaneously, provide the following:
    a. Provide one set of motor overloads in the bypass and one set of interlocked contacts in each motor circuit.
    b. Provide a three position A/B/remote selector switch.
    c. In "A" or "B", motor A or motor B will be active. In "Remote", a remote contact closure signal from the Control and Instrumentation System will select the active motor.
    d. Mechanically and electrically interlock contactors to prevent both motors being activated simultaneously.
9. Where AFD is indicated to serve two or more motors intended to run simultaneously, provide the following:
    a. Include fusing and thermal overload protection for each motor circuit.

M. Factory startup test:
1. Provide a certified factory start-up for each drive by factory authorized service center:
    a. Certified start-up form: Filled out for each drive with a copy provided to BNL, and a copy kept on file at Manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Turn AFD's over to Div. 16 contractor for mounting and wiring. Section 25 23 00 contractor shall be responsible for testing, startup, BNL instruction, and performance verification.

B. Install in accordance with manufacturer's installation instructions and as specified.

C. Where AFD's are mounted on air handling unit casing(s), provide bracing and coordinate with air handling unit manufacturer.

D. Cover and protect units from installation dust and contamination until environment is cleaned and ready for operation.

E. Field wiring and interlocks:
1. Output disconnects:
    a. Provide field wiring between AFD and contacts at output motor disconnect switches to shutdown AFD prior to disconnecting motor from drive.
    b. Contacts open prior to interruption of motor circuit.
    c. When there are multiple motors driven by one AFD, contacts must be interlocked in series so that if any motor is disconnected, AFD will be switched off.

3.2 TESTING AND START UP

A. Factory testing:
1. Provide test results to confirm that adjustable frequency drive has been tested to substantiate designs according to applicable ANSI and NEMA Standards.
2. Tests shall verify not only performance of unit and integrated assembly, but also suitability of enclosure venting and rigidity.
3. In addition, unit shall be factory tested in accordance with ANSI Standards.
4. Submit factory test reports.

B. Field start up and testing:
1. Provide services of a factory trained representative at site to supervise installation and startup.

2. Test machines under operation through full speed range and record data at full load, 75 percent load, 50 percent load and 25 percent load, for a minimum of 1 hour at each load.
3. Field test according to ANSI Standards.

C. Set field adjustable time delay relays. Verify delay with Division 26.

D. Drive shall be adjusted to prevent operation of motor and load at a speed less than two times the natural frequency of the vibration isolation system:

Isolator Deflection (inches)	Minimum Speed Driven Load (RPM)
1/2 IN	600
3/4 IN	430
1 1/2 IN	300
2 1/2 IN	240
3 1/2 IN	200

3.3 BNL INSTRUCTIONS

A. Provide services of manufacturer's representative for 8 hours to instruct BNL's operating personnel:
   1. Instruction hours shall be in addition to testing and startup hours.

B. Schedule this period when equipment is completely installed and tested and can be operated under normal load.

C. Provide instruction on each system type.

END OF SECTION

SECTION 25 50 00
BUILDING MANAGEMENT AND CONTROL SYSTEM

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

A. This Building Management and Control System (BMCS) shall be an extension of the existing Automated Logic Web Control campus control system. All controls and components shall be 100% compatible with the existing system and all points shall be accessible through all existing operator's terminals.

B. The control system shall consist of a high-speed, peer-to-peer network of DDC controllers and a web-based operator interface. Depict each mechanical system and building floor plan by a point-and-click graphic. A web server with a network interface card shall gather data from this system and generate web pages accessible through a conventional web browser on each PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface.

C. The system shall directly control HVAC equipment as specified. Each zone controller shall provide occupied and unoccupied modes of operation by individual zone. Furnish energy conservation features such as optimal start and stop, night setback, request-based logic, and demand level adjustment of setpoints as specified.

D. Provide for future system expansion to include monitoring of occupant card access, fire alarm, and lighting control systems.

E. System shall use the BACnet protocol for communication to the operator workstation or web server and for communication between control modules. Schedules, setpoints, trends, and alarms specified in paragraph Sequence of Operation and Input/Output Survey.

F. Contractor's Responsibility: The Contractor shall furnish and install a complete direct digital control (DDC) system as hereinafter specified:
   1. The control system shall include all direct digital control modules, all sensors, transmitters, automatic valves, automatic dampers, actuators, relays, switches, wire, tubing, thermometers, gauges, and conduit external to the DDC panels and all other necessary equipment and control devices required to maintain the conditions as described and detailed in Plans and Specifications.
   2. All supply power transformers for the panel and the panel enclosures shall be provided as specified or required for the specific equipment being furnished.
   3. The Contractor shall mount the DDC panels and run the input/output wiring to the panels and the communication wiring between the panels. The Contractor shall be responsible for the coordination of his work with other Contractors for the complete installation as described in these Specifications.

G. Electrical Power: Electrical Contractor shall provide power to certain locations as indicated on the Electrical Drawings. Power shall be provided by a separately fused dedicated circuit and with an insulated ground wire from the power panel ground. All electrical power wiring shall be in conduit as described in the Electrical Section of these Specifications. Temperature control panels shall have no exposed electrical connections above 30 volts. Provide shield or other personal protection barriers. Provide wiring diagram in each panel.

H. Information on Drawings: See the Drawing set for flow diagrams, sensor locations, and temperature control diagrams.

I. Provide Building Management and Control System incorporating Direct Digital Control (DDC), energy management and equipment monitoring consisting of the following elements:

1. Microprocessor based remote control panels interfacing directly with sensors, actuators, and environmental delivery systems to provide complete standalone DDC/EMS functionality. (i.e., HVAC equipment, etc.).
2. Communication network to allow data exchange between remote panels and central building management computer.
3. Personal computer (PC) based central and associated operator station(s), and software functioning as the primary operator interface for BMCS. System shall utilize a graphics front end.
4. Pneumatic, electric and electronic control for all items indicated including dampers, valves, panels and pneumatic and electrical installation.
5. Interface with campus control system via site Ethernet.

J. Air terminal unit damper operators and controls: DDC controllers, actuators, transformers, and disconnects shall be furnished under this section. They shall be factory installed and wired by the air terminal unit manufacturer. Provide 120V/24V transformer and power disconnect for each air terminal unit to be factory installed and wired to power all control devices in the unit. Air terminal units are to have a single 120V power connection.

K. Smoke and fire/smoke dampers and operators are furnished and installed under Specification Section 23 31 13. This Contractor shall coordinate type of operators required with that section of the specifications. Control connection and damper operation as described in the sequence of operation to be provided under this section of the specifications.

L. Control dampers: Duct mounted automatic control dampers are furnished under this section but are installed under Section 23 31 13. Actuators for all control dampers are furnished and installed by controls contractor under this section. Contractor shall coordinate exact size of damper with contractor performing work under Section 23 31 13 and shall submit all sizes for approval.

M. Duct mounted smoke detectors are furnished under Division 26. They shall be mounted under this section. Power and alarm wiring shall be furnished and installed under Division 26. All control wiring required to accomplish sequence of operation herein specified shall be furnished and installed under this section.

N. Provide submittals, installation, data entry, programming, startup, test and validation of BMCS, instruction of BNL's representative on maintenance and operation of BMCS, as-built documentation, and system warranty.

1.2 SYSTEM PERFORMANCE

A. Performance Standards: System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems):
1. Graphic Display: A graphic with 20 dynamic points shall display with current data within 5 seconds.
2. Graphic Refresh: A graphic with 20 dynamic points shall update with current data within 8 seconds and shall automatically refresh every 8 seconds.
3. Configuration and Tuning Screens: Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 seconds.
4. Object Command: Devices shall react to command of a binary object within 2 seconds. Devices shall begin reacting to command of an analog object within 2 seconds.
5. Alarm Response Time: An object that goes into alarm shall be annunciated at the workstation within 15 seconds.
6. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every 5 seconds. Select execution times consistent with the mechanical process under control.
7. Performance: Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per second. Select execution times consistent with the mechanical process under control.

8. Multiple Alarm Annunciation: Each workstation on the network shall receive alarms within 5 seconds of other workstations.

1.3 OWNERSHIP OF PROPRIETARY MATERIAL

A. Project-specific software and documentation shall become BNL's property. This includes, but is not limited to:
   1. Graphics.
   2. Record drawings.
   3. Database.
   4. Application programming code.
   5. Documentation.

1.4 WORK BY OTHERS

A. Setting in place of valves, flow meters, water pressure and differential taps, flow switches, thermal wells, dampers, airflow stations, and current transformers.

B. This Contractor shall coordinate with other contractors as necessary to assure all pipe, duct, and wall mounted devices are properly located and installed.

C. Certain process equipment will be furnished under these specifications or by BNL, as indicated on the Drawings, with control and monitoring systems included as part of the equipment. The contractor shall coordinate central control and/or monitoring functions for this equipment as specified in this Section with the equipment vendors.

1.5 QUALITY ASSURANCE

A. System to be installed by competent mechanics, with full responsibility for proper operation of BMCS, including debugging and proper calibration of each component in entire system.

B. Codes and approvals:
   1. Complete BMCS installation to be in strict accordance with national and local electrical codes, and Division 26 of these specifications. All devices designed for or used in line voltage applications to be UL listed.
   2. All microprocessor based remote devices: UL916 and UL864 listed.
   3. All BMCS central equipment: UL916 listed.
   4. All electrical environmental control and monitoring devices: UL429 and/or UL873 listed.
   5. Following current UL standards are applicable: UL429 Electrically Operated Valves, UL555 Fire Dampers, UL873 Temperature Indicating and Regulating Equipment, UL916 Energy Management Equipment.
   6. Following current NFPA Standards and Guides are applicable: NFPA-70 National Electric Code, NFPA-90A Air Conditioning Systems, NFPA-90B Warm Air Heating, Air Conditioning.
   7. All electronic equipment shall conform to the requirements of FCC regulation Part 15, Section 15 governing radio frequency electromagnetic interference for Class A computing devices and shall be so labeled.

C. All system components shall be fault tolerant:
   1. Provide satisfactory operation without damage at 110 percent and 85 percent of rated voltage, and at ± 3-hertz variation in line frequency.
   2. Provide static, transient, short circuit, and surge protection on all inputs and outputs. Communication lines to be protected against incorrect wiring, static transients, and induced magnetic interference. Bus connected devices to be a.c. coupled, or equivalent so that any single device failure will not disrupt or halt bus communication.
   3. All real time clocks and data file RAM to be battery or capacitor backed with sufficient capacity to provide 24-hour backup.

D. System overall reliability requirement: The system, including all components and appurtenances, shall be configured and installed to yield a Mean Time Between Failure (MTBF) at least 1000 hours.

E. System Accuracy - Provide a DDC system, which shall display and control each system variable to the level of accuracy specified below. System shall maintain this level of accuracy for one year from date of Acceptance:
   1. Space temperature control accurate to ±0.1 °F where high accuracy control is indicated.
   2. Space temperature control accurate to ±1.0 ºF elsewhere.
   3. Duct temperature control accurate to ±0.1 °F where indicated.
   4. Duct temperature control accurate to ±0.5 °F.
   5. Water temperature control accurate to ±0.5 ºF.
   6. Relative humidity control accurate to ±5.0 percent RH.
   7. Water differential pressure control accurate to ±5.0 percent of setpoint.
   8. Air static pressure control accurate to ±5.0 percent of setpoint.
   9. Water flow control accurate to ±5.0 percent of setpoint.
   10. Air flow control accurate to ±5.0 percent of setpoint.

F. All field equipment shall be rated for continuous operation under ambient environmental conditions of 35 to 120 °F dry bulb and 10 to 95 percent relative humidity, non-condensing. Instrumentation and control elements shall be rated for continuous operation under the ambient environmental temperature, pressure, humidity and vibration conditions specified or normally encountered for the installed location.

1.6 SUBMITTALS

A. Shop drawings:
   1. Data sheets of all products.
   2. Valve, damper, and well and tap schedules showing size, configuration, capacity, and location of all equipment.
   3. Data entry forms for initial parameters. All text and graphics to be approved prior to data entry.
   4. Wiring and piping interconnection diagrams, including panel and device power and sources.
   5. Equipment lists of all proposed devices and equipment.
   6. Software design data including:
      a. Flow chart of each DDC program showing interrelationship between inputs, PID functions, all other functions, outputs, etc.
      b. Sequence of operation relating to all flow chart functions.
   7. Control sequence.
   8. DDC installation, block diagrams, and wiring diagrams for each piece of equipment.
   9. DDC panel physical layout and schematics.
   10. Building level overview of control system architecture.
   11. Data entry forms for initial parameters. All graphics to be approved prior to data entry.
   12. Sketches of all graphics.
   13. Graphic penetration tree showing all graphics and all points.
   14. Detailed color conventions proposed for all graphics and graphic elements and states.
   15. Data on any proprietary protocols to allow user to write a custom driver/interface.

B. Project information:
   1. Certification of installer qualifications.

C. Contract closeout information:
   1. Operating and maintenance manuals.
   2. BNL instruction report.
   3. Training provided by BMCS contractor.
   4. Provide digital copies of submittal items 1 through 10.

PART 2 - PRODUCTS

2.1 CONTROL SYSTEM

A. Acceptable manufacturer:
   1. Temperature Control System:
      a. Base:
         1) Automated Logic Corporation- no substitutions permitted:
            a) ME or MEX Series controllers for AHU's and equipment.
            b) LGR for routers
            c) ZN141V+ controllers for air terminal units.
            d) Z551 for fan coils
            e) RSpro for room temperature sensors unless otherwise indicated.
            f) See architecture drawing for specific controllers
            g) No substitutions permitted.
   2. Air flow monitoring stations:
      a. Base:
         1) Ebtron.
   3. Site Chilled water ultrasonic flow meter:
      a. Base:
         1) Siemens Sitrans.
      b. Alternate:
         1) Flexim
   4. Process chilled water and hot water ultrasonic flow meter:
      a. Base:
         1) Siemens Sitrans.
      b. Alternate:
         1) Flexim.
         2) Dynasonics .
   5. Dampers and pneumatic damper actuators:
      a. Base:
         1) 1. Ruskin.
      b. Alternate:
         1) Johnson.
         2) Siemens.
   6. Control valves standard accuracy:
      a. Base:
         1) Siemens.
      b. Alternate:
         1) Johnson.
         2) Fisher.
         3) Baumann.
   7. Terminal valves:
      a. Base:
         1) Neptronics.
      b. Alternate:
         1) Belimo.
   8. Freezestats:
      a. Base:
         1) Johnson.
      b. Alternate:
         1) Penn.
         2) Siemens T.
   9. Pressure and differential Pressure transmitters:
      a. Base:
         1) Veris.

b. Alternate:
    1) Setra.
    2) Rosemount.

10. Pressure and differential Pressure transmitters:
    a. Base:
        1) Veris.
    b. Alternate:
        1) Setra.
        2) Rosemount.
11. Humidity sensors:
    a. Base:
        1) Vasala.
    b. Alternate:
        1) GE.
12. High accuracy temperature transmitters:
    a. Base:
        1) Conax Technologies.
13. Temperature sensors:
    a. Base:
        1) Bapi.
    b. Alternate:
        1) Minco.
14. Other control devices may be of varied manufacturers whose products are capable of meeting performance requirements.
15. Contractor is responsible for quality and satisfactory operation of devices, and for overall performance of system.
16. Other manufacturers desiring approval comply with Section 00 26 00.

B. Monitoring and control system:
    1. Include:
        a. Temperature sensors.
        b. Humidity sensors.
        c. Controllers.
        d. Switches.
        e. Relays.
        f. Valves.
        g. Dampers.
        h. Damper operators.
        i. Thermostats.
        j. Humidistats.
        k. Airflow measuring sensors.
        l. Water flow measuring sensors.
        m. Pressure transducers.
        n. Other associated controls required to maintain conditions described in detail on drawings, together with thermometers, gauges and other accessory equipment.
    2. Space temperature and humidity control.
    3. Control of air handling units.
    4. Control of exhaust systems.
    5. Control of cooling systems.
    6. Control of heating systems.
    7. Control of process systems.
    8. Control panels.
    9. Provide complete system of wiring and air piping as necessary to fill intent of these specifications.
    10. Control sequences indicated illustrate basic control functions only. Provide additional controls required to meet intent of these specifications and make a complete system.

2.2 MATERIALS

A. Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by BNL. Spare parts shall be available for at least five years after completion of this contract.

2.3 COMMUNICATION

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ASHRAE/ANSI Standard 135-2001, BACnet.

B. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

C. Internetwork operator interface and value passing shall be transparent to internetwork architecture:
   1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internetwork controller.
   2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute control strategies specified in this section. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.

D. Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clocks daily from an operator-designated controller via the internetwork. If applicable, system shall automatically adjust for daylight saving and standard time.

E. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

2.4 OPERATOR INTERFACE

A. Operator Interface: Web server shall reside on high-speed network with building controllers. Each standard browser connected to server shall be able to access all system information.

B. Communication: Web server or workstation and controllers shall communicate using BACnet protocol. Web server or workstation and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ASHRAE/ANSI 135-2001, BACnet Annex J.

C. Hardware: Each workstation shall consist of the following:
   1. Hardware Base: Industry-standard hardware shall meet or exceed DDC system manufacturer's recommended specifications and shall meet response times specified in this section. Workstation shall be IBM-compatible PCs with a minimum of:
      a. Intel Pentium 2.66 GHz processor.
      b. 1 GB RAM
      c. 40 GB hard disk providing data at 100 MB/sec.
      d. 48x CD-ROM read/write drive.
      e. Serial, parallel, and network communication ports and cables required for proper system operation.
      f. Wall mounted combination touch screen monitor computer
      g. Wall mounted keyboard and mouse

D. Operator Functions: Operator interface shall allow each authorized operator to execute the following functions as a minimum:
   1. Log In and Log Out: System shall require user name and password to log in to operator interface.
   2. Point-and-click Navigation. Operator interface shall be graphically based and shall allow operators to access graphics for equipment and geographic areas using point-and-click navigation.
   3. View and Adjust Equipment Properties: Operators shall be able to view controlled equipment status and to adjust operating parameters such as setpoints, PID gains, on and off controls, and sensor calibration.
   4. View and Adjust Operating Schedules: Operators shall be able to view scheduled operating hours of each schedulable piece of equipment on a weekly or monthly calendar-based graphical schedule display, to select and adjust each schedule and time period, and to simultaneously schedule related equipment. System shall clearly show exception schedules and holidays on the schedule display.
   5. View and Respond to Alarms: Operators shall be able to view a list of currently active system alarms, to acknowledge each alarm, and to clear (delete) unneeded alarms.
   6. View and Configure Trends: Operators shall be able to view a trend graph of each trended point and to edit graph configuration to display a specific time period or data range. Operator shall be able to create custom trend graphs to display on the same page data from multiple trended points.
   7. View and Configure Reports: Operators shall be able to run preconfigured reports, to view report results, and to customize report configuration to show data of interest.
   8. Manage Control System Hardware: Operators shall be able to view controller status, to restart (reboot) each controller, and to download new control software to each controller.
   9. Manage Operator Access. Typically, only a few operators are authorized to manage operator access. Authorized operators shall be able to view a list of operators with system access and of functions they can perform while logged in. Operators shall be able to add operators, to delete operators, and to edit operator function authorization. Operator shall be able to authorize each operator function separately.

E. System Software:
   1. Operating System: Web server shall have an industry-standard professional-grade operating system using Microsoft Windows XP Professional.
   2. System Graphics: Operator interface shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using dynamic colors to represent zone temperature relative to zone setpoint:
      a. Functionality: Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones or equipment, and to edit setpoints and other specified parameters.
      b. Animation: Graphics shall be able to animate by displaying different image files for changed object status.
      c. Alarm Indication: Indicate areas or equipment in an alarm condition using color or other visual indicator.
      d. Format: Graphics shall be saved in an industry-standard format such as BMP, JPEG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins (such as Active-X and Macromedia Flash).

F. System Tools: System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from each workstation or web browser interface. Software shall be installable on standard IBM-compatible PCs with no limit on the number of copies that can be installed under the system license:
   1. Automatic System Database Configuration: Each workstation or web server shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.
   2. Controller Memory Download: Operators shall be able to download memory from the system database to each controller.
   3. System Configuration: Operators shall be able to configure the system.
   4. Online Help: Context-sensitive online help for each tool shall assist operators in operating and editing the system.
   5. Security: System shall require a user name and password to view, edit, add, or delete data:
      a. Operator Access: Each user name and password combination shall define accessible viewing, editing, adding, and deleting functions in each system application, editor, and object.
      b. Automatic Log Out: Automatically log out each operator if no keyboard or mouse activity is detected. Operators shall be able to adjust automatic log out delay.
      c. Encrypted Security Data: Store system security data including operator passwords in an encrypted format. System shall not display operator passwords.
   6. System Diagnostics: System shall automatically monitor controller and I/O point operation. System shall annunciate controller failure and I/O point locking (manual overriding to a fixed value).
   7. Alarm Processing: System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Configure and enable alarm points as specified in Input/Output Summary. Alarms shall be BACnet alarm objects and shall use BACnet alarm services.
   8. Alarm Messages: Alarm messages shall use an English language descriptor without acronyms or mnemonics to describe alarm source, location, and nature.
   9. Alarm Reactions: Operator shall be able to configure (by object) actions workstation or web server shall initiate on receipt of each alarm. As a minimum, workstation or web server shall be able to log, print, start programs, display messages, send e-mail, send page, and audibly annunciate.
   10. Alarm Maintenance: Operators shall be able to view system alarms and changes of state chronologically, to acknowledge and delete alarms, and to archive closed alarms to the workstation or web server hard disk from each workstation or web browser interface.
   11. Trend Configuration: Operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data and shall be able to archive data to the hard disk. Trends shall be BACnet trend objects.
   12. Object and Property Status and Control: Operator shall be able to view, and to edit if applicable, the status of each system object and property by menu, on graphics, or through custom programs.
   13. Reports and Logs: Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.
   14. Standard Reports: Furnish the following standard system reports:
      a. Objects: System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location, or by combination of filter criteria.

b. Alarm Summary: Current alarms and closed alarms. System shall retain closed alarms for an adjustable period.
c. Logs: System shall log the following to a database or text file and shall retain data for an adjustable period:
   1) Alarm History.
   2) Trend Data: Operator shall be able to select trends to be logged.
   3) Operator Activity: At a minimum, system shall log operator log in and log out, control parameter changes, schedule changes, and alarm acknowledgement and deletion. System shall date and time stamp logged activity.

15. Custom Reports: Operator shall be able to create custom reports that retrieve data, including archived trend data, from the system, that analyze data using common algebraic calculations, and that present results in tabular or graphical format. Reports shall be launched from the operator interface.
16. Graphics Generation: Graphically based tools and documentation shall allow Operator to edit system graphics, to create graphics, and to integrate graphics into the system. Operator shall be able to add analog and binary values, dynamic text, static text, and animation files to a background graphic using a mouse.
17. Graphics Library: Complete library of standard HVAC equipment graphics shall include equipment such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. Library shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. Library graphic file format shall be compatible with graphics generation tools.
18. Custom Application Programming: Operator shall be able to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:
    a. Language: Language shall be graphically based and shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks.
    b. Programming Environment: Tool shall provide a full-screen, cursor-and-mouse-driven programming environment that incorporates word processing features such as cut and paste. Operator shall be able to inset, add, modify, and delete custom programming code, and to copy blocks of code to a file library for reuse in other control programs.
    c. Independent Program Modules: Operator shall be able to develop independently executing program modules that can disable, enable and exchange data with other program modules.
    d. Debugging and Simulation: Operator shall be able to step through the program observing intermediate values and results. Operator shall be able to adjust input variables to simulate actual operating conditions. Operator shall be able to adjust each step's time increment to observe operation of delays, integrators, and other time-sensitive control logic. Debugger shall provide error messages for syntax and for execution errors.
    e. Conditional Statements: Operator shall be able to program conditional logic using compound Boolean (AND, OR, and NOT) and relational (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
    f. Mathematical Functions: Language shall support floating-point addition, subtraction, multiplication, division, and square root operations, as well as absolute value calculation and programmatic selection of minimum and maximum values from a list of values.
    g. Variables: Operator shall be able to use variable values in program conditional statements and mathematical functions:

1) Time Variables: Operator shall be able to use predefined variables to represent time of day, day of the week, month of the year, and date. Other predefined variables or simple control logic shall provide elapsed time in seconds, minutes, hours, and days. Operator shall be able to start, stop, and reset elapsed time variables using the program language.
2) System Variables: Operator shall be able to use predefined variables to represent status and results of Controller Software and shall be able to enable, disable, and change setpoints of Controller Software as described in Controller Software section.

G. Portable Operator's Terminal: Provide all necessary software to configure an IBM-compatible laptop computer for use as a Portable Operator's Terminal. Operator shall be able to connect configured Terminal to the system network or directly to each controller for programming, setting up, and troubleshooting.

H. BACnet: Web server or workstation shall have demonstrated interoperability during at least one BMA Interoperability Workshop and shall substantially conform to BACnet Operator Workstation (B-OWS) device profile as specified in ASHRAE/ANSI 135-2001, BACnet Annex L.

2.5 CONTROLLER SOFTWARE

A. Building and energy management application software shall reside and operate in system controllers. Applications shall be editable through operator workstation, web browser interface, or engineering workstation.

B. System Security: See "Security" and "Operator Activity" under "Operator Interface".

C. Scheduling: System shall provide the following schedule options as a minimum:
1. Weekly: Provide separate schedules for each day of the week. Each schedule shall be able to include up to 5 occupied periods (5 start-stop pairs or 10 events).
2. Exception: Operator shall be able to designate an exception schedule for each of the next 365 days. After an exception schedule has executed, system shall discard and replace exception schedule with standard schedule for that day of the week.
3. Holiday: Operator shall be able to define 24 special or holiday schedules of varying length on a scheduling calendar that repeats each year.

D. System Coordination: Operator shall be able to group related equipment based on function and location and to use these groups for scheduling and other applications.

E. Binary and Analog Alarms: See "Alarm Processing" under "Operator Interface".

F. Alarm Reporting: See "Alarm Reactions" under "Operator Interface".

G. Remote Communication: System shall automatically contact operator workstation or server on receipt of critical alarms.

H. Maintenance Management: System shall generate maintenance alarms when equipment exceeds adjustable runtime, equipment starts, or performance limits. Configure and enable maintenance alarms as specified in Input/Output Summary.

I. Sequencing: Application software shall sequence fans and pumps as specified.

J. PID Control: System shall provide direct- and reverse-acting PID (proportional-integral-derivative) algorithms. Each algorithm shall have anti-windup and selectable controlled variable, setpoint, and PID gains. Each algorithm shall calculate a time-varying analog value that can be used to position an output or to stage a series of outputs.

K. Staggered Start: System shall stagger controlled equipment restart after power outage. Operator shall be able to adjust equipment restart order and time delay between equipment restarts.

L. Energy Calculations:

1. System shall accumulate and convert instantaneous power (kW) or flow rates (gpm) to energy usage data.
2. System shall calculate a sliding-window average (rolling average). Operator shall be able to adjust window interval to 15 minutes, 30 minutes, or 60 minutes.
3. System shall calculate a fixed-window average. Window interval start shall be defined by utility meter digital input signal to synchronize system's and utility's fixed-window averages.

M. Anti-Short Cycling: Binary output objects shall be protected from short cycling by means of adjustable minimum on-time and off-time settings.

N. On and Off Control with Differential: System shall provide direct- and revers-acting on and off algorithms with adjustable differential to cycle a binary output based on a controlled variable and setpoint.

O. Runtime Totalization: System shall provide an algorithm that can totalize runtime for each binary input and output. Operator shall be able to enable runtime alarm based on exceeded adjustable runtime limit. Configure and enable runtime totalization and alarms as specified in Input/Output Summary.

2.6 CONTROLLERS

A. General: Provide Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), and Smart Actuators (SA) as required to achieve performance specified in "System Performance".

B. BACnet:
1. Building Controllers (BCs). Each BC shall have demonstrated interoperability during at least one BMA Interoperability Workshop and shall substantially conform to BACnet Building Controller (B-BC) device profile as specified in ASHRAE/ANSI 135-2001, BACnet Annex L.
2. Advanced Application Controllers (AACs). Each AAC shall conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ASHRAE/ANSI 135-2001, BACnet Annex L and shall be listed as a certified B-AAC in the BACnet Testing Laboratories (BTL) Product Listing.
3. Application Specific Controllers (ASCs). Each ASC shall conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ASHRAE/ANSI 135-2001, BACnet Annex L and shall be listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.
4. Smart Actuators (SAs). Each SA shall conform to BACnet Smart Actuator (B-SA) device profile as specified in ASHRAE/ANSI 135-2001, BACnet Annex L and shall be listed as a certified B-SA in the BACnet Testing Laboratories (BTL) Product Listing.
5. BACnet Communication:
   a. Each BC shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.
   b. BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.
   c. Each AAC and ASC shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
   d. Each SA shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.

C. Communication:
1. Service Port. Each controller shall provide a service communication port for connection to a Portable Operator's Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.
2. Signal Management. BC and ASC operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.

3. Data Sharing. Each BC and AAC shall share data as required with each networked BC and AAC.
4. Stand-Alone Operation. Each piece of equipment shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network.

D. Environment: Controller hardware shall be suitable for anticipated ambient conditions:
1. Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -20°F to 140°F.
2. Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 32°F to 120°F.

E. Real-Time Clock: Controllers that perform scheduling shall have a real-time clock.

F. Serviceability:
1. Controllers shall have diagnostic LEDs for power, communication, and processor.
2. Wires shall be connected to a field-removable modular terminal strip or to a termination card connected by a ribbon cable.
3. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.

G. Memory:
1. Controller memory shall support operating system, database, and programming requirements.
2. Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.
3. Each ASC and SA shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.

H. Immunity to Power and Noise: Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

I. Transformer: ASC power supply shall be fused or current limiting and shall be rated at a minimum of 125% of ASC power consumption.

2.7 INPUT AND OUTPUT INTERFACE

A. General. Hard-wire input and output points to BCs, AACs, ASCs, or SAs.

B. Protection: Shorting an input or output point to itself, to another point, or to ground shall cause no controller damage. Input or output point contact with up to 24 V for any duration shall cause no controller damage.

C. Binary Inputs: Binary inputs shall monitor the on and off signal from a remote device. Binary inputs shall provide a wetting current of at least 12 mA and shall be protected against contact bounce and noise. Binary inputs shall sense dry contact closure without application of power external to the controller.

D. Pulse Accumulation Inputs: Pulse accumulation inputs shall conform to binary input requirements and shall accumulate up to 10 pulses per second.

E. Analog Inputs: Analog inputs shall monitor low-voltage (0-10 Vdc), current (4-20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.

F. Binary Outputs: Binary outputs shall send an on-or-off signal for on and off control. Building Controller binary outputs shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.

G. Analog Outputs: Analog outputs shall send a modulating 0-10 Vdc or 4-20 mA signal as required to properly control output devices. Each Building Controller analog output shall have a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.

H. Tri-State Outputs: Control three-point floating electronic actuators without feedback with tri-state outputs (two coordinated binary outputs). Tri-State outputs may be used to provide analog output control in air terminal unit damper motors only.

I. Universal Inputs and Outputs: Inputs and outputs that can be designated as either binary or analog in software shall conform to the provisions of this section that are appropriate for their designated use.

2.8 POWER SUPPLIES AND LINE FILTERING

A. Power Supplies: Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity:
   1. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand 150% current overload for at least three seconds without trip-out or failure.
      a. Unit shall operate between 32°F and 120°F. EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
      b. Line voltage units shall be UL recognized and CSA listed.

B. Power Line Filtering:
   1. Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:
      a. Dielectric strength of 1000 V minimum
      b. Response time of 10 nanoseconds or less
      c. Transverse mode noise attenuation of 65 dB or greater
      d. Common mode noise attenuation of 150 dB or greater at 40-100 Hz

2.9 PORTABLE OPERATOR'S TERMINAL

A. General:
   1. Portable Operator's Terminal (POT) for operator readout of system variables, override control, and adjustment of control parameters. The POT shall consist of a laptop computer with associated software to execute the following functions. The display and keyboard must be under password control to prevent tampering. Hand held, plug-compatible with Network Control Processors (NCP), Local Control Processors (LCP), and LCP space thermostats. Provide 1 unit.
   2. Functionality:
      a. Automatically display a sequential all point summary.
      b. Allow display and/or changing of digital point state, analog point value, time and date, application and DDC parameters, analog limits, time schedules, run time counts and limits, daylight savings time changeover, time/event initiation, and programmable offset values.
      c. Allow access to initialization routines and diagnostics, and enable/disable of points, initiators and programs.

3. Complete with command keys, data entry keys, cursor control keys, and liquid crystal alphanumeric display. Access via self-prompting menu selection with next menu/previous menu, and step forward/step backward within given menu. Connection of POT to panel shall not interrupt, or interfere with normal network operation.
4. Provide access to all LCPs on respective bus. Displays to provide text via 64 character minimum screen with English descriptors.

2.10 REMOTE PANEL HARDWARE

A. General:
   1. Network control panels (NCPs) serving AHUs, exhaust fans, hot and chilled water systems, and similar systems, and local control panels (LCPs) serving air terminal units, heaters, and other individual devices, shall be compatible with BMCS system communication protocol.
   2. Microprocessor based remote panels with EPROM operating system (OS), and minimum 10 MHz operating speed. DDC programs and data files shall be in EPROM with RAM image to allow simple additions and changes. All EPROM socketed for easy replacement.
   3. EPROM/RAM DDC programs and data files to provide for instant loop recovery upon power restoration after outage beyond that which is power backed. Provide power backup of 4-hour instant recharge capacitor, or 12-hour trickle recharged batteries. RAM images, including all user additions, and changes to be up/down line loadable to central disk for backup.
   4. RAM DDC programs and data files without EPROM backup provided with 72 hours of battery backup complete with automatic monitoring, and "replace battery" alarm messaging. Upon power restoration after outage beyond that which is power or EPROM backed, all RAM to be automatically downloaded and remote panel automatically reinitialized. Systems without EEPROM or EPROM default programs shall provide automatic daily diagnostic and verification routines with historical logging and retrieval to assure that RAM based programs do not become altered or corrupted. Complete automatic download of all RAM shall occur within one hour after power restoration and battery loss.
   5. All backup power to support clocks. Clocks to be automatically synchronized upon system recovery.
   6. The panels serving air handling units, chilled, hot water, glycol, and process cooling water system shall have integral LCD display and key pad, which will allow all points to be viewed and adjusted at the panel. Panel shall have ability to display software alarms and to automatically scan all inputs/outputs with rotating display.
   7. The panels serving air handling units, exhaust fans, and pumps which are powered from generator-backed emergency power shall be powered from an emergency power source. In addition, they shall be provided with a storage battery powered uninterruptible power supply located in or adjacent to the control panel and sized to operate a minimum of 10 minutes. This is to assure that the controllers continue to function seamlessly during commercial power outage and upon transfer to generator power.
   8. Real time clock to have one hundred year calendar with automatic leap year. Provide time of day, day of week, and date.

B. Remote panels provided with capacity to accommodate maximum of 64 input/output (I/O) points. Remote panels configured with analog and digital inputs and outputs, and pulse counting totalizers as required for application, such that primary input, output, and all control logic is resident in single microprocessor for network independent standalone closed loop DDC. Provide socket for portable operator's terminal (POT).

C. Panel inputs selected for application utilizing sensor types specified.

D. Remote panel outputs to be digital for discrete control, or true variable voltage/variable current outputs for driving analog pneumatic transducers. Analog outputs with minimum incremental resolution of one percent of operating range of controlled device. Output points to have manual HOA switches on control panel:

1. NCPs: Thirty-two bit microprocessors for DDC and energy management applications, peer-to-peer communications with other NCPs and host computer, and coordination and data concentration for subnetwork of up to 150 LCPs.
2. NCP configuration restrictions:
   a. Each air handling unit shall be on a separate controller
   b. All points for individual air handler or other major system functions shall be served from the same master panel
   c. Each DDC panel shall have a minimum of 10% of its I/O functions as spare capacity. The type of spares shall be in the same proportion as the implemented I/O functions on the panel, but in no case shall be less than two spare points of each implemented I/O type.
3. LCPs: Sixteen bit microprocessors for DDC and terminal unit control applications, and subnetwork communications. Triac/ Tristate outputs are allowed only on air terminal unit damper controllers. Reheat valves shall be modulating from a 0 – 10 VDC signal. Use of triac/tristate outputs on central systems such as AHU's is not acceptable.

E. Panel electronics installed in finished steel enclosures. Equipment room panels with hinged doors containing all load relays, transducers, and associated equipment.

2.11 DATA COMMUNICATIONS

A. General:
1. System shall utilize parent/child hierarchal server configuration. The building communications network shall be interfaced to a BNL supplied local Automated logic Webcntrol server configured as a child server. Contractor set up and program all alarm routing of critical alarms to also be sent to the site parent Automated Logic Webcntrl server via the site Ethernet. This will allow access to all system points from any computer on site by logging in through an internet explorer. System graphics will be available as web pages from the system server.
2. All NCPs and operator's terminals shall be interconnected with a communications network which must utilize native BACnet communication over a high speed ARCNET 156kbps network. All devices must be configured identically.
3. The use of a proprietary communications network (e.g. All LCPs interconnected via secondary networks managed by NCPs) with a two-way gateway between the panel network and the main network must be transparent to the system operator and approved by the engineer prior to bid. Proprietary network, if used, shall be as described below.

B. All NCPs interconnected via primary peer-to-peer communications network. LCPs also connected together via secondary networks managed by NCPs. All communications to be via twisted pair wires. DDC microprocessor failures shall not cause loss of communications of the remainder of any network. All networks to support sensor sharing, global application programs, and bus-to-bus communications without the presence of host PC:
1. NCPs capable of transmitting message to any other NCP.
2. Messages transmitted to be positively acknowledged as received, or negatively acknowledged as not received. Negative acknowledgements require retransmission of message.
3. Bus connected devices with no messages to transmit must send "I'm Ok"(or similar) message each bus cycle.
4. Full communications sustained with as few as two operational devices on any segment of bus.
5. Each NCP provided with communications watchdog to assure that an individual NCP cannot permanently occupy bus.
6. All messages to contain CRC 16 bit checkword.
7. Error recovery and communication initialization routines resident in each bus connected device.
8. Multi bus communications capability provided allowing exchange of data, and execution of programs across individual peer buses.

9. Editing and overriding local stand-alone panel programs shall be possible remotely via modem.

C. NCP communications network to support true peer protocol so each NCP has equal rights for data transfer, and report in its predetermined time slot. Each device on bus to be capable of taking over function of bus monitor to assure that loss of any single device (controller, terminal or network server) will not cause total bus failure.

D. LCPs to be managed by NCPs via active network to provide:
   1. Alarm detection and reporting.
   2. Response to operator station data requests and commands.
   3. POT communications from LCP to any other networked LCP, and from NCP to any connected LCP.
   4. LCP program loading.

E. All air handlers and major systems shall use Automated Logic ME Series controllers.

2.12 PNEUMATIC AND ELECTRICAL SYSTEM AND DEVICES

A. All electric switch devices to be UL listed for application. All water thermostats and temperature sensors provided with separable copper, Monel, or stainless steel well with extended neck for use on insulated piping.

B. Miscellaneous, electric, pneumatic, and mechanical devices to include:
   1. Automatic dampers, duct and air handling unit mounted:
      a. Suitable for 3000 fpm velocity and 4 IN wg static pressure differential.
      b. Opposed blade type for modulating action, Parallel blade type for 2 position operation except all mixing box dampers shall be parallel blade configured to direct outside and return air together to maximize mixing.
      c. Damper frames: Extruded aluminum hat channel, 1/8 IN minimum wall thickness, with flanges for duct mounting.
      d. Blades: Not over 6-IN wide heavy gauge extruded aluminum, airfoil shape.
      e. Damper bearings: Oil impregnated sintered bronze.
      f. Blade edge seals: Extruded vinyl.
      g. Jamb seals: Flexible stainless steel compression
      h. Low leakage: A damper 24-IN wide by 24-IN high shall not have leakage greater than 25 cfm when tested at 4 IN wg in accordance with AMCA Standard 500.
      i. Linkage: out of air stream.
   2. Automatic control valves, Standard accuracy:
      a. 2-1/2 IN and smaller to be screwed type with bronze body, 3 IN and larger, flanged with cast iron body.
      b. Valves ANSI rated to withstand pressures and temperatures encountered.
      c. Valves to have stainless steel stems, and spring loaded Teflon packing with replaceable discs.
      d. Modulating straight through water valves provided with equal percentage contoured throttling plugs. All three-way valves provided with linear throttling plugs so total flow through valve remains constant regardless of valve's position. Valves sized for pressure drop equal to coil they serve, but not to exceed 5 psi. Size two-way valve operators to close valves against pump shut off head.
      e. Modulating steam valves to have linear characteristics for 90 percent of closing stroke, and equal percentage for final 10 percent. Valves sized for entering steam pressure indicated with pressure drop through valves not to exceed 20 percent of main steam pressure. Provide dual valves of 1/3 - 2/3 capacity split when valve sizes are larger than 3”:
         1) All valve materials in contact with steam shall be rated for 350 ºF superheated steam.
      f. Terminal equipment valves:

1) Straight through or three way type as indicated. Bronze body, brass trim. Stems polished stainless steel and packing ethylene-propylene suitable for both chilled water and 250 degree hot water service. Neprtonics modulating contored V ball valve with 0-10 vdc input signal, Pressure ratings as required for intended service.

3. Pneumatic actuators:
   a. All automatically controlled devices including valves and dampers , unless specified otherwise elsewhere, to be provided with pneumatic actuators sized to operate their appropriate loads, with sufficient reserve power to provide smooth modulating action, or two position action and tight closeoff. Electric actuators may be used for fin tube control valves or small general exhaust dampers less than 2 SQ FT. The chemical storage rooms are an exception and shall use pneumatic dampers.
   b. Where two or more pneumatic actuators are to be operated in sequence, provide digital sequencing with separate analog pneumatic outputs.
   c. Operators shall move dampers and valves full stroke in less than six seconds. Proportioning operators shall be provided with positive positioning devices.
   d. Provide automatic damper operators: Pneumatic piston type:
      1) Damper operators shall not be directly mounted to sheet metal surfaces of less than 16 gauge. Where it is required to mount operators on these surfaces, a steel channel structural support shall be provided.
      2) Provide in proper size and number to secure true throttling or 2 position action as required.
      3) Furnish for installation outside ductwork and connected to extended shaft.
      4) Operators for unit mounted dampers: Sized for 4 IN static pressure differential across closed dampers.
      5) Provide for all automatic dampers.
4. Air terminal units shall have DDC controls and shall utilize electronic actuators on volume damper and reheat valve (refer to input/output points summary and sequence of operation). Provide and program DDC controller, ship to VAV manufacturer for factory mounting. See Section 23 36 00. Provide ZN Series controller with 0 – 10 VDC modulating output for reheat hot water valve.
5. Safety low limit thermostats: Snap acting, single pole, single or double throw, manual reset switch which trips if temperature sensed across any 12 inches of bulb length is equal to or below set point. Minimum 20 feet length of bulb. Provide one foot of bulb length for each 1.5 square feet of coil face area. Mount thermostats using flanges and element holders. Low limit thermostats (freezestat) shall have multiple contacts or shall be installed with relay loop to allow low limit thermostats to be directly connected to the motor starter/AFD and to the BMCS.
6. Electric thermostats: Line voltage or low voltage type suitable for application. Low voltage type heating thermostats to have adjustable heat anticipation.
7. Instrument Pressure Gages: Black letters on white background, 1-1/2 inch diameter, stem mounted with suitable dial range. Install pressure gages on main and branch lines at each receiver controller, at input to each actuator, at inputs and outputs from each relay and switch, and signal lines at each transmitter.

2.13 STANDARD ACCURACY ELECTRONIC DATA INPUTS AND OUTPUTS

A. Input/output sensors and devices matched to requirements of remote panel for accurate, responsive, noise free signal output/input. Control input to be highly sensitive and matched to loop gain requirements for precise and responsive control:
   1. In no case shall computer inputs be derived from pneumatic sensors.

B. Temperature sensors:
   1. Except as indicated below, all wall mounted space temperature sensors shall be RSpro and be programmed to allow +- 2 F set point adjustment. Scale on adjustment shall indicate temperature:
      a. The following locations shall have sensor without set point adjustment:
         1) Corridors.

2) Lobbies.
3) Toilet rooms
4) Storage rooms.
5) Mechanical rooms.
6) Electrical and communication rooms.
7) Elevator equipment rooms.

b. Setpoints of all wall mounted space temperature sensors shall also be adjustable through the operator's terminal or Portable Terminal, over-riding local control where provided.

c. Wall mounted space temperature sensors shall be linear within ±0.5 ºF between 40 and 90ºF.

d. Wall temperature sensors shall include an override button to bring system to occupied mode and an LCD temperature display.

e. Wall temperature sensors shall have a communication jack to allow a laptop to talk to the VAV controller.

2. Duct and air handling unit temperature sensors to be averaging type. Averaging sensors shall be of sufficient length (a maximum of 1.8 sq.ft. of cross sectional area per 1 lineal foot of sensing element) to insure that the resistance represents an average over the cross section in which it is installed. The sensor shall have a bendable copper sheath. Linear within ±0.5 ºF between 0 and 100 ºF.

3. Water sensors provided with separable copper, Monel or stainless steel well with extended neck for use on insulated piping. Linear within ±0.5 ºF between 32 and 212 ºF.

4. Outside air wall mounted sensors provided with sun shield. Linear within ±0.5 ºF between -20 and 120 ºF.

C. Relative humidity sensors, 0-10 VDC output, to be capacitance type with 10 percent to 90 percent range with an accuracy of plus or minus 2 percent of full scale. Relative humidity set points shall be adjustable through the operator's terminal or portable terminal, over-riding local control where provided. Duct mounted humidity sensors provided with sampling chamber:

1. Base:
   a. Vaisala
2. Alternate:
   a. GE GEH series

D. Differential and static pressure sensors and switches:

1. The pressure transducer shall withstand up to 150 % of rated pressure with and accuracy of plus or minus 1 percent of full scale. The sensing element shall be capsule, diaphragm, bellows, bourdon tube, or solid state. Pressure sensors (all types) installed on liquid lines shall have drains. Pressure sensors installed on steam lines shall have drains and siphons. All pressure sensors shall have valves for isolation, venting and taps for calibration. Pressure sensors shall be verified by calibration. Differential pressure sensors shall have nulling valves.

2. Pressure transducers:
   a. Base:
      1) Veris
   b. Alternate:
      1) Setra.
      2) Rosemount.

3. Pressure switches shall have a repetitive accuracy of plus or minus 2 percent of their operating range and shall withstand up to 150% of rated pressure. Switch shall have a snap acting form C contact rated for the application:
    a. Pressure switches (all types installed on liquid lines shall have drains. Pressure sensors installed on steam lines shall have drains and siphons. All pressure switches shall have valves for isolation, venting and taps for calibration. Pressure switches shall be adjusted to the proper set point and shall be verified by calibration. Pressure switches shall be mounted higher than the process connection. Differential pressure switches shall have nulling valves. Switch contact ratings and duty shall be selected in accordance with NEMA ICS 1. Switches shall have visual indicator of setpoint.
4. Provide differential pressure transmitters and gauges for air handling unit filters in pressure ranges to match full loaded filter pressure drop plus 50%. Provide with isolation valves and calibration taps:
    a. Provide Dwyer magnahelic series gauges with isolation valves and calibration taps,.
5. Differential pressure transducers:
    a. Base:
        1) Veris
    b. Alternate:
        1) Setra.
        2) Rosemount.
6. Fan proof-of-flow sensor to be self calibrating current transducers by ACI or Veris, 0-10 VDC output.
7. Pump proof-of-flow sensor to be self calibrating current transducers by ACI or Veris, 0-10 VDC output.

E. Electronic airflow measuring stations:
1. Air Flow and Temperature Measurement:
    a. Thermal dispersion technology anemometer using instrument grade self-heated thermistor sensors with thermistor temperature sensors.
    b. Factory tested prior to shipment and shall not require calibration or adjustment over the life of the equipment when installed in accordance to manufacturer's guidelines.
    c. Manufacturer shall provide test data for accuracy performance prior to bid date. Vortex shedding arrays are not acceptable. Pitot tube and differential pressure sensing arrays are not acceptable. Auto zeroing sensors are not acceptable.
2. Flow Station Construction:
    a. Type: Duct Mounted.
    b. Sensors: Two glass-encapsulated thermisters at each measuring point - self heated thermistor and temperature sensor:
        1) Glass-filled polypropylene housing.
        2) Factory-calibrated at 16 airflow rates and 3 temperatures to NIST-traceable standards for both airflow and temperature.
    c. Probe construction:
        1) Gold anodized aluminum alloy tube.
        2) 304 stainless steel mounting brackets.
        3) Constructed as insertion, internal, or standoff mounting, depending on installation requirements.

d. Probe sensor density:

Area (sq.ft.)	Sensors
<= 1	2
>1 to< 4	4
4 to < 8	6
8 to < 12	8
12 to < 16	12
>= 16	16

e. Probe operating ranges:
   1) Airflow: 0 to 5000 FPM.
   2) Temperature: -20 to 160 °F.
   3) Relative Humidity: 0 to 99% non-condensing.

3. Transmitter:
   a. Type: Microprocessor Based, totally solid state.
   b. Power Requirement: 24 VAC, isolated from other
   c. devices and not grounded. AFMS manufacturer shall furnish a 1:1 isolation transformer for each duct location.
   d. Capable of processing up to 16 independent sensing points per location.
   e. Output signal offset/gain adjustment.
   f. Adjustable digital filter to stabilize airflow output.
   g. Field configurable for either I.P.or S.I. units.
   h. Local digital display on face of cabinet for indicating individual sensor airflow and temperature readings.
   i. Wall-mounted NEMA 1 enclosure.
4. Performance:
   a. Electronics temperature range: 30 to 120 °F.
   b. Flow station temperature range: -20 to 160 °F.
   c. Flow station velocity range: 0 to 5,000 ft./min.
   d. Flow station pressure drop: less than 0.005 IN WC at 2000 ft/min.
   e. Flow station humidity range: 0 to 99% RH (non-condensing).
5. Analog output signals: 0-10 VDC:
   a. Sensor velocity accuracy: 2% reading.
   b. Sensor temperature accuracy: ± 0.15°F.
   c. Type: linear.
6. Ebtron Gold Series or approved equal.

F. Steam flow meter:
   1. Steam flow meter shall be vortex sheding mass flow meter with temperature compensation
   2. Provision shall be made for pressure transmitters to be mounted on the retractor assembly to provide pressure signal with only one pipe penetration.
   3. Body shall be 304 or 316 Stainless steel.
   4. Turn down shall be minimum of 12 to 1.
   5. Accuracy shall be +-1.5% of flow.
   6. Unit shall have integral control logic to locally display flow rate and total. The output for flow shall be a digital pulse output.
   7. Output for pressure shall be 4-20 mA with digitally adjusted span. The entire unit shall require a 24 VDC nominal power supply.
   8. Suitable for 150 psi steam.
   9. Rosemount 6”model 8800 DR with remote LCD display or approved equal.

G. Thermal Energy Ultrasonic Water Flow Meter:
   1. Provide for chilled water system.
   2. Non-intrusive ultrasonic flowmeter.
   3. 1000:1 turndown ratio.

4. I/O capabilities: 0-10 volt, pulse generator, relay.
5. Measure flow rate.
6. Features:
   a. LCD display.
   b. Datalogger memory.
   c. Password protection.
   d. Programmable math functions.
7. Clamp-on flow transducers support all pipe sizes.
8. No cutting of pipe required for installation.
9. Outputs:
   a. Flow rate.
   b. Malfunction alarm.
10. Provide removable insulation blanket with vapor proof cover.
11. Siemens Sitrans.

H. Differential Pressure Monitor:
1. Differential pressure monitor for use in clean rooms.
2. Locate monitor where shown on plans. Monitor shall continuously measure the pressure differential between the clean rooms and the corridor/adjacent room.
3. Range: -0.2000 to +0.2000 inches of water gauge.
4. Accuracy: ±0.002 inches of water gauge.
5. Resolution: 5% of reading.
6. Monitor features:
   a. Digital display in units of inches of water.
   b. Visual red and green lights that provide room status information at a glance,
   c. Hidden operator panel.
   d. Audio alarm to alert staff at loss of containment.
   e. Mute key.
7. Analog output to building automation system. Pressure differential reading shall be used by the BMCS to vary airflow into the room via the supply air system. Alarm BNCS workstation if differential drops below 0.01” w.g.
8. Acceptable manufacturers:
   a. TSI.
   b. TriaTek.

I. Outputs: Control relays and analog output transducers to be compatible with remote panel. Relays suitable for loads encountered. Analog output transducers designed for precision closed loop control with pneumatic repeatability error no greater than 1-1/2 percent.

J. Standard accuracy temperature sensors:
1. Base:
   a. Bapi.
2. Alternate:
   a. Minco.
3. 10,000 ohm curve 2 thermistor.
4. Immersion type with ss well.
5. Duct type with .25 in dia stainless steel probe
6. Duct averaging type with 3/16 " copper" probe.
7. All above with metal enclosure box for connections.
8. Outdoor air sensor with abs enclosure and sun shield.

K. Conductivity/resistivity meter:
1. Base: Mettler Toledo Thornton Model M300.
2. Dual channel with matching NEMA 4x wall/pipe mount enclusrue.
3. Dual resistivy sensors suitable to measure 500 ohm-cm to 18 mohm-cm with temperature sensor.
4. Accuracy: ± 0.05 percent of reading or 0.5 ohm whichever is greater.

5. Input voltage: 120 VAC.
6. Analog output signals 4-20 ma dc.
7. With LCD display in mohm-cm.
8. UL listed.

2.14 CONTROL AIR SUPPLY

A. Connect to compressed air system provided by plumbing for this project.

B. Air Filters:
   1. Air filter/pressure regulator station of sufficient capacity to supply all connected equipment.
   2. Two combination dirt and coalescing-type oil filters and pressure regulators in parallel, with shut-off valves shall be provided.
   3. Efficiency: 100 percent efficient for particles down to 0.3 micron in diameter.
   4. Oil Removal: Reduced to 0.01 ppm.
   5. Each filter bowl shall be rated for 150 psig maximum working pressure and shall be transparent.
   6. Provide pressure gauge on inlet and outlet of pressure regulators.
   7. Provide pressure gauge on outlet of filters.
   8. Provide pressure relief set at 30 PSI in low pressure compressed air line.

C. Control Air Piping and Tubing:
   1. Control air piping shall be copper tubing for pressure above 45 PSIG and where non-metallic tubing is not allowed. Conceal piping except in mechanical rooms or areas where other piping is exposed.
   2. Copper Tubing:
      a. ASTM B88 or STM B280, Type L, hard drawn where exposed and either hard drawn or annealed where concealed.
      b. Fittings shall be tool made bends; solder joint wrought copper, ANSI Bl6.22; or flared compression type.
      c. Solder: ASTM B32-08 tin/lead.
   3. Non-Metallic Air Piping:
      a. Virgin polyethylene non-metallic tubing, ASTM D 1 248, Type 1, Category 5, Class B or C. Tubing shall be self-extinguishing under ASTM-D635 flammability test. Use compression or push-on polyethylene fittings.
      b. Non-metallic single tubing and jacketed multiple tube bundles (harness): Tubing and jacketing materials shall be produced from a flame retardant virgin polyethylene exceeding the performance requirements of ASTM Dl 693 for stress crack resistance and have a flammability class 94V-2 when tested in accordance with UL 94 test procedures. Tubing installed in air handling spaces shall be classified for fire resistance and low smoke producing characteristics and shall be UL approved for use in such spaces. Tubing in bundles (harness) shall be individually number coded at regular intervals.
      c. Non-metallic tubing not permitted inside masonry walls, above non-accessible ceilings, and other non-accessible locations.

D. Provide filter/regulator/gauge for main air at each control panel which utilizes control air. Norgren or equal.

PART 3 - EXECUTION

3.1 GENERAL

A. The Building Management and Control System (BMCS) shall be designed, installed, and commissioned in a turnkey fully implemented and operational manner; including all labor not noted in paragraph "Work by Others" of Part I of this section of these specifications, and not noted in other sections of these specifications.

3.2 SEQUENCE OF OPERATION

A. General:
   1. HVAC systems shall be controlled with Direct Digital Control (DDC) according to sequence contained in this section of specifications and on drawings. Each DDC control panel shall be stand-alone:
      a. Additional points or software programming not listed but which are required to meet following sequences of operation shall be provided.
   2. House controllers, relays, transducers, and other components required for stand-alone control in NEMA 1 enclosure with lockable door.
   3. All AFD's shall be monitored by BMCS for trouble conditions. Operator will use AFD control panel for diagnostics.
   4. Setpoints:
      a. All setpoints given in the sequence of operations or in the drawings are for system startup and are preliminary. Optimum operating setpoints must be determined during actual occupancy and will be affected by many factors. These may include:
         1) Weather conditions.
         2) Building occupancy.
         3) Building utilization patterns.
         4) Variations in building construction.
         5) Variations in operating characteristics of actual installed building equipment.
      b. It is the responsibility of the building operators to determine those settings and operating methods which provide the best balance of operating efficiency and occupant comfort. This is an ongoing process. Optimum settings change as operating conditions change.
   5. All controller inputs, outputs, and adjustable setpoints and constants shall be readable and settable from the operator's terminal.

B. Sequence of operation is given in Drawings.

3.3 DATA CONTROL (D/C) AND GRAPHICS

A. Provide all software required to accomplish sequence of operations, including all data and control points not listed on input/output points summary.

B. In addition to graphics of building systems with dynamic data points as noted in following data and control and graphic summary, and graphics required under digital system management sections, following additional graphics shall be provided:
   1. Building layouts (floor plans).
   2. Any other graphics necessary for logical penetration.
   3. Sequence of operation (window split screen view).
   4. Flow charts for critical DDC loops.
   5. Supervisor graphics.
   6. System configuration.
   7. Display VVR and CVR boxes, and reheat coil locations on building floor plans.
   8. Display duct mounted humidifier locations on building floor plans.
   9. Display fire and smoke damper locations on building floor plans.
   10. Display air handling unit locations and configuration (flow diagram, DDC Logic Diagram and control sequence).
   11. Display heating, and chilled water mains and valve locations with valve I.D.corresponding to valve index indicating service, size, valve type, and location.
   12. Flow diagram of chilled water system showing pumps and locations of differential pressure switches, and display all points indicated on I/O summary.
   13. Display all pneumatic and DDC sensors, thermostats, and humidistats on floor plan corresponding to air terminal or other controlled device locations.
   14. Display pneumatic air system configuration showing air compressors, air dryers, regulators, etc.

15. Display all DDC panels, indexed to correspond with system configuration.

C. Include Pseudo points for display in logical groups and graphics. Commandable pseudo points to be commandable directly from all displays.

D. Each analog point to have unique remote panel resident dual high, and dual low limit alarm threshold engineering units. Where specified, provide floating (band above and below set point) alarm limits.

E. Each digital output to have software-associated monitored input. Any time monitored input does not track its associated command output within programmable time interval, "command failed" alarm shall be reported.

F. Where calculated points (such as CFM) are shown, they shall appear in their respective logical groups. Respective unconditioned raw data (such as logarithmic differential pressure) points to also be grouped in special group for display and observation independent of logical groups.

G. Where data or control points are required to accomplish digital control or energy management sequences specified, but not listed in I/O summary, Contractor shall provide the points necessary to accomplish the specified sequence.

H. Primary analog input and analog output of each DDC loop to be resident in single remote panel containing DDC algorithm, and shall function independent of any peer or mux communication links. Secondary (reset type) analog inputs may be received from the peer network, but approved default values and/or procedures shall be substituted in DDC algorithm for this secondary input in network communications fail or if secondary input becomes erroneous or invalid.

I. Provide the ability to plot trend graphs of any input variable for any interval.

3.4 INSTALLATION

A. All wiring and tubing to be properly supported, and run in neat and workmanlike manner. All wiring and tubing shall run parallel to or at right angles to building structure. All piping and wiring within enclosures to be neatly bundled, and anchored to prevent obstruction to devices and terminals.

B. Unitized cabinet type for each system under automatic control with relays and controls mounted in cabinet and pilot lights, push buttons and switches flush on cabinet panel face. ANSI/NEMA 1, general purpose utility enclosures with enameled finished face panel. Mount control panels adjacent to associated equipment on vibration free walls or free standing angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide engraved plastic nameplates for instruments and controls inside cabinet and engraved nameplate on cabinet face. Provide Panduit raceway with cover for wiring inside control cabinets.

C. 120V power wiring is provided under Div. 16 to certain locations as shown on the Electrical Drawings. BMCS Contractor is responsible to extend this wiring to any additional location where control system requires power. Where low voltage power is required this contractor shall provide suitable transformers and circuit.

D. BMCS Contractor shall inspect each air terminal unit and verify that all control devices furnished under this section have been properly installed and wired by the air terminal unit manufacturer before unit power supply is energized.

E. BMCS Contractor to be responsible for all electrical installation required for fully functional system, and not shown on electrical plans or required by electrical specifications. All wiring shall be in accordance to all local and national codes and requirements of Div. 16:
   1. All line voltage wiring to be installed in conduit.
   2. All low voltage and current limited electronic wiring shall be #18 AWG minimum shielded cable. Shielded cable shall be Belden New Generation Type 6300FE or approved equal.
   3. All wiring in finished spaces including central control room to be concealed.
   4. All systems to be powered from emergency power circuits.

F. Unless indicated otherwise, locate thermostats, humidistats and sensors for room monitoring and control immediately inside of door adjacent to light switch:
   1. Where light switch is in an entry way to room, locate on wall within room, at same elevation as light switch, so it is capable of sensing true space conditions.
   2. Coordinate location to avoid conflict with wall mounted casework and similar features.
   3. Prior to installation, coordinate locations with Architect/Engineer.

G. All pneumatic equipment and connecting piping to be installed in a neat and workmanlike manner by trained mechanics in direct employ of control manufacturer:
   1. Non-metallic tubing may be used and shall be virgin polyethylene, meeting stress-crack test ASTM-D1693, 60T. Tubing shall be self-extinguishing under ASTM-D635 flammability test. This tubing shall be run within adequately supported rigid metallic raceway, electrical tubing or duct. Non-metallic tubing shall not be used for main vertical risers in building and shall not be used upstream of main pressure regulators.
   2. Where push-on joints are utilized with non-metallic tubing, clamping devices must be used to prevent tubing slipping off of connector.
   3. Properly supported hard copper tubing with soldered joints and tool-made bends may be used, and shall be provided with 12 IN flexible polyethylene connections at valves or dampers.
   4. Provide regulators as required to set pressure required for control devices. Number and location of regulators shall be determined by temperature controls contractor. Air relief valves shall be provided to protect control devices.

H. Identification:
   1. Provide laminated, engraved plastic nameplates for control panels. Other equipment devices furnished, including sensors, switches, valves, gages, actuators and all other item furnished under this section shall be identified with plastic embossed labels adhered to the device. Each nameplate shall identify the function, such as "mixed air low limit" or "cold deck temperature sensor" Laminated plastic shall be one-eighth inch thick black with white center core. Nameplates shall be a minimum of 1 inch by 3 inch with minimum one quarter inch high engraved block lettering. Nameplates for devices smaller than 1 inch by 3 inch shall be attached by a nonferrous metal chain. Submit proposed wording of each nameplate with hardware submittal.
   2. Instrumentation and Control Diagrams: Provide framed drawings including the sequence of controls, wiring and verbal description in laminated plastic showing complete diagrams for all equipment furnished and interfaces to all existing equipment, at each respective equipment location. Condensed operating instructions explaining preventive maintenance procedures methods of checking the system for normal safe operation and procedures for safely starting and stopping the system manually shall be prepared in typed form, framed as specified for the diagrams and posted beside the diagrams. Proposed diagrams, instructions and other sheets shall be submitted prior to posting.
   3. Provide labels on each control cable indicating connection points.

I. BMCS Contractor shall enter all computer programs and data files into related computers, including all control programs, initial approved parameters and settings, English descriptors, and colorgraphics complete with dynamic dispersed data. In addition, following to be user implemented, shall have samples installed for training and validation:
   1. Trend log.
   2. Alarm message (action taking message).
   3. Run time maintenance message.
   4. Trouble action message.
   5. Dynamic trend plot (6 points).

J. BMCS Contractor to maintain diskette copies of all data file, and application software for reload use in event of system crash or memory failure. One copy to be delivered to BNL during training session, and one copy archived at local software vault provided by BMCS manufacturer within 10 miles of project site.

3.5 SYSTEM VERIFICATION PROCEDURE

A. Upon completion of all wiring by the BMCS Contractor, approval shall be made by BNL's Construction Inspection Department.

B. Upon such approval being achieved, BNL shall make the necessary tie-in to the Campus Environmental Control System:
   1. Upon completion of the aforementioned, a system startup shall be conducted. See section 23 90 00 mechanical system commissioning for additional details.

C. Upon conclusion of the final checkout, the BMCS Contractor's responsibility reverts to standard warranty of materials and installation hereinafter specified.

D. Provide test plan and test procedures for the performance verification tests for approval. Explain in detail actions and expected results to demonstrate compliance with the requirements of this specification and the method for simulating the necessary conditions of operation to demonstrate performance of the system. Deliver Test Plans documentation for the performance verification tests to BNL's representative 30 days prior to the performance verification tests. Provide draft copy of operation and maintenance manual with performance verification test.

3.6 CONTROL SYSTEM CHECKOUT AND TESTING

A. Startup Testing: Complete startup testing to verify operational control system before notifying BNL of system demonstration. Provide BNL with schedule for startup testing. BNL may have representative present during any or all startup testing:
   1. Calibrate and prepare for service each instrument, control, and accessory equipment furnished under Section 25 50 00.
   2. Verify that control wiring is properly connected and free of shorts and ground faults. Verify that terminations are tight.
   3. Enable control systems and verify each input device's calibration. Calibrate each device according to manufacturer's recommendations.
   4. Verify that binary output devices such as relays, solenoid valves, two-position actuators and control valves, and magnetic starters, operate properly and that normal positions are correct.
   5. Verify that analog output devices such as I/Ps and actuators are functional, that start and span are correct, and that direction and normal positions are correct. Check control valves and automatic dampers to ensure proper action and closure. Make necessary adjustments to valve stem and damper blade travel.
   6. Prepare a log documenting startup testing of each input and output device, with technician's initials certifying each device has been tested and calibrated.
   7. Verify that system operates according to sequences of operation. Simulate and observe each operational mode by overriding and varying inputs and schedules. Tune PID loops and each control routine that requires tuning.
   8. Alarms and Interlocks:
      a. Check each alarm with an appropriate signal at a value that will trip the alarm.
      b. Trip interlocks using field contacts to check logic and to ensure that actuators fail in the proper direction.
      c. Test interlock actions by simulating alarm conditions to check initiating value of variable and interlock action.

B. Calibration shall be demonstrated by the BMCS contractor in the presence of the Architect or BNL's representative. Should random sampling indicate improper commissioning, BNL reserves the right to subsequently witness complete calibration of the system at no additional cost to BNL.

3.7 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration: Prior to acceptance, perform the following performance tests to demonstrate system operation and compliance with specification after and in addition to tests specified in Article 3.6 "Control System Checkout and Testing". Provide Engineer with log documenting completion of startup tests:
   1. Engineer will be present to observe and review system demonstration. Notify Engineer at least 10 days before system demonstration begins.
   2. Demonstrate actual field operation of each sequence of operation as specified in the "Input/Output Summary". Provide at least two persons equipped with two-way communication. Demonstrate calibration and response of any input and output points requested by Engineer. Provide and operate test equipment required to prove proper system operation.
   3. Demonstrate compliance with "System Performance" in Part 1 of this section.
   4. Demonstrate compliance with sequences of operation through each operational mode.
   5. Demonstrate complete operation of operator interface.
   6. Demonstrate each of the following:
      a. DDC loop response: Supply graphical trend data output showing each DDC loop's response to a setpoint change representing an actuator position change of at least 25 percent of full range. Trend sampling rate shall be from 10 seconds to 3 minutes, depending on loop speed. Each sample's trend data shall show setpoint, actuator position, and controlled variable values. Engineer will require further tuning of each loop that displays unreasonably under- or over-damped control.
      b. Building fire alarm system interface.
      c. Trend logs for each system: Trend data shall indicate setpoints, operating points, valve positions, and other data as specified in the points list provided with each sequence of operation. Each log shall cover three 48-hour periods and shall have a sample frequency not less than 10 minutes or as specified on its points list. Logs shall be accessible through system's operator interface and shall be retrievable for use in other software programs.
   7. Tests that fail to demonstrate proper system operation shall be repeated after Contractor makes necessary repairs or revisions to hardware or software to successfully complete each test.

B. Acceptance:
   1. After tests described in this specification are performed to the satisfaction of both Engineer and BNL, Engineer will accept control system as meeting completion requirements. Engineer may exempt tests from completion requirements that cannot be performed due to circumstances beyond Contractor's control. Engineer will provide written statement of each exempted test. Exempted tests shall be performed as part of warranty.
   2. System shall not be accepted until completed demonstration forms and checklists are submitted and approved as required.

C. Demonstrate to authorities that all required safeties and life safety functions are fully functional and complete.

D. Make personnel accessible to provide necessary adjustments and corrections to systems as directed by balancing agency.

E. After completion of validation procedures, contractor shall perform validation demonstration in the presence of the Architect or BNL's representative, as dictated by BNL. Witnessed validation demonstration shall consist of:
   1. Running each specified report.
   2. Display and demonstrate each data entry to show site specific customizing capability. Demonstrate parameter changes.
   3. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
   4. Execute digital and analog commands in graphic mode.

5. Demonstrate DDC loop precision and stability via trend logs of inputs and outputs (6 loops minimum).
6. Demonstrate EMS performance via trend logs and command trace.
7. Demonstrate scan, update, and alarm responsiveness.
8. Demonstrate spreadsheet/curve plot software, and its integration with database.
9. Demonstrate on-line user guide, and help function and mail facility.
10. Demonstrate digital system configuration graphics with interactive upline and downline load, and demonstrate specified diagnostics.
11. Demonstrate multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.
12. Demonstrate class programming with point options of beep duration; beep rate, alarm archiving, and color banding.

3.8 MANUALS (FOLLOWING MANUALS TO BE PROVIDED)

A. Functional design manual: The functional design manual shall identify the operational requirements for the system and explain the theory of operation, design philosophy, and specific functions. A description of hardware and software functions, interfaces, and requirements shall be provided for all system operating modes.

B. Hardware manual: Furnish a hardware manual describing all equipment provided including a general description and specification, installation and checkout procedures, equipment electrical schematics and layout drawings, system schematics and I/O wiring lists, and alignment and calibration procedures.

C. Software manual: The software manual shall describe all furnished software, starting with a system overview and proceeding to a detailed description of each software module. The manual shall be oriented to enable proper integration, loading, testing and program execution. Provide flow charts or diagrams or equivalent documentation, as approved in advance by BNL's representative, in hard copy enabling the logical step-by-step analysis of the program listings. Substitutions of different format are not acceptable.

D. Maintenance Manual: The maintenance manual shall provide descriptions of maintenance for all equipment including inspection, periodic preventative maintenance, fault diagnosis and repair or replacement of defective components.

3.9 TRAINING

A. Provide training for any new control systems provided.

B. All training to be by BMCS manufacturer and utilize specified manuals, as built documentation, and on-line help utility:
   1. Provide classroom instruction course at site:
      a. Minimum 2 days for 25 individuals.

C. Operator training to include one initial on-site eight hour sessions encompassing:
   1. Sequence of operation review.
   2. Sign on-sign off.
   3. Selection of all displays and reports.
   4. Commanding of points, keyboard, and mouse mode.
   5. Modifying English text.
   6. Use of all dialog boxes and menus.
   7. Modifying warning limits, alarm limits, and start-stop times.
   8. System initialization.
   9. Download and initialization of remote panels.
   10. Purge and/or dump of historical data.
   11. Use of portable operator's terminal.
   12. Troubleshooting of sensors (determining bad sensors).
   13. Password modification.

D. After initial training, BMCS manufacturer shall include 8 additional hours of training for miscellaneous instruction requested by BNL.

3.10 WARRANTY

A. All components, system software, parts, and assemblies supplied by BMCS manufacturer to be guaranteed against defects in materials and workmanship for two years from acceptance date.

B. Labor to troubleshoot, repair, reprogram, or replace system components shall be furnished by BMCS Contractor at no charge to BNL during warranty period.

C. All corrective software modifications made during warranty service periods to be updated on all user documentation, and on user and manufacturer archived software disks.

END OF SECTION

DIVISION 26

ELECTRICAL

SECTION 26 00 10
ELECTRICAL GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Drawings use and interpretation:
   1. Drawings are diagrammatic and indicate general arrangement of systems and equipment, except:
      a. Specific installation details.
      b. When specific dimensions are indicated for electrical equipment it is intended that these be limiting dimensions. When proposed equipment exceeds these limiting dimensions, advise Architect. Features and functions of specified equipment shall not be superceded by these limiting dimensions.
   2. For exact locations of building elements, refer to dimensioned architectural/structural drawings.
   3. Field measurements take precedence over dimensioned drawings.
   4. Intention is to indicate size, capacity, approximate location, direction and general relationship of one work phase to another, but not exact detail or arrangement.

B. Installation of all systems and equipment is subject to clarification as indicated in reviewed shop drawings and field coordination drawings.

C. Description of systems:
   1. Provide materials to provide functioning systems in compliance with performance requirements specified.
   2. Provide modifications required by reviewed shop drawings and field coordinated drawings.

1.2 QUALITY ASSURANCE

A. Perform all work in accordance with but not limited to:
   1. All authorities having jurisdiction.
   2. Federal, state and local codes, regulations and ordinances.
   3. Underwriter's (UL) code requirements.
   4. Occupational Safety and Health Act (OSHA).
   5. Factory Mutual System (FM) requirements.
   6. Americans with Disabilities Act Accessibility Guidelines (ADAAG).
   7. National Electrical Code, NFPA 70, Current Edition.
   8. New York State Building Code, Current Edition.
   9. NFPA-72: Installation, maintenance and use of protective signalling systems.
   10. NFPA-30: Flammable and combustible liquids code.
   11. NFPA-45: Fire protection for laboratories using chemicals.
   12. NFPA-780: Lightning protection code.
   13. NFPA-90A: Installation of air conditioning and ventilation systems.
   14. NFPA-101: Life safety code.
   15. ANSI/ASME-A17.1: Elevator code.
   16. NFPA-13: Installation of sprinkler systems.
   17. NFPA-37: Installation and use of stationary combustion engines and gas turbines.
   18. NFPA-110: Emergency and standby power systems.

1.3 SUBMITTALS

A. Contract closeout information:
   1. Final performance test report.

1.4 DEFINITIONS

A. Weatherproof (WP): Indicates rating suitable for wet or damp location.

1.5 PROTECTION

A. Provide covering and shielding for all equipment to protect from damage.

B. Protect nameplates on motors and similar equipment, to prevent defacing.

C. Repair, restore or replace damaged, corroded and rejected items.

1.6 JOB CONDITIONS

A. Examine Contract Documents to determine how other work will affect execution of electrical work.

B. Make arrangements for and pay for necessary permits, licenses, and inspections.

C. Determine and verify locations of all existing utilities on or near site:
   1. Cause as little interference or interruption of existing utilities and services as possible.
   2. Schedule work which will cause interference or interruption in advance with BNL, Architect, authorities having jurisdiction and all affected trades.
   3. Arrangements for interruptions shall be made one week in advance before proposed interruption.

D. Temporary construction power and communications (See Division 1).

E. Record drawings:
   1. Keep a complete set of all electrical drawings in job site office for indicating actual installation of electrical systems and equipment.
   2. Provide accurate record of routing of all concealed conduit.
   3. Use this set of drawings for no other purpose.
   4. Where any material, equipment, or system components are installed differently from that indicated, indicate differences clearly and neatly using ink or indelible pencil.
   5. At project completion, submit record set of drawings.

1.7 ENVIRONMENTAL CONDITIONS

A. General:
   1. Provide NEMA 1 enclosures for electrical equipment unless otherwise indicated.

B. Conduit: See Section 26 00 10.

C. Cable: See Section 26 05 19.

D. Boxes and Fittings: See Section 26 05 34.

E. Damp and wet locations:
   1. Exterior applications:
      a. Provide NEMA 3R enclosures for electrical equipment.

F. Hazardous locations:
   1. All equipment, wiring, devices, etc., within hazardous location(s) shall be of explosion-proof construction in strict accordance with NEC.
   2. All exposed non-current carrying parts of entire electrical system shall be grounded in hazardous location(s) in strict accordance with NEC.
   3. Hazardous locations shall be classified NEC Class 1, Division 2, Group B, C, and D:
      a. 1033 Flammable.

1.8 TEMPORARY POWER

A. See Section 01 50 00 – Temporary Facilities.

1.9 CLEANROOM PROTOCOL

A. All work within the clean zone shall be installed in accordance with Section 13 60 13 Special Clean Zone Requirements and 13032 Cleanroom Protocol.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Use only prime quality, new materials, apparatus and equipment.

B. Material and equipment: Current and standard design of manufacturers regularly engaged in their production.

C. Use UL labeled and listed electrical materials and fabricated assemblies.

D. Structural steel for supports: ASTM-A36:
   1. Galvanize members installed in areas of high humidity or condensation.
   2. Furnish other members with shop coat of rust inhibiting primer.
   3. Shop fabricate for field assembly using bolts.
   4. Minimize field welding.
   5. Retouch primer and galvanizing after field cutting or welding.

E. Rain hoods and counter flashings not exposed to view:
   1. Stainless steel: Minimum 20 GA.
   2. Sheet copper: Minimum 24 OZ.

F. Rain hoods and counter flashings exposed to view: As specified in Section 07 62 00.

G. Access doors, panels and frames: See Section 08 31 16:
   1. Provide access panels and/or doors at walls, and inaccessible ceilings as required to permit access to equipment, junction boxes, pull boxes, cable tray, and devices requiring service, adjustment, or inspection.
   2. Size:
      a. As required to allow access, inspection, service, and removal of items served.
      b. Minimum 18 x 18 IN.

2.2 FIRESTOPPING

A. Firestop all penetrations of fire rated walls, floors and assemblies:
   1. Penetrations shall comply with UL listing for construction or assembly.

B. Use materials and methods as specified in Section 07 84 00.

PART 3 - EXECUTION

3.1 GENERAL

A. Use only thorough, highly skilled, and experienced personnel.

B. When changes in location of any work are required, obtain approval of Architect before making change:
   1. Make changes at no extra cost.

C. Do not change indicated sizes without written approval of Architect.

D. Provide all necessary offsets and crossovers in conduits, raceways, cabletrays and ducts.

E. Install exposed conduits parallel to walls and ceilings and vertically plumb, unless otherwise indicated.

F. Where electrical items penetrate fire and/or smoke rated walls, ceilings and floors, comply with Section 07 84 00.

3.2 CUTTING AND PATCHING

A. Provide cutting, fitting, repairing, patching and finishing of installed work:
   1. Include installed work of other sections where it is necessary to disturb such work to permit installation of electrical work.
   2. Repair or replace existing or new work disturbed.

B. Avoid cutting, where possible, by setting sleeves or frames, and by requesting openings in advance.

C. Before cutting, obtain approval of Architect:
   1. Use only approved methods.
   2. Cut all holes neatly and as small as possible to admit work.
   3. Do not weaken walls or floors; locate holes in concrete to miss structural sections.

D. Locate openings and sleeves to permit neat installation of conduits and equipment.

E. Do not remove or damage fireproofing materials:
   1. Install hangers, inserts, supports, and anchors prior to installation of fireproofing.
   2. Repair or replace fireproofing removed or damaged, at no extra cost.

3.3 EXCAVATING AND BACKFILLING

A. Excavating, trenching, and backfilling:
   1. See Section 31 23 33.

3.4 INSTALLATION OF EQUIPMENT

A. Install all equipment in accordance with manufacturer's recommendations.

B. Provide all necessary anchoring devices and supports:
   1. Use structural supports suitable for equipment.
   2. Check loadings and dimensions of equipment with shop drawings.
   3. Do not cut, or weld to, building structural members.

C. Verify that equipment will fit support layouts indicated:
   1. Where substitute equipment is used, revise indicated supports to fit at no additional cost.

D. Arrange for necessary openings to allow entry of equipment:
   1. Where equipment cannot be installed as structure is being erected, provide and arrange for building-in of boxes, sleeves or other devices to allow later installation.

E. Make all penetrations through roofs prior to installation of roofing. For penetrations required after installation of roofing:
   1. In built-up roofing (BUR), provide all curbs, cants and base flashings.
   2. In standing-seam metal roof, arrange and pay for flashing work by authorized roofer.

F. Provide rain hoods and metal counter flashing and make all penetrations of electrical work through walls and roofs water and weathertight:
   1. Furnish all clamps, waterproofing material and labor necessary.
   2. Where metal flashings are applied over concrete, paint concrete with 1/8 IN of mastic cement first.
   3. Set flashing in mastic cement, watertight.

G. Pay for repair and replacement of roof construction, damaged by this work. Repairs shall be done in manner which will not nullify roof warranty.

H. Install equipment to permit easy access for normal maintenance:
   1. Maintain easy access to switches, motors, drives, pull boxes, receptacles, etc.
   2. Relocate items which interfere with access.

I. Provide concrete foundations or pads for all floor mounted electrical equipment:
   1. Provide 4 IN high concrete pads.
   2. Use minimum 3,000 PSI concrete in accordance with Division 3 requirements.
   3. Reinforce with 6 x 6 IN - W2.9 x W2.9 mesh, with short dowels into floor at 12 IN OC around perimeter.
   4. Chamfer top edges 3/4 IN.
   5. Make all faces smooth.
   6. Set anchor bolts for equipment.
   7. Pads: 2 IN larger than equipment base on all sides.

3.5 PAINTING

A. See Section 09 06 10.

3.6 FIELD QUALITY CONTROL

A. Perform indicated tests to demonstrate workmanship, operation, and performance:
   1. Conduct tests in presence of Architect and, if required inspectors of agencies having jurisdiction.
   2. Arrange date of tests in advance with Architect, manufacturer and installer.
   3. Give minimum of 24 hours notice to all inspectors.
   4. Furnish or arrange for use of electrical energy, steam, water, diesel fuel, or gas required for tests.
   5. Furnish all lubricating materials required for test.

B. Repair or replace equipment and systems found inoperative or defective and retest:
   1. If equipment or system fails retest, replace it with products conforming with Contract Documents.
   2. Continue remedial measures and retests until satisfactory results are obtained.

C. Test equipment and systems as indicated for each item, unless otherwise recommended by manufacturer.

3.7 FINAL PERFORMANCE TEST

A. Perform panel load balance, short circuit, and freedom from ground, and ground test (including ground fault protection where provided):
   1. As part of putting systems in operation, provide tabulated results of load balance and voltage at each switchboard, panelboard and motor control center. Use true RMS measuring metering devices.
   2. Provide written report that all circuits have been energized and no short circuits exist.
   3. Provide written report that the phase rotation of all distribution equipment and all three phase utilization equipment is in accordance with Brookhaven National Lab Standards.

3.8 ADJUST AND CLEAN

A. Inspect all equipment and put in good working order.

B. Clean all exposed and concealed items.

C. Where new work occurs in existing areas where no other work has been done, clean area and restore to original condition.

3.9 PUTTING SYSTEMS IN OPERATION - START UP

A. Put all systems into satisfactory operation prior to final acceptance, at time agreed to by General Contractor, BNL and Architect.

B. Operate all systems in good working order for period of 5 working days.

3.10 DEVICE MOUNTING

A. Dimensions are to center of device unless otherwise indicated. Coordinate outlet locations with all architectural millwork and/or casework elevations.

B. Locate exit signs and fire alarm flashing lights so that all are visible from all corridor locations.

C. Relocate signs as required to resolve conflicts.

3.11 IDENTIFICATION AND LABELING

A. Nameplates: Provide indoor/outdoor, scratch proof, sunlight resistant, 4 mil flexible pressure sensitive adhesive backed vinyl labels:
   1. Label shall be suitable for ambient temperatures of – 40 degF to 176 degF and subject to continuous exposure to alcohols, detergents, grease and oil:
      a. Equal to Brother PT-9400 or Brady Handimark.
   2. Provide background and text colors as follows:
      a. Fire Alarm System: Red with black text.
      b. Normal Distribution System: Black with white text.
      c. Emergency Branch (equipment served by EATS): Yellow with black text.
      d. Optional Standby Branch (equipment served by QATS): Green with black text.
   3. Unit substation:
      a. Provide nameplate on incoming and outgoing sections. Provide 3/4 IN high text indicating:
         1) Equipment name, ie.: "ISB Unit Substation USA".
   4. Switchgear, switchboard, distribution panel and motor control center nameplates:
      a. Center nameplate near top of first section. Provide 3/4 IN high text indicating:
         1) Equipment name and branch, i.e., "Panel XXXX - Life Safety Branch".
         2) Voltage, phase and wire, i.e., "480Y/277V, 3 Phase, 4 Wire".
         3) Source, i.e., "Source - Switchboard XXXX".
      b. Provide similar nameplates for each main and feeder device. Mount label adjacent to or on cover of device. Provide 1/4 IN high text indicating:
         1) Description of load, i.e., "Load - Panelboard XXX".
   5. Panelboard nameplates:
      a. Center nameplate near top of each section. Provide 1/2 IN high text indicating:
         1) Equipment name and branch, i.e., "Panel XXXX - Life Safety Branch".
         2) Voltage, phase and wire, i.e., "480Y/277V, 3 Phase, 4 Wire".
         3) Source, i.e., "Source - Switchboard XXXX".
   6. Disconnect switches, transformers, contactors, thermal element switches, starters, etc. nameplates:
      a. Center nameplate near top of face plate or cover. Provide 1/4 IN high text indicating:
         1) Description of load, i.e., "Load - AHU-XXX".
         2) Source, i.e., "Source - MCC-XXXX".
   7. Transfer switches:
      a. Center nameplate near top of cover. Provide 1/2 IN high text indicating:
         1) Description of load, i.e., "Distribution Board XXXX - Life Safety Branch".
         2) Normal source, i.e., "Normal Source - Switchboard XXXX".
         3) Emergency source, i.e., "Emergency Source - Switchboard XXXX".
   8. Fire alarm, security, laser entryway control, and other system control cabinet nameplates:
      a. Center nameplate near top of cover. Provide 1/2 IN high text indicating:
         1) Description of system, i.e., "Fire Alarm System Control Panel".
   9. Relays and relay cabinet nameplates:
      a. Center nameplate near top of cover. Provide 1/2 IN high text indicating:
         1) Description of item controlled, applicable system or function and type of device, i.e., "AHU-XXX FA Shut Down Relay" or "Lighting Relay Cabinet XXX".

B. Device plates: See Section 26 27 26.

C. Paint outlet boxes, junction boxes and enclosures, except switchboard and panelboard enclosures, for emergency circuits as follows:
   1. Fire Alarm System: Red.
   2. Emergency Branch (equipment served by EATS): Yellow.
   3. Optional Standby Branch (equipment served by QATS): Green.

D. Paint all fire alarm and emergency system feeder conduits with 2 IN wide band 10 FT on center as scheduled in Paragraph C above:
   1. Pressure-sensitive, color-impregnated tape will be acceptable.

E. Pull and junction boxes for feeders:
   1. Provide wrap-on wire markers on each conductor indicating source i.e., "Source – Switchboard XXXX" and load i.e., "Load – Panelboard XXXX".

F. Pull and junction boxes for branch circuits:
   1. Indicate, on cover, the panel and circuit number(s) using permanent marker pen.
   2. Where two or more neutrals of the same phase are provided, permanently mark each neutral with its associated phase conductor(s).

G. Conductor identification:
   1. Provide wrap-on wire markers on each conductor in panelboard, switchboard, terminal strips, etc. Marker shall indicate pole or terminal strip position. Control wire mark shall match equipment manufacturers shop drawings. Wire markers shall be Thomas and Betts Type WBC.

H. High voltage signs:
   1. All distribution equipment rated over 600 volts and/or pull and junction boxes containing conductors rated over 600 volts shall have a sign posted on the front and rear as applicable:
      a. 1 to 1-1/2 IN high red letters stenciled on a 3 IN high white background.
      b. Sign shall read, "DANGER -- HIGH VOLTAGE".

I. Identification of working space:
   1. Provide orange hazard tape on the floor at all electrical equipment indicating the width and depth of the minimum working clearances indicated in NEC Article 110.26:
      a. Tape shall be 2 IN wide solid orange abrasion resistant high strength polyethylene with pressure sensitive adhesive back and suitable for permanent floor applications.
      b. Provide tape at all 120 volt and above electrical equipment including panelboards, relay cabinets, transformers, motor control centers, disconnect switches, starters, adjustable emergency drives, etc., which are located in any space other than the main electrical room and the exterior service yards.

END OF SECTION

SECTION 26 00 11
WIRING EQUIPMENT FURNISHED BY OTHERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide all conduit, wiring, outlet boxes, receptacles, circuit breakers, fittings, switches, starters, (with overloads) etc., to make final connections to all equipment.

B. Connect:
   1. Elevator equipment, (Division 14).
   2. Heating, ventilation, cooling and plumbing system equipment, (Division 23).
   3. Automatic door equipment, (Division 8).
   4. Projection screens, (Division 11).
   5. Fixed and/or movable equipment, (Division 11).

PART 2 - PRODUCTS

2.1 ELEVATOR

A. Provide following for each elevator:
   1. Shunt trip circuit breaker:
      a. Locate on wall near door of machine room.
      b. Provide conduit and wire from switch to controller.
   2. 30 A S/N, 120V disconnecting switch for 120V power supply for controls and signal circuit:
      a. Locate adjacent to elevator switch.
      b. Provide conduit and wire for switch to controller.
      c. Connect to shunt trip circuit breaker.
   3. 30A S/N, 120V disconnect switch for car lights and fan:
      a. Locate adjacent to elevator switch. Extend circuit to J-box at midpoint of shaft as directed by elevator installer.
   4. 120V GFCI duplex receptacle and vapor-tight fixture in each elevator pit, with switch located 48 IN above pit floor.
   5. Telephone outlet J-box with empty 3/4 IN conduit to telephone cabinet:
      a. Locate at midpoint of each shaft or at elevator controller as directed by elevator installer.

2.2 DIVISION 23 EQUIPMENT

A. Provide all conduit, wire, and connect all Division 23 Equipment.

B. Provide all motor starters except where AFD's or packaged or prewired units are indicated in Mechanical Equipment Schedule:
   1. Connect all motors.
   2. Provide starters with solid state overload protection for all motors not having such protection, except as otherwise indicated.
   3. Starters: See Section 26 24 19.

C. Coordinate solid state overload settings with installed motors.

D. Mount adjustable frequency drives furnished by Division 23:
   1. Mount AFD's in accordance with manufacturer's recommendations and instructions.
   2. Connect line and load power circuits.
   3. Provide working clearances in accordance with NEC.

4. Mount floor mounted units on 4 IN housekeeping pad.
5. Mount wall mounted units on room walls, columns, or free standing steel supports.
6. Wall mounted units may be mounted on the air handling unit casing. Provide bracing and coordinate with air handling unit manufacturer.

2.3 AUTOMATIC DOOR EQUIPMENT

A. Provide all conduit, wiring, outlet boxes, etc., to make final connections to all motors, switches, safety mats, proximity detectors, remote control units, electric dead bolts.

B. Switches for control of automatic doors furnished by door manufacturer, installed by electrical.

C. See Section 28 31 00 for connections to fire alarm system.

2.4 PROJECTION SCREENS

A. Provide all conduit, wiring, outlet boxes, etc., to make final connections to power projection screens and associated UP/STOP/DOWN switches.

B. UP/STOP/DOWN switches furnished by door manufacturer, installed by electrical.

2.5 DIVISION 11 EQUIPMENT

A. Provide all conduit, wiring, outlet boxes, receptacles, circuit breakers, fittings, switches, etc., to make final connections to all equipment.

B. Where equipment items are to be connected using plug and receptacle, provide receptacle compatible with plug.

C. Where equipment is to be directly connected, use flexible conduit as indicated in Section 26 05 33.

D. See Division 11 and electrical plans for equipment to be connected.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install components in accordance with manufacturer's recommendations and instructions.

B. Perform work in accordance with applicable Division 26 sections.

C. Wire equipment complete properly connected and energized.

D. Provide conduit and wiring as required for directly-connected switches as indicated or required.

END OF SECTION

SECTION 26 05 13
MEDIUM VOLTAGE CABLE

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. EPR insulated cable shall comply with the following:
   1. NEMA Publication No. WC 74-2000, ICEA Publication S-93-639, 5-46 kV Shielded Power Cable for Use in the Transmission & Distribution of Electric Energy,
   2. AEIC (Association of Edison Illuminating Companies) Publication No.CS-6, Specifications for Ethylene Propylene Rubber Insulated Shielded Power Cables Rated 69 KV
   3. UL1072 Medium Voltage Power Cables.

B. Splices and terminations shall comply with the following:
   1. IEEE 404- IEEE Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 to 500000 V
   2. IEEE 48- IEEE Standard Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV through 765 kV.
   3. IEEE 386- IEEE Standard for Separable Insulated Connector System for Power Distribution Systems above 600 V.

C. High potential testing shall comply with the following:
   1. IEEE 400-IEEE Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems.
   2. IEEE 510- IEEE Recommended Practices for Safety in High-Voltage and High-Power Testing.
   3. InterNational Electrical Testing Association (NETA)- Acceptance Testing Specifications For Electrical Power Distribution Equipment and Systems.

D. Qualifications:
   1. Cable technician:
      a. Five years experience in handling, terminating and splicing medium voltage cables.
      b. Specifically trained by a factory representative on the terminations and splices to be used on the project. If not trained on the products to be used, on-site training by the factory representative shall be preformed before any terminations or splices are made.
   2. Cable testing :
      a. Cable testing may be performed by the Contractor.
      b. The cable tester shall have been engaged in full practice in the final inspection, testing, calibration, and adjusting of electrical distribution systems, for a minimum of five years.
      c. The cable tester shall have a calibration program with accuracy traceable every six months in an unbroken chain, to the National Institute of Standards and Technology (NIST).
      d. Cable testing shall be in accordance with the following safety standards:
         1) OSHA
         2) NFPA 70E
         3) IEEE 510
      e. Inspection, testing, and calibration shall be performed by an acceptable engineering technician, with a minimum of five years experience inspecting, testing, and calibrating electrical equipment, systems and devices. Qualification of engineering technician shall be submitted to the Engineer for approval prior to the start of work.

1.2 SUBMITTALS

A. Product data:
   1. Technical data on each type of cable.
   2. Technical data on each type of splice and termination.

B. Samples:
   1. Cable sample: Not to be returned. Length submitted to include all stamped on information including:
      a. Manufacturers name.
      b. Plant number or designation.
      c. Conductor size.
      d. Copper.
      e. Voltage rating.
      f. Insulation type and level.
      g. Insulation thickness.
      h. UL designation.
      i. Type MV-105.

C. Project information:
   1. Cable Technician qualifications.
   2. Engineering Technician qualifications.
   3. Cable pulling tension record from pulling rig dynamometer.
   4. Cable test reports signed by the engineering technician including the following information:
      a. Summary of Project.
      b. Description of equipment/components tested.
      c. Visual inspection report.
      d. Description of tests.
      e. Test results including appropriate test forms.
      f. Conclusions and recommendations.
      g. Identification of test equipment used.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Ship cable with removable watertight end seals, and store in dry place.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Medium voltage cable:
      a. Base:
         1) Okonite.
         2) Kerite.
         3) Southwire.
         4) Pirelli Cable.
         5) American Insulated Wire.
   2. Splices and terminations:
      a. Base:
         1) 3M.
         2) Raychem.
         3) Elastimold.
         4) Cooper Power Systems.
   3. High dielectric, arc proof and insulating tape:
      a. Base:
         1) 3M.

2) Okonite.

2.2 MEDIUM VOLTAGE POWER CABLE

A. Medium voltage cable: Single conductor, copper, rated 105 degC wet or dry, EPR, 133 percent insulation level, Type MV-105.
   1. 15 kV rated, 5.6 mm, 220 mil average thickness.
   2. Minimum spot thickness 90 percent of average thickness.

B. Cable shall be no more than 12 months old and each reel shall have label indications name of manufacturer and date of manufacture.

C. Conductor: Compressed concentric round, Class B, stranded, annealed base copper.

D. Conductor shield: Free stripping layer of extruded semi-conducting EPR firmly bonded to the insulation.

E. Insulation: Ethylene Propylene Rubber (EPR).

F. Insulation shield: Free stripping layer of extruded semi-conducting EPR.

G. Shield: Helically applied 0.13 mm, 5 mil uncoated copper tape overlapped a minimum of 12.5 percent.

H. Outer jacket: Oil and sunlight resistant PVC.

I. Armor: None.

J. Armor Jacket: None.

2.3 SPLICES AND TERMINATIONS

A. Splicing and terminating materials:
   1. Acceptable to and as recommended by cable manufacturer.
   2. Equal to or exceed rating of cable.

B. Splices: Hot shrink manufactured kit type in accordance with IEEE 404 and suitable for water immersion.
   1. Conductor splices: Compression type.
   2. Insulation, shield and jacket splices:
      a. In-line splices: Raychem HVS 1520S Series.
      b. Wye splices: Raychem HVSY 1520S Series.

C. Terminations:
   1. Within substation enclosures: Hot shrink manufactured kit type in accordance with IEEE 48 Class 1 terminations utilizing high dielectric constant stress control tube:
      a. Conductor termination: Compression type lug.
      b. Insulation, shield, and jacket terminations: Raychem HVT-150-SG Series.
   2. Within 15 kV pad mounted SF6 switch enclosures: Deadfront, modular, separable insulated connectors in accordance with IEEE 386.
      a. 600A deadbreak elbows with pulling eye, grounding eye and test point.
         1) Elbows shall be compatible with other manufacturers of deadbreak bushings.
         2) Refer to Section 15 kV Pad Mounted SF6 Switch for deadbreak bushings.
         3) Cooper Power Systems 600 Series.

2.4 ARC PROOF TAPE

A. Flexible, conformable, organic fabric coated one side with flame-retarded flexible elastomer; self-extinguishing; and shall not support combustion.

B. 3M Scotch 77.

2.5 INSULATING TAPE FOR USE WITH ARC PROOF TAPE

A. Woven glass fabric with pressure-sensitive thermosetting adhesive.

B. 3M Scotch 69.

2.6 PULLING LUBRICANT

A. Pulling lubricant: Approved by cable manufacturer.

PART 3 - EXECUTION

3.1 CABLE PULLING

A. Do not install cable during wet conditions.
   1. Prior to pulling cables, drain or pump out manholes and other low points if standing water is present.
   2. Blow out conduits with dried compressed air if moisture is present in conduits.
   3. Install end caps immediately on all cut ends of cable prior to pulling, and maintain end caps while pulling in cable.
      a. If end caps are damaged, remove and install new end caps.
      b. Do not remove end caps until ready to terminate or splice cable.

B. Do not install conductors when ambient temperature is near minimum as recommended by manufacturer for installation of the type of conductor insulation.

C. Set up reels as close to duct entrance as possible.

D. Do not bend cable permanently or temporarily to radius less than 12 times cable diameter.

E. Provide cable protector at duct entrance.

F. Pull all cables occupying same conduit together.

G. Make attachment to cable to be pulled by woven basket grips or directly to conductor.

H. Use swivel connector.

I. Seal cable ends.

J. Use no pulling lubricant on first or last 5 FT of cable.

K. Pull cables slowly and steadily:
   1. Do not exceed 50 FPM.
   2. Stop only if absolutely necessary.

L. Maximum pulling tension on conductor not greater than smaller of following:
   1. Manufacturer's allowable tension.
   2. 0.008 LB/cm x cm for copper conductors when pulling eye is employed where cm is the circular mill area of single conductor, total area of the several conductors in a single cable, or the total area of conductors of all cables pulled at the same time.
   3. 5000 LB.

M. Tension on pulling devices not greater than the smaller of the following:
   1. Manufacturer's allowable tension.
   2. 1000 LB per grip when basket grip is employed.

N. Tension limiting side wall pressure not greater than the smaller of the following:
   1. Manufacturer's allowable tension.
   2. 300 LB per mm foot for radius of curvature.

O. Provide pulling rig with pulling tension indicating and recording dynamometer.
   1. Submit record of the actual pulling tension of each cable pull. Submittal shall indicating compliance with allowable pulling tension.

2. Replace cables when actual pulling tensions exceeds the allowable pulling tension.

3.2 SPLICING AND TERMINATING

A. Install splices and terminations acceptable to the cable manufacturer and in accordance with the splice and termination kit manufacturer's instructions.

B. Splices and terminations shall be performed by qualified individual(s) with a minimum of five years of experience in splicing and terminating the same or similar types of cable, splices and terminations approved for installation.

C. Ground shield at each termination.

3.3 ARC-PROOFING

A. Install one 1/4 IN, minimum, overlapped layer of arcproof tape on all cable exposed in manholes and pull and junction boxes. Bind with one layer of glass cloth insulating tape.

3.4 TESTING OF CABLES

A. Field tests: Comply with following requirements:
   1. After all terminations and splices have been made, and prior to connections to equipment, provide following acceptance tests:
      a. Shield continuity test.
      b. DC high potential tests.
   2. New Cable:
      a. Tests shall be performed and submitted on new cable.
      b. Test new cable after installation, splices and terminations have been made but before connection to equipment and existing cables.
   3. Existing Cables:
      a. Test shall be performed and submitted on existing cable interconnected to new cable.
      b. After testing new cable and connection to existing cable has been completed, test interconnected cable. Disconnect cable from all equipment that might be damaged by test voltages.
   4. High Potential Test:
      a. Leakage current test shall be high potential D.C. step voltage method.
      b. Prior to high potential test, test cable and shields for continuity, shorts, and grounds.
      c. High potential test shall measure leakage current from each conductor to insulation shield. Use corona shields, guard rings, taping, mason jars, or plastic bags to prevent corona current from influencing readings. Unprepared cable shield ends shall be trimmed back one inch or more for each 10kV of test voltage.
   5. Safety Precautions:
      a. Exercise suitable and adequate safety measures prior to, during, and after high potential tests, including but not limited to placing warning signs and preventing people and equipment from being exposed to test voltages.
   6. Test Voltages:
      a. New shielded cable D.C. test voltages shall be as follows:

Rated Circuit Voltage Phase-to Phase Volts	Wire Size AWG or MCM	Test Voltage kV 133 Percent Insulation Level
2001-5000	2-1000	25
5001-8000	2-1000	35
8001-15000	2-1000	65

      b. Existing cable of all types interconnected to new cable shall be tested at 1.7 times existing cable rated voltage.
   7. High Potential Test Method:

a. Apply voltage in approximately 8-10 equal steps.
b. Raise voltage slowly between steps.
c. At end of each step, allow charging currents to decay, and monitor time interval of decay.
d. Read leakage current and plot curve of leakage versus test voltage on graph paper as test progresses. Read leakage current at same time interval for each voltage step.
e. Stop test if leakage currents increase excessively or “knee” appears in curve before maximum test voltage is reached.
    1) For new cable, replace cable and repeat test.
    2) For existing cable interconnected to new cable, notify BNL for further instructions.
f. Upon reaching maximum test voltage, hold voltage for five minutes. Read leakage current at 30- second intervals and plot curve of leakage current versus time on same graph paper as step voltage curve.
    1) Stop test if leakage current starts to rise, or decreases and again starts to rise. Leakage current should decrease and stabilize for acceptable cable.
g. Terminate test and allow sufficient discharge time before testing next conductor.

8. Replace all cable that fails testing.
    a. Any cable which has terminations and/or splices which are suspected to have caused failure under criteria for resistance decrease or disparity of insulation values may be re-terminated and/or re-spliced and retested.
    b. Second failure shall be cause for replacement.
    c. In all cases where cable is questionable due to testing results, Architect/Engineer will determine replacement requirements.
9. Retest all replaced cable.
10. Submit complete test results.

END OF SECTION

SECTION 26 05 19
LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SCOPE

A. Feeders, 600 volt and below, shall be copper conductors in conduit.

B. Branch circuits, 600 volt and below, from the branch circuit panelboards to the outlet or utilization equipment shall be copper conductor in conduit. Type MC Metal Clad cable may be used concealed above accessible ceilings and within drywall partitions. Type MC metal clad cable may be used exposed directly above branch circuit panelboards.

1.2 SUBMITTALS

A. Product data.
   1. Type MC Metal Clad cable.

B. Project information:
   1. Test report.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Splices and taps for smaller than No.6 AWG wire:
      a. Base:
         1) 3M.
         2) Ideal Electric.
         3) Heyco Molded Products.
         4) Elastimold.
         5) Buchanan Construction Products.
   2. Type MC Metal Chad cable:
      a. Base:
         1) AFC Cable Systems.
         2) Okonite.
         3) Southwire.

B. Wire for 600 volts and below: Single conductor, soft drawn, copper wire with 600 volt insulation, UL listed.
   1. For feeders and branch circuits: Type THWN/THHN or XHHW.
   2. For exterior feeder and branch circuits: Type XHHW.
   3. For branch circuits served by GFCI circuit breakers: Type XHHW.
   4. Use no wire smaller than No.12 AWG, except as follows:
      a. Smaller size wire may be used only where specifically indicated.
      b. No.14 AWG may be used for pilot control and signal circuits.
   5. Size conductors to match over current protective device unless larger conductors are indicated.
   6. No.10 and smaller wire: Solid conductor.
      a. Provide stranded conductor between adjustable frequency drives and their motor(s) served.
   7. No. 10 AWG conductor to be used for 20 ampere, 120V circuits exceeding 100 FT.
   8. No. 10 AWG conductor to be used for 20 ampere, 277V circuits exceeding 200 FT

C. Splices and taps for smaller than No.6 AWG wire:
   1. 3M, "Scotchlok" or "Hyflex".
   2. Ideal "Wingnut" or "Wirenut".
   3. Heyco.
   4. Elastimold insulated conical spring-type connectors.

D. Splices and taps for No.6 AWG wire and larger: Use compression connectors with prestretched insulation to equal insulation of wire being spliced.

E. Splices and taps - General: Do not make splices and taps with crimp or indenter-type connectors.

F. Pulling lubricant: Water based type containing no waxes, greases, silicones or polyalkylene glycol oils or waxes. Lubricant shall be compatible with conductor and approved by conductor manufacturer.

G. Color coding: Color code all conductors in accordance with NEC as follows:
   1. Color code all wiring.
   2. Use following colors in lighting and power wiring:

	208Y/120 VOLT	480Y/277 VOLT
Phase 1	Black	Brown
Phase 2	Red	Orange
Phase 3	Blue	Yellow
Neutrals	White	Gray
Ground	Green	Green

   3. Color shall be solid and continuous throughout the entire length of the conductor. Color coding at conductor ends is not acceptable.
   4. Use following colors in single phase lighting and receptacle circuits:
      a. Separate neutral associated with 120 volt, Phase 1: White with three continuous black strips for the entire length of the conductor.
      b. Separate neutral associated with 120 volt, Phase 2: White with three continuous red strips for the entire length of the conductor.
      c. Separate neutral associated with 120 volt, Phase 3: White with three continuous blue strips for the entire length of the conductor.
      d. Neutral for 208V single phase and three phase circuits: White.
      e. Neutral for 480 volt single phase and three phase circuits: Gray.
   5. Isolated equipment grounding conductor: Green with one or more yellow stripe(s).
   6. Provide label for conductor color code at all panelboards.

H. Type MC Metal Clad cable: Multi-conductor type THHN 600 volt insulated copper conductors with a polypropylene assembly tape over all conductors and all within an interlocking galvanized steel or aluminum armor:
   1. Listed per UL 1569 Metal Clad cable.
   2. Suitable for use in environmental air handling spaces.
   3. Maximum of three phase conductors per cable.
   4. Conductors shall be color coded as specified above.
   5. Provide insulated equipment grounding conductor.
   6. Fittings shall be steel or malleable iron, clamp type with insulating throat and UL listed for use with type MC cable.
   7. AFC Cable Systems, Inc Type MC.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lighting and receptacle home runs indicated are for identification purposes only.

B. Install all line voltage and low voltage wiring in conduit unless otherwise indicated.

C. Install conductors per manufacturers recommendation. Do not exceed allowable pulling tension.

D. Install no more than 3 phase conductors in one conduit.

E. The neutral conductor shall be considered as a current carrying conductor.

F. Provide a separate neutral conductor for each phase conductor in all branch circuits including lighting circuits. Shared (common) neutrals in multi-circuit homeruns are unacceptable.

G. Provide secondary feeders from K-rated transformers with neutral conductors sized at 200 percent of the phase conductor size.

H. In laboratory and service galley surface metal raceways, twist the phase, neutral, and isolated equipment grounding conductors of each circuit within the surface metal raceway. Provide a minimum of three twists per foot of circuit. Conductors shall be twisted prior to placement within raceway. Tie-wrap conductors adjacent to each device and at maximum two foot increments.

I. Twist phase conductors between adjustable frequency drive (AFD) and motor in all motor circuits controlled by AFD. Provide a minimum of three twist per foot of circuit. Conductors shall be twisted prior to pulling into conduit.

J. Install no more than 30 current carrying conductors in surface raceways or any compartment within a multi-compartment wireway.

K. Provide neutral in all circuits serving lab areas including circuits to: 250V, 2P, 3W, single phase grounding receptacles; 250V, 3P, 4W, three phase grounding receptacles; junction boxes for hardwired equipment; and to all disconnect switches. Leave slack for future connection to device or equipment. Provide insulated connector at end of conductor.

L. Provide green insulated equipment grounding conductor in all circuits.

M. Provide isolated equipment grounding conductor to all isolated ground receptacles.

N. Provide conductor identification as indicated in Section 26 00 10.

3.2 TYPE MC METAL CLAD CABLE

A. Install cable in accordance with manufacturer’s written instruction.

B. Cable shall be concealed above accessible ceilings and within drywall partitions or exposed directly above branch circuit panelboards located in electrical or mechanical rooms.

C. Cable shall be routed parallel or perpendicular to structure.

D. Cables shall be independently supported.

E. Damaged cable shall be replaced.

3.3 TESTING

A. Perform insulation resistance test on each feeder conductor.

B. Testing may be performed by the Contractor.

C. Testing shall be in accordance with conductor manufacturer's recommendations.

D. Provide test report of all tests performed.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Shop drawings:
   1. Ground grid.

B. Product data:
   1. Technical data on each component.

C. Project information:
   1. Test reports.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Ground rods:
      a. Base:
         1) Eritech.
      b. Optional:
         1) Blackburn.
         2) Harger.
   2. Exothermic weld kits:
      a. Base:
         1) Cadweld.
      b. Optional:
         1) Thermoweld.
         2) Harger.

B. Ground rods:
   1. Ground rods shall be two section copper-clad steel with high strength steel core and electrolytic grade copper outer sheath molten welded to core. Length and manufacturer's name shall be stamped at top. Size shall be 3/4 IN diameter and 10 FT long.

C. Conductors:
   1. Wire and cable: As specified in Section 26 05 19.
      a. Below grade conductors shall be bare copper cable.
      b. Above grade conductors shall be insulated copper cable except bare conductors which are indicated within enclosures.
   2. Ground bus shall be bare annealed copper bar minimum 1/4 IN x 4 IN x length indicated.

D. Connectors:
   1. Welded connections shall be exothermic type. Kits shall be of the proper type and size for conductors or other material being connected.
   2. Pressure and compression type connectors shall be as specified in Section 26 05 19.
   3. Conduit hubs shall be cast bronze.
   4. Pipe clamps shall be heavy duty cast bronze.
   5. Soldered connections are unacceptable.

E. Instrument reference terminal strip:
   1. Provide with three 1/4 IN copper threaded screw binding post with insulated mounting and 3/4 IN cap nut. Equal to Hampden HB series.
   2. Provide copper ground bar between binding post equivalent to #6 AWG.
   3. Provide lug for terminating #6 ground conductor.
   4. Mount binding post on cover-plate. Cut holes to prevent rotation of binding post.
   5. Binding post, ground bar, lug and grounding conductor shall be insulated and isolated from all other material.
   6. Provide label with 1/4 IN high black letters on green background "Instrument Reference Ground".
   7. Flush mount in minimum 4 gang back box with stainless steel cover-plate where indicated.
   8. Surface mount in minimum 3 IN x 2-1/4 IN x 8 IN aluminum housing with aluminum cover-plate where indicated.

F. Conduit:
   1. Conduit shall be as specified in Section 26 05 33.

G. Conduit fittings:
   1. Grounding locknuts and insulated grounding bushings shall be as specified in Section 26 05 34.

PART 3 - EXECUTION

3.1 GENERAL

A. Ground electrical system, raceway systems, enclosures, equipment, etc., in accordance with NEC and authorities having jurisdiction.

B. Where sizes and quantities indicated differ from NEC requirements, provide the larger sizes and quantities.

C. Where conductors are installed in steel conduit, bond conductor to each end of the conduit.

D. Seal conduit where direct buried conductors enter the conduit.

3.2 INSTALLATION

A. Grounding electrode system:
   1. Install ground grid with perimeter and cross conductors and ground rods as indicated on Drawings.
   2. Conductors shall be bare copper embedded in the concrete foundation or direct buried minimum 36 IN below finish grade or below slab-on-grade.
   3. Install ground rods where indicated to a depth where a minimum 6 IN from top of rod to finish grade is provided. Provide test wells where indicated on drawings.
   4. All below grade connections shall be exothermically welded.

B. Substation Grounding.
   1. Ground substation and perimeter fence as indicated on Drawings and in accordance with IEEE Standard 80-2000 Guide for Safety in AC Substation Grounding.

C. Grounding riser.
   1. Install grounding buses where indicated and of the sizes indicated on the Drawings.
   2. Interconnecting grounding buses with insulated grounding conductors and of the sizes indicated on the Drawings.
   3. Install grounding electrode conductors, bonding jumper (when not routed with phase conductors), and instrument reference ground conductors in PVC conduit.
   4. Connect conductors to bus with two hole compression lugs.
   5. Each instrument reference ground bus shall be the single point ground for that associated lab module.

6. Interconnect instrument reference terminal strips in a radial configuration. Loops and daisy chains are unacceptable.
7. The instrument reference ground system shall be completely insulated and isolated from all other material.

D. Bonding of piping systems:
1. Provide bonding jumper from electrical equipment room ground bus to metal piping systems including but not limited to:
   a. Domestic water.
   b. Fire water.
   c. Chilled water supply.
   d. Chilled water return.
   e. Steam supply.
   f. Condensate return.
   g. Compressed air.
2. Bonding jumper shall be minimum #4/0.

E. Separately derived systems:
1. Separately derived systems include:
   a. Substation transformers.
   b. Dry type transformers.
   c. Standby generator.
2. Connect grounding electrode conductor from:
   a. Substation transformer to:
      1) Substation yard grounding electrode system.
   b. Lab dry type transformer to:
      1) Nearest building steel.
      2) Associated lab power system ground bus.
   c. Other than lab dry type transformer to:
      1) Nearest building steel.
   d. Standby generator to:
      1) Substation yard grounding electrode system.
3. Grounding electrode conductor shall be unspliced and in conduit in accordance with NEC Article 250-66 unless indicated larger on drawings.
4. Provide main bonding jumper between neutral and ground terminals.
   a. Provide mean to isolate neutral.
      1) Provide disconnecting link at main switchboard.
   b. Main bonding jumper shall be the same size as the grounding electrode conductor.

F. Equipment grounding conductor:
1. Install separate green insulated equipment grounding conductor in all feeders and in all branch circuits. Install equipment grounding conductor in the same raceway as the circuit conductors. Size shall be in accordance with NEC Article 250-122 unless indicated larger on drawings.
2. Ground raceways, enclosures, equipment, etc., to provide a complete and redundant equipment grounding conductor.
   a. Where nonmetallic conduit is used, the insulated equipment grounding conductor shall be the sole type of equipment grounding conductor.
3. Where metallic conduits terminate without mechanical connection to metallic enclosures (stub-ups at equipment enclosures) provide each conduit with a grounding type insulated bushing. Bond each bushing to the grounding bus within the enclosure with bare copper conductor.
4. Where metallic conduits connect to metallic enclosure through knockouts, bond conduit to enclosure with bonding bushing, bonding locknuts or bonding jumper.
5. Install grounding screw or grounding clip in outlet boxes. Provide bonding jumper from outlet box to ground terminal of grounding receptacles except where isolated ground receptacles are provided.

G. Isolated equipment grounding conductor:
   1. Install insulated and isolated equipment grounding conductor in 208Y/120 volt systems serving sensitive electronic lab equipment. Install isolated equipment grounding conductor in same raceway as equipment grounding conductor. Size shall be the same size as the equipment grounding conductor unless indicated larger on drawings.
   2. Isolated equipment grounding conductor shall be bonded to the equipment grounding conductor at the shielded isolation transformer. No other intentional or unintentional contact shall be made with the equipment grounding conductor.
   3. Provide insulated and isolated grounding terminal strip in electronic grade panelboards.
   4. Connect isolated equipment grounding conductor to ground terminals of isolated ground receptacles.
   5. In laboratories where direct connected equipment is indicated to have an isolated ground, provide insulating non-metallic raceway fitting at the point of attachment of the raceway to the equipment. Connect isolated equipment grounding conductor to ground terminals of equipment.

H. Instrument reference terminal strip: Install where indicated on drawings. Connect to instrument reference grounding bus with #6 in PVC conduit.

I. Hazardous locations:
   1. Provide grounding in accordance with NEC Article 501.
   2. Provide ground bus and bond #10 AWG exposed insulated conductor to all non-current carrying metallic surfaces within classified location.

3.3 TESTING

A. Provide earth resistance test of grounding electrode system. Perform test using fall of potential method in accordance with IEEE Standard 142. Perform test at least 48 hours after any precipitation.

B. Remove neutral disconnecting links and main bonding jumpers at switchgear and unit substations and provide ground megger test of neutral system. Perform test at each unit substation. Temporarily disconnect all TVSS equipment during test. Reconnect upon completion of test.

C. Remove main bonding jumper at the generator and at all dry type transformers and provide ground megger test of neutral system. Perform test at each separately derived system. Temporarily disconnect all TVSS equipment during test. Reconnect upon completion of test.

D. Remove bonding jumper from isolated equipment grounding terminal at panelboard and/or shielded isolation transformer serving electronic grade panelboards and provide ground megger test of isolated equipment grounding conductor. Perform test at each electronic grade panelboard. Temporarily disconnect all TVSS equipment during test. Reconnect upon completion of test.

E. Remove bonding jumper(s) and conductor to building ground grid from instrument reference ground bus and provide ground megger test of instrument reference ground system. Perform test at each instrument reference ground bus. Reconnect upon completion of test.

F. Provide test reports of all tests performed. For grounding electrode system resistance test provide weather observations.

END OF SECTION

SECTION 26 05 33
CONDUITS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Conduit runs are diagrammatic. Verify locations in field.

1.2 SUBMITTALS

A. Shop drawings:
   1. Conduit routing indicating: (If conductors within the conduit are twisted.)
      a. Size.
      b. Elevation.
      c. Material type.

B. Product data:
   1. Sealers.

C. Contract closeout information:
   1. As-build drawings with plans and elevations indicating routing with dimensions of concealed conduit in floors and walls.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Steel conduit:
      a. Base:
         1) Allied Tube & Conduit.
         2) LTV Conduit.
         3) Republic Steel.
         4) Triangle Wire & Cable.
         5) Wheatland Tube.
         6) Youngstown.
   2. PVC coated steel conduit:
      a. Base:
         1) Robroy Industries.
         2) Occidental Coating.
         3) Schuller International.
   3. Neoprene coated flexible steel conduit:
      a. Base:
         1) Anaconda.
         2) Electri-Flex.
         3) Kellems.
   4. PVC conduit:
      a. Base:
         1) Carlon Electrical Products.
         2) Ethyl.
         3) Cantex.
         4) Condux.

B. Conduit:
   1. Rigid steel conduit (RGS):
      a. Hot dipped galvanized exterior coating.
      b. Enamel or lacquer baked-on interior.
      c. In accordance with underwriter's laboratories UL 242.
   2. Intermediate metal conduit (IMC): Steel.
      a. Hot dipped galvanized exterior coating.
      b. Enamel or lacquer baked-on interior.
      c. In accordance with underwriter's laboratories UL 6.
   3. Thinwall electrical metallic tubing (EMT): Steel.
      a. Electro-galvanized zinc exterior coating.
      b. Lacquer coated interior.
      c. In accordance with underwriter's laboratories UL 797 and Federal Spec WWT-806V.
   4. Flexible steel conduit for motor and equipment connections: Galvanized with continuous copper content or separate grounding conductor.
      a. Neoprene-coated type: With approved liquid-tight connectors; Anaconda Seal-Tite type LIA.
   5. Rigid PVC conduit: High impact polyvinyl chloride, meeting minimum requirements of NEC.
      a. Concrete encased: Carlon Electric Products, Type 40.
      b. Fittings: PVC, solvent weld type, with connectors and threaded adapters as required.
   6. Stamp each length with name or trade mark of manufacturer, nominal trade size, type of material, and affix UL label.
   7. PVC coated steel conduit: Galvanized rigid steel conduit with 40 mils minimum coating of PVC.

2.2 SUPPORTS, SLEEVES AND SEALS

A. Conduit hangers - General: Threaded rods minimum 1/4 IN, with straps or clamp conduit holder.
   1. Do not use the following to support conduit:
      a. Wire including ceiling support wires.
      b. Perforated strap hangers.
      c. Plastic or nylon tie wraps.
   2. Use trapeze assemblies for multiple conduits.
   3. Provide sufficient hangers for support of electrical work and equipment to limit load on single hanger to 25 LB, maximum.
      a. Conduit 1 IN and smaller shall be supported at maximum 5 FT spacing.
      b. Conduit 1-1/4 IN and larger shall be supported at maximum 8 FT spacing.
   4. Hangers in metal roof deck: Do not extend above tops of ribs, or otherwise interfere with vapor retarder, insulation or roofing.

B. Hanger fasteners: Provide preset inserts, expansion anchors and beam clamps to attach hangers to structure.
   1. Drill and set expansion anchors horizontally in solid masonry wall or into the side of concrete beams and joist at the neutral axis of the member.
   2. Do not drill into the underside of concrete beams or joist.
   3. Do not use explosive driven fasteners.
   4. Do not use concrete nails in masonry walls.
   5. Toggle bolts may be used in hollow masonry and gypsum board walls. Provide support backing in stud wall as required to support the load.
   6. Sheet metal screws may be used in metal studs.
   7. Attachments to hollow metal deck may be by means of prepunched tabs, prepunched holes or with screws it the sides of the ribs, or toggle bolts in the bottom of the rib.

C. Sleeves: Black iron pipe, RGS or IMC sized to accommodate work passing through.

D. Sealer for sleeves and openings around conduit: UL listed for assembly. See Section 07 84 00.

E. All penetrations of floor slab at mechanical rooms above grade shall be sealed off and waterproofed.

2.3 SCHEDULE OF CONDUIT APPLICATIONS

A. Use rigid steel conduit or intermediate metal conduit in following locations:
   1. Underground (RGS only).
   2. Exposed exterior locations (RGS only).
   3. In concrete.
   4. Under concrete slabs on grade.
   5. Entering or exiting slabs up to 12 IN above finish floor.
   6. In exterior masonry walls.
   7. In damp and wet locations.
   8. In explosion-proof areas (RGS only).

B. Thinwall EMT may be used for other 600 volt and below indoor dry applications.

C. Concrete encased Schedule 40 PVC conduit may be used for underground and under concrete slabs on grade.
   1. Exterior lighting: See Section 26 56 00.
   2. Underground distribution: See Section 26 05 43.
   3. Provide a green grounding conductor of proper ampacity in each PVC conduit.
   4. 45 degree and greater bends in PVC conduit runs shall be made with rigid steel conduit.

D. Use no conduit smaller than 3/4 IN.

E. Size conduit in accordance with NEC unless indicated larger.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

A. Install all conduits concealed within walls and above finished ceilings.

B. Exposed overhead conduit may be used in mechanical, electrical and other equipment rooms except conduit drops to flush mounted devices in walls.

C. Exposed conduit may be used in service galleys.

D. Exposed conduit may be used in labs serving wall mounted disconnects and other surface mounted equipment other than surface metal raceway.

E. Exposed vertical runs of conduit may be used in labs serving equipment mounted on service frames and carriers.

F. Install no conduit within concrete columns.

G. Install no conduit under or within concrete slabs on grade.
   1. Except where serving exterior circuits.
   2. Except in lengths less than 2 FT between floor trench and floor box.

H. Install no conduit in elevated floor slabs.

I. Run conduit in straight lines at right angles to or parallel with walls, beams or columns.

J. Keep conduit away from waterlines or heating duct lines. Where crossings are unavoidable, leave minimum 6 IN clearance.

K. Do not cross conduit in front of access door in walls, ceilings, duct work, AHU's etc.

3.2 UNDERGROUND INSTALLATIONS

A. Steel conduits in contact with earth or a vapor retarder, that are not completely encased in concrete: Coat with 2 coats asphaltum before installation, or use PVC coated steel conduit.

B. Install exterior underground conduit 30 IN minimum below grade and as indicated in duct bank profiles.

C. Encase underground PVC branch circuit conduits in 3 IN minimum of concrete.

D. Encase underground PVC feeder conduits in 3 IN minimum of concrete. Provide reinforcing steel throughout the entire length of duct.

E. Where conduit enters a building and after installation of conductors or pull wires, seal conduit to prevent entry of water, gases or vapors.

3.3 CONDUIT INSTALLATION

A. No conduit or raceway shall enter or pass through a lab unless it serves that lab.

B. No feeders shall be routed within labs or in galleys adjacent to labs. Only feeders serving panels within service galleys shall be routed within service galleys.

C. Support all conduit systems from building structure or walls with approved hangers.
   1. Do not support from piping, ducts or support systems for piping or ducts.
   2. Do not install to prevent ready removal of equipment, piping, ducts or ceiling tiles.
   3. Do not support from ceiling or ceiling support systems.

D. Sum of angles in any conduit run shall not exceed 360 degrees.
   1. Where more bends are necessary, install condulet or pullbox.
   2. A hand conduit bender may be used on 3/4 IN RGS, IMC or EMT conduit and 1 IN EMT conduit. Use manufactured elbows or a conduit bending machine for larger sizes.

E. Cut conduit square and butt solidly in couplings.

F. Make joints in threaded conduit watertight with white nonleaded compound applied to male threads only.
   1. Cut square, ream smooth, and properly thread field joints to receive couplings.
   2. Do not use running threads.

G. Fit all conduit ends at switch and outlet boxes with approved lock nuts and bushing forming approved tight bond with box when screwed tightly in place.

H. Remove moisture and debris from conduit before wire is drawn into place. Tightly plug ends of conduit with tapered wood plugs or plastic inserts until wire is pulled.

I. Neatly seal openings around conduits, etc., where they pass through fire rated construction or exterior walls or roof.

3.4 CONNECTIONS AND FITTINGS

A. Above lay-in tile ceilings, make connections to lay-in type fixtures with 3/8 or 1/2 IN x 6 FT long flexible steel conduit.
   1. Include No.18 branch and grounding conductors.
   2. Arrange conduit and box systems for easy removal of lay-in ceiling.

B. Connect switch legs for narrow switches in hollow metal jamb posts using 1/2 IN flexible steel conduit.

C. Connections to vibration isolated equipment: See Section 26 05 48, Vibration Isolation.
   1. Use neoprene coated type with liquid tight connectors in damp and wet locations.

D. Install expansion joint fittings on conduit at all building expansion joints where conduit is in slab, rigidly attached to structure, or where otherwise necessary to compensate for thermal expansion and contraction.

E. Use sealing fittings on rigid galvanized conduit in hazardous areas. Install in accordance with NEC.

END OF SECTION

SECTION 26 05 34
BOXES

PART 1 - GENERAL

1.1 SUBMITTALS

A. Product data:
   1. Floor boxes.
   2. Expansion joint fittings.
   3. Sealing fittings.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Galvanized boxes:
      a. Base:
         1) Appleton Electric.
         2) Thomas & Betts / Steel City.
         3) Raco Manufacturing & Engineering.
   2. Corrosion resistant boxes and fittings:
      a. Base:
         1) Crouse-Hinds Lighting.
         2) Appleton Electric.
   3. Conduit fittings:
      a. Base:
         1) Appleton Electric.
         2) Thomas & Betts / Steel City.
         3) Raco Manufacturing & Engineering.
         4) O-Z/Gedney.
   4. PVC coated conduit fittings and boxes:
      a. Base:
         1) Robroy Industries.
         2) Occidental Coating.
   5. Box supporting brackets:
      a. Base:
         1) Caddy.

B. Galvanized boxes shall be galvanized steel minimum 14 gauge. Finish shall be "Hot Dip" whenever available.

C. Lighting outlet boxes:
   1. Galvanized, 4 IN octagon or square, minimum 2 1/8 IN deep.
   2. Verify proper depth with partition type and thickness.
   3. Provide with proper fittings to support and attach lighting fixtures.
   4. Support outlet boxes for fixtures and other ceiling-mounting devices in lay-in acoustical tile ceilings by bar hangers anchored to ceiling construction members which do not interfere with tile removal.
   5. Provide box extensions as required and square cut tile rings in all types of wall construction and suspended ceilings. Rings shall be installed such that device plates fit snug against finished surfaces.

D. Surface mounted boxes in dry locations:
   1. Galvanized 4 IN octagon or square, minimum 1 1/2 IN deep with 1/2 IN raised steel cover.

E. Surface mounted boxes in damp or wet locations:
   1. Corrosion resistant cast ferrous metal type, with threaded hubs and neoprene gasket: Crouse-Hinds Type FS.

F. Outlet boxes for flush wall devices:
   1. Single conduit (dead end) or device – 3 IN x 2 IN x 2 1/2 IN deep switch box.
   2. Two or more conduits or two devices – 4 IN square x 2 1/8 IN deep.
   3. Three or more devices – multigang 3 IN x 2 IN x 2 1/2 IN deep switch boxes.
   4. Provide 3 3/4 IN high masonry box in masonry walls. Locate at top or bottom of masonry course.
   5. Provide welded square cut tile ring or square drawn ring equal to RACO #768, 769, 773-796 for all flush mounted locations. Depth of ring shall be such that the ring is flush with the finished surface. Rings shall be installed such that device plates fit snug against finished surfaces.
   6. Provide barriers between switches in boxes with 277 volt switches on opposite phases.

G. Pull and junction boxes:
   1. Galvanized steel with screwed or bolted cover.
   2. Size per NEC, minimum 4 IN square.
   3. Boxes up to 12 IN x 12 IN – 14 gauge.
   4. Boxes 12 IN x 12 IN and larger – 12 gauge.
   5. Boxes 100 cubic inch and larger shall comply with UL50 electrical cabinets and boxes.

H. Multi-service floorbox.
   1. Floorbox shall be four compartment, fully adjustable, cast iron suitable for flush mounting in slabs-on-grade and above grade slabs.
   2. Floorbox size shall be 14 1/2 x 11 7/8 x 3 7/16 IN.
   3. Four independent wiring compartments for duplex receptacles or communication devices.
      a. Two power compartments shall have a minimum wiring capacity of 27 cubic inches with one 1 IN knockout. Provide device mounting plate to accept duplex receptacle.
      b. Two communication compartments shall have a minimum wiring capacity of 36 cubic inches with one 1 IN and two 1 1/4 IN knockouts. Coordinate device mounting plate with Section 27 05 32.
   4. Provide maximum 1 7/8 IN per pour adjustment and maximum 3/4 IN after pour adjustment.
   5. Cover shall be die-cast aluminum, textured finish, flanged, 8 x 6 3/4 IN with blank hinged access doors with sliding panels for cable egress.
   6. Wiremold RFB4-CI-1 floorbox with S36BBTCAL cover.
   7. Provide other types as indicated on drawings. See floor box schedule.

I. Poke-thru device:
   1. Flush mounted in tile or carpeted floor with brushed aluminum trim flange and black slide covers. Comply with requirements for scrub water exclusion.
   2. Provide one 20 amp, 125 volt, 2 pole, 3 wire NEMA 5-20R duplex receptacle.
   3. Provide accommodations for up to four Cat 5e and/or fiber optic connectors. Coordinate connector type with 16745.
   4. Maintain fire rating of floor assembly.
   5. Suitable for use in plenum ceilings.
   6. Wiremold RC3ATCAL.
   7. Provide other types as indicated on drawings. See floor box schedule.

J. Box supporting brackets: Caddy SGB Series.

K. Conduit bodies:
   1. Cast ferrous metal type, with gasketed cover in wet and damp locations.
   2. 99.4 percent copper free aluminum in indoor dry locations.

L. Fittings and boxes with PVC coated steel conduit: Specified boxes and fittings with 40 mils minimum coating of PVC.

M. Pull and junction boxes in PVC conduit: Minimum 4 IN square plastic boxes.

N. Where RGS or IMC enters a box or other fitting through a knockout, an approved double locknut and bushing shall be provided.
   1. Conduit bushings shall be threaded type, having insulated inserts equal to O.Z., steel, type "B". Bushings for feeder conduits shall be grounding type, having lay-in type lug.

O. Provide EMT conduit with steel set screw, insulated throat, concrete tight type couplings and connectors as manufactured by Appleton #4000ST/5000S Series, OZ/Gedney #4000ST/5000S Series, UL/CSA listed, meeting Federal Spec #WF408D. Other type fittings will not be acceptable.

P. Flexible conduit connectors shall be UL listed for grounding, squeeze type, malleable iron with insulated throat, one or two screw type as O-Z/Gedney, T&B, Raco or approved equal (set screw type, die-cast or screw-in type are not acceptable).

Q. Liquidtight fittings shall be UL listed for grounding, ferrule and sleeve type with insulated throat as O-Z/Gedney "4Q" series, T&B, Appleton "ST" or approved equal.

R. Expansion joint fitting: Watertight deflection type, O-Z , type "DX" or approved equal.

S. Conduit seals: Watertight and vaportight, O-Z, Type "FSK" or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mounting of outlet boxes for concealed wiring.
   1. Boxes mounted adjacent to studs shall be attached directly to stud with a minimum of 4 metal screws.
   2. Boxes that are not attached directly to studs shall be attached to bracket spanning studs. Bracket shall be attached to studs with 2 screws at each end. Attach box to bracket with 2 screws minimum.

B. When a metallic junction box for electrical receptacles or switches is contained within a 1 or 2-hour rated fire or smoke wall of gypsum drywall construction and an opening is provided for the box in the surface of that wall, the area of the opening may not exceed 16 square inches, unless the junction box is protected by an approved method such as a UL listed "putty pad".
   1. The aggregate area of all such junction boxes in a rated wall not protected by an approved method shall not exceed 100 square inches in 100 square feet of wall area as measured from floor to structural deck or rated membrane.
   2. Junction boxes with openings on opposite faces of rated walls shall have a horizontal separation of 24 inches as a minimum, regardless of box size, unless protected by an approved method.
   3. Locations of studs do not have any bearing on the above requirements, nor does the use of mineral wool fire safing alter these requirements.

C. Thread fittings for rigid conduit and IMC.

D. Install rigid conduits squarely into boxes. Rigidly clamp to box with locknut on outside and inside and provide bushing on inside.

E. Fill unused punched-out openings in boxes with proper closures.

F. Use outlet boxes sized to accommodate quantity of conductors enclosed.

G. Provide pull boxes or junction boxes in conduit runs where indicated or as required to facilitate pulling of wires or making of connections. Make covers of all boxes accessible.

H. Spray paint inside of boxes and exposed conduits for 3 IN beyond the outlets with non-flammable paint per Section 26 00 10.

I. Stagger outlet boxes where located back to back a minimum of 12 IN to minimize sound transmission between rooms.

END OF SECTION

SECTION 26 05 35
SURFACE METAL RACEWAYS AND WIREWAYS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Surface metal raceways shall be provided for branch circuit wiring and voice, telecommunications, video and other low-voltage wiring as indicated.

1.2 SUBMITTALS

A. Shop drawings:
   1. Surface metal raceway.

B. Product data:
   1. Surface metal raceway.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Surface metal raceway:
      a. Base:
         1) Wiremold/Isoduct.
         2) Post Glover/Versa-duct.
   2. Wireway:
      a. Base:
         1) Hoffman Engineering.
         2) Square D.
   3. Floor trench duct:
      a. Base:
         1) Square D.
         2) Walker.
         3) Thomas & Betts/Steel City.

B. Surface metal raceway: One or two piece steel raceway with base and snap-on cover for mounting power and/or communication devices:
   1. Refer to drawings for types.
   2. Provide fittings and accessories for a complete installation. Provide base with fittings where applicable.
   3. Provide wire clips to hold conductors/cables in places.
   4. Provide 2 IN radius inserts at elbows within the communication compartment.
   5. Raceway shall be electrically continuous and listed as an equipment grounding conductor.
   6. Base, cover, fitting and accessory finish shall be gray and suitable for field repainting.
   7. Device mounting plate shall be high impact resistant plastic mounting bracket and trim plate which overlaps the raceway cover to provide a seamless transition between the plate and the cover:
      a. Provide single, duplex, GFCI, twistlock and/or blank faceplate as required by layout indicated on the drawings.
      b. Provide communication faceplates which accept voice/data jacks/connectors as specified and/or full or half blank inserts as required by layout indicated on the drawings.

c. Coordinate communication outlet requirements with supplier of voice/data communication system.

C. Wireway: NEMA I lay-in wire-way:
1. Arrange wireway cover for removal, hinging and locking closed by captive type fasteners.
2. Finish: Gray baked-enamel, over phosphatized surfaces.
3. With necessary fittings, with or without knockouts, with solid cover where passing through partitions, with manufacturer's name or trademark visible after installation.
4. Designed for continuous grounding.

D. Floor trench ducts: 6 IN wide, 2 IN deep waterproof with dividers, removable covers and suitable fittings:
1. Cover shall be maximum 3 FT long with gasket seals.
2. Coordinate trim type with finish floor material.
3. Provide two equal sized compartments separated by an adjustable partition.
4. Provide end closures at each end.
5. Provide vertical riser at wall feed points.
6. Wiremold – VA Trench duct.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

3.2 SURFACE RACEWAY INSTALLATION

A. Mount surface raceway on walls or support channels as indicated on drawings and as indicated in manufacturer's instruction sheets.

B. Use one section for runs up to ten feet. Do not use random scraps to assemble a run less than ten feet.

C. Install wiring devices of the type, quantity and location indicated on drawings.

D. All raceway systems shall be installed complete, including insulating bushings and inserts where required by manufacturer's installation sheets. All unused raceway openings shall be closed.

E. Do not install more than 30 current carrying conductors in any compartment of any surface raceway.

F. Maintain equipment grounding continuity of surface raceway systems.

END OF SECTION

SECTION 26 05 43

UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Shop drawings:
   1. Manholes, signed and sealed by professional engineer.
   2. Duct bank layouts, sections and elevations indicating existing and final grade elevation, ductbank elevation and elevation of crossing utilities.

1.2 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Store conduit to avoid warping or deterioration.

B. Store plastic conduit on flat surface protected from direct rays of sun.

1.3 JOB CONDITIONS

A. Protect existing utilities and structures as indicated in Section 26 00 10.

B. Provide full access to public and private premises, to fire hydrants, street crossings, sidewalks and other points as designated by BNL.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Manholes:
      a. Base:
         1) Smith-Midland.
         2) Rotondo Precast.
         3) Strongwell.

2.2 DUCT SYSTEM

A. Duct system: Single or multiple, round-bore rigid steel conduit or Schedule 40 PVC conduits completely encased in concrete as indicated:
   1. Conduit:
      a. Rigid PVC conduit: As specified in Section26 05 33.
      b. Rigid steel conduit: As specified in Section 26 05 33.
   2. Separators: PVC. Conduit, wood or other materials are unacceptable.
   3. Concrete: 3000 PSI. Conform to Division 3 requirements.
   4. Reinforcing steel: ASTM-A615 Grade 60. Conform to Division 3 requirements.

B. Pull wire: 3/16 IN kevlar cord with marked footage, free of kinks and splices.

C. Marker tape: 3 IN wide, .005 IN thick red colored plastic tape with continuous metallic backing and a .001 IN corrosion resistant metallic foil core. Tape shall be labeled "electric" or "communication" at intervals not exceeding 10 FT.

2.3 MANHOLES

A. Electric and communication manholes:

1. Precast reinforced concrete: Two piece construction with inside dimensions as indicated on the drawings.
2. Concrete: Minimum 4000 PSI at 28 days. Conform to Division 3 requirements.
3. Reinforcing:
   a. Bars: ASTM A615 Grade 60.
   b. Welded wire fabric: ASTM A185.
4. Design Criteria:
   a. Dead loads:
      1) Concrete: 150 pounds per cubic foot.
      2) Earth: 120 pounds per cubic foot.
   b. Lateral loads:
      1) Equivalent fluid pressure: 60 pounds per square foot per foot of depth.
      2) ASSHTO Traffic Surcharge: 2 feet of earth.
   c. Live Loads:
      1) Rear wheel truck load: 20,800 pound, H20 ASSHTO.
5. Joint sealant: Preformed butyl rubber between precast sections.
6. Knockouts: Provide knockouts in wall conforming to the arrangement and configuration of duct banks indicated on the drawings.
7. Cover and frame: Cast iron with 36 inch diameter clear. Label covers "ELECTRIC" or "COMMUNICATION" as applicable with 2 inch high letters.
8. Collars: Precast reinforced concrete.
9. Sump with grate: 12 inch x 12 inch x 6 inch with cast iron grate.
10. Cable racks and arms: Galvanized with porcelain insulators or heavy duty fiberglass reinforced plastic:
    a. Vertical stanchion shall be minimum 36 inch with equally spaced arm mounting holes. Provide two stanchions on each manhole wall.
    b. Arms length shall be appropriate for cable installation. Provide holes in the arms for cable ties. Provide one spare arm on each stanchion.
11. Pulling irons: Provide one pulling iron opposite each knockout panel.
12. Ladder rungs: 3/4 inch diameter, 16 inch wide, 7 inch off the wall and spaced 12 inch on centers.
13. Ground rod sleeves: Provide two sleeves in opposite corners for ground installation.

2.4 BACKFILL MATERIAL

A. Backfill Material: See Section 31 23 33.

PART 3 - EXECUTION

3.1 EXCAVATING AND TRENCHING - GENERAL

A. Excavating and Trenching: See Section 31 23 33.

3.2 INSTALLATION OF DUCT SYSTEM

A. Lay all duct lines to minimum grade of 4 IN in 100 FT:
   1. Grade may be from one manhole to next, or both ways from high point between manholes, depending on contour of finished grade.

B. Install duct lines so that top of concrete is not less than 30 IN below finished grade or finished paving at any point.

C. Provide minimum 12 IN separation between electric and communication ducts.

D. Where underground conduits run parallel with pipelines, a one (1) foot minimum clearance shall be maintained, and at crossings, a one (1') minimum clearance shall be maintained below the bottom of the pipes. Conduits should cross under existing pipes when practical and reasonable.

E. Accomplish changes in direction of runs exceeding total of 10 degrees, either vertical or horizontal, by long sweep bends with minimum radius of 25 FT:
   1. Provide rigid steel elbows at turn-ups to electrical equipment.
   2. Manufactured bends: Minimum radius of 48 IN for ducts of 3 IN in diameter and larger.
   3. Long sweep bends may be made up of one or more curved or straight sections and/or combinations thereof.

F. The number, size and arrangement of conduits in the cast-in-place underground duct bank sections shall be as indicated on the drawings. Outer encasement of concrete shall be 3" minimum with 7-1/2 IN between conduit centers.

G. Stagger conduit joints a minimum of 12 IN in concrete encased duct banks.

H. Conduit spacers shall be sized to allow for the full separation of conduits as indicated on the drawings and spaced a maximum of eight (8) feet on centers.

I. Provide steel reinforcement throughout the duct bank as indicated on the drawings.

J. Duct lines shall be doweled to the manhole with rebar.

K. Terminate conduits in end bells where duct lines enter manholes.

L. Thoroughly clean conduit before using or laying.

M. Lay no conduit in water or in unsuitable weather or trench conditions.

N. During construction and after duct line is completed, plug ends of conduits to prevent water washing into conduit or manholes:
   1. Take particular care to keep conduits clear of concrete, dirt, and any other substance during course of construction.

O. Make conduit joints in accordance with manufacturer's recommendations for conduit and coupling selected:
   1. Make conduit joints watertight.
   2. Make plastic conduit joints by brushing plastic solvent cement on inside of plastic coupling fitting and outside of conduit ends.
   3. Slip conduit and fitting together with quick one-quarter-turn twist to set joint tightly.

P. Encase each conduit completely in concrete not less that 3 IN beyond any surface of conduit:
   1. Do not place concrete until conduits have been inspected by Architect/Engineer.
   2. Mix, place and cure concrete in accordance with Division 3 requirements.

Q. Pneumatic rodding may be used.

R. Color top layer of concrete encasement red by heavily sprinkling with red oxide cement coloring while still wet.

S. After completion of duct bank section, same shall be thoroughly cleaned by passing a mandrel, no smaller in diameter than ¼ inch less than conduit size, through each conduit. After this initial cleaning with the mandrel, each conduit shall be thoroughly cleaned and dried by pulling an approved swab and spiral wire brush back and forth until a satisfactorily clean condition has been obtained. Contractor shall then pull three 10 feet long pieces of 500kcmil cable through each conduit 3" and larger and examine for any damage after each pass. Broken or obstructed conduits shall be repaired and rechecked with the mandrel.

T. After cleaning of conduits, install a 3/16" Kevlar pull string with marked footage in each spare conduit.

U. Place detectable marker tape centered above duct bank 12 IN below finish grade. Tape shall have appropriate labeling for type of duct.

3.3 INSTALLATION OF MANHOLES

A. Determine exact location of each manhole after careful consideration has been given to location of other utilities, grading, and paving:
   1. Do not begin construction until location of each manhole has been approved by BNL.

B. Set manhole depth to maintain minimum 8 IN earth cover and as required to maintain duct bank drainage.

C. Set manhole level on minimum 6 IN gravel bed.

D. Set manhole frame and cover:
   1. In paved areas, set top of frame and cover flush with finish surface of pavement.
   2. In unpaved areas, set top of frame and cover approximately 1/2 IN above finish grade.
   3. Provide precast collar(s) with mortared joints as required to elevate frame and cover to finish grade.
   4. Grout frame to manhole top of to collar.
   5. Paint exterior of the frame with two coats of asphaltic paint.

E. Drive two 3/4 IN diameter 10 FT long copper-clad ground rods. Leave 4 IN of rod exposed.

F. Provide #4/0 ground around perimeter of manhole 1 FT below top. Support at minimum 3 FT spacings. Provide #4/0 connection to each manhole ground rod and to each #4/0 duct bank ground conductor.

G. Bond all metallic surfaces with #6 bare copper conductor to the ground rods or #4/0 perimeter ground.

3.4 BACKFILLING

A. Backfilling: See Section 31 23 33.

3.5 COMPACTION

A. Compaction: See Section 31 23 33.

END OF SECTION

SECTION 26 05 48

VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide vibration control devices, materials, and related items. Perform all work as indicated on drawings and as specified herein to provide complete vibration isolation systems in proper working order.

1.2 QUALITY ASSURANCE

A. Coordinate the size, location and special requirements of vibration isolation equipment and systems with other trades. Coordinate plan dimensions with size of housekeeping pads.

B. Provide vibration isolators of the appropriate sizes and proper loading to meet the specified requirements.

C. Provide any incidental materials needed to meet the requirements stated herein, even if not expressly specified or indicated on drawings, without claim for additional payment.

D. Verify correctness of equipment model numbers and conformance of each components with manufacturer's specifications.

E. Should any electrical equipment cause excessive noise or vibration, provide remedial work required to reduce noise and vibration levels. Excessive is defined as exceeding the manufacturer's specifications for the unit in question.

F. Upon completion of the work, BNL shall inspect the installation and shall inform the installing contractor of any further work that must be completed. Make all adjustments as directed by BNL that result from the final inspection. This work shall be done before vibration isolation systems are accepted.

1.3 SUBMITTALS

A. Shop drawings:
   1. A complete description of products to be supplied, including product data, dimensions, specifications, and installation instructions.
   2. Detailed selection data for vibration isolator supporting the generator, including:
      a. The isolator type.
      b. The actual load.
      c. The static deflection expected under the actual load.
      d. Specified minimum static deflection.
      e. The additional deflection-to-solid under load.
      f. The ratio of spring height under load to spring diameter.

B. Product data:
   1. Specifications and installation instructions.
   2. Detailed selection data for each vibration isolator supporting equipment, including:
      a. The equipment identification mark.
      b. The isolator type.
      c. The actual load.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Double neoprene pads and hanger neoprene:
      a. Base:
         1) Mason Industries.
         2) Kinetics Noise Control.
         3) Vibration Mountings & Controls.
   2. Flexible electrical connections:
      a. Base:
         1) Crouse-Hinds.
         2) Spring City Electrical Mfg. Co.

2.2 VIBRATION ISOLATION MOUNT TYPES

A. Type DNP (Double Neoprene Pad):
   1. Neoprene pad isolators shall be formed by two layers of 1/4 IN to 5/16 IN thick ribbed or waffled neoprene, separated by a stainless steel or aluminum plate. These layers shall be permanently adhered together. Neoprene shall be 40 to 50 durometer. The pads shall be sized so that they will be loaded within the manufacturer's recommended range.
   2. Type DNP isolators shall be formed from one of the following products or approved equal:
      a. Type WSW: Mason Industries.
      b. Type NPS: Kinetics Noise Control.
      c. Multi Layers of Series Shear-Flex or Maxi-Flex: Vibration Mountings & Control.

2.3 FLEXIBLE ELECTRICAL CONNECTIONS

A. Type A:
   1. Flexible Electrical Connection Type A shall be a prefabricated unit incorporating a flexible and watertight outer jacket, grounding strap, plastic inner sleeve to maintain smooth wire way, and end hubs with tapered electrical threads to fit standard threaded rigid metal conduit.
   2. Flexible Electrical Connection Type A shall be Crouse-Hinds (Syracuse, NY) "XD Expansion/Deflection Coupling", Spring City Electrical Mfg. Co., (Spring City, PA) "Type DF Expansion and Deflection Fitting".

B. Type B:
   1. Flexible Electrical Connection Type B shall be field fabricated using a minimum 24 IN length of flexible conduit.

C. Type C:
   1. Flexible Electrical Connection Type C shall be field fabricated using a minimum 48 IN length of flexible conduit with a minimum 90 degree bend.

2.4 GENERATOR ISOLATION

A. The engine generator set shall be rigidly mounted on a steel rail skid base.

B. The skid base shall be resiliently mounted on the concrete foundation.
   1. Skid base shall be supported on spring isolators that achieve at least 1-1/2 IN deflection under load.
   2. Provide side-mounted height saving brackets for attachment of the isolators positioned on the sides of the skid base that are parallel to the axis of rotation.
   3. There shall be at least 1 IN clearance between the underside of the skid base and the slab.
   4. Spring isolators shall be "Floor Spring and Neoprene Travel Limited" Type FSNTL as indicated in Section 20 05 50.

C. The generator enclosure shall be rigidly mounted to the concrete foundation.

D. The muffler exhaust pipe shall be rigidly connected to the roof of the generator enclosure.

E. The muffler shall be resiliently supported from the roof of the generator enclosure on spring and neoprene isolators that achieve at least 1-1/2 IN deflection under load.
   1. Spring and neoprene isolators shall be "Hanger Spring and Neoprene" Type HSN as indicated in Section 20 05 50.

F. Electrical connections from the ductbank to the generator shall be provided with a off-set bend in the liquid-tight flexible conduit to allow three dimensional freedom of movement of the generator.

PART 3 - EXECUTION

3.1 APPLICATION

A. Dry type transformers (480-208/120V):
   1. Transformers shall be mounted on type DNP isolators.
   2. Electrical connections to transformers shall be made using flexible connections Type C.

B. Mechanical equipment:
   1. Electrical connections to vibration isolated mechanical equipment shall be made using flexible electrical connections Type C.

C. Across vibration isolation joints in the structural system:
   1. Electrical connections across vibration isolation joints in the structural system shall be made using flexible connections Type A or Type B.

3.2 INSTALLATION

A. General:
   1. In all cases, isolated electrical equipment shall be positioned so that it is free-standing and does not come in rigid contact with the building structure or other systems.

B. Isolation mounts:
   1. All mounts shall be aligned squarely above or below mounting points for the supported equipment.
   2. If a housekeeping pad is provided, the isolators shall bear on the housekeeping pad and the isolator base plate shall rest entirely on the pad.
   3. Hanger rods for vibration isolated support shall be connected to structural beams or joists, not to the floor slab between beams and joists. Provide suitable intermediate support members as necessary.
   4. Vibration isolation hanger elements shall be positioned as high as possible in the hanger rod assembly, but not in contact with the building structure, and so that the hanger housing may rotate a full 360 degrees about the rod axis without contacting any object.

C. Flexible electrical connections:
   1. Type C connections shall be installed with a minimum 90 degree bend.
   2. Rigid conduit on the isolated-equipment side of the flexible connections, and the flexible connection itself, shall not be tied to the building construction or other rigid structures.

END OF SECTION

SECTION 26 05 73

SHORT-CIRCUIT/COORDINATION/ARC FLASH STUDY

PART 1 - GENERAL

1.1 REFERENCE

A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.2 DESCRIPTION

A. Short circuit, protective device coordination, and arc flash studies have been performed for equipment utilizing SKM System Analysis Power Tools for Windows software. In general, equipment and protective devices have been selected and analyzed to minimize arc flash incident energies. Protective device setting tables and single line diagrams with arc flash results are included at the end of this section. Additional report information and electronic files are available for Contractor's use.

B. The study has been performed using acceptable manufacturers from individual specification sections. Equipment and protective device settings have been selected to reduce arc flash energies below 8 cal./cm2 whenever possible.

C. Alternate approved manufacturers are acceptable. Equipment will be evaluated during shop drawing submission and review. Equipment which would cause arc flash energies to increase above 8 cal./cm2 will be cause for rejection.

D. Equipment suppliers may perform independent studies to verify performance of proposed devices. Studies must be performed using "SKM System Analysis, Inc.," Power Tools Electrical Engineering Software.

E. Contractor must submit as-built system data for inclusion in a final study report prior to equipment startup.

F. Contractor shall install arc flash PPE labels prior to startup. BNL standard labels will be provided for Contractor's use.

1.3 REFERENCE STANDARDS

A. BNL SBMS Subject Area: Electrical Safety (Section 5, Design and Installation of Electrical Equipment).

B. IEEE 141 - Recommended Practice for Electric Power Distribution and coordination of Industrial and Commercial Power Systems.

C. IEEE 241 - Recommended Practice for Electric Power Systems in Commercial Buildings.

D. IEEE 242 - Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.

E. IEEE 399 - Recommended Practice for Industrial and Commercial Power System Analysis.

F. IEEE 1015 - Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems.

G. ANSI C37.13 - Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures.

H. ANSI C57.12.00 - Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.

I. NFPA-70E – Standard for Electrical Safety in the Workplace.

J. IEEE 1584 – Guide for Performing Arc Flash Hazard Calculations.

1.4 SUBMITTALS

A. Submit equipment data in accordance with referenced specification sections. Owner will evaluate proposed submissions utilizing the SKM computer model.

B. If elected, submit independent SKM model of proposed equipment for Owner's approval.

C. Preliminary short-circuit and protective device coordination studies are required to evaluate the submission of distribution equipment shop drawings:
   1. The drawings and specifications indicate the general requirements for the electrical equipment being provided. Upgrade and modification to equipment characteristics and ratings will be finalized by the results of the short circuit and protective device coordination studies at no additional cost to the owner. Field settings of devices and adjustments to the new equipment to accomplish conformance with the accepted short circuit and protective device coordination studies shall be carried out by the contractor at no additional cost to the owner. Any proposed deviations from the system indicated on drawings and in specifications shall include demonstration of short circuit and breaker coordination.
   2. Short circuit study shall be approved prior to manufacture of equipment.
   3. Coordination and arc flash studies shall be approved prior to energizing equipment.
   4. Arc flash labeling shall be installed prior to energizing equipment.

D. Submit as built one line diagrams to reflect approved shop drawings, actual cable lengths, breaker settings, and any other approved field changes.

E. Final short-circuit, protective device coordination studies, and arc flash analysis shall be issued after equipment is installed but before it is energized.

F. Final report shall include:
   1. One-line diagram.
   2. Descriptions and scope of the study.
   3. Tabulations of circuit breaker fuse and other protective device ratings versus calculated short circuit duties.
   4. Time versus current coordination curves, tabulations of circuit breaker trip unit settings and fuse selection.
   5. Fault current calculations.
   6. Recommendations.
   7. Three phase arcing current ratings for each piece of electrical equipment indicated on one-line diagram.
   8. Required PPE (Personal Protective Equipment) level labels for each piece of electrical equipment (medium voltage switches, substations, switchboards, switchgear, motor control centers, distribution panels, panelboards, UPS and downstream panels, Inverters and down stream panels, remote motor controllers, enclosed switches, etc.).

G. If Contractor has prepared all studies, submit all electronic files associated with short circuit, coordination and arc flash studies to allow review and future use of the files. Provide (2) copies on CD and (2) hard copies in binders. Files shall be complete to allow exact regeneration of all studies.

H. If Owner completes studies, Contractor will be provided with (1) hard copy of the one line drawing containing all final arc flash results.

1.5 QUALIFICATIONS

A. Electrical analysis has been performed by Owner or his designated representative.

B. If elected, short circuit, coordination studies, and arc flash analysis may be conducted by the Contractor under the supervision and approval of a Registered Professional Electrical Engineer.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.1 SHORT CIRCUIT STUDY

A. Entire electrical system including lighting and appliance panelboards and all upstream equipment (automatic transfer switches, remote motor controllers, enclosed switches, etc.) shall be modeled to facilitate the arc flash study as required below.

B. Use typical conductor impedances.

C. Transformer design impedances shall be used when test impedances are not available.

D. Provide:
   1. Calculation methods and assumptions.
   2. Selected base per unit quantities.
   3. One-line diagram.
   4. Source impedance data, including utility system and motor fault contribution characteristics.
   5. Typical calculations.
   6. Tabulations of calculated quantities.
   7. Results, conclusions, and recommendations.

E. Calculate short circuit momentary and interrupting duties for a three phase bolted fault at:
   1. Utility's supply termination point.
   2. Branch circuit panelboards, if above 10,000 AIC.
   3. Enclosed Switches.

F. Protective Device Evaluation:
   1. Evaluate equipment and protective devices and compare to short circuit ratings.

3.2 PROTECTIVE DEVICE COORDINATION STUDY

A. Entire electrical system including lighting and appliance panelboards and all upstream equipment (automatic transfer switches, remote motor controllers, enclosed switches, etc.) shall be modeled to facilitate the arc flash study as required below.

B. Time-current curves shall be displayed on log-log scale paper.

C. Include on each curve sheet a title and legend, identifying portion of the system covered.

D. Identify device by manufacturer type, function and tap, time delay, and instantaneous settings recommended.

E. Selective Coordination:
   1. All circuit breakers associated with the fire pump, elevator, and emergency lighting shall be selectively coordinated per the National Electric Code NEC 2005.

F. Plot characteristics where applicable:
   1. Electric utility's protective device.
   2. Low voltage fuses including minimum melt, total clearing and damage bands.
   3. Low voltage circuit breaker trip devices.
   4. Transformer full-load current, magnetizing inrush current, and ANSI transformer withstand parameters.
   5. Conductor damage curves.
   6. Ground fault protective devices.
   7. Motor starting characteristics and motor damage points.
   8. Generator short circuit decrement curve and generator damage point.

9. All CT ratios.

3.3 ARC FLASH POTENTIAL STUDY

A. Arc flash potential study shall be performed after short circuit and protective device coordination studies have been completed.

B. Three phase arcing currents for each piece of electrical equipment shall be indicated on a one line diagram of the entire electrical system including 208Y/120V panelboards and all upstream equipment.

C. Calculations shall be performed using an iterative process:
   1. Study shall include calculations for minimum flash protection boundary (measured in meters and feet), incident energy at working distance of 18" (measured in cal/cm^2), required PPE level, limited approach, restricted approach and prohibited approach boundaries (measured in meters and feet).
   2. Calculations shall be performed using both NFPA 70E and IEEE 1584 methods for each piece of equipment. Worst case calculation for each piece of equipment shall be used for report:
      a. Minimum Flash Protection Boundary shall be 4'-0" even if calculated to be less.
      b. Assume maximum arc duration to be 2 seconds.
      c. Do not exclude equipment below 240V fed from transformers rated 125kVA or below. BNL requirements exceed those outlined in NFPA 70E and IEEE 1584.
   3. Pieces of equipment that will require PPE greater than level 1 shall be investigated:
      a. Investigation shall include adjustment of upstream breaker settings to determine if required PPE level can be reduced with minimal compromise to breaker coordination with other upstream breakers.
      b. Investigation shall continue until lowest PPE level for each piece of electrical equipment can be reached with minimal impact to breaker coordination.
      c. Compromises to breaker coordination as a result of lowering the required PPE level shall be listed and documented for review by Architect/Engineer.

3.4 FINAL REPORTS

A. One Line Diagram

B. Input Data:
   1. Cable and conduit materials.
   2. Transformers.
   3. Circuit resistance and reactive values.

C. Short Circuit Data:
   1. Source fault impedance.
   2. Generator contributions.
   3. X to R ratios.
   4. Asymmetry factors.
   5. Motor contributions.
   6. Short circuit kVA.
   7. Symmetrical and asymmetrical fault currents.

D. Recommended Protective Device Settings:
   1. Circuit Breakers:
      a. Adjustable pickups and time delays (long time, short time, ground).
      b. Adjustable time-current characteristic.
      c. Adjustable instantaneous pickup.
   2. Phase and Ground Relays:
      a. Current setting.
      b. Time setting.
      c. Instantaneous setting.

d. Specialty non-overcurrent device settings (ex. Relay 27/47, 81 O/U, 25, etc.).

3. Fuses:
   a. Types.
   b. Rating.

E. Arc Flash Potential Study Data:
   1. Calculated three phase arcing currents for all electrical equipment.
   2. PPE rating for all electrical equipment.
   3. BNL standard PPE labels will be provided by BNL and installed by Contractor.
   4. Compromises to breaker coordination resulting from lowering of PPE value at a particular piece of electrical equipment.

3.5 FIELD ADJUSTMENT

A. Adjust relay and protective device settings according to the recommended settings table provided by the coordination study.

B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.

C. Notify Owner in writing of any required major equipment modifications.

3.6 INSTALLATION

A. Install BNL standard PPE labels on each piece of equipment prior to energizing equipment.

B. PPE label shall be clearly visible upon approach to equipment.

C. For large pieces of equipment, label shall be placed near main overcurrent device or incoming feeder to equipment.

D. Label shall be mounted at a minimum of 42” to bottom and maximum of 66” to top above finished floor.

E. Laminate final one line diagram and mount within the facility where directed by Owner.

END OF SECTION

SECTION 26 09 13
POWER MONITORING AND CONTROL

PART 1 - GENERAL

1.1 SUBMITTALS

A. Shop drawings:
   1. Outline drawings of assembly.
   2. One line diagrams and wiring diagrams for assembly and components.
   3. Interconnection wiring diagrams.

B. Product data:
   1. Technical data on each component.

C. Contract closeout information:
   1. Operating and maintenance data.
   2. BNL instruction reports.

1.2 SYSTEM DESCRIPTION

A. The power monitoring system shall consist of electronic circuit monitors, display units and circuit breaker interface modules installed as required or indicated in the project drawings.
   1. The power monitoring system shall be connected to a Local Area Network (LAN) for remote monitoring from a personal computer workstation.

B. The power monitoring system shall utilize local system display units to display circuit monitor data.

PART 2 - PRODUCTS

2.1 POWER MONITORING SYSTEM

A. Acceptable manufacturers:
   1. Power monitoring system:
      a. Base:
         1) Eaton Electrical. (Eaton Power Expert 2000 series)
      b. Optional:
         1) Schneider Electric/Square D. (Powerlogic PM800 series)
         2) Siemens Energy & Automation.
   2. Manufacturer must have local service organization.

B. All equipment: UL listed.

2.2 POWER MONITORING SYSTEM OPERATION

A. The power monitoring system shall monitor points in power distribution system and provide local and remote readings as indicated.

B. The power monitoring system shall, through software / web-interface on a personal computer workstation, provide for:
   1. Monitoring multiple devices at one time.

2.3 CIRCUIT MONITORS

A. Description:
   1. Design shall be based on Eaton Power Expert 2000 series. Sample model number: PXM2250MA65145.
   2. The electronic circuit monitors shall provide metering values such as frequency, current, voltage, power factor, power, demand current and real power, and accumulated real and reactive energy.
   3. Each circuit monitor shall retain historical circuit data, time and date, setup and configuration values, and diagnostics data in the event of a control power failure, without the need for an internal battery.

B. Installation:
   1. Electronic circuit monitors shall be installed by the switchgear manufacturer for all circuits as indicated by the project drawings.
   2. All control power, CT, PT, and communications wiring shall be factory installed and harnessed.
   3. Where external circuit connections are required, terminal blocks shall be provided and the manufacturer's drawings must clearly identify the interconnection requirements, including wire type, to be used.

C. Circuit monitor characteristics:
   1. The electronic circuit monitors shall accept inputs from industry standard instrument transformers (120VAC secondary PTs and 5A secondary CTs).
   2. Current and voltage signals shall be digitally sampled at a rate high enough to provide accurate RMS sensing.
   3. All setup parameters required by circuit monitor shall be stored in nonvolatile memory (no battery backup) and retained in the event of a control power interruption.
   4. Each circuit monitor shall also maintain, in nonvolatile memory, a maximum and minimum value for each of the Instantaneous Values reports, as well as the time and date of the highest peak for all of the peak demand readings.
   5. The following minimum instantaneous readings shall be reported by the circuit monitor:
      a. Frequency.
      b. Temperature.
      c. Current, per phase rms.
      d. Neutral current, rms.
      e. Current, 3-phase average rms.
      f. Current, apparent rms.
      g. Voltage, phase-to-phase & phase-to-neutral.
      h. Power factor, per phase.
      i. Power factor, 3-phase total.
      j. Real power, 3-phase total.
      k. Reactive power, 3-phase total.
      l. Apparent power, 3-phase total.
   6. The following minimum demand readings shall be reported by the circuit monitor:
      a. Average demand, real power.
      b. Peak demand, real power.
   7. The following energy readings shall be reported by the circuit monitor:
      a. Accumulated energy.
      b. Accumulated reactive energy.

D. The circuit monitor shall have the ability to monitor separate inputs from various devices and report the status of each input to a system display unit or personal computer workstation.

E. Outputs shall be passwork-protected to prevent unauthorized reconfiguration of the system and may be disabled by a keyswitch located in front of the monitor.

F. Each circuit monitor shall display, on an integral display, the following electrical parameters (as a minimum):
   1. Current, per phase RMS.
   2. Voltage, phase-to-phase RMS.
   3. Voltage, phase-to-neutral RMS (per phase).
   4. Real power, 3-phase total.
   5. Reactive power, 3-phase total.
   6. Apparent power, 3-phase total.
   7. Power factor.
   8. Frequency.
   9. Peak demand, real power.
   10. Accumulated energy (MWH and MVARH).

G. Reset of the following parameters shall be allowed from the circuit monitor:
   1. Peak demand power.
   2. Energy (MWH).
   3. Reactive energy (MVARH).

H. Circuit monitor setup shall be allowed from the circuit monitor display. Setup parameters shall include:
   1. CT rating (XXXX:5).
   2. PT rating (XXXXX:120).
   3. System type (3-wire or 4-wire).
   4. Demand interval (5 to 60 minutes).

I. All reset and setup functions shall be keyswitch-protected to prevent unauthorized/accidental changes.

J. Provide CT's and PT's where not provided under other sections.

2.4 SYSTEM DISPLAY UNITS (SDU)

A. Description:
   1. Each SDU shall provide real-time access to all metering and device data available for each monitored device.

B. Installation:
   1. Each SDU shall be installed by the manufacturer as indicated in the project drawings.
   2. Each SDU shall be flush mounted in switchgear or large power panelboard door panels as indicated.

C. Characteristics:
   1. Each SDU shall access and display the data available from selected circuit monitors and circuit breaker interface modules connected to an individual data transfer network.
   2. Each SDU shall utilize a high contrast, backlit liquid crystal display (LCD) to provide high reliability and readability in all lighting conditions.
   3. Backlighting and contrast levels shall be adjustable.

D. Keypad:
   1. Each SDU shall allow for easy operation by providing a keypad with large keys for operator selections.
   2. Each key shall have a raised perimeter and tactile feedback to ensure a positive response even with gloved hand operation.
   3. The keys shall be clearly marked to indicate function and shall be separated into meaningful groups with display prompts to aid operator selections.

E. Configuration:
   1. Each SDU shall be configured by the manufacturer with all necessary data, such as CT ratios, PT ratios, device nameplates, demand alarm setpoints, etc., as required for proper operation.

2. It shall be possible to modify the SDU configuration using the integral keypad. This capability shall be password-protected to prevent unauthorized modifications.

F. Data Viewing:
1. All data shall be accessible from the SDU.
2. Data shall be displayed in a logically organized form, complete with proper scalings and units.
3. It shall be possible to sequentially view all available data from a selected circuit monitor or circuit breaker interface module by single keystroke advancing through the various display pages.
4. It shall be possible to view the same data from multiple circuit monitors or circuit breaker interface modules by single keystroke advancing from monitor to monitor or module to module.

G. Display Reset:
1. The SDU shall permit the reset of minimum-maximum values, accumulated energy values and time-and-date stamps stored in the circuit monitors. This capability shall be password-protected to prevent unauthorized access.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all components as indicated and in accordance with manufacturer's instructions and recommendations.

B. Power monitoring system components included within the power equipment lineups shall be factory installed, wired and tested prior to shipment to the job site.

C. Provide all wiring required to externally connect equipment lineups.

D. Interconnection wiring requirements shall be clearly identified on the power monitoring system drawings.

3.2 TESTING

A. Provide a representative of manufacturer to supervise startup and testing of system.

B. Testing to include a complete working demonstration of the power monitoring system with simulation of possible operating conditions which may be encountered.

C. Provide manufacturer's representative for 5 days of start-up assistance.

3.3 BNL PERSONNEL TRAINING

A. Provide up to 32 hours of on-site training for power monitoring system.

B. Training to include documentation and hands on exercises necessary to enable operations personnel to assume full operating responsibility for the power monitoring system after completion of training.

END OF SECTION

SECTION 26 09 43
LOW VOLTAGE LIGHTING CONTROL SYSTEM

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Networked low voltage lighting control system with Building Automation System (BAS) integration.

B. System commissioning.

1.2 RELATED SECTIONS

A. Section 26 00 10 – General ELectrical Requirements

B. Section 26 24 16 – Panelboards.

C. Section 26 05 13 – Medium Voltage Cables.

D. Section 26 05 33 – Conduit.

E. Section 26 51 13 – Building Lighting.

1.3 PRODUCTS FURNISHED AND INSTALLED UNDER OTHER SECTIONS

A. Lighting Control Equipment included in this Section shall be furnished by Section 25 50 00, and installed by Div 26.

B. Control wiring from switches and sensors to the Lighting relay panel, wiring from the lighting relay panel to the fixture and power wiring to the lighting relay panel shall be provided by Div 26.

C. Communication wiring between the lighting relay panels and the BAS shall be provided and installed by Section 25 50 00.

D. Programming, commissioning, and field training for the system shall be provided by Section 25 50 00.

1.4 SYSTEM DESCRIPTION

A. The lighting control system shall be a network of lighting control panels, all associated network interfaces, control modules, input modules, panel processor, relays, photocells, switches, and sensors. Include entire lighting control network wiring with interface to BAS Section 25 50 00 contractor.

B. Provide an internal transceiver port per panel for software communication over the BAS network utilizing native BACnet MS/TP (ASHRAE Standard 135-2001) communication protocol.

C. Lighting Control System shall communicate to BAS directly, no gateway shall be utilized. BAS workstation shall program, schedule and monitor room lighting activity and lighting control devices.

D. System shall provide control of lights throughout building including offices labs, open collaboration/ lounge areas, support areas, toilet rooms, mechanical areas, circulation corridors and stairs, lobbies, and site as shown on plans, risers, schedules and described below.

1. Typical Enclosed office shall have dual level lighting. Office shall have two relay activated on or off with an occupancy sensor and a photocell located at the ceiling and with two switches on one keypad located at the entry to each module. The low level shall be controlled by the override occupancy sensor all day. The high level shall be operated by override switch only and daylight harvesting photocell all day. A time schedule shall also turn lights off with a flash warning. System shall be able to adjust priority between schedule and control devices. HVA/C setback in offices shall operate in conjunction with lab lighting. System shall use the same schedule in offices for HVA/C setback and lighting operation. Additionally, system shall coordinate lighting and HVA/C setback for non scheduled override conditions.
2. Typical labs modules shall have dual level lighting. Module shall have two relay activated on or off with two switches on one keypad located at the entry to each module. The low level shall be controlled by both a time schedule during the day and override switch at night. The high level shall be operated by override sitch only. A time schedule shall also turn lights off with a flash warning. System shall be able to adjust priority between schedule and control devices. HVA/C setback in labs shall operate in conjunction with lab lighting. System shall use the same schedule in labs for HVA/C setback and lighting operation. Additionally, system shall coordinate lighting and HVA/C setback for non scheduled override conditions.
3. Circulation corridors and lobbies shall have relay activated on or off. Space shall be on a time schedule with occupancy sensors at night. A time schedule shall also turn lights off with a flash warning. System shall be able to adjust priority between schedule and control devices.
4. Entries, plaza and main lobby shall have relays activated by on/off schedules and low voltage override switches. Selected areas will also have photocell for daylight sensing and on/off control of lights when adequate daylight is available. System shall be able to adjust priority between schedule and control devices.
5. Toilet rooms shall have relay activated on or off with occupancy sensors. A time schedule shall also turn lights off with a flash warning.
6. Support areas shall have relay activated on or off by schedules and / or switch or occupancy sensor. Mechanical and electrical rooms shall be controlled by timer switches.
7. Walkways shall have relay activated on or off with photocell control for dusk to dawn lighting.

E. BAS workstation shall alarm if relay status does not correspond with time schedule or override signal.

F. Refer to lighting relay schedules for identification of how each relay is to be controlled, and which devices, if any, shall be capable of overriding the standard control method.

1.5 SUBMITTALS

A. Follow Section 01 33 00. Make all submittals at one time. Partial submittals will not be accepted. Where manufacturer's data or documentation is requested in initial and subsequent submittals, data or documentation originated by anyone other than the manufacturer will not be approved. Clearly identify any exceptions or deviations to this specification or any related Sections.

B. Shop Drawings: Show typical and one-line wiring diagrams and equipment layout. Include equipment installation outline and connection diagrams for external wiring.

C. Product Data: Submit manufacturer's original printed data sheet(s) and model number for each product furnished under this Section; include a complete itemized list of all components for the specified system. Indicate coverage patterns of occupancy sensors.

D. Schedules: Submit schedules for relays panels indicating relay number; circuit connection control device and schedules.

E. Informational Submittals:
   1. Manufacturer's Installation Instructions.
   2. Statement of Supplier and Installer Qualifications:
      a. Certificates of completion of manufacturer's training, or manufacturer's proof that supplier is acceptable to manufacturer and that manufacturer's warranty will be honored.
   3. Graphic Screens: Two-step approval process:
      a. Submit initial conceptual screens showing how the system shall operate; make submission prior to manufacture of hardware.
      b. Provide second submission at time of commissioning to show final screen layouts incorporating "as-wired" conditions.
   4. Project Record Documents: Using shop drawings, show wiring and layout drawings to record actual construction.
      a. Provide accurate record drawings that indicate the load controlled by each relay and the identification number for that relay; and identify the physical location of each switch connected to an input.
   5. Operation and Maintenance Data.
   6. Manufacturer Special Warranty: Provide written warranty for replacement parts of any portion of the lighting control system equipment that fails due to material or workmanship for a period of twenty four (24) months from date of substantial completion of system installation, which is defined as when BNL obtains beneficial use of the system.
      a. Ship replacement parts within 24 hours for any component that fails due to material or workmanship during the warranty period.
      b. Manufacturer shall provide free telephone support to the BNL for the duration of the warranty period.
   7. Installer Special Warranty: Provide written warranty for labor and materials to replace any portion of the lighting control system equipment or wiring that fails due to materials or workmanship for a period of twenty four (24) months from date of substantial completion of system installation, which is defined as when BNL obtains beneficial use of the system.

1.6 QUALITY ASSURANCE

A. National Electrical Code.

B. National Electrical Manufacturers' Association.

C. UL - Lighting Control Panels shall be UL listed as a complete system under UL 916 Energy Management Equipment.

D. FCC Emissions Standards specified in Part 15 for Class A application. Telephone Override System shall also be in compliance with standards specified in Part 68.

1.7 DELIVERY, STORAGE AND HANDLING

A. Deliver controllers, sensors and time switches to Div 26 to meet construction schedule.

B. Coordinate physical size of all equipment with the architectural requirements of the spaces into which the equipment will be installed.

1.8 MAINTENANCE SERVICE

A. Extended Service Coverage: Maintenance agreements shall be available from the manufacturer to provide service for the system both during and after the warranty period.

B. Local Support: The manufacture shall have service representatives within a 50-mile radius of the installation.

PART 2 - PRODUCTS

2.1 DESIGN STANDARD MANUFACTURER

A. Kele Autophos Series: Substitutions are permitted as per Division 25. Building Automation System manufacturer shall submit written approval of manufacturer and devices specified in this section, and accept responsibility of assurance of system operation and integration.

B. Acceptable Substitutions, subject to coordination with BAS is: Douglas Lighting Control, WattStopper and Lutron. System must meet the functional and performance requirements specified herein, to be considered. Submit a detailed line-by-line compliance comparison of any alternate system.

2.2 LIGHTING CONTROL PANEL HARDWARE

A. Enclosure: Each relay panel shall have the following features:
   1. Minimum 16 gauge steel construction; paint inside and outside.
   2. Provide 16, 24 or 48 relay sizes as indicated by relay schedule to control circuits indicated on the electrical drawings.
   3. Maximum 24 inch wide and variable height depending on the relay capacity of the enclosure.
   4. Provide a barrier to separate low voltage compartment from high voltage compartment.
   5. Provide a cover secured by screws to enclose the high voltage compartment. Provide cover with a clearly marked label to warn of the danger of high voltage.
   6. The unit shall be provided with the maximum number of relays shown on schedule without requiring the addition of any automation cards, relay output modules or additional electronics. Label unused relays as “SPARE”.
   7. Door shall be provided with key lock and painted to match enclosure.
   8. Lighting Control Relay: Each controlled circuit shall be connected through a single pole, single throw momentary-pulsed mechanically latching contactor rated at 20 amps, 120-277 VAC. Relay shall be:
      a. Mechanically latching relay using a dual coil technology and shall have manual override function.
      b. Relays shall attach to the barrier and plug into the Relay Interface Board via quick connect plug in connectors. Relays that use screw terminations for low voltage connections shall not be acceptable.
      c. Load contacts shall be rated as follows: 20A, 125 VAC Tungsten; 20 A @ 277 VAC. Ballast or Resistive: 0.5 HP @ 125 VAC; 1.5 HP @ 277 VAC.
      d. All relays shall be factory wired for low voltage control; field wiring or field rewiring is not acceptable regardless of panel zoning requirements.
      e. Relay shall utilize low in-rush technology rated 20A, 277 VAC. Warranty relays for use with electronic ballasts.
   9. High Voltage Compartment Divider (HVCD): Provide a HVCD to separate 120V from 277V within the high voltage compartment. Mount the HVCD in the high voltage compartment between the relays as a barrier between the two different voltages. The HVCD shall not require any tools for mounting and can be placed between any of the panel relays.

2.3 SYSTEM ELECTRONICS

A. General: The system electronics shall consist of pre-assembled electronics including a panel controller, output interface modules, optional switch input modules as required by the drawings, network control modules, network link modules, interconnect cables and power supply. The unit shall be capable of interaction with Section 25 50 00 BAS without additional lighting control panel hardware.

B. Panel Controller:

1. 48 Output Capability: Unit shall provide switching for up to 48 loads. Outputs shall be sequenced to reduce the inrush effects on the power system.
2. Commanded Load Feedback: Unit shall provide feedback of the commanded state of each lighting zone.
3. Selectable Output Energize Time: Unit shall provide selectable energize duration from 0.024 to 1.56 seconds. All circuits shall not be turned ON or OFF simultaneously, but staged ON and OFF to prevent line surges.
4. Relay Grouping: Unit shall provide selectable grouping of relays. Any output can be assigned to any lighting zone without any rewiring.
5. Manual Override: Unit shall provide manual override of each lighting zone.
6. Occupant Flash Warning: Unit shall provide selectable occupant flash warning with selectable on time after the occupant flash warning from 10 seconds to 60 minutes in duration. After commissioning of system, set post-flash on time for 1 minute. Verify timing with BNL. Flash warning shall only apply to loads that are timing “off”.
7. Output Refresh Rate: Unit shall provide the capability to send commands to its outputs to assure proper status based on a user selectable rate of every 3-30 minutes.
8. Selectable Switch Inputs: Unit shall provide maintained, momentary ON, momentary OFF, momentary ON/OFF and linked switch inputs with selectable switch input timers of up to 18 hours. A minimum of 24 switch inputs for each lighting relay panel shall be provided with the capability to expand to 56 switch inputs. Wiring of override devices and terminations within relay panels must be included in shop drawing submission.
9. Selectable Switch Input Polarity: Unit shall provide for normally open or normally closed switch inputs. Isolated RS-485 serial communications port.
10. Local Status LED’s: Unit shall provide separate status LED’s for each of the 60 lighting zones, 60 outputs. For troubleshooting and system commissioning, provide serial communication LED’s to indicate a serial command has been detected, end of serial command detected, serial address matches the unit address, checksum correct, legal serial command detected, and this unit has acted on incoming serial command.
11. Memory Loss Protection: Provide non-volatile memory so data is not lost during power outages or brown outs. Battery backed memory is not permitted.
12. Filtering: Provide filters to reduce noise emissions and power line spikes.
13. EPROM and EEPROM Diagnostics: Unit shall have the software capability to run a diagnostic check of the unit's EPROM (Electrically Programmable Read Only Memory) and EEPROM (Electrically Erasable Programmable Read Only Memory) at any time. If the panel detects any problem with its memory after power-up, a warning LED shall flash to indicate a problem exists.
14. Serial Priority: Unit shall provide the capability to have serial commands take priority over momentary switch inputs. This feature only applies to systems that utilize the RS-485 communication capability.
15. Maintained Input Priority: Maintained switch inputs shall have the capability of taking priority over serial commands and momentary switch inputs.
16. Independent Operation: Capability to function independently of other panels if a network failure occurs. All specified features shall continue to operate.
17. Output Interface Module: Each of the low voltage coils on the outputs shall plug into an interface for ease of installation and replacement. Systems that use screw terminals to connect the low voltage coil control wiring are not acceptable. Systems that do not use an interface module separate from the panel controller are not acceptable. Systems with eight outputs or less connected directly to the panel controller are acceptable.
18. Switch Input Module: The switch input modules shall provide 24 - 56 switch inputs each. Up to three optional switch input modules shall connect to one panel controller via a single ribbon cable. This shall provide the capability for 96 optional switch inputs, plus 24 standard switch inputs for a total of 120 switch inputs. An override switch input connected to any panel shall be capable of operating relays in all panels.

19. Panel Controller Power Supply: Unit shall provide a single transformer with primary fusing; capable of 120V or 277V ±10 percent, primary power. Units with single primary transformers are not acceptable. Provide a grounding stud in the high voltage compartment. Power shall be provided from the panelboard busses.
20. Panel Transformer: Unit shall provide a low voltage transformer with primary fusing fed from panel power supply and capable of feeding all low voltage override devices connected to that panel.
21. Integration with Building Automation System: The panel shall interface to Section 25 50 00 BAS over BACnet. All programming, scheduling, monitoring and control of lighting circuits shall be from the BAS software. Each lighting circuit from the panel shall be a mapped point to the BAS without any third party software or hardware. All graphic lighting control floor plans shall be on BAS software. Lighting relay panel shall support BACnet and/or Modbus, and include an RS-485 communication port. Override devices connected to any and all lighting relay panels shall communicate with the BAS, as specified in Section 25 50 00.

2.4 MISCELLANEOUS COMPONENTS

A. Photocells: The photoelectric device shall be a Class 2, low voltage, ambient light sensor capable of sensing light levels for outdoor and indoors. Design device to interface directly with the analog input of the lighting control system. The sensor shall supply an analog signal proportional to the light measured. Sensor output shall provide for zero or offset based signal.
   1. Interior for daylight harvesting: Design manufacturer is Kele # MK7-B-CCF. Sensor shall have translucent or Fresnel lens dependant on application with range of 50-750 FC. Coordinate mounting and required hardware with field conditions at mounting location.

B. Exterior: Design manufacturer is Kele # MK7-B-CR.Provide a hood over the aperture to shield the sensor from direct sunlight. Locate sensor in shadow-free roof location, and orient it to face North. Completely encase sensor circuitry in an optically clear epoxy resin. Mount sensor to a standard threaded 1/2 inch conduit or fit a 1/2 inch knockout. Sensor range shall be between 0 and 750 FC. Factory set sensors to lowest detectable light levels, and provide a 15 minute delay to prevent false tripping. Sensors shall be UL wet labeled. Motion Sensor: 360 degree Dual Technology:
   1. Design Standard Manufacturer: Kele # DT-300 Sensors shall have 360 degree field of view and 1600 square feet of coverage.
   2. Sensors shall be specifically designed for energy conservation.
   3. Sensors shall utilize ultrasonic and infrared technology to prevent false tripping.
   4. When the sensor detects motion, it shall make a dry contact closure. If it fails to detect motion during the user selected time delay period, it shall break the contact closure.
   5. Operation shall be silent.
   6. Sensors shall be designed specifically for the size and use of the area in which they will be used.
   7. Provide power packs and control wiring as required.

C. Motion Sensor PIR Technology:
   1. Design Standard Manufacturer: Kele # CX100 /200
   2. Sensors shall be specifically designed for energy conservation.
   3. Sensors shall utilize infrared technology.
   4. When the sensor detects motion, it shall make a dry contact closure. If it fails to detect motion during the user selected time delay period, it shall break the contact closure.
   5. Operation shall be silent.
   6. Sensors shall be designed specifically for the size and use of the area in which they will be used.
   7. Provide power packs and control wiring as required.

D. Motion Sensor Dual Technology:
   1. Design Standard Manufacturer: Kele/Wattstopper # DT-300
   2. Sensors shall be specifically designed for energy conservation.

3. Sensors shall utilize a combination of infrared technology and ultrasound technology.
4. When the sensor detects motion, it shall make a dry contact closure. If it fails to detect motion during the user selected time delay period, it shall break the contact closure.
5. Operation shall be silent.
6. Sensors shall be designed specifically for the size and use of the area in which they will be used.
7. Provide power packs and control wiring as required.

E. Low Voltage Momentary Switch:
1. Design Standard Manufacturer: Kele KSW-T-W.
2. Momentary toggle switch shall turn lights "on" pushed up and turn lights "off" when pushed down.
3. Stainless steel finishes and ganged as indicated on the Drawings

F. Low Voltage Timed Switch:
1. Design Standard Manufacturer: Kele AS-100
2. 24 volt, single pole, double throw isolated relay.
3. Time-out adjustable from 5 minutes to 12 hours. Provide scrolling option to override preset time.
4. Flash warning shall occur one minute prior to lights timing "off".
5. Sensor shall contain a liquid crystal display of time cycle.

2.5 SOURCE QUALITY CONTROL

A. Component Pre-testing: All components and assemblies shall be factory pre-tested and burned-in prior to installation.

2.6 LIGHTING SOFTWARE AND GRAPHIC SCREENS

A. Real-time monitoring and control of system relays.

B. System Security: Password protected, user defined access codes shall provide a minimum of 4 levels of system entry to ensure system security. Software shall be capable of logging programming changes, date of change, and user who initiated change.

C. Sufficient memory to store daily conditions and alarm notifications for a period of 24 months.

D. Software programming stored in non-volatile memory, with redundant copy created by database and stored on the computer's hard disk.

E. Software reports shall provide hard copy documentation of system status and alarm conditions identifying date, time, type of alarm failure, as well as date and time that alarm condition was rectified.

F. Upload and download capability for off-line programming and data storage.

G. Capable of viewing programmed time schedules as well as current status on a room-by-room basis.

H. Control Flexibility: Capable of assigning any override device to any relay via programming.

I. Hardware Diagnostics: Provide capability to identify hardware malfunctions in remote units.

J. Graphic User Interface:
1. Provide graphic screen of floors indicating rooms or areas, loads controlled.
2. Icons on graphic screen shall monitor system parameters and shall include the following:
   a. Time schedule status.
   b. Control device override status.
   c. Alarms for system failures.

K. Provide data logging and reporting capabilities by room for system parameters. Selective Historical Reports shall be generated from information stored in files, and printed on command after entering the following:
   1. Password
   2. Room Number or Relay Number
   3. Starting and ending date for report.

PART 3 - EXECUTION

3.1 COORDINATION

A. Contractor shall coordinate all Work of this section with work of other sections to provide a complete and operable system.

3.2 INSTALLATION

A. Lighting Control Equipment included in this Section installed by Division 26. Control wiring from sensors and time switches to the Lighting relay panel, wiring from the lighting relay panel to the fixture and power wiring to the lighting relay panel shall be provided by Division 16. Communication wiring between the lighting relay panel and the BAS shall be provided by BAS contractor. Commissioning and programming of the equipment shall be provided by this section in conjunction with BAS.

B. Install the lighting control equipment according to the manufacturers written instructions. Contractor shall make all necessary wiring connections to external devices and equipment.

3.3 CONTROL WIRING INSTALLATION

A. Provide and install all wiring between control devices as indicated in the contract drawings, details, and/or indicated in the manufacturer’s submittal package.

B. Bundle and support wiring in enclosures.

C. Install the lighting control equipment according to the manufacturers written instructions. Contractor shall make all necessary wiring connections to external devices and equipment.

D. Ensure that conduit for line voltage wires enters panel in line voltage areas and conduit for low voltage control wires enters panel on low voltage areas. Check manufacturer’s drawings for location of line and low voltage areas.

E. For low voltage wiring, provide wire type, size and quantity as recommended by the manufacturer.

F. Adhere to manufacturer's recommendations as to maximum wire length and maximum quantity of relays per switch.

3.4 FIELD TESTING

A. Factory trained technicians shall provide one (5) days of system testing after installation to verify proper operation and confirm that the enclosure wiring and addressing conform to the wiring documentation.

3.5 MANUFACTURER'S FIELD SERVICES

A. Arrange and pay for the services of factory-authorized service representatives to commission, test and program the lighting control system.

3.6 CLEANING

A. The contractor shall remove all paint spatters and other spots, dirt and debris from the equipment. Clean equipment and devices internally and externally using methods and materials recommended by the manufacturer.

3.7 DEMONSTRATION AND TRAINING

A. Factory trained application engineers shall provide eight hours of on-site training for the BNL's representatives in the operation of the system, as well as future telephone support. Set-up and commissioning of the lighting control system includes:
   1. Confirmation of interface units, computer and peripherals
   2. Confirmation of system operations.

3.8 COMMISSIONING

A. After the system has been installed and the network wiring is operational, the Contractor shall secure the services of a factory-trained representative of the manufacturer to verify correct operation of all system components. The factory-trained representative(s) shall verify that the Contractor has properly installed and interconnected all components. They shall start up all equipment and demonstrate that it meets the requirements of this specification.

3.9 LABELING

A. Provide relay cabinet labeling as specified in Section 26 00 10.

B. Identify all circuit locations in each respective panel with load and location served.
   1. Room names and numbers in directory shall be final building room names and numbers as identified by government and not room names and number identified on plans.
   2. Directory shall be typed.
   3. Provide directory frame on inside of door.

END OF SECTION

SECTION 26 11 16
SECONDARY UNIT SUBSTATIONS

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Unit substation design, testing and assembly: Conform to ANSI, IEEE and NEMA standards.

B. Each unit substation shall consist of a single High Voltage (HV) incoming line section close coupled to a liquid-filled substation type transformer close coupled to with a Low Voltage (LV) outgoing line section.

C. Factory inspection and witness testing: The government reserves the right for factory inspection and witness testing of high voltage switches and/or transformers:
   1. Notify government three (3) weeks in advance of factory testing.

1.2 SUBMITTALS

A. Shop drawings:
   1. Include all dimensions, ratings, high and low voltage terminal connections, arrestors, switches, etc., for the complete substation assembly.

B. Product data:
   1. Technical data on each component.

C. Contract closeout information:
   1. Operating and maintenance data.
   2. Test reports.
   3. Spare fuses.

PART 2 - PRODUCTS

2.1 UNIT SUBSTATION

A. Acceptable manufacturers:
   1. Unit substation:
      a. Base:
         1) Eaton Cutler-Hammer.
      b. Optional:
         1) Square D.
         2) Siemens.

B. Unit substations: Consisting of high voltage (HV) incoming line section, transformer section and (LV) outgoing line section, factory or field assembled to form single integral free standing, totally enclosed unit:
   1. Provide individual units with provisions for jacking, lifting, skidding and rolling.
   2. Suitable for outdoor installation.
   3. All components comply with applicable NEMA and ANSI standards.
   4. Brace entire assembly including HV section and core and coil assembly of transformer as a unit to withstand the mechanical and thermal forces caused across the low voltage external terminals without any damage, either thermal or mechanical, while operating at HV rating; calculate bracing on the basis of 500 MVA available on the incoming side of the unit substation.
   5. Connect sections by bolted flanges.

2.2 HV INCOMING LINE SECTION

A. HV incoming line section: 15kV metal-clad switchgear, outdoor non-walk-in type:
   1. Cable entry: From bottom.
   2. Construct for entrance and termination of three (3) single conductor, 15 KV cables.
   3. Provide ground bus in HV terminal compartment to connect to area ground.
   4. Provide three 12 KV, intermediate class, metal oxide gapless type lightning arrestors for grounded system. Select arrestors to limit sparkover voltage to less than 80 percent of transformer BIL HV rating. Connect arrestors to line side of breaker.
   5. Insulation barriers shall be provided between live parts and between live parts and grounded parts.
   6. The switchgear assembly shall consist of individual vertical sections housing various combinations of circuit breakers and auxiliaries, bolted together to form a rigid metal-clad switchgear assembly:
      a. BIL rating (of enclosure and circuit breaker, either individually or as a unit): 95 kV
      b. Provide access doors with provision for padlocking.
      c. Provide protected ventilation openings, as required.
      d. Provide thermostatically controlled 250 watt, 120 volt rated space heater in each bay. Heater shall be factory wired and fused protected. On-Off control shall be accessible without opening high voltage compartment.
      e. Completely enclose all major parts of primary circuit (such as circuit breaker, buses and potential transformers) with grounded metal barriers.
      f. Finish: Chemically cleaned and treated for good bond; primed; finish painted with acrylic lacquer, light gray (ANSI Color 61) or medium light gray (ANSI Color 49).
   7. Buses and Connections:
      a. Buses shall be silver-plated copper and shall be fully insulated along their entire length.
      b. Main bus shall be rated at 1200 amperes.
      c. All bus joints and connections shall be plated, bolted and insulated with easily installed boots.
      d. Brace buses to withstand fault currents equal to the close-and-latch rating of installed breakers.
      e. Temperature rise of all buses and connections shall be in accordance with ANSI standards and shall be documented by design tests.
      f. Provide a non-insulated copper ground bus extending the entire length of the switchgear.
   8. Circuit breaker compartments: Design to house circuit breakers indicated:
      a. Breaker levering mechanism shall be cell mounted and shall include all necessary interlocks to render breaker mechanism mechanically trip-free during levering procedure.
      b. Provide high current spring-type contacts to ground breaker in operating and test positions.
      c. Stationary primary disconnecting contacts shall be silver-plated copper and shall be field replaceable.
      d. Bright orange steel shutters shall automatically cover the stationary primary disconnecting contacts when breaker is in the disconnected position or has been removed from the cell.
      e. Breaker shall be horizontal drawout type on retractable support rails.
      f. Welded guide rails for positioning breaker and all other necessary hardware shall be an integral part of each breaker cell.
      g. Blocking devices shall interlock breaker frames sizes to prevent installation of a lower ampacity or interrupting capacity element in a cell designed for a breaker of higher ratings.
   9. Circuit Breakers: Vacuum interrupter, draw-out type; 3 pole, 60 Hz:
      a. See specification Section 26 28 00.
   10. Current transformers: Appropriate ratio, with relay and metering accuracy:
      a. Mechanical rating: Equal to momentary rating of circuit breaker.

b. Insulated for full voltage rating of switchgear.
c. Three phase current transformers.
d. One zero sequence current transformer.

11. Control power transformer: With primary fuses and secondary circuit breaker:
    a. Insulated for full voltage rating of switchgear.
    b. Mount on drawout drawer contained in an enclosed auxiliary compartment:
        1) Shutters shall isolate bus stabs when drawer is withdrawn.
        2) Provide mechanical interlock to require secondary breaker to be open before drawer can be withdrawn.
12. Breaker control switch: With red and green indicating lights.
13. Control wiring: No.14 AWG, minimum, type MTW tinned copper wire.
14. Provide a maintenance mode selector switch to adjust the circuit breaker protection settings to a lower setting to reduce arc flash incident energy potential. See coordination study for setting information.

2.3 TRANSFORMER SECTION

A. Transformer: Oil immersed outdoor substation type, natural draft cooled with provisions for future forced air cooling (ONAN/Future ONAF):
    1. Capacity rating: KVA as indicated on drawings, 3 phase, 60 Hz.
    2. HV voltage rating: 13.8 KV, connected delta:
        a. Provide two 2-1/2 percent FCAN taps and two 2-1/2 percent FCBN taps.
        b. Provide tap changing mechanism, externally operable in de-energized condition only. Mechanism shall be padlockable.
    3. Basic impulse level: 95 KV BIL, HV rating and 30 KV BIL, LV rating.
    4. LV rating: 480/277 V, connected wye.
    5. 55 degC rise above a 40 degC ambient. Transformer shall be capable of carrying a 12 percent continuous overload without exceeding 65 degC rise above a 40 degC ambient.
    6. Impedance: 5.75 percent on its base KVA rating plus or minus 7.5 percent.
    7. Rated sound level: Not greater than ANSI/NEMA standards.
    8. Core and coil assembly: Wound core (five-legged) type with copper windings.
    9. Tank: Sealed, for top oil temperature from 50 degC to 106 degC, and to withstand 7-1/2 PSI pressure without permanent distortion:
        a. Bolted on cover with tamperproof fastenings.
        b. Cooling panels on back and sides, if required.
        c. Lifting lugs and jacking pads welded to tank.
    10. No fastening devices externally removable.
    11. One inch drain valve with sampling device.
    12. Dial type thermometer with resettable high temperature indicator.
    13. One inch upper filter press and filling plug.
    14. Liquid level indicator.
    15. Pressure vacuum gauge.
    16. Pressure relief valve.
    17. Provisions for future forced air cooling shall include the necessary preparation for the future installation of an oil temperature relay, control cabinet, 120 volt fans, wiring, etc.

B. RC snubber: Series connected resistor and capacitor shall be connected between the transformer primary terminal and ground:
    1. RC snubber shall absorb and dampen high frequency transients.
    2. Size resistor and capacitor to match system surge impedance.

2.4 LOW VOLTAGE OUTGOING SECTION

A. General:
    1. Low voltage outgoing section: Air terminal cabinet arranged for bottom entry cables.
    2. NEMA two hole copper spade terminals.

3. Terminals shall be arranged and braced to support the number of conductors indicated on drawings.

B. High Resistance Grounding System:
   1. General:
      a. High resistance grounding system shall be pulsing type with fault detection via current relay suitable for use on a 480Y volt, 3 phase, 3 wire, 60 hertz distribution system.
      b. The resistors and instruments shall be mounted within the low voltage outgoing section. The metering and controls shall be mounted within the indoor switchgear.
      c. The resistor assembly shall be a self-contained housing having an instrument compartment and a resistor compartment. The instrument compartment shall be segregated from the resistor compartment by means of steel barriers.
      d. Tapped resistors with taps wired out to a convenient front accessible terminal block. Taps shall provide 1 to 5 amperes of ground current in 1 amp increments. Resistors shall be heavy-duty industrial type, edgewound or wirewound design. Each resistor tube shall have a stamped steel rating nameplate. The resistor assembly shall be interconnected with 200 degree C rated #8 AWG wire. All connections to the resistor assembly shall be #8 AWG SIS wire.
      e. All wiring in the grounding circuit from the neutral point to the system ground terminal shall be #8 AWG type SIS minimum. All control wiring shall be #14 AWG type SIS minimum.
      f. Provide ventilators with removable air filters located on the roof and/or sides of the section to ensure adequate ventilation within the enclosure.
   2. Metering and Controls:
      a. A switchboard type ground current ammeter, 1% accuracy, 250-degree scale, 0 to 10 A ac.
      b. System control selector switch with PULSE/NORMAL/TEST positions. Switch shall spring-return from the test position.
      c. Reset control selector switch with AUTO/MANUAL/RESET positions. Switch shall spring-return from RESET position. The AUTO position shall cause the ground fault relay to automatically reset when a ground is no longer detected. The MANUAL position shall cause the ground alarm relay to latch and remain latched until the selector is moved to the RESET position by the operator.
      d. A green lamp to indicate that the system is in normal condition, a red lamp to indicate that a ground fault has been detected, and a white lamp that flashes at the same rate and at the same time as the pulsing contactor.
      e. An instruction nameplate that provides the operator with a step-by-step procedure for operating the controls.
      f. A rating nameplate that states the maximum ground current, maximum pulse current and duty rating of the equipment at maximum current levels.
      g. An alarm horn with an alarm silence pushbutton and re-alarm timer. The horn shall be a high-decibel type. Alarm silence control shall reset when ground relay is reset. Alarm shall automatically re-sound at the end of a 2- to 48-hour field-settable time interval if alarm has been silenced but ground fault still exists. Re-alarm timer shall not be defeatable via any control device.
      h. Ground fault relay with harmonics filter to prevent nuisance tripping. Ground fault relay shall have a UL 1053 label.
      i. One normally open and one normally closed ground fault alarm contact.
      j. Test loops (for convenient attachment of a snap-on hand-held ammeter) in the ground current and test current circuits.
      k. A test circuit protected by a current-limiting fuse rated 200,000 amperes and operated by the system control switch via a panel-mounted test circuit relay. The test circuit shall connect phase B to ground through a current-limiting resistor. The test circuit shall not be direct-wired to the door-mounted test switch. The test circuit relay shall be constrained from operating if a ground fault is presently being detected.

l. A pulsing contactor, controlled by an adjustable timer. The timer shall allow an adjustment range of 0-10 seconds.
m. 120 Vac control power transformer for self-contained operation. The control power transformer shall have current limiting primary fuses rated 200,000 AIC at the system voltage.
n. Primary disconnect switch mounted ahead of test and control power fuses.

2.5 CONCRETE PAD

A. Provide concrete pad below substation sized and located as indicated on drawings.

B. Coordinate opens in pad with approved submittals.

C. Slope pad to prevent ponding of rain water.

PART 3 - EXECUTION

3.1 FACTORY TESTING

A. Each transformer shall receive all standard routine tests as required by ANSI C57.12.00 and performed as specified by ANSI C57.12.90.

B. Short Circuit withstand capability shall be verified by full short circuit tests on a similar unit in accordance with the latest revision of ANSI C57.12.00 and ANSI C57.12.90.

C. Additional tests, as indicated below will also be required, if not already included in the standard battery of test:
1. Schedule of testing.
a. Resistance Measurements.
b. Ratio Tests.
c. Polarity and Phase-Relation Tests.
d. No-Load Losses.
e. Exciting Current.
f. Impedance and Load Test.
g. Applied Potential Test.
h. Induced Potential Test.
i. Temperature Test.

3.2 INSTALLATION

A. Install all components as indicated and in accordance with manufacturer's published instructions and recommendations.

3.3 LABELING

A. Provide labeling as specified in Section 26 00 10.

END OF SECTION

SECTION 26 12 19
LOW VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Product data:
   1. Technical data on each type of transformer.
   2. No load core loss and full load coil loss data.
   3. Percent impedance and X/R ratio data.

B. Contract closeout information:
   1. Operating and maintenance data.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Dry-type transformers:
      a. Base:
         1) EATON Cutler-Hammer.
         2) Siemens.
         3) Square D.

B. Non-K-rated dry-type transformers: Air cooled, 3-coil, two winding type:
   1. Voltage rating: 480 volt, 3 phase, 3 wire delta primary and 208Y/120 volt, 3 phase, 4 wire wye secondary, 60 cycle.
   2. Three phase, 30-KVA and above: Four 2-1/2 percent FCBN taps and 2 above, suitable for indoor service, arranged for floor or wall mountings indicated:
      a. Insulation: Class H 220 degC with average temperature rise not exceeding 115 degC based on 40 degC ambient at full load.
   3. KVA rating as indicated.
   4. Copper windings.
   5. Energy efficiencies shall comply with NEMA TP-1.
   6. Rated sound level equal to or below NEMA maximums.
   7. Impedance between 3.0 percent and 5.0 percent.
   8. Three phase, below 30-KVA: Class B, F or H insulation and two 5 percent FCBN taps.
   9. Provide ground fault monitor where indicated on drawings.

C. K-rated shielded dry type transformer: Air cooled, 3-coil, two winding with electrostatic shield and suitable for use with non-linear loads:
   1. Voltage rating: 480 volt, 3 phase, 3 wire delta primary and 208Y/120 volt, 3 phase, 4 wire wye secondary, 60 cycle.
   2. K-rating: UL listed for non-sinusoidal current loads with a K-factor of 13.
   3. KVA rating: As indicated.
   4. Copper windings.
   5. Energy efficiencies shall comply with NEMA TP-1.
   6. Core: High grade, non-aging, grain oriented silicon steel with high permeability and low hysteresis and eddy current losses. Magnetic flux density shall be well below the saturation point to prevent core saturation by harmonics with a 10 percent primary overvoltage.
   7. Impedance: Between 3.0 percent and 5.0 percent.
   8. Neutral terminal: Sized at 200 percent of phase terminal.

9. Electrostatic shield: Full width, single turn placed between primary and secondary windings and grounded to the transformer core.
10. Insulation: Class H, 220 degC with an average temperature rise not to exceed 115 degC based on a 40 degC ambient at full load and rated K-factor.
11. Taps: Two 2.5 percent FCAN and four 2.5 percent FCBN.
12. Sound rating: Equal to or below NEMA maximums.
13. Enclosure: Indoor, ventilated, NEMA 1.

D. Vibration isolation: See Section 26 05 48.

E. External wiring connections: See Section 26 05 48.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as indicated and in accordance with manufacturer's recommendations and instructions.

B. Provide wall mounting brackets, trapeze mounting brackets and/or rack mount on unistrut frame as indicated or as required.

C. Floor-mounted transformers shall be mounted on concrete pads per Specification 26 00 10.

D. Provide labeling per Specification 26 00 10.

END OF SECTION

SECTION 26 23 00
LOW VOLTAGE SWITCHGEAR

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide dead front type, low-voltage metal enclosed double-ended switchgear utilizing drawout power air circuit breakers with main-tie-main manual transfer as indicated.

B. Provide high resistance grounding system as specified in Section 26 11 16.

1.2 QUALITY ASSURANCE

A. Low-voltage metal enclosed switchgear assembly and all components shall be designed, manufactured and tested in accordance with latest applicable standards as follows:
   1. ANSI-C37.13 (Low-voltage power circuit breakers).
   2. ANSI-C37.16 (Low-voltage power circuit breakers).
   3. ANSI-C37.17 (Trip devices).
   4. ANSI-C37.20.1 (Switchgear assemblies).
   5. ANSI-C37.51 (Switchgear assemblies).
   6. ANSI-C39.1 (Meters).
   7. NEMA SG-3 (Low-voltage power circuit breakers).
   8. NEMA SG-5 (Switchgear assemblies).
   9. UL 1066 (Low-voltage power circuit breakers).
   10. UL 1558 (Switchgear assemblies).

B. Factory inspection and witness testing: The government reserves the right for factory inspection and witness testing:
   1. Notify government three weeks in advance of factory testing.

1.3 SUBMITTALS

A. Shop drawings:
   1. Assembly: Including but not limited to the following:
      a. Outline drawings of assemblies including floor plans, elevations and sections.
      b. One line diagrams and wiring diagrams for assembly and components.
      c. Interconnection wiring diagrams.
      d. Component list.
      e. Nameplate schedule.
      f. Conduit space locations within assembly.
      g. Assembly ratings.
      h. Major component ratings.
      i. Cable terminal sizes.

B. Product data:
   1. Technical data on each component.
   2. Certified test reports on protective devices, in enclosures.
   3. Overcurrent protective device time-current characteristic curves, specifications and ratings, for coordination with source and load protective devices.

C. Project information:
   1. Factory test reports.
   2. Ground fault test report.
   3. Certifications.

D. Contract closeout information:
   1. Operating and maintenance data.
   2. Instruction report.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Low voltage drawout metal enclosed switchgear:
      a. Base:
         1) EATON Cutler Hammer.
      b. Optional:
         1) Square D Co.
         2) Siemens Energy & Automation, Inc.

B. Ratings:
   1. Voltage: 480 volt, 3 phase, 3 wire. Entire assembly shall be suitable for 600 volts maximum service.
   2. AIC rating: Assembly shall be rated to withstand mechanical forces exerted during short circuit conditions when connected directly to power source having the following available fault current at rated voltage: 65,000 amperes symmetrical.
   3. Bus system ANSI 4-cycle short circuit withstand rating: 65,000 amperes symmetrical.
   4. Circuit breaker minimum interrupting capacity: 65,000 amperes symmetrical:
      a. To assure a fully selective system, all circuit breakers shall have 30 cycle short time withstand ratings equal to symmetrical interrupting ratings, regardless of whether equipped with instantaneous trip protection or not.

C. Construction:
   1. Switchgear shall consist of required number of vertical sections bolted together to form a rigid assembly:
      a. Sides and rear shall be covered with removable covers.
      b. All edges of front covers or hinged front panels shall be formed.
      c. Provide ventilators located on top of switchgear over breaker and bus compartments to ensure adequate ventilation within enclosure.
   2. Provide adequate lifting means to allow assembly to be moved into installation position and bolt directly to Contractor supplied floor sills set level in concrete per manufacturer's recommendations.
   3. Make provisions for jacking of shipping groups, for removal of skids or insertion of equipment rollers. Base of assembly shall be suitable for rolling directly on pipes without skids.
   4. Each vertical steel unit forming part of switchgear line-up shall be a self-contained housing having one or more individual breaker or instrument compartments, a centralized bus compartment and a rear cabling compartment.
   5. Segregate each individual circuit breaker compartment or cell from adjacent compartments and sections, including bus compartment, by means of steel barriers:
      a. Provide drawout rails and primary and secondary disconnecting contacts.
      b. Provide removable hinge pins on breaker compartment door hinges.
   6. Stationary part of primary disconnecting devices for each power circuit breaker shall consist of a set of contacts extending to rear through a glass polyester insulating support barrier. Corresponding moving finger contacts suitably spaced shall be furnished on power circuit breaker studs which engage in only connected position:
      a. Assembly shall provide multiple silver-to-silver full floating high pressure point contacts with uniform pressure on each finger maintained by springs.
      b. Each circuit shall include necessary three-phase bus connections between section bus and breaker line side studs.

c. Load studs shall be equipped with insulated copper load extension busses terminating in solderless type terminals in rear cable compartment of each structure.
d. Bus extensions shall be silver-plated where outgoing terminals are attached.

7. Secondary disconnecting devices shall consist of floating fingers mounted on removable unit and engaging flat contact segments at rear of compartment. Secondary disconnecting devices shall be silver-plated and sliding contact engagement shall be maintained in "connected" and "test" positions.
8. Removable power circuit breaker element shall be equipped with disconnecting contacts, wheels and interlocks for drawout application:
   a. Provide "connected", "test", "disconnected" and "removed" positions for breakers, all of which permit closing of compartment door.
   b. Breaker drawout element shall contain a worm gear levering "in" and "out" mechanism with removable lever crank.
   c. Provide mechanical interlocking so that breaker is in tripped position prior to levering "in" or "out" of cell.
   d. Provide capability to padlock breaker open to prevent manual or electric closing. Padlocking shall also secure breaker in "connected", "test" or "disconnected position by preventing levering.
9. Provide insulating flash shield above each circuit breaker to prevent flashover from arc chutes to ground.
10. Provide safety shutter in cell which automatically covers line and load stabs when circuit breaker is withdrawn to protect against incidental contact.
11. Provide rear compartment steel barrier between cable compartment and main bus to protect against inadvertent contact with main or vertical bus bars.
12. Provide metal barrier full height and depth between adjacent vertical structures in cable compartment.
13. Provide glass polyester full height and depth barrier between adjacent vertical structures in bus compartment with appropriate slots for main bus.
14. Provide visual inspection windows at the rear of the switchgear to allow operators view of all cable terminations for thermal inspections with doors closed.
15. Cutler Hammer type Magnum DS low voltage metal enclosed switchgear utilizing type Magnum DS power air circuit breakers.

D. Bus:
1. Provide silver plated copper bus bars.
2. Main horizontal bus bars shall be mounted with all three phases arranged in same vertical plane.
3. Bus sizing shall be based on ANSI standard temperature rise criteria of 65 degC over a 40 degC ambient (outside enclosure).
4. Provide full capacity neutral bus where neutral bus is indicated.
5. Provide copper equipment ground bus firmly secured to each vertical section structure. Extend entire length of switchgear. Ground bus short time withstand rating shall meet that of largest circuit breaker in assembly.
6. Provide high-tensile strength and zinc plated conductor hardware.
7. Provide belleville type washers for bus joints.

E. Wiring/terminations:
1. Provide small wiring, fuse blocks and terminal blocks within switchgear as required.
2. Control wiring shall be type SIS.
3. Wire bundles shall be secured with nylon ties and anchored to assembly by prepunched wire lances.
4. Connect current transformer secondary leads to conveniently accessible short circuit terminal blocks before connecting to any other device.
5. Provide four (4) shorting screws with provisions for storage.
6. All groups of control wiring leaving switchgear shall be provided with terminal blocks with suitable numbering strips.

7. Provide wire markers at each end of all control wiring.
8. Provide plug in terminal blocks for all shipping split wires.
9. Terminal connections to remote devices or sources shall be front accessible via removable trays above each circuit breaker. Control fuses for electrically operated circuit breaker shall be located in trays.
10. Provide NEMA 2 hole mechanical or compression type lugs for all line and load terminations suitable for 75 degC rated copper cable. Termination system shall be provided such that no additional cable bracing, tying or lashing is required to maintain short circuit withstand ratings of the assembly.
11. Provide lugs in incoming line section for connection of main grounding conductor. Provide additional grounding lugs as indicated.

2.2 CIRCUIT BREAKERS

A. Mains, tie and feeder circuit breakers shall be drawout low voltage power air circuit breakers with solid-state trip units:
   1. See Specification Section 26 28 00.

2.3 MISCELLANEOUS DEVICES

A. Control power transformer:
   1. Fused control power transformers shall be provided as required for proper operation of equipment. Provide manual disconnect ahead of primary fuses.
   2. Provide transfer scheme to maintain control power with any one main circuit breaker open.

B. Zero Sequence CT's and Low-Medium-High Amp Meters:
   1. Provide each feeder circuit breaker with a zero sequence CT and Amp Meter to register a ground fault condition controlled by the high resistive ground system. Amp meter reading shall be Low-Medium-High and shall be mounted at the circuit breaker door.

C. Transient Voltage Surge Suppression Device:
   1. Install Transient Voltage Surge Suppression Device (TVSS) as indicated on drawings and as specified in Section 26 43 13. Mount TVSS within switchgear. Provide fused disconnect ahead of TVSS and connect to main bus. Locate TVSS to minimize length of conductors between main bus and TVSS. Provide remote indicating devices on the door to mimic indication on TVSS.

D. Key interlock:
   1. Provide key interlock to prevent the unit substation high voltage circuit breaker from being opened until the associated switchgear main circuit breaker is opened.
   2. Provide key interlock to prevent the tie circuit breaker from being closed unless one of the two main circuit breakers is opened.

2.4 CUSTOMER METERING EQUIPMENT

A. Current transformers (CT): Dry, indoor, 600V type with short-circuiting device, and with accuracies to meet latest ANSI and NEMA requirements for burden connected to its secondaries:
   1. Mount and brace to withstand mechanical stresses resulting from rated short circuit currents.
   2. Provide CT's for each phase, neutral and ground of the associated incoming feeder.

B. Potential source: Provide fused potential tap.

C. Meter 1:
   1. Multi-function digital meter:
      a. Provide a 3 element meter for use on a 480Y volt 3 phase 3 wire system.
      b. Program the meter to display real power (KW), apparent power (KVA) and energy consumption (KWH).
      c. Meter shall be panel mounted on the front of the switchgear.
      d. Meter shall be Trans Data Mark-V, Solid State Energy Meter with SCADA / EMS real time metering point option and telephone Modem option..

2. Power recorder:
   a. Provide power recorder with each digital meter.
   b. Provide cabling and interface with the digital meter.
   c. Provide communication output via RS485 Modbus RTU and telephone line to permit remote monitoring.

D. Meter 2:
   1. Provide meter as described in Section 26 09 13.

2.5 FINISH

A. All exterior and interior steel surfaces of switchgear shall be properly cleaned and provided with rust-inhibiting phosphatized coating. Color and finish of switchgear shall be manufacturer's standard.

2.6 ACCESSORIES

A. Provide two portable static full function test set to check the time over-current characteristics of each trip unit.

B. Provide rail mounted, top of switchgear, traveling type circuit breaker lifter.

C. Remote power racking device:
   1. Provide two portable remote power racking devices.
   2. Suitable for use with low and medium voltage drawout power circuit breakers with a screw type racking system.
   3. Locking base to prevent movement during racking procedure.
   4. Adjustable torque with torque limiter.
   5. Universal joint to allow up to 1 IN misalignment.
   6. Three light status indicator indicating breaker position.
   7. Remote operator controller with 25 FT control cable. Controller shall include one insert pushbutton and one remove pushbutton.
   8. 120 volt power cord with 5-15P plug.

PART 3 - EXECUTION

3.1 FACTORY TESTING

A. Switchgear shall be completely assembled, wired, adjusted and tested at factory. After assembly complete switchgear shall be tested to assure accuracy of wiring and functioning of all equipment. Main bus system shall be given a dielectric test of 2200 volts for one minute between live parts and ground and between opposite polarities.

B. Wiring and control circuits shall be given a dielectric test of 1500 volts for one minute or 1800 volts for one second between live parts and ground, in accordance with ANSI C37.20.1.

3.2 INSTALLATION

A. Locate switchgear(s) as indicated.

B. Equipment shall be installed and checked per manufacturer's recommendations. This shall include but not be limited to:
   1. Ensure that pad location is level to within 1/8 IN.
   2. Ensure that all bus bars are torqued to manufacturer's recommendations.
   3. Assemble all shipping sections, remove all shipping braces and connect all shipping split mechanical and electrical connections.
   4. Measure and record Megger readings phase-to-phase, phase-to-ground and neutral-to-ground.
   5. Inspect and install all circuit breakers in their proper compartments.

3.3 FIELD QUALITY CONTROL

A. Provide qualified factory-trained manufacturer's representative to assist Contractor in installation and start-up of equipment for a period of working days to be determined. Manufacturer's representative shall provide technical direction and assistance to Contractor in general assembly of equipment, connections and adjustments, and testing of assemblies and components contained therein.

3.4 MANUFACTURER'S CERTIFICATION

A. A qualified factory-trained manufacturer's representative shall certify in writing that equipment has been installed, adjusted, and tested in accordance with manufacturer's recommendations.

3.5 TESTING

A. Ground fault: Test installed ground fault system in main normal switchgear in compliance with NEC. Use high current injection method to test system and submit report indicating device settings, tripping time in cycles for each device, test current and date of test as well as name of certified testing firm that performed the test.

3.6 LABELING

A. Provide switchgear labeling as specified in Section 26 00 10.

END OF SECTION

SECTION 26 24 13
SWITCHBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide switchboard(s) as specified herein and shown on the associated electrical drawings.

1.2 QUALITY ASSURANCE

A. System standards:
   1. ANSI/IEEE C12.16 – Solid State Electricity Metering.
   2. ANSI C39.1 - Electrical Analog Indicating Instruments.
   3. ANSI C57.13 - Instrument Transformers.
   4. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches.
   5. NEMA PB 2 - Deadfront Distribution Switchboards, File E8681
   6. NEMA PB 2.1 - Proper Handling, Installation, Operation and Maintenance of Deadfront Switchboards Rated 600 Volts or Less.
   7. NEMA PB 2.2 - Application Guide for Ground Fault Protective Devices for Equipment.
   8. UL 489 - Molded Case Circuit Breakers.
   9. UL 891 - Dead-Front Switchboards.
   10. UL 943 - Ground Fault Circuit Interrupters.
   11. UL 1053 - Ground-Fault Sensing and Relaying Equipment.
   12. CSA 22.2 No. 5 - M1986 Molded Case Circuit Breakers.
   13. Federal Specification W-C-375B/Gen - Circuit Breakers, Molded Case, Branch Circuit And Service.

1.3 SUBMITTALS

A. Shop drawings:
   1. One line diagrams and wiring diagrams for assembly and components.
   2. Interconnection wiring diagrams.
   3. Front and side enclosure elevations with overall dimensions shown.
   4. Conduit entrance locations and requirements.
   5. Nameplate legends.
   6. Switchboard instrument details.

B. Product data:
   1. Technical data on each component.
   2. Overcurrent protective device time-current characteristic curves, specifications and ratings, for coordination with source and load protective devices.

C. Project Information:
   1. Certified test reports on protective devices, in enclosures if requested by Architect/Engineer.

D. Contract closeout information:
   1. Operating and maintenance data.
   2. BNL instruction report.
   3. Ground fault system test report.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:

1. Switchboards:
    a. Base:
        1) Eaton Cutler Hammer.
        2) Schneider Electric/Square D.
        3) Siemens.
2. Eaton Electrical types are indicated for quality and performance reference.

B. Switchboard(s): As described herein and as indicated in diagrams and schedules:
1. Arrange switchboard(s) as indicated and coordinate space requirements with space allotment.

2.2 SWITCHBOARDS-GENERAL

A. Service voltage: 480 V, 3 phase, 3 wire.

B. Accessibility: Front only.

C. Construction: NEMA Standard PB-2 1995, Deadfront Distribution Switchboards:
1. Completely-enclosed, self-supporting metal structure:
    a. Provide required number of formed and welded vertical panel sections, incorporating circuit protective devices and other associated equipment as indicated.
2. Bolt all fastenings between vertical sections.
3. Completely enclose switchboard(s) on front, sides, top and rear with removable sheet steel plates minimum 12 GA.
4. Provide bolted frame rear to support and house cables and other items.
5. Switchboard bussing and protective devices shall be rated for short circuit stresses as indicated.
6. Neatly lace all control wiring and leave flexibility at hinge locations.

D. Buses:
1. Buses shall be tin-plated copper.
2. Provide main horizontal bus of rating indicated, full-size continuous with provision for future extension.
3. Tin plate each main bus and tap connection over full surface of joints.
4. Heat rise of all buses shall not exceed ANSI/UL-891 listings.
5. Tightly fasten main bus connections to insure maximum conductivity.
6. Properly brace feeder circuit bussing.
7. Provide continuous copper ground bus rated 50 percent of main bus rating for switchboard(s):
    a. Solidly bond to each structure near bottom.
8. Do not use cabling inside switchboards as substitute for bus bar conductors, unless otherwise indicated.

E. Finish: Two coats of light gray enamel on all surfaces. Rustproof all sheet steel parts after fabrication, prior to painting.

F. Provide means for padlocking all main and feeder devices in open position.

G. Feeder Devices:
1. Individually mounted feeder devices.
2. Molded case circuit breaker(s):
    a. Provide adjustable long time, short time, instantaneous and ground fault electronic trip unit.
    b. See specification Section 26 28 00.

2.3 CUSTOMER METERING EQUIPMENT

A. Current transformers (CT): Dry, indoor, 600V type with short-circuiting device, and with accuracies to meet latest ANSI and NEMA requirements for burden connected to its secondaries:
1. Mount and brace to withstand mechanical stresses resulting from rated short circuit currents.

2. Provide CT's for each phase, and ground of the associated incoming feeder.

B. Potential source: Provide fused potential tap.

C. Multi-function digital meter:
1. Provide meter as described in Section 26 09 13. Refer to single line diagram drawings for quantity and locations of meters.

2.4 MISCELLANEOUS DEVICES

A. Control power transformer:
1. Fused control power transformers shall be provided as required for proper operation of equipment. Provide manual disconnect ahead of primary fuses.

B. Surge Protective Device:
1. Install Transient Voltage Surge Suppression (TVSS) as indicated on drawings and as specified in Section 26 43 13. Mount TVSS within switchgear. Provide fused disconnect ahead of TVSS and connect to main bus. Locate to minimize length of conductors between main bus and TVSS. Provide remote indicating devices on the door to mimic indication on TVSS.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Locate switchboard(s) as indicated.

3.2 TESTING

A. Ground fault: Test installed ground fault system in main normal switchboard. Use high current injection method to test system and submit report indicating device settings, tripping time in cycles for each device, test current and date of test as well as name of certified testing firm that performed the test.

3.3 LABELING

A. Provide switchboard labeling as specified in Section 26 00 10.

END OF SECTION

SECTION 26 24 16
PANELBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide power panelboard(s) and lighting and appliance panelboard(s) as specified herein and as indicated on associated schedules and drawings.

B. Panelboard schedule are located in Appendix-Panelboard Schedules and are a part of this specification.

C. Provide all breakers with provisions to pad lock each breaker in the off position.

D. Provide panelboards with SPD where indicated.

E. Provide voltage alert pilot light on cover of all panelboards.

1.2 QUALITY ASSURANCE

A. System standards:
   1. NEMA PB-1 – Panelboards.
   2. NEMA PB-1.1 – Instructions for Safe Installation, Operation and Maintenance of Panelboards rated 600 volt or Less.
   3. NEMA KS 1 – Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
   4. UL 50 – Enclosures for Electrical Equipment.
   5. UL 67 – Panelboards.
   6. CSA Standard C22.2 No. 29-M1989 – Panelboards and Enclosed Panelboards.
   7. Federal Specification W-P-115C – Type I Class 1.
   8. Federal Specification W-P-115C – Type II Class 1.

1.3 SUBMITTALS

A. Shop drawings:
   1. Identify panelboards by alphanumeric designation with branch circuit breaker sizes and types indicated in panelboard schedules or one-line-diagram.

B. Product data:
   1. Technical data on each type of panelboard.

C. Contract closeout information:
   1. Operating and maintenance data.

PART 2 - PRODUCTS

2.1 PANELBOARDS

A. Acceptable manufacturers:
   1. Panelboards:
      a. Base: Same manufacturer for all panels on project:
         1) EATON Cutler Hammer.
         2) Square D.
         3) Siemens.

B. All panelboards: Dead front type:
   1. Provide dead front metal barrier over circuit breakers and bus which allows access to gutters without exposure to live parts.
   2. Provide with non-insulated equipment grounding terminal strip located in top or bottom gutter including main grounding lug and individual terminals for 100 percent of panel circuits including spare circuits and space provisions; increase gutter space accordingly for grounding strip.
   3. Provide lighting panelboards with branch circuit connection to main bus arranged for sequence phasing.
   4. Provide feed-thru lugs or sub-feed lugs for 2 and 3 section panels.
   5. Equip bus bars for panelboard with main lugs or main circuit breaker, capacity as required or indicated.
   6. Bus bars in lighting and appliance panelboards shall be covered and phase isolated.
   7. Panelboard bussing to be silver plated copper.
   8. Provide panelboard buses fully rated for specified interrupting rating. Series rating of panelboards and overcurrent protective devices is not acceptable.
   9. All space provisions shall be totally bussed.
   10. Provide hinged door in door construction for all panelboards.
   11. Panelboards served by a K-rated transformer shall be provided with a single 200 percent neutral bus.
   12. Provide integral Transient Voltage Surge Suppression (TVSS) per specification 26 43 13 where indicated on plans or schedules.
   13. Voltage alert pilot light.

C. Circuit breaker panelboards:
   1. Bolted-on or Square D I-Line circuit breaker type. Plug-in circuit breakers not acceptable.
   2. Lighting and appliance panelboards shall accept branch circuit breakers up to 125A. Above 125A, sub-feed circuit breakers may be used.
   3. A branch circuit breaker shall not be allowed to be used as a main breaker unless specifically indicated.
   4. In larger power and distribution panelboards, provide main buses and back panels which permit changing of circuit breakers without additional machining, drilling or tapping.
   5. All multi-pole breakers of single handle and common trip.
   6. All multi-pole breakers, 100A rated and larger shall include means for padlocking in off position.
   7. Provide shunt trip mechanism on breakers where indicated.
   8. Provide ground fault protection as indicated coordinated with upstream devices.
   9. Design so a combination of one, two and three pole circuit breaker can readily be assembled in the same panelboard.
   10. Multi-section panels shall have equal height boxes.

D. Electronic grade panelboards:
   1. Electronic grade panelboards are circuit breaker panelboards with an integrally mounted transient voltage surge suppression device.
   2. The electronic grade panelboards shall meet all the specifications of this section as well as those in Section 26 43 13, Transient Voltage Surge Suppression.
   3. Neutral bus shall be rated 200 percent.
   4. Provide isolate equipment grounding bus in addition to equipment grounding bus.
   5. Electronic grade panelboards are designated on the Panelboard Schedules.

E. Circuit breakers: Thermal-magnetic type unit construction, employing quick-make and quick-break toggle mechanisms for manual operation as well as automatic operation:
   1. 1, 2 and 3 pole circuit breaker ratings:
      a. In 120/208 V panelboards: Minimum 10,000 AIC symmetrical, or greater as indicated.
      b. In 277/480 V panelboards: Minimum 14,000 AIC symmetrical, or greater as indicated.
   2. Handles with three positions: "OFF", "ON", and "TRIPPED".

3. When circuit breaker opens on overload or short circuit, operating handle shall automatically assume "TRIPPED" position and clearly indicate abnormal condition of circuit.
4. Units operable in any position and removable from front of panelboard without disturbing adjacent units.
5. Tandem or half-size circuit breakers not allowed.

F. Ground fault circuit interrupter circuit breakers:
1. Operate on differential transformer principle; rated 20A, 120V or 240V, Class A fault-trip sensitivity of 5 milliamperes, UL approved, with built-in testing switch and ON-OFF switch.
2. Provide in panelboards in lieu of standard circuit breakers to serve circuits in wet locations.
3. Provide separate neutral for each interrupter circuit where neutral is required.

G. Cabinets: Trim, door and box, of galvanized sheet steel, code thickness:
1. 5-3/4 IN deep with gutter space meeting NEC requirements for wire termination space in panelboards.
2. Distribution panelboards: Cabinet depth not to exceed 12 IN, with gutter space meeting NEC requirements for wire termination space in panelboards.
3. Fasten trim to cabinet by means of approved adjustable clamps.
4. Equip door with chrome-plated combination lock and catch; supply two milled keys with each lock; key locks alike.
5. Provide directory frame on inside of door.
6. Finish: Primed, one coat gray lacquer.
7. Identify all circuit locations in each respective panel with load and location served:
   a. Directory shall be typed.
   b. Mechanical equipment identified in directory shall be identified by BNL-furnished designation and not designation indicated on plans.
   c. Room names and numbers in directory shall be final building room names and numbers as identified by BNL and not name or number indicated on plans.

H. Voltage alert pilot light: Indicate presents of voltage via LED's and redundant circuitry:
1. Voltage alert pilot light shall be 40 – 750 VAC LED type with 8 LED's, 2 per Line 1, Line 2, Line 3 and Ground (or Neutral where available).
2. LED'S shall flash when a minimum of 30 VAC is voltage present.
3. Pilot light shall be mounted on the front cover of the equipment enclosure.
4. Pilot light shall be 40 mm in diameter and mount in a standard 30 mm knockout.
5. Provide four 6 FT #18AWG 1000V leads. Connect to line side of main lugs or main circuit breaker.
6. Voltage alert pilot light shall be equal to Diversified Electronics #UPA-130.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as indicated and in accordance with manufacturer's recommendations and instructions.

B. Support panelboard cabinets from wall structure via steel support cross members bolted to wall structure or from steel support framework.

C. Wall mounted panelboards shall be installed 6 IN above floor minimum. Large panels that rest on floor shall be mounted on house-keeping pads per specification 26 00 10.

3.2 LABELING

A. Provide panelboard labeling as specified in Section 26 00 10.

B. Permanently post, at each panelboard, the conductor color coding scheme specified in Section 26 05 19.

END OF SECTION

SECTION 26 24 19
MOTOR CONTROL EQUIPMENT

PART 1 - GENERAL

1.1 SUBMITTALS

A. Shop drawings:
   1. Motor control equipment:
      a. Outline drawings of assembly.
      b. One line diagrams and wiring diagrams for assembly and components.
      c. Interconnection wiring diagrams.

B. Product data:
   1. Technical data on each type of controller and/or feeder device.

C. Contract closeout information:
   1. Operating and maintenance data.
   2. BNL instruction report.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Motor control centers:
      a. Base:
         1) EATON Cutler-Hammer.
         2) Square D.
         3) Siemens.
         4) Allen-Bradley.

B. Motors:
   1. Verify all motor sizes and types of control from approved mechanical shop drawings.
   2. Motors 1/2 HP and above: 460V, three phase, 60 cycle; provide 3 phase combination magnetic starters.
   3. Do not provide starters if indicated as part of Division 25 work.
   4. Motors below 1/2 HP: 115V, single phase, 60 cycle; provide manual thermal element units.

2.2 ENCLOSURES

A. General:
   1. Service voltage: 480 V, 3 phase, 60 cycle.
   2. Branch circuit short circuit protection: Motor circuit protector (MCP):
      a. Operating handle shall clearly indicate whether MCP is on, off or tripped.
      b. Provide means to lock each operating handle in off position with cover closed by means of one to three padlocks.
      c. Interlock so that operating handle must be in off position before door can be opened.
   3. Finish: Thoroughly clean structure inside and out after fabrication and apply prime coat, and two coats of light gray (ANSI Color 61) or medium light gray (ANSI Color 49) enamel, inside and out.

B. Motor control centers: NEMA Standard Construction, Class I, Type B:
   1. Incoming line: Main lugs, main circuit breaker or main fused switch as indicated.

2. Configuration: Front mounted units accessible from the front only and front and rear mounted units as indicated.
3. Structure units: Totally enclosed, free-standing type with structures joined together to form one assembly:
   a. Fabricate of not less than 14 GA steel, with 16 GA steel doors, in standardized units.
   b. Design so that units may be readily removed or future structures added as required.
   c. Provide each structure with two horizontal wiring spaces, one at top and one at bottom, which will line up with adjacent units to form convenient wiring raceway entire length of control center.
   d. Provide each structure with vertical wiring space between starter cell and side sheet for unit wiring, equipped with cable tie supports to hold cables and wiring in place.
   e. Bottom shall have ample unrestricted space for conduit and feeder entry.
   f. Doors: Formed round corners, rolled edges, neoprene gaskets, and at least two heavy duty hinges, held closed by means of quick-captive fasteners.
   g. Fabricate doors as part of structure and not part of starter, to cover openings after starters have been removed.
   h. Provide main horizontal bus, rated as indicated, across top of each structure; full capacity, full-length with provisions for extension.
   i. Bus bars: High-strength copper, of rectangular cross section; support in each structure by means of bus supports.
   j. Provide each structure with vertical 1/4 x 2 IN, minimum, copper bus to distribute incoming power to each unit in structure.
   k. Brace bussing for 42,000 RMS symmetrical amperes minimum, or greater as indicated.
   l. Provide continuous copper ground bus rated 50 percent of main bus rating for motor control center.
4. Circuit breaker (MCP) and linestarter units: Built-in interchangeable modular height combinations:
   a. Line plug-in, pull-out, lock-out type.
   b. Provide guides in structure for supporting and aligning unit starter during removal or replacement.
   c. Plug-in units: With tin-plated, pressure type line disconnecting stabs of high-strength copper alloy.
   d. Lock-out latch to enable electrician to padlock unit in "pull-out" position and at same time isolate stubs and entire unit from bus. Hold each unit in place by means of quick-captive fasteners.
   e. Totally-enclosed and effectively baffled to isolate any ionized gases which may occur within unit starter.
   f. Ventilated so that it can be located anywhere within structure using same overload heaters for same load.
5. Feeder tap unit: Circuit breaker type.
6. Cutler Hammer/Westinghouse Series 1200.

C. Combination controller/disconnect: NEMA standard construction, Type A wiring in NEMA 1 general purpose enclosure:
   1. Combination motor controller with motor circuit protector.
   2. Cutler Hammer/Westinghouse Class A206 with motor circuit protector.

D. Separately mounted controller: NEMA standard construction, Type A wiring in NEMA 1 general purpose enclosure:
   1. Cutler Hammer/Westinghouse Class A200.

2.3 AUTOMATIC CONTROLLERS

A. General:
   1. Provide with three overload relays for complete single-phasing and overload protection.
   2. Provide H.O.A. selector switch and red and green pilot lights for each motor starter on cover of each unit where indicated on drawings or schedules.

3. Provide with two extra NO and NC interlocking contacts in addition to seal-in contacts.
4. Provide 480/120 volt control transformer with 2 primary and one secondary fuse.
5. Overload relays: Solid state.

B. Combination full voltage non-reversing starters:
1. External manual reset thermal overload relays.
2. Cutler Hammer/Westinghouse class A-206 with motor circuit protector.

2.4 MANUAL CONTROLLER

A. Manual thermal element units: 120/240 volt, single phase, maximum 1 HP, with overload protection and toggle switch:
1. Provide means for padlocking in off position.
2. Cutler Hammer/Westinghouse Type MS.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as indicated and in accordance with manufacturer's recommendations and instructions.

B. Floor mount on concrete pad per Specification 26 00 10.

C. Set adjustable trip settings of motor circuit protectors to match characteristics of motor installed.

D. Set adjustable solid state overload settings to match characteristics of motor installed.

E. Provide heater elements which match characteristics of motor installed.

F. Mount adjustable frequency drives furnished by Division 25. Refer to Sections 25 23 00 and 26 00 11.

END OF SECTION

SECTION 26 27 26
WIRING DEVICES

PART 1 - GENERAL

1.1 SUBMITTALS

A. Product data:
   1. Technical data on each type of device.
   2. Product Data: Describe configurations, finishes, colors, and dimensions for floor boxes, receptacles, switches, device plates, dimming switches, dimming systems, occupancy sensors, receptacle strips, multi-outlet assemblies.
   3.

B. Project information:
   1. Occupancy sensor test report.

C. Contract closeout information:
   1. Manufacturer's installation instructions.
   2. Special Warranty: Warrant occupancy sensor switches for 5 years from date of Substantial Completion.

1.2 QUALITY ASSURANCE

A. Provide wiring devices conforming to the following standards:
   1. Underwriter's Laboratories (UL):
      a. Switches (UL 20).
      b. Receptacles, plugs and connectors (UL 498).
      c. Device plates (UL 514 and 514A).
      d. Ground fault circuit interrupters (UL 943).
   2. National Electric Manufacturers Association (NEMA):
      a. General purpose wiring devices (NEMA WD-1).
      b. Wiring devices dimensional requirements (NEMA WD-6).
   3. US Federal Specifications:
      a. Fed Spec switches (WS-896E).
      b. Fed Spec receptacles (WC-596F).
      c. Fed Spec device plates (W-P-455).

1.3 WARRANTIES

A. Provide 5 year warranty on following devices:
   1. Occupancy sensors.

PART 2 - PRODUCTS

2.1 MATERIALS - GENERAL

A. Acceptable manufacturers:
   1. Wiring devices:
      a. Base:
         1) Hubbell.
      b. Optional:
         1) Leviton Manufacturing.
         2) Pass & Seymour.
         3) Cooper Wiring Devices.

c. All wiring devices shall be provided by the same manufacturer.

2.2 SWITCHES

A. Lighting switches:
1. Heavy duty, Specification grade, quiet-operating toggle-type 120-277 volts, AC only, 2 hp at 240V, 1 hp at 120V, 20 amp rated unless otherwise indicated:
   a. Standards: NEC Article No. 404; NEMA; UL.
   b. Switches shall be listed per UL 20 and certified by UL to Federal Specification WS-896E, and shall be visibly marked "Fed Spec WS-896".
   c. All switches shall be equipped with a green grounding terminal.
   d. Wiring Type: Back and side, for #10 AWG if required.
   e. Type: Flush, quiet, AC, totally enclosed brush tumbler, toggle handle, single pole, 3-way and 4-way as shown.
   f. Modifications: Pilot light, key operation, interchangeable type as shown.
2. Use gray devices.
3. Refer to symbol legend.
4. Design Standard Manufacturer: HUBBELL. Substitutions subject to Section 01 25 13 are:
   a. Cooper Wiring Devices.
   b. Leviton.
   c. Lutron.
   d. Pass and Seymour.
   e. Other substitutions are not permitted.
5. Toggle-type switch:
   a. Single-pole: Hubbell HBL1221.
   b. Double-pole: Hubbell HBL1222.
   c. Three-way: Hubbell HBL1223.
   d. Four-way: Hubbell HBL1224.
   e. Single-pole key switch: Hubbell 1221-L.
   f. Red pilot light switch with illuminated toggle in the ON position: Hubbell HBL1221-PL.
   g. Momentary contact double-throw, three position, center-off switch: Hubbell HBL1557.

B. Local timer switches:
1. Design Standard Manufacturer: Watt Stopper “TS-400”. Substitution subject to Section 01 25 13 is:
   a. Tork.
   b. Other substitutions are not permitted.
2. Standards: UL, ANSI/IEEE, California Title 24 listed.
3. Performance: Wall mounted, digital timing switch with adjustable time pre-set (5 minutes to 12 hours) and OFF switch, and one minute advance flash warning before lights switch off; optional beep warning every five seconds once remaining time reaches one minute; lights can be switched off at any time during the time cycle by pressing the on/off switch.
4. Rating: 120 or 277 volt, 1200 watt fluorescent load, compatible with electronic ballasts and compact fluorescent lamping: zero crossing circuitry. Provide low voltage device and associated power pack where used to control loads 1200 watts and higher.
5. Provide five year product warranty.

C. Wall-box lighting dimmers:
1. Design Standard Manufacturer: LUTRON; Nova T series. Substitution subject to Section 01 25 13 is:
   a. Lightolier.
   b. Other substitutions are not permitted.
2. Description: Sliding with preset button for on/off, rated for size (600, 1000, 1500, 2000 watt) and type (incandescent, magnetic or electronic low voltage, fluorescent) of load connected.
3. Standards: UL, ANSI/IEEE, California Title 24 listed.

4. Circuitry: Solid-state with air gap switch; power failure memory restoring lights to preset level; radio frequency suppression filter.
5. Cover Plates: Decorative style with finish as selected from manufacturer's standards. At locations with multiple devices, mount gangable wall boxes as recommended by dimmer manufacturer, to provide continuous faceplate appearance.
6. Ballasts: Dimming type, compatible with intensity selector; refer to Section 26 51 00.
7. Multiple Location Switching: Provide one single pole, 3-way pre-set dimmer and 3-way or 4-way switches, as required, at other locations.
8. All devices shall be UL listed specifically for the required loads (i.e., incandescent, fluorescent, low voltage, electronic low voltage). Universal dimmers are not acceptable.
9. Electronic solid state type, rated for load, 120 and 277 volts AC.
10. All dimmers shall incorporate an air gap which shall be accessible without removing the faceplate. The air gap switch shall be capable of meeting all applicable requirements of UL 20 for air gap switches in dimmers.
11. All dimmers shall provide power failure memory. Should power be interrupted and subsequently returned, the light intensity will return to the same levels set prior to the power interruption.
12. Dimmers shall be tested to withstand voltage surges of up to 600 V and current surges of up to 200 A without damage per ANSI/IEEE Standard C62.41-1980.
13. .
14. Dimmer control shall be linear slide. Dimmer shall provide a smooth and continuous Square Law dimming curve.
15. Finish: White.
16. Faceplate shall snap on to the device with no visible means of attachment. Metal heat sink/mounting plate shall not be visible on front, top, bottom, or sides of device. At locations with multiple devices, one seamless, multi-gang faceplate shall be provided. Contractor is responsible for coordination of proper faceplate size and type.

D. Occupancy Sensors:
1. Passive Infrared Wall Mounted Switch:
   a. Design Standard Manufacturer: Watt Stopper "WS-200". Substitution subject to Section 01 25 13 is:
      1) Sensor Switch.
      2) Other substitutions are not permitted.
   b. Standards: UL, California Title 24 listed.
   c. Performance: Wall mounted motion sensor using infrared to detect moving personnel (minimum 300 square foot coverage for desktop activity with a field of view of 180 degrees). When motion is detected lights switch ON; if no motion is detected after a pre-selected (adjustable) duration, lights automatically switch OFF. Selectable automatic or manual control mode, integrated light level sensor, adjustable intensity (2 to 200 footcandles), light level and time delay switches, and compatible with electronic ballasts.
   d. Rating: 60HZ, 0 to 500 watts incandescent, 0-800 watts at 120V; 0-1200 watts at 277V.
   e. Finish: White.
   f. Provide five year product warranty.
   g. Sensor shall combine analog and digital processing to provide immunity to RFI and EMI.
   h. Sensor shall have a DIP switch to control the following functions:
      1) Built-in light level feature adjustable from 8 to 180 foot candles.
      2) Automatic-ON or manual-ON operation.
      3) Time delay adjustable from 30 seconds to 30 minutes.
      4) High/low sensitivity adjustments.
   i. Sensor shall not protrude more than 3/8" from the wall.
   j. For normal operation, sensor shall have two positions only: OFF and AUTO.
2. Dual-Level Occupancy Sensor Switches – Wall Mounted:

a. Design Standard Manufacturer: Watt Stopper “WA-300”. Substitution subject to Section 01 25 13 is:
   1) Sensor Switch.
   2) Other substitutions are not permitted.
b. Standards: UL, California Title 24 listed.
c. Perofmance: Wall mounted infrared motion sensor capable of controlling two independent lighting loads or circuits with isolated second relay; selectable time delay before shutting off lights (5, 10, 15, 20, or 30 minutes); dual on/off buttons for independent control of loads; integrated adjustable light level sensor for controlling secondary relay (8 to 180 footcandles); compatible with electronic ballasts.
d. Rating: 60HZ, 0 to 500 watts incandescent, 0-800 watts at 120V; 0-1200 watts at 277V.
e. Finish: White.
f. Provide five year product warranty.
g. Sensor shall combine analog and digital processing to provide immunity to RFI and EMI.
h. Sensor shall have a DIP switch to control the following functions:
   1) Built-in light level feature adjustable from 8 to 180 foot candles.
   2) Automatic-ON or manual-ON operation.
   3) Time delay adjustable from 30 seconds to 30 minutes.
   4) High/low sensitivity adjustments.
i. Sensor shall not protrude more than 3/8” from the wall.
j. For normal operation, sensor shall have two positions only: OFF and AUTO.

3. Dimmable Occupancy Sensor Switches – Wall Mounted:
   a. Design Standard Manufacturer: Watt Stopper “WD-180” for 277V; “WD-170” for 120V. Substitution subject to Section 01 25 13 is:
      a) Sensor Switch.
      b) Other substitutions are not permitted.
   2) Standards: UL, California Title 24 listed.
   3) Compatible for use with the following:
      a) Philips Lighting Ecotron with line voltage phase control.
      b) Advance Mark X electronic dimmable ballasts.
      c) Incandescent fixtures.
   4) Description: Wall mounted infrared motion sensor (150 square foot coverage for desktop activity); adjustable time delay before shutting off lights (30 seconds to 30 minutes); integral slide dimmer; compatible with electronic ballasts.
   5) Rating: 10-500 watts at 277V; 10-500 watts at 120V.
   6) Finish: White.
   7) Provide five year product warranty.
   8) Sensor shall combine analog and digital processing to provide immunity to RFI and EMI.
   9) Sensor shall have a DIP switch to control the following functions:
      a) Built-in light level feature adjustable from 8 to 180 foot candles.
      b) Automatic-ON or manual-ON operation.
      c) Time delay adjustable from 30 seconds to 30 minutes.
      d) High/low sensitivity adjustments.
   10) Sensor shall not protrude more than 3/8” from the wall.
   11) For normal operation, sensor shall have two positions only: OFF and AUTO.

4. Dual Technology Ceiling Mounted Directional Occupancy Sensor (180deg):
   a. Design Standard Manufacturer: WATT STOPPER “DT-200”. Substitution subject to Section 01 25 13 is:
      1) Sensor Switch.
      2) Other substitutions are not permitted.
   b. Standards: UL, California Title 24 listed.

c. Performance: Ceiling mounted dual technology (infrared and ultrasonic) directional motion sensor; detection range up to 50 feet from sensor. When motion is detected lights switch ON; if no motion is detected after a pre-selected (adjustable) duration, lights automatically switch OFF. Provide with integrated light level sensor, adjustable intensity (from 3 to 200 footcandles); time delay (15 seconds to 30 minutes) switches, and compatible with electronic ballasts.
d. Rating: 24VDC; 19mA.
e. Finish: White.
f. Provide five year product warranty.
g. Accessories: Provide quantity required to adequately switch loads controlled via occupancy sensor:
   1) Power Pack: Provides 24VDC operating power to sensors, and switches up to 20 amps of ballasted load. Provide 120 or 277V, as required.
   2) Slave Pack: Switches up to 20 amps of ballasted load. Provide 120 or 277V, as required.
h. Walking motion coverage up to 1500 sq. ft. when ceiling mounted at 12 feet with 180 deg field view.
i. Each technology shall have independent sensitivity adjustments.
j. Two outputs: one based on occupancy. The second based on occupancy with hold OFF for light level sensing DIP switch adjustable from 2.5 to 430 foot candles.
k. Provide 24 VDC power supply, ceiling mounting bracket and swivel mounting bracket.

5. Occupancy Sensor Switches - 360 Degree Ceiling Mounted:
   a. Design Standard Manufacturer: Watt Stopper “DT-355”. Substitution subject to Section 01 25 13 is:
      1) Sensor Switch.
      2) Other substitutions are not permitted.
   b. Standards: UL, California Title 24 listed.
   c. Performance: Ceiling mounted 360 degree dual-technology (infrared and ultrasonic) occupancy sensor with 1400 sq ft coverage. When occupancy is detected lights switch ON; if occupancy is not detected after a pre-selected (adjustable) duration, lights automatically switch OFF. Provide integrated light level sensor, adjustable intensity (10 to 300 footcandles); and adjustable time delay (5 to 30 minutes). Unit shall be compatible with electronic ballasts.
   d. Rating: 120/277V.
   e. Finish: White.
   f. Provide five year product warranty.
   g. Accessories: Provide quantity required to adequately switch loads controlled via occupancy sensor:
      1) Power Pack: Provides 24VDC operating power to sensors, and switches up to 20 amps of ballasted load. Provide 120 or 277V, as required.
      2) Slave Pack: Switches up to 20 amps of ballasted load. Provide 120 or 277V, as required.
   h. Walking motion coverage up to 1400 sq. ft. when ceiling mounted at 360 deg field view
   i. Each technology shall have independent sensitivity adjustments.
   j. Two outputs: one based on occupancy. The second based on occupancy with hold OFF for light level sensing DIP switch adjustable from 2.5 to 430 foot candles.
   k. Provide 24 VDC power supply, ceiling mounting bracket and swivel mounting bracket.
6. Low Temperature, Gasketted Motion Sensor Switches – Wall Mounted:
   a. Design Standard Manufacturer: Watt Stopper “CB”. Substitution subject to Section 01 25 13 is:
      1) Sensor Switch.
      2) Other substitutions are not permitted.
   b. Standards: UL, California Title 24 listed.

c. Description: Wall mounted infrared motion sensor with swivel mounting bracket; CB-100-1 coverage pattern of 8 feet by up to 90 feet, CB-100-2 bi-directional coverage pattern of 5 feet by up to 50 feet in each direction, or CB-100 fanning coverage pattern of up to 50 feet; selectable time delay before shutting off lights (15 seconds, 5 minutes or 10 minutes); gasketted water-tight enclosure; operating temperature range of -40 to 95 degrees F; UL 773A rated raintight; compatible with electronic ballasts.
d. Rating: 24VDC, 20mA; provide with associated power pack for 120/277V operation.
e. Provide 5 year product warranty.

7. Exterior Motion Sensor/Photocell Switches – Surface Mounted:
   a. Design Standard Manufacturer: Watt Stopper "EN". Substitution subject to Section 01 25 13 is:
      1) Sensor Switch.
      2) Other substitutions are not permitted.
   b. Standards: UL, California Title 24 listed.
   c. Description: Wall or ceiling mounted infrared motion sensor uses 3/4 inch threaded nipple to attach to standard NEMA weatherproof junction box; EN-200 coverage pattern of 10 feet by up to 100 feet or EN-100 fanning coverage pattern of up to 50 feet; adjustable delay before shutting off lights; integrated adjustable light level sensor (0.4 to 42 footcandles) to select level below which lights will turn on; operating temperature range of -40 to 130 degrees F; UL 773A rated raintight; compatible with electronic ballasts.
   d. Rating: 0-1000 watts at 120V or 277V.
   e. Provide 5 year product warranty.

E. Switching Power Pack:
1. Power pack shall be a shelf contained transformer and relay module measuring 1.75 IN x 2.75 IN x 1.5 IN.
2. Power and slave packs shall have dry contacts capable of switching 20 amp ballast load, 13 amp incandescent, 1 hp @ 120 VAC, 60 Hz; 20 amp ballast @ 277 VAC, 60 Hz.
3. Power pack shall provide a 24 VDC, 100 mA output.
4. Power packs shall be capable of parallel wiring without regard to AC phases on primary.
5. Power pack can be used as a stand alone, low voltage switch, or can be wired to sensor for auto control.
6. Power pack shall have low voltage teflon coated leads, rated for 300 volts, suitable for use in plenum applications.
7. Provide control wire as recommended by manufacturer in conduit.
8. Wattstopper Models B120E-P and B277E-P.

2.3 DUPLEX AND SINGLE RECEPTACLES

A. Receptacle outlets:
1. Specification grade.
   a. Specification grade receptacles shall be listed per UL 498 for general use and certified by UL to Fed Spec WC-596F, and shall be visibly marked with the "UL-FS" mark to confirm certification:
      1) Constructed with impact resistant nylon or polyester face and body.
      2) 0.050 IN brass nickel-plated backstrap with one piece ground design.
      3) 0.040 IN brass nickel-plated contacts.
2. Flush, grounding convenience outlets for side wiring, or side and back wiring.
3. Use gray devices.
4. Use gray devices on equipment branch circuits.
5. Refer to symbol legend.

B. 20A, 125V, 2 pole, 3 wire grounding, duplex: NEMA 5-20R; Hubbell HBL5362.

C. 20A, 125V, 2 pole, 3 wire grounding, single; NEMA 5-20R; Hubbell HBL5361.

D. Weatherproof receptacles: Type as indicated on drawings:

1. Mount on "FS" cast metal box.
2. Suitable for wet location when receptacle is not in use:
   a. Gasketed and self-closing lift cover.
      1) Single outlets: Hubbell HBL7423 WO.
      2) Duplex outlets: Hubbell HBL5206 WO.
      3) Duplex GFI receptacles: Hubbell WPFS26.
3. Suitable for wet location when receptacle is in use:
   a. High impact polycarbonate with single gasketed lift cover; NEMA 3R rating while in use; tinted lid.
      1) Hubbell/Raco Rayn Tite II weatherproof cover with receptacle type as indicated.

E. GFI type duplex receptacles: With built-in ground fault interruption, 5-mA sensitivity, indicator and reset. UL listed:
   1. 20A, 125V, 3 wire duplex: NEMA 5-20R; Hubbell GF5362.

F. Isolated ground receptacles: Device type as indicated with receptacle ground isolated from conduit grounding system:
   1. Gray device with orange triangle.
   2. Specification grade, Hubbell and IG-5362.

2.4 SPECIAL PURPOSE RECEPTACLES

A. NEMA 6-20R receptacle: 20A, 250V, 2 pole, 3 wire grounding, side and back wired, single; black; Hubbell HBL5461I.

B. NEMA 14-20R receptacle: 20A, 125/250V, 3 pole, 4 wire, 1 phase grounding, single; NEMA 14-20R; black; Hubbell HBL8410.

C. NEMA 15-20R receptacle: 20A, 250V, 3 pole, 4 wire, 3 phase grounding, single; black; Hubbell HBL8420.

D. NEMA 5-30R receptacle: 30A, 125V, 2 pole, 3 wire grounding, single; black; Hubbell HBL9308.

E. NEMA 6-30R receptacle: 30A, 250V, 2 pole, 3 wire grounding, single; black; Hubbell HBL9330.

F. NEMA 14-30R receptacle: 30A, 125/250V, 3 pole, 4 wire, 1 phase grounding, single; black; Hubbell HBL9430A.

G. NEMA 15-30R receptacle: 30A, 250V, 3 pole, 4 wire, 3 phase, grounding, single; black; Hubbell HBL8430A.

H. NEMA 6-50R receptacle: 50A, 250V, 2 pole, 3 wire, 1 phase, grounding, single; black; Hubbell HBL9367.

I. NEMA 14-50R receptacle: 50A, 125/250V, 3 pole, 4 wire, 1 phase, grounding, single; black; Hubbell HBL9450A.

J. NEMA 15-50R receptacle: 50A, 250V, 3 pole, 4 wire, 3 phase, grounding, single; black, Hubbell HBL8450A.

K. NEMA L5-20R receptacle: 20A, 125V, 2 pole, 3 wire, 1 phase, grounding, single, twist-lock; black; Hubbell HBL2310.

L. NEMA L6-20R receptacle: 20A, 250V, 2 pole, 3 wire, 1 phase, grounding, single, twist-lock; black; Hubbell HBL2320.

M. NEMA L14-20R receptacle: 20A, 125/250V, 3 pole, 4 wire, 1 phase, grounding, single, twist-lock; black; Hubbell HBL2410.

N. NEMA L15-20R receptacle: 20A, 250V, 3 pole, 4 wire, 3 phase, grounding, single, twist-lock; black; Hubbell HBL2420.

O. NEMA L5-30R receptacle: 30A, 125V, 2 pole, 3 wire, 1 phase, grounding, single, twist-lock; black; Hubbell HBL2610.

P. NEMA L6-30R receptacle: 30A, 250V, 2 pole, 3 wire, 1 phase grounding, single, twist-lock; black; Hubbell 2620.

Q. NEMA L14-30R receptacle: 30A, 125/250V, 3 pole, 4 wire, 1 phase, grounding, single, twist-lock; black; Hubbell HBL2710.

R. NEMA L15-30R receptacle: 30A, 250V, 3 pole, 4 wire, 3 phase, grounding, single, twist-lock; black; Hubbell HBL2720.

S. Refer to contract documents for other types.

2.5 DEVICE PLATES

A. Manufacturer: Same as wiring device manufacturer.

B. Standards: NEC Articles No. 404 and No. 406; UL.

C. Device plates for concealed wiring: single or ganged in one piece with beveled edges that match faces of plates:
   1. For Recessed Boxes: High abuse reinforced nylon. Color: White:
      a. Clean room: Stainless steel, brushed finish

D. Device plates for surface type cast-metal boxes: Stainless steel steel Corrosion resistant cast ferrous metal designed for application.

E. Ganging: As required by number of devices.

F. Weatherproof: Gasketted, cast aluminum, spring-loaded lift cover plates.

G. Labeling: Provide circuit label on each receptacle device plate indicating panelboard and circuit number supplying the device. Provide NEMA type label on each special receptacle device plate:
   1. The label shall be indoor/outdoor, high gloss, durable, scratch proof, flexible, dimensionally stable, pressure sensitive adhesive backed vinyl film type.
   2. Label shall be suitable for use in ambient temperatures from –40 degF to 176 degF.
   3. Label shall be suitable for continuous exposure to alcohols, detergents, grease and oils.
   4. Circuit label shall have one line of text centered on label indicating panelboard name and circuit number separated by a hyphen.
   5. NEMA type label shall have two lines of text with NEMA type centered on the top line and voltage, phase, wire and amperes centered on the bottom line.
   6. Text shall be 1/8 IN high.
   7. Background and text color as follows:
      a. Normal distribution system: Clear with black text.
      b. Emergency branch (devices served by EATS): Yellow with black text.
      c. Optional Standby branch (devices served by QATS): Green with black text.
   8. Other Types: As shown or specified.
   9. Explosion-proof surface mounted switch:
      a. Single-pole: Crouse-Hinds EFS-1129 and/or EFS-2129.
      b. See Section 26 00 10 for hazardous areas.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Locate devices as indicated and as scheduled in Section 26 00 10.

B. Center outlets with regard to paneling, furring, trim, etc.

C. Any outlet which is improperly located must be corrected at Contractor's expense.

D. Set outlets plumb or horizontal and extending to finished surface of wall, ceiling or floor as case may be without projecting beyond same.

E. Install receptacles, switches, etc., indicated on wood trim, cases or other fixtures symmetrically. Where necessary, set with long dimension of plate horizontal, or gang in tandem.

F. Install vertically mounted receptacles with the ground pin down. Install horizontally mounted receptacles with the ground pin to the left.

G. Where fluorescent dimming is indicated, extend Class 1 or Class 2 wiring with 600 V insulation in conduit with power conductors from dimmer to dimming ballast.

H. GFCI receptacles shall be connected so that downstream devices are not protected by GFCI receptacle.

I. Occupancy Sensors:
   1. The locations and quantity of sensors shown on the drawings are diagrammatic and indicate only the rooms and spaces to be provided with sensors.
   2. Verify sensor type, quantity, location, aiming and sensitivity with manufacturer's recommendations.
   3. All controlled spaces shall be tested to insure 90 to 100 percent coverage of the controlled space. If test fails, adjust sensitivity, re-aim, relocate, and/or add sensor(s) as required at no cost to BNL.
   4. Power supplies and slave units if required shall be located above accessible ceilings.
   5. Verify and adjust all adjustable settings of each sensor with BNL preferences.

3.2 OCCUPANCY SENSOR TESTING

A. Perform walk test of all spaces controlled by occupancy sensors.

B. Verify aiming and sensitivity of each sensor.

C. Record final settings of each sensor.

END OF SECTION

SECTION 26 28 00
OVERCURRENT PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 SUBMITTALS

A. Product data:
   1. Technical data on each type of device.
   2. Time-current curves for all devices on project.
   3. Submit with associated switchgear, panelboard or other assembly.

B. Project information:
   1. All data necessary, and as requested by the government, to allow the government to prepare a complete coordination study.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Overcurrent protective devices.
      a. Base:
         1) EATON Cutler Hammer.
      b. Optional:
         1) Square D.
         2) Siemens.
   2. Fuses:
      a. Base:
         1) Bussmann.
      b. Optional:
         1) Shawmut.
         2) Brush.
         3) Littelfuse.

B. Equipment and devices by same manufacturer.

C. EATON Cutler Hammer and Bussmann types listed for quality, performance short circuit coordination study reference. Refer to short circuit coordination study for system breaker types.

2.2 CIRCUIT BREAKERS

A. Molded case type: Unit construction, quick make, quick break, manual and automatic operation, 3 position "on" "off" and "tripped". "Tripped" condition clearly indicated. All poles open and close simultaneously:
   1. Thermal magnetic type providing inverse time overload and instantaneous short circuit protection by means of a thermal magnetic element. Interchangeable trip as indicated:
      a. 120/240V, 15A through 100A:
         1) 10,000 AIC - Type BAB.
         2) 22,000 AIC - Type QBHW.
         3) 65,000 AIC - Type GB.
      b. 240V, 125A through 225A:
         1) 10,000 AIC - Type CA.
         2) 22,000 AIC - Type CAH.
         3) 25,000 AIC – Type JA.

c. 240V, 125A through 400A: 65,000 AIC - Type KDB.
d. 277/480V, 15A through 100A: 14,000 AIC - Type GHB.
e. 277/480V, 15A through 150A:
   1) 25,000 AIC - Type FD.
   2) 65,000 AIC - Type HFD.
f. 480V, 100A through 400A:
   1) 14,000 AIC – Type KG.
   2) 35,000 AIC - Type KDB.
   3) 65,000 AIC - Type HKD.

B. Solid State trip type providing inverse time overload, adjustable instantaneous short circuit, and short time delay protection by means of a solid state trip element with associated current monitors and flux transfer shunt trip. Provide interchangeable rating plug and push-to-trip button. Built-in adjustable ground fault protection as indicated:
   a. 240V, 75A through 400:
      1) 42,000 AIC - Type LC.
      2) 65,000 AIC - Type HLC.
   b. 240V, 400A through 800A:
      1) 42,000 AIC - Type MC.
      2) 65,000 AIC - Type HMC.
   c. 240V, 800A through 1200A:
      1) 42,000 AIC - Type NC.
      2) 65,000 AIC - Type HNC.
   d. 240V, 1000A through 3000A: 125,000 AIC - Type PC.
   e. 480V, 75A through 400A: 35,000 AIC - Type HLC, Type HLD, Type HKD.
   f. 480V, 400A through 800A: 50,000 AIC - Type HMC.
   g. 480V, 800A through 1200A: 50,000 AIC - Type HNC.
   h. 480V, 1000A through 3000A: 100,000 AIC - Type PC.
   2. Current-limiting type providing inverse time overload, instantaneous short circuit, and current- limiting protection:
      a. 15A through 100A, Type FCL:
         1) 240V - 200,000 AIC.
         2) 480V - 150,000 AIC.
      b. 125A through 400A, Type LCL:
         1) 240V - 200,000 AIC.
         2) 480V - 150,000 AIC.
      c. 400A through 800A, Type NB Tri-Pac with current-limiting fuses:
         1) 240V - 200,000 AIC.
         2) 480V - 200,000 AIC.
      d. 800A through 1600A, Type PB Tri-Pack with current-limiting fuses:
         1) 240V - 200,000 AIC.
         2) 480V - 200,000 AIC.

C. Draw-out power air type solid state trip element with two-step stored energy mechanism. Provide interchangeable sensor element. Rate for application at 100 percent of frame size:
   1. Manually operated or Electricaly operated. (refer to single line diagram drawings).
   2. Draw-out construction. Roll out type operated by removable crank handle. Interlock with door.
   3. 50A through 800A, Type DSII-608:
      a. 480V - 65,000 AIC.
   4. 50A through 1600A, Type DSII-616:
      a. 480V - 65,000 AIC.
   5. 800A through 3200A, Type DSII-632:
      a. 480V - 65,000 AIC.
   6. 800A through 4000A, Type DSII-840:
      a. 480V - 85,000 AIC.

7. Trip unit, Type Digitrip RMS 810:
    a. Each drawout low-voltage power circuit breaker shall be equipped with a solid-state tripping system consisting of three (3) current sensors, microprocessor-based trip device and flux-transfer shunt trip to provide adjustable time-current protection functions with true RMS current sensing.
    b. Interchangeable rating plugs shall establish the maximum continuous trip ratings of each circuit breaker. Rating plugs shall be fixed type. Rating plugs shall be interlocked so they are not interchangeable between frames, and interlocked such that a breaker cannot be closed and latched with the rating plug removed.
    c. Main, tie and feeder trip units shall be provided with the following individually adjustable time/current curve shaping solid-state elements:
        1) Long delay pickup and time.
        2) Short delay pickup and time with selective flat or l^2t curve shaping.
        3) Instantaneous pickup.
        4) Ground fault current pickup and time with selective flat or l^2t curve shaping.
    d. Provide a ground fault protection scheme on the main and tie circuit breakers suitable for use with a multi-grounded neutral system.
    e. A four-digit, 3/4-inch high, high output LED alphanumeric display shall be provided to indicate the following data:
        1) Cause of trip.
        2) Instantaneous value of maximum phase and ground current.
        3) Level of fault current that initiated an automatic trip operation.
    f. The trip unit shall include a potential transformer module, suitable for operation up to 600V, 50/60 Hz. The primary of the potential transformer module shall be connected internally to the load side of the circuit breaker through a dielectric disconnect plug. The unit shall calculate and display the following power and energy parameters:
        1) Peak demand (Megawatts).
        2) Present demand (Megawatts).
        3) Energy consumption (Megawatt-hours).

D. Motor circuit protector (MCP) providing adjustable instantaneous short circuit protection only by means of a magnetic or solid state trip element:
    1. Molded case construction, Series C Type HMCP.
    2. Current-limiting as indicated or required providing 200,000 AIC by means of a current-limiter attachment.
    3. See motor control center schedules for required sizes and interrupting ratings.

E. 15 KV, vacuum interrupter, draw-out circuit breaker:
    1. Operation: By electrically charged, mechanically and electrically trip-free, spring type stored with energy mechanism, with provision for manual charging and slow closing of contacts for inspection and adjustment.
    2. Provide secondary disconnecting contacts which automatically engage in the operating positions.
    3. Provide mechanism which moves breaker between operating and disconnect positions, with interlock to prevent movement to or from operating position unless breaker contacts are open.
    4. Breaker control voltage: 120 V AC, 60 Hz.
    5. Each breaker shall contain three vacuum interrupters separately mounted in a self-contained, self-aligning pole unit which can be easily removed.
    6. Provide each interrupter with a contact wear gap indicator requiring no tools to indicate available contact life, easily visible when breaker is removed from cell.
    7. Secondary contacts shall be silver-plated:
        a. Automatically engaged in the breaker operating position.
        b. Manually engaged in the breaker test position.
    8. Provide interlocks for following functions:
        a. To prevent closing of breaker between operating and test positions.

b. To trip breaker upon insertion or removal from housing.
c. To discharge stored energy mechanism upon insertion or removal from housing.

9. Each breaker shall have the following ratings:
   a. Maximum voltage: 15 kV.
   b. BIL rating: 95 kV.
   c. Continuous current: 1200 Amperes.
   d. Short circuit current at rated maximum voltage: 37 kA.
   e. Closing and latching capability: 130 kA.
   f. 3 second rating: 48 kA.
   g. Nominal 3 phase MVA Class: 1000 MVA.
   h. Rated interrupting time: 5 cycles.
10. Multi-function overcurrent relays:
   a. The relay shall be a solid-state microprocessor-based multifunctional type that operates from the 5 ampere secondary output of current transformers. The relay shall provide ANSI 50/51N protective functions for each of the three (3) phases, and ANSI 50/51N or 50/51G ground fault protection functions as shown on the plans or as determined by the coordination study. The relay shall be true rms sensing of each phase and ground. Ground element shall be capable of being utilized in residual, zero sequence, ground source connection schemes, or deactivated
   b. The primary current transformer rating being used for phase and ground protection feeding the device shall be programmable for current transformers with primary current ratings from 5 through 5,000 amperes
   c. Both the phase and ground protection curves shall be independently field-selectable and programmable with or without load. Curves shall be selectable from the following:
      1) IEEE: Moderately inverse, very inverse, extremely inverse.
      2) IEC: A, B, C or D.
      3) Thermal: Flat, lt, I^2t, I^4t.
   d. The relay shall be field-configurable to have either of the following function combinations assigned to its two form A contacts:
      1) One contact assigned ANSI 51 phase and ANSI 51 ground and the other contact assigned ANSI 50 phase and ANSI 50 ground.
      2) One contact assigned ANSI 51/50 phase and the other contact assigned 51/50 ground.
   e. The relay shall have a built-in alphanumeric display capable of displaying the following information with metering accuracy of +/- one (1) percent of full scale (l_n) from 0.04 x l_n to 1 x l_n and +/- two (2) percent of full scale (l_n) from 1 x l_n to 2 x l_n:
      1) Individual phase currents.
      2) Ground current.
      3) Cause of trip.
      4) Magnitude and phase of current causing trip.
      5) Phase or ground indication.
      6) Peak current demand for each phase and ground since last reset.
      7) Current transformer primary rating.
      8) Programmed phase and ground set points.
   f. Relay shall have the following features:
      1) Integral manual testing capability for both phase and ground protection function. Testing shall be selectable to either operate contact outputs or not operate output contacts.
      2) Zone selective interlocking capability for short time and ground fault protection.
      3) Continuous self-testing of internal circuitry.
      4) Unit failure alarm contact for customer use.
      5) Programmable lockout/self reset after trip function.
      6) Programmable set points for device curve selection.
      7) Programmable inputs, such as current transformer ratios.
      8) Access to program and test modes shall be via sealable hinged cover for security.

g. Relay shall be suitable for operating temperatures from -30 degrees to 55 degrees C. Relay shall be suitable for operating with humidity from 0 to 95% relative humidity (non-condensing).
h. Relay shall have communication capability over a two-wire twisted pair area network to a central computer for storage and/or printout:
   1) Ability to transmit all information contained in the relay such as currents, set points, cause of trip, magnitude of trip current, and open-close trip status.
   2) Ability to close and open the associated breaker with proper access code from remote location over the communication network when the relay is DIP switch configured in remote close/open mode.
i. Relay alarm and/or trip contacts shall not change state if power is lost or an undervoltage occurs. These contacts shall only cause a trip upon detection of an overcurrent or fault condition based upon programmed settings. A “protection OFF” alarm shall be provided which is normally energized when the relay is powered and the self-diagnostics indicates the unit is functional. Upon loss of power or relay failure, this alarm relay shall be de-energized providing a failsafe protection OFF alarm.
j. Provide a dual-source power supply (DSPS) for each relay. During normal operation, relay control power shall be provided by the switchgear auxiliary 120 Vac, or 240 Vac, 50/60 Hz power source. If the normally connected auxiliary ac voltage is not available, the relay shall operate solely from the breaker main current transformers (CTs).
k. Provide the relay in a drawout case allowing for removal and replacement of the relay unit without disruption of the wiring. The drawout case shall have quick release operation with two-stage disconnect operation. The removal of the relay inner chassis shall disconnect the trip circuits and short the CT secondaries before the unit control power is disconnected. Provide protection against false tripping.
l. Cutler-Hammer: Digitrip DT-3000.

2.3 FUSES

A. UL Class L fuses: Dual-element time-delay and current-limiting type fuses; UL Class L listed for 200,000 rms AIC symmetrical; Bussmann "Low-Peak" 600V, 601-6000A, Type KRP-C:
   1. Use for main and main feeder devices over 600A, where fuses are indicated.

B. UL Class RK-1 dual-element fuses: Dual-element time-delay and current-limiting rejection type fuses; UL Class RK-1 listed for 200,000 rms AIC symmetrical; Bussmann "Low-Peak" 0-600A, 250V Type LPN-RK and 600V Type LPS-RK:
   1. Use for main feeder devices 600A and smaller where fuses are indicated.

C. UL Class RK-5 fuses: Dual-element time-delay and current-limiting rejection type fuses; UL Class RK-5 listed for 200,000 rms AIC; Bussmann "Fusetron" 1/10-600A, 250V Type FRN-RK and 600V FRS-RK:
   1. Use for motor feeder and branch circuit devices where fuses are indicated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in switchgear, panelboards and motor control centers as indicated in those sections.

B. Install individually enclosed as specified in other sections or indicated. Use NEMA 1 enclosure unless indicated otherwise.

C. Set adjustable devices as indicated in coordination study.

END OF SECTION

SECTION 26 28 16
ENCLOSED SAFETY SWITCHES

PART 1 - GENERAL

1.1 SUBMITTALS

A. Product data:
   1. Technical data on each type of disconnect switch.

B. Contract closeout information:
   1. Operating and maintenance data.
   2. Maintenance materials: Spare fuses, 10 percent or minimum of 3 of each type and rating of installed fuses.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Safety switches:
      a. Base:
         1) EATON Cutler-Hammer.
         2) Square D.
         3) Siemens.
   2. All fuses in fusible-type devices: Same manufacturer.

2.2 SAFETY SWITCHES

A. Safety switches: Fusible and non-fusible type, NEMA Type HD Heavy Duty construction, unless otherwise indicated:
   1. Enclosure: NEMA 1 unless otherwise indicated.
   2. Provide weatherproof disconnect switches as required by Section 26 00 10.
   3. Switch blades fully visible in OFF position with door open.
   4. Contact operation quick-make and quick-break.
   5. Provide solid neutral where neutral conductor is provided.
   6. Switches for motor circuits to be horsepower rated.
   7. Switches for motor circuits controlled by Adjustable Frequency Drives (AFD) shall include one N.O. and one N.C. contact which operates with the initial movements of the switch and prior to the opening of the main switch.
   8. Provide padlocking provisions in OFF position.
   9. Finish: Baked enamel over rust-inhibiting primer.
   10. Fuses for fusible switches: See Section 26 28 00.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as indicated and in accordance with manufacturers instructions and recommendations.

B. Mount on wall or unistrut frame adjacent to motor served.

C. Switches for motor circuits controlled by AFD's shall be electrically interlocked to the controlling AFD via contacts provided in switch.

D. Provide labeling per Section 26 00 10.

END OF SECTION

SECTION 26 32 13
DIESEL ENGINE DRIVEN GENERATOR SETS

PART 1 - GENERAL

A. Provide a complete emergency system to automatically provide an alternate source of power in the event of a normal power outage.

B. The emergency system consists of a diesel engine generator set, automatic transfer switches, controls and all associated accessories.

C. The engine generator set shall consist of an engine, generator, sub-base fuel tank, silencer, vibration isolation, weather protective sound attenuated enclosure, controls and all associated accessories.

D. The automatic transfer switches specified in Section 26 36 23 shall be provided by the engine generator set manufacturer in order to establish and maintain a single source of responsibility and coordination for the complete emergency system.

E. The complete emergency system shall be factory tested before shipment and field tested after installation.

1.2 QUALITY ASSURANCE

A. The engine generator set shall be designed, built, assembled, factory tested, installed and field tested in accordance with all applicable ANSI, IEEE, NEMA, UL, UL 142, API 650, API 620 and NFPA standards including NFPA-30, NFPA-37, NFPA-70 and NFPA-110.

B. The manufacturer of the engine generator set shall manufacture the engine, the generator or the engine and generator.

C. The engine generator set manufacturer shall have been manufacturing the engine and/or the alternator for a minimum of ten years.

D. The engine generator set manufacturer shall assemble the engine and generator into one unit in the engine generator set manufacturer's factory.

E. The engine generator set manufacturer shall have been assembling and testing engine generator set for a minimum of ten years.

F. The engine generator set manufacturer shall have an authorized local distributor/supplier within 50 miles of the site that can provide installation, field testing, maintenance, parts and service through factory trained personnel on a 24 hour basis and able to respond within 4 hours of notification.

1.3 SUBMITTALS

A. Shop drawings:
   1. Submit all components together to permit checking of entire system, coordination between components and coordination of sensing devices required for local and remote derangement signal annunciator.

B. Product data:
   1. Technical data on all components.

C. Project information:
   1. Environmental permits.
   2. Test reports and certifications.

D. Contract closeout information:
   1. Operating and maintenance data.
   2. BNL instruction reports.
   3. Prorata warranty for batteries.

PART 2 - PRODUCTS

2.1 ENGINE GENERATOR UNIT

A. Engine generator unit: Diesel engine direct-connected to alternating current generator mounted on suitable rigid steel skid supports:
   1. Provide with vibration isolator assemblies consisting of both mechanical spring and rubber pad to control both high and low frequency vibrations between major components, subbase and structural foundation:
      a. Spring isolators shall be designed for seismic zone 1.
   2. Base rating on operation at rated RPM when equipped with all operating accessories.
   3. Mount unit with radiator on subbase suitable for installation on concrete foundation.

B. Acceptable manufacturers:
   1. Engine generator unit:
      a. Base:
         1) Caterpillar.
      b. Optional:
         1) Cummins/Onan.
         2) Kohler.
   2. Silencers:
      a. Base:
         1) Maxim.
         2) GT Exhaust Systems.
         3) Nelson.
   3. Battery charger:
      a. Base:
         1) Charles.
         2) LaMarche.
         3) Onan.
   4. Governor:
      a. Base:
         1) Woodward Governor.
         2) Barber Colman.
   5. Radiator:
      a. Base:
         1) Modine.
         2) IEA.
   6. Vibration isolators:
      a. Base:
         1) Mason Industries.
         2) Kinetics Noise Control.
         3) Vibration Mounting & Controls, Inc.

2.2 ENGINE

A. Engine: Four cycle, 1800 RPM, full compression ignition, single acting, solid-injection unit, either vertical or V-type with trunk-type pistons:
   1. Make engine perform satisfactorily on commercial grade No.2 domestic burner oil.
   2. Provide with removable full wet-type cylinder liners of close grained alloy iron, heat treated for proper hardness to obtain maximum life.

3. Capable of operating at idle or light loads for extended periods of time.
4. Provide for precombustion of fuel or similar means for prevention of carbonization.
5. Provide components indicated.

B. Injection pumps and valves: Type not requiring adjustment in service, which may be individually removed and replaced from parts stock:
1. Provide individual injection pumps and valves for each cylinder.
2. Fuel injection pumps: Positive action, constant-stroke, actuated by cam driven by gears from engine crankshaft.
3. Fuel lines between injection pumps and valves: Heavy seamless tubing, same length for each cylinder.
4. Provide flexible fuel line connectors at engine.

C. Oil pump: Gear-type lubricating oil pump to supply oil under pressure to main bearings, crank pin bearings, pistons, timing gears, camshaft bearings and valve rocker mechanism:
1. Spray cool and lubricate pistons.
2. Provide oil filters so located that lubricating oil is continuously filtered, except during periods when oil is automatically by-passed to protect vital parts when filters are clogged.
3. Filter elements accessible and easily removable.
4. Filter elements: Effective full flow, replaceable resin-impregnated cellulose type.
5. Equip filter system with spring-loaded by-pass valve as insurance against stoppage of lubricating oil circulation in event filters become clogged.
6. Oil cooler: Water-cooled, engine-mounted.

D. Fuel system:
1. Fuel pump: Built-in gear-type, engine-driven fuel transfer pump, capable of supplying fuel at constant pressure against head of 12 FT.
2. Equip fuel system with replaceable fuel filter elements arranged for easy removal without breaking any fuel line connections or disturbing fuel pumps or any other part of engine.
3. Locate all fuel filters in one accessible housing, ahead of injection pumps to thoroughly filter fuel before it reaches pumps.
4. Use no screens or filters requiring cleaning or replacement of injection pumps or valve assemblies.

E. Governor: Fully enclosed electronic type governor with actuator capable of providing accurate speed control within 1 percent of rated speed, complete with panel-mounted electronic assembly with ramp generator and speed-sensing modules.

F. Air cleaners: Engine-mounted, dry type air cleaners of sufficient capacity:
1. Provide one or more.

G. Electric starting system:
1. Sufficient capacity to crank at speed which will start engine under normal operating conditions.
2. Automatic controls to provide automatic cranking of engine when normal power fails.
3. Prevent excessive cranking which could damage cranking motor.
4. Automatic stop controls.
5. Starter motors with positive-engagement feature.

H. Cooling system: Sufficient capacity for cooling engine when delivering full output, in ambient temperature not over 125 degF at altitude of 1000 FT above sea level:
1. Unit mounted radiator:
   a. Provide core guard flexible duct adapter.
   b. Provide site glass at top of unit.
2. Provide heavy duty core and fan guards.
3. Fill system with solution of 50-50 water and ethylene glycol anti-freeze to prevent freezing at temperatures as low as minus 30 degF.

I. Jacket water heater: Provide two heaters to maintain coolant at 90 degF. Include thermostat:
   1. 208V, single phase.

J. Silencer:
   1. Critical type.
   2. Seamless, stainless steel, flexible, exhaust adapter for exhaust outlet to silencer.
   3. Locate silencer within enclosure and supported from enclosure structure.

K. Engine instruments and controls:
   1. Engine-mounted instruments panel:
      a. Fuel pressure gauge.
      b. Oil pressure gauge.
      c. Oil temperature gauge.
      d. Water temperature gauge.
      e. Automatic cycle cranking and over-crank protection.

L. Safety controls: Equip engine with automatic safety controls to shut down engine in event of low lubricating oil pressure, high jacket water temperature, overspeed or overcrank.

M. Auxiliary control devices: Either integral with specified engine instruments, control, and safety devices or as separate devices as required to operate various signal circuits specified for remote annunciator panel.

N. Provide minimum three NO/NC auxiliary contacts for interface with louvers, fans or other miscellaneous equipment. Contacts shall operate when generator is started.

O. Subbase fuel tank: Provide sub-base day tank mounted underneath engine generator unit. The tank must be elevated a minimum of 2” to prevent corrosion associated with ground contact and to permit complete inspection of the structure:
   1. Heavy gauge steel with top and bottom baffles.
   2. Heavy gauge steel channel side supports.
   3. 1/4 IN drain.
   4. 1-1/2 IN fuel level gauge.
   5. 2 IN fill-locking fill cap.
   6. Primer and enamel exterior to match engine generator unit.
   7. Vent sized to tank.
   8. Double wall with alarm contact for rupture basin alarm. Provide contacts for remote alarm:
      a. The secondary containment tank must be capable of sustaining a minimum of five (5) pounds per square inch (gauge) pressure for testing the interstitial space for leaks.
   9. The tank must have a positive means of preventing overfilling. A sight gauge and/or whistle vent is acceptable.
   10. Low level alarm float switch to indicate when operating supply is under 3 hours. Provide contacts for remote monitoring:
      a. Provide control wiring in conduit from sub-base tank low level alarm to generator mounted control panel and remote derangement annunciator.
   11. Minimum 24 hour full load capacity.
   12. Provide vent on tank:
      a. Withstand pressure of day tank shall exceed total developed static head imposed by vent.
   13. Tank must be externally coated. The coating must, as a minimum, consist of a primer coat, a bond coat, and two or more final coats of paint, or have an equivalent surface coating system designed to prevent corrosion and deterioration. As a minimum, coatings and application methods must meet the requirements of the Steel Structures Painting Council and National Association of Corrosion Engineers.
   14. Pryco PYSB Series.

2.3 BATTERIES

A. Batteries: Dry-charged, lead-acid type:

1. Furnish electrolyte separately for use when installation is complete and unit is ready for testing:
    a. Provide 3 year prorata warranty on engine-starting batteries.

B. Battery rack: Rack connected with suitable battery cables.

C. Battery charger: Output current rating of at least 1/20th of ampere hour capacity of battery and capable of automatically switching between low rate (float) mode and high rate (equalize) mode:
1. Include solid state rectifiers, DC voltmeter and ammeter, fuse input and output, and 115 V AC input.
2. Malfunction alarm contacts for loss of AC power voltage, low and high battery voltage, loss of charge and loss of high rate charge.

2.4 GENERATOR

A. Generator: 4-pole or 6-pole revolving field type with permanent magnet exciter and magnetic amplifier or SCR voltage regulator. No commutator or commutator brushes allowed:
1. Minimum continuous standby ratings: As indicated, substantiated by manufacturer's standard published curves and conform to NEMA MG-1 specification. Special ratings or maximum ratings are not acceptable:
    a. Generator shall be rated to serve up to 50 percent non-linear load without exceeding standard NEMA temperature rise.
2. Minimum efficiency: 92 percent at 50 to 110 percent of nominal standby rating, less than 30 percent instantaneous voltage dip at full load and rated power factor and suitable for simultaneous operation with other future units connected in parallel.
3. Stator and rotor: Class F insulated with 100 percent epoxy impregnation and overcoat of resilient insulating material to reduce possible fungus and/or abrasive deterioration.
4. Directly connect stator to engine flywheel housing. Gear driven generators are not acceptable.
5. Drive rotor through semiflexible driving flange to ensure permanent alignment.
6. Self ventilating with suitable blower, air inlet and outlet openings.
7. Provide terminal box of adequate size for entrance of flexible conduit for generator leads out bottom from either side.
8. Generator drive free from critical torsional vibration within operating range.
9. Provide generator mounted main circuit breaker: Solid state molded case type, ratings as indicated.

B. Voltage regulator: SCR type, to maintain 2 percent voltage regulation from 0 to full load with steady state modulation not exceeding plus 1/2 percent including cross-current compensation to provide maximum of 5 percent unbalance in kva load sharing between this unit and possible future generators:
1. Provide automatic protection against short circuits on system.
2. Permit unit to operate at no load below rated frequency for engine start up and shut down procedures.
3. Provide voltage level and gain controls for normal operating adjustments.
4. Provide voltage level control with minimum range of plus or minus 5 percent from rated voltage.
5. Mount regulator, volts per hertz type, in generator housing on suitable vibration isolators.
6. Provide "series boost" type short-circuit current sustaining attachment to allow downstream circuit breakers to trip sequentially.

C. Generator instruments and controls: Generator mounted NEMA 1 type, vibration isolated, code thickness steel instruments and control panel(s):
1. AC voltmeter and phase selector switch.
2. AC ammeter and phase selector switch.
3. Hand-off-auto engine, start-stop control switch.
4. Frequency meter.
5. Running time meter.

6. Indicating wattmeter with on-off switch.
7. Governor control rheostat.
8. Cool down time delay 0-15 MIN adjustable.
9. Green light "ON" to indicate standby power generator system is supplying load.
10. Red shut down indicating lights as follows:
    a. Overcrank.
    b. Overspeed.
    c. Low lubricating oil pressure.
    d. High engine water temperature.
11. Amber alarm indicator lights as follows:
    a. Low engine water temperature (less than 70 degF).
    b. Low fuel.
    c. Control switch not in auto position.
    d. Battery charger malfunctioning.
    e. Low battery voltage.
12. Amber prealarm indicator lights as follows:
    a. High engine water temperature.
    b. Low lubricating oil pressure.
13. Dry contacts for remote alarms wired to terminal strips.
14. Voltage level adjustment rheostat.
15. Panel illumination lights and switch.
16. Common audible alarm to indicate when one or more of alarm or prealarm conditions exist.

2.5 GENERATOR REMOTE DERANGEMENT SIGNAL ANNUNCIATOR

A. Generator remote derangement signal annunciator:
    1. Flush mounted, with flush plate of No.4 finish, stainless steel, 20 x 20 IN x 4-1/4 IN deep:
        a. Circuits: 24 volts DC powered from starting batteries. Verify circuit voltage to match battery voltage.
        b. Provide red and green signal lamps, buzzer, silencing switch, lamp test switch, relays, solid-state components, and engraved function identifications.

B. Annunciator functions:
    1. Green light "ON" to indicate generator is operating to supply power to load.
    2. Separate red light for each shutdown or alarm condition and amber light for each prealarm condition and common buzzer with silence/ acknowledge switch.
    3. Shut down indicating lights as follows:
        a. Overcrank.
        b. Overspeed.
        c. Low lubricating oil pressure.
        d. High engine water temperature.
    4. Alarm indicator lights as follows:
        a. Low engine water temperature (less than 70 degF).
        b. Low fuel.
        c. Control switch not in auto position.
        d. Battery charger malfunctioning.
        e. Low battery voltage.
        f. Fuel in tank rupture basin.
    5. Prealarm indicator lights as follows:
        a. High engine water temperature.
        b. Low lubricating oil pressure.
        c. When generator "main breaker" is open.

C. Remote monitoring:
    1. Provide two NO and two NC auxiliary contacts to be monitored by the BMCS system as follows:
        a. Generator running.

b. Generator pre-alarm or alarm.
c. Generator shutdown.
d. Generator low fuel level

2.6 WIRING

A. Conduit: Galvanized steel, flexible heat resistant "Sealtite" conduit.

B. Terminal strip: Terminate wiring at identified terminals on terminal strip in NEMA 12 junction box.

C. Conductors: Stranded copper with THHN insulation.

2.7 ENGINE GENERATOR ENCLOSURE

A. Outdoor weather protective, sound attenuated, self-contained, freestanding, reach-in design enclosing engine-generator set, muffler, sub-base fuel tank and vibration isolators:
   1. Twelve gauge steel post and supports with fourteen gauge steel removable panels.
   2. Fourteen gauge steel lockable hinged doors with corrosion resistant stainless steel hardware and fasteners.
   3. Each side of the engine-generator shall be easily accessible for routine inspection and service.
   4. Louvers shall provide adequate ventilation.
   5. Cambered roof to prevent water accumulation.
   6. Enclosure shall be metal prepped, primed with two coats of self-etching primer, and finished with two coats of the factory standard acrylic enamel paint.
   7. Provide anchor bolts for casting into the slab to attach enclosure to pad.

B. The sound pressure level produced by all sources of noise emission from the generator enclosure (including intake air openings, discharge air openings, casing radiated, and the exhaust system) at a distance of 50 feet in any direction from the enclosure shall not exceed 70 dBA:
   1. Sound absorbing materials used in the interior walls, ceiling and doors shall have properties including 1200 degrees F continuous service, non-combustible, does not absorb moisture, will not mildew, does not promote or contribute to corrosion and shall include a galvanized, perforated interior liner.
   2. Provide additional sound absorption and/or reduction materials to achieve the required sound pressure levels.

2.8 VIBRATION ISOLATION

A. Refer to Section 26 05 48.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all components as indicated and in accordance with manufacturer's recommendations and instructions.

B. Install all wiring on engine in conduit except control wiring may be factory installed in high temperature loom.

C. Provide control wiring in conduit between generator control panel, remote derangement signal annunciator panel(s) and remote devices as described under generator instrument and controls paragraph and generator remote derangement signal annunciator paragraph of this specification.

3.2 FACTORY PERFORMANCE TEST

A. Each prime mover shall be individually tested. Derating factors for the proposed site shall be applied to test data. Test shall be for continuous period of no less than 2 hours. Test procedure shall be as follows:
   1. Start prime mover and upon reaching rated RPM, pick up 100 percent of nameplate KW rating at rated power factor in one step.
   2. Observe and record the cranking time(s) required to start and run for each prime mover.
   3. Observe and record the time required to come up to operating speed for each prime mover.
   4. Record voltage and frequency overshoot for each prime mover.
   5. Record voltage, frequency and amperes.
   6. Record oil pressure, water temperature where applicable and battery charge rate at first load acceptance and at 15 minute intervals thereafter for each prime mover.

3.3 FIELD PERFORMANCE TEST

A. Provide two load tests and one cycle crank tests. Tests one and two shall be for continuous period of no less than two hours each.

B. Test number one:
   1. With prime mover(s) in a "cold start" condition and emergency load at normal operating level, initiate a normal power failure by opening all switches or breakers supplying normal power to facility.
   2. Observe and record the time delay on engine start.
   3. Observe and record the cranking time(s) required to start and run for each prime mover.
   4. Observe and record the time required to come up to operating speed for each prime mover.
   5. Record voltage and frequency overshoot for each prime mover.
   6. Observe and record time required to achieve steady-state condition with all switches transferred to emergency position.
   7. Record voltage, frequency and amperes.
   8. Record oil pressure, water temperature where applicable and battery charge rate at 5-minute intervals for the first 15 minutes and at 15 minute intervals thereafter for each prime mover.
   9. Return normal power to facility, record time delay on retransfer to normal for each switch and cooldown time delay for each prime mover.

C. Test number two:
   1. Immediately after completion of test number one, start prime mover and upon reaching rated RPM, pick up 100 percent of nameplate KW rating in one step:
      a. Building load can serve as part or all of load, supplemented by a load bank of sufficient size to provide load required. Unity power factor is acceptable for on-site testing.
   2. Observe and record the cranking time(s) required to start and run for each prime mover.
   3. Observe and record the time required to come up to operating speed for each prime mover.
   4. Record voltage and frequency overshoot for each prime mover.
   5. Observe and record time required to achieve steady-state condition.
   6. Record voltage, frequency and amperes.
   7. Record oil pressure, water temperature where applicable and battery charge rate at first load acceptance and at 15 minute intervals thereafter for each prime mover.

D. Cycle crank test: Perform test for each prime mover. Utilize any method recommended by manufacturer to prevent prime mover(s) from running. Put control switch into "run" position to cause prime mover to crank. Observe complete crank/rest cycle as follows:
   1. A complete cranking cycle shall consist of an automatic crank period of approximately 15 seconds duration followed by a rest period of approximately 15 seconds duration. Upon starting and running of the prime mover, further cranking shall cease. Two means of cranking termination shall be utilized so that one will act as a backup to the other to prevent inadvertent starter engagement. Cranking limiter time shall be 75 seconds for cycle crank.

E. Furnish load banks of required ratings necessary for tests.

F. Record engine fuel consumption by means of test equipment.

G. Test all safeties specified for generator instruments and controls and generator derangement signal annunciator as recommended by manufacturer and as required to verify proper operation.

H. Demonstrate proper operation of all equipment connected to and/or interfaces with the emergency system including:
   1. Egress lighting including battery operated equipment.
   2. Mechanical equipment including time delay on motor re-start.
   3. Elevator emergency mode operation.
   4. Remote dearrangement alarm panel.
   5. BMCS monitoring points.
   6. Generator exerciser.

END OF SECTION

SECTION 26 36 23
AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide automatic transfer switches for the following loads:
   1. Emergency branch.
   2. Optional Standby branch.

1.2 SUBMITTALS

A. Shop drawings:
   1. Switches:
      a. Outline drawings of assembly.
      b. One line diagrams and wiring diagrams for assembly and components.
      c. Interconnection wiring diagrams.

B. Product data:
   1. Technical data on each size and type of transfer switch.

C. Contract closeout information:
   1. Operating and maintenance data.
   2. BNL instruction report.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Automatic transfer switches:
      a. Base:
         1) ASCO.
         2) Russelectric.
         3) Zenith Products.
         4) Onan.
         5) Kohler.
   2. Manufacturer of switches shall have a certified service representative within 50 miles of job site.

B. Automatic transfer switches: Electrically operated mechanically held 3 phase AC, air-break type, with supervisory relays on each phase of normal source and supervisory frequency/voltage relay for emergency source:
   1. ANSI/UL-1008 listed for paragraph 30.3 emergency service.
   2. Adjust normal source supervisory relays to transfer load if voltage on any phase drops below 70 percent of normal and to restore load to normal source when normal source voltage on all phases is 90 percent or more.
   3. Obtain voltage for main contact operating solenoid from source to which load is being transferred.
   4. 480 volt.
   5. Make mechanical design of switch such that it will positively open all ungrounded conductors from normal source before connection is made to alternate source and will positively open alternate source before connection is made to normal source.

6. Design mechanical interlock so it cannot be readily disabled, disconnected, improperly adjusted, removed or otherwise made inoperative.
7. Switch shall have provisions for visual inspection of switch blades and contacts.
8. Silver-surface main contacts and protect by arcing contacts.
9. Make all contacts and coils readily accessible for replacement from front of panel without major disassembly.
10. Provide red and green indicating lights with fuses, identification nameplates, and test switch on front to simulate normal power failure at switch.
11. Rate each individual switch as indicated.
12. Provide engine starting contacts and all other auxiliary contacts and accessory devices for functions to be performed.
13. Provide time delay on engine start, field adjustable from 0 to 10 SEC, by SEC, and factory set at 4 SEC, to avoid unnecessary starting caused by short time outages.
14. Provide time delay on retransfer to normal, field adjustable from 2 to 30 minutes, by minute, and factory set at 5 minutes to avoid erratic operation caused by short time reestablishment of normal source.
15. Automatic transfer switches serving Emergency Branch (EATS):
    a. Transfer to be made to generator automatically within 10 SEC maximum.
16. Automatic transfer switches serving Optional Standby Branch (QATS):
    a. Provide time delay on transfer to generator, field adjustable from 0-120 SEC, by SEC, and factory set at 10 SEC.
17. Provide one of the following to prevent out-of-phase transfers in either direction:
    a. Dual operator with transition time delay field adjustable 1-300 seconds; set at 3 seconds.
    b. In-phase monitor: Manufacturer shall coordinate window width with transfer switch operating speed to limit inrush currents to normal starting currents or less.
    c. Neutral position integral to transfer switch with transition time delay field adjustable 1-300 seconds; set at 3 seconds.

C. Automatic transfer switches:
1. ASCO, Bulletin 940.
2. Russelectric RMT.
3. Zenith ZTS.
4. Onan OT.
5. Kohler S38/S140.
6. Square D, Class 8901.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Locate switches in switchboards or wall-mounted as indicated.

B. Connect as indicated in one-line diagram.

END OF SECTION

SECTION 26 41 13
LIGHTNING PROTECTION SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide system complying with UL and bearing the Master-C label.

1.2 QUALITY ASSURANCE

A. System standards: ANSI/UL-96A, and NFPA-780.

1.3 SUBMITTALS

A. Shop drawings:
   1. Lightning protection system:
      a. Roof penetration details.
      b. Complete layout indicating all connections, down conductors and grounding tripads.

B. Product data:
   1. Technical data on each component.

C. Contract closeout information:
   1. UL Master label.

PART 2 - PRODUCTS

2.1 LIGHTNING PROTECTION SYSTEM

A. Lightning protection system: Complete Master Label lightning protection system.

B. Acceptable manufacturers:
   1. Lightning protection system:
      a. Base: Listed in lightning protection section of current edition of UL electrical equipment test.
         1) Harger Lightning Protection.
         2) Thompson Lightning Protection.
         3) Robbins Lightning Protection.
         4) Heary Brothers Lightning Protection.
         5) Independent Protection.
         6) AC Erico Lightning Protection.
         7) National Lightning Protection.

2.2 MATERIALS

A. Materials - General: Labeled for lightning protection systems by UL.
   1. All components designed to blend in with appearance of building so that it appears as part of building.
   2. Maximum concealed system as required to meet Architect's requirements.

B. Conductors: Copper or aluminum, grade ordinarily used for commercial electric work and of weight required by height of building.
   1. Conductors above the roof shall be copper or aluminum and shall be compatable with roofing material to prevent galvanic corrosion.
      a. Attach conductors to building with proper cast bronze, copper, or aluminum base with adhesive or fasteners to adapt to building design.

2. Conductors below the roof and in contact with soil shall be copper.

C. Air terminals: Solid copper or aluminum rod with tapered point, of height required.
   1. Attach rods to building with proper cast bronze, copper, or aluminum base with adhesive or fasteners to adapt to building design.
   2. On sloped roofs, provide swivel adapter to allow vertical mounting of rod.
   3. Mid roof terminals shall be safety tipped type.

D. Ground rods: 3/4 IN x 10 FT copper weld.

E. Main ground connection fittings: See Section 26 05 26.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Do not install copper conductors or fastenings in contact with aluminum surfaces.

B. Structural steel columns may be used as down conductors.

C. Terminate each downlead cable in grounding arrangement suitable to local soil condition and applicable codes.
   1. Maximum ground resistance: 10 ohms.
   2. Use tripods each containing three rods, located as required.
   3. Make connection to ground rods with Cadweld method for all connections buried in earth.
   4. If necessary, drive additional ground rods to obtain 10 ohms.
   5. Do not cover or bury ground rods until observed by Architect.

D. Interconnect all metal bodies on roof (such as ventilators, stacks, pipes, gutters, downspouts, ducts, tracks, antennas, water pipes, ladders) to main conductor system.

E. Interconnect all metal bodies within bonding distance in accordance with NFPA 780.

F. Provide connection to incoming electric and telephone service ground per NEC for common bonding.

G. Provide connection to all underground metallic pipe services entering the building.

H. Provide roof flashings or other method approved by roof manufacturer for down conductor or fittings passing through roofs. Do not use pitch pockets.

I. Adhesives and fasteners shall be compatible with roofing material. Coordinate with roofing manufacturer.

J. Remove and replace any items found not in compliance with specification requirements.

END OF SECTION

SECTION 26 43 13

TRANSIENT VOLTAGE SUPPRESSION FOR LOW VOLTAGE EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. This specification includes equipment that clamps transient voltage, diverts surge current and attenuates high-frequency electrical line noise.

B. TVSS's shall be provided in the following applications:
   1. Internally mounted within the switchgear and electronic grade panelboard enclosures.

1.2 QUALITY ASSURANCE

A. The specified system shall be designed, manufactured, tested, and installed in compliance with the following standards:
   1. American National Standards Institute and Institute of Electrical and Electronic Engineers (ANSI/IEEE-C62.41 and ANSI/IEEE-C62.45).
   2. Federal Information Processing Standards Publication 94 (FIPS PUB 94).
   3. Federal Specification (W-P-115b and W-C-375a, b).
   4. National Electrical Manufacturers Association (NEMA LS-1, AB-1, PB-1, PB-1.1 and PB-1.2.
   5. National Fire Protection Association (NFPA-70 [NEC], NFPA-75 and NFPA-78).
   6. Underwriters Laboratories (ANSI/UL-50, Enclosures for Electrical Equipment, ANSI/UL-67, Panelboards, ANSI/UL-489, Molded Case Circuit Breakers and Circuit Breaker Enclosures, ANSI/UL-943, Ground Fault Circuit Interrupters, ANSI/UL-1283, Electromagnetic Interference Filters and ANSVUL 1449 Second Edition, Transient Voltage Surge Suppressors).
   7. Military Standard 220A.

B. Internally mounted TVSS equipment shall be UL-1449 and UL-1283 component recognized as a transient voltage surge suppressor and electromagnetic interference filter and shall be UL-witnessed/tested within switchgear and panelboard enclosures as applicable.

1.3 DEFINITIONS

A. Clamping Voltage: The applied surge shall be induced at the 90 degree phase angle of the applied system frequency voltage. The voltage measured at the end of the 6 IN output leads of the TVSS and from the zero voltage reference to the peak of the surge.

B. Let-Through Voltage: The applied surge shall be induced at the 90 degree phase angle of the applied system frequency voltage. The voltage measured at the end of the 6 IN output leads of the TVSS and from the system peak voltage to the peak of the surge.

C. Maximum Continuous Operating Voltage (MCOV): The maximum steady state voltage at which the TVSS device can operate and meet its specification within its rated temperature.

D. Maximum Surge Current: The maximum 8x20 microsecond surge current pulse the TVSS device is capable of surviving on a single-impulse basis without suffering either performance degradation or more than 10 percent deviation of clamping voltage at a specified surge current. Listed by mode, since number and type of components in any TVSS may vary by mode.

E. Protection Modes: This parameter identifies the modes for which the TVSS has directly connected protection elements, i.e., line-to-neutral (L-N), line-to-line (L-L), line-to-ground (L-G), neutral-to-ground (N-G).

F. Surge Current per Phase: The per phase rating is the total surge current capacity connected to a given phase conductor. For example, a wye system surge current per phase would equal L-N plus L-G; a delta system surge current per phase would equal L-L plus L-G. The N-G mode is not included in the per phase calculation.

G. System Peak Voltage: The electrical equipment supply voltage sine wave peak (i.e., for 480/277 volt system the L-L peak voltage is 679V and the L-N peak voltage is 392V).

1.4 SUBMITTALS

A. Shop drawings:
   1. Submit all unit dimensions, weights, mounting provisions, connection details and layout diagram(s) of each unit.

B. Product data:
   1. Standard Catalog Data Sheet.
   2. UL 1449 product listing data.
   3. UL 1283 product listing data.
   4. Signed and Certified Clamping Voltage data from a third party testing laboratory, including oscilloscope waveform snap shots for IEEE C62.41 Category C3 and B3 waveforms. Testing shall be in accordance with IEEE C62.45.
   5. Signed and Certified spectrum analysis from a third part testing laboratory verifying the device meets the indicated noise attenuation. Testing shall be in accordance with MIL-STD-220A.
   6. Signed and Certified Surge Current data from a third party testing laboratory.
   7. Signed and Certified Repetitive Surge Current data from a third party testing laboratory.

C. Contract closeout information:
   1. Operating and maintenance data.
   2. Copy of five (5) year warranty on SPD equipment.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Transient Voltage Surge Suppression:
      a. Base:
         1) EATON Cutler-Hammer.
         2) Square D/Advanced Protection Technologies.
         3) Siemens Energey & Automation/Sentron.
      b. Optional:
         1) Current Technology.
         2) United Power.
         3) Liebert.
         4) Lea Dynatech.

B. Environmental requirements:
   1. Storage temperature range shall be minus 40 degF to plus 185 degF.
   2. Operating temperature range shall be minus 40 degF to plus 140 degF.
   3. Relative humidity range shall be 5 percent to 95 percent non-condensing.
   4. Capable of operation at altitudes up to 13,000 feet above sea level.
   5. No audible noise.
   6. No appreciable magnetic fields. System shall be capable of use directly in computer rooms or in any other location without danger to data storage systems or devices.

C. Electrical Requirements:
   1. The nominal unit operating voltage and configuration shall be as indicated on the drawings. The nominal unit operating frequency shall be 60 Hz.
   2. The maximum continuous operating voltage (MCOV) of all suppression components utilized in the unit shall be greater than 115 percent of the nominal system operating voltage.
   3. Tested and suitable for ANSI/IEEE C62.41 Category C3 environments.
   4. Protection modes:
      a. For a wye configured system, device must have directly connected suppression elements between line-neutral (L-N), line-ground (L-G), and neutral-ground (N-G).
   5. Maximum surge current rating:
      a. Switchgear applications:
         1) Maximum surge current rating per phase shall be minimum 400kA.
         2) Maximum surge current rating per mode shall be minimum 200kA.
      b. Electronic grade panelboard applications:
         1) Maximum surge current rating per phase shall be minimum 120kA.
         2) Maximum surge current rating per mode shall be minimum 60kA.
   6. Maximum suppression voltage rating (SVR):
      a. 120/208V system: 400 volt (L-N, L-G, N-G).
      b. 277/480V system: 800 volt (L-N, L-G, N-G).
   7. Maximum ANSI/IEEE Category C3 let through voltage based on IEEE C62.41 and C62.45 recommended procedures for Category C3 surges (20 kV, 10 kA):
      a. 120/208V: 470 volt (L-N).
      b. 277/480V: 900 volt (L-N).
   8. All TVSS equipment shall be capable of surviving more than 2500 ANSI/IEE C62.41 category C3 transients without failure or more than 10 percent degradation of UL 1449 clamping voltage.
   9. EMI/RFI filter shall provide minimum 50 dB noise attenuation at 100 kHz using MIL-STD-220A insertion loss test method.
   10. Surge current shall be equally distributed to all components to ensure equal stressing and maximum performance.
   11. Suppression system shall not utilize gas tubes, spark gaps or other components which short or crowbar the line leading to interruption of power.
   12. Multiple TVSS units shall not be connected in series to achieve the specified performance.
   13. Provide 200 kAIC internal fusing at the component level.
   14. Safety and diagnostic monitoring:
      a. Solid state monitoring of each mode and power loss in any phase. Monitoring of fuse status only is unacceptable.
      b. Audible alarm and surge counter. Surge counter shall utilize self-contained batteries with a nominal life of ten (10) years.
      c. Form C dry contacts (NO/NC) for remote status monitoring. Alarm contact shall change state if any fault condition occurs.
      d. Externally visible green/red solid state indicator lights. Absence of a green light and presence of red light shall indicated which mode(s) or phase(s) have been damaged. Fault detection will activate a flashing trouble light.

D. Internally mounted TVSS equipment:
   1. Provide 200 kA input fuses integrally mounted to the TVSS unit. Provide integrally mounted fused disconnect if TVSS is not connected via branch circuit breaker.
   2. TVSS equipment shall be mounted in the factory of the enclosure manufacturer.
   3. TVSS equipment shall be connected directly to the protected equipment bus on the load side of the mains. If bus is not possible, provide minimum #1/0 conductors at a maximum length of 12 IN.
   4. Diagnostics shall be remotely mounted on the cover of the equipment enclosure and visible from outside the enclosure.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install TVSS equipment per manufacturer's recommendations.

3.2 TESTING

A. The unit(s) shall be thoroughly factory-tested before shipment. Testing of each unit shall include but shall not be limited to quality assurance checks, MCOV and clamping verification tests. The MCOV testing shall consist of the unit(s) being burned-in at the applicable MCOV for a minimum of one (1) hour.

B. When MEGGER testing the distribution system, temporarily disconnect all connections to TVSS equipment. Reconnect upon completion of test.

3.3 WARRANTY

A. The manufacturer shall provide a Limited Five-Year Warranty from date of shipment against failure when installed in compliance with applicable national/local electrical codes and the manufacturer's installation, operation and maintenance instructions.

END OF SECTION

SECTION 26 51 13
BUILDING LIGHTING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Interior luminaires and accessories.

B. Exterior building mounted luminaires and accessories.

C. Lamps and ballasts.

1.2 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

A. Install lighting control relays furnished under Section 26 51 13.

1.3 RELATED SECTIONS

A. Section 11 53 13 - Fume Hoods, for fume hood fixtures.

B. Section 13 34 39 - Prefabricated Rooms, for controlled environmental room fixtures.

C. Section 14 21 23 - Geared Traction Elevators - Passenger, for elevator fixtures

D. Section 26 24 16 - Panelboard.

E. Section 26 56 00 - Site Lighting.

F. Section 26 09 43 - Low Voltage Lighting Control System. .

1.4 SUBMITTALS

A. Pre-Approval:
   1. Prior to submitting Shop Drawings and Product Data, submit manufacturer and model number proposed for each fixture specified.
   2. Submittals must be received by A/E at least 30 calendar days before scheduled ordering of fixtures.
   3. Actual date of pre-approval submittals shall be determined by C/M and shall allow sufficient time for potential disapprovals, re-submittal for pre-approval, ordering, Shop Drawing and Product Data preparation, submittal for A/E review(s), fabrication, delivery, and installation, all in compliance with overall Project Schedule.
   4. Shop Drawings and Product Data, if submitted without pre-approval, or not compliant with pre-approval comments, will be returned without review.

B. Shop Drawings; Show:
   1. Details of construction and finishes. Catalog cuts without required details will not be approved.
   2. Fixture and accessory drawings (indicate scale).
   3. For continuous pattern fixtures, indicate layout, individual section lengths, and lamp quantities. Show details of connections, corners and extensions, end plates, and mounting. Include pendant or bracket locations and show remote transformers and ballast.
   4. List of fixture types and quantities.
   5. Lamp catalog cut sheet shall clearly indicate lamp selection, lamp length, lamp wattage, lumen output, color temperature, CRI, lamp life, base configuration, and where applicable, TCLP compliance and beam angle.
   6. Ballast catalog cut sheet shall clearly indicate ballast selection, type and quantity of lamps it operates, ballast factor, input wattage, voltage, end-of-lamp life sensing shut off, THD, inrush current, lamp starting method, and where applicable, dimming range.

7. Details of lenses for fixtures with RFI shielding.
8. .

C. Product data:
1. For down and semi-down lights used for general illumination: Submit photometric data by an independent testing laboratory when requested. Show optical performance developed using methods of IES of North America as follows:
   a. Coefficients of utilization.
   b. Visual Comfort Probability data for fluorescent fixtures only; for a 100 footcandle room with reflectance of 80 percent at ceiling, 50 percent at walls, and 20 percent at floor.
   c. Candlepower data presented graphically and numerically, in 10 degree increments. Develop data for up and down quadrants normal, parallel, and at 45 degree to lamp if light output is asymmetric.
   d. Zonal lumens stated numerically in 10 degree increments as above.
2. For other fixtures, show candlepower curves graphically and numerically, in 10 degree increments or smaller for narrow-beam fixtures and lamps.

D. Samples:
1. Finishes: Only when specifically requested, submit 4 x 6 inch samples of each type of finish specified, on metal to be used.
2. Fixtures: Only when specifically requested; following shop drawings, product data, and finishes; deliver one sample fixture of each type requested to A/E's office.
   a. Samples shall be complete with lamps, ballasts, cords and other accessories, ready for operation.
   b. After review and approval, transfer sample fixtures from A/E's office to job site for comparison with fixtures delivered for installation. Approved unblemished samples may be used in the work.

E. Informational Submittals:
1. Manufacturer's installation instructions.
2. Certificates: Certify that each product meets or exceeds specified requirements.
3. Special Warranty: Warrant electronic ballasts for three years from Date of Substantial Completion. Include labor allowance for full cost of ballast installation.

F. Delivery, Storage and Handling: Follow Section 01 65 00.
1. Protect fixtures from damage using appropriate material, cartons, plastic wrapping and other protective means.

G. Maintenance Material: Follow Section 01 77 00.
1. Lamps: 25lamps of each type used.
2. Ballasts: 10 of each type and size used.
3. Emergency Lamp Sockets: 5 of each type used.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Use fixtures conforming to UL Standards, bearing UL labels, and manufactured in accordance with NEC.

B. Make fixture parts of materials resistant to corrosion and thermal and mechanical stresses encountered in normal application. Provide accessory equipment such as starters, sockets and lampholders, approved by UL and ETL, unless otherwise noted.

C. Electrical components shall be accessible and removable through fixture without having to remove fixture from ceiling.

D. Use catalog numbers listed as a guide only. Follow modifications and other requirements shown or specified.

E. Coordinate fixtures with ceiling construction. Advise A/E of discrepancies between fixture catalog references shown or specified and actual ceiling construction, prior to submission of shop drawings. Failure to do so will require correction at no additional cost.

2.2 FIXTURE CONSTRUCTION

A. Housings:
   1. Fluorescent Fixtures: Minimum 22 gauge sheet steel; integral end plates and trim flanges to suit ceiling construction. Provide wire way covers with captive retainers to allow access to electrical components without use of tools.
   2. Incandescent, HID and Compact Fluorescent Fixtures: Minimum 22 gauge sheet steel, or minimum 16 gauge sheet aluminum, unless noted otherwise. Provide auxiliary junction box secured to mounting frame.
   3. Extruded aluminum housings, where scheduled, shall be at least 1/8 inch thick.
   4. Punch and form housings prior to finishing (post-paint).

B. Trim: For square and rectangular fixtures, miter and continuously weld corners. Miter perimeter inverted T-Bar angles at corners. Do not butt or overlap squared ends. Finish joints smooth.

C. Castings: Uniform quality, free from imperfections affecting strength and appearance. Exterior surfaces, if not receiving a finish coat, shall be smooth and match adjacent surfaces. Apply at least one coat of clear methacrylate lacquer unless a painted finish is specified.

D. Lens/Louver Frames: Extruded aluminum with mitered corners unless scheduled otherwise. Hinging or other normal motion shall not cause lens or louver to drop out.

E. Gaskets: Provide gaskets at face plates or frames of recessed fixtures which serve as ceiling trim and which allow interior access. Provide moisture seal gaskets at exterior locations and in other areas designated. Secure frames to fixture bodies with screws or other means, to result in tight installation, without light leaks. See schedules for other types of seals and gaskets.

F. Ventilation: Provide ventilation openings of adequate size and quantity to permit operation of lamps and ballast without affecting rated output or life expectancy. Include wire mesh screens.

G. Lamp Holders:
   1. Position sockets so that lamps are in optically correct relation to fixture components.
   2. Secure sockets by screws to fixture enclosure or husk. Spring mounted sockets are not approved. Do not use plastic or sheet metal sockets unless specified otherwise.
   3. Incandescent: Porcelain body; nickel plated brass socket, pre-lubricated with silicone compound.
   4. Fluorescent: White urea plastic body; silver plated phosphor bronze or beryllium copper contacts.
   5. High Intensity Discharge: Porcelain body; nickel plated brass socket, pre-lubricated with silicone compound.

H. Ballast and Transformers:
   1. Comply with UL and ANSI specifications. Show display labels and/or symbols of approval by UL.
   2. Provide required voltage, frequency and power factor.
   3. Ballasts shall comply with U.S. Federal Efficiency laws.
   4. Manufacturer shall maintain ISO 9001 certified facility.
   5. Equipment shall not contain PCBs.

I. Fluorescent Ballasts:
   1. General:
      a. Lamp current crest factor shall be 1.7 or less.
      b. Use quietest NEMA rated noise level and highest sound rating available; Class A+.
      c. Ballasts shall tolerate operation at 158 degrees F (70 degrees C) case temperature, without damage. Ballasts shall be suitable to operate in:

1) Indoor heated or air conditioned spaces: 50 to 104 degrees F ambient temperature. Pre-packaged environmental rooms shall utilize ballasts suitable to start and operate under conditioned temperature of room.
2) Outdoors or in unheated spaces: zero to 104 degrees F.

d. Provide "Class P" rating internal resetting thermal protector for core and coil.
e. Ballast shall operate without tripping within plus/minus 10 percent of normal voltage.
f. Ballasts shall comply with FCC Part 18 non-consumer equipment, Class A for EMI.
g. High power factor.
h. Ballasts shall provide transient immunity as recommended by ANSI C62.41.
i. Ballasts shall operate lamps with no visible flicker. Frequency of operation shall be greater than 30,000 Hz.
j. Ballasts shall be capable of withstanding sustained open and short circuit conditions without damage.
k. Use multi-lamp ballasts in fixtures with multiple lamps, unless otherwise noted. Rapid-start lamps on single-lamp ballasts shall have one circuit-interrupting socket per lamp.
l. Use identical ballasts within each fixture type. Fixture design, fabrication, and assembly shall prevent overheating or cycling of lamps and ballasts under all conditions.
m. Mount lamps on rapid-start circuits within 1 inch of grounded metal, minimum 1 inch wide, as long as lamp.
n. Sockets with open-circuit voltage over 300 volts: Safety type, designed to open supply circuit on lamp removal.
o. Mount to inside top of fixture housings, with ballast surfaces and housing in complete contact for efficient conduction of ballast heat.
p. Integral leads shall be color coded to ANSI standards.

2. Solid State Electronic T4, T5 Compact Fluorescent Ballasts:
a. Manufacturers: Substitutions not permitted.
1) Universal.
2) Advance.
3) Sylvania.
b. Standards: UL, ANSI, FCC Paragraph 18, subparagraph C (EMI/RFI).
c. Rating: High frequency; Class P with automatically reclosable thermal device; High power factor; 120V or 277V as required; Compatible with lamping.
d. Frequency: In accordance with NEMA recommendations, above 30kHz, and avoid frequency ranges of 27-31 kHz, 34-41 kHz, and 55-61 kHz.
e. Features: Programmed start; ballast factor between 0.80 and 1.15 depending on lamp; end-of-lamp life sensing cut-off.
f. Distortion: Less than 20 percent THD reflected on line input.
g. Ballast inrush current shall not exceed 20 times operating current.
h. Ballast shall allow for re-lamping without the need to cycle power.
i. Provide five year manufacturer warranty.

3. Solid State Electronic T8, T5 Long Tube Fluorescent Ballasts:
a. Manufacturers: Substitutions not permitted.
1) Universal.
2) Advance.
3) Sylvania.
b. Standards: UL, IEEE 587 Category A (Transient Protection), FCC Paragraph 18, subparagraph c for non-consumer (EMI).
c. Description: Instant start; high frequency, Class P; Sound Rating A+; high power factor; internally protected from line transients; 120V or 277V; multi–lamp ballasts, as indicated; providing independent lamp operation (ILO), allowing remaining lamps(s) to maintain full light output if one or more lamps fail.
d. Frequency: In accordance with NEMA recommendations, above 30kHz, and avoid frequency ranges of 27-31 kHz, 34-41 kHz, and 55-61 kHz.
e. Distortion: Less than 20 percent THD reflected on line input.
f. Ballast inrush current shall not exceed 20x operating current.

g. Ballast Factors: Between 0.87 and 1.0 for T8 lamps, unless otherwise noted; minimum 1.0 for T5 and T5HO lamps, unless otherwise noted.
h. Provide five year manufacturer's warranty.

4. Fluorescent Dimming Ballasts; Long Tube Lamps, Line Voltage
   a. Design Standard Manufacturer: LUTRON "HI-LUME". Substitution subject to Section 01 25 13 is:
      1) Sylvania.
   b. Dimming shall be smooth and continuous without flicker, down to 1 percent light output for T8 fluorescent and T5 compact long tube lamps.
   c. High power factor.
   d. Ballast Factor at Full Light Output: 0.93 minimum.
   e. Distortion: Less than 20 percent THD reflected on line input.
   f. Standards: UL, ANSI, FCC (EMI).
   g. Wall Box Dimming Controls: Compatible with ballast. Same dimming ballast must be used with all fixtures controlled by same wall box dimming switch.
   h. Class A sound rating.
   i. Class P thermally protected.
   j. Lead length between ballast and lamps must be less than 7 feet for T8 and 3 feet for T5.
   k. Provide three year manufacturer's warranty.
5. Fluorescent Dimming Ballasts; Long Tube Lamps, 10-Volt
   a. Design Standard Manufacturer: LUTRON "ECO-10". Substitutions subject to Section 01 25 13 are:
      1) Sylvania.
      2) Universal.
      3) Advance.
   b. High power factor.
   c. Ballast Factor at Full Light Output: 0.93 minimum.
   d. Distortion: Less than 20 percent THD reflected on line input.
   e. Standards: UL, ANSI, FCC (EMI).
   f. Wall Box Dimming Controls: Compatible with ballast. Same dimming ballast must be used with all fixtures controlled by same wall box dimming switch.
   g. Dimming shall be smooth and continuous without flicker, down to 5 percent light output; 1 percent light output for T5 and T5HO.
   h. Class A sound rating.
   i. Class P thermally protected.
   j. Phase control ballasts require three line voltage wires- hot, dimmed hot, and neutral; 10-Volt DC ballasts require two line voltage wires (hot and neutral), and two low voltage 0-10VDC Class 2 wires.
   k. Provide three year manufacturer's warranty.
6. Fluorescent Dimming Ballasts; Compact Lamps, Line Voltage
   a. Design Standard Manufacturer: LUTRON "HI-LUME". Substitutions subject to Section 01 25 13 are:
      1) Sylvania.
      2) Universal.
      3) Advance.
   b. Compact fluorescent lamps must have 4 pin bases.
   c. High power factor.
   d. Ballast Factor at Full Light Output: 0.93 minimum.
   e. Distortion: Less than 20 percent THD reflected on line input.
   f. Standards: UL, ANSI, FCC (EMI).
   g. Wall Box Dimming Controls: Compatible with ballast. Same dimming ballast must be used with all fixtures controlled by same wall box dimming switch.
   h. Dimming shall be smooth and continuous without flicker, down to 5 percent light.
   i. Class A sound rating.
   j. Class P thermally protected.
   k. Provide three year manufacturer's warranty.

7. Emergency Battery Ballasts:
   a. Manufacturers: Substitutions are not permitted.
      1) Bodine.
      2) Dual-Lite.
      3) Emergi Lite.
   b. Standards: UL#924.
   c. Description: Self-contained fluorescent inverter battery pack designed to convert a fluorescent fixture into an emergency light. Sealed maintenance-free nickel cadmium battery unit designed to operate at ambient temperatures not over 131 degrees F. Charger Design for dual voltage 120/277 volt 60 Hz operation using solid state circuitry; constant current type capable of recharging batteries in a maximum of 24 hours. Unit shall be self-diagnostic with pre-programmed microprocessor that continuously monitors charging current and battery voltage, and automatically tests operation for 30 seconds every 30 days and for 90 minutes once per year. Flashing status indicator light shall be provided for alarm conditions. Audible alarm shall be available as an additional alarm option. Provide audible alarm, except where noted otherwise on Drawings. Self-diagnostic, self-testing units shall not be provided in animal holding rooms; provide units with test switch on ballast channel inside sealed fixtures.
   d. Transfer: Solid state type to automatically and instantly energize two lamp load upon failure of AC supply. One lamp shall be capable of operation upon failure of other lamp. Battery protection circuit shall automatically shut down lamp load to protect battery from deep discharge.
   e. Inverter: Solid state type designed to operate lamps as specified.
   f. Housing: Mount components, battery-charger-inverter, in a common enclosure constructed of 20 (min.) gauge steel housing. Design housing mounting inside fixture ballast channel. Provide housings suitable for use in sealed and gasketed fixtures when used in gasketed fixtures.
   g. Performance: Upon failure of normal AC source, an automatic relay circuit shall instantly apply battery power to inverter circuit to operate one lamp in single lamp luminaire or two lamps in multiple lamp luminaires for at least 90 minutes, at minimum initial output of:
      1) 1300 lumens for 32 watt T8 lamps.
      2) 700 lumens for T5 long tube compact fluorescent lamps.
      3) 200 lumens for twin tube compact fluorescent lamps under 13 watts.
      4) 300 lumens for 2-pin quad tube compact fluorescent lamps.
      5) 300 lumens for 4-pin compact fluorescent lamps.
   h. Accessories: Provide a remote indicator light when fixture construction prevents visible mounting within fixture.
   i. Provide five year manufacturer's warranty.
8. High Intensity Discharge Ballasts:
   a. Manufacturers: Substitutions are not permitted.
      1) Advance.
      2) Universal.
      3) Venture.
   b. Standards: UL and ANSI.
   c. Encased and potted where subject to moisture.
   d. For indoor and non-weatherproof conditions use UL listed Type 1; for outdoor conditions use UL listed Type 2.
   e. High power factor.
   f. Constant wattage auto-transformer or constant wattage type.
   g. Suitable to operate within plus/minus 10 percent voltage variation.
   h. Drop-out voltages; 66 percent of nominal.
   i. Suitable to operate in:
      1) Indoor heated or air conditioned spaces: 50 to 104 degrees F ambient.
      2) Exterior or unheated spaces: Minus 20 to 104 degrees F.

j. Insulation: Class H, 356 degrees F.
k. Accessories: Relays for auxiliary quartz lamp where noted.
l. Thermally protect recessed and remotely located ballasts.
m. Lamp Current Crest Factors: Less than 2.0 for mercury vapor and 1.8 for metal halide and HPS.
n. Igniters shall be designed to withstand 10,000 hours of continuous pulsing and six months of lamp open circuit operation without failure.
o. Provide two year manufacturer's warranty
p. Other types: As scheduled.
q. Electronic HID – Metal Halide:
   1) Design Standard Manufacturer: AROMAT/Vossloh-Schwabe. Substitutions must be approved equal, subject to Section 01 25 13.
   2) Standards: UL, ANSI, FCC Part 18C, Class A and non-consumer limits for EMI and RFI.
   3) Ballast shall tolerate plus/minus 10 percent voltage variations with less than plus/minus 0.5 percent variation in output power. Less than plus/minus 3 percent variation in output power within all ranges of accepted ANSI lamp voltages.
   4) Ballast shall operate lamps at a frequency of less than 200 Hz to minimize acoustic resonance inside lamp arc tube and to minimize lamp flicker. Use of "square wave" output must be approved by lamp manufacturer.
   5) Lamp Current Crest Factor: Less than 1.5.
   6) Ballast shall have thermal protection shutdown. Ballasts shall be able to tolerate operation at 176 degrees F (80 degrees C) case temperature without damage. Ballast shall operate in ambient temperatures down to minus 20 degrees F.
   7) High Power Factor
   8) Class A sound rating
   9) Total Harmonic Distortion shall not exceed 15 percent.
   10) Minimum Ballast Factor: 1.0
   11) When used in recessed fixtures, ballast shall be marked "Suitable for recessed use".
   12) Ballast shall be thermally protected and incorporate lamp shutdown circuitry for end of lamp life to prevent excessive pulsing of failed lamps.
   13) Ballast shall be capable of 15 foot remote mounting.
   14) Power Supply Electrolytic Capacitors shall have a minimum rating of 5000 hours at 105°C.

9. Low-Voltage Incandescent Transformers:
   a. Manufacturers: Same as fixture manufacturer.
   b. Provide at required or specified input and output voltages and wattage with integral primary and secondary circuit breaker protection.
   c. Where used with Class 2 wiring, provide multiple individual secondary outputs with circuit breakers each not exceeding 60 watts.
   d. Control device must be compatible with type of transformer, and coordinated prior to submission of shop drawings.

2.3 LAMPS

A. Manufacturers: Substitutions are permitted subject to Section 01 25 13.
   1. General Electric Company.
   2. North American Phillips.
   3. Sylvania/Osram Lighting Products Company.
   4. Venture.
   5. Ushio.

B. General:
   1. Where lamps are specified for individual luminaires or lighting equipment, provide lamps so that fixtures are completely lamped and in normal operating condition.
   2. Incandescent lamps: Inside white frosted for "A", "PS" and "R" types; clear for "PAR" types; rated for normal operation at 125 volts.

3. Halogen lamps: Line or low voltage with wattage, bulb type and beam spread as scheduled. Provide MR type lamps with dichroic reflectors unless scheduled otherwise.
4. Compact Fluorescent Lamps: Designed for operation with electronic ballast, twin, triple or quad tube, 3500 degree color temperature with minimum 82 CRI. Furnish lamps from one manufacturer to ensure color uniformity.
5. Long Tube Fluorescent Lamps – T8: Extended performance, 3500 degree K color temperature with minimum 85 CRI, 3000 lumens and 24,000 hour rated life unless otherwise noted. Furnish lamps from one manufacturer to ensure color uniformity. Lamps types available as TCLP compliant, shall be supplied.
6. Long Tube Fluorescent Lamps – T5: H or HO, 3500 degree K color temperature with minimum 82 CRI, 20,000 hour rated life unless otherwise noted. Furnish lamps from one manufacturer to ensure color uniformity. Lamps types available as TCLP compliant, shall be supplied
7. Metal Halide: Pulse-start where available; burning position must be consistent with luminaire design; clear or phosphor coated as recommended by fixture manufacturer; heat resisting borosilicate glass envelope. Upon breakage, lamp shall automatically extinguish.
8. Ceramic Tube Metal Halide: Pulse start operated with electronic ballast, 200 degree K maximum color temperature shift over life, 3000 degree K color temperature with minimum 81 CRI and 4000 degree K color temperature with minimum 90 CRI.
9. High Pressure Sodium Vapor: Clear or coated heat resistant borosilicate glass envelope as recommended by fixture manufacturer.
10. Quartz: Heat resistant borosilicate glass envelope.
11. Size: As scheduled.
12. Other Types: As indicated.

2.4 FINISHES

A. Finishes: As selected from manufacturer's standards unless scheduled otherwise.

B. Painted surfaces, except as scheduled otherwise:
   1. Manufacturer's standard metal pretreatment and baked or air dried, light stabilized enamel finish; acrylic, alkyd, epoxy, polyester or polyurethane.
   2. White finishes shall have minimum 85 percent reflectance.

C. Unpainted Aluminum Surfaces:
   1. Interior Fixtures: Clear anodic coating, satin finish, except as scheduled otherwise.
   2. Exterior Fixtures: Clear anodic coating.

2.5 REFLECTORS

A. High-purity #12 aluminum reflector sheet, 0.047 inch (15 gauge) or heavier if specified, free from fabrication or assembly damages. No exposed rivets, springs or other hardware after installation. Shape reflectors in modified elliptical or parabolic contour to produce no apparent brightness. Lamp image or any part of lamp shall not be visible in 45 degree zone.

B. Reflector and Baffle Finish: First-quality "Alzak" anodized finish, of specular color as specified.

2.6 FLUORESCENT FIXTURE LENSES

A. Design Standard Manufacturers: Manufacturers or model numbers listed are the design standards.

B. Description: Extruded 100 percent virgin acrylic male conical prismatic, minimum thickness 0.150 inch, size as required. ICI Acrylics Inc. Type K19; or ALP Inc. Type ALP 19.

C. Lenses for Fixtures with Radio Frequency Interference (RFI) Shielding: ICI Acrylics Type KSH-12RF.

1. Smooth back side of lenses shall contain a square grid of metallic links and grounding bus bar composed of 70 percent silver.
2. Provide at least 3 contact points between lens bus bar and fixture frame. Ground the door frame and enclosure through a flexible conductive connection.

2.7 MOUNTING ACCESSORIES

A. Provide appropriate mounting accessories for each fixture, compatible with various structural conditions encountered. Provide fastening clips (earthquake clips) for lighting fixtures supported from framing members of suspended ceilings.

B. Recessed Fixtures:
   1. Plaster Frames: Provide frames for fixtures installed in gypsum board and concealed suspension system ceiling tile. Make frames of non-ferrous metal or suitably rustproof after fabrication.
   2. Baffles and Gaskets: As required to prevent light leakage.
   3. Flanged fixtures are required in all ceiling systems except exposed grid lay-in panel type.
   4. Thermally protect incandescent and HID fixtures.

C. Fixture Suspension Material:
   1. Unfinished Spaces: 1/2 inch minimum diameter pendant, unless otherwise noted.
   2. Finished Spaces: Unless otherwise noted, provide manufactured cable or stem and outlet box canopy; contemporary design with swivel self-aligning features; size canopy to cover outlet box; finished to match fixture. Coordinate pendant location with ceiling tiles/ceiling grid, and submit coordinated mounting accessories as part of shop drawing submission. For high intensity discharge lamps, use stems suspended from swivel shock-absorbing fittings.

2.8 LIGHTING TRACK

A. Design Standard Manufacturers: Manufacturers or model numbers scheduled are the design standards. Substitutions are permitted subject to Section 01 25 13

B. Standards: UL.

C. Description: Continuous housing with two insulated polarized conductors, accessible along entire length by means of appropriate fittings; rated 20 amperes at 120V; compatible with lighting fixture fittings.

D. Material: Extruded aluminum with matte white baked enamel finish, unless scheduled otherwise.

E. Accessories: Dead-end cover; live-end cover; extensions, corners, cross connectors, grid ceiling adapter kit including outlet box, spacer plate, canopy mounting kit to cover outlet box, clamps to mount track, and clips to mount track to clamp; recessed mounting kit; other accessories as required.

F. Mounting: As shown.

2.9 EMERGENCY BATTERY WALL PACK FIXTURES

A. Manufacturers: Substitutions are permitted subject to Section 01 25 13
   1. Dual-lite.
   2. Emergilite.
   3. Lithonia.

B. Standard: UL; New York Department of Labor and Industry.

C. Description: Self-diagnostic, self-contained units to automatically furnish full rated illumination instantaneously upon failure of normal power source.

D. Battery:

1. Description: Maintenance-free lead-calcium 6 volt, with minimum output capacity of 15 watts for 90 minutes.
2. Continuous operation of a minimum of two sealed beam lamps for 90 minutes before capacity of battery is exceeded.

E. Case:
1. Wall mounted, ventilated UV stabilized, impact resistant polycarbonate with visual indicators in plain view; facilities for mounting 2 lamps on unit.
2. Finish: White.
3. Connections: Suitable for 120 or 277 volt input and 6 volt output.

F. Components:
1. Transfer Circuit: Automatically energize lamps upon failure of normal source; de-energize lamps and activate high-rate charge upon restoration of normal source.
2. Battery Charger: Automatic two-rate or acceptable solid-state pulse type capable of replacing maximum charge taken out in 1-1/2 hour emergency discharge period within 12 hours; manual two-rate charger will not be accepted. Provide visual signal to indicate state of charge.
3. Integrally mounted, adjustable emergency lights.
4. Integrally mounted status lights.
5. Self-Diagnostics and self-testing.

G. Accessories:
1. Remote Lights: 6 watt, sealed beam lamp in adjustable wall mounted fixture, UL listed for wet locations. Provide black finish.

2.10 LIGHTING FIXTURES

A. Design Standard Manufacturers: Manufacturers or model numbers scheduled are the design standards. Substitutions are permitted subject to Section 01 25 13

B. Ballasted fixtures shall comply with NEC requirements and be supplied with a disconnecting means accessible to qualified persons before servicing or maintaining the ballast.

C. Refer to schedule on drawings for fixture descriptions and manufacturer.

PART 3 - EXECUTION

3.1 COORDINATION

A. Fixture layouts are diagrammatic and approximate. Review and approve fixture locations shown on acoustical ceiling shop drawings prior to installation. Coordinate required plenum clearances with ductwork and piping. In exposed ceiling areas, coordinate fixture locations, mounting heights, and supports with other trades.

B. Coordinate fixture mounting type with ceilings prior to submission of shop drawings. Advise A/E of any discrepancy. Failure to do so will result in correction at no additional cost to BNL.

3.2 INSTALLATION

A. Assemble, wire and install lighting fixtures, with lamps, in such manner to ensure correct operation.

B. Lighting fixtures weighing less than 56 pounds shall have, in addition to requirements specified, two 12 gauge steel wire safety hangers connected from opposite ends of fixture housing to structure above. These wires may be slack.

C. Support lighting fixtures weighing 56 pounds or more directly from structure with approved hangers.

D. Ground entire fixture to building grounding system.

E. Support system for custom products and lowering devices shall be designed and approved by a licensed structural engineer based upon actual fixture being installed. Installation instructions and details shall be submitted for information only as part of the fixture shop drawing review process.

F. Fasten lighting fixtures supported by suspended ceiling systems to ceiling framing system with hold-down clips and to building structure with two No. 12 gauge steel hanger wires connected to opposite corners of the fixture.

G. Coordinate trim type with reflected ceiling plans and/or room finished schedules prior to submittals.

H. Locate fixtures in accordance with reflected ceiling plans.

I. Locate in exact center of tile when indicated. Relocate misplaced fixtures and replace damaged ceiling materials.

J. Mount lighting fixtures at heights indicated in Section 26 00 10 and as indicated on drawings.

K. Provide access panels for recessed light fixtures that require access for maintenance when such access is not provided for in design of fixture. See Section 26 00 10.

L. Orientate the fluorescent lamps of all 2 FT x 2 FT troffers and non-directional compact fluorescent downlights within a single room in the same direction.

M. At all exit signs, provide mounting type, single or double face, and directional arrows as required for proper exiting.

3.3 RECESSED FIXTURES

A. Note that specifications for recessed fixtures generally do not include mounting accessories, and that each fixture type may be used in several different ceiling types. Verify mounting details for each space; provide correct fixture flange mounting accessories for each condition.

B. Attach lay-in fluorescent troffers to ceiling suspension system, for alignment only.

C. Attach fixtures to suspension system following NEC Section 410-16c., unless fixture is independently supported. Attachment device, minimum of two per fixture, shall have capacity of 100 percent of lighting fixture weight acting in any direction.

D. Support downlights and exit signs with rails spanning between runners of suspension system.

E. Support fluorescent troffers in gypsum board ceilings from plaster frames, with adjustable lugs on side of fixture or yoke mounting as recommended by fixture manufacturer.

F. Support down lights in metal pan and gypsum board ceilings from plaster frames.

G. Support fluorescent troffers in metal pan ceilings.

H. Center fixtures in acoustical tile unless shown otherwise.

I. Use unwired or pre-wired incandescent and high intensity discharge fixtures as required. Do not use pre-wired fixtures for through-wiring unless UL approved for the purpose.

3.4 SURFACE MOUNTED AND PENDANT HUNG FIXTURES

A. Attach surface-mounted lighting fixtures to ceiling system with positive clamping devices that completely surround supporting members. Attach safety wires between clamping device and adjacent ceiling hanger or to structure above. In no case shall fixture load exceed design carrying capacity of supporting member.

B. Support pendant-hung lighting fixtures directly from structure above, using 9 gauge steel wire, without relying on ceiling suspension system for support.

C. Pierce ceiling material for hangers and outlet boxes as required.

D. Do not remove ceiling material above surface mounted fixtures.

E. Hang fixtures plumb with continuous rows in alignment.

F. Unless otherwise noted, suspend fixtures in each room or area at the same height regardless of varying clear height conditions. Provide various stem lengths as required.

3.5 CONTINUOUS FIXTURE PATTERNS

A. Fasten sections together for continuously aligned appearance, with no dimpling or light leakage. Provide end extensions where required.

B. Where fixtures run continuously around inside or outside corners, provide prefabricated corner pieces. Run fixture lenses, baffles or louvers continuously with fixture. Miter and/or fan at corners as directed.

C. Where continuous runs do not end at a wall or fascia, provide a finished end plate, with no visible holes and concealed fasteners.

D. Coordinate pendant location to permit alignment between rows or patterns.

E. Use the following lamp types and combinations to provide a continuous light appearance over total length of assembly.
   1. Long tube lamps in 3 and 4 foot lengths. Where required, provide a 2 foot lamp in spaces less than 3 feet.
   2. Total light length shall equal total continuous length minus 12 inches maximum. Six inch maximum non-lamped end lengths.

3.6 FLUORESCENT BALLASTS

A. Use electronic ballasts unless otherwise noted.

B. Use multi-lamp ballasts wherever possible, and single lamp ballasts where necessary.

3.7 DIMMED FLUORESCENT LAMPS

A. In accordance with NEMA recommendations, lamps must be operated at full output for a minimum of 12 hours prior to dimming.

3.8 EMERGENCY BATTERY BALLASTS

A. Where emergency battery ballasts are shown controlled via wall switch, wire ballast so lamps will not operate when normal power is available and switch is turned off. Lamps will operate in emergency mode regardless of switch position.

B. Fixture manufacturer shall supply emergency battery ballasts with fixture.

C. Emergency Battery Ballasts located within animal holding rooms shall not contain audible alarms and shall not be provided with self diagnostics.

3.9 HIGH INTENSITY DISCHARGE BALLASTS

A. Provide auxiliary quartz lamps where noted for illumination while HID lamps are on warm-up or restrike cycle. Provide delay relays to keep quartz lamp in operation until HID lamp reaches approximately 50 percent of full illumination. Relay delay shall be accomplished by timer or voltage sensor. Use relay for quartz lamp, with contacts electrically independent of other wiring so that emergency wiring can be used.

3.10 ADJUSTABLE FIXTURES

A. Aim adjustable fixtures as directed. When surfaces are illuminated by several fixtures, make final adjustment in presence of A/E. In general, perform this work at night with no light from stray sources. Use light meter to obtain as even a distribution as possible.

B. Aiming shall occur upon substantial completion of project including, but not limited to installation of all artwork, millwork, furniture, and plantings. Contractor shall provide all necessary ladders, scaffolding, or lifts required for accessing fixtures.

3.11 LIGHTING TRACK

A. Mount lighting track as scheduled. Connect building wiring to conductors in track at outlet box. Install lighting fixtures on track where instructed.

B. Provide framing member above suspended ceiling to support track. Extend framing member full length of track; attach track securely. Pierce ceiling material as required for supports. Provide sway bracing so that lighting track will remain stable when lighting fixtures are inserted or removed.

3.12 EMERGENCY BATTERY WALL PACK FIXTURES

A. Connect conduit directly to units; do not use plug-in connection.

B. Mount lights on each unit, number as shown. Mount each remote light on an outlet box cover plate, and splice wiring in box. Feed remote lights from batteries with wire sized in accordance with manufacturers recommendations for voltage drop and ampacity. Aim at night, with no stray light from other sources, to maximize light along egress route.

C. Test and verify proper operation prior to BNL occupancy.

3.13 RELAMPING, CLEANING AND ADJUSTING

A. Replace failed lamps immediately prior to BNL occupancy.

B. Replace noisy ballasts as directed.

C. Align luminaires and clean lenses, reflectors and louvers of fingerprints, paint splatters, dirt and debris.

D. Use cleaning materials and methods that will not damage finish.

E. Touch up damages to luminaire finish.

3.14 SPECIAL PROTECTION

A. Wherever fixtures are provided with protective covers suitable for use after installation, leave such covers in place throughout construction period, and remove immediately prior to BNL occupancy.

3.15 ADJUST AND CLEAN

A. Wipe all lighting fixture reflectors, lenses, lamps and trims, clean, after installation. All fixtures shall be installed with caution so as to avoid any fingerprints or smudges on surfaces of parabolic louvers and downlight reflectors. Any fixtures with fingerprints or smudges shall be cleaned.

B. Replace all inoperable lamps with new lamps prior to final acceptance.

C. Adjust all incandescent fixture sockets to match the lamp specified.

D. Aim all track heads and adjustable fixtures as directed by Architect.

END OF SECTION

SECTION 26 56 00
SITE LIGHTING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Outdoor luminaires and accessories.

B. Lamps and ballasts.

C. Poles, concrete bases and accessories.

D. Grounding.

1.2 RELATED SECTIONS

A. Section 26 00 10 – General Electrical Requirements

B. Section 26 05 43 – Underground Raceways and Ducts for Electrical Systems

C. Section 26 05 33 - Conduit.

D. Section 26 05 19 - Low Voltage Electrical Power Conductors and Cables

E. Section 26 51 13 – Building Lighting, for exterior building mounted luminaires.

1.3 SUBMITTALS

A. Shop Drawings: Show the following:
   1. Details of construction and finishes. Catalog cuts without required details will not be approved.
   2. Fixture and accessory drawings (indicate scale).
   3. List of fixture types and quantities.
   4. Wattage and voltage ratings of lamps and ballasts.

B. Product Data:
   1. Photometric data by an independent testing laboratory. Show optical performance developed following methods of IES of North America.
   2. Include photometric data including isofootcandle curves; brightness values; distribution; maximum and average illumination values; efficiency and others as requested.

C. Samples:
   1. Finishes: Submit 4 x 6 inch samples of each type of finish specified on metal to be used.
   2. Fixtures: Only when requested, submit (following submittal of shop drawings, product data and samples) one sample fixture of each type requested. Samples shall be complete with lamps, ballasts, cords and other accessories, ready for operation. After review and approval, transfer sample fixtures from A/E's office to job site for comparison with fixtures delivered for installation. Approved, unblemished samples may be used in the work.

D. Informational Submittals:
   1. Manufacturer's Installation Instructions.
   2. Certificates: Certify that each product complies with specified requirements.

1.4 DELIVERY, STORAGE AND HANDLING: FOLLOW SECTION 01 65 00

A. Protect poles during shipping and handling with individual wrapping of moisture-resistant paper or other means to prevent damage.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Use fixtures conforming to UL Standards, bearing UL label, and manufactured in accordance with NEC.

B. Make fixture parts of materials resistant to corrosion and to thermal and mechanical stresses encountered in normal application. Provide accessory equipment such as starters, sockets and lampholders approved by UL and ETL, unless otherwise noted.

2.2 FIXTURE CONSTRUCTION

A. Enclosures: Complete with closed cell neoprene gaskets to form weatherproof assembly.

B. Castings: Uniform quality, free of imperfections affecting strength and appearance. Exterior surfaces not receiving a finish coating shall be smooth and shall match adjacent surfaces. Apply at least one coat of clear methacrylate lacquer unless a painted finish is specified.

C. Ballasts: Low temperature type, with reliable starting to 20 degrees F; high power factor; constant wattage regulated output; withstand Primary voltage variation of +15 percent without extinguishing or damaging lamps; start lamp at -20 degrees F.

D. Housing: Weatherproof; hinged and gasketed access door with catch; slip-fitter with set screws.

E. Lamp Socket: Heavy duty porcelain.

F. Hardware: Stainless steel or hot dip galvanized steel, except as noted otherwise.

G. Fuse Holders:
   1. Manufacturer: Bussman Type "HEB". Substitutions are permitted subject to Section 01 25 13.
   2. Description: In-line waterproof fuse holder rated 600V for a miniature fuse.
   3. Capacity: Rated at 30 amps at 600 V.

H. Fuse: Manufacturer's Designation: Bussman KTK, 13/32 x 1-1/2 inches, set at 3 amps.

2.3 POLES AND ACCESSORIES

A. Metal Poles: Square, seamless aluminumcontinuously welded to base; with 2 x 4 inches grounding stud in shoe-base model.

B. Transformer Base: Cast aluminum; large access door; sufficient space for ballast, required number of conduits, and splices; welded grounding stud; internal anchor bolt hardware.

C. Shoe Base: Bolt covers with tamper-proof stainless steel hardware.

D. Assembly: Designed to withstand wind loading of 100 mph, with luminaires and brackets mounted.

E. Anchor Bolts: As recommended by pole manufacturer. Provide anchor bolt templates, flat washers, lock washers, leveling shims and hex nuts.

F. Metal Pole Finish: Aluminum

G. Ground Rods: Copper.

H. Circuit Identification: Provide 75 mm x 25 mm aluminum tag riveted to pole that identifies the building name, electrical distribution panel name, and circuit number.

2.4 LAMPS

A. Manufacturers: Substitutions are not permitted.
   1. General Electric Company.
   2. North American Phillips.

3. Sylvania/Osram Lighting Products Company.
4. Venture.

B. General:
1. Where lamps are specified for individual luminaires or lighting equipment, provide lamps so that fixtures are completely lamped and in normal operating condition.
2. LED: According to luminaire manufacturer. LED's shall be withina replaceable module from the manufacturer.
3. Metal Halide: Pulse-start where available; burning position must be consistent with luminaire design; clear or phosphor coated as recommended by fixture manufacturer; heat resisting glass envelope. Upon breakage, lamp shall automatically extinguish.
4. High Pressure Sodium Vapor: Clear or coated heat resistant glass envelope as recommended by fixture manufacturer.
5. Quartz: Clear heat resistant glass envelope.
6. Size: As indicated.
7. Finishes: Follow Section 26 51 13.
8. Other types: As indicated.

2.5 HIGH INTENSITY DISCHARGE BALLASTS

A. Manufacturers: Substitutions are not permitted.
1. Advance.
2. Universal.
3. Valmont.
4. Venture.

B. Standards: UL and ANSI.

C. Encased and potted where subject to moisture.

D. For indoor and non-weatherproof conditions use UL listed Type 1; for outdoor conditions use UL listed Type 2.

E. High power factor.

F. Constant wattage auto-transformer or constant wattage type.

G. Suitable to operate within plus or minus 10 percent voltage variation.

H. Drop-out voltages; 66 percent of nominal.

I. Suitable to operate in:
1. Indoor heated or air conditioned spaces: 50 to 104 degrees F ambient.
2. Exterior or unheated spaces: minus 20 to 104 degrees F.

J. Insulation: Class H, 356 degrees F.

K. Accessories: Relays for auxiliary quartz lamp where noted.

L. Thermally protect recessed and remotely located ballasts.

M. Lamp Current Crest Factors: Less than 2.0 for mercury vapor and 1.8 for metal halide and HPS.

N. Ignitors shall be designed to withstand 10,000 hours of continuous pulsing and six months of lamp open circuit operation without failure.

O. Other types: As scheduled.

P. Electronic HID - Metal Halide:
1. Design Standard Manufacturer: AROMAT. Substitutions must be approved equal, subject to Section 01 25 13.
2. Standards: UL, ANSI, FCC Part 18C, Class A and non-consumer limits for EMI and RFI.

3. Ballast shall tolerate plus/minus 10 percent voltage variations with less than plus/minus 0.5 percent variation in output power. Less than plus/minus 3 percent variation in output power within all ranges of accepted ANSI lamp voltages.
4. Ballast shall operate lamps at a frequency of less than 200 Hz to minimize acoustic resonance inside lamp arc tube and to minimize lamp flicker. Use of "square wave" output must be approved by lamp manufacturer.
5. Lamp Current Crest Factor: Less than 1.5.
6. Ballast shall have thermal protection shutdown. Ballasts shall be able to tolerate operation at 176 degrees F (80 degrees C) case temperature without damage. Ballast shall operate in ambient temperatures down to minus 20 degrees F.
7. High Power Factor.
8. Class A sound rating.
9. Total Harmonic Distortion shall not exceed 15 percent.
10. Minimum Ballast Factor: 1.0.
11. When used in recessed fixtures, ballast shall be marked "Suitable for recessed use".
12. Ballast shall be thermally protected and incorporate lamp shutdown circuitry for end of lamp life to prevent excessive pulsing of failed lamps.
13. Ballast shall be capable of 15 foot remote mounting.
14. Power Supply Electrolytic Capacitors shall have a minimum rating of 5000 hours at 105°C.

2.6 LIGHTING FIXTURES

A. Design Standard Manufacturers: Manufacturers or model numbers scheduled are the design standards. Substitutions where permitted are subject to Section 01 25 13.

B. See schedule on drawings for fixture descriptions and manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Site lighting shall be a complete assembly of luminaire, pole and concrete base.

B. Assemble, wire and install lighting fixtures with lamps, in such manner to ensure correct operation.

C. Install rigid steel conduit elbow in concrete base to lead wiring into pole base. Splice wires in base of pole, and train leads up pole to luminaire. Provide encapsulated splice kits for wiring in handholes, manholes and underground junction boxes.

D. Follow Section 26 05 05 for installation and coordination of concrete base and anchor bolts. Set poles plumb and secure. Face access door away from traffic. Install ground rod adjacent to pole base.

E. Aim adjustable fixtures as directed. Make final adjustments in presence of A/E. In general, perform this work at night without moonlight. Obtain as even and effective a distribution as possible.

F. Install a fuse holder in each phase conductor feeding outdoor pole mounted lighting fixtures. Locate fuse holders in transformer bases or in handholes of poles with shoe bases. Provide fuse holders to isolate overhead fixtures from total circuit if trouble should occur.

G. Run wiring for site lighting power in 1-1/4 inch Schedule 40 PVC conduit unless otherwise noted. Follow Section 26 05 43.

H. Install marking tape over each buried conduit. Follow Section 26 05 33.

3.2 RELAMPING AND CLEANING

A. Replace failed lamps immediately prior to BNL occupancy.

B. Replace noisy ballasts as directed.

C. Clean luminaires and lenses of paint splatter, dirt and debris.

D. Touch up damages to luminaire and pole finish.

END OF SECTION

SECTION 26 70 00
LASER ENTRYWAY CONTROL SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. The laser entryway control system shall limit access to laser control areas and provide interlocks with laser equipment to prevent exposure of harmful levels of laser radiation to untrained personnel.

B. Access controls to the laser control areas shall be configured in a non-defeatable mode of operation where no safety override features are enabled.

C. The system shall allow rapid egress of personnel from within the laser control area (via panic door hardware) and rapid entry into the laser control area under emergency conditions (via emergency access pushbuttons).

D. The system shall interface with the fire alarm system to disengage the system during a fire emergency.

E. The system shall interface with the security system to limit access when lasers are permitted to be activated, and to release entry door electric strikes to allow rapid egress/entry under emergency conditions.

F. Each laser controlled area shall be provided with a separate laser entryway control system which shall include, but not limited to, a control panel, laser warning lights, emergency access pushbuttons, emergency laser stop pushbuttons, magnetic door switches, and interface with the fire alarm and security systems. Provide all necessary components to provide a complete system and to perform the specified operations.

1.2 QUALITY ASSURANCE

A. Design and construction standards:
   1. Brookhaven National Laboratory Environment Safety and Health Standard ESH 1.5.3 Interlock Safety for Protection of Personnel.
   2. Applicable UL Standards. If UL listing is not available, the system shall be reviewed and approved by the Brookhaven National Laboratory Electrical Safety Committee and Authority Having Jurisdiction.

B. Design, installation and operation criteria:
   1. The system shall be designed, installed and operated in accordance with the Brookhaven National Laboratory Laser Safety Office.
   2. System components, assembly and operation shall be in accordance with the Brookhaven National Laboratory Electrical Safety Committee and Authority Having Jurisdiction.

1.3 SUBMITTALS

A. Shop drawings:
   1. Floor plans with device layouts.
   2. System wiring diagrams.
   3. Detailed sequence of operation.
   4. Proposed testing checklist.

B. Product data:
   1. Technical data on each component.

C. Contract closeout information:
   1. Completed testing checklist.
   2. Operating and maintenance data.
   3. BNL instruction report.

1.4 OPERATION

A. Sequence of operation shall be as follows:
   1. When the control panel "power on" key switch is in the "off" position:
      a. Access to the laser control area is controlled by the building security system card readers and electric door strikes.
      b. All control panel indicating lights are off.
      c. The laser warning lights are off.
   2. When the control panel "power on" key switch is switched to the "on" position:
      a. The control panel "power on" indicating light shall light.
      b. The laser warning lights shall indicate “BEAM OFF”.
   3. When all doors and all magnetic door switches are closed, the control panel "doors closed" indicating light shall light.
   4. With all door switches closed, pressing the control panel "engage" pushbutton shall:
      a. Start a 5 second pre-engage warning period.
      b. Operate the magnetic lock output relay to allow the laser entryway control system to take control of the entry door electric strikes from the security system card reader. The entry doors shall remain locked.
      c. Sound the control panel audible warning device.
   5. At the end of the 5 second pre-engage warning period the system shall:
      a. Engage.
      b. Operate the laser interlock output contacts permitting the lasers to be activated.
      c. Light the control panel “interlock on” indication light.
      d. Indicate “BEAM ON” at the laser warning lights.
      e. Silent the control panel audible warning device.
   6. While the system is engaged, pressing any egress door panic bar, pressing any "emergency laser stop" pushbutton, or opening any magnetic door switch shall:
      a. Disengage the system.
      b. Operate the laser interlock output contacts to de-activate all lasers.
      c. Operate the magnetic lock output relay to return control of the entry door electric strikes to the security system card readers.
      d. Turn off the control panel "door closed" and "interlock on" indicating lights.
      e. Indicate "BEAM OFF" at the laser warning lights.
   7. While the system is engaged, pressing any "emergency access" pushbutton or the activation of the fire alarm system shall:
      a. Open the entry door electric strike circuit unlocking the entry doors to allow free entry to the laser control area.
      b. Disconnect input power to the laser entryway control panel which shall:
         1) Disengage the system.
         2) Turn off all control panel indication lights.
         3) Turn off the laser warning lights
   8. Turning the control panel "power on" key switch to the "off" position shall:
      a. Disengage the system, if not already disengaged.
      b. Turn off all control panel indication lights.
      c. Turn off the laser warning lights.
   9. If the safety features disengage the system, the system can only be re-engaged by pressing the control panel “engage pushbutton” while all doors are closed as indicated above.
   10. If the safety features disconnect input power to the system, the system can only be re-engaged by resetting the “emergency access” pushbutton, or resetting the fire alarm system, and turning the “power on” switch to the off position and restarting the sequence of operation from the start.

B. The system shall be setup in a non-defeatable configuration. The control panel "exit pushbutton" shall be disconnected or reconnected to the "emergency laser stop" circuit to prevent overriding any safety features. A time delay, to allow "authorized" entry or exit while lasers are permitted to be active, are unacceptable:
   1. After the system has been engaged, permitted entry/exit to/from the laser control area can only occur by turning the control panel "power on" key switch to the "off" position.
   2. After the permitted entry/exit has occurred, the system may be reengaged as indicated in the above sequence of operation.

C. Upon loss of power to the control panel, all components shall return to the fail safe position deactivating all lasers and return access control to the security system card reader.

D. The system shall have the future capability of operating in the defeatable mode by enabling the control panel "exit" pushbutton, or by connecting entry device(s) and/or exit device(s) to the "exit request" terminals. Activation of an “exit request” device will release the entry door electric strikes for an adjustable time delay period (3 to 30 second) to allow authorized entry or exit. During this delay period, the “exit now” control panel indication light shall light and the control panel audible warning device shall sound. If, at the end of the delay period, a door is still open, the system shall disengage.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Laser entryway control system:
      a. Base:
         1) Rockwell Laser Industries, Inc., Cincinnati, Ohio, Laser Sentry Entryway Control System.
         2) Kentek Corporation, Pittsfield, NH, ENTRY-GUARD™ Safety Interlock System (SIS).

B. Control panel:
   1. Microprocessor based controls providing entryway control to laser control areas in accordance with ANSI Z136.1.
   2. Surface mounted NEMA 1 enclosure with hinged cover and manufacturer’s standard finish.
   3. Accept inputs from:
      a. Emergency stop circuits to disconnect input power to the control panel.
      b. Two magnetic door switch circuits to disengage the system (which can be shunted to allow future authorized entry/exit – not to be utilized with initial set-up).
      c. Two safety circuits to disengage the system.
      d. A remote "system enable" switch to allow the system to be remotely engaged (not to be utilized with the initial set-up).
      e. An override exit request device to allow authorized entry/exit with lasers activated (not to be utilized with the initial set-up).
   4. Output contacts to control laser warning light "BEAM ON" or "BEAM OFF" indication.
   5. 12 VDC output when interlocks are activated.
   6. 30 VDC, 1 amp output contacts as follows:
      a. Four sets of normally open output laser interlock contacts to permit laser(s) to be activated which operate when the system is engaged.
      b. Three sets of normally open/normally closed output auxiliary interlock contacts which operate when the system is engaged.
      c. One set of normally open/normally closed output contacts to take/return control of the entry door electric strikes from/to the security system which operate at the start of the 5 second pre-engage warning period.

d. One set of normally open/normally closed output contacts to release electric door strikes to allow authorized entry or exit which operate when exit request is requested (not to be utilized with the initial set-up).

7. 3 to 30 second adjustable entry/exit time delay (not to be utilized with the initial set-up).
8. Audible warning device to sound during 5 second pre-engage period (and entry/exit time delay - not to be utilized with the initial set-up).
9. Internal 12 VDC power supply with external 120/16 VAC receptacle connected transformer.
10. Diagnostics.
11. Rockwell Laser Industries, Laser Sentry Control Panel.

C. Laser warning light:
1. Two sections independently controlled backlit illuminated laser warning sign with stenciled cover indicating "BEAM ON" or "BEAM OFF" status.
2. 10.25 x 14.25 x 4 inch surface mounted NEMA 1 enclosure. Finish to match control panel.
3. Two 9-watt compact fluorescent lamps with 120 volt electronic ballasts.
4. Control relays for switching fluorescent lamps.
5. Lamp test switch.
6. Rockwell Laser Industries, Bi-Lume Lighted Laser Warning Sign.

D. Emergency access pushbutton:
1. Semi-flush mounted pushbutton type with two normally closed latching contacts and a blue lexan cover labeled "EMERGENCY ACCESS".
2. Rockwell Laser Industries, Laser Sentry Emergency Stop Button.

E. Emergency laser stop pushbutton:
1. Semi-flush mounted pushbutton type with one normally closed contact and a red lexan cover labeled "EMERGENCY LASER STOP".
2. Rockwell Laser Industries, Laser Sentry Emergency Stop Button.

F. Magnetic door switch:
1. Single pole, single throw, normally open, hermetically sealed contacts.
2. Magnetic and switch shall be recessed in door and door frame.
3. Coordinate hardware requirements with supplier of door and door frame.

G. Security system control panel: Provided by Section 28 05 19.

H. Card reader: Provided by Section 28 05 19.

I. Door panic bar: Provided by Division 8.

J. Power transfer hinge: Provided by Division 8.

K. Fire alarm relay: Provided by 28 31 00.

L. Laser Curtin and Track Assembly: Provided by Division 11

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install laser entryway control system in accordance with the Brookhaven National Laboratory Laser Safety Office.

B. Install laser entryway control system per manufacturer’s recommendations and instructions.

C. Install all cables and conductors in concealed conduit.

D. Mounting heights:
1. Control panel: 54 inch AFF to top of panel.
2. Laser warning light: 60 inch AFF to top of panel.
3. Emergency access pushbutton: 72 inch AFF.

4. Emergency laser stop pushbutton: 48 inch AFF.

3.2 TESTING

A. Perform a comprehensive test of each component of each system for proper operation. Perform correctional work when required.

B. Complete a detailed typed checklist of system operation for each system with a separate line for each operation of each component with the anticipated system response and a check-off space verifying correct operation.

C. Notify the government two week in advance of testing to allow BNL observation.

3.3 TRAINING

A. Provide one 4 hour on-site training session to instruct maintenance staff personnel in complete system operation and maintenance by authorized distributor personnel.

END OF SECTION

SECTION 26 80 00
ELECTRICAL SYSTEMS COMMISSIONING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section includes specification of Division 26 subcontractors' responsibilities in the commissioning process.

B. The list of commissioned equipment and systems is found in Section 01 91 13.

C. Commissioning is a systematic process of ensuring that all building systems perform interactively according to the design intent, basis of design, construction documents, and BNL's system operational needs. The commissioning process coordinates system documentation, equipment startup, control system calibration, testing and balancing, performance testing, and operator training.

D. BNL has retained the services of a commissioning agent that will assist in the startup and documentation of the electrical and control systems. They shall be referred to as the test engineer for this section of specifications.

E. It is not intended that all trades stand by and be present during check out. If there involvement is not required to operate or check out the equipment, the trade responsible for the equipment shall be present to operate their equipment. Problems related to other trades shall be addressed via a commissioning punch list.

1.2 RELATED WORK

A. Related Documents: Refer to the following sections for related work:
   1. Construction Drawings and general provisions of the contract, including general and supplementary conditions, and Division 1 specification sections, apply to this section.
   2. Section 01 91 13 – Building Commissioning.
   3. Section 13 60 19 – Cleanroom Certification.
   4. Section 23 90 00 – Mechanical Systems Commissioning.

1.3 COMMISSIONING RESPONSIBILITIES

A. Electrical Subcontractors. The commissioning responsibilities applicable to the electrical contractor are as follows. All references apply to commissioned equipment only.

B. Construction and Acceptance Phases:
   1. Attend a commissioning scoping meeting and other necessary meetings to facilitate the commissioning process, as directed by the Test Engineer.
   2. Assist in the development of startup and prefunctional testing procedures. BNL test engineer will create the actual test procedures and fill out the test forms.
   3. Provide support to the Test Engineer for development of functional performance test procedures. Review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
   4. During the startup and initial checkout process, execute and document the electrical-related portions of the prefunctional checklists provided by the Test Engineer for all commissioned equipment.
   5. Perform startup and system operational checkout procedures. Test engineer shall witness and document checkout.

6. Provide skilled technicians to execute starting of equipment and to support the Test Engineer in execution of the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving. Assist the Test Engineer in interpreting the monitoring data, as necessary
7. Correct deficiencies (differences between specified and observed performance) as identified during testing.
8. Prepare Operation and Maintenance manuals according to the contract documents, including clarifying and updating the original sequences of operation to as-built conditions.
9. Prepare red-line as-built drawings for all drawings and final as-builts for contractor-generated coordination drawings.
10. Provide training of BNL's operating personnel as specified in the contract documents.
11. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

C. Warranty Period:
1. Execute seasonal or deferred functional performance testing, witnessed by the Test Engineer, according to the specifications.
2. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

1.4 SUBMITTALS

A. Division 26 subcontractors shall provide submittal documentation relative to commissioning as required in this Section and Section 01 91 13.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Division 26 subcontractors shall provide all test equipment necessary to fulfill the testing requirements of this Division.

B. Refer to Section 01 91 13 for additional Division 26 requirements.

PART 3 - EXECUTION

3.1 STARTUP

A. The electrical subcontractors shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in 01 91 13. Division 26 subcontractors have start-up responsibility and are required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the contract documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially or in whole to the Test Engineer or BNL.

B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems, or sub-systems at the discretion of the Test Engineer. Beginning system testing before full completion does not relieve the subcontractors or the Contractor from fully completing the system, including all prefunctional checklists as soon as possible.

3.2 FUNCTIONAL PERFORMANCE TESTS

A. Refer to Section 01 91 13 for a list of systems to be commissioned and for a description of the process for specific details on the required functional performance tests.

B. Subcontractors shall support the Contractor and Test Engineer in execution of the Functional Performance Test procedures as specified herein.

3.3 TESTING DOCUMENTATION, NON-CONFORMANCE AND APPROVALS

A. Refer to Section 01 91 13 for specific details on non-conformance issues relating to prefunctional checklists and tests.

3.4 OPERATIONS AND MAINTENANCE (O&M) MANUALS

A. Division 26 subcontractors shall compile and prepare documentation for all equipment and systems covered in Division 26 and deliver to the Contractor for inclusion in the O&M manuals, according to Section 01 78 43.

B. The Test Engineer shall receive a copy of the O&M manuals for review.

3.5 TRAINING OF BNL PERSONNEL

A. The Contractor shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed. Refer to Section 01 91 13 for additional details.

B. The Test Engineer shall be responsible for overseeing and approving the content and adequacy of the training of BNL personnel for commissioned equipment. Refer to Section 01 91 13 for additional details.

C. Electrical Subcontractor. The electrical subcontractor shall have the following training responsibilities:
   1. Provide the Contractor with a training plan at least four weeks before the planned training.
   2. Provide designated BNL personnel with comprehensive training in the understanding of the systems and the operation and maintenance of each major piece of commissioned electrical equipment or system.
   3. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment is required. More than one party may be required to execute the training.
   4. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
   5. Training shall include:
      a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
      b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
      c. Discussion of relevant health and safety issues and concerns.
      d. Discussion of warranties and guarantees.
      e. Common troubleshooting problems and solutions.
      f. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
      g. Discussion of any peculiarities of equipment installation or operation.
   6. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and maintenance of all pieces of equipment.
   7. The electrical contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.

END OF SECTION

DIVISION 27

COMMUNICATIONS

SECTION 27 05 28
TELEPHONE CONDUIT SYSTEMS

PART 1 - GENERAL

1.1 GENERAL DESCRIPTION

A. The intent is to provide a complete pathway system to route telecommunications between the outside plant, entrance room, telecommunications equipment rooms, and individual voice and data outlets.

B. The work required under this section consists of providing cable trays, conduits, boxes, raceways, etc., for telecommunications wiring included in this project. Telecommunications wiring includes cables for data, voice, and future signal requirements.

1.2 WORK INCLUDED

A. Cable tray and conduits as shown on the drawings, as specified herein and in accordance with Section 26 05 33.

B. Raceway and outlet boxes as specified in the drawings, as specified herein and in accordance with Section 26 05 34.

C. Conduits through walls and floors for cable routes.

D. Cable trays and raceways in hallways above ceilings for distribution routes for telecommunications cabling.

E. Laboratory surface metal raceway is specified in Section 26 05 33.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Section 26 00 10 - Electrical General Requirements.

B. Section 26 05 33 - Conduits.

C. Section 26 05 34 - Boxes.

D. Section 27 05 32 - Telecommunications Cabling.

1.4 SUBMITTALS

A. Submittal catalog cut sheets for the following items: pullboxes, cable tray, fittings, accessories and data supporting support design.

PART 2 - PRODUCTS

2.1 HORIZONTAL DISTRIBUTION SYSTEMS

A. A combination voice/data outlet shall consist of a 4-11/16 IN square by 2-1/8 IN deep flush mounted box with double-gang, square drawn extension or tile ring. Each outlet box shall have a 1 IN EMT conduit to cable tray system.

B. A voice-only outlet shall consist of a 4-11/16 IN square by 2-1/8 IN deep flush mounted box with single-gang, square drawn extension or tile ring. Outlet box shall have a 1 IN EMT conduit to cable tray system.

C. A data-only outlet shall consist of a 4-11/16 IN square by 2-1/8 IN deep flush mounted box with double-gang, square drawn extension or tile ring. Outlet box shall have a 1 IN EMT conduit to cable tray system.

D. Surface mounted raceway in Labs shall have a backbox and 1-1/2 IN EMT conduit stubbed into the accessible ceiling space.

E. Cable tray system shall be a center rail aluminum type tray system with 6 IN rung spacing and shall include all necessary accessories for mounting and joining. Cable tray shall have a NEMA 12C load rating and be wall and ceiling hung depending on the location. Depth and width shall be as shown on drawings. Manufacturer shall be Mono-Systems, Inc., B-Line Systems, Inc. or approved equal.

2.2 SERVICE ENTRANCE CONDUITS

A. Four 4 IN conduits shall be installed as shown on the drawings. Terminate entrance conduits entering MDF room from below to extend 4 IN above finished floor.

B. Service entrance elbows indicated as pulling LBs on drawings shall be Crouse-Hinds #LBD Series sized accordingly.

2.3 RISER CONDUITS

A. Two 4 IN conduits shall be installed between the telecommunications entrance room and each telecommunications equipment room as shown on the drawings.

2.4 FIRE STOPS

A. In all buildings, floor/ceiling assemblies, stairs, and elevator penetrations must be sealed with a 2-hour fire stop assembly at a minimum, unless otherwise noted.

B. Walls must be sealed with a 2-hour fire stop assembly at a minimum.

C. See Section 07 84 00 - Fire Stopping.

D. Fire stop material inside conduits penetrating fire rated construction shall be restorable.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. Work shall be performed in accordance with the National Electrical Code and Division 26 of the specifications.

B. Install cable tray per the manufacturer's instructions. Design the cable tray system to handle fully loaded cable trays with supports at intervals not to exceed 8 FT. Coordinate installation of cable tray with other work to allow a minimum 12 IN vertical clearance from piping, conduits, ductwork, etc.

C. Conduits carry cables entering the cable tray system shall be bonded to the cable tray system. Conduit location shall be coordinated with the cable tray system so that the conduit does not come closer to the cable trays system than 6 IN above or below the cable tray centerline. Indelibly mark station conduit at hallway distribution end with Room # that conduit serves.

D. Every effort shall be made to arrange station conduits such that the flow of installed cables promote the minimum length back to the telecommunications equipment room and the least amount of bends in the cables.

E. Conduit sections shall contain no more than two 90 degree bends between ends that allow cable to be fed and pulled. Provide pullboxes sized in accordance with EIA/TIA 569 and located in accessible locations where more than two 90 degree bends must be installed from start to end of conduit run. LB fittings shall not be permitted.

F. Debur conduit ends and provide bushings.

G. Provide pull cords in conduit. Pull cords in riser conduit shall be wire with minimum 200 lb. test.

H. Conduit through the floor or ceiling of the service entry room or a telecommunications equipment room shall extend at least 4 inches into the room.

I. Entrance conduits shall be continuous from the outside manhole into the building telecommunications entrance room. Securely fasten all entrance conduits to the building to withstand any cable placing operation. Seal the inside-building end of conduits to prevent water, vapors, or gases from entering building utilizing rubber conduit plugs, water plugs, or duct sealer.

END OF SECTION

SECTION 27 05 32
TELECOMMUNICATIONS CABLING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Intra-building materials and equipment to support information technology transport systems including telephony, high-speed local area networking (LAN) and wide area networking (WAN).

B. Site cabling from Building 515 through the outside duct bank system into the MDF.

1.2 RELATED SECTIONS

A. Section 07 84 00 - Firestopping and Firesafing.

B. Section 26 00 10 - Basic Electrical Materials and Methods.

C. Section 26 05 19 - Conductors and Cables, for power wiring.

D. Section 26 05 33 - Conduits.

E. Section 26 05 36 - Cable Trays.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Provide all product data and shop drawing submittals for this Section in one complete package. Make all submittals at one time. Partial submittals will not be accepted. Where manufacturer's data or documentation is requested in initial and subsequent submittals, data or documentation originated by anyone other than the manufacturer will not be approved.
   2. Submit detailed parts list for each communications room.
   3. Submit room layout and elevation shop drawings showing configuration, installation details and marking of:
      a. Equipment racks.
      b. Cable management
      c. Patch panels
      d. Termination blocks
   4. Submit a list of test equipment by manufacturer and model number proposed for use in certifying the performance of the cable systems.

B. Product Data:
   1. Submit product data sheets for all products and materials proposed for use in this project. Where data sheets show products that are not being submitted as part of this project, highlight or mark the specific products being submitted.

C. Informational Submittals:
   1. Manufacturer's Installation Instructions.
   2. Test Reports.
   3. Submit proof of technical training received by personnel responsible for installing and testing the equipment and materials specified in this Section.
   4. Demonstration and Instruction Statement from LT.
   5. Project Record Documents: Furnish Record Drawings. Drawings shall include, but not be limited to, raceway location and type. Include termination location.
   6. Operation and Maintenance Data.

1.4 QUALITY ASSURANCE

A. Perform work in accordance with contract documents and governing codes and standards, including but not limited to the latest editions of:
   1. National Fire Protection Association (NFPA) Standards: NFPA 70 – National Electric Code.
   2. American National Standards Institute, Telecommunications Industry Association, Electronic Industries Alliance standards including all updates, errata and addenda up to the bid due date:
      a. ANSI/TIA/EIA-568-B.1.2.3, Commercial Building Telecommunications Cabling Standard.
      b. ANSI/TIA/EIA-569-B, Commercial Building Standard for Telecommunications Pathways and spaces.
      c. ANSI/TIA/EIA-606-A, Administration Standard for Commercial Telecommunications Infrastructure.
      d. ANSI J-STD-607-A, Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.
      e. ANSI/TIA/EIA-526-7, Measurement of Optical Power Loss of Installed Single Mode Fiber Cable Plant.
      f. ANSI/TIA/EIA-526-14A, Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant.
   3. Manufacturer's instructions covering the installation of listed equipment, devices and materials.

B. All personnel performing the work of this Section shall be thoroughly familiar with the cabling methods set forth in the latest release of the BICSI TDMM (Building Industry Consulting Services International Telecommunications Distribution Methods Manuals).

1.5 GENERAL REQUIREMENT

A. The Contractor is held responsible to be familiar with the provisions contained herein and with other Sections of this Specification as applicable to the completion of the installation.

1.6 SCOPE OF WORK

A. Work covered by this Section shall consist of furnishing labor, equipment, supplies, materials, and testing unless otherwise specified, and in performing the following operations recognized as necessary for the installation, termination, labeling of multipair copper cable, coaxial cable and fiber optic cable as described on the Drawings and/or required by these specifications.

B. Contractor shall provide all hardware necessary for the routing and management of communications cabling as shown on the Drawings and/or required by these specifications.

1.7 INTENT OF DRAWINGS AND SPECIFICATIONS

A. These Specifications, together with the Drawings accompanying them, are intended to depict the installation requirements necessary to support this Project. Contractor shall furnish materials shown and/or called for on the Drawings but not mentioned in the Specifications, or vice versa, that are necessary for the installation and support of communications cabling, whether or not specifically called for in both. In addition, Contractor shall provide incidental equipment and materials required for the completion of systems included in this contract whether or not specified or shown on the Drawings.

PART 2 - PRODUCTS

2.1 TELECOMMUNICATIONS MATERIALS

A. The materials and products specified herein reflect the minimum acceptable standards of fabrication and manufacture:
   1. All materials and products supplied by the Contractor and specified herein are to be new, unused, of first quality and in original packaging or shipping containers or as shown on drawings and described in Item 3.1:
   2. Acceptable manufacturers:
      a. Base: Leviton/Mohawk:
         1) As indicated in individual paragraphs throughout this section and on the drawings.
      b. Optional:
         1) Ortronics.
         2) Berk-Tek.
         3) Acceptable Equals.
      c. Other manufacturers desiring approval comply with Section 00 26 00:
         1) Material shall be an acceptable equal in quality and performance to the base manufacturer.
      d. Material shall be provided by manufacturers with systems integration similar to Leviton/Mohawk.

2.2 CABLES

A. Unshielded Twisted Pair Cable – Voice and Data:
   1. Manufacturer: Mohawk; Part No. M58281.
   2. Description; 4-pair, Category 6, UTP cable with blue CMP rated jacket.

B. Unshielded Twisted Pair Cable – Security:
   1. Manufacturer: Mohawk; Part No. M58288.
   2. Description; 4-pair, Category 6, UTP cable with orange CMP rated jacket.

C. Optical fiber: Singlemode:
   1. Manufacturer: Corning; Part No. 012E88-33131-29.

D. Optical fiber: Multimode:
   1. Manufacturer: Corning; Part No. 012S88-33190-29.

E. Optical fiber: Site cable:
   1. Manufacturer: Corning:
      a. The fiber cable shall contain 24 50/125 micron multimode fiber strands and 72 singlemode fiber strands for a total of 96 strands.
      b. Optical fibers shall be placed inside a loose buffer tube.
      c. Each buffer tube shall contain up to 12 fibers.

2.3 TERMINATION HARDWARE

A. Modular work area outlet jack:
   1. Refer to detail drawings for outlet specifications.

B. Security modular jack:
   1. Refer to detail drawings for outlet specifications.

C. Modular faceplates:
   1. Refer to detail drawings for faceplate specifications.

D. Patch panels:
   1. Leviton # 69270-U48, Category 6, T568A wired patch panel.

E. Optical fiber enclosures – Single-mode:
   1. Manufacturer: Corning; Part No. PCH-04U.

2. Description; Fiber optic enclosure/splice housing.

F. Optical fiber enclosures – Multi-mode:
1. Manufacturer: Corning; Part No. PCH-04U.
2. Description; Fiber optic enclosure/splice housing.

G. Fiber optic connectors – Single-mode:
1. Manufacturer: Corning; Part No. 95-200-42.
2. Description; Unicam, ultra PC polish, SC connector with ceramic ferrule.

H. Fiber optic connectors – Multi-mode:
1. Manufacturer: Corning; Part No. 95-050-41.
2. Description; Unicam pretium performance SC connector with ceramic ferrule.

I. Connector Panel with SC Adapters:
1. Manufacturer: Corning; Part No. CCH-CP12-59.
2. Description; Connector panel with 6 duplex SC adapters for single-mode fiber.

J. Connector Panel with SC Adapters:
1. Manufacturer: Corning; Part No. CCH-CP12-57.
2. Description; Connector panel with 6 duplex SC adapters for multi-mode fiber.

K. Splice Tray Bracket:
1. Manufacturer: Corning; Part No. PC4-SPLC-12SR.

L. Fiber Optic Terminations:
1. The vendor is responsible for terminating all fibers within a fiber optic cable.
2. Multimode:
   a. Each multimode fiber shall be fusion spliced to 900um pigtail.
   b. Each pigtail shall have an SC PC (Polished Connecter) connector.
   c. Each splice shall be protected with a heat shrink sleeve.
   d. Each splice shall be placed in a splice tray.
3. Single-mode:
   a. Each multimode fiber shall be fusion spliced to 900um pigtail.
   b. Each pigtail shall have an SC UPC (Ultra Polished Connecter) connector.
   c. Each splice shall be protected with a heat shrink sleeve.
   d. Each splice shall be placed in a splice tray.
4. Manufacturer shall be Corning Cable Systems or approved equal.
5. Testing:
   a. The vendor shall provide attenuation values and method of determining attenuation for each fiber.

2.4 CABLE MANAGEMENT

A. Suspended Cable Wire Management Hardware, Type 1: Non-continuous cable supports:
1. Primary Use: Primary method of supporting cables in ceiling areas not equipped with cable tray.
2. Manufacturer: ERICO CableCatTM J-hook series CAT12, CAT21, CAT32, and CAT64.
3. Description:
   a. Non-continuous cable supports shall provide a bearing surface of sufficient width to comply with required bend radii of high-performance cables; UL Listed.
   b. Non-continuous cable supports shall have flared edges to prevent damage while installing cables.
   c. Non-continuous cable supports sized 1 5/16” and larger shall have a cable retainer strap to provide containment of cables within the hanger. The cable retainer strap shall be removable and reusable and be suitable for use in air handling spaces.
   d. Non-continuous cable supports shall have an electro-galvanized or G60 finish and shall be rated for indoor use in non-corrosive environments.

B. Suspended Cable Wire Management Hardware Type 2: Adjustable non-continuous cable support sling:
   1. Primary Use: To provide support for cables in horizontal, overhead cable paths where cable tray is not available.
   2. Manufacturer: ERICO CADDY CableCat CAT425.
   3. Description:
      a. Constructed from steel and woven laminate; sling length can be adjusted to hold up to 425 4-pair UTP; rated for indoor use in non-corrosive environments. Rated to support Category 5 and higher cable, or optical fiber cable; UL Listed.
      b. Adjustable non-continuous cable support sling shall have a static load limit of 100 lbs.
      c. Adjustable non-continuous cable support sling shall be suitable for use in air handling spaces.

C. Hook and Loop Cable Tie:
   1. Primary Use: Adjustable, releasable, and reusable hook and loop cable ties protecting against over-tensioning of high performance fiber and copper cables.
   2. Manufacturer: Panduit Tak-Ty Cable Ties.

D. Nonmetallic Flexible Corrugated Raceway:
   1. Manufacturer: Carlon Plenum-Gard.
   2. UL Listed.
   3. Meet UL 910 standards for Plenum Optical Fiber/Communications raceways.
   4. Provide all fittings to form a complete integrated raceway system.

E. Cable Runway:
   1. Manufacturer: CPI; part No. 11275-712.
   2. Description: Twelve-inch wide cable runway, UL classified for suitability as an equipment grounding conductor.

2.5 EQUIPMENT RACKS AND ACCESSORIES

A. Floor mounted equipment rack:
   1. Manufacturer: Panduit; Part No. CMR19X84.
   2. Description: 19” EIA rack, UL listed for 1,000 lbs load rating.

B. Rack mounted power strip:
   1. Manufacturer: CPI; Part No. 12851-708.
   2. Description: 125V/20A 66-inch length with 20 NEMA 5-20R Outlets.

C. Labels:
   1. Primary Use: To provide permanent marking and identification of cables and components.
   2. Acceptable Manufacturers: Contractor's option to meet specified requirements:
      a. Brady ID Pro.
      b. Brother.
   3. Description:
      a. Pre-printed, or machine printed on-site; permanent adhesive backing; smudge-resistant.
      b. Labels shall be sized appropriately for the item to which it will be applied and the number of characters to be displayed.
      c. Do not use typefaces smaller than 10 point; for maximum legibility sans serif typefaces are preferred.
      d. Labels shall be appropriately colored for maximum contrast; black uppercase lettering on white label stock is preferred.
      e. Label nomenclature shall be protected by a permanent, water-resistant, transparent top layer.

2.6 CONDUIT AND ACCESSORIES

A. Pull Boxes: Size boxes in accordance with Table 4.7 of the 11th edition of the BICSI TDMM.

PART 3 - EXECUTION

3.1 PREPARATION

A. Before starting work in a particular area of the project, visit site and examine conditions under which work must be performed including preparatory work done under other Sections, other contracts or by the LT. Report conditions that may affect work adversely in writing.

3.2 COORDINATION: FOLLOW SECTION 01 32 16

A. Coordinate work of this section with work of other trades. Check contract drawings, as well as shop drawings, of all subcontractors to verify and coordinate spaces in which work of this Section will be installed.

B. Perform work so that progress of entire project including work of other sections is not interfered with or delayed. Obtain detailed installation information from all manufacturers of equipment provided under other sections.

C. Do not interrupt existing services. Existing services shall remain operational at all times. If the existing services need to be disrupted for any reason, contact the LT and schedule the aforementioned shutdown at least 24 hours in advance.

3.3 TELECOMMUNICATIONS INSTALLATION

A. General:
   1. This Section describes the installation locations for the products and materials, as well as methods and LT's Standards associated with the Telecommunications Installation portions of the Project. These Specifications, along with the drawings and other LT supplied specifications shall be followed during the course of the installation.
   2. The Contractor is required to be currently listed as a registered Leviton Certified Installer and provide personnel for telecommunications installations who are certified. See Warranty information within this section.
   3. The Contractor is instructed to coordinate his efforts with the other tradesmen who may be working within the same vicinity to avoid conflict and lost time.
   4. The Contractor is to install all materials plumb, square and in a workman-like manner.
   5. The Contractor is required to supply all necessary tools, equipment, accessories safety equipment, protective clothing, etc., as customary for the craft and necessary for the installation.
   6. The Contractor shall verify space requirements and locations with LT before starting cable installations and terminations.
   7. The Contractor shall verify the cable type and jacket rating required with the LT before starting cable installation.
   8. The Contractor shall verify existing cable fill in skeletal conduit, raceway or cable tray system before installation of additional cables so as not to exceed 40 percent cable fill. Contractor will be responsible for installation of additional skeletal conduit, raceway or cable tray where additional cables to be added will exceed the 40 percent cable fill.

3.4 SKELETAL AND EMPTY STATION CONDUITS

A. Provide a nylon pull cord in each empty conduit to facilitate future installation of cables.

B. Provide a nylon pull cord in each empty conduit and extended in raceway to openings for faceplates to facilitate future installation of cables.

3.5 COPPER RISER CABLE INSTALLATION

A. Refer to Project Drawings as applicable for cable quantity, sizes and routing.

B. Contractor shall install a pull rope within riser conduits before installation of cable if none exists.

C. Cables shall be terminated in order on wiring blocks as specified. Layout to be provided by LT's Representative.

D. All cable terminations to be made using impact tool designed for patch panel termination.

E. Contractor is responsible for obtaining and following manufacturer's installation instructions for correct termination of cables and wire management at wiring block.

3.6 COPPER TELEPHONE AND DATA STATION CABLING

A. New building construction will utilize category 6 cabling and termination hardware for voice and category 6 cabling and termination hardware for data. Terminations shall conform to T568A wiring standard.

B. Refer to detail drawings for outlet and faceplate specifications:
   1. Standard Telecom Outlet Devices in Flush Mounted Devices:
      a. Voice device shall consist of (1) Orange CAT 6, eight position/eight conductor (8P8C) modular jack.
      b. Data device shall consist of (1) Orange CAT 6, 8P8C modular jack.
   2. Standard Telecom Outlet Devices in Surface Mounted Raceway:
      a. Voice device shall consist of (1) Orange CAT 6, 8P8C modular jack.
      b. Data device shall consist of (1) Orange CAT 6, 8P8C modular jack.
   3. Voice Outlet Device:
      a. Telephone device shall consist of (1) Orange CAT 6, 8P8C modular jack.

C. Wall phone outlets shall utilize a stainless steel phone plate.

D. The copper telephone horizontal cabling will be terminated on patch panel.

E. Horizontal cabling shall be terminated following manufacturers guidelines.

F. Contractor is responsible to obtain and follow installation instructions for telecom products for correct termination and wire management of cables on respective products.

G. LT to provide future cross terminations to Campus switch.

3.7 FIBER OPTIC CABLING INSTALLATION

A. Refer to Project Drawings as applicable for fiber optic cable quantity, sizes, and routing.

B. Contractor shall install a pull rope within riser conduits before installation of cable if none exists.

C. Terminate each fiber optic cable on each end according to type with SC connectors. Obtain manufacturer's installation instructions for termination. Use materials and tools recommended by manufacturer for termination.

D. Fiber optic riser cables require testing at both 850nm and 1300nm and shall adhere to the following:
   1. An overall loss of (.50 dB per mated connectors + 3.5 dB per km) shall not be exceeded between any two termination points with an output bandwidth for 160MHz at 850 nm.
   2. An overall loss of (.50 dB per mated connectors + 1.5 dB per km) shall not be exceeded between any two termination points with an output bandwidth for 500MHz at 1300 nm.

3.8 GENERAL CABLE INSTALLATION

A. Station cable will be installed by the contractor.

B. The contractor responsible for station cable installation & termination shall adhere to the BNL Standard for jack designation as follows:
   1. Building # - Floor # - Jack #.

C. Upon completion of this effort, BNL Telecommunications requests a complete set of facility floor plans with all outlet/connector designation documented on same.

D. The specifications for the jack terminations will be the Leviton.

E. Both voice and data slots for all gang boxes be labeled with V and D for VOICE & DATA respectively.

F. Cable lengths within boxes shall be adequate to permit installation and removal of device for inspection without damage to cable or connections (minimum of 12 IN).

G. Cable bends shall not be greater than that recommended by the manufacturer of the cable.

H. Care shall be taken so as not to damage cable during the installation process and that manufacturer's pull tension specification is not exceeded.

I. Route cables so that no horizontal cable exceeds 90 meters between wiring closet termination and device jack termination. Contact LT's Representative if this is not probable with closet location.

J. Provide a minimum 8 FT - 0 IN and maximum 10 FT - 0 IN of slack. Loop at the wiring closets to be contained in the cable tray.

K. Within wiring closets, cables shall be wrapped using hook and loop type reusable cable ties, a minimum of every 3 FT - 0 IN for cable organization. Wire ties shall be tightened so as not to deform cable jackets and thus affect cable performance:
   1. To prevent damage, do not use plastic cable ties to bundle, organize or manage UTP or fiber optic cables.

L. Cable fill in station conduits, skeletal conduits, raceway and cable tray shall not exceed 40 percent cable fill.

3.9 LABELING AND IDENTIFICATION

A. Handwritten labels shall not be acceptable except for temporary use during construction.

B. Attach labels to cables, patch panels, termination blocks and faceplates.

C. When labels are applied to round objects such as cables, ensure that label will not unwrap itself due to stress relief. Apply labels as shown and as identified on cable pull schedules. Place labels on both ends of cables between four and six inches from the end of the outer sheath. Hand-lettered labels may only be used for temporary labeling during installation. If at any time during the work, a label becomes illegible, damaged or removed, replace it with a new label.

D. Nameplates and labels shall be securely attached to the equipment.

E. All cables shall be clearly labeled at both ends.

F. All faceplates are to be labeled with typed labels per manufacturer standards. Coordinate all labeling with building tenant.

G. Labeling:
   1. All horizontal cables shall be labeled with self-laminating marking tape, Brady ID-Pro labeler or Brothers P-Touch labeling system. All wiring blocks, patch panels, and faceplates shall be labeled with Brady ID-Pro labels or Brothers P-Touch labeling system. Identification shall be as follows:
      a. At the communications room, the copper riser cables shall be labeled at each end with the information indicating termination of the opposite end of the cables. This shall include floor level, room number and cable number. Place label on a visible part of cable close to wiring block for ease of identification after termination.
      b. At the communication room end, the voice and data horizontal cables shall be labeled with the information indicating termination of the opposite end of the cables. This shall include room location and jack designation. Place label on a visible part of cable within 12 IN of termination point for ease of identification after termination.
         Size of letters and numbers shall be no less than 5/16 IN high by 1/8 IN wide.
      c. At the outlet location, the horizontal cables shall be labeled 4 IN from termination.

This shall be visible by removing outlet cover plate. For rooms with multiple outlet locations, identification would begin with the first receptacle to the left of the main entrance to the room and continuing clockwise around the room. Size of letters and numbers shall be as indicated within this section.

d. At the communications room, voice riser cables are terminated on their respective patch panels. Label only 1st and last pairs on each row. Place cable number of riser cable on wiring block label in center of label.

e. At the communications room, voice horizontal cables are terminated on their respective patch panels, with pairs on the blocks labeled in ascending room number order. All horizontal cables from same room should be terminated in sequential order on patch panels. Single 4-pair cables will be labeled with a room location and a jack designation. Place label on jacket of cable within 3 IN of the wiring block.

f. At the communications room, data horizontal cables are terminated on their respective patch panels, with jacks on the panels labeled in ascending room number order. All horizontal cables from same room should be terminated in sequential order at the patch panels.
e.g. Single 4-pair cables will be labeled with a room location and a jack designation. Place label on visible part of the cable within 1 IN of the termination.

g. At the outlet location, the jacks will be labeled on the Leviton faceplates using the plastic insert to cover a printed identification tag with room number and proper jack designation as follows: Room numbers – telecom number.
Size of letters and numbers on labels for patch panels shall be no less than 3/32 IN high by 1/16 IN wide.

2. LT to provide instruction for labeling of elevator phones, ETS phones, Fiber Optic, and other special circuits.
3. LT to provide instruction for labeling in lab areas, etc. that do not distribute from the MDF or IDF.
4. All riser cables shall be labeled at each end with the information indicating: 1) Cable origination building number, 2) Cable origination room number, 3) Floor level, 4) type of cabinet (cat 6, Fiber Optic, ETC.), 5) rack number, 6) Block number, 7) Terminal Number.

3.10 CABLE TESTING

A. BNL representative may witness field tests.

B. BNL may perform independent testing.

C. Contractor will incur all costs for retesting and consumables required by unacceptable test results.

D. Daily Test Equipment Preparation: Properly configure cable test equipment each day before testing and include the following:
1. Verify that the test equipment is still within the manufacturer's calibration warranty period.
2. Verify that the test equipment is set to “auto test” and that proper cable type and associated parameters are selected.
3. Verify that the test equipment's selected nominal velocity of propagation matches the cable being tested.
4. Perform a self-test of test equipment to confirm its proper ability to function.
5. Connect test equipment to its matched “smart” terminator and perform an auto test to confirm that the test equipment and terminator are functioning properly.

E. Copper Cable Tests: Use an EIA/TIA TSB-67 Level III or higher tester to automatically perform the following tests:
1. Line Mapping (End-to-End Connectivity). Check four-pair wiring for proper wiring configuration, open conductors, shorted conductors, crossed pairs, and reversed pairs.
2. Loop Resistance (DC-Steady State). Connect an ohmmeter across one end of the cable pair with the shorting terminator across the other end of the cable pair:

a. Measure steady-state DC resistance and compare it to the cable manufacturer's standard values.
b. Values greater than allowed resistance are considered to have failed and values smaller than allowed resistance are considered to have passed.

3. Attenuation: Transmit several signals at increasing frequencies across each conductor and then:
   a. Measure the signal loss in units of decibels (dB).
   b. Measure test frequencies and permitted dB loss values at each test frequencies.
   c. Refer to loss values specified in EIA/TIA 568B.
4. Cable Length: Record the cable length from either the length markings on the cable jacket or from hand-held multi-function test equipment incorporating time-domain reflectometer circuitry.
5. Capacitance: Test each twisted pair with a capacitance meter:
   a. Test the opposite end of the twisted pair for an open circuit.
   b. Pass test results must yield capacitance within 2 percent of the cable manufacturer's specification.
6. Near-End Crosstalk: Measure both the outlet and distribution end of the link:
   a. The worst pair of cable with near-end crosstalk must be measured in dB.
   b. Test frequencies and permitted worst pair dB crosstalk values at each of the test frequencies are specified in EIA/TIA 568B for cable (pending).
7. The result of each test is either “pass” or “fail”.
8. Repair or replace and retest failed cables until passing results are achieved.

F. Preparing Fiber Optic Test Equipment: Properly adjust fiber optic test equipment before use:
   1. Follow the equipment manufacturer's detailed instruction manual.
   2. Calibrate variable unit adjustments on test equipment to match the cable manufacturer's cable transmission parameters.

G. Fiber Optic Cable and Component Test: Use test equipment approved by BNL and perform the following inspection and tests for fiber optic cable. Properly clean the optical connector end faces before connector contact is made for testing or circuit connection:
   1. Fiber Optic Cable Length Measurement: Record cable length (in feet) from either length markings on the cable jacket or form optical time-domain reflectometer (OTDR) measurements on the “Outlet Cable Test Form”.
   2. Fiber Optic Connector Validation Test: Inspect each fiber optic connector assembly with 400X visual inspection:
      a. Reject the connector assembly if visible imperfection penetrates the fiber core or if the imperfection risks future damage to the core or mating connector's surface.
      b. Reject the connector assembly if the connector loss displayed does not meet the manufacturer's specifications.
      c. Reject the connector assembly if the connector reflectance causes a link return to exceed acceptable link return loss.
      d. Replace rejected connector assemblies and retest until acceptable measurements are obtained.
   3. Optical Reference Level Measurements:
      a. Connect the optical source to the power meter with 2- to 3-meter jumper cables that have transmission characteristics identical to the optical link being measured.
      b. Record optical power levels in dBm after operational stabilization; primarily after ambient thermal conditions are reached.
      c. Repeat this procedure during the measurement process to verify the integrity of fiber optic test jumpers and the optical source.
      d. Record the optical source and power meter serial numbers of units used on each outlet cable test form in the test equipment section.
   4. Optical Link Attenuation Measurements: Measure optical link attenuation after both ends of the fiber optic have been terminated and mounted into coupler panels:

a. Record and measure the link attenuation with an optical source and power meter to other end.
b. Connect the source at one end of the optical link and connect the power meter to other end.
c. Record the power received in dB for each wavelength.
d. Reverse the location of both source and power meter, and repeat the test.
e. Calculate the average recorded power levels for each wavelength and record it in dB.

5. Optical Link Return Loss Measurement: Measure and record the optical link return measurement for single-mode optical links.

H. Progress Reports: Submit one hard copy of the completed report beginning one week after cable termination work commences and continuing for the duration of the project. Group weekly submittals by the name of the person performing the terminations, with the company name in the miscellaneous note section. Reports are due to BNL's proper authority by 4:00 p.m. each Friday.

I. All equipment shall be installed in a neat and workmanlike manner, arranged for convenient operation, testing and future maintenance.

J. All paired cables shall be installed and terminated by technicians experienced in the termination of cables on connector blocks.

K. All fiber optic cables shall be installed and terminated by technicians experienced in the termination of fiber optic cables.

L. The Contractor shall employ certified system installation technicians and have at least 5 years experience in the installation of similar and equivalent systems.

M. The Contractor shall supply verification of experience, for this type of work, to the LT for approval before performing any work.

3.11 AS-BUILT INFORMATION

A. Contractor shall provide as-built information to LT to accompany all test result information.

B. As-built information shall be in red-lined format on a copy of construction drawings. Indicate location of all TOs, if different than original drawing, skeletal or riser conduit changes, and all additions and deletions pertaining to telecommunications.

C. If construction drawings are not utilized, Contractor shall provide all telecommunications location information on an accurate scaled floor plan.

3.12 SYSTEM WARRANTY REQUIREMENTS

A. Contractor shall perform all labeling requirements and provide testing documentation for verification as described herein.

B. Contractor shall submit cable records to reflect all moves, adds, and changes.

C. Contractor shall provide floor plans showing locations of all telecommunication outlets and spaces. See paragraph 3.11.

D. Contractor shall perform these requirements for category 6 link configuration as stated to adhere to 25-year system performance guarantee as defined by the cable and hardware manufacturers.

END OF SECTION

DIVISION 28

ELECTRONIC SAFETY AND SECURITY

SECTION 28 05 00
BASIC ELECTRONIC SECURITY REQUIREMENT

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Introduction:
   1. Electronic Security System (ESS) includes proprietary equipment specified under Section 28 05 19. Components and aspects of the ESS shall be furnished and installed by the ESS Contractor unless noted otherwise. ESS shall be a complete turnkey system provided by an ESS Contractor. ESS Contractor shall be a single firm with overall responsibility for every aspect of the integrated ESS from procurement through installation, testing, and post acceptance technical support and warranty.

B. System Description:
   1. The ESS is an expansion of an existing Software House C-Cure 9000 Access Control System (ACS) now in operation on the Brookhaven National Laboratory Campus. The work under this Section is to provide new ESS devices, local access controllers, card readers, magnetic contact door position switches, and connections to electric door hardware. ESS security network and network connections shall be provided by BNL.
   2. The function of the ESS is to control access, organize and present alarm, text, and event information to security operators to assist them in assessing and dispositioning potential threats to Government personnel and facilities. ESS shall control access to building and selected areas within building via a network of microprocessor based control panels, which automatically operate a system of card readers.
   3. ESS shall utilize Software House iSTAR EDGE, two-reader IP edge devices with PoE+ (Power over Ethernet Plus) compatible with 24 volt electric mortise locks specified under Division 8.
   4. ESS shall comply with Federal Government standard HSPD-12, (Homeland Security Presidential Directive 12).
   5. ESS shall be brought on line in Federal Information Processing Standard FIPS 140-2 mode (Security Requirements for Cryptographic Modules) in accordance with Department of Energy requirements.
   6. ESS equipment shall meet FIPS-201, (Personal Identity Verification of Federal Employees and Contractors) and FIPS-197, (Advanced Encryption Standards AES).
   7. The system shall be capable of acting as part of a local area network or wide area network with other computer systems. The network media shall include, but not be limited to Ethernet over CAT 6 cable and fiber optic cable. ESS network connections to Building 50 head end equipment shall be provided by BNL including Ethernet switches and their associated fiber optic cables except as noted otherwise.
   8. The ESS shall be customized to meet the requirements of the Government security directors. The ESS shall be responsible for coordinating with Government groups for programming ESS features and functions into the existing head end system. Typical coordination items includes graphic maps, alarm messages, security schedules, sequences of operation and functional matrix.

9. Local processor inputs shall monitor dry contacts for changes of state that reflect alarm conditions. The local processor shall have alarm inputs which allow wiring as normally open or normally closed contacts for alarm conditions. It shall also provide line supervision for each input by monitoring each input for abnormal open, grounded, or shorted conditions using dc current change measurements. The local processor shall report intrusion alarms and line supervision alarms, card reader, power supply, tamper alarms, self-diagnostic alarms and Ethernet communications failures to the existing redundant Software House C-CURE 9000 Security System Servers at the Brookhaven National Laboratory Central Alarm Station. Alarms shall be reported for any trigger event or condition that persists for longer than 500 milliseconds. Each alarm condition shall be transmitted immediately upon detection.
10. Cabling to all system card readers shall include sufficient, properly terminated conductors to achieve full utilization of the remote RS-485 flash firmware upgrade feature and independent reader tamper switch monitoring.

C. ESS Contractor Qualifications:
1. ESS Contractor shall be a single firm primarily engaged in and responsible for the system application design, installation, configuration, programming, testing, and training of end users. ESS Contractor must be able to provide continuing maintenance and technical support after project completion.
2. Manufacturer of the proposed system shall require resellers to pass a formal training program prior to being certified as authorized to sell and install the system. Such certification shall require annual re-qualification. The ESS Contractor proposing the system shall be in possession of such a certification.
3. ESS Contractor shall meet Government requirements for performing work and shall have a minimum of 8 years experience in successfully completing projects of equivalent scope and magnitude with major product categories as herein specified. At a minimum such projects shall include the installation and integration of access control, intrusion detection, video surveillance and networks, and command consoles. This evidence shall consist of a list of 3 similar projects that have been completed and operational for a minimum of 3 years. For each facility, list name, description, and location of installation; date of contract completion; BNL's representative to contact, including address and telephone number; Construction Manager or General Contractor's representative to contact, including address and telephone number; and BNL's representative to contact, including address and telephone number. Provide a list of all jobs/projects in the past five (5) years in which this firm has been involved in litigation or criminal action with a client, city, county, state, or federal governmental agency and the status thereof.
4. Dealer / Integrator must have current Software House Enterprise Level, Premier Certification.
5. Dealer / Integrator must deliver the specified services utilizing technical and support staff that are Software House factory trained and certified.
6. Dealer / Integrator must be a Dell and Microsoft Certified Partner.
7. Dealer / Integrator must demonstrate (through customer references) the successful installation and ongoing maintenance of a minimum of five (5) Software House Enterprise Security and Event Management Systems utilizing the C-CURE 800/8000/9000 platforms.
8. Dealer / Integrator must demonstrate (through customer references) the successful installation of industrial Access Control / Intrusion Detection Systems at a minimum of three (3) local, state or federal government facilities.
9. Dealer / Integrator must demonstrate (through customer reference) direct participation in the construction of at least one (1) Secure Compartmented Information Facility. (SCIF)
10. Dealer / Integrator must be UL 2050 Certified.
11. Dealer / Integrator must demonstrate (through customer reference) the successful installation of at least one (1) PACS / LACS System Integration using the Imprivata OneSign solution. Dealer / Integrator must be a registered Imprivata Partner.
12. Dealer / Integrator must employ a dedicated staff of Information Technology specialists with documented Microsoft and Cisco Certifications.

13. All Dealer / Integrator personnel assigned to this project, in any role, must be United States Citizens.
14. All Dealer / Integrator personnel assigned to this project must have undergone documented pre-employment background investigations with criminal history check.
15. All Dealer / Integrator personnel assigned to this project who will perform services at the BNL site, will be required to possess at least one Federal Government Issued Common Access Credential such as TWIC, FRAC, etc.
16. Dealer / Integrator Senior PM, Senior Engineer, Senior Technician and Account Manager must be willing to submit to a U.S. Department of Energy "Q" Access Authorization Investigation upon request of BNL LPD. Note that this is a comprehensive Single Scope Background Investigation with credit check. At least one of the listed Dealer / Integrator representatives must be able to obtain a United States Department of Energy "Q" Access Authorization.
17. Dealer / Integrator shall guarantee 24 x 7 x 365 x 4 hour Mission Critical Systems Emergency Response capability utilizing a Software House factory trained and certified Senior Technician. This requirement will be addressed under separate contract.
18. Questions and or concerns regarding any aspect of this project should be directed to the BNL Technical Representative. Please contact:

    John Primiano
    Project Engineer I
    Physical Security Systems
    Brookhaven National Laboratory
    Laboratory Protection Division
    24 Upton Rd. South
    Bldg. # 50
    Upton, NY 11973
    631-344-4496 Office
    631-578-7903 Cell
    631-344-5688 Fax
    E-mail: primiano@bnl.gov

D. Division of Responsibilities and Coordination with Other Trades:
1. ESS Contractor shall be responsible for installation of all equipment, devices, and accessories required for a complete system including but not limited to conduit, raceway, wire, fiber optic cables, fiber optic patch panels, junction boxes and enclosures, power supplies and accessories as required, specified, shown on contract documents and in accordance with ESS manufacturer's requirements and applicable codes.
2. ESS Contractor shall examine the Drawings and Specifications of other trades whose work may influence the installation of the security systems. ESS Contractor shall include services required to coordinate and observe the installation of the security system with the work of other trades, to include, but not necessarily limited to, Electrical Contractor, Door Contractor and Telecommunications Contractor.
3. Prior to the start of Work, ESS Contractor shall review the Project Drawings and Specifications and shall closely coordinate his work with that of Electrical (Division 28) Contractor. In particular, ESS Contractor shall coordinate such work as, including, but not limited to, the following: 120 VAC power feeds, the power supply panels, wiring, conductors, boxes, conduit, raceway, for the security system components. ESS Contractor shall pay close attention that Electrical Contractor observes the required separation of security signal conductors from electrical power conductors.

4. ESS Contractor shall provide all low voltage wire and cable and shall be responsible for all low voltage connections. ESS Contractor shall be responsible for coordinating and monitoring the installation of conduit, raceways, electrical boxes, junction boxes, and electrical power, which shall be the work of Electrical Contractor. It shall be the responsibility of ESS Contractor to provide Electrical Contractor with complete information regarding 120 VAC requirements, as well as all low voltage raceway and conduit requirements.
5. Electrical Contractor shall furnish and install the electrical power supply panels, conductors, conduit, raceway systems, and terminations for the supply of 120 VAC power to security system components. Electrical Contractor shall furnish and install low voltage (security system) empty raceway, conduit with pull strings, and boxes. Electrical Contractor shall make high voltage connections.
6. Door (Division 08) Contractor, shall provide Work on security doors, such as, but not limited to, the preparation of security doors (either at the factory or in the field, as required) to accept security devices such as balanced magnetic switch sets (door position switches) to be installed and connected by ESS Contractor. Door Contractor is responsible for the pre-installation of electric locks, electric strikes, and similar electronic or electrical locking assemblies, which shall be wired by Division 8 to junction box or enclosure provided by ESS Contractor above accessible ceilings on the secure side of doors. ESS contractor shall furnish wiring to Division 8 contractor. Those items that are supplied by the Door Contractor but not physically connected to doors such as power boosters or automatic door actuators shall be installed by Electrical Contractor including device mounting, raceways and 120 volt power. ESS Contractor shall provide low voltage ACS interface and control wiring to power boosters and automatic door actuators. ESS Contractor shall attend a pre-installation conference with the Door Contractor to review and coordinate wiring of electrical door hardware.
7. BNL Responsibilities: BNL shall provide Network Connectivity to existing Software House C-Cure 9000 head end system in building 50 including fiber optic cables originating at Building 50 and terminating in fiber optic patch panels provided by ESS Contractor.

1.2 RELATED SECTIONS

A. Section 08 71 00 Door Hardware.

B. Section 26 00 10 Electrical General Requirements.

C. Section 28 05 19 Security Devices.

1.3 GENERAL CONDITIONS

A. Submittals after award of contract:
   1. System Drawings:
      a. Device wiring and installation drawings shall be complete wiring, conduit and raceway layout including the precise locations of all junction and utility boxes, local controllers, termination panels, power supplies, spare conduits, and all other equipment noted. Show conduit sizes and runs and terminal-to-terminal connections of wiring between all components in the system. Identify each circuit and component by alphanumeric characters based on Contract Document nomenclature. Identify unused circuits and capacities within each piece of equipment. Show manufacturer's part number, AWG size, construction, insulation type, wiring color code and rating for conductors and cables. Drawings shall clearly illustrate mounting locations and methods, with particular detail for the installation of door status switches, wiring to locking hardware, and request-to-exit devices at doors. While some drawing details may be "typical," the Drawings shall illustrate the installation detail of each unique application.
      b. Functional System block diagram or riser diagram, identifying all system components, servers or connections to servers, network switches, network communications protocols, local processors, wire type and quantity, and approximate distances.
      c. Describe operation for each part of the system in a narrative, tabular or matrix format.

d. Local processor installation, including typical block and wiring diagrams shall show dimensions, power requirements, component layout, spare capacities and provisions for expansion. Include power supply, and circuit capacity calculations and voltage drop proving compliance with Contract Documents.
e. Field equipment enclosure drawings with local processor installation and schematics shall indicate exact installation details including dimensions of wireways, conduits runs, equipment racks and enclosures.
f. Floor Plan Layout Drawings: Show location on floor plan drawings of all components required for operation whether or not they are referenced in the Contract Documents. Identify components with nomenclature referenced to wiring diagrams. All floor plan information shall be legible and drawn to an industry standard scale.
g. Details of connections to power sources, including power supplies and grounding.
h. Details of surge protection device installation.
i. Door schedules and details shall provide the following information as appropriate in each case: (1) door number; (2) door type; (3) door position status sensor; (4) locked/latched status sensor; (5) request-to-exit type; (6) request-to-exit location; (7) auxiliary request-to-exit device, (8) lock type; (9) power requirements; (10) access control type; (11) special installation requirements; (12) timed-shunt times; (13) shunt type; (14) precise, to-scale mounting location; (15) zone or point designation; (16) remote control of lock by specific and designated control console(s); (17) access control panel number for each door. (19) Describe operation for each door type.
j. Coordination drawings including details of all electronic and physical interfaces between the ESS, all integrated systems and all systems of other trades interfaced to the ESS including the exact point and type demarcation. Show locations of interfaces in both wiring diagram and floor plan format.

2. Manufacturer’s Product Data:
   a. Manufacturer's data for all materials and equipment, including terminal devices, wiring, cables, local processors and head end equipment provided under this specification. Submit manufacturer's original printed sheets showing dimensions, performance data and listings/approvals. Facsimile copies of manufacturer's data sheets will not be approved. Submit data on products furnished under this Section whether or not they are referenced in Contract Documents. Where data sheets show multiple product items, highlight data pertinent to products furnished.
   b. Submit product data sheets for wiring and cable to be provided under this section including fiber optic cables, low voltage power supply wiring, data/communications cabling, jumper cables, specialty cables, etc. Describe wire type, construction and size. Data shall prove suitability of wiring submitted for specific use.
3. Calculations:
   a. Submit all calculations used in designing the ESS including:
      1) Power supply requirements: Provide calculations to define power supply requirements for each component of the system in accordance with manufacturer’s instructions for power supplies that are not an integral part of the component.
      2) Voltage drop and circuit capacity calculations including analysis and calculations to define the type and size of all cables connecting all system components in accordance with Manufacturer’s instructions.
      3) Calculations used in sizing equipment specified.
      4) Battery standby capacity calculations.
      5) Alarm response time calculations.
      6) Command response time calculations.

B. Documentation to be submitted by the ESS Contractor upon completion of system installation:
   1. "As–builts": Upon completion of installation, the Contractor shall prepare "as–built" drawings of the system. These "As–builts" shall be 36 IN x 48 IN format mylar reproducible drawings of each floor plan indicating exact device locations, panel terminations, cable routes, and wire numbers as tagged and color–coded on the cable tag.

2. Additionally, final point–to–point wiring diagram of each type of device (on 36 IN x 48 IN format) shall be included in the "as–builts".
3. "As–builts" shall be submitted to the BNL for approval prior to the system acceptance walk–through.
4. Final “as-built” versions of all shop drawings shall be submitted in AutoCAD Version 2000 or later DWG format. Include two copies on CD/DVD ROM disks.
5. Operation and maintenance manuals: Three (3) sets of operating manuals shall be provided explaining the operation and maintenance of the system.

C. Quality assurance:
1. Components of electronic security system shall be installed in accordance with the following codes and standards and codes and standards listed on drawing G-100A-L:
   a. New York State Building Code.
   b. National Electrical Code.
   c. Department of Energy Standards.
2. Security system components shall be listed on GSA Approved Products List.
3. Components of electronic security system shall comply with the following federal government standards:
   a. HSPD-12, (Homeland Security Presidential Directive 12).
   b. FIPS-201, (Personal Identity Verification of Federal Employees and Contractors)
   c. FIPS-197, (Advanced Encryption Standards AES)
   d. FIPS 140-2, (Security Requirements for Cryptographic Modules)
4. Components of electronic security system shall be UL listed under the following standards:
   a. UL 294, Access Control System Units.
   b. UL 1076, Proprietary Burglar Alarm Units and System.
5. ESS Contractor shall provide the services of technical representatives who are familiar with all components, installation procedures and software of the installed system; are certified by the manufacturer of the proposed system; and are approved by the BNL. These representatives shall be present on the job site during the preparatory and initial phases of quality control to provide technical assistance. These representatives shall also be available on an as needed basis to provide assistance with follow-up phases of quality control. These technical representatives shall participate in the testing and validation of the system and shall provide certification that their respective system portions meet the contractual requirements.
6. ESS Contractor shall participate in integrated systems testing undertaken as part of the Commissioning process of other trades where other trades interface with ESS components. Such integrated system tests include but are not limited to power failure and power back up systems testing and operation of automatic doors. ESS Contractor shall make technical representatives available who are familiar with all components, installation procedures and software of the installed system when other trades are testing systems that are integrated or interfaced with ESS components.

D. Warranty: Components, parts, and assemblies supplied by Manufacturers and installed by Contractor shall be warranted against defects in material and workmanship for a period of 12 months (parts and labor), commencing upon date of acceptance by BNL. Warranty service shall be provided by a qualified factory–trained service representative.

E. Service/Maintenance:
1. System maintenance and repair of system or workmanship defects during the warranty period shall be provided by the Contractor free of charge (parts and labor).
2. Periodic testing of the system shall be carried out on a quarterly basis to ensure the integrity of communication with head end system.
3. Contractor shall correct any system defect within six (6) hours of receipt or call from the BNL.

1.4 GENERAL REQUIREMENTS

A. ESS Contractor shall furnish all equipment required for a complete installation, which is not supplied by BNL or other Contractors as part of the requirements listed in other sections of this specification. In general, the scope of work, included in Part 1 of this section describes equipment furnished by BNL or others. Where the ESS Contractor is responsible for installing equipment furnished by BNL or others, he will take full responsibility for the care and security of that equipment upon receipt of the equipment at the job site.

B. All equipment furnished by the ESS Contractor shall be kept secure and dry at the job site. Equipment that can be affected by ambient conditions shall be stored in a conditioned environment. The ESS Contractor shall provide all required storage facilities for this equipment on the job site.

C. ESS Contractor-furnished equipment shall be new and left in original container until installed. BNL reserves the right to inspect this equipment prior to installation and reject any equipment not cared for in an appropriate or defined fashion.

D. Refer to Section 16010 for additional requirements.

1.5 CONDUIT, RACEWAY AND FITTINGS

A. Conduit: Wire and cables shall be run in conduit to junction boxes or enclosures concealed above accessible ceilings. Wiring and cables concealed above accessible ceilings shall be run in conduit from junction boxes and enclosures to nearest security cable tray. Cable tray is specified under section 16744 and shown on telecommunications drawings. Wiring and cables exposed to view shall be installed in metal conduit throughout. Conduit shall meet the requirements of Section 16110 and the following:

1. Conduit shall be UL listed with approved fittings.
2. Conduit shall be minimum 3/4 inch, sized and supported in accordance with the NEC and limited to 40 percent fill.
3. Running threads shall not be permitted. Approved threaded couplings shall be used on full weight conduit. Each end of any conduit terminating in a box of any kind shall be provided with a lock nut inside and outside of the box and with an approved insulating-type bushing.
4. Conduit bends shall be the long radius type without kinks, flattening or crushing. For all bends in conduits 1 IN or larger, standard elbows shall be used except where long pulls are involved. All conduits shall be run at right angles or parallel to walls and floors indoors and to the supporting structures outdoors and all changes in direction shall be made with conduit fittings or standard elbows. Conduit runs outdoors shall be installed with a slight incline in such a manner as to insure against trouble from the collection of trapped condensation.
5. For above grade conduit installations, pull boxes shall be installed in all straight runs of conduit a minimum of every 100 feet, in all runs. With one right angle bend a minimum of 75 feet; in all runs with two, or three right angle bends a minimum of 50 feet. This requirement does not relieve the Contractor of the responsibility for providing pull points on all long conduit runs as required, so as not to over-stress and/or damage the wire or cable.
6. Open conduit ends, including those terminating in boxes, shall be plugged or capped as soon as installed, and so maintained during construction to prevent the entrance of moisture and dirt. All conduit shall be carefully cleaned and dried inside before the installation of wire.
7. Conduit and fittings shall conform to the following:
   a. EMT - Steel set screw type fittings.
   b. IMC – Intermediate Metal Conduit:
      1) Material: Steel, intermediate wall thickness, hot dipped galvanized.
      2) Joints: Standard pipe thread with coupling, deliver with thread protector on conduit up to 2 IN.
   c. Rigid Steel Conduit - Cast ferrous metal (condulets) having ample wiring space, full threaded hubs, and watertight covers with gaskets.

8. Conduit installed outdoors or where subject to water, must enter equipment and junction boxes from the side or the bottom. Where top entry is a necessity, watertight conduit hubs shall be used. Rain tight fittings shall be used in all outdoor locations.
9. Conduit shall be kept a minimum of 6 IN away from all hot water or steam pipes. Where this is not possible, the pipes shall be insulated.

B. Flexible Metal Conduit:
1. Flexible metal conduit shall be installed where called for in the drawings, to provide a flexible connection to equipment requiring position adjustments, or where fished through walls, above ceilings, or within other building cavities as shown on drawings or approved by the BNL. Flexible metal conduit shall not be used where EMT can be utilized.
2. Flexible metal conduit shall be UL approved with UL approved angle wedge type insulated throat fittings specifically manufactured for use with flexible metal conduit. Flexible metal conduit shall be 1/2 IN minimum.

C. Liquid Tight Flexible Metal Conduit:
1. Liquid-tight flexible metal conduit where called for shall be fabricated of galvanized steel flexible tubing, with thermo-plastic jacket extruded over tubing. Liquid tight flexible metal conduit shall match size of conduit system to which it connects unless noted otherwise.
2. Fittings for liquid tight flexible metal conduit shall be steel.
3. Liquid tight flexible metal conduit shall be used for all flexible connections in the basement and penthouse and for all connections to instruments having a NEMA 3, 4, 7 or 9 enclosure.

D. Pull Boxes, Junction Boxes and Equipment:
1. Suitable boxes shall be provided where indicated on drawings, called for in the specifications, or as may be required to facilitate the installation and pulling of wires or cables.
2. Boxes shall be sized to accommodate wiring without sharp bends or overcrowding, and shall in all cases comply with NEC requirements, and the cable manufacturer's requirement.
3. Interior boxes shall be galvanized steel and bear the label of the Underwriters Laboratories, Inc. and conform to NEMA Standard for Type 1 enclosures.
4. Exterior boxes shall be corrosion resistant and bear the label of the Underwriters Laboratories, Inc. and conform to NEMA Standard for Type 3, 3R or 4.
5. All boxes shall be independently and adequately supported and shall not be supported by the conduit system.
6. Boxes for special purposes, such as relay boxes, shall be the type and manufacture as shown on the drawings. Boxes shall be furnished complete with sub-panels and a finish coat of enamel paint. Color of paint to be specified by BNL.
7. Junction box and pull box covers shall have nameplates identifying tag names for cables in box. Refer to interconnection diagrams for tag names.
8. No "cut-in" boxes will be accepted.

1.6 EQUIPMENT MOUNTING

A. Provide all necessary hangers, brackets, steel frames, equipment racks, and pipe stands necessary to properly support all equipment and conduit as required. Where possible, parallel conduits shall be grouped neatly on structural racks and secured in position.

B. Provide channel support-to-support panels, terminal boxes, and groups of instruments. Equipment shall not be mounted directly on walls, or ceilings. Provide 3/4 IN plywood backboards for mounting equipment in communications rooms.

C. All hangers, brackets and channel supports shall be galvanized steel, Unistrut.

D. All structural steel members or steel frames shall be hot-rolled carbon steel. Shapes shall conform to the types already in use in the facility. Steel members shall be welded to existing structures in accordance with the American Welding Society for procedures, appearance and quality of welds.

E. All steel shall be galvanized except steel members welded to existing steel which are presently painted and are used solely to support the new equipment or conduit.

F. All fasteners, supports, clamps and anchors shall be of the correct type for the purpose. Fasteners shall be as follows:
   1. In hollow or lath construction, toggle or machine bolts, with suitable bearing plates.
   2. For structural iron, machine bolts, or approved clamps. Beam clamps can be used on structures free from vibration.
   3. For solid masonry, metallic expansion shields and machine screws, in concrete, provide approved inserts.
   4. Power driven fasteners and anchors may be used in areas designated by BNL. Where used, it will be the Contractor's responsibility to use the correct anchor and charge for the type of construction encountered.

G. All brackets, hangers, bolts and nuts shall be galvanized.

H. Twenty percent spare space shall be provided in all racks and each spare space shall be not less than three inches for future conduit.

PART 2 - EXECUTION

2.1 INSTALLATION

A. Install equipment and materials in accordance with manufacturer recommendations and in accordance with:
   1. Installation criteria defined in these specifications and in the construction documents.
   2. Approved submittals.
   3. Applicable requirements of referenced standards.

2.2 GENERAL

A. The security systems shall include all devices, components, parts, wire, cable, conduit, etc. as specified herein, or in other sections of the specification, and connected to perform all functions and operate according to the system description and function. ESS Contractor shall coordinate with other Contractors working in the same areas or providing support services (120 volt AC) to his equipment.

2.3 EQUIPMENT INSTALLATION AND LABELING REQUIREMENTS

A. Equipment which must be serviced, operated or maintained shall be located in fully accessible locations. Locations shown on contract documents are diagrammatic and approximate. With aid of supplier's technical representative, determine final location of devices. Changes to locations indicated on contract documents shall be coordinated with and approved by BNL prior to installation.

B. Electrical equipment must be located so as to provide minimum working space as required by NEC.

C. The Contractor shall coordinate with all other trades as to the exact location of all devices, wire ways, cable trays, security data outlets, and conduit locations prior to installation.

2.4 DEVICE INSTALLATION AND LABELING REQUIREMENT

A. Equipment and devices shall have nameplates. Nameplates shall be permanently adhered to the device with screws or double-sided tape specifically made for this application. Nameplates shall include device tag names, as shown on contract documents noted on the drawings. Nameplates shall be approved by BNL prior to installation.

2.5 CONDUIT/WIRE INSTALLATION AND LABELING

A. Wire and cable shall be continuous from terminal to device with no splices.

B. Cable and wire labels shall be approved by BNL. Wire labels shall include tag names as listed on the interconnection diagram.

C. All cables within relay panels should be run in slotted plastic wire duct. Where wire duct is not provided, cables shall be installed using BNL approved nylon tie-wraps and anchor blocks.

D. All control wiring shall be verified as to field device and cable integrity before being terminated at either end per the following procedure:
   1. Attach Digital Ohm Meter across Conductors of control cable at panel end.
   2. Have person at device end short wires together; verify that continuity is established.
   3. Isolate wires at device and check for continuity from control wires to shield, shield to ground, and control wires to ground
   4. If continuity is observed on any of the readings in step #3, correct problem or replace cable.
   5. If all readings in step #3 show non-continuity, then label and terminate cable at this time.
   6. When terminating field device, strip back shield, cut drain wire, and cover, any exposed shielding with heat shrink tubing. Terminate shield drain wire at control Panel.

E. Wires shall be installed in strict accordance with the National Electrical Code, and in particular with Article 725. All communication, signal and instrument cable with insulation of less than 300 volts (Class 2 and 3), and fiber-optic cable shall be kept separate by at least 2 IN from all power and Class 1 control circuits, or a partition shall be installed between these classes of cables.

F. Solderless connections shall be used for wire terminations. Where wires terminate in other than a compression-type terminal, an BNL approved spade-type wire terminator shall be crimped to the wire.

G. Any penetration of a firewall shall be sealed to maintain the fire rating of the wall.

H. Junction boxes shall be painted yellow to identify them as being part of the security system.

2.6 SUPERVISION

A. ESS Contractor shall provide the following services as part of the contract:
   1. Supervision of sub–contractors.
   2. Coordination of other contractors for system–related work (electrical contractor, finish hardware contractor, BNL, and general contractor).
   3. Attending site construction/coordination meetings.
   4. Keeping updated construction drawings at the construction site.
   5. Meeting construction deadlines per the construction schedule.

2.7 SYSTEM STARTUP

A. Satisfaction of the requirements below does not relieve the ESS Contractor of responsibility for incorrect installations, defective equipment items, or collateral damage as a result of ESS Contractor work/equipment. ESS Contractor shall not apply power to the system until after:
   1. System equipment items and ESS Network have been set up in accordance with manufacturer's instructions.
   2. A visual inspection of the system has been conducted to ensure that defective equipment items have not been installed and that there are no loose connections.
   3. System wiring has been tested and verified as correctly connected.
   4. System grounding and transient protection systems have been verified as properly installed.
   5. Power supplies to be connected to the system have been verified as the correct voltage, phasing, and frequency.

2.8 PROGRAMMING

A. ESS contractor shall provide comprehensive programming of local controllers, adjunct control and signaling modules and existing Software House C-CURE 9000 redundant Security System Servers in accordance with sequences indicated on drawings and specific instructions of assigned Brookhaven National Laboratory Security Systems Engineer. ESS shall update Software House C-CURE 9000 computer graphics at existing redundant Access Control Servers, to include all readers, doors and alarm points associated with the Work of this Section.

B. ESS Contractor shall enter sufficient data for performance verification testing. Personnel data base entry shall be provided by BNL.

2.9 TESTING

A. Component Testing: ESS Contractor shall perform component testing of the conduit, wire, fiber optic cables, system. ESS Contractor shall calibrate and test all equipment, verify ESS operation, place the integrated system in service, and test the integrated system. Ground rods installed by the ESS Contractor shall be tested as specified in IEEE Std 142. The ESS Contractor shall deliver a report describing results of functional tests, diagnostics, and calibrations, including written certification to the Government that the installed complete system has been calibrated, tested, and is ready to begin performance verification testing. It is recommended that the ESS Contractor use the approved performance verification test as a guideline when the field test is conducted.

B. Operational Testing: ESS Contractor will perform operational testing and verify that all system components are fully operational. ESS Contractor shall demonstrate that the completed system complies with the contract requirements. Using approved test procedures, all physical and functional requirements of the project shall be demonstrated. The performance verification test, as specified, shall not be started until after receipt by the ESS Contractor of written permission from the BNL, based on the ESS Contractor's written report. The report shall include certification of successful completion of Component Testing. The BNL may terminate testing at any time when the system fails to perform as specified. Upon successful completion of the performance verification test, the ESS Contractor shall deliver test reports and other documentation as specified to the BNL.

C. Acceptance Test Plan Form: An acceptance test plan shall be submitted for approval by ESS Contractor prior to the acceptance walk–through. This form shall include separate sections for each device/panel/unit as well as a column indicating the manufacturer’s performance allowance/margin, a column indicating the result of the testing performed by ESS Contractor (pass/fail), and an empty column for recording findings during the walk–through.

2.10 TRAINING

A. Training will be provided by BNL.

2.11 COMMISSIONING

A. ESS Contractor shall certify completion in writing and schedule the commissioning walk–through.

B. ESS Contractor shall provide all tools and personnel needed to conduct an efficient commissioning process

C. ESS Contractor shall develop complete testing procedures for all devices, equipment, networks, workstations, software, functions and aspects of the ESS specified in this Section. This shall include but not be limited to each door and opening on the Access Control Schedule drawings, development of commissioning checklists and procedures to Initial Equipment/System Verification, Data Transmission Media, Surge Protection, Equipment Enclosure Tamper Switch, Power Failure/Battery Backup, Line Supervision, Balanced Magnetic Switch (Door Status Switch), ESS Operator Commands, ESS Reaction to Heavy Load Conditions and ESS Throughput.

END OF SECTION

SECTION 28 05 19
SECURITY DEVICES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. ESS Contractor shall provide an Electronic Security System (ESS) as indicated in the drawings and specifications. Work under this Section is to provide new ESS devices to be connected, interfaced and integrated into existing Software House C-Cure 9000 now in operation on the Brookhaven National Laboratory Campus.

B. Work includes but is not limited to card readers, magnetic contact door position switches, programmable access control units, input and output relay modules, copper and fiber optic cables, wiring electric door hardware to junction box above door, low voltage power supplies, conduit, raceways and accessories required for a complete system functioning as specified.

C. This Section describes functional requirements of security devices including manufacturer, make and model numbers of equipment.

1.2 RELATED SECTIONS

A. Section 08 71 00 Door Hardware.

B. Section 26 00 10 Electrical General Requirements.

C. Section 28 05 00 Basic Electronic Security Requirement.

PART 2 - PRODUCTS AND EXECUTION

2.1 PROPRIETARY SECURITY CONTROL EQUIPMENT

A. Access Control Panel (ACP): Software House iSTAR EDGE Intelligent Network Controller:
1. Meets following regulatory requirements: FCC Part 15, UL 294, and UL 1076.
2. Designed in accordance with U.S. Government Federal Information Processing Standard (FIPS) 140-2 and shall be listed on the FIPS 140-2 Pre-Val list.
3. Incorporate Advanced Encryption Standard (AES) 256-bit encryption for controller-to-host and controller-to-controller communications. The encryption standard shall be certified by the National Institute for Standards and Technology (NIST) as compliant with the U.S. Government's Federal Information Processing Standard (FIPS) 197.
4. Supports up to 2 directly connected readers.
5. Provided with PoE Plus module with 24 volt output compatible with electric locks specified under Division 8.
6. Communication between the System Server and the controller, and from controller to controller, is via TCP/IP only.
7. Each controller may be configured to accept IP address and device names from local DHCP (Dynamic Host Configuration Protocol), WINS (Windows Internet Naming Service) or DNS (Domain Name System) servers.
8. The controller shall have on-board 10/100bT Ethernet (RJ-45) port and shall not require external devices to connect to the network.
9. The controller shall also contain one RS 232 port for local diagnostics.
10. Provided with Cabinet Tamper normally closed and pre-wired to the enclosure door to report opening of the door as a tamper event.

11. Power fail, low battery and critically low battery inputs shall be normally closed and pre-wired from the controller power supply system to report main power fail and low battery conditions as required. The critically low battery input shall also initiate an automatic backup of all system data to compact flash memory.

B. Proximity Type Card Readers (CR):
   1. Software House Model SWH-4000 Series.
   2. Wiegand Communication Protocol.
   3. Multi-technology reader supporting the following card technologies:
      a. HID proximity.
      b. CASI® ProxLite®.
      c. Deister proximity.
      d. ISO 14443A serial number.
      e. MIFARE® serial number.
      f. DESFire serial number.
      g. ISO 14443B serial number.
      h. ISO 15693 serial number.
      i. iCLASS® serial number.
      j. MIFARE sectors.
      k. FIPS 201 PIV II.
   4. Mullion Reader: Model SWH-4000, provided where shown.
   5. Single Gang Reader: Model SWH-4100.
   6. Single Gang with Keypad: Model SWH-4200, provided where shown.
   7. All readers provided with RS-485 wiring for remote firmware flash upgrade integrated into the reader cable.
   8. All readers provided with wiring for tamper connections integrated into the reader cable.

2.2 SECURITY DEVICES AND ACCESSORIES

A. ESS Contractor shall provide devices and material required for a complete system in addition to the equipment listed as proprietary.

B. Door Position Status Switch (DS): Swinging Doors:
   1. ESS Contractor Furnished and Installed. Coordinate with Division 8.
   2. GE Sentrol Model: 1076-CH.
   3. UL listed.
   4. Recessed 3/4” steel door contact.
   5. For wood doors provide magnet mounting accessories and/or adhesives in accordance with manufacturer recommendations.
   6. Biased for higher security applications.
   7. Form C: Single Pole Double Throw (SPDT).
   8. Rated for 0.25 Amps @ 30VAC/DC.
   9. Gray color.
   10. Hermetically sealed reed switch encapsulated in polyurethane.
   11. Open or Closed Loop.
   12. 3/8” maximum gap.

C. Door Position Switch (DS): High Security Overhead Door Magnetic Contact:
   1. ESS Contractor Furnished and Installed.
   2. GE Sentrol Model 2727A.
   3. Surface Mounted.
   4. UL listed for indoor and outdoor use under UL 634.
   5. Balanced, Triple Biased, cannot be defeated with external magnet.
   6. Supervised Loop.
   7. Anodized Aluminum Housing.
   8. Flexible Stainless Steel Conduit.
   9. Single Pole Double Throw (SPDT).
   10. Gap distance of 0.7 to 2.0 inches.

D. Fiber Optic Cable:
   1. Fiber optic cables shall be provided by BNL except where otherwise noted.
   2. Provide fiber optic cables where drawings indicate fiber optic cables to be provided by ESS Contractor.
   3. Fiber optic cables shall be nonconductive multimode 50/125 micron fibers, suitable for plenum and riser installations, orange color coded, and shall meet the requirements of ANSI/TIA/EIA.

2.3 COMMAND CENTER

A. Connections to existing campus security network shall be provided by BNL.

B. Initial programming is specified in Section 16700. Data entry after system acceptance shall be provided by BNL.

2.4 INSTALLATION

A. Grounding: Electrical Contractor shall properly earth ground ESS equipment to prevent electrostatic charges and other transient electrical surges from damaging ESS panels.

B. Primary power: Electrical Contractor shall provide dedicated 120 VAC power circuits to the ESS as shown on drawings. The circuits shall be connected to the emergency power system.

C. The following general guidelines shall be followed for wiring installation:
   1. ESS Contractor shall provide cables consistent with the manufacturer's recommendations and as indicated on the contract drawings. Cables shown on contract drawings are for information only. All wiring types, sizes and quantities shall be approved by Software House Engineer prior to installation.
   2. Wiring and cables shall be run in conduit to junction boxes or enclosures concealed above accessible ceilings. Wiring and cables concealed above accessible ceilings shall be run in conduit from junction boxes and enclosures to nearest security cable tray. Cable tray is specified under section 16744 and shown on telecommunications drawings. Wiring and cables exposed to view shall be installed in metal conduit throughout.
   3. Wiring shall be appropriately color–coded with permanent wire markers.
   4. Cables shall be marked with cable markers at each end and a master list affixed to the inside of the main control panel by means of a 3 IN x 5 IN label; one label required for each sub–control and main control panel.
   5. All wiring shall be home run from each device to the main control panel without splices. Splicing of cables shall only be permitted at the above locations and at security devices. All splices at door contacts shall be tinned and soldered before being insulated by means of PVC insulating tape, crimps or heat shrink tubing.
   6. Copper conductors shall be used.
   7. Data wires shall not be enclosed in conduit or raceways containing AC power wires.
   8. Cables shall be rated for 300 volts.
   9. Devices and wiring shall be UL listed Class 2 power limited.

D. Power Line Surge Protection:
   1. ESS shall be protected from EMI and lightning surges. Equipment connected to alternating current circuits shall be protected from power line surges. Equipment protection shall withstand surge test waveforms described in IEEE C62.41. Fuses shall not be used for surge protection.

E. Sensor Device Wiring and Communication Circuit Surge Protection:
   1. Inputs shall be protected against surges induced on device wiring. Outputs shall be protected against surges induced on control and device wiring installed outdoors and as shown. Communications equipment shall be protected against surges induced on any communications circuit. Cables and conductors, except fiber optics, shall have surge protection circuits installed at each end. Protection shall be furnished at equipment, and additional triple electrode gas surge protectors rated for the application on each wireline

circuit shall be installed within 3 feet of the building cable entrance. Fuses shall not be used for surge protection.

F. Conduit shall be concealed within the building structure wherever possible.

G. All conduit and wiring installation shall be carried out in accordance with the latest edition of the National Electrical Code.

H. Flexible stainless steel conduits provided by the manufacturer with balanced magnetic switches for overhead doors and roof hatches shall not be modified in the field by shortening the conduit. Coordinate installation of signaling resistors with BNL.

2.5 WARRANTY

A. ESS Contractor shall warranty all equipment, labor, and materials for a period of one (1) year from the date of acceptance by the BNL.

END OF SECTION

SECTION 28 31 00
FIRE ALARM SYSTEM

PART 1 - GENERAL

1.1 GENERAL DESCRIPTION

A. The fire alarm system (FAS) shall be a software programmable, microprocessor-based fire alarm system using addressable device technology to provide protective premises manual and automatic fire alarm service, sprinkler supervisory and waterflow alarm service and voice alarm service.

B. System shall interface with other building systems for the purpose of initiating fire safety functions including elevator recall, elevator shutdown, HVAC fan shutdown, smoke door closure, etc.

C. Digital alarm communicator transmitter (DACT) shall transmit alarm, supervisory and trouble conditions to a continuously manned location.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this section.

B. The work covered by this section is to be coordinated with related work as specified elsewhere in the specifications. Requirements of the following sections apply:
   1. Division 26: Electrical Systems
   2. Division 23: HVAC Systems

C. The System and all associated operations shall be in accordance with the following:
   1. NFPA 72, National Fire Alarm Code (latest edition).
   2. NFPA 70, National Electrical Code (latest edition).
   3. New York State Building Code (NYSBC).
   4. New York State Mechanical Code (NYSMC).
   5. Underwriter Laboratories (UL).
   6. Factory Mutual (FM).
   7. BNL ES&H Standard 4.4.0.
   8. ADA/ABA Accessibility Guidelines.

1.3 SYSTEM DESIGN REQUIREMENTS

A. The fire alarm control panel (FACP) shall provide panel space to accommodate future system expansion by 20 percent.

B. Initiating device circuits (IDC) shall be Style B.

C. Signal line circuits (SLC) for addressable devices shall be Style 4 and shall be sized and installed to accommodate a 50 percent future increase in number of devices attached to each circuit.

D. Notification appliance circuits (NAC) shall be Style Y. Audible appliance NAC's shall be sized and installed to accommodate a 100 percent future increase in the number of devices attached to a circuit with a maximum power loss of 50 percent (3 dB loss). Visual appliance NAC's shall be sized and installed to accommodate a 50 percent future increase in the number of devices attached to a circuit with a maximum voltage drop of 10 percent.

E. In high ambient noise areas, i.e. mechanical rooms, motor bell/strobe combination shall be used.

F. DC power supplies shall be sized to accommodate a 50 percent increase in connected load. Audio amplifiers shall be sized to accommodate a 100 percent increase in connected load.

G. The control unit shall receive 120 VAC power via a dedicated branch circuit with a disconnecting means, and shall be identified (in red marking) as “Fire Alarm Circuit”. The location of the circuit disconnecting means shall be permanently identified at the fire alarm control panel.

H. The system shall automatically transfer to battery standby upon failure of 120 VAC power. Loss of primary power shall sound a trouble signal at the FACP. The FACP shall indicate when the system is operating on an alternate power supply. The system shall be provided with sufficient battery capacity to operate the entire system upon loss of normal 120 VAC power in a normal supervisory mode for a period of 24 hours with 15 minutes of “all-call” alarm operation at the end of this period.

I. The system batteries shall be supervised so that a low battery or a depleted battery condition, or disconnection of the battery shall be indicated at the control unit and displayed for the specific fault type. The system shall support NAG Lockout feature to prevent subsequent activation of Notification Appliance Circuits after a Depleted Battery condition occurs in order to make use of battery reserve for front panel annunciation and control.

J. The system shall support 100 percent of addressable devices in alarm or operated at the same time, under both primary (AC) and secondary (battery) power conditions.

K. All circuits requiring system-operating power shall be 24 VDC and shall be individually fused at the control unit.

L. Remote Access:
   1. FACP shall have the capability to provide Remote Access through a Dial-Up Service Modem using the public switched telephone system of a private switched telephone system.
   2. A personal computer or technician’s laptop, configured with terminal emulation software shall have the ability to access the FACP for diagnostics.
   3. FACP shall have the capability to provide third party access through serial interface connections and be agency listed for specific interfaces and for the purpose.

1.4 SYSTEM OPERATION

A. Required Functions: The following are required system functions and operating features:
   1. Priority of Signals: Fire alarm events have highest priority. Subsequent alarm events are queued in the order received and do not affect existing alarm conditions. Priority Two, Supervisory and Trouble events have second-, third-, and fourth level priority, respectively. Signals of a higher-level priority condition occurred first. Annunciate all events regardless of priority or order received.
   2. Non Interfering: An event on one zone does not prevent the receipt of signals from any other zone. All zones are manually resettable from the FACP after the initiating device or devices are restored to normal. The activation of an addressable device does not prevent the receipt of signals from subsequent addressable device activations.
   3. Transmission to Remote Central Station: Automatically route alarm, supervisory, and trouble signals to a BNL remote fire command center.
   4. Annunciation: Operation of alarm and supervisory initiating devices shall be annunciated at the FACP, indicating the location and type of device.
   5. General Alarm: A system general alarm initiated by a manual fire alarm station, sprinkler waterflow alarm switch, spot type smoke detector, spot type heat detector or air-sampling smoke detector shall include:
      a. Indication of alarm condition at the FACP (and the annunciators).
      b. Identification of the device or zone that is the source of the alarm at the FACP and the annunciators.
      c. Operation of audible and visible notification devices throughout the building until silenced at FACP.
      d. Closing doors normally held open by magnetic door holders.
      e. Shutting down supply and return fans Dampers associated with each fan shall close when their associated fan stops.

f. Notifying the BNL fire department.

6. In addition to the general alarm functions above:
   a. Operation of an elevator machine room smoke detector, elevator hoistway smoke detector or an elevator lobby smoke detector at any floor other than the first floor shall signal the associated elevator to return to the first floor per ASME A17.1.
   b. Operation of an elevator lobby smoke detector at the first floor shall signal the associated elevator to return to the designated alternate floor per ASME A17.1.
   c. Operation of an elevator hoistway smoke detector or elevator machine room smoke detector shall signal the associated elevator to flash the fireman's hat warning signal in the elevator cab.
   d. Operation of an elevator hoistway heat detector or elevator machine room heat detector shall signal the elevator shunt-trip disconnect switch to open and remove power from the affected elevator per ASME A17.1.
7. Supervisory Operations: Upon activation of a sprinkler system supervisory device such as fire pump controller relay, low air pressure switch, valve position supervisory switch or activation of a duct mounted smoke detector, the system shall operate as follows:
   a. Activate the system supervisory service audible signal and illuminate the LED at the control unit and the graphic annunciator.
   b. Pressing the Supervisory Acknowledge key will silence the supervisory audible signal while maintaining the Supervisory LED "on" indicating off-normal condition.
   c. Record the event in the FACP historical log.
   d. Transmission of supervisory signal to BNL fire department.
8. In addition to the supervisory operations above, operation of a duct mounted smoke detector shall shut down its associated fan. Dampers associated with the fan shall close when the fan stops running for any reason.
9. Restoring the condition shall cause the Supervisory LED restore system to normal.
10. Alarm Silencing: If the "Alarm Silence" button is pressed, all audible and visible alarm signals shall cease operation.
11. System Reset:
    a. The "System Reset" button shall be used to return the system to its normal state. Display messages shall provide operator assurance of the sequential steps as they occur. The system shall verify all circuits or devices are restored prior to resetting the system to avoid the potential for re-alarming the system.
    b. Should an alarm condition continue, the system will remain in an alarmed state.

B. Analog Smoke Sensors:
1. Monitoring: FACP shall individually monitor sensors for calibration, sensitivity, and alarm condition, and shall individually adjust for sensitivity. The control unit shall determine the condition of each sensor by comparing the sensor value to the stored values.
2. Environmental Compensation: The FACP shall maintain a moving average of the sensor's smoke chamber value to automatically compensate for dust, dirt, and other conditions that could affect detection operations.
3. Programmable Sensitivity: Photoelectric Smoke Sensors shall have 7 selectable sensitivity levels ranging from 0.2 percent to 3.7 percent, programmed and monitored from the FACP.
4. Sensitivity Testing Reports: The FACP shall provide sensor reports that meet NFPA 72 calibrated test method requirements. The reports shall be viewed on a CRT Display or printed for annual recording and logging of the calibration maintenance schedule.
5. The FACP shall automatically indicate when an individual sensor needs cleaning.
6. The FACP shall continuously perform an automatic self-test on each sensor which will check sensor electronics and ensure the accuracy of the values being transmitted. Any sensor that fails this test shall indicate a trouble condition.
7. Magnet test activation of smoke sensors shall be indicated as an alarm but distinguished by its label and history log entry as being activated by a magnet.

C. Surge Protection:
   1. Install surge protection on normal AC power for the FACP and its accessories. Install on all system wiring external to the building housing and the FACP as recommended by the manufacturer, and per Article 800 of the National Electric Code.

1.5 SUBMITTALS

A. General: Submit the following according to Conditions of Contract and Division 1 Specification Sections:
   1. Product data sheets for system components highlighted to indicate the specific products, features, or functions required to meet this specification. Alternate or as-equal products submitted under this contract must provide a detailed line-by-line comparison of how the submitted product meets, exceeds, or does not comply with this specification.
   2. Wiring diagrams from manufacturer.
   3. Shop drawings showing system details including location of FACP, all devices, riser diagram, conduit runs, circuiting and details of graphic annunciator.
   4. System power and battery charts with performance graphs and voltage drop calculations to assure that the system will operate per the prescribed backup time periods and under all voltage conditions per UL and NFPA standards.
   5. System operation description including method of operation and supervision of each type of circuit and sequence of operations for all manually and automatically initiated system inputs and outputs. A list of all input and output points in the system shall be provided with a label indicating location of use of IDC, NAC, relay, sensor, and auxiliary control circuits.
   6. Submit scaled and dimensioned isometric drawings of the air sampling network piping showing all bends, tees and sampling ports. Submit a printout of the manufacturer's calculation program for determining the size of sampling ports and verifying that smoke transport times are shorter than noted in manufacturer's instructions. Submit full size detail drawings of sampling ports for approval by the Architect.
   7. Operating instructions for FACP.
   8. Operation and maintenance data for inclusion in Operating and Maintenance Manual. Include data for each type product, including all features and operating sequences, both automatic and manual. Provide the names, addresses, and telephone numbers of service organizations.
   9. Product certification signed by the manufacturer of the fire alarm system components certifying that their products comply with indicated requirements.
   10. Record of field tests of system.
   11. Record of Completion (supplied by BNL) based on NFPA 72 (paragraph 1c).

1.6 QUALITY ASSURANCE

A. Installer Qualifications: A factory authorized installer is to perform the work of this section.

B. Each and all items of the Fire Alarm System shall be listed as a product of a single fire alarm manufacturer under the appropriate category by Underwriters Laboratories, Inc. (UL) and shall bear the "UL" label and/or FM listed.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. The manufacturer shall be a nationally recognized company specializing in fire alarm and detection systems. This organization shall employ factory trained and NICET certified technicians.

B. Simplex Grinnell – 4100U FACP and all peripherals. Contact (Kevin Quigley @ (631) 404-1000

C. Siemens - XLSV and all peripherals. Contact Paul Sanfilippo @ (516) 796-6121

2.2 MATERIALS

A. Fire Alarm Control Panel: (No approved equal):
   1. The fire alarm system control panel (s) shall be Simplex Model 4100U Series or Siemens XLSV and comply with UL 864, "Control Units for Fire-Protective Signaling Systems".
   2. The following FACP hardware shall be provided:
      a. Power limited base panel with 120 VAC input power.
      b. 2,000 point capacity where (1) point equals (1) monitor (input) or (1) control output.
      c. 2,000 points of annunciation where one (1) point of annunciation equals:
         1) (1) LED driver out put on a graphic drivers or (1) switch input on a graphic switch input module.
         2) (1) LED on panel or (1) switch on panel.
      d. Provide battery voltage and ammeter readouts from the LCD display.
      e. Signal card circuits to match project requirements with 20 percent spare.
      f. Class B zone modules to match project requirements with 20 percent spare.
      g. (1) auxiliary electronically resetable fused 2A @ 24 VDC output, programmable disconnect operation for 4-wire detector reset door release auxiliary use.
      h. (1) auxiliary relay, SPDT 2A @32 VDC, programmable as a trouble relay either as normally energized or de-energized or as an auxiliary control.
      i. (1) 4-point relay module-10 amp.
      j. Minimum (4) Form "C" auxiliary relay circuits (Form C contacts rated 2A, 24 VDC, resistive), operation is programmable for trouble alarm, supervisory of other fire response functions. Relays shall be capable of switching up 1/2 A @ 120 VAC inductive.
      k. Remote Unit Interface: Supervised serial communication channel for control and monitoring of remotely located annunciators and I/O panels.
      l. Common event DACT or Point Reporting DACT.
      m. Service Port Modem for dial in passcode access to all fire control panel information.
      n. (2) 12 VDC batteries. Capable of maintaining system in normal supervisory mode for 48 hours plus 15 minutes of alarm operation.
   3. Cabinet: Lockable with "B" key steel enclosure. Arrange unit so all operations required for testing or for normal care and maintenance of the system are performed from the front of the enclosure. If more than a single unit is required to form a complete control unit, provided exactly matching modular unit enclosures.
   4. Alphanumeric Display and System Controls: Panel shall include a minimum of 80 character LCD display to indicate alarm, supervisory, and component status messages and shall include a keypad for use in entering and executing control commands.
   5. Software: The fire alarm system shall allow for loading and editing instructions and operating sequences as necessary. Capability of storing and downloading while the system is in operation, and a backup system, shall be included. On-site programming to accommodate system expansion is required. All software operations shall be stored in a non-volatile programmable memory within the fire alarm control unit. Loss of primary and secondary power shall not erase the instructions stored in memory.
   6. History Logs: Provide a means to recall alarms and trouble conditions in chronological order for the purpose of recreating an event history. A separate alarm and trouble log shall be provided.
   7. Recording of Events: Record all alarm, supervisory, and trouble events by means of a system printer. Include the type of signal (alarm, supervisory, or trouble), the device identification, date and time of the occurrence. Differentiate alarm signals from all other printed indications.

B. Addressable Manual Pull Stations:
   1. Shall be Addressable Single action type, red Lexan or metal, and finished in red with molded, raised-letter operating instructions of contrasting color. Station will mechanically latch upon operation and remain so until manually reset by opening with a key common with the control units.

2. Protective Shield (if required) shall be tamperproof, clean Lexan shield and red frame that easily fit over manual pull stations.

C. Addressable Spot-Type Photoelectric Only Smoke Sensors: (Do not use ionization type.)
   1. Shall comply with UL 268, "Smoke Detectors for Fire Protective Signaling Systems", including the following features:
      a. Operating Voltage: 24 VDC, nominal.
      b. Self-Restoring: Detectors do not required resetting or readjustment after actuation to resort normal operation.
      c. Plug-In Arrangement: Sensor and associated electronic components are mounted in a module that connects to a fixed base with a twist-locking plug connection. Base shall provide break off plastic tab that can be removed to engage the head/base locking mechanism. No special tools shall be required to remove head once it has been locked. Removal of the detector head shall interrupt the supervisory circuit of the fire alarm detection loop and cause a trouble signal at the control unit.
      d. Each detector assembly shall contain a magnetically actuated test switch to provide for easy alarm testing at the sensor location.
      e. Ease sensor base shall contain LED that will flash each time it is scanned by the Control Unit (once every 4 seconds). In alarm condition, the detector head LED shall be on steady.
      f. Each sensor shall be scanned by the Control Unit for its type identification to prevent inadvertent substitution of another sensor type. Upon detection of a "wrong device", the control unit shall operate with the installed device at the default alarm settings for that sensor; 2.5 percent obscuration for photoelectric sensor, 135˚F and 15˚F rate-of-rise for the heat sensor, but shall indicate a "Wrong Device" trouble condition.
      g. The sensor's electronics shall be immune from false alarms caused by EMI and RFI. Removal of the sensor head for cleaning shall not require the setting of the addresses.

D. Addressable Duct-Mounted Photoelectric Smoke Detector:
   1. Shall be photoelectric type, with sampling tube of design and dimensions as recommended by the manufacturer for the specific duct size and installation conditions where applied and shall incorporate the following features:
      a. The Duct Housing shall provide a supervised relay driver circuit for driving up to 15 relays with a single "Form C" contact rated at 7 A @ 28 VDC or 10 A @ 120 VDC.
      b. Duct Housing shall provide a relay control indicator Yellow LED.
      c. Compact Duct Housing shall have a transparent cover to monitor for the presence of smoke. Cover shall secure to housing by means of four (4) captive fastening screws.
      d. Duct Housing shall provide two (2) Test Ports for measuring airflow and for testing. These ports will allow aerosol injection in order to test the activation of the duct smoke detector.
      e. Duct Housing shall provide a magnetic test area and red sensor status LED.
      f. For maintenance purposes, it shall be possible to clean the duct housing sampling tubes by accessing them through the duct housing front cover.
      g. Each duct detector shall have a Remote Test Station with an alarm LED and test switch where required by BNL.

E. Addressable Heat Sensors:
   1. Shall be combination fixed-temperature and rate-of-rise unit with plug-in base and alarm indication lamp: 135˚F fixed-temperature setting except as indicated.

F. Alarm-Notification Appliances: Wall mount all audible/visual devices:
   1. Audible/visible device shall be speaker/strobes that match fire alarm panel make and model with field selectable wattage ranges from 1/8 watt to 8 watts. For outdoor use, use waterproof speaker. Use Wheelock motor bell/strobe in high noise areas in place of speaker/strobe.

2. Notification Appliance Circuit provided synchronization of strobes at a rate of 1 Hz and operates horns with a Temporal Code Pattern operation. The circuit shall provide the capability to silence the audible signals, while the strobes continue to flash over a single pair of wires. The capability to synchronize multiple notification appliance circuits shall be provided.

G. Addressable Circuit Interface Modules:
   1. There shall be two types of modules:
      a. Type 1: Monitor Circuit Interface Module:
         1) For conventional 2-wire smoke detector and/or contact device monitoring with Class B or Class A wiring supervision. The supervision of the zone wiring will be Class B. This module will communicate status (normal, alarm, trouble) to the FACP.
         2) For conventional 4-wire smoke detector with Class B wiring supervision. The module will provide detector reset capability and over-current power protection for the 4-wire detector. This module will communicate status (normal, alarm, trouble) to the FACP.
      b. Type 2: Line Powered Monitor Circuit Interface Module:
         1) This type of module is an individually addressable module that has both its power and its communications supplied by the two wire multiplexing signaling line circuit. It provided location specific addressability to an initiating device by monitoring normally open dry contacts. This module shall communicate four zone status conditions (normal, alarm, current limited, trouble) to the FACP.
         2) All Circuit Interface Module shall be supervised and uniquely identified by the control unit. Module identification shall be transmitted to the control unit for processing according to the program instructions. Modules shall have an onboard LED to provide an indication that the module is powered and communicating with the FACP. The LED shall provide a troubleshooting aid since the LED blinks on poll whenever the peripheral is powered and communicating.

H. Air Sampling Smoke Detectors: Fenwal Analaser II. There is no approved equal.

2.3 WIRING

A. Fire alarm wiring to be solid only.

B. Fire alarm wiring shall be 16 AWG minimum, 2 pair twisted shielded FPLR or FPLP (where required) for fire alarm devices.

C. Audio/visual circuits shall use 2 pair twisted shielded #12 AWG FPLR or FPLP for bell/strobe combination. For speaker/strobe combination: Speaker (1) pair #16 AWG (min.) twisted, shielded. Strobe: (1) pair #14 AWG (min.) unshielded.

D. Provide at least two spare cables for each type of circuit (signaling line, audible notification appliance, visual notification appliance, auxiliary power, etc.) from the FACP to each floor terminal cabinet. Label each cable at both ends to identify the cable and its intended use.

2.4 SPARE PARTS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents:
   1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but not less than 1 unit.
   2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but not less than 1 unit.
   3. Smoke, Fire, and Flame Detectors: Quantity equal to 10 percent of amount of each type installed, but not less than 1 unit of each type.
   4. Detector Bases: Quantity equal to 2 percent of amount of each type installed, but not less than 1 unit of each type.

5. Keys and Tools: One extra set for access to locked and temperproofed components.
6. Audible and Visual Notification Appliances: One of each type installed.
7. Fuses: Two of each type installed in the system.
8. Additional amplifiers for speaker system if back-up amplification is not installed.

PART 3 - EXECUTION

A. Installation General:
   1. Install system components and all associated devices in accordance with applicable NFPA standards and manufacturer's recommendations.
   2. Installation personnel shall be supervised by persons who are qualified and experienced in the installation, inspection, and testing of fire alarm systems. Examples of qualified personnel shall include, but not be limited to, the following:
      a. Factory trained and certified personnel.

B. Furnish all materials, labor, equipment and accessories, including but not limited to, fire alarm systems, initiating devices, notification appliances, controls, supervisory devices and accessories:
   1. The Fire Alarm System shall consist of all necessary hardware equipment and software programming to perform the following functions:
      a. Fire alarm and detection operations.
      b. Control and monitoring of elevators, smoke control equipment, door hold-open devices, fire suppression systems, emergency power systems, and other equipment as indicated in the drawings and specifications.
   2. Notify a BNL representative two (2) days in advance of any necessary interruption of the fire alarm system required to complete the scope of this Contract. All final connections and terminations to the existing system or interruption of service to existing equipment will be performed by BNL personnel. Obtain from the BNL representative standard BNL "Out of Service" signs to be installed on all new fire alarm stations and/or fire alarm stations rendered temporarily inoperable during the scope of this Contract. Cover all "Out of Service" fire alarm stations with cardboard enclosures until activated. Remove and return signs to BNL representative after stations are activated. Paint fire alarm junction boxes "BLUE" and mark with adhesive labels furnished by BNL.
   3. Record of Completion:
      a. See NFPA 72 4.5.1.3: Requirements for Certificate of Completion. Contractor to comply with NFPA 72 and all BNL standards. Issue to BNL a "Record of Completion" after completing operational acceptance tests. (Record of Completion form shall be supplied to the Contractor by BNL).
      b. Every system shall include the following documentation, which shall be delivered to BNL upon final acceptance of the system. Final payment will be dependant on all items below being submitted to BNL:
         1) A manufacturer's operations and maintenance manual and installation instructions covering all systems and system equipment.
         2) As-built drawings.
         3) Acceptance Tests: Upon completion of an installation of alterations, all functions of the system shall be tested, including operation of the system in various alarm and trouble modes for which it is designed (e.g., open circuit, grounded circuit, power outage, etc.). Satisfactory tests of the entire system shall be made in the presence of BNL Construction Inspector and BNL's authority having jurisdiction.
         4) Provide training to cognizant BNL personnel on installation, testing and maintenance of the system installed or altered.
         5) Record of Completion form issued by BNL-Completed.

END OF SECTION

DIVISION 31

EARTHWORK

SECTION 31 10 00
SITE CLEARING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Site clearing, tree protection, stripping topsoil and demolition.

B. Related Sections include but are not necessarily limited to:
   1. Division 0 - Procurement and Contracting Requirements.
   2. Division 1 - General Requirements.
   3. Section 31 22 00 – Site Excavation and Rough Grading.
   4. Section 31 22 19 - Topsoiling and Finished Grading.
   5. Section 31 25 00 - Soil Erosion and Sediment Control.

1.2 QUALITY ASSURANCE

A. The Contractor shall submit a written description of the proposed equipment to be used for clearing and grubbing before work begins. Equipment will be inspected by BNL equipment inspector prior to use. The Contractor shall submit a plan for the use of this equipment detailing the location(s) to be used, the work safety zone around the equipment, operational requirements or restrictions, etc. The Contractor's approved Health and Safety Plan must include the appropriate personnel and environmental safety provisions for use of such equipment.

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION

3.1 PREPARATION

A. Provide barricades, coverings and other protection necessary to prevent drainage to existing improvements to remain.
   1. Protect improvements on adjacent land.
   2. Restore improvements damaged by this work to original condition, as acceptable to BNL, other parties, and authorities having jurisdiction.

B. Protect existing trees and other vegetation to remain against damage.
   1. Do not smother trees by stockpiling construction materials or excavated materials within drip line.
   2. Avoid foot or vehicular traffic or parking of vehicles within drip line.
   3. Provide temporary protection as required.

C. Repair or replace trees and vegetation damaged by construction operations.
   1. Repair to be performed by a qualified tree surgeon.
   2. Remove trees, listed as to remain, which cannot be repaired due to Contractor's operations, and replace with a quantity of trees with total caliper equal to that of the trees lost.

D. BNL will obtain authority for removal and alteration any work on adjoining land.

3.2 SITE CLEARING

A. Topsoil Removal:
   1. Topsoil: Surface soil found in depth of not less than 4 IN and reasonably free of subsoil, objects over 2 IN in any dimension, weeds, and roots.
   2. Strip topsoil to depths encountered.
      a. Remove heavy growths of grass before stripping.
      b. Stop topsoil stripping sufficient distance from such trees to prevent damage to main root system.
      c. Separate from underlying subsoil or objectionable material.
   3. Stockpile topsoil where directed.
      a. Construct storage piles to freely drain surface water.
      b. Seed or cover storage piles to prevent erosion.
   4. Borrow topsoil:
      a. Reasonably free of subsoil, objects over 3 IN DIA, weeds and roots.

B. Clearing:
   1. Clear from within limits of construction all trees marked to be removed.
      a. Include shrubs, brush, downed timber, rotten wood, heavy growth of grass and weeds, vines, rubbish, structures and debris.

C. Grubbing (remove):
   1. Grubbing shall consist of the removal of all vegetation including trees, shrubs and ground covers. Stumps and roots larger than 2 IN diameter, and matted root systems shall be removed to a depth not less than 18 IN below the original ground surface. Work shall also include the removal and disposal of all felled trees, brush and stumps.
   2. Use only hand methods for grubbing adjacent to the tree zone to be protected.

D. Disposal of Waste Materials:
   1. Do not burn combustible materials on site.
   2. Remove all waste materials from site.
   3. Do not bury organic matter on site.

3.3 ACCEPTANCE

A. Upon completion of the site clearing, obtain BNL's acceptance of the extent of clearing, and depth of stripping.

END OF SECTION

SECTION 31 22 00
SITE EXCAVATION AND ROUGH GRADING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Definitions:
   1. Unsuitable material: Debris and/or soil material judged unsuitable by Engineer for support of slabs or other site improvements.
   2. Engineer: Soils Engineer employed by BNL, empowered to conduct inspections and make approvals.

B. Related sections include but are not necessarily limited to:
   1. Division 0 - Procurement and Contracting Requirements.
   2. Division 1 - General Requirements.
   3. Section 02 41 00 - Site Clearing.
   4. Section 31 22 19 - Topsoiling and Finished Grading.
   5. Section 31 25 00 - Soil Erosion and Sediment Control.

1.2 QUALITY ASSURANCE

A. Compaction density test:
   1. Modified Proctor, ASTM-D1557.

B. Layout work by Surveyor registered in State of New York.

C. BNL will hire an independent soils laboratory to conduct in place moisture and density tests.
   1. Contractor to pay for retests of material not passing initial tests.

1.3 SUBMITTALS

A. Material Test Reports: From a qualified testing agency to comply with the following requirements:
   1. Classify on-site or borrow soil material to be used for fill and backfill in accordance with ASTM D 2487.
   2. Compaction curve for each on-site or borrow soil material to be used for fill and backfill in accordance with ASTM D 1557.

B. Preexcavation Photographs or Videotape: Identify existing conditions of adjacent construction and existing conditions to remain as required by BNL and submit to BNL before work begins.

1.4 JOB CONDITIONS

A. Site information: Data in subsurface investigation reports was used for the basis of the design and are available to the Contractor for information only. Conditions are not intended as representations or warranties of accuracy or continuity between soil borings. BNL will not be responsible for interpretations or conclusions drawn from this data by Contractor.
   1. Additional test borings and other exploratory operations may be performed by Contractor, at the Contractor's option; however, no change in the Contract Sum will be authorized for such additional exploration.
   2. Subsurface information:
      a. Test boring logs are available for information only. BNL assumes no responsibility for the accuracy of the information.
      b. The test borings are believed to be a reasonable indication of existing soil conditions. The Contractor shall verify conditions affecting the work and make his own interpretation of the test boring information.

c. A geotechnical engineering report has been prepared for this project by GEI Consultants and is available to Bidders and Contractors for information purposes and is not a part of the Contract Documents. The location and log of each boring is shown in this report for the Contractor's information. The depth of the water table at the time of the boring is shown on the log. This report was prepared for design purposes only and may not be sufficient to prepare an accurate bid or for other purposes. Contractors wishing copies of the report may secure them from GEI Consultants by calling 860-368-5300 at a nominal charge with the understanding that its scope is limited to design considerations.

B. Protect existing facilities, utilities (overhead and underground), sidewalks, and pavement.
   1. Repair damaged items.
   2. Cost of repair to items not indicated paid by BNL.
   3. Notify BNL and make emergency repair as directed.

C. Protect graded areas against erosion.
   1. Re-establish grade where settlement or washing occurs at no extra cost.

D. Site may have buried potentially hazardous materials.
   1. If encountered, contact BNL and Architect.
   2. BNL will be responsible for removal and disposal.

E. Traffic: Minimize obstruction or interference with adjacent roads, streets, walks, and occupied or used facilities during earthwork operations:
   1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from BNL.
   2. Provide alternate routes around closed or obstructed traffic ways as required by BNL.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Structural Fill:
   1. Structural fill shall consist of hard, durable sand and gravel, free of clay, organic matter, surface coatings, and other deleterious materials. Soil finer than the No. 200 sieve (the "fines") shall be nonplastic. Structural fill shall meet the following gradation requirements:

Sieve Size	Percent Passing By Weight
3 inches	100
1/2 inch	50 – 100
No. 4	35 – 100
No. 16	20 – 90
No. 50	5 – 40
No. 200 (fines)	0 – 10

   2. In addition to complying with the above gradation requirements, the structural fill shall be well graded, i.e., there should have sufficient amounts of all particle sizes within the size range of the material.
   3. Structural fill shall be used within the building limits and where indicated on the plans (Note: Natural Sand can be considered suitable subgrade for building support. However, after excavation to the suitable subgrade level, the Sand layer should be proofrolled (Section 5.1 of the Geotechnical Report).

4. Excavated Natural Sand to be used for fill below foundations will generally be suitable for reuse as structural fill. However, additional gradation tests should be performed on the excavated Sand to determine its suitability as structural fill (Section 4.6 of the Geotechnical report).

B. Common Fill:
1. Common fill (identified as fill in the Geotechnical Report) shall consist of hard, durable sand and gravel, free of clay, organic matter, surface coatings, and other deleterious materials. Soil finer than the No. 200 sieve (the "fines") shall be nonplastic. Common fill shall meet the following gradation requirements:

Sieve Size	Percent Passing By Weight
6 inches	100
3 inches	80 – 100
No. 4	20 – 100
No. 200 (fines)	0 – 20

C. Aggregate Subbase:
1. Aggregate subbase shall consist of 3/8 inch minus crushed stone, and shall consist of hard, durable, crushed or broken rock material, free from loam or clay, surface materials, or other deleterious materials. The material shall conform to the following gradation requirements:

Sieve Size	Percent Passing By Weight
1/2 inch	100
3/8 inch	85 – 100
No. 4	10 – 30
No. 8	0 – 10
No. 16	0 – 5

PART 3 - EXECUTION

3.1 PREPARATION

A. Layout units, structures, piping, roads, parking areas and walks and establish their elevations.

B. Perform other layout work required.

C. Replace benchmarks to original location and elevation if displaced or destroyed.

3.2 GENERAL

A. Overexcavate soil below paving as shown on drawings.

B. Excavate and grade materials to design elevations.

C. Excavate and grade site to subgrades of paved and unpaved areas as indicated.

D. Excavate for miscellaneous footings, slabs, walks and other structures.

E. Cut and fill as required to bring existing grades to subgrades.

F. Furnish and place additional approved material required to bring subgrade to proper line and grade.

G. During construction, shape and drain embankments and excavation.

H. Maintain ditches and drains to provide drainage.

I. Provide pumping if required.

J. Remove unsuitable materials which cannot be compacted as specified and replace with suitable material.
   1. Dispose material off site as directed.

K. Remove materials unsuitable to receive fill and replace with suitable material.

3.3 EXCAVATION, GENERAL

A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions:
   1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

3.4 LAYOUT FOR ROUGH GRADING

A. Before fill is started, scarify to a minimum depth of 6 IN under new roads, parking lots, or streets or on steep slopes.

B. Construct embankments and fills to lines and grades.

C. Make completed fill correspond to shape of typical cross section or contour indicated regardless of method used to indicate shape, size, and extent of line and grade of work.

D. Ensure that stones larger than 3 IN, are not placed in upper 8 IN of fill or embankment.

E. In areas where existing ground surface is steeper than one vertical to four horizontal, bench and scarify surface in order to spread fill horizontally so that fill material will bond with existing surface.

F. Place and compact fill material in 8 IN thick layers to required elevations.

G. Place soil fill on subgrades free of mud, frost, snow, or ice. Fill materials should not be placed on soils that have been recently subjected to precipitation or saturation. All wet soils should be removed or allowed to dry prior to continuation of fill placement operations. Borrow fill materials, if required, should not contain wet or frozen materials at the time of placement.

3.5 SUBGRADE INSPECTION (PROOF ROLLING)

A. Notify Geotechnical Engineer when excavations have reached required subgrade.

B. Proof-roll subgrade in the presence of the Geotechnical Engineer.

C. Proof-roll subgrade below pavements to identify soft pockets and areas of excess yielding. Do not proof-roll wet or frozen subgrades:
   1. Proof-roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 20 tons.
   2. Proof-roll subgrade in two directions perpendicular to each other. Vehicle speed shall not exceed 3 MPH.
   3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping and replace with compacted engineered fill.
   4. In small areas where proof rolling is not practical, dynamic cone penetration test may be performed.

D. Subgrades damaged by freezing, frost, rain, ponding water, or construction operations shall be reconstructed

3.6 AGGREGATE SUBBASE COURSE

A. Place subbase course on subgrades free of mud, frost, snow, or ice:

1. Shape aggregate subbase course to required crown elevations and cross-slope grades.
2. A layer of aggregate subbase material 6 IN or less can be placed as a single layer and compacted.
3. Aggregate subbase material exceeding 6IN in thickness shall be placed in equal thickness and compacted. No layer shall exceed 6 IN in depth.
4. Compact aggregate subbase course at optimum moisture content at a minimum 95 percent of maximum dry unit weight according to ASTM D 1557.

3.7 SOIL MOISTURE CONTROL

A. Each fill or backfill soil layer should be within 2 percent of optimum moisture content before compacting:
   1. Subgrade soils exceeding optimum moisture content by 2 percent shall be removed and replaced with satisfactory soil.

3.8 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Soil layers compacted by heavy equipment shall not exceed 8 IN in depth.

B. Soil layers to be compacted by hand-operated tampers shall not exceed 4 IN in depth.

C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 1557:
   1. Structural fill shall be compacted in maximum 9 inch thick, loose lifts to at least 95 percent of the maximum dry density determined in accordance with ASTM D 1557 (Modified AASHTO Compaction).
   2. Common fill shall be compacted in maximum 12 inch thick, loose lifts to at least 92 percent of the maximum dry density determined in accordance with ASTM D 1557 (Modified AASHTO Compaction).
   3. Aggregate subbase shall be compacted in maximum 9 inch thick, loose lifts, and compacted with 4 to 6 passes of vibratory compaction equipment.

3.9 GRADING

A. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:
   1. Lawn or Unpaved Areas: Plus or minus 1 IN.
   2. Walks: Plus or minus 1 IN.
   3. Pavements: Plus or minus 1/2 IN.

3.10 FIELD QUALITY CONTROL

A. Testing Agency: BNL will engage a qualified independent geotechnical engineering testing agency to perform field quality-control testing. The Geotechnical Engineer shall be a representative of BNL.

B. The testing agency will be responsible for inspecting and testing subgrades for each fill or backfill layer accordance with ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:
   1. Paved Areas: At subgrade and at each compacted fill and backfill layer, at least one (1) test for every 2000 SQ FT or less of paved area, but in no case fewer than three (3) tests.
   2. Retaining Wall Backfill: At each compacted backfill layer, at least one (1) test for each 100 FT or less of wall length, but no fewer than two (2) tests.

C. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.

3.11 PROTECTION

A. Protect graded areas from traffic, freezing, and erosion.

B. Repair and reestablish grades in areas that have eroded, settled or disturbed by construction operations or weather conditions. Compact areas as specified.

C. Remove trash and debris from site.

3.12 LAYOUT FOR ROUGH GRADING

A. BNL to review rough grade.

END OF SECTION

SECTION 31 22 19
TOPSOILING AND FINISHED GRADING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Topsoiling and finished grading.

B. Related Sections include but are not necessarily limited to:
   1. General Conditions Governing All Contracts.
   2. Section 31 10 00 - Site Clearing.
   3. Section 31 22 00 - Site Excavation and Rough Grading.
   4. Section 31 25 00 - Soil Erosion and Sediment Control.
   5. Section 32 92 19 - Seeding.
   6. Section 32 92 22 - Wild Flower Seeding.
   7. Section 32 93 13 - Plants and Planting.

C. Location of Work: All areas within limits of grading and all areas outside limits of grading which are disturbed in the course of the work.

1.2 SITE CONDITIONS

A. Verify amount of topsoil stockpiled and determine amount of additional topsoil, if necessary to complete work.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Topsoil:
   1. Original surface soil typical of the area.
      a. Shall meet the requirements of NYSDOT Topsoil Section 713-01.
   2. Existing topsoil stockpiled under Section 31 10 00.
   3. Capable of supporting native plant growth.

2.2 TOLERANCES

A. Finish Grading Tolerance: 0.1 FT plus/minus from required elevations.

PART 3 - EXECUTION

3.1 PREPARATION

A. Correct, adjust and/or repair rough graded areas.
   1. Cut off mounds and ridges.
   2. Fill gullies and depressions.
   3. Perform other necessary repairs.
   4. Bring all sub-grades to specified contours, even and properly compacted.

B. Loosen surface to depth of 2 IN, minimum.

C. Remove all stones and debris over 2 IN in any dimension.

3.2 PLACING TOPSOIL

A. Do not place when subgrade is wet or frozen enough to cause clodding.

B. Spread to compacted depth of 4 IN for all disturbed earth areas.

C. If topsoil stockpiled is less than amount required for work, furnish additional topsoil at no cost to BNL.

D. Provide finished surface free of stones, sticks, or other material 2 IN or more in any dimension.

E. Provide finished surface smooth and true to required grades.

F. Restore stockpile area to condition of rest of finished work.

3.3 ACCEPTANCE

A. Upon completion of topsoiling, obtain BNL's acceptance of grade and surface.

B. Make test holes where directed to verify proper placement and thickness of topsoil.

END OF SECTION

SECTION 31 23 00

BUILDING EXCAVATION, FILLING, AND BACKFILLING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Definitions:
   1. Unsuitable material: Debris and/or soil material (Common Fill – Fill) judged unsuitable by Geotechnical Engineer for support of slabs and foundations or for use as a fill or backfill material.
   2. Maximum dry density: As determined using ASTM-D1557 (Modified Proctor).
   3. Geotechnical Engineer: Geotechnical Engineer registered in the state of New York employed by BNL to inspect foundation work.

1.2 QUALITY ASSURANCE

A. Site Information: Refer to Section 31 22 00, under Part -1, General.

B. Subsurface soils investigations have been made at project site.
   1. Soils information was obtained for use in preparing foundation design and is provided for information only.
   2. Availability of soils report information is indicated in specifications.
   3. Examine site and soils report and make independent determination of character of materials and conditions to be encountered.

C. Inspection and compaction density tests:
   1. BNL will hire the Geotechnical Engineer to inspect earthwork and to conduct in-place compaction moisture-density tests and confirm allowable soil bearing pressure of 5000 psf for footings.
   2. Initial test at each location will be paid by BNL.
   3. If initial test fails, Contractor pays for retesting.

D. Tolerances of subgrade:
   1. 0.10 FT plus/minus from required elevations.

1.3 SUBMITTALS

A. Project information:
   1. Results of compaction testing of fill materials per ASTM D1557.
   2. Results of sieve analysis per ASTM D422.
   3. At least one set of tests for compaction testing and sieve analysis shall be required for each proposed source of each fill material and the Contractor shall conduct additional tests should the material gradation, based on visual examination, change.

1.4 JOB CONDITIONS

A. Contractor is responsible for:
   1. Determining safe slopes of excavations for the earth materials encountered.
   2. Shoring and bracing excavations as required to protect personnel, utilities, existing construction and new work.
   3. Removing bracing when safe.
   4. Protecting from damage (or replacing as directed) to sidewalks, pavements and other facilities resulting from settlement, lateral movement, undermining erosion or other hazards created by earthwork operations.
   5. Complying with rules and regulations governing earthwork and respective utilities.

6. Providing adequate barricades and warning lights as required to protect persons and property and to satisfy applicable regulations.
7. Maintaining bench marks, movements and other reference points and replacing any disturbed or destroyed.

B. Disposal locations:
1. Contractor may dispose of excess unsuitable fill at a location on the Brookhaven National Laboratory (BNL) site, designated by BNL, within 1-1/2 miles of the project site.
2. Trees and stumps, if clipped, may be deposited at the BNL stump dump, approximately 1/4 mile west of the Sewage Treatment Plant.
3. Removed asphalt and concrete can be deposited at a location on the BNL site, designated by BNL, within 1-1/2 miles of the project site.

C. Borrow locations: For structural fill, Contractor may utilize one or more borrow areas on the BNL site, designated by BNL, within 1-1/2 miles of the project site.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Refer to Section 31 22 00, under Part 2 "MATERIALS" for definition of structural fill.

PART 3 - EXECUTION

3.1 EXCAVATION - GENERAL

A. Excavate to dimensions and elevations indicated regardless of materials encountered. If unsuitable material is encountered, over excavate as directed by Geotechnical Engineer.
1. Allow additional space as required for construction operations and inspection of foundations.

B. Remove old foundations, building construction, and other materials concealed beneath present grade, as required to execute work, and as indicated.

C. Remove and replace unsuitable material with compacted Structural Fill as directed by Geotechnical Engineer.

D. Properly level off bottoms of excavations.

E. Where cuts are required to bring floor slabs to proper elevations, excavate to level below slabs allowing for required Structural Fill.
1. Remove rocks greater than 6 IN, lumps of silt or clay, frozen material, vegetation, existing uncontrolled fill, organic soil and materials and other deleterious materials.
2. Scarify top 8 IN of earth below Select Structural Fill and recompact to 98 percent of maximum dry density using vibratory methods under the supervision of Geotechnical Engineer. Limit traffic on subgrade to prevent disturbance.

F. During freezing conditions, the subgrades and each lift of backfill must be compacted before water in the subgrade or backfill can freeze. Frozen material shall not be placed as backfill, nor should backfill, foundations or pavements be placed on frozen soil. If during construction, the top layer of soil becomes frozen, it shall be removed before backfill, foundations or pavements are placed on it. When the air temperature is below 25 degF, placement of fill or exposure of final subgrades shall not be allowed unless special procedures approved by the Geotechnical Engineer are used to prevent freezing. If foundations, slabs or pavements are built and left exposed during the winter season, precautions shall be taken to prevent damage due to frost heave.

G. Control grading around building.
   1. Pitch surface to prevent water from running into excavated areas or damaging structure.
   2. Maintain pits and trenches where footings will be placed free of water.
   3. Provide dewatering required to keep excavated spaces clear of water during construction. Water intercepted by dewatering shall be discharged in accordance with local, state and federal rules and regulations.
   4. When springs or running water are encountered, notify Architect. Provide free discharge of water by trenches or pumps, and drain to appropriate point of disposal as directed.

3.2 FOOTINGS

A. All footing subgrades and subgrades shall be proof rolled. Provide undisturbed, level, dry, unfrozen surfaces free of foreign or loose material for placement of footings floors.

B. All subgrades described in item above shall have safe bearing capacity of 5000 psf. Obtain Geotechnical Engineer's approval of all subgrades before placing concrete.

C. Do not carry excavations lower than indicated, except when directed by Geotechnical Engineer.

D. If excavations are made below indicated level, fill with concrete of same strength as foundation concrete or Structural Fill at no extra cost. Compact Structural Fill as directed by Geotechnical Engineer. Extend Structural Fill 12 IN beyond footings on all sides.

E. When excavations become soft and wet, remove soft material and replace with concrete of same strength as foundation concrete or Structural Fill, at no extra cost. Compact Structural Fill as directed by Geotechnical Engineer. Extend Structural Fill 12 IN beyond footings on all sides.

F. When freezing temperatures are expected, do not excavate to full depth unless footings can be placed immediately. Protect bottoms of excavations from freezing if placement is delayed.

3.3 SUBGRADE PREPARATION, FILLING, AND BACKFILLING

A. Remove rocks, lumps, frozen ground, soft or wet material, vegetation, and other foreign material upon which fill or backfill is to be placed as directed by Geotechnical Engineer.

B. Before scarifying subgrade, obtain approval of Geotechnical Engineer.

C. Scarify top 8 IN of excavation surface or subgrade and compact to 98 percent of maximum dry density using moderate weight vibratory roller or plate compactor, as directed by Geotechnical Engineer.

D. Place fill material in 6 IN lifts and compact each lift to 98 percent maximum dry density per ASTM-D1557 using vibratory method.

E. Maintain moisture between 3 percent above/below optimum moisture content during compaction.

F. Compact fill and backfill using vibratory roller, vibratory plate, and/or tamper compactors. Vibratory plate or tamper compactors shall be used for compaction within 10 FT of the backs of walls.

G. Where steeper than one vertical to four horizontal, step surface with steps not exceeding 12 IN or slope surface not exceeding one vertical to 50 horizontal.

H. Correct and recompact compacted material not meeting specified compaction requirements. Continue corrective measures until required compaction has been attained.

I. Do not backfill against part of walls, piers, or columns until each part has reached design strength and has been inspected by BNL who must authorize backfilling.
   1. Do not place fills against walls until floor slabs at top and bottom of walls are in place.
   2. Bring backfill up uniformly around building and individual wall units. Both sides of walls shall be backfilled simultaneously so that there is no more than 2 FT difference in fill height.

J. Do not backfill against foundations, walls, curbs, footings, and areaways until concrete forms have been removed, masonry work has been pointed, and concrete finishing, dampproofing, and waterproofing have been completed.

3.4 GRADING NEXT TO BUILDING

A. To provide drainage evenly slope finished grade away from building walls at slopes not less than one (1) vertical to fifty (50) horizontal.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: BNL will engage a qualified independent geotechnical engineering testing agency to perform field quality-control testing. The Geotechnical Engineer shall be a representative of BNL.

B. The testing agency will be responsible for inspecting and testing subgrades for each fill or backfill layer in accordance with ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:
   1. Building Areas (includes the area up to 5 FT outside building limits: At each compacted fill and backfill layer, at least one (1) test for every 2000 SQ FT or less of building area, but in no case fewer than three (3) tests.
   2. Isolated Footings (includes the area up to 5 FT outside footing limits: At least three tests at each compacted fill and backfill area, or criteria for Building Areas, whichever results in more tests.
   3. Foundation Wall Backfill: At each compacted backfill layer, at least one (1) test for each 100 FT or less of wall length, but no fewer than two (2) tests.
   4. Trench Backfill: At each compacted initial and final backfill layer, at least one (1) test for each 150 FT or less of trench length, but no fewer than two (2) tests.

C. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.

D. If the gradation properties of the fill, backfill, or subgrade material changes, or if requested by BNL or Geotechnical Engineer, the testing agency shall conduct additional laboratory modified proctor tests to reevaluate the maximum dry density of the fill, backfill, or subgrade material. These tests shall be conducted at the frequency necessary to support the field quality control testing effort.

3.6 ACCEPTANCE OF WORK

A. Obtain BNL and Geotechnical Engineer's approval of each earthwork operation before next operation.

B. Notify BNL and Geotechnical Engineer in sufficient time for inspection.

3.7 DISPOSAL OF EXCESS AND WASTE MATERIAL

A. Remove waste and excess materials, including excess earth, unsuitable materials, trash and debris, and legally dispose of it off BNL's property.

END OF SECTION

SECTION 31 23 33

TRENCHING, BACKILLING, AND COMPACTING FOR UTILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Excavation, trenching, backfilling and compacting for all underground utilities.
   2. Sewers, channel, and drain piping.
   3. Water piping (potable, plant, process and non-potable).
   4. Electrical and mechanical pipes, duct banks, conduits, and direct burial cables.
   5. All related utility and process appurtenances.

B. Related Sections include but are not necessarily limited to:
   1. Division 0 - Procurement and Contracting Requirements.
   2. Division 1 - General Requirements.
   3. Section 31 22 00 - Site Excavation and Rough Grading.
   4. Section 22 14 00 - Storm Drainage System.
   5. Section 31 23 50 - High Pressure Steam and Condensate Systems.
   6. Section 22 14 10 - Precast Concrete Utility Structures.
   7. Section 22 11 00 - Water Distribution System.
   8. Section 31 23 60 - Underground Chilled Water System.
   9. Section 31 23 70 - Exterior Compressed Air Distribution.
   10. Section 22 13 00 - Sanitary Sewers.
   11. Division 24 - Electrical.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Society for Testing and Materials (ASTM):
      a. C33, Standard Specification for Concrete Aggregates.
      b. D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/f(2,700 kN-m/m)).
      c. D2487, Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System.

B. Qualifications:
   1. BNL will provide an independent geotechnical testing laboratory to conduct in-place moisture-density tests for backfilling to assure that all work complies with this Specification.

1.3 DEFINITIONS

A. Engineer: Independent geotechnical consultant hired to monitor project execution.

1.4 SUBMITTALS

A. Shop Drawings:
   1. Trench Safety Plan and/or trench shoring drawings including current certification of trench shields (trench boxes) if employed.
   2. Submit respective pipe or conduit manufacturer's data regarding bedding methods of installation and general recommendations.
   3. Submit sieve analysis reports on all granular materials to Engineer prior to use.

B. LEED Information:
   1. LEED Credits MR 4.1 and 4.2, Recycled Content: Product data indicating percentages by weight of post-consumer and post-industrial recycled content for products having recycled content; include statement indicating costs for each product having recycled content.
   2. LEED Credits MR 5.1 and 5.2, Regional Materials: For products and materials required to comply with requirements for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.

1.5 SITE CONDITIONS

A. Avoid overloading or surcharge a sufficient distance back from edge of excavation to prevent slides or caving. Maintain and trim excavated materials in such manner to be as little inconvenience as possible to public and adjoining property.

B. Provide full access to public and private premises and fire hydrants, at street crossings, sidewalks and other points as designated by BNL to prevent serious interruption of travel.

C. Protect and maintain bench marks, monuments or other established points and reference points and if disturbed or destroyed, replace items to full satisfaction of BNL and controlling agency.

D. Verify location of existing underground utilities.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Backfill Material:
   1. Refer to Section 31 22 00 – Site Excavation and Rough Grading.

B. Bedding Materials:
   1. Aggregate subbase:
      a. Refer to Section 31 22 00 – Site Excavation and Rough Grading.
   2. As approved by the Engineer.

PART 3 - EXECUTION

3.1 GENERAL

A. Remove and dispose of unsuitable materials as directed by Engineer, legally off-site in accordance with the General Conditions Governing all Contracts.

3.2 EXCAVATION

A. Unclassified Excavation:
   1. Remove loose/weathered rock excavation, clay, silt, gravel, hard pan, loose shale, and loose stone as directed by Engineer.

B. Trench Excavation:
   1. Excavate trenches by open cut method to depth shown on Drawings and necessary to accommodate work.
   2. Open trench outside buildings, units, and structures:
      a. No more than the distance between two manholes, structures, units, or 300 LF, whichever is less.
      b. Field adjust limitations as weather conditions dictate.
   3. Trenching within buildings, units, or structures:
      a. No more than 100 LF at any one time.

4. Any trench or portion of trench, which is opened and remains idle for 7 calendar days, or longer, as determined by BNL, may be directed to be immediately refilled, without completion of work, at no additional cost to BNL. Said trench may not be reopened until BNL is satisfied that work associated with trench will be prosecuted with dispatch.
5. Observe following trenching criteria:
   a. Trench size.
      1) Excavate width to accommodate free working space.
      2) Maximum trench width at top of pipe or conduit may not exceed outside diameter of utility service by more than the following dimensions:

OVERALL DIAMETER OF UTILITY SERVICE	EXCESS DIMENSION
All pipe	16 IN (min)
All pipe	24 IN (max)

      3) Cut trench walls vertically from bottom of trench to 1 FT above top of pipe, conduit, or utility service.
      4) Keep trenches free of water. Include cost of dewatering in original proposal.

C. Trenching for Electrical Installations:
   1. Observe paragraph 3.2 B "Trench Excavation"
   2. Modify for electrical installations as follows:
      a. Open no more than 600 LF of trench in exterior locations for trenches more than 12 IN but not more than 30 IN wide.
      b. Any length of trench may be opened in exterior locations for trenches which are 12 IN wide or less.
      c. Do not over excavate trench.
      d. Cut trenches for electrical runs with minimum 30 IN cover, unless otherwise specified.
      e. See Division 16 for additional requirements.

D. Subgrade Stabilization:
   1. Stabilize the subgrade when directed by BNL.
   2. Observe the following requirements when unstable trench bottom materials are encountered.
      a. Notify BNL when unstable materials are encountered.
      b. Remove unstable trench bottom caused by Contractor failure to dewater, rainfall, or Contractor operations.
         1) Replace with aggregate subbase bedding with no additional compensation.

3.3 BACKFILLING METHODS

A. Do not backfill until tests to be performed on system show system is in full compliance to specified requirements.

B. Trench Backfill:
   1. Perform in accordance with the following:
      a. Place backfill in lift thicknesses capable of being compacted to densities specified.
      b. Avoid displacing joints and appurtenances or causing any horizontal or vertical misalignment, separation, or distortion.

C. Water flushing for consolidation is not permitted.

D. Backfilling for Electrical Installations:
   1. Modify for electrical installation as follows:
      a. Observe notes and details on electrical drawings for fill in immediate vicinity of direct burial cables.

3.4 COMPACTION

A. General:
   1. Place and assure bedding, backfill, and fill materials achieve an equal or "higher" degree of compaction than undisturbed materials adjacent to the work.
   2. In no case shall degree of compaction be below 95% of maximum dry density per ASTM D1557.

3.5 FIELD QUALITY CONTROL

A. Testing:
   1. See Section 01 45 23 for Contractor's testing responsibilities.
   2. Assure BNL has immediate access for testing of all soils related work.
   3. Ensure excavations are safe for testing personnel.

END OF SECTION

SECTION 31 23 50

HIGH PRESSURE STEAM AND CONDENSATE SYSTEMS (30 TO 150 PSIG)

PART 1 - GENERAL

1.1 GENERAL INFORMATION

A. This section covers all high pressure steam and condensate piping from the existing manhole to a point 4 IN inside the building wall.

B. All work shall meet requirements of ANSI-B31.9 “Code for Building Service Piping”.

C. Furnish a complete system of factory pre-insulated steel piping for the specified service. The system shall be a combination of a drainable, dryable, testable type conduit system, suitable for all ground water and soil conditions, site Classification “A”, with an external covering of polyurethane insulation and an HDPE jacket. The system shall be provided as specified below and shown on the drawings.

D. The pre-insulated pipe manufacturer shall make a complete layout of the system showing anchors, expansion provisions, and building entrance details. Means for expansion must be made in pipe offsets or loops unless this is compensated for integrally in the system.

E. All straight sections, fittings, anchors, and other accessories shall be factory prefabricated to job dimensions and designed to minimize the number of field welds. The design shall be computer analyzed by the piping system manufacturer to determine stresses and movements of the service pipe and to insure that the system design is in strict conformance with ANSI B31.1 latest edition, and stamped by a registered professional engineer.

F. Related Sections include but are not necessarily limited to:
   1. Section 31 23 33 “TRENCHING, BACKFILLING AND COMPACTING FOR UTILITIES”.
   2. Section 20 05 00 “GENERAL MECHANICAL REQUIREMENTS”.
   3. Section 20 11 00 “PIPES AND FITTINGS”.
   4. Section 20 05 23 “MANUAL VALVES”.
   5. Section 20 05 19 “PIPING SPECIALTIES”.
   6. Section 20 05 29 “PENETRATIONS AND SUPPORTS”.
   7. Section 20 12 00 “WELDING PRESSURE PIPING”.

1.2 SUBMITTALS

1. LEED Credits MR 4.1 and 4.2, Recycled Content: Product data indicating percentages by weight of post-consumer and post-industrial recycled content for products having recycled content; include statement indicating costs for each product having recycled content.
2. LEED Credits MR 5.1 and 5.2, Local Regional Materials: For products and materials required to comply with requirements for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Pre-insulated steam and condensate conduit piping system:
      a. Base:

1) Thermacor Process.

b. Optional:

1) Thermal Pipe Systems.

2) Perma-pipe.

2.2 PIPE

A. Pre-insulated Steam and Condensate Conduit Piping System:

1. The conduit shall be 10 gauge, welded, smooth-wall black steel conforming to ASTM A-139, A-134, and A-135. Conduit shall be tested at the factory to insure air and watertight welds prior to any fabrication or application of coating. No internal coating of conduit is required.
2. Conduit closures shall be 10 gauge steel, furnished with the conduit at a ratio of one closure for each fabricated item or length. Closures shall be field welded over adjacent units after pipe insulation.
3. Piping in the conduit shall be standard weight (Std. Wt. is the same as Sch. 40 through 10 IN), steel, ASTM A-53, Grade B, ERW 2 IN and larger and A-106 SWI for 1-1/2 IN and smaller. Steam lines shall be standard weight, and condensate lines shall be extra strong (XS is the same as Sch. 80 through 8 IN). Pipe joints shall be welded in accordance with the Pressure Piping Code, ASME/ANSI B 31.1.
4. The Class "A" pipe insulation shall be mineral wool applied in the following thicknesses:
   a. 1-1/2 IN for 3 IN pipe and 2 IN for 6 IN pipe.
5. All pipes within the outer casing shall be supported at not more than 9 FT intervals. Supports are designed to allow for continuous airflow and drainage of the conduit in place. Straight section supports are designed to occupy not more than 10% of the annular air space. Supports shall be of the type whereby insulation thermally isolates the carrier pipe from the outer conduit. The surface of the insulation shall be protected at the support by a sleeve not less than 12 IN long.
6. Pre-fabricated ells and loops shall be furnished and installed where shown on plans and shall consist of pipe, insulation, and conduit conforming to the same specification as hereinbefore stated in straight runs. Expansion loops shall be designed in accordance with the stress limits as dictated by the Power Piping Code, ASME/ANSI B31.1. Loop piping shall be installed in conduit suitably sized to handle calculated pipe movement. Elbows, loops, offsets, or any other direction changes shall conform to the standards set by ASME B31.1, Code for Power Piping.
7. Terminal ends of conduits inside manholes, pits, or building walls shall be equipped with end seals consisting of a 1/2 IN steel pipe welded to the pipe and conduit, followed by 16 IN steel sleeve, and with a 2 IN overlap of the heat shrink sleeve. End seals shall be equipped with drain and vent openings. Terminate all conduits 2 IN beyond the inside face of manhole or building walls.
8. Pre-fabricated anchors shall be furnished and installed where shown on plans and shall consist of a steel plate, welded to pipe and conduit. The steel anchor plate shall be 1/2 IN thick and shall be 1-1/2 IN larger horizontally and 1-1/2 IN larger vertically than the HDPE jacket outer diameter. Heat shrink wrap shall be used to seal the overlap of anchor water shed over the HDPE jacket.
9. A concrete thrust block shall be cast over the anchor plate and conduit, large enough for firm anchorage into undisturbed trench sidewalls and/or bottom. The concrete block shall be at least 36 IN in length and extend a minimum of 12 IN beyond the top and bottom of the anchor plate. Pre-insulated pipe manufacturer shall be responsible for design of thrust blocks to be based upon site soils data provided by the Contractor.
10. Wall sleeves with leak plates shall be provided at all building and manhole entries to provide an effective moisture barrier. The space between the conduit and wall sleeve shall be made watertight by use of Link-Seal® pipe penetration seals or equal assemblies, which will also provide electrical isolation.

11. The steel conduit for the steam and condensate shall be insulated with polyurethane foam insulation to a minimum thickness of 1 IN. Insulation shall be rigid, minimum 90% closed cell polyurethane with a minimum 2.0 LBS per cubic foot density, compressive strength 30 psi @ 75°F, and a coefficient of thermal conductivity (K factor) not higher than .15 @ 75°F per ASTM C518. Maximum conduit interface temperature shall not exceed 200°F.
12. Jacketing material shall be extruded, black, high density polyethylene (HDPE), having a minimum wall thickness of 125 mils for jacket sizes less than or equal to 12 IN, 150 mils for jacket size larger than 12 IN to 20 IN, and 175 mils for jacket sizes greater than 20 IN. The inner surface of the HDPE jacket shall be oxidized by means of corona treatment, flame treatment (patent pending), or other approved methods. This will ensure a secure bond between the jacket and foam insulation preventing any ingression of water at the jacket/foam interface.
13. Straight run joints are insulated using a wrap around HDPE jacket placed over the field joint and insulated with polyurethane foam. The HDPE jacket is sealed with a heat shrink sleeve, as recommended by the manufacturer.
14. Conduit fittings are factory pre-fabricated and pre-insulated with urethane to the thickness specified and jacketed with a molded, extrusion welded, or butt fusion welded PE jacket. No taping or hot air welding shall be allowed.

2.3 FITTINGS AND COUPLINGS

A. Steel pipe fittings: For steam: Seamless standard class carbon steel butt welding. For condensate: Seamless extra strong class carbon steel butt welding:
   1. Socket welding fittings: ANSI/ASME-B16.11 and ASTM-A234.
   2. Butt welding fittings: ASTM-A234 Grade WPB, ANSI/ASME-B16.9, ANSI/ASME-B16.25 and ASTM-A105.

B. Unions (1/2 IN – 2 IN) 2000 LB Carbon steel, socket weld, ground joint, integral seats, conforming to ASTM A105.

C. Flanges: 150 LB class carbon steel, raised face, conforming to ASTM-A105 and ANSI-B16.5. Figure numbers are Tube Turn's:
   1. 1/2 IN – 2 IN Schedule 80 bore, socket weld.
   2. 3 IN and Over:
      a. Welding Neck Flanges: Figure 30.
      b. Slip-On Flanges: Figure 50.
      c. Blind Flanges: Figure 70.
   3. Gaskets: Ring-type, 150 LB class:
      a. For steam and condensate systems: Flexitallic 304 Stainless Steel, 1/8 IN thick, spiral wound.
   4. Bolts:
      a. HPS and HPC: Alloy steel stud bolts, conforming to ASTM-A193, Grade B7.

D. Elbolets and Thredolets: Bonney Forge, carbon steel, 3000 LB class, conforming to ASTM-A105 Grade II.

E. Weldolets: Bonney Forge, carbon steel, extra strong class butt welding end connection, conforming to ASTM-A105 Grade II.

2.4 VALVES

A. Blowdown Valves:
   1. Crane Model B-3604UX-W, 600 LB forged steel, socket weld, 13% Cr trim.

B. Shutoff Valves:
   1. 2 IN and Under: Sharpe Series 84 Class 800 or SVF Series N6/N7 socket weld 720 psi, cold, non-shock, high performance ball valve with 316 stainless steel ball and stem, graphite seat and Grafoil seals capable of withstanding temperature to 1000°F.

2. 2-1/2 IN thru 4 IN (Condensate): Crane Figure 47XUF, 150 LB class, raised face flanged gate valve, carbon steel body, outside screw and yoke, Exelloy or Exelloy faced carbon steel solid wedge disc.
3. 4 IN and Over (Steam): Steam: Weir Power Industrial or Zwick/Tri-con triple offset, metal seated, zero leakage butterfly valve, lug, ANSI Class 150 with carbon steel body, 316 stainless steel disc, metal seat, graphite packing material.

C. Actuators:
1. 6 IN butterfly valve actuator: Rotork Model Series IW with weathertight ductile iron housing, epoxy coated, carbon steel shaft and gears and adjustable mechanical end of travel stops. Actuator shall be rated for buried service, lifetime lubricated, 6000 IN/LBS output torque with E-flange input.
2. 10 IN butterfly valve actuator: Rotork Series IW with weathertight ductile iron housing, epoxy coated, carbon steel shaft and gears and adjustable mechanical end of travel stops. Actuator shall be rated for buried service, lifetime lubricated 10,000 IN/LBS output torque with E-flange input.

D. Check Valves:
1. 2 IN and Under: Apollo No. F97D ball check valve Class 300, 13% chrome-moly trim HF seats, conventional port, bolted cap with socket weld ends.

2.5 STRAINERS AND TRAPS

A. Steam Trap Assembly: Trap shall be Yarway Series 721 inline renewable tilting disc-type thermodynamic trap with chrome-moly body in ASME SA-182 GR.F-11 and stainless steel trim. End connections shall be ANSI Class 600 socket welded. Trap shall have an integral strainer with stainless steel screen, and integral blow-off valve.

2.6 GAUGES

A. Pressure Gauges: Weksler Type AA14C, 1/4 IN bottom connection, white dial, numerals range of 0 to 200 psig with 20 psi figure intervals, with Type A03B siphon, and Type A10 tee handle cock.

2.7 REUSABLE INSULATION COVERS

A. Insulation Technology, Heat Holder, F-1000 2 IN thick eleven (11) lb./cu. ft. density fiberglass mat encased in inner and outer surfaces of 550T teflon coated fabric suitable for service temperatures of 600°F with two (2) parallel rows of double sewn seams of ten (10) stitches per inch, stainless steel quilting and lacing hooks, and permanently attached stainless steel legend tag indicating size, type, and class of item covered.

B. Composite insulation, jacket, and adhesive shall be UL labeled and listed, have a flame spread of 25 or less, a smoke developed rating of 50 or less, and meet requirements of ASTM-E84 and NFPA 255. High density and expanded plastics will not be accepted, regardless of fire retardant additives or manufacturer's claims.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation of underground steam and condensate piping including equipment, materials, workmanship, fabrication, assembly, erection, examination, inspection and testing shall be in accordance with ASME B31.1.

B. The installing contractor shall be responsible to excavate, string conduit, weld test, place in trench, backfill, or otherwise treat and install the system as per the specifications and the directions furnished by the manufacturer and approved by the design engineer in accordance with plans and specifications. Factory-trained field technical assistance shall be provided for the critical periods of the installation, i.e., unloading, field joint instruction, cold springing and testing.

C. Manufacturer's field installation instructor:
   1. An instructor who is technically qualified to determine whether or not the installation is being made in accordance with the manufacturer's recommendations shall be present during critical periods in installation and test of the system. On completion of the installation, the contractor shall deliver to BNL a certificate from the manufacturer stating that the installation has been made in accordance with the manufacturer's recommendations.

D. Conduit air test:
   1. All field welds at conduit closures shall be tested for leaks before applying heat shrinkable sleeves. During test, all field welds shall be checked with soap suds and rewelded if necessary until air tight at 15-psig pressure.
   2. The contractor shall furnish all necessary equipment and labor to perform the air test, including air compressor, gauges, conduit caps, temporary pipe and connections, etc. Tests shall be completed to the satisfaction of BNL and the architect /engineer.

E. Pre-engineered systems shall be provided with all straight pipe and fittings factory pre-insulated and pre-fabricated to job dimensions.

F. Underground systems shall be buried in a trench not less than 2 FT deeper than the top of the pipe and not less than 18 IN wider than the combined O.D. of all piping systems. A minimum thickness of 24 IN of compacted backfill placed over the top of the pipe will meet H-20 highway loading.

G. Trench bottom shall have a minimum of 6 IN of sand, pea gravel, or specified backfill as a cushion for the piping. All field cutting of the pipe shall be performed in accordance with the manufacturer's installation instructions.

H. All ferrous pipe field joints shall be welded by competent mechanics and hammer tested under hydrostatic pressure of 250 psig or one and one-half times the design pressure, whichever is greater. Concealed pipe welds in prefabricated conduit fittings shall be factory tested the same as specified for field welds prior to assembly.

I. Install valves with stems horizontal or above centerline of pipe.

J. Provide flanges or unions at valves, traps, strainers, connection to equipment or as indicated.

K. Keep the interior and ends of new piping and existing piping affected by the contractors operations, cleaned of water and foreign matter during installation.

L. For steam manholes only, provide reusable insulation covers on all valves 2-1/2 IN and larger, and expansion joints.

M. For steam manholes, all steam and condensate piping not part of the conduit system shall be the same pipe materials used in the conduit system. These pipes shall be insulated in accordance with Section 20 07 00, except for any part receiving a reusable insulation cover.

3.2 PIPING

A. Test and inspect piping before burying, covering or concealing.

B. Provide fittings for changes in direction of piping and for connections.

3.3 JOINTS

A. Joints shall be socket welded, butt welded, and flanged.

B. Welding performed per Specification Section 20 12 00.

3.4 SLOPES

A. Slope of Pipes: Down in direction of flow 1 IN in 40 FT, unless otherwise indicated on Drawings.

3.5 REUSABLE INSULATION COVERS

A. Install covers after adjacent pipe and fitting insulation, and jacketing is in place. Overlap covers a minimum of 3 IN on pipe insulation. Once in place, lace covers tight with stainless steel wire.

END OF SECTION

SECTION 31 23 60
UNDERGROUND CHILLED WATER SYSTEMS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Cement-lined ductile iron pipe, pipe fittings and accessories for chilled water supply and return distribution piping. Piping connects the Site Chilled Water to building as shown on the drawings. Underground chilled water shall terminate 4 inches inside of building.

B. Valves

C. Anchors

1.2 RELATED WORK

A. Section 31 22 00 – Site Excavation and Rough Grading

B. Section 31 23 33 – Trenching, Backfilling and Compacting for Utilities

1.3 REFERENCES

A. ANSI/AWWA C111 - Rubber Gasket Joints for Ductile Iron and Gray-Iron Pressure Pipe and Fittings.

B. ANSI/AWWA C151 - Ductile-Iron Pipe Centrifugally Cast in Metal Models or Sand-Line Molds, for Water or Other Liquids.

C. ANSI/AWWA C110/A21.10-82 Ductile Iron and Gray Iron Fittings, 3 in. through 48 in., for water and other liquids.

D. ANSI/AWWA C205 - Cement Mortar Protective Lining and Coating for Steel Water Pipe - Shop Applied.

E. ANSI/AWWA C504 - AWWA Standard for Rubber-Seated Butterfly Valves.

F. AWWA C601 - Standard Methods for the Examination of Water and Waste Water.

1.4 QUALITY ASSSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body.

1.5 SUBMITTALS

A. Submit product data under provisions of Supplementary Conditions.

B. Include data on pipe materials, pipe fittings, valves, operators, and accessories.

C. Detailed pressure and leakage testing procedure.

D. LEED Information:
   1. LEED Credits MR 4.1 and 4.2, Recycled Content: Product data indicating percentages by weight of post-consumer and post-industrial recycled content for products having recycled content; include statement indicating costs for each product having recycled content.
   2. LEED Credits MR 5.1 and 5.2, Local Regional Materials: For products and materials required to comply with requirements for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Supplementary Conditions.

B. Store and protect products under provisions of Supplementary Conditions.

C. Deliver and store valves in shipping containers with labelling in place.

D. Delivery and Storage: Materials delivered to site shall be inspected for damage, unloaded, and stored with the minimum of handling. Store materials on site in enclosures or under protective coverings. Store rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Inside of pipes and fittings shall be kept free of dirt and debris.

E. Handling: Pipe, fittings, and other accessories shall be handled in such a manner as to insure delivery to the trench in sound undamaged condition. Special care shall be taken not to injure pipe coatings or linings. If coatings or linings of pipe or fittings are damaged, satisfactory repairs shall be made at no extra cost to BNL. Pipe shall be carried to the trench not dragged. Rubber gaskets that are not installed immediately shall be stored undercover out of direct sunlight.

PART 2 - PRODUCTS

2.1 PIPING

A. Pipe & Fittings 4 IN Dia. and Over (CHWS & CHWR):
   1. Ductile iron pressure class 350 for pipe sizes 4 IN to 12 IN and pressure class 250 for pipe sizes 14 IN and over in accordance with ANSI/AWWA C150/A21.50 and ANSI/AWWA C151/A21.51.
   2. Double thickness cement mortar lined and bituminous seal coated inside and outside in accordance with ANSI/AWWA C104/A21.4.
   3. Joints:
      a. Restrained joints shall be U.S. Pipe TR Flex or American Cast Iron Company Flex Ring Joint or approved equal.
      b. Push-on joints used in conjunction with restrained joints shall be in accordance with ANSI/AWWA C111/A21.11.
      c. Flanged Joints: Pipe shall be shop fabricated in accordance with ANSI/AWWA C115/A21.15. Pipe barrels and flanges shall have tapered pipe threads in accordance with ANSI B2.1. Bolt circle and bolt holes shall match those of ANSI B16.1 Class 125 flanges and ANSI B16.5 Class 150 flanges.
         1) Gaskets shall be rubber (EPDM) full-faced 1/8 IN thick.
         2) Bolts, studs, and nuts shall be low carbon steel per ASTM A 307 Grade B.

2.2 VALVES

A. Ball Valves:
   1. 2 IN and under
      a. 150 LB, bronze body, screwed ends, bronze ball and stem, TFE seats, standard port lever operated.
      b. Valve shall be Powell Fig. #4210T, Crane or approved equal.

B. Butterfly Valves (Exterior):
   1. Class 150B, AWWA C504, ASTM A-126 Class B, cast iron, stainless steel stem, bronze corrosion resistant disc, Buna-N or EPDM resilient seat, and cast iron bushed, suitable for buried service.
   2. Provide with sealed, grease packed traveling nut or gear type self-locking operator with 2 IN square nut ended extension shaft sized for specific depth requirement. Extension shaft shall be fastened to valve operator nut.

3. Valves shall also be provided with valve position indicator showing valve position, direction to close, number of turns full open to full closed, bushings, washers, inch nut, adapters and all items required to provide a complete indicator assembly.
4. Stamp unique valve no. (e.g.: CHWS-1 6 IN, CHWR-1 6 IN) on valve position indicator plate. Both generic number and unique number shall be marked on each valve assembly.
5. Valve shall be Pratt "Groundhog" or an approved equal.

2.3 AUTOMATIC AIR VENT

A. Cast iron body with stainless steel float with resilient seat material. Provide for working pressure up to 200 psi. Model No. 21 AR as manufactured by Armstrong Machine Works or an approved equal.

2.4 VALVE BOXES

A. Standard 5-1/4 IN screw type adjustable with legend "WATER" cast into the cover plate.

B. Provide a 2 IN diameter brass or stainless steel valve tag for each valve on which the valve size, number, and service shall be indicated. For example: 12 IN - #6 CHWS. The tags shall be securely attached to the equipment just below the valve box cover.

PART 3 - EXECUTION

3.1 PREPARATION

A. Remove scale and dirt, on inside and outside, before assembly.

B. Prepare piping connections to equipment with flanges or unions.

3.2 INSTALLATION – PIPING

A. Pipe Laying and Jointing: Pipe, fittings, and accessories will be carefully inspected by BNL before and after installation and those found defective will be rejected. Pipe and fittings shall be free from fins and burrs. Before being placed in position, pipe, fittings and accessories shall be cleaned, and shall be maintained in a clean condition. Proper facilities shall be provided for lowering sections of pipe into trenches. Pipe shall be cut accurately to measurements established at the site and shall be worked into place without springing or forcing. Any pipe or fitting that does not allow sufficient space for proper installation of jointing material shall be replaced by one of proper dimensions. Blocking or wedging between bells and spigots will not be permitted. Bell-and-spigot pipe shall be laid with the bell end pointing in the direction of laying. The pipe shall be graded by straight lines, taking care to avoid the formation of any dips or low points. Pipe shall be supported at its proper elevation and grade, care being taken to secure firm and uniform support. Wood support blocking will not be permitted. The full length of each section of pipe and fittings shall rest solidly on the pipe bed, with recesses excavated to accommodate bells, joints, and couplings. Anchors and supports shall be provided where necessary and where indicated for fastening work into place. Proper provision shall be made for the expansion and contraction of pipe lines. Trenches shall be kept free of water until joints have been properly made. Open ends of pipe at the end of each day's work shall be closed temporarily with wood blocks or bulkheads. Pipe shall not be laid when conditions of trench or weather are unsuitable.

B. Route piping in orderly manner and maintain line and gradient.

C. Anchorage: Provide restrained joints except as where otherwise indicated on the drawings. Use restrained joints at all changes of direction of piping. Provide in accordance with Manufacturer's recommendations. Anchorage shall be designed to withstand all loads associated with hydrostatic testing of piping system.

D. Excavate and backfill in accordance with Section 31 23 33 "Trenching, Backfilling and Compacting for Utilities" for work of this Section.

E. Prior to starting system verify system is complete, flushed and clean. Provide full flow pipe capacity flushing, under directions of BNL.

F. Identify supply pipe with a contrasting color continuous stripe painted on the top of the pipe. Stripe width shall be 25% of pipe diameter. Color shall be approved by BNL.

3.3 TESTING

A. After installation, but before backfill, every joint will be examined and inspected for proper installation by Contractor and BNL. Repair all unacceptable joints. After approval by BNL backfill piping to elevation of compressed air piping system. Contractor shall provide blanks at Station 0+00 for testing and shall remove blanks after system is accepted.

B. After backfilling pressure test and leakage test pipe.

C. Pressure Test - Each valved section of pipe shall be filled with water slowly at the specified test pressure, based on the elevation of the lowest point of the section under test and corrected to the elevation of the test gauge, shall be applied by means of a pump connected to the pipe in a manner approved by BNL. Valves shall not be operated in either the opening or closing direction at differential pressures above the rated pressure.
   1. Hydrostatic: Test at a pressure of 165 psi. Repair all leaks found and retest.
   2. Test pressures shall be continuously maintained for a minimum time of two (2) hours. Test pressure shall not vary by more than +5 psi for the duration of the pressure test.
   3. Before applying the specified test pressure, air shall be expelled completely from the pipe and valves. If permanent air vents are not located at all high points, the contractor shall install corporation cocks at such points so that air can be expelled as the line is filled with water. After all the air has been expelled, the corporation cocks shall be closed and the test pressure applied.

D. Leakage Test - The leakage test shall be conducted concurrently with the pressure test.
   1. Leakage shall be defined as the quantity of water that must be supplied into the newly laid pipe, or any valved section thereof, to maintain pressure within 5 psi of the specified test pressure after the air in the pipeline has been expelled and the pipe has been filled with water. Leakage shall not be measured by a drop in pressure in a test section over a period of time.
   2. No pipe installation will be accepted if the leakage is greater than that determined by the following formula in which L is the allowable leakage, in gallons per hour; S is the length of pipe tested, in feet; D is the nominal diameter of the pipe, in inches; and P is the average test pressure during the leakage test, in pounds per square inch gauge.

$$L = \frac{SD\,(P)^{0.5}}{133{,}200}$$

   3. This formula is based on an allowable leakage of 11.65 gpd, per mile, per inch nominal diameter at a pressure of 165 psi.

E. Provide all pumps, compressors, test connections, leak rate apparatus, and gages necessary. All equipment, instruments, and other appurtenances which may be damaged during testing shall be either blocked off, gagged or disconnected. In no case shall piping or any component be subjected to pressures exceeding their ratings.

F. Pressure and leakage testing shall be witnessed by BNL and documented. 24 hours notice shall be given to permit sending representative to witness the tests.

G. Test fluids and water shall be clean and free from debris and contaminants. Water shall be clean and potable.

H. Acceptance of installation shall be determined on the basis of test pressure and allowable leakage. If any test of pipe laid does not continuously maintain pressure as specified or discloses leakage greater than that specified, the contractor shall, at his own expense, locate and make repairs as necessary until the leakage is within the specified allowance.

I. All visible leaks are to be repaired regardless of the amount of leakage.

J. Upon successful completion and acceptance of tests, piping shall be relieved of pressure, and completely drained. In addition to vents and drains, all new line valves shall be open during the draining period.

END OF SECTION

SECTION 31 23 70
EXTERIOR COMPRESSED AIR DISTRIBUTION

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Steel pipe, pipe fittings, valves, and accessories for compressed air distribution system. Piping connects the site compressed air to two buildings as shown on the drawings. This system provides clean, dry, oil-free instrument quality air for laboratory use. Underground compressed air shall terminate 4 inches inside the building.

1.2 RELATED WORK

A. Section 31 22 19 – Site Excavation and Rough Grading

B. Section 31 23 33 – Trenching, Backfilling and Compacting for Utilities

1.3 REFERENCES

A. ANSI/AWWA C504 - Standard for Rubber seated Butterfly Valves

B. ANSI B16.5, 1981 - Steel Pipe Flanges and Flanged Fittings

C. ASTM A53-82 - Pipe, Steel

D. ANSI B16.21 - Flat gaskets for Pipe Flanges.

E. ANSI B16.25 - Butt welding Ends.

F. ASME Section IX - Welding Qualifications

1.4 SUBMITTALS

A. Submit product data under provisions of Supplementary Conditions.

B. Include data on pipe materials, pipe fittings, and accessories.

C. LEED Information:
   1. LEED Credits MR 4.1 and 4.2, Recycled Content: Product data indicating percentages by weight of post-consumer and post-industrial recycled content for products having recycled content; include statement indicating costs for each product having recycled content.
   2. LEED Credits MR 5.1 and 5.2, Local Regional Materials: For products and materials required to comply with requirements for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of General and Supplementary Conditions.

B. Store and protect products under provisions of General and Supplementary Conditions.

PART 2 - PRODUCTS

2.1 PIPING (CA)

A. Piping: Steel pipe, seamless, conforming to ASTM A53 for Schedule 40 pipe with ANSI/AWWA C105 high density polyethylene or polypropylene copolymer extruded plastic jacket as manufactured by GSI, Standard Pipe protection Div. "X-TRU-Coat"; Energy Coatings Co. "ENCOAT"; or Raychem Co. or approved equal.

1. Over areas where field weld joints and flanges are located, plastic sheath in the field using the shrink-sleeve coating repair method in accordance with manufacturer's recommendation. Other areas shall be plastic sheathed using the tape coating repair method such as Polyker #930 series with an overwrap of #900; Raychem, GSI, Inc. or Energy Coatings Co., or approved equal.

B. Fittings: Forged steel conforming to ASTM A234, butt welded type ASNI B16.9.

C. Joints: Welded to ANSI B31.1.

D. Flanges: 150 LB raised or flat face, ANSI B16.1, Slip-On or weld neck with Standard weight carbon, steel ASTM A105. Heavy hex head machine bolts, each with one heavy hex nut, ASTM A307, Grade. B.

E. Gaskets: 150 LB full face, 1/8 IN thick red rubber.

2.2 BUTTERFLY VALVES

A. Class 150B, AWWA C504, ASTM A536, ductile iron, stainless steel stem, bronze or corrosion resistant disc, Buna-N or EPDM seat, and bronze bushed suitable for buried service.

B. Provide with sealed, grease packed traveling nut or gear type self-locking operator with square ended extension shaft sized for specific depth requirement. Extension shaft shall be fastened to valve operator.

C. Valves shall also be provided with valve position, direction to close, number of turns full open to full closed, bushings, washers, 2 inch nut, adapters and all items required to provide a complete indicator assembly.

D. Stamp unique valve number (e.g.: CA-1 3 IN) on valve position indicator plate. Both generic and unique identification numbers shall be marked on each valve.

E. Valve shall be Pratt "Groundhog" except under 4 IN shall be Pratt "2FII", or approval equal.

2.3 VALVE BOXES

A. Standard 5-1/4 IN screw type adjustable, with legend "AIR" cast into the cover plate.

B. Provide a 2 IN diameter brass or stainless steel valve tag for each valve on which the valve size, number, and service shall be indicated. For example: CA-1 3 IN. The tags shall be securely attached to the equipment just below the valve box cover.

PART 3 - EXECUTION

3.1 PREPARATION

A. Remove scale and dirt, on inside and outside, before assembly.

3.2 INSTALLATION

A. Route piping in accordance with drawings and maintain gradient.

B. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

C. Maintain minimum depth of 3' above pipe: Maintain uniform gradient to minimize changes of direction.

D. Maintain cleanliness of system during construction and testing. Cap all open ends at the end of each work day to avoid contamination of system.

E. Excavate in accordance with Sections 31 22 00 and 31 23 33.

F. Provide as-built sketch acceptable to BNL prior to backfilling.

G. Bedpipe and backfill in accordance with Sections 31 22 00 and 31 23 33.

3.3 TESTING

A. After installation, examination and inspection of piping but before backfilling, piping shall be pneumatically pressure tested. Provide all pumps, compressors, test connections and gages necessary. All equipment, instruments, and other appurtenances which may be damaged during testing shall be either blocked off, gagged or disconnected. In no case shall piping or any component be subjected to pressures exceeding their ratings. Testing against system valves will not be allowed.

B. Test pressures shall be continuously maintained for a minimum time of 60 minutes and held for such time for all joints to be visually examined and soap bubble tested for leaks. All leaks shall be promptly repaired and the system retested.

C. Pressure testing shall be witnessed by BNL and documented. 24 hours notice shall be given to permit sending representative to witness the tests.

D. Pneumatic
   1. Pneumatic testing shall require evacuation of all personnel not directly involved in performing or witnessing the test. Area shall be "roped-off" under direction of BNL.
   2. Preliminary test at 15 psig and check for leaks. Repair any leaks found.
   3. Final test shall be at 150 psig. Isolate system from source of pressure and allow system to stand for four (4) hours, at which time no drop in pressure shall occur.
   4. Swab all joints with standard high film strength soap solution and check for bubbles (leaks) or for difficult cases, use refrigerant traced air or nitrogen and halide leak detector.

E. A safety relief valve installed either on the equipment or the portion of line being tested shall be utilized.

F. Test fluids shall be clean and free from debris and contaminants.

G. Upon successful completion and acceptance of tests, piping shall be relieved of pressure.

END OF SECTION

SECTION 31 25 00
SOIL EROSION AND SEDIMENT CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Soil erosion and sediment control.

B. Related Sections include but are not necessarily limited to:
   1. General Conditions Governing All Contracts.
   2. Section 31 10 00 - Site Clearing.
   3. Section 31 22 00 - Site Excavation and Rough Grading.
   4. Section 31 23 33 - Trenching, Backfilling and Compaction for Utilities.
   5. Section 31 22 19 - Topsoiling and Finished Grading.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. New York State Standards and Specifications for Erosion and Sediment Control, latest edition.
   2. New York Stormwater Management Design Manual, latest edition.

1.3 SUBMITTALS

A. LEED Information:
   1. LEED Credits MR 4.1 and 4.2, Recycled Content: Product data indicating percentages by weight of post-consumer and post-industrial recycled content for products having recycled content; include statement indicating costs for each product having recycled content.
   2. LEED Credits MR 5.1 and 5.2, Regional Materials: For products and materials required to comply with requirements for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.
   3. LEED Credit MR 6.0, Rapidly Renewable Materials: Manufacturers' product data for products manufactured from rapidly renewable material; indicate type of rapidly renewable material.

1.4 EROSION CONTROL PRINCIPLES

A. Conduct work so that all soil, fuels, oils, bituminous materials, chemicals, sanitary sewage, and other potentially harmful materials resulting from construction are confined within the limits of construction and prevented from entering storm drainage systems, water courses, or ground water.

B. Strip vegetation, grade and perform other soil disturbances in a manner which minimizes soil erosion.

C. Retain and protect existing vegetation as much as is feasible.

D. Keep area which is exposed and free of vegetative cover to a minimum, within practical limits.

E. Protect exposed critical areas during prolonged construction or other land disturbance by temporary seeding, mulching or other suitable stabilization measures.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Silt fence.
   1. Silt Fence Fabric: The fabric shall meet the following specifications unless otherwise approved by the appropriate erosion and sediment control plan approval authority. Such approval shall not constitute statewide acceptance.

Fabric Properties	Minimum Acceptable Value	Test Method
Grab Tensile Strength (lbs)	90	ASTM D1682
Elongation at Failure (%)	50	ASTM D1682
Mullen Burst Strength (PSI)	190	ASTM D3786
Puncture Strength (lbs)	40	ASTM D751 (modified)
Slurry Flow Rate (gal/min/sf)	0.3	
Equivalent Opening Size	40-80	US Std Sieve CW-02215
Ultraviolet Radiation Stability (%)	90	ASTM G-155

   2. Fence Posts (for fabricated units): The length shall be a minimum of 36 IN long. Wood posts will be of sound quality hardwood with a minimum cross sectional area of 3.0 square inches. Steel posts will be standard T and U section weighing not less than 1.00 pounds per linear foot.
   3. Wire Fence (for fabricated units): Wire Fencing shall be a minimum 14 gage with a maximum 6 IN mesh opening, or as approved.
   4. Prefabricated Units: Envirofence, Geofab, or approved equal may be used in lieu of the above method providing the unit is installed per details shown.

B. Grass Seed: Annual ryegrass.

PART 3 - EXECUTION

3.1 PREPARATION

A. Prior to General Stripping Topsoil and Excavating:
   1. Install silt fence to control runoff.

B. Temporarily topsoil stockpiles:
   1. Rate: 1/2 LB/1000 SF.
   2. Reseed as required until good stand of grass is achieved.

3.2 DURING CONSTRUCTION PERIOD

A. After rough grading, sow temporary grass cover over all exposed earth areas.

B. Construct inlets as soon as possible.
   1. Excavate and tightly secure sediment traps completely around inlets.

C. Do not disturb existing vegetation (grass and trees).

D. Remove sediment from behind silt fence to prevent overtopping.

E. Topsoil and fine grade slopes and swales.
   1. Seed and mulch as soon as areas become ready.

3.3 NEAR COMPLETION OF CONSTRUCTION

A. Grade to finished or existing grades.

B. Fine grade all remaining earth areas, then seed and mulch.

END OF SECTION

SECTION 31 27 00
BIORETENTION

PART 1 - GENERAL

1.1 SUMMARY

A. Preparation and installation of soil mixture for filtration of surface storm water run-off within the bioretention area.

1.2 RELATED SECTIONS

A. Refer to Civil Drawings.

B. Refer to Landscape Drawings.

C. Section 31 22 00, SITE EXCAVATION AND ROUGH GRADING.

1.3 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM), 1916 Race Street Philadelphia, PA. 19103.

1.4 SUBMITTALS

A. Submit in accordance with Division 1 in sufficient detail to show full compliance.

B. Submit manufacturer's product description, criteria, limitations, applications, and technical data.

C. Prior to installation, submit test results of final soil mix for fertility, pH, micronutrient analysis, organic content, and particle gradation.

D. LEED Information:
   1. LEED Credits MR 4.1 and 4.2, Recycled Content: Product data indicating percentages by weight of post-consumer and post-industrial recycled content for products having recycled content; include statement indicating costs for each product having recycled content.
   2. LEED Credits MR 5.1 and 5.2, Regional Materials: For products and materials required to comply with requirements for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.
   3. LEED Credit MR 6.0, Rapidly Renewable Materials: Manufacturers' product data for products manufactured from rapidly renewable material; indicate type of rapidly renewable material.

PART 2 - PRODUCTS

2.1 SUBSTITUTIONS

A. Requests for substitutions will be considered under provisions of Division 1.

B. All applications for substitution must include samples and technical data.

C. All permitted equals must be approved in writing by the Landscape Architect.

2.2 PLANTING DESIGN MIX

A. The planting mix shall be composed of 50-60% sand, 20-30% compost, and 20-30% native or imported top soil.

B. Sand Component
   1. Sand shall be washed, coarse graded sand. River sand is NOT acceptable.
   2. Sand shall comply with the following:

Sieve No.	Aggregates
3/8	100
4	95-100
8	70-95
16	45-85
30	20-65
50	5-30
100	0-5
200	

   3. Sand shall have an effective particle size (D10) ranging from 0.30 – 0.55 millimeters.
   4. Sand shall have a uniformity coefficient (D60/D10) of less than 3.

C. Compost Component
   1. Compost shall be organic matter such as bone meal, rotted manure, decomposed wood derivatives, recycled compost, or worm castings. Peat moss is NOT acceptable.
      a. Composted Rice Hulls: Hammer milled rice hulls, composted for a minimum of 24 months, pH 5.7, and water retention 50% by weight.
      b. Bone meal: Raw, finely ground, commercial grade, minimum of 3 percent nitrogen and 20 percent phosphorous.
      c. Rotted manure: Composted, unleached horse, chicken, or cattle manure, heat treated to kill weed seeds, containing a maximum 25 percent by volume of straw, sawdust, or other bedding materials, free of stones, sticks, soil, and toxic substances harmful to plants, fully composted or stabilized with nitrogen.
      d. Decomposed Wood Derivatives: ground bark, sawdust, yard trimmings, or other wood waste material free of stones, sticks, soil, and toxic substances harmful to plants, fully composted or stabilized with nitrogen.
   2. Compost shall have an organic matter content of 35-65% per ASTM D-2974.
   3. Compost shall have a carbon to nitrogen ratio between 20:1 and 35:1.

D. Soil Component
   1. Soil shall be native or imported topsoil.
   2. Soil shall have a maximum clay content of 5%. If existing soils have a clay content exceeding 5%, appropriate amendments shall be utilized to dilute the clay content to allowable tolerances. Allowable amendments include those listed under Part 2.2(C)(1).
   3. Soil shall not be obtained from bogs, marshes, or steep, clayey soils.
   4. Soil shall not be stripped, collected, or deposited in a wet condition.
   5. Soil shall be free of unwanted vegetation.

E. Performance Standards
   1. Final soil mix shall have a minimum long-term hydraulic conductivity of one inch (1 IN) per hour per ASTM D-2434 at 80% compaction per ASTM D-1557.
   2. Final soil mix shall have a pH between 5.5 and 7.0.
   3. Final soil mix shall have a minimum organic content of 10% by dry weight per ASTM D-2974.
   4. Less than 25% of the final soil mix shall pass through a #200 sieve. 100% of the final soil mix shall pass through a 3/4 IN sieve.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that prepared trenches are ready to receive work described under this section. Commencement of installation means acceptance of existing conditions.

3.2 PREPARATION

A. Blend final soil mix in ratios indicated under Part II. Component parts shall be dry at time of mixing. All component parts shall be evenly distributed throughout the mix, and any clumps of component materials shall be removed.

B. Have soil analyzed by soil testing agency and submit written analysis stating the textural class; particle size; percentage of nitrogen, phosphorus, and potash; soluble salt content; organic matter content; and pH value of the soil.

3.3 INSTALLATION

A. Final Soil Mix
   1. Lay final soil mix from bottom of trench or top of overflow pipe wrapped in geotextile fabric to finished grade elevations in 8 inch lifts.
   2. Hand tamp each lift to compact soil mixture at 80% per ASTM D-1557.
   3. Allow for placement of erosion control matting by subtracting the thickness of the mat from finished grade in the final soil mix lift.

B. Planting
   1. Install plant material per Plants and Planting specification 02950.
   2. Mulch entire area uniformly to a depth of 3 IN with organic mulch.

3.4 MAINTENANCE

A. Upon completion of work described in Section 3.3, thoroughly water at a rate of one inch (1 IN) of water per week. Maintain water schedule until new plant material has become established.

B. Install silt fencing on the uphill side of all planted areas to prevent the migration of unwanted materials (stone fines, silt, etc.) into the planting mix. Maintain until end of construction period.

3.5 PROTECTION

A. Protect installed plantings and soil mix from damage until Final Acceptance.

END OF SECTION

DIVISION 32

EXTERIOR IMPROVEMENTS

SECTION 32 12 16
ASPHALTIC CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Asphaltic pavement.

B. Related Sections include but are not necessarily limited to:
   1. General Conditions Governing All Contracts.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. ASTM International (ASTM):
      a. D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3).
   2. Federal Specifications (FS):
      a. TT-P-115E, Paint, Traffic Highway, White.
   3. Construction standards: New York State, Department of Transportation, "Standard Specifications" (NYSDOT Standard Specifications - Construction and Materials Volume 1: General Provisions, Earthwork, Bases and Subbases, Hot Mix Asphalt, Portland Cement Concrete dated January 2, 2002).

B. Testing Agency Qualifications: Qualified according to ASTM D 3666 for testing indicated.

C. Preinstallation Conference: Conduct conference at Project site to comply with requirements of Division 1 Section "Project Meetings". Review methods and procedures related to asphalt paving including, but not limited to, the following:

   1. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
   2. Review condition of substrate and preparatory work performed by other trades.
   3. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.
   4. Review and finalize construction schedule for paving and related work.
   5. Verify availability of materials, paving Installer's personnel, and equipment required to execute the Work without delays.
   6. Review inspection and testing requirements, governing regulations, and proposed installation procedures.
   7. Review forecasted weather conditions and procedures for coping with unfavorable conditions.

D. Miscellaneous:
   1. Should conflicts arise between standard specifications of government agencies mentioned herein and Contract Documents, Contract Documents shall govern.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.

B. Job-Mix Designs: Certification of approval (by authorities having jurisdiction) of each job mix proposed for the Work.

C. Qualification Data: For qualified Manufacturer and Installer to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and BNLs, and other information as required.

D. LEED Information:
   1. LEED Credits MR 4.1 and 4.2, Recycled Content: Product data indicating percentages by weight of post-consumer and post-industrial recycled content for products having recycled content; include statement indicating costs for each product having recycled content.
   2. LEED Credits MR 5.1 and 5.2, Regional Materials: For products and materials required to comply with requirements for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.

1.4 PROJECT CONDITIONS

A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:
   1. Tack Coat: Minimum surface temperature of 60 deg F.
   2. Binder Courses: Minimum surface temperature of 40 deg F. and rising at time of placement.
   3. Wearing Course: Minimum surface temperature of 60 deg F at time of placement.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Asphaltic Concrete: Per New York State, Department of Transportation, Standard Specifications, including latest updated versions.
   1. Wearing course: Type 7.
   2. Binder course: Type 3.

B. Line Paint:
   1. Nonreflective.
   2. White or Blue as shown on drawings.
   3. Fed Spec TT-P-115E.

2.2 MIXES

A. Comply with mix design category per New York State, Department of Transportation, Standard Specifications, including latest updated versions.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to support aggregate subbase course, asphalt paving and imposed loads.

B. Proof-roll subgrade below asphalt paving with heavy, pneumatic-tired equipment to identify areas that are unstable or otherwise unsuitable, and requiring additional compaction prior to start of paving installation.

C. Notify BNL in writing of any unsatisfactory conditions. Do not begin aggregate subbase course or paving installation until unsatisfactory conditions have been corrected.

D. Start of aggregate subbase course or asphalt paving installation indicates acceptance of subgrade conditions and suitability for support of aggregate subbase course, asphalt paving and imposed loads.

3.2 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade or aggregate subbase course is ready to receive paving.

3.3 INSTALLATION

A. Construct to line, grade and section as shown on Drawings and in accordance with referenced State Specifications.

B. Install layer of structural fill compacted to 95 percent of maximum density in accordance NYSDOT.

C. Install binder course to the thickness shown on the Drawings and compact to 95 percent of average maximum theoretical density in accordance with NYSDOT.

D. Install surface course to the thickness shown on the Drawings and compact to 95 percent of average maximum theoretical density in accordance with NYSDOT.

E. Construct joints to ensure continuous bond between adjoining paving sections. Construct joints free of depressions with same texture and smoothness as other sections of hot-mix asphalt paving.

F. Tolerance of Finished Grade: ±0.10 FT from required elevations.

G. Testing:
   1. Thickness and in-place density testing will be in accordance with NYSDOT.

3.4 LINE PAINTING

A. Thoroughly clean surfaces which are to receive paint.

B. Make completely dry before paint is applied.

C. Do not paint until minimum of 5 days has elapsed from time surface is completed. A longer period may be required if directed by BNL.

D. Do not apply paint over wet surfaces, during wet or damp weather, or when temperature is below 40 DegF.

E. Lay out markings and striping in accordance with Drawings. Width of painted lines: 4 IN minimum, unless shown otherwise.

END OF SECTION

SECTION 32 13 13
CONCRETE PAVING AND CURBS

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Construction minimum standards: State of New York, Department of Transportation, "Standard Specifications for Construction and Materials", 2002, as amended to date.

B. Should conflicts arise between standard specifications of government agencies mentioned herein and Contract Documents, the more stringent shall govern.

1.2 SUBMITTALS

A. Product data:
   1. Concrete mix design.

B. LEED Information:
   1. LEED Credits MR 4.1 and 4.2, Recycled Content: Product data indicating percentages by weight of post-consumer and post-industrial recycled content for products having recycled content; include statement indicating costs for each product having recycled content.
   2. LEED Credits MR 5.1 and 5.2, Regional Materials: For products and materials required to comply with requirements for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.
   3. LEED Credit MR 6.0, Rapidly Renewable Materials: Manufacturers' product data for products manufactured from rapidly renewable material; indicate type of rapidly renewable material.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Expansion joint filler: Per ASTM-D545, Flexible Foam.
      a. Base:
         1) Sonneborn Building Products, "SonoFlex F".
      b. Optional:
         1) Meadows, WR, "Ceramar".

B. Concrete (air-entrained):
   1. For vehicular paving: Class "C", per Section 502.
   2. For walk paving: Class "A", per Section 608.
   3. For curb and gutter: Class "A" per Section 609.
   4. LEED requirement: Mix for exposed concrete surfaces shall provide albedo of minimum 0.30 reflectivity as measured in accordance with ASTM-E408.
   5. Compression strength (28 days): 3000 PSI (typical); 4500 PSI at vehicle paving.

C. Welded wire fabric:
   1. ASTM-A185 or ASTM-A497.
   2. Walk paving: 6 x 6 - W1.4 x W1.4.

D. Dowels, load transfer devices, tie bars, reinforcing bars, etc.: ASTM-A615, Grade-60.

E. Sealant:
   1. F.S.TT-S-00227F, type 1, class A, polyurethane type.
   2. Use self-leveling type for horizontal joints.
   3. Use gun grade, non-sag type for horizontal and vertical joints.

F. Liquid curing compound:
   1. Comply with AASHTO M148 and State Specifications.

PART 3 - EXECUTION

3.1 CONSTRUCTION - GENERAL

A. Construct to line and grade indicated.

B. Construct in accordance with State specifications.

3.2 CONCRETE VEHICULAR PAVING

A. On properly compacted aggregate subbase, install concrete; finish with burlap drag.
   1. Construct with reinforcing as detailed.

B. Provide longitudinal and transverse control joints in locations indicated.
   1. 1/2 IN wide by 0.25 depth of slab with 1/4 IN radius edges at top, or:
   2. Saw cut, 1/8 IN by minimum 0.25 depth of slab.
   3. Fill with sealant.

C. Provide expansion joints in locations indicated.

D. Provide construction joints at end of each day's work and whenever necessary to suspend work for a period of more than 30 minutes.
   1. Key joints with 2 x 1 IN key.
   2. Provide 1/2 IN diameter by 30 IN long deformed tie bars at 30 IN OC, centered in pavement; perpendicular to joint.
   3. Provide 1/2 IN wide by 1 IN deep joint with 1/4 IN radius edges at top.
   4. Seal with sealant.

E. Cure concrete per State Specifications.

3.3 CONCRETE WALK PAVING

A. On properly compacted aggregate subbase, install 4 IN layer of concrete with welded wire mesh centered in slab.
   1. Place walk paving 1/4 IN above top of any adjacent, abutting curb.
   2. Slope surface at 1:50 transversely toward curb.
   3. Finish: Light broom finish.

B. Provide expansion joint material between walk paving and back of curb.

C. Provide contraction joints:
   1. Construct tooled (dummy) joints.
   2. Keep joints straight and perpendicular to edge of walk unless otherwise indicated.
   3. Locate joints as indicated.

D. Provide expansion joints as indicated and where walks meet other structures.
   1. Expansion joints at maximum 30 FT OC.
   2. Set joint filler to within 1/2 IN of surface.
   3. Do not seal transverse joints of single width walks.
   4. Seal other joints.

E. Construct curb ramps.

F. Correct areas where "bird baths" occur to eliminate ponding conditions.

G. Cure concrete per State Specifications.

3.4 CONCRETE CURB

A. Construct curb as detailed.

B. Provide contraction joints at maximum 10 FT OC using metal templates or saw cutting.
   1. Cut top and face of curb.

C. Provide 3/4 IN expansion joints, at maximum 100 FT O.C.
   1. Do not seal joints.

D. Depress curbs for curb ramps.

E. Cure concrete per State Specifications.

END OF SECTION

SECTION 32 14 13
PRECAST CONCRETE PAVERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Concrete pavers set in aggregate setting bed.
   2. Edge restraints for unit pavers.
   3. Joint sand stabilizer.

1.3 SUBMITTALS

A. Product Data: For each product indicated.

B. Samples: Showing the full range of colors, textures, and patterns available for each type of unit paver indicated:
   1. Include Samples of material for joints and accessories involving color selection.

C. LEED Information:
   1. LEED Credits MR 4.1 and 4.2, Recycled Content: Product data indicating percentages by weight of post-consumer and post-industrial recycled content for products having recycled content; include statement indicating costs for each product having recycled content.
   2. LEED Credits MR 5.1 and 5.2, Regional Materials: For products and materials required to comply with requirements for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.

1.4 QUALITY ASSURANCE

A. Build mockups for each form and pattern of unit paver:
   1. Build mockups for each type to show pattern of pavers, joints, edge restraint, setting bed, and subbase. Mock up shall be a minimum of 4 FT x 4 FT.
   2. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.5 PROJECT CONDITIONS

A. Cold-Weather Protection: Do not use frozen materials or build on frozen subgrade or setting beds.

B. Do not install paver system if ground is muddy or frozen.

PART 2 - PRODUCTS

2.1 UNIT PAVERS

A. Concrete Pavers: Solid, interlocking paving units, ASTM C 936, made from normal-weight aggregates in sizes and shapes indicated supplied by a member of the Interlocking Concrete Pavement Institute (ICPI):

1. HANOVER ARCHITECTURAL PRODUCTS, Inc.: 240 Bender Road, Hanover PA 17331.
2. Color and Texture:
   a. Refer to drawing sheets.

2.2 ACCESSORIES

A. Paver Edge Restraints:
   1. Manufacturer:
      a. Snap Edge, website: www.snapedgeusa.com .

2.3 AGGREGATE SETTING-BED MATERIALS

A. Aggregate Subbase: Refer to Section 31 22 00, SITE EXCAVATION AND ROUGH GRADING.

B. Geotextile: Woven or nonwoven polyester or polypropylene geotextile, with a permeability rating 10 times greater than that of subgrade soil and an apparent opening size small enough to prevent passage of fines from leveling course into base course.

2.4 BEDDING AND JOINT SAND

A. Bedding and joint sand shall be clean, non-plastic, free from deleterious or foreign matter. The sand shall be natural or manufactured from crushed rock. When concrete pavers are subject to vehicular traffic, the sands shall be as hard as practically available.

B. Grading of sand samples for the bedding course and joints shall be done according to ASTM C 136. The bedding sand shall conform to the grading requirements of ASTM C 33 as shown in Table 1. The joint sand shall conform to ASTM C144 as shown in Table 2.

Table 1
Grading Requirements for **Bedding Sand**

ASTM C 33	
Sieve Size	Percent Passing
3/8 IN (9.5 mm)	100
No. 4 (4.75 mm)	95 to 100
No. 8 (2.36 mm)	85 to 100
No. 16 (1.18 mm)	50 to 85
No. 30 (600mm)	25 to 60
No. 50 (300mm)	10 to 30
No. 100 (150mm)	2 to 10

Table 2
Grading Requirements for **Joint Sand**

ASTM C 144		
Sieve Size	Natural Sand Percent Passing	Manufactured Sand Percent Passing
No.4 (1.18 mm)	100	100
No. 8 (2.36 mm)	95 to 100	95 to 100
No. 16 (1.18 mm)	70 to 100	70 to 100
No. 30 (600mm)	40 to 75	40 to 100
No. 50 (300mm)	10 to 35	20 – 50
No. 100	2 to 15	10 to 25
No. 200	0	0-10

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Mix pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.

B. Cut unit pavers with motor-driven masonry saw to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible:
   1. For concrete pavers, a block splitter may be used.

C. Joint Pattern: As indicated.

D. Tolerances: Do not exceed 1/16 IN unit-to-unit offset from flush nor 1/8 IN in 24 IN and 1/4 IN in 10 FT from level, or indicated slope.

E. Provide edge restraints as indicated. Install edge restraints before placing unit pavers.

3.2 UNIT PAVER APPLICATION

A. Compact soil subgrade: Refer to Section 31 22 00, “Site Excavation and Rough Grading”.

B. Proof-roll prepared subgrade and correct deficient areas.

C. Place aggregate subbase in thickness indicated. Compact by tamping with plate vibrator.

D. Place geotextile over base course, overlapping ends and edges at least 12 IN.

E. Place sand leveling course and screed to a thickness of 1-1/4 to 1-1/2 IN, taking care that moisture content remains constant and density is loose and constant until pavers are set and compacted. The screeded sand should not be disturbed. Place sufficient sand to stay ahead of the laid pavers. Do not use the bedding sand to fill depressions in the base surface.

F. Ensure that pavers are free of foreign materials before installation.

G. Lay the pavers in the pattern(s) as shown on the drawings. Maintain straight pattern lines. Set pavers with handtight joints, being careful not to disturb leveling base. Cut pavers to be placed along the edge with a double blade paver splitter or masonry saw. Units cut no smaller than one-third of a whole paver are recommended along edges subject to vehicular traffic.

H. Vibrate the pavers, sweeping dry joint sand into the joints and vibrating until they are full. This will require at least two or three passes with the vibrator. Do not vibrate within 3 FT of the unrestrained edges of the paving units.

I. All work to within 3 FT of the laying face must be left fully compacted with sand-filled joints at the completion of each day.

J. Sweep off excess sand when the job is complete.

K. The final surface elevations shall not deviate more than 3/8 IN under a 10 FT long straightedge.

L. The surface elevation of pavers shall be 1/8 to 1/4 IN above adjacent drainage inlets, concrete collars or channels.

3.3 FIELD QUALITY CONTROL

A. After removal of excess sand, check final elevations for conformance to the drawings.

END OF SECTION

SECTION 32 14 15
PERVIOUS CONCRETE PAVING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section shall cover pervious vehicular concrete constructed upon the prepared subgrade and in conformance with the lines, grades, thickness, and cross sections shown. Construction shall include the following:
   1. Pervious concrete design mix.
   2. Subgrade design.
   3. Integral color.

1.2 RELATED WORK

A. Laboratory and Field Testing Requirements: Section 01 45 23, TEST AND INSPECTIONS.

B. Subgrade Preparation: Section 31 22 00, SITE EXCAVATION AND ROUGH GRADING.

1.3 DESIGN REQUIREMENTS

A. Design all elements with the latest published version of applicable codes.

1.4 SUBMITTALS

A. In accordance with Section 01 30 00, SUBMITTAL PROCEDURES, furnish the following:

B. Manufacturers' Certificates and Data certifying that the following materials conform to the requirements specified.
   1. Expansion joint filler
   2. Reinforcement
   3. Curing materials
   4. Integral color pigment.
   5. Agreggate

C. Data and Test Reports: Statement of Mix Design
   1. 1. Prepared by batch plant servicing subject project.
   2. 2. Include the following information:
      a. Name, address, and telephone number of batch plant preparing statement of mix design.
      b. Date of mix design.
      c. Mix design number.
      d. Integral color used.
      e. Gradations for sand and aggregate.
      f. Material weights, specific gravity, and absolute volumes.
      g. Basis of testing, i.e. UBC 2605 D4 and Title 24 2604 D4.
      h. Water/cement ratio.
      i. Air entrainment.
      j. Seven and 28 day compression test results of trial mixes or standard deviation analysis of an established mix.
      k. Signature of testing laboratory manager.
      l. List State where Project will be built.
      m. Stamped and signed by registered Engineer licensed in the State of New York.
   3. Submit source and certification or proof of quality (and compatibility of admixtures) for each of the constituents of the proposed concrete mixes. Compatibility of admixture must be certified.

4. Review and approval of mix designs by Architect does not relieve the Contractor of responsibility to provide concrete of the quality and strengths required by the Contract Documents.

D. LEED Information:
   1. LEED Credits MR 4.1 and 4.2, Recycled Content: Product data indicating percentages by weight of post-consumer and post-industrial recycled content for products having recycled content; include statement indicating costs for each product having recycled content.
   2. LEED Credits MR 5.1 and 5.2, Regional Materials: For products and materials required to comply with requirements for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.

1.5 PRE-CONCRETE CONFERENCE

A. General: At least 15 days prior to submittal of design mixes, conduct a meeting to review proposed methods of concrete construction to achieve the required results.

B. Agenda: Includes but is not limited to:
   1. Submittals.
   2. Coordination of work.
   3. Availability of material.
   4. Concrete mix design including admixtures.
   5. Methods of placing, finishing, and curing.
   6. Finish criteria required to obtain required flatness and levelness.
   7. Timing of floor finish measurements.
   8. Material inspection and testing.

C. Attendees: Include but not limited to representatives of Contractor; subcontractors involved in supplying, conveying, placing, finishing, and curing concrete; lightweight aggregate manufacturer; admixture manufacturers; Resident Engineer; Consulting Engineer; Testing Laboratories Representative for concrete testing and finish.

D. Minutes of the meeting: Contractor shall take minutes and type and distribute the minutes to attendees within five days of the meeting.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products who complies with ASTM C 94/C 94M requirements for production facilities and equipment.
   1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."

B. Contractor qualification: unless otherwise approved by the BNL, Contractor shall provide evidence of employment of two (2) NRMCA certified Pervious Concrete Technicians, and who must be on site, working as members of each placement crew, during all pervious concrete placement.

C. Testing Agency Qualifications: An independent agency qualified according to ASTM C 1077 and ASTM E 329 for testing indicated, as documented according to ASTM E 548.

D. Mockups: Cast mockups of full-size sections of pervious concrete pavements (10’X10’X6” 2 CY pervious section) to demonstrate method of placement, consolidation, determination of compaction effort, typical joints, surface finish, texture, and standard of workmanship. Place one mockup for each mix design.
   1. Build mockups in the location and of the size indicated or, if not indicated, as directed by the Project Engineer.
   2. Notify Engineer seven days in advance of dates and times when mockups will be constructed.

3. Obtain Engineer's approval of mockups before starting construction.
4. Maintain approved mockups during construction in an undisturbed condition as a standard for judging the completed pavement.
5. Mockups shall have two cores taken from each panel in accordance with ASTM C42 at a minimum of seven (7) days after placement of the pervious concrete. The cores shall be measured for thickness, void structure and unit weight. The average of all production cores shall not be less then the specified design thickness. After thickness determination, the cores shall be trimmed and measured for unit weight in the saturated condition as described in paragraph 6.3.1 “Saturation” of ASTM C140 “Standard Methods of Sampling and Testing Concrete Masonry Units”. The trimmed cores shall be immersed in water for 24 hours, allowed to drain for one (1) minute, surface water removed with a damp cloth, then weighed immediately. Range of satisfactory unit weight values is +/- 5 pcf of the design unit weight.
6. Demolish and remove approved mockups from the site when directed by BNL at the end of the project.

1.7 PROJECT CONDITIONS

A. Keep Work area clean, and in a safe and workmanlike condition so that rubbish, waste and debris do not interfere with work of other trades or building occupants.

B. Prevent surrounding soil erosion from clogging pervious pavement.

C. Transit mix trucks shall be restricted from driving on pervious pavement subbase. Utilize conveyors as necessary.

PART 2 - PRODUCTS

2.1 GENERAL

A. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source throughout the project:

B. Pervious concrete: ASTM C 150, Type I or II. May be supplemented with fly ash per ASTM C618, Class C of F, or ground granulated blast furnace slag cement.

C. Pervious Concrete Aggregate: 3/8 IN maximum course aggregate locally available. Rounded river gravel or crushed stone.
   1. Aggregate must be clean and washed, free of dust (less than 1.5 percent).

D. Water: ASTM C 94/C 94M.

E. Air-Entraining Admixture: ASTM C 260.

F. Fibers: Use fibrillated variable length polypropylene fiber or equivalent.
   1. Remove fibers from bags before adding to mix to prevent balling.

G. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.
   1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
   2. Retarding Admixture: ASTM C 494/C 494M, Type B.
   3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
   4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
   5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, type G.
   6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.
   7. Calcium chloride not permitted.

2.2 INFILTRATION BASIN AGGREGATE

A. The Contractor shall provide the source of materials, gradation, laboratory test results.
   1. Infiltration Bed Aggregate Material
      a. AASHTO Size No. 3 Aggregate Gradation

Opening	Percent Finer, by weight
2 1/2 IN	100
2 IN	90 to 100
1 1/2 IN	35 to 70
1 IN	0 to 15
3/4 IN	- -
1/2 IN	0 to 5
3/8 IN	- -
No. 4	- -
No. 8	- -

   2. Infiltration Bed Aggregate Choker Course Material
      a. AASHTO Size No. 57 Aggregate Gradation

Opening	Percent Finer, by weight
2 1/2 IN	- -
2 IN	- -
1 1/2 IN	100
1 IN	95 to 100
3/4 IN	- -
1/2 IN	25 to 60
3/8 IN	- -
No. 4	0 to 10
No. 8	0 to 5

2.3 CURING MATERIALS

A. Moisture-Retaining Cover: ASTM C 171, 6 mil polyethylene sheeting or white burlap-polyethylene sheet. Required for pervious concrete.

B. Water: Potable.

2.4 RELATED MATERIALS

A. Color Pigment: Use integral color only.

2.5 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301, for each type and strength of normal-weight concrete determined by either laboratory trial mixes or field experience.
   1. Use a qualified independent testing agency for preparing and reporting proposed concrete mixture designs for the trial batch method.
   2. Mix design adjustments may be requested by Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant; at no additional cost to BNL. Laboratory test data for revised mix design and strength results must be submitted to and accepted by BNL before using in work.

B. Proportion mixtures to provide Portland cement pervious concrete with the following properties:
   1. Compressive Strength (28 Days): 3500 psi.
   2. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.29
   3. Cement per Cubic Yard: 503lbs.

4. For other admixtures, adjust proportions for 0.29 water to cement (W/C) ratio and typical dosage rates for 6 percent air entrainment. The mix will be stiff and retarder may be added to facilitate placement.
5. Final void ratio must be between 15 percent and 21 percent.
6. Aggregate weights are dry-weights – in-situ moisture and absorption must be taken into account.

C. Add air-entraining admixture at manufacturer's prescribed rate for exterior concrete.

D. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.
1. Use water-reducing admixture in concrete, as required, for placement and workability.
2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions. Obtain prior approval for use of hydration retarder for use in pervious concrete.

E. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 requirements.

2.6 CONCRETE MIXING

A. Ready-Mixed Concrete:
1. Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M.
2. Furnish batch certificates for each batch discharged and used in the Work.
3. Mixing and delivery time for PCPC shall not exceed 60 minutes.

2.7 GEOTEXTILE FABRIC

A. A geotextile filter fabric should be placed under the subbase and up the sides of the subbase to prevent migration of silts and clay fines from the subgrade horizontally or vertically into the subbase material and as shown in the plans Geotextile fabric shall be tested for the ability to allow water to readily penetrate the fabric.

2.8 FORMS

A. Use metal or wood forms that are straight and suitable in cross-section, depth, and strength to resist springing during depositing and consolidating the concrete, for the work involved.

B. Do not use forms if they vary from a straight line more than 1/8 IN in any 10 FT long section, in either a horizontal or vertical direction.

C. Wood forms should be at least 2 IN thick (nominal). Wood forms shall also be free from warp, twist, loose knots, splits, or other defects. Use approved flexible or curved forms for forming radii.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proceed with concrete pavement operations only after nonconforming conditions have been corrected and subgrade is ready to receive pavement.

C. A plate compactor may be used to compact the surface of the subbase aggregate to provide a firm and level surface for placement of the pervious concrete mix.

3.2 PREPARATION

A. Remove loose material from compacted subbase surface immediately before placing concrete.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for pavement to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

C. Elevate the form grade 3/8” to ½” above forms if vibratory screed and compacted roller are used separately.

3.4 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edgings true to line with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline, unless otherwise indicated.
   1. When joining existing pavement, place transverse joints to align with previously placed joints, unless otherwise indicated on the approved jointing plan.

B. Construction Joints: Set construction joints at side and end terminations of pavement and at locations where pavement operations are stopped for more than 15 minutes.

C. Isolation Joints: Not Used

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-third of the concrete thickness, as follows:
   1. Grooved Joints: Form contraction joints after initial compaction by grooving and finishing each edge of joint with grooving tool to a 3/8 IN radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate groover marks on concrete surfaces.

E. Edging: Tool edges of curbs and walks in concrete after initial floating with an edging tool to a 1/4 IN radius. Repeat tooling of edges after applying surface finishes. Eliminate tool marks on concrete surfaces.

3.5 CONCRETE PLACEMENT – GENERAL

A. Inspection: Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast in. Notify other trades to permit installation of their work.

B. Remove snow, ice, or frost from subbase surface and reinforcement before placing concrete. Do not place concrete on frozen surfaces.

C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

D. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.

E. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

F. Consolidate concrete according to ACI 301 by mechanical vibrating equipment supplemented by hand tamping.
   1. Use only square-faced shovels for hand spreading and consolidation.
   2. Do not over consolidate concrete.
      a. Internal vibration and form edge vibration is not allowed.
   3. Screed pavement surfaces with a straightedge and strike off.

4. Screed pervious concrete to elevated forms using minimal vibration and then remove elevated forms if used. A power roller screed is used to provide final compaction of the pervious concrete to the top of the finish form height. After insuring the edges of the forms are uniformly filled with pervious concrete, immediately cover with plastic sheeting. Use a heavy roller to compact to the original form height. Install contraction joints within 15 minutes of concrete placement, mist concrete, and recover with plastic sheeting secured to prevent removal.
    a. Do not use free sand or dirt to secure sheeting to surface.
    b. The plastic sheeting shall be secured at the edges so as to prevent the entry and movement of air under the sheeting.
5. When adjoining pavement lanes are placed in separate pours, do not operate equipment on concrete until pavement has attained 85 percent of its 28-day compressive strength.
6. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
    a. When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.
    b. Do not use frozen materials or materials containing ice or snow.
    c. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mix designs.
7. Hot Weather Placement: Comply with ACI 301 and as follows when hot-weather conditions exist:
    a. Cool ingredients before mixing to maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
    b. Fog-spray forms and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.6 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Obtain prior approval for retarder use on pervious concrete.

D. Curing Methods:
1. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover per “RELATED MATERIALS” in Part 2 of this section.
2. Place in widest practicable width, with sides and ends lapped at least 12 IN, and sealed by waterproof tape or adhesive as necessary.
3. Immediately repair any holes or tears during curing period using cover material and waterproof tape. Keep cover in place a minimum of 7 days.
    a. Do not use stock piles of dirt or sand.
    b. The plastic sheeting shall be placed and secured over the pervious concrete immediately after final compaction with the power roller screed. The concrete surface shall be covered within 15 minutes after final compaction and jointing.
4. Curing compound is not required. If hot and windy conditions are present, the exposed surfaces of the pervious concrete can be misted lightly with plain water to prevent excessive drying of the surface prior to placement of the plastic sheeting.

3.7 PAVEMENT TOLERANCES

A. Comply with tolerances of ACI 117 and as follows:
1. Elevation: 1/4 IN.

2. Thickness: Plus 3/8 IN, minus 1/4 IN.
3. Surface: Gap below 10 FT long, unleveled straightedge not to exceed 1/4 IN.
4. Joint Spacing: 3 IN.
5. Contraction Joint Depth: Plus 1/4 IN, no minus.
6. Joint Width: Plus 1/8 IN, no minus.

3.8 QUALITY CONTROL

A. Strength of each concrete mix will be satisfactory if average of any 3 consecutive compressive strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.

B. Test results shall be reported in writing to Engineer, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

C. Remove and replace concrete pavement where unsatisfactory pavement is placed.

D. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.9 REPAIRS AND PROTECTION

A. Testing of Mock-up
1. After a minimum of seven (7) days following each placement, three cores of each day's pour shall be taken in accordance with ASTM C42.
2. Core holes shall be filled with pervious concrete of the design mixture.
3. A compressive strength test shall be the average compressive strength from two (2) specimens obtained from the same composite sample and tested at 28 days.
4. A minimum of one test for each day's placement of pervious concrete in accordance with ASTM C172 and with ASTM C29 to verify unit weight shall be conducted. Delivered unit weights are to be determined in accordance with ASTM C29 using a 0.25 cubic foot cylindrical metal measure. The measure is to be filled and compacted in accordance with ASTM C29 paragraph 11. The unit weight of the delivered concrete shall be +/- 5pcf of the design unit weight.

B. Remove and replace concrete pavement that is broken, damaged, or defective or that does not comply with requirements in this Section.

C. Protect concrete from damage. Exclude traffic from pavement for at least 14 days after placement. When construction traffic is permitted, maintain pavement as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain concrete pavement free of stains, discoloration, dirt, and other foreign material. Sweep concrete pavement not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION

SECTION 32 31 13
CHAIN LINK FENCE AND GATES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fence framework, fabric, and accessories.

B. Gates and gate hardware.

C. Clearing.

1.2 REFERENCES

A. Specification of Metallic-Coated Steel Chain Link Fence Fabric, published by Chain Link Fence Manufacturers Institute, Washington, DC 20036.

B. American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.
   1. ASTM A239 - Test Method for Locating the Thinnest Spot in a Zinc (Galvanized) Coating on Iron or Steel Articles by the Preece Test (Copper Sulfate Dip).
   2. ASTM F567 - Practice for Installation for Chain-Link Fence.

1.3 SUBMITTALS

A. Environmental Information:
   1. LEED Credit MR 4.1 and 4.2, Recycled Content: Product data indicating percentages by weight of post-consumer and post-industrial recycled content for products having recycled content; include statement indicating costs for each product having recycled content.
   2. LEED Credit MR 5.1, Local/Regional Materials: Manufacturer's certification indicating final point of assembly for products and materials located within 500 miles of Project site. Include manufacturer's name, address and phone number.

PART 2 - MATERIALS

2.1 FABRIC

A. Height: Refer to plans.

B. Composed of individual wire pickets helically wound and interwoven from No. 9 gage steel wire to form a continuous chain link fabric having a 2 IN diamond mesh pattern.

C. Salvages twisted and barbed, top and bottom.

D. Hot-dip galvanized after weaving.

E. Zinc coating of not less than 1.2 OZ/SQ FT of bare wire surface.

2.2 LINE POSTS

A. 2.875 IN outside diameter standard steel pipe weight 4.65 LB/LF or approved equal.

2.3 END, CORNER, ANGLE, AND PULL POSTS

A. Use 2.875 IN outside diameter steel pipe weighing 6.56 LB/LF or approved equal.

2.4 GATE POSTS

A. Double gates: 4 IN outside diameter iron pipe weighing 9.11 LB/FT or approved equal.

2.5 POST TOPS

A. Pressed steel or malleable iron designed as a weather tight closure cap for tubular posts.

B. Provide one cap for each post, unless equal protection is afforded by combination post top cap and barbed wire supporting arm where barbed wire is required.

C. Where top rail is used, provide tops to permit passage of top rail.

2.6 FABRIC TIES

A. No. 9 aluminum wire of approved design for use on line posts every 14 IN and on top rails every 24 IN.

2.7 BRACE AND TENSION BANDS

A. Unclimbable type with 5/16 IN diameter square-shouldered steel carriage bolts, non-removable from outside fence.

2.8 TENSION BARS

A. For attaching fabric to terminal posts: 3/16 IN by 3/4 IN high carbon steel attached to terminal post by means of beveled edge bands.

2.9 TOP RAIL

A. 1.66 IN outside diameter seamless steel pipe weighing 2.27 LB/LF or approved equal.

B. Galvanized by hot-dip process after fabrication.

C. To pass through bases of extension arms and form a continuous brace from end to end of each section of fence.

D. Provide with expansion rail couplings and suitable hot-dip galvanized connections.

2.10 BRACE PIPE

A. Same material as the top rail.

2.11 MISCELLANEOUS FITTINGS

A. Ferrous fittings required to make a complete installation to the malleable iron, pressed steel, aluminum, or forgings shall be hot-dip galvanized.

2.12 GATES

A. Manufacturer: Same as fence manufacturer.

B. Frames: 1.9 IN outside diameter steel pipe weighing 2.7 LB/LF with necessary intermediate braces of 1.66 IN outside diameter steel pipe weighing 2.27 LB/LF.

C. Pipe, fittings, stretcher bars, hook bolts, hinges, latches, truss-rods, and other accessories: Heavily galvanized by the hot-dip process.

D. Gate Fabric. Match fence fabric.

E. Latches for walk gate shall be fork type latch that will automatically engage latch post and fitted for padlock.

F. Hinges shall be of heavy, industrial type, hot-dip galvanized, offset type, allowing gates to swing back parallel with line of fence.

2.13 CONCRETE

A. Materials as specified in Section 03 33 00 - Cast-In-Place Concrete.

B. Proportions: 1:2:4.

C. Compressive strength: Not be less than 2,500 psi at 28 days.

PART 3 - EXECUTION

3.1 FENCE

A. Erect fencing in straight lines between angle points by skilled personnel experienced in this type of construction.

B. Erect in accordance with the manufacturer's recommendations as approved and with these Specifications.

C. The top rail of the fence shall be at the top of the fabric.

D. Fasten chain link fabric to end posts with stretcher bars and clamps at approximately 14 IN centers and to line posts and top rail with wire or bands at approximately

E. 24 IN centers.

3.2 POST SPACING AND SETTING

A. Post Holes: Refer to plans.

B. Space posts on centers and in true lines.

C. Set posts plumb.

D. Fill remainder of hole with concrete.

E. The top surface of the foundation shall extend above finished grade not less than 1 IN and shall have a crown watershed finish

F. After concrete has set, install accessories.

3.3 GATES

A. Brace gate posts diagonally to adjacent line posts to ensure stability.

B. Hang gates and adjust hardware so that gates operate satisfactorily from open or closed position.

3.4 BRACING

A. Install brace pipe midway between the top rail and extend from the terminal post to the first adjacent line post.

B. Fasten securely to the posts by heavy-pressed steel and malleable fittings.

C. Truss securely from line post to base of terminal post with a 3/8 IN truss rod and tightener.

3.5 CLEANUP

A. Upon completion of the fence installation, clean up waste material resulting from the operation.

END OF SECTION

SECTION 32 92 19
SEEDING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Location of work:
   1. Establish grass on areas within limits of grading, as indicated, which are not occupied by other planting or construction.
   2. Seed disturbed areas outside limits of construction.

1.2 QUALITY ASSURANCE

A. Minimum standards: U.S. Department of Agriculture (USDA), Federal Seed Act (53 Stat.1275) Rules and Regulations, as amended to date.

1.3 SUBMITTALS

A. Project information:
   1. Prior to delivery of materials, submit certificates certifying that materials meet requirements specified.
   2. Submit certified copies of reports for following materials:
      a. Seed indicating mixture percentage, botanical and common name(s), percentage by weight, and percentages of purity, germination and weed seed.
      b. Seed labeled in accordance with Federal Seed Act and equaling or exceeding specification requirements.
      c. Fertilizer indicating chemical analysis.
   3. Copies of invoices for fertilizer, indicating grade furnished, to determine total quantity applied.

B. Contract closeout information:
   1. Warranty.
   2. Maintenance data.

C. LEED Information:
   1. LEED Credits MR 4.1 and 4.2, Recycled Content: Product data indicating percentages by weight of post-consumer and post-industrial recycled content for products having recycled content; include statement indicating costs for each product having recycled content.
   2. LEED Credits MR 5.1 and 5.2, Regional Materials: For products and materials required to comply with requirements for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.
   3. LEED Credit MR 6.0, Rapidly Renewable Materials: Manufacturers' product data for products manufactured from rapidly renewable material; indicate type of rapidly renewable material.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver seed in standard sealed containers labeled with producer's name and seed analysis, and in accord with US Department of Agriculture Rules and Regulations under Federal Seed Act.

B. Deliver fertilizer to site in original, unopened containers labeled with manufacturer's chemical analysis.

1.5 JOB CONDITIONS

A. Perform seeding when conditions and planting season are suitable for successful results.

B. Actual dates for seeding will vary depending on construction schedule and pending weather conditions. Notify Architect of anticipated dates for doing work at least 30 days in advance.

1.6 WARRANTY

A. Warrant seeded areas for 1 year from Substantial Completion.

B. Replacement materials and methods identical to original.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Establish a smooth, healthy, uniform, close stand of grass from specified seed.

B. Grass seed:
   1. Fresh, clean, new crop seed.
   2. Species, proportions and minimum percentages of purity, germination, and maximum percentage of weed seed, as specified.
   3. Grass seed: 35 percent Genesis Tall Fescue, 30 percent Falcon II Tall Fescue, 30 percent Rebel III Tall Fescue, and 5 percent Preakness Blue Grass; or approved equal.

C. Mulch:
   1. Clean, weed free, threshed straw of oats, wheat, barley, rye, beans, peanuts, rice or other locally available mulch material.
   2. Do not use mulch containing a quantity of matured noxious weed seeds or other species that will be detrimental to seeding, or provide a menace to surrounding land.
   3. Do not use mulch material which is fresh or excessively brittle, or which is decomposed and will smother or retard growth of grass.
   4. Anchor mulch to soil by disking.

D. Fertilizer:
   1. Commercial fertilizer of 18-46-0 analysis, meeting applicable requirements of State and Federal Law.
   2. Do not use cyanamic compounds or hydrated lime.

E. Water for planting purposes:
   1. Supplied by BNL.
   2. Provide equipment necessary to transport water from source to required locations.
   3. Do not waste water.

PART 3 - EXECUTION

3.1 SOIL PREPARATION

A. Limit preparation to areas which will be planted soon after preparation.

B. Prior to applying fertilizer, loosen areas to be seeded to minimum depth of 4 IN with double disc or other suitable device if soil has become hard or compacted.

C. Remove stones over 1 IN in any dimension, sticks, roots, rubbish and other extraneous matter.

D. Correct surface irregularities in order to prevent pocket or low areas which will allow water to stand.

E. Spread lime uniformly over designated areas at rate of 50 LB/1000 SF.

F. After application of lime, prior to applying fertilizer, loosen areas to be seeded if soil has become hard or compacted.

G. Grade areas to be seeded to smooth, even surface with loose, uniformly fine texture.
   1. Roll and rake, remove ridges and fill depressions, as required to meet finished grades.
   2. Fine grade just prior to planting.

H. Distribute fertilizer uniformly over areas to be seeded at rate of 8.3 LB/1000 SF.
   1. Use suitable distributor.
   2. Incorporate fertilizer into soil to depth of at least 2 IN.

I. Restore areas to be seeded to specified condition if eroded or otherwise disturbed between finished grading and planting.

J. If fertilizer application rate is determined, by invoices submitted, to be less than that specified, apply additional fertilizer.

3.2 SEEDING BY DRILLING OR BROADCAST

A. Do not use seed which is wet, moldy or otherwise damaged.

B. Use approved mechanical power driven drills or seeders, or mechanical hand seeders, or other approved equipment.

C. Distribute seed evenly over entire area at not less than 4 LB/1000 SF, 50 percent sown in one direction, remainder at right angles to first sowing.

D. Stop seeding when work extends beyond most favorable planting season or when satisfactory results cannot be obtained because of drought, high winds excessive moisture, or other factors.
   1. Resume work only when favorable condition develops.

E. Lightly rake seed into soil to depth of 1/4 IN followed by light rolling or cultipacking.

F. Immediately protect seeded areas against erosion by mulching.
   1. Spread mulch in a continuous blanket using 1-1/2 TON/ACRE to depth of 4 or 5 straws.
   2. Disk anchoring:
      a. Anchor mulch by punching it into soil to depth of 2 to 3 IN by using a disk, clodbuster, or other approved equipment.

3.3 MAINTENANCE

A. Maintain seeded areas for 90 days after seeding.
   1. Water, fertilize, weed, mow, trim, roll, regrade, reseed as required.
   2. Establish a smooth, healthy, uniform, close stand, free of eroded or bare areas, weeds and surface irregularities.

B. Provide and maintain temporary piping, hoses and watering equipment as required to keep seeded areas uniformly moist for proper growth.
   1. Lay out temporary watering system and arrange watering schedule to avoid walking over muddy and newly seeded areas.
   2. Prevent puddling and water erosion and displacement of seed and/or mulch.

C. Mow seeded areas as soon as there is enough top growth to cut with mower set at recommended height for principal species and before height exceeds 3 IN.
   1. Repeat mowing as required to maintain height.
   2. Do not delay mowing until grass blades bend over and become matted.
   3. Do not mow when grass is wet.
   4. Time initial and subsequent mowings as required to maintain height of 1-1/2 to 2 IN.
   5. Do not mow lower than 1-1/2 IN.
   6. Remove no more than one-half grass leaf surface at any time.

D. Remulch with new mulch in areas where mulch has been disturbed by wind or maintenance operations sufficiently to nullify its purpose.

E. Anchor as required to prevent displacement.

F. Replant bare areas using same materials specified.

END OF SECTION

SECTION 32 92 22
WILDFLOWER SEEDING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Location of work: Establish wildflowers on areas where indicated.

1.2 SUBMITTALS

A. Project information:
   1. Certificates for wildflower mixture, stating botanical and common name of each plant species, percent composition, percent purity, minimum percent of germination and amount of pure live seed (PLS).
   2. Certify that each container of seed delivered is fully labeled in accordance with State and Federal Seed Laws and equals or exceeds specification requirements.

B. Contract closeout information:
   1. Maintenance data.
   2. Warranty.

C. LEED Information:
   1. LEED Credits MR 4.1 and 4.2, Recycled Content: Product data indicating percentages by weight of post-consumer and post-industrial recycled content for products having recycled content; include statement indicating costs for each product having recycled content.
   2. LEED Credits MR 5.1 and 5.2, Regional Materials: For products and materials required to comply with requirements for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.
   3. LEED Credit MR 6.0, Rapidly Renewable Materials: Manufacturers' product data for products manufactured from rapidly renewable material; indicate type of rapidly renewable material.

1.3 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver seed in standard sealed containers labeled with producer's name and seed analysis, and in accordance with US Department of Agriculture Rules and Regulations under Federal Seed Act.

1.4 JOB CONDITIONS

A. Perform seeding just prior to rainy season or during dry season, provided area is irrigated for 6 weeks after seeding.

1.5 WARRANTY

A. Warrant seeded areas for 1 year from Substantial Completion.

B. Reseed bare, dead, or dying areas during warranty period using same materials specified.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:

1. Wildflower seed mixture:
    a. Base:
        1) Ernst Conservation Seeds
2. Herbicide:
    a. Base:
        1) Roundup.
        2) Kleenup.

B. Establish a healthy, uniform stand of wildflowers from specified seed.

C. Wildflower seed:
1. Fresh, clean, new crop seed.
2. Wildflower seed mixture:
    a. Meadow Mix #1 Custom Native Grass Mix.
    b. Meadow Mix #2 Northeastern US Roadside Native Seed Mix – ERNMX-105.
    c. Festuca rubra "Molate".

D. Mulch:
1. Clean, seed free, threshed straw of oats, wheat, barley, rye, beans, peanuts or other locally available mulch material.
2. Do not use mulch containing noxious weed seeds or other species that will be detrimental to seeding, or provide a menace to surrounding land.
3. Do not use mulch material which is fresh or excessively brittle, or which is decomposed and will smother or retard growth of wildflowers.

E. Herbicide:
1. Roundup; or Kleenup.

F. Water:
1. Supplied by BNL.
2. Provide equipment necessary to transport water from source to required locations.
3. Do not waste water.

PART 3 - EXECUTION

3.1 WEED CONTROL

A. Plow soil to uproot existing weeds and vegetation.
1. Delay watering until vegetation is dead.
2. Remove dead vegetation by raking.

B. Irrigate area to encourage germination of new weed seeds.
1. Provide consistent moisture for 2 weeks for germination.

C. After new weeds are over 2 IN tall, spray area with herbicide.
1. Do not plow soil again after using herbicide.
2. Wait minimum 2-3 weeks before planting wildflowers.

D. If areas have been recently graded and are free of weed vegetation, disregard paragraph A above, and begin with paragraph B.

E. Perform finished grading just prior to planting with minimal disturbance to surface soil.

3.2 SOIL PREPARATION

A. Limit preparation to areas which will be planted soon after preparation.

B. Remove stones over 1 IN in any dimension, sticks, roots, rubbish and other extraneous matter.

C. Correct surface irregularities in order to prevent standing water in pockets or low areas.

D. Grade areas to smooth, even surface with loose, uniformly fine texture.

E. Roll and rake, remove ridges and fill depressions, as required to meet finished grades.

F. Restore areas to specified condition if eroded or otherwise disturbed between finished grading and planting.

3.3 SEEDING

A. Do not use seed which is wet, moldy or otherwise damaged.

B. Use approved mechanical power driven drills or seeders, or mechanical hand seeders, or other approved equipment.

C. Distribute seed evenly over entire area at not less than 1/2 LB per 1,000 SQ FT for Meadow Mix #1 and #2 and at not less than 5 LBS per 1,000 SQ FT for Festuca, rubra "Molate".

D. Use clean, dry sand as a carrier if required to achieve even distribution (1 or 2 parts sand to 1 part seed).
   1. If seeding by hand or mechanical hand seeder, sow 50 percent in one direction and remainder at right angle to first sowing.

E. With mechanical hand seeders, use clean, dry sand as a carrier (if required) to achieve even distribution (1 or 2 parts sand to 1 part seed).

F. With mechanical power driven drills, use cornmeal as a carrier.

G. Stop work when satisfactory results cannot be obtained because of drought, high winds, excessive moisture, or other factors.

H. Resume work only when conditions are favorable.

I. Lightly rake seed into soil to maximum depth of 2-3 times seed thickness.

J. If using power drill, drill to maximum of 1/4 IN depth and firm soil with cultipacker.

K. Hydroseeding/hydromulching is an acceptable method of seeding.
   1. Apply seed with 5-10 percent of mulching fiber.
   2. Apply balance of mulch separately as second step.

L. Immediately protect seeded areas against erosion by mulching.
   1. Spread mulch in a continuous blanket using 1.5 TON/ACRE to depth of 4 or 5 straws.
   2. Disc or crimp mulch into soil.
   3. If required, protect slopes with netting.

3.4 WATERING

A. Provide and maintain temporary piping, hoses and watering equipment as required to keep seeded areas uniformly moist for proper growth.
   1. Lay out temporary watering system and arrange watering schedule to avoid walking over muddy and newly seeded areas.
   2. Prevent puddling and water erosion and displacement of seed and mulch.

B. Water for 6 weeks after planting.

3.5 MAINTENANCE

A. Maintain seeded areas for 6 weeks after seeding, if planted in spring. If planted in fall, inspect 6 weeks after final frost in the following spring.

B. Substantial completion at 90% coverage.

C. Anchor mulch as required to prevent displacement.

D. Remulch in areas where mulch has been disturbed by wind or maintenance operations sufficiently to nullify its purpose.

E. Replant bare areas using same materials specified.

F. Pull weeds germinating with wildflowers, spot sprayed with herbicide, or selectively cut with string trimmer.

G. Fertilizer for wildflowers and Festuca rubra is not permitted.

H. Mowing:
   1. Festuca rubra “Molate”: Mow or prune above hight of Festuca rubra grass seedlings (approximately 4 - 6 IN). Mow or prune during early spring. Do not mow after early summer.
   2. Wildflowers: If planted in spring, mow to a height of no less than 8 IN in late July. Mow to a height of 4 – 6 IN in early spring, each following year.

END OF SECTION

SECTION 32 93 13
PLANTS AND PLANTING

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Nursery Stock Standard: "American Standard for Nursery Stock", ANSI-Z60.1.

B. Work performed by qualified nurseryman or landscape contractor.

C. Qualifications of Pruners: Experienced plantsmen.

1.2 SUBMITTALS

A. Planting Schedule.

B. Samples:
   1. Organic Mulch: 1/2 LBS of each type.

C. Contract Closeout Information:
   1. Warranty.
   2. Maintenance data.

D. LEED Information:
   1. LEED Credits MR 4.1 and 4.2, Recycled Content: Product data indicating percentages by weight of post-consumer and post-industrial recycled content for products having recycled content; include statement indicating costs for each product having recycled content.
   2. LEED Credits MR 5.1 and 5.2, Regional Materials: For products and materials required to comply with requirements for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.
   3. LEED Credit MR 6.0, Rapidly Renewable Materials: Manufacturers' product data for products manufactured from rapidly renewable material; indicate type of rapidly renewable material.

1.3 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Do not prune trees and shrubs before delivery, except as approved by BNL. Protect bark, branches, and root systems from sun scald, drying, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of exterior plants during delivery. Do not drop exterior plants during delivery.

B. Handle plants at all times so that roots or balls are adequately protected from breakage of balls, from sun and drying winds.

C. Plants with dried out tops or roots will be rejected.

1.4 JOB CONDITIONS

A. Protect existing improvements and trees:
   1. Repair or replace damaged items.

B. Protect completed work.

C. Verify location and existence of underground utilities:
   1. Protect existing utilities from damage due to construction activity.
   2. Repair damage to utility items.

D. If plant locations conflict with existing improvements or rock, BNL will select other locations:
   1. Make changes at no extra cost.
   2. Do not change location of plants without permission of Architect.
   3. Where tree locations fall under existing overhead wires, or crowd existing trees, adjust locations as directed by BNL.

E. Do not plant when ground is frozen or muddy or when temperature is below 32 degF.

1.5 WARRANTY

A. Remove and replace new plants supplied, which are impaired, dead or dying during 1 year from initial acceptance.

B. Replacement materials and methods identical to original.

C. Plants replaced under warranty will not have a second warranty, except as stated in paragraph D below.

D. If fall planted material is dead or dying in the spring, replace material during that spring season. If said plants fail again during growing season, replace again in the fall. Every plant must leaf out and be in a healthy condition at beginning of growing season.

E. Transplanted existing material will not be covered under warranty, unless they were not properly maintained.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Topsoil: Refer to Section 31 22 19, “Topsoiling and Finish Grading”.

B. Plant Materials:
   1. Species and size indicated:
      a. No substitutions without written approval of Architect.
   2. Sound, healthy, vigorous, with normal top and root systems.
   3. Free from diseases, insect pests or their eggs.
   4. Nursery grown stock, freshly dug.
   5. No heeled-in, cold storage or collected stock.
   6. Grown in same or colder climatic zone as project.

C. Trees:
   1. Single leader, straight trunk (unless otherwise indicated in plant list).
   2. Well branched, free of branches up to 5 FT high (unless otherwise indicated in plant list).
   3. Symmetrical growth.

D. Balled and burlapped plants: Firm, natural balls of soil wrapped with burlap or strong cloth and tied.

E. Container Grown Plants:
   1. Roots well established in soil, but not root bound.
   2. Grown in container for at least one growing season.

F. Plant Soil Mix:
   1. Use one part soil excavated from pit and one part top soil. Add soil amendments as recommended by the Soil Testing Agency. Thoroughly mixed.
   2. Modify soil, if needed, with sand and/or organic matter.

G. Organic Mulch: Shredded hardwood or pine bark chips of approved commercial grade free of noxious weeds, mold, or other deleterious materials.

H. Organic Matter: Bone meal, rotted manure, decomposed wood derivatives, recycled compost, or worm castings. Peat moss is not acceptable.

I. Sand: Clean and free of toxic materials, ASTM-C33.

J. Water for planting purposes:
   1. Supplied by BNL.
   2. Provide equipment necessary to transport water from source to required locations.
   3. Do not waste water.

K. Antidesiccant: Emulsion that will provide a film over plant surfaces permeable enough to permit transpiration.

PART 3 - EXECUTION

3.1 PREPARATION

A. Immediately heel-in or plant bare root material.

3.2 PLANTING PROCEDURE

A. General:
   1. Layout: Stake all plant material locations and layout bedlines prior to beginning installation. Architect may approve layout or make adjustments to plant material locations to meet field conditions.
   2. Excavate materials without additional cost.
   3. Loosen bottom of pits prior to planting.

B. Bed Establishment:
   1. Edge beds.
   2. Loosen subgrade of planting beds to a minimum depth of 8 IN.
   3. Remove stones larger than 1 IN in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off BNL's property.
   4. Thoroughly blend plant soil mix off-site before spreading or spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend plant soil mix.
   5. Spread plant soil mix to a depth of 4 IN but not less than required to meet finish grades after natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
   6. Finish Grading: Grade planting beds to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

C. Tree and Shrub:
   1. Pits and Trenches: Excavate circular pits with sides sloped inward. Trim base leaving center area raised slightly to support root ball and assist in drainage. Do not further disturb base. Scarify sides of plant pit smeared or smoothed during excavation. Excavate approximately three times as wide as ball diameter.
   2. Set trees and shrubs plumb and in center of pit or trench with top of root ball 2 IN above adjacent finish grades:
      a. Balled and Burlapped: Remove burlap and wire baskets from tops of root balls and partially from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
      b. Container Grown: Carefully remove root ball from container without damaging root ball or plant.

c. Place plant soil mix around root ball in layers, tamping to settle mix and eliminate voids and air pockets. When pit is approximately one-half backfilled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed. Water again after placing and tamping final layer of planting soil mix.

3. Organic Mulching: Apply 3-IN average thickness of organic mulch extending 12 IN beyond edge of planting pit or trench. Do not place mulch within 3 IN of trunks or stems.
4. Tree and Shrub Pruning: Prune, thin, and shape trees and shrubs according to standard horticultural practice. Prune trees to retain required height and spread. Do not cut tree leaders; remove only injured or dead branches from flowering trees. Prune shrubs to retain natural character. Shrub sizes indicated are sizes after pruning.

D. Ornamental Grasses and Perennials:
1. Set out and space ground cover and plants as indicated.
2. Dig holes large enough to allow spreading of roots, and backfill with plant soil mix.
3. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.
4. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.
5. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

E. Mulching:
1. Mulch tree planting pit after saucer has been shaped to depth of 3-IN with organic mulch.
2. In massed plantings, mulch entire area uniformly to depth of 3-IN with organic mulch.
3. If mulching is delayed and soil has dried out, water plants thoroughly before spreading mulch.

F. Pruning:
1. Remove dead or damaged branches.
2. Thin trees to about two-thirds of initial branching.
3. Remove only dead or damaged branches from conifers.

G. Protect exterior plants from damage due to landscape operations, operations by other contractors and trades, and others. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged exterior planting.

3.3 CLEAN-UP

A. Remove debris and waste materials, and excess earth materials.

B. Reseed any damaged turf areas.

3.4 FINAL ACCEPTANCE

A. Final Acceptance: Base on compliance with the following:
1. Total Plants on Site: Plants have been accepted and required number of replacements are in place. Plants are in a healthy condition.
2. Mulching and Weeding: Plant beds and saucers are properly mulched and free of weeds.
3. Supports: Stakes and guys are in good condition.
4. Remedial Work: Remedial measures directed by BNL have been carried out to ensure plant survival.

3.5 MAINTENANCE

A. Maintain new and transplanted materials for one year from initial acceptance:
1. Water when necessary.
2. Remove dead or dying branches, and sprouts.
3. Maintain mulch depth.
4. Weed plant beds and pits.

END OF SECTION

DIVISION 41

MATERIAL PROCESSING AND HANDLING EQUIPMENT

SECTION 41 22 00
HOISTS, TROLLEYS, AND MONORAILS

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Standards for detailed specification requirements for materials, methods, tests and physical parameters:
   1. American Society of Mechanical Engineers (ASME):
      a. HST-2: Performance Standard for Hand Chain Manually Operated Chain Hoists.
      b. HST-1: Performance Standard for Electric Chain Hoists.
   2. ANSI-B30.11.

B. Furnish equipment made by a recognized reputable manufacturer.

C. Have all welding done by certified welders in accordance with American Welding Society Standards.

D. Provide equipment that is locally serviceable with replacement parts readily available.

E. After installation is complete, provide services of a representative of equipment supplier and provide supervision of any final adjustments.

F. Give BNL personnel complete instructions regarding proper operation and maintenance procedures.

G. Secure from manufacturer's representative a written report stating installation has been examined and units are installed properly and in accordance with manufacturer's recommendations.
   1. Submit report to BNL.

1.2 SUBMITTALS

A. Shop drawings:
   1. Include shop drawings with structural calculations for track and supports, reports of tests verifying strength of inserts and rail, track layout including arrangement of supports, splices, and connections, and details of equipment.

B. Product data:
   1. Equipment and systems.

C. Contract closeout information:
   1. Maintenance data.
   2. BNL instruction report.
   3. Certification of installation in accordance with manufacturer's recommendations.

1.3 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Handle, unload, and store equipment in full accordance with manufacturer's recommendations.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. 1. Laboratory room monorails and related trolleys:
      a. Base:
         1) Spanco Inc.; model 700SRS track, heavy duty.

b. Optional:
1) Zimmerman Handling Systems.
2) Gorbel.
3) TC/American Monorail.

2. Hoists:
a. Base:
1) Coffing Hoists.
b. Optional:
1) Ingersoll-Rand.
2) Harrington Hoists.
3) Tractel Inc.

B. Schedule of conveying systems:
1. See schedule at end of this Section.
a. Model numbers in schedule are products by Coffing Hoists, as indicated, to describe quality and other basic characteristics of equipment.
2. Provide systems as indicated.
3. "Hook height" of 12 FT is minimum acceptable distance from bottom of hook in full raised position to nearest floor surface.
4. Refer to drawings for location of hoists, monorails, and other equipment.

2.2 HOISTS

A. Provide electric and hand geared hoists, as indicated, and provide hoists to lift capacities over height specified.

B. Electric chain hoists:
1. Design load carrying parts so that calculated static stress in material, based on rated capacity, does not exceed 20 percent of average ultimate strength of material.
2. Provide hook-mounted suspension.
3. Provide link chain or roller chain, heat-treated, of suitable hardness and of suitable strength for hoisting services specified.
4. Form load and idler wheels to fit links of the type of chain used.
5. Guard against chain jamming between load wheel or sprocket and any portion of hoist under normal usage.
6. When lower blocks with load wheels or sprockets are used, provide enclosed type blocks that guard against chain jamming in normal usage.
7. Carry lower block load wheels or sprockets on suitable bearings.
8. Furnish full swiveling forged steel load hooks with gate or swing latch.
9. Use anti-friction bearings throughout hoist mechanism.
10. Provide high strength, high efficiency spur and helical gears with precision cut teeth.
11. Enclose gears in oil tight housing with provision for operating gears and load brake in oil bath.
12. Provide load brake to prevent undue acceleration of the load during lowering:
a. Automatic mechanical type.
13. Brake capable of sustaining rated load.
14. Furnish enclosed, reversible, 460 volts, 3 phase, 60 Hertz AC type TEFC motor rated at 30 minute duty cycle.
15. Design for two lifting speeds of 5.3 FT/min and 16 FT/min.
16. Furnish hoist motor brake of internal multiple disc, magnetic type interlocked with motor control to quickly stop motor when power is interrupted.
17. Design motor brake to be self compensating for wear so that no adjustment is required and to hold rated capacity independent of load brake.
18. Provide transformer to reduce voltage to controls.
19. Provide upper limit switch to prevent load hook, loaded or unloaded, from exceeding upper safe limit of travel.
20. Provide following items:

a. Lower limit switch to stop hoist when hook reaches its lower limit.
b. Chain containers.

C. Hand geared chain hoists:
1. Furnish hand chain spur geared hoists constructed and designed for safety of operation and durability of all components.
2. Replacement parts must be interchangeable and readily accessible.
3. Design load carrying parts so that calculated static stress in material, based on rated capacity, does not exceed 25 percent of average ultimate strength of material.
4. Furnish load chains of close link coil type or roller chain type.
5. Each link of uniform size and shape and free from scale.
6. Manufacture load chain wheels from steel, pearlitic malleable iron or nodular cast iron.
7. Form load and idler sheaves to fit chain.
8. Furnish hand chain of endless coil type with a drop that is about 600 mm less than specified lift of hoist.
9. Supply chain with yield point at least 3 times required hand chain pull for rated load.
10. Manufacture hand chain wheels from steel, malleable iron, high strength cast iron, or aluminum alloy.
11. Equip handwheel with suitable chain guard to prevent hand chain from slipping or jumping wheel rim.
12. Manufacture hooks from forged steel.
13. Provide that bottom hook free to swivel in loaded condition without twisting chain.
14. Equip hoist with automatic mechanical load brake which will prevent lowering of load unless manual power is applied to hand chain.
15. Use sleeve or anti-friction type bearings.
16. Enclose gearing in sealed construction and provide life time lubrication.
17. Provide following features:
    a. Load limit clutch to automatically prevent hoist from lifting loads greater than rated capacity.
    b. Latched hooks.
    c. Chain containers.

D. Identification - Mark hoist with following:
1. Name and address of manufacturer.
2. Manufacturer's unit identification number.
3. Rated load.
4. Voltage of AC or DC power supply and phase and frequency of AC power supply, if applicable.
5. Rated amperage, if applicable.

E. Warnings:
1. Affix to hoist or lower load block or controls, in a readable position a durable label or labels displaying following safe operating procedures.
2. Word WARNING or other legend designed to bring label to attention of an operator.
3. Cautionary language against:
    a. Lifting more than rated load.
    b. Operating hoist when hook is not centered under hoist.
    c. Operating hoist with twisted, kinked or damaged chain.
    d. Operating damaged or malfunctioning hoist.
    e. Lifting people, or lifting loads over people.
    f. Removing or obscuring warning label.

2.3 TROLLEYS

A. Provide hand geared and manually operated trolleys, as indicated, and provide trolleys completely compatible with hoists, cranes and monorails specified.
1. Total capacity of trolley:

a. Ultimate load carrying capacity of trolley based on ultimate strength of material used (with a five to one safety factor) and bearing life.
b. Ultimate load carrying capacity includes live load, weights of all equipment and a proper allowance for impact.
c. Use bearings rated to provide a minimum B-10 life of 5000 hours based on 75 percent of wheel load, excluding impact, and on an assumed speed of 245 FT/second.

2. Provide trolley stops that engage trolley frame rather than trolley wheels.
3. The hoist trolley design will incorporate a two-piece, stamped steel body with a removable clevis pin that allows for hook-mounting.
4. The clevis will be tapered to center the hoist hook and evenly distribute the weight to all hoist trolley wheels. Non-tapered pins with washers are unacceptable.
5. The hoist trolley will have self-centering wheels to match the track's profile.
6. Drop lugs will be utilized on both sides of the hoist trolley, and will limit the hoist trolley drop to a maximum of 25 mm in the event of wheel, axle, or load bar failure.
7. Only rigid body (non-articulating) hoist trolleys will be acceptable.

2.4 MONORAILS

A. Provide monorails with enclosed track in locations indicated.

B. Assure track is completely compatible with trolley and hoists specified.

C. Enclosed track:
1. Monorails will use only an enclosed track design that permits trolleys and festoon carriers to ride on the lower inside flange. The track must keep most dirt and dust off the rolling surface. I-beam and patented track cranes with exposed flanges are unacceptable.
2. Tracks for runways will be fabricated of a high-strength, cold rolled steel.

D. Materials and installation:
1. Provide end stops at all track ends.
2. Insure that track splices have been designed by track supplier and are located at support points.
3. See Structural drawings for embedded plates in slabs at monorail support points.
4. Arrange supports for easy removal of track for repair or replacement.
5. Align track true and level at locations indicated.

2.5 ELECTRIFICATION AND CONTROLS

A. Provide electrical power to motor driven hoists using festoon tagline system.
1. Equip with plastic wheels.
2. Include all components needed for a complete and operable system.

B. Controls:
1. Provide wall-mounted push button control stations with reversing type contactors for electric hoists.
2. Control station operable from 115 V power supply.
3. Provide ON/OFF and directional buttons at 4 FT AFF.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation by manufacturer or authorized representative.

B. Assure all required components are properly installed.

C. Verify operation prior to Acceptance and correct all deficiencies.

3.2 OPERATIONAL TESTING

A. Perform in presence of BNL.

B. Instruct BNL's personnel in correct operation and maintenance.

3.3 FINAL CLEANUP

A. Leave units in correct operational condition.

B. Perform final cleaning.

3.4 SCHEDULE

HOIST SCHEDULE						
Room No.	**Floor Plan Reference Sheet**	**Crane Mounting Type**	**Crane Load**	**Hoist Type**	**Model No.**	**Notes**
138	QL-101A	Monorail	1/2 ton	Manual	LHH-1/2	12 FT Lift
229	QL-102A	Monorail	1 ton	Electric	JLC-2016	1 Chain, 2 Speed, 12 FT Lift

Note: Model numbers are by base manufacturer Coffing Hoists.

END OF SECTION

A P P E N D I X

ISB FINAL DESIGN GEOTECHNICAL REPORT

GEI Consultants

Geotechnical
Environmental and
Water Resources
Engineering

Geotechnical Report

Interdisciplinary Science Building 1

Final Design Phase
Brookhaven National Laboratory
Upton, New York

Submitted to:
HDR Architecture, Inc.
1101 King Street, Suite 400
Alexandria, VA 22314

Submitted by:
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September 11, 2009
Project 080830-1-1101

STATE OF NEW YORK
NATHAN L. WHETTEN
075120-1
LICENSED PROFESSIONAL ENGINEER

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Table of Contents

1. Introduction 1
1.1 Introduction 1
1.2 Summary 1
1.3 Scope of Work 1
1.4 Project Personnel 2
1.5 Authorization 2
1.6 Project Vertical Datum 2

2. Site and Project Description 3
2.1 Site Description 3
2.2 Project Description 3

3. Subsurface Conditions 4
3.1 Subsurface Explorations 4
3.2 Laboratory Testing 4
3.3 Subsurface Soil Conditions 4
3.4 Groundwater Conditions 5

4. Foundation Recommendations 7
4.1 Foundation Design 7
4.2 Floor Slab Design 7
4.3 Groundwater Levels and Foundation Drainage 8
4.4 Settlement 8
4.5 Seismic Design 8
4.6 Reuse of Existing Fill 8
4.7 Retaining Walls 8
4.8 Pavement Design Criteria 9

5. Final Design Services and Limitations 10
5.1 Subgrade Preparation 10
5.2 Dewatering 10
5.3 Excavation 10
5.4 Freezing Conditions 10
5.5 Backfilling and Compaction 11

6. Construction Phase Services and Limitations 12
6.1 Construction Phase Services 12
6.2 Limitations 12

Table of Contents (cont.)

Tables

1 Requirements for Structural Fill
2 Requirements for Common Fill
3 Requirements for Crushed Stone

Figures

1 Site Location Map
2 Exploration Location Plan
3 Recommended Active Lateral Earth Pressures for Unrestrained Walls
4 Recommended At-Rest Lateral Earth Pressures for Restrained Walls
5 Recommended Passive Earth Pressures

Appendices

A Test Boring Logs
B Results of Laboratory Testing
C Groundwater Level Measurements Provided by BNL

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1. Introduction

1.1 Introduction

This report summarizes the results of subsurface explorations and our geotechnical design and construction recommendations for final design of the proposed Interdisciplinary Science Building (ISB) at Brookhaven National Laboratory in Upton, New York. The project involves the construction of a three-story building with a footprint area on the order of about 50,000 square feet. The building will include a basement laboratory.

1.2 Summary

The subsurface explorations encountered up to about 6 feet of existing fill overlying natural sand. We recommend that the proposed building be founded on spread footing foundations with slab-on-grade floors supported by the natural sand or by compacted structural fill. The existing fill should be removed within the building limits and replaced with compacted structural fill.

1.3 Scope of Work

Our scope of services included the following:

- Developed a subsurface exploration program consisting of test borings for final design of the facility and engaged a subsurface exploration contractor to conduct the borings.
- Developed a health and safety plan governing the conduct of our fieldwork and to protect worker health and safety during the field program.
- Coordinated the test boring program, described the soil samples, and prepared test boring logs.
- Arranged for a testing laboratory to perform tests on representative soil samples recovered from the borings.
- Evaluated the subsurface conditions encountered in the test borings and prepared this report.

1.4 Project Personnel

The following personnel performed services for this project:

Steven Hawkins	Field Engineer
Richard Connors, E.I.T.	Geotechnical Engineer
Nathan Whetten, P.E.	Project Manager
Peter Heynen, P.E.	Technical Review

1.5 Authorization

Our work was conducted in accordance with our revised proposal dated June 24, 2009. Authorization to proceed was provided by HDR Architecture, Inc., on May 21, 2009.

1.6 Project Vertical Datum

Elevations in this report are in feet. The vertical coordinate system is Brookhaven National Laboratory (BNL) ’94. We understand that BNL ’94 is substantially equivalent to National Geodetic Vertical Datum of 1929 (NGVD-29).

2. Site and Project Description

2.1 Site Description

The project site is located within BNL, southwest of the intersection between Brookhaven Avenue and Rochester Street (refer to Figures 1 and 2). A one-story building (BNL Building 185) occupies a portion of the site near the intersection of Brookhaven Avenue and Rochester Street.

Ground surface outside the building is paved or landscaped with grass. The ground surface slopes gently downward to the east, from about El. 90 on the west side of the site to about El. 80 along Rochester Street.

2.2 Project Description

The proposed ISB building will be a three-story structure with a footprint area of about 50,000 square feet as shown in Figure 2. A small laboratory will be constructed within a basement area in the central portion of the building and is shown in Figure 2. Floor grade for the ground level floor will be about El. 85.5, and the basement floor grade will be about El. 64.5. The basement area will also feature two laboratory pits located at about El. 57.5.

We understand that the existing building (BNL Building 185) near the corner of Brookhaven Avenue and Rochester Street will be demolished prior to construction.

3. Subsurface Conditions

3.1 Subsurface Explorations

New England Boring Contractors (NEBC) of Glastonbury, Connecticut, drilled six test borings (B1 through B6) at the approximate locations shown in Figure 2 on March 26 and 27, 2008 as part of the Conceptual Design Phase. For the Final Design Phase of the project, NEBC drilled seven additional test borings (B7 through B13) and installed one temporary groundwater monitoring well (B8) at the approximate locations shown in Figure 2 on July 20 and 21, 2009. The well was grouted following the completion of the subsurface exploration program according to BNL's requirements for temporary groundwater monitoring wells.

Test borings were advanced using hollow stem auger boring techniques to a maximum depth of 42 feet below ground surface. Split-spoon samples with Standard Penetration Tests (SPTs) were obtained continuously to a depth of 8 to 12 feet, and at 5-foot intervals, thereafter. A GEI Consultants, Inc. (GEI) engineer monitored the borings, described the soil samples, and prepared test boring logs. Test boring logs from both phases are presented in Appendix A.

3.2 Laboratory Testing

GeoTesting Express Inc., of Boxborough, Massachusetts, performed 12 mechanical gradation analyses on soil samples recovered from the test borings. Results of laboratory testing are presented in Appendix B.

3.3 Subsurface Soil Conditions

The descriptions of the subsurface conditions provided below are based on our observations of soil conditions encountered in test borings drilled for this project. Subsurface conditions are known only at the boring locations, and conditions between explorations may differ from those described in this report.

Surface Cover - A 3- to 8-inch-thick layer of topsoil, described as dark brown silty sand with roots and organic matter, was present at ground surface at borings B1, B2, B3, B4, B10, B11, B12, and B13. Borings B5, B6, B7, B8, and B9 were drilled in the paved portion of the site. The thickness of the asphalt pavement and subbase materials is approximately 6 inches.

Fill - Fill was encountered below the surface cover in all of the borings to depths ranging from 1 to 6 feet. The fill was typically described as orange-brown to brown silty sand with Unified Soil Classification System (USCS) soil classifications of SM, SW-SM, and SW. Additionally, a 2-foot-thick layer of concrete was encountered in boring B-12 at approximately 2 feet below ground surface. SPT N-values in the fill ranged from 4 to 37 blows per foot of sampler penetration (bpf) and averaged approximately 19 bpf, indicating the fill varies from loose to dense. The driller detected occasional cobbles during drilling.

Fill is typically a heterogeneous, man-placed material, commonly containing random materials such as concrete, brick, wood, glass, debris, and other materials. The SPT split-spoon sampler used in the boring has an inside diameter of 1-3/8 inches and cannot sample larger particles. Therefore, materials with particle sizes larger than the sampler opening may be present within the fill but were not observed in split-spoon samples. Variations in the fill from one location to another are expected.

Sand – Sand was encountered underlying the fill materials to boring termination depths ranging between approximately 22 feet and 42 feet. The sand is typically described as tan, light brown or whitish brown, narrowly to widely graded sand with gravel with USCS soil classifications of SW, SP, SW-SM, and SP-SM. SPT N-values ranged from 7 to more than 50 bpf, and were typically between 15 and 50 bpf (medium dense to dense). The driller detected occasional cobbles and boulders during drilling.

3.4 Groundwater Conditions

Groundwater was encountered during drilling on March 27, 2008 in boring B4 at a depth of 39 feet, corresponding to about El. 44 and on July 20, 2009 in boring B8 at a depth of 40 feet, corresponding to about El. 45. These levels are approximately 20 feet below the basement floor grade (El. 64.5) and about 13 feet below the proposed laboratory pit grade (El 57.6). However, these measurements were made during drilling and may not represent stabilized groundwater.

A temporary groundwater monitoring well was installed by GEI in boring B8 to observe groundwater levels during exploration. The temporary well was installed on July 20, 2009. Groundwater measurements were made immediately following well installation and were made again on July 21, 2009. Although water was measured during drilling at a depth of 40 feet, water was below the bottom of the well (42 feet) after drilling and on the following day.

BNL provided a hydrograph of water levels measured in groundwater monitoring wells 075-01, 075-02, and 085-160. Monitoring well 075-01 is located approximately 250 feet north of the site, 075-02 is approximately 220 feet northeast of the site, and 085-160 is approximately 580 feet south of the site.

According to the data, BNL measured the groundwater level in each of the three wells annually between 1990 and 2007. The hydrographs show that groundwater levels varied between approximately El. 36 to El. 50. These water levels are 15 to 29 feet below the proposed basement floor grade (El. 64.5), and 7.5 to 21.5 feet below the proposed laboratory pit grade (El. 57.6). Groundwater level information provided by BNL is presented in Appendix C.

Groundwater levels are expected to vary with season, precipitation, and other factors, and may be different from measured levels. Groundwater level measurements represent conditions at the times and locations the measurements were made. Different groundwater levels may occur at other times and locations.

4. Foundation Recommendations

4.1 Foundation Design

We recommend that the proposed building be supported on spread footings bearing directly on the natural sand, or on compacted structural fill placed after removal of existing fill. We recommend a maximum allowable bearing pressure of 2.5 tons per square foot, which assumes that footings are at least 3 feet wide. The bearing pressure for footings less than 3 feet wide should be proportionally reduced. We recommend that all footings be at least 2 feet wide.

Exterior footings should bear at least 4 feet below the adjacent finished grade for frost protection. Footings at heated interior locations should bear at least 18 inches below the bottom of the floor slab. The tops of footings should be at least six inches below the bottom of the overlying floor slab.

Differential settlement will likely occur between basement walls and the adjacent first floor slab-on-grade. We recommend that a joint be provided at this location to allow for some differential settlement. Backfill against basement walls located inside the building perimeter and below the adjacent first floor slab should be appropriately compacted to reduce settlement of the slab.

Elevation differences between adjacent footings (e.g., basement level footings relative to first floor elevation footings) should be such that the inclination of the line from edge to edge of the footings is not steeper than 2 horizontal to 1 vertical.

4.2 Floor Slab Design

We recommend that building floor slabs and basement floor slabs bear on a minimum six inch thick layer of compacted structural fill.

We recommend that the modulus of subgrade reaction (K_s) be calculated as follows:

$$K_s = 350\left(\frac{B+1}{2B}\right)^2$$

Where B is equal to the minimum width of slab in feet, and K_S is in pounds per cubic inch.

4.3 Groundwater Levels and Foundation Drainage

Based on historic groundwater level information provided to us by BNL and the groundwater levels observed during the drilling program, groundwater is expected to be about 15 to 29 feet below the basement floor level (El. 64.5) and 7.5 to 21.5 feet below the proposed laboratory pit grade (El. 57.6). Therefore, underslab drainage is not required.

We recommend that a perimeter drain be provided around the basement at foundation grade. The invert level for the drain should be set below the basement floor grade. A typical perimeter drain detail is shown in Figures 3 and 4.

We understand that stormwater detention chambers will be constructed below the pavement, and a detention basin will be constructed on the site. These nearby structures provide sources of water that could transmit water or water vapor to the basement space. We recommend that the floor slab and basement walls be waterproofed to avoid water and water vapor infiltration into the basement. Based on our experience, we recommend a waterproofing product such as Bituthene 3000 for walls and Preprufe 300R for the floor (both items manufactured by W.R. Grace), or similar products.

4.4 Settlement

We estimate that total settlement of spread footings will be less than about 1 inch, and differential settlement between columns will be less than about ½ inch. Settlement will occur as the loads are applied.

4.5 Seismic Design

The soil beneath the proposed building is classified as a stiff soil profile for earthquake design purposes as defined by the New York State Building Code. The corresponding site class is D. The soil is not susceptible to liquefaction.

4.6 Reuse of Existing Fill

Based on the results of sieve analyses conducted on soil samples recovered from the borings, we anticipate that the natural sand located on site may be suitable for reuse as compacted structural fill below building foundations. The existing fill materials located on site may be suitable for use as common fill in pavement and landscaped areas.

4.7 Retaining Walls

Retaining walls should be backfilled with compacted structural fill. We recommend that a drain be provided behind retaining walls as indicated in Figures 3 and 4. Drains should

consist of a perforated drainage pipe surrounded by crushed stone. The recommended material gradations for structural fill and crushed stone are provided in the attached tables.

Recommended lateral earth pressures are provided in Figures 3 through 5. Figure 3 provides recommended active earth pressures for unrestrained walls which are allowed to translate or rotate such as landscape-type retaining walls. Figure 4 provides recommended at-rest earth pressures for restrained walls which are not allowed to move, such as basement walls which are restrained from movement by the first floor level. Figure 5 provides recommended passive lateral earth pressures.

4.8 Pavement Design Criteria

The conditions disclosed during the subsurface investigation indicate that proofrolled existing fill material, natural sand, and compacted structural fill will be suitable for support of proposed pavements.

The recommended minimum flexible pavement sections are as follows:

Layer	Material	Parking Areas Thickness (Inches)	Roadway Areas Thickness (Inches)
Bituminous Wearing Course	NYSDOT Type 7 or 7F Top	1.0	1.5
Bituminous Binder Course	NYSDOT Type 3 Binder	2.0	2.5
Base	Structural Fill	10	10

Prior to placement of base course materials, all subgrade areas should be proofrolled as described in subsection 5.1. If subgrade instability is observed during proofrolling, the unstable soil should be removed and replaced with compacted structural fill. We recommend that proofrolling be observed by qualified geotechnical personnel.

5. Final Design Services and Limitations

5.1 Subgrade Preparation

Existing fill within the building footprint area and within the influence zone of foundation bearing stresses should be removed entirely. Removing the fill will expose the natural sand, which is suitable for building support. After excavation to the suitable subgrade level has been completed, we recommend that the subgrade be proofrolled with successive passes of a self-propelled vibratory compactor. The purpose of proofrolling is to recompact soil that has become loose or disturbed during excavation. Soils observed to heave or become unstable during proofrolling should be removed and replaced with compacted structural fill. Bearing surfaces should be free of standing water, frost, and loose soil before placement of reinforcing steel and concrete. Areas of the subgrade disturbed by traffic or surface water should be re-compacted.

5.2 Dewatering

Groundwater is expected to be below excavation subgrade levels and excavation dewatering will likely be limited to controlling surface runoff and water from other sources. We anticipate that open pumping from filtered sumps located within excavations will be feasible. The site should be graded to direct runoff away from excavations.

5.3 Excavation

Excavation is expected to be in soil and conventional excavation with backhoes, scrapers, and other earthmoving equipment appears feasible. Boulders may be encountered in the excavations.

We anticipate that sloped open cut excavations will be feasible in most areas. Temporary lateral support of excavations may be necessary to protect nearby utilities and other structures. Steel sheeting piling or soldier piles and lagging appear feasible. All excavations should be performed in accordance with Occupational Safety and Health Agency requirements.

5.4 Freezing Conditions

Subgrades should be free of frost before placement of concrete. Frost-susceptible soils that have frozen should be removed and replaced with compacted structural fill. The footing and the soil adjacent to the footing should be protected from freezing until they are backfilled.

Soil placed as fill should be free of frost, as should be the ground on which it is placed. Extended periods of freezing temperatures could result in frost penetration below concrete slabs and into the subgrade. We recommend that slabs-on-grade exposed to extended periods of freezing temperatures be heated or insulated to prevent freezing of the subgrade.

5.5 Backfilling and Compaction

Structural fill placed within the building limits should meet the gradation and compaction requirements for structural fill (Table 1). Fill outside the building limits should meet the gradation and compaction requirements for common fill (Table 2). Crushed stone for retaining wall drains should meet the gradation requirements for crushed stone (Table 3). The compaction requirements for structural fill noted in Table 1 should be accomplished with a heavy vibratory roller with appropriate moisture conditioning that generally will require addition of water. However, heavy rollers should not be used to compact the fill within 2 feet of the face of retaining walls. Vibratory plates or other light weight equipment should be used within this zone in lieu of heavy rollers.

Structural fill should extend to the lateral limits below foundations defined by 1H:1V lines sloped outward and downward from points located 2 feet outside the bottom exterior edges of footings. Fill placed outside these limits may consist of common fill.

6. Construction Phase Services and Limitations

6.1 Construction Phase Services

We recommend that GEI be engaged during final design to review plans and specifications to confirm that our recommendations have been interpreted and implemented as intended.

We also recommend that a GEI field representative be present on site to observe removal of existing fill, to confirm that the exposed subgrades are suitable for building support, and consistent with conditions encountered in the borings. We recommend that a GEI engineer observe placement and compaction of fill materials.

6.2 Limitations

This report was prepared for the exclusive use of HDR Architecture, Brookhaven Science Associates, and the design team. Our professional services for this project have been performed in accordance with generally accepted engineering practices. No warranty, expressed or implied, is made.

Our recommendations are based on the project information provided to us at the time of this report and may require modification if there are any changes in the nature, design, or location of the proposed structure. We cannot accept responsibility for designs based on our recommendations unless we are engaged to review the final plans and specifications to determine whether any changes in the project affect the validity of our recommendations and whether our recommendations have been properly implemented in the design.

The recommendations in this report are based in part on the data obtained from the subsurface explorations. The nature and extent of variations between explorations may not become evident until construction. If variations from the anticipated conditions are encountered, it may be necessary to revise the recommendations in this report.

Tables

Table 1 - Requirements for Structural Fill

Structural Fill shall consist of hard, durable sand and gravel, free of clay, organic matter, surface coatings, and other deleterious materials. Soil finer than the No. 200 sieve (the "fines") shall be nonplastic. Structural Fill shall meet the following gradation requirements:

Sieve Size	Percent Passing by Weight
3 Inches	100
½ Inch	50 – 100
No. 4	35– 100
No. 16	20 – 90
No. 50	5 - 40
No. 200 (fines)	0 – 10

In addition to complying with the above gradation requirements, the structural fill should be well graded, i.e. there should have sufficient amounts of all particle sizes within the size range of the material.

Structural Fill shall be compacted in maximum 9-inch-thick, loose lifts to at least 95 percent of the maximum dry density determined in accordance with ASTM D1557 (Modified AASHTO Compaction).

Table 2- Requirements for Common Fill

Common fill shall consist of hard, durable sand and gravel, free of clay, organic matter, surface coatings, and other deleterious materials. Soil finer than the No. 200 sieve (the "fines") shall be nonplastic. Common Fill shall meet the following gradation requirements:

Sieve Size	Percent Passing by Weight
6 Inches	100
3 Inches	80 – 100
No. 4	20 – 100
No. 200 (fines)	0 - 20

Common fill shall be compacted in maximum 12-inch-thick, loose lifts to at least 92 percent of the maximum dry density determined in accordance with ASTM D1557 (Modified AASHTO Compaction).

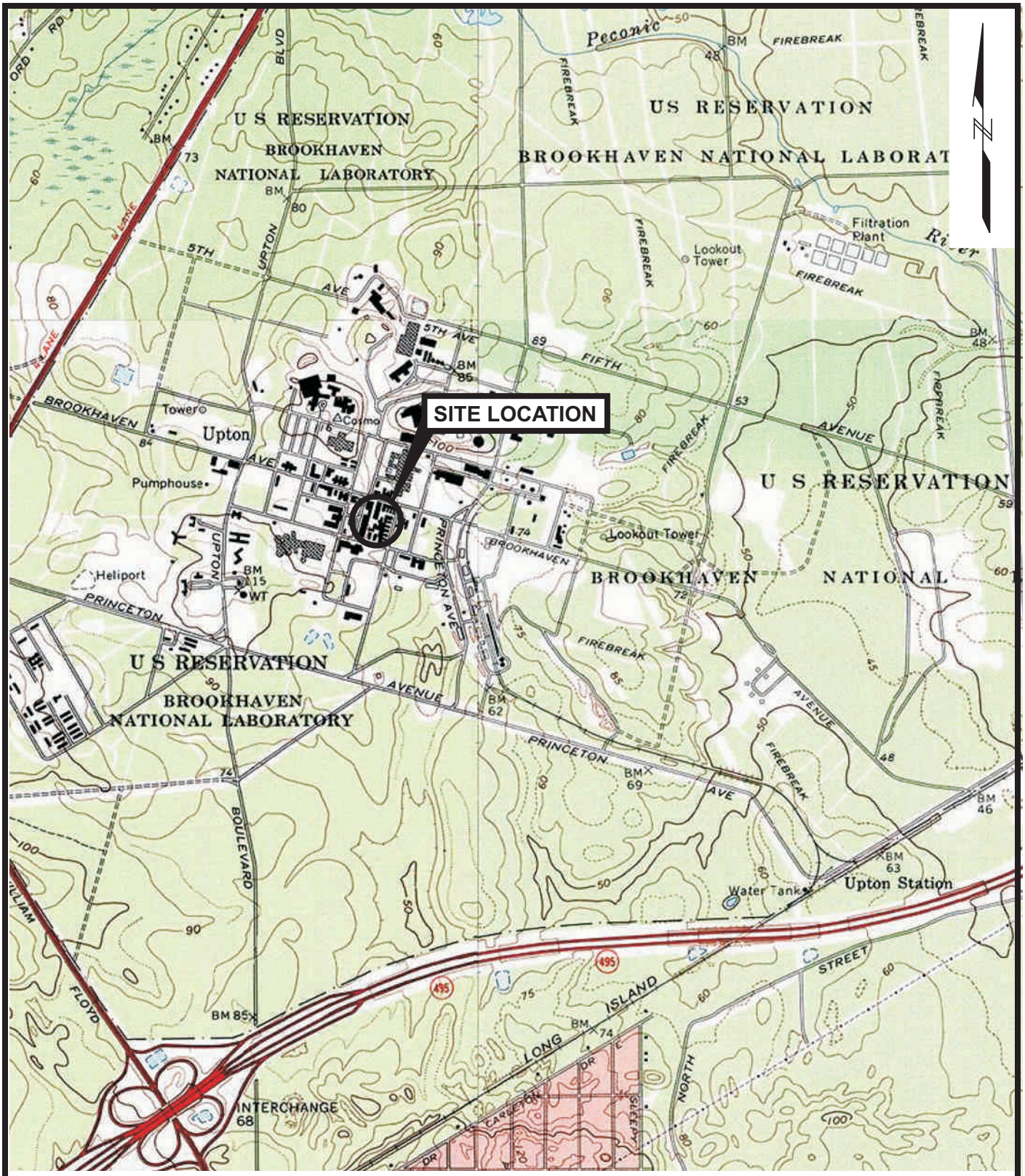
Table 3 - Requirements for Crushed Stone

Crushed Stone shall consist of a 3/8-inch minus crushed stone, and shall consist of hard, durable, crushed or broken stone, free from loam or clay, surface materials, or other deleterious materials. The material shall conform to the following gradation requirements:

Sieve Size	Percent Passing by Weight
½ Inch	100
3/8 Inch	85 -100
No. 4	10-30
No. 8	0-10
No. 16	0-5

Crushed stone should be compacted in maximum 9-inch-thick, loose lifts. Crushed stone should be compacted with 4 to 6 passes of vibratory compaction equipment.

Figures



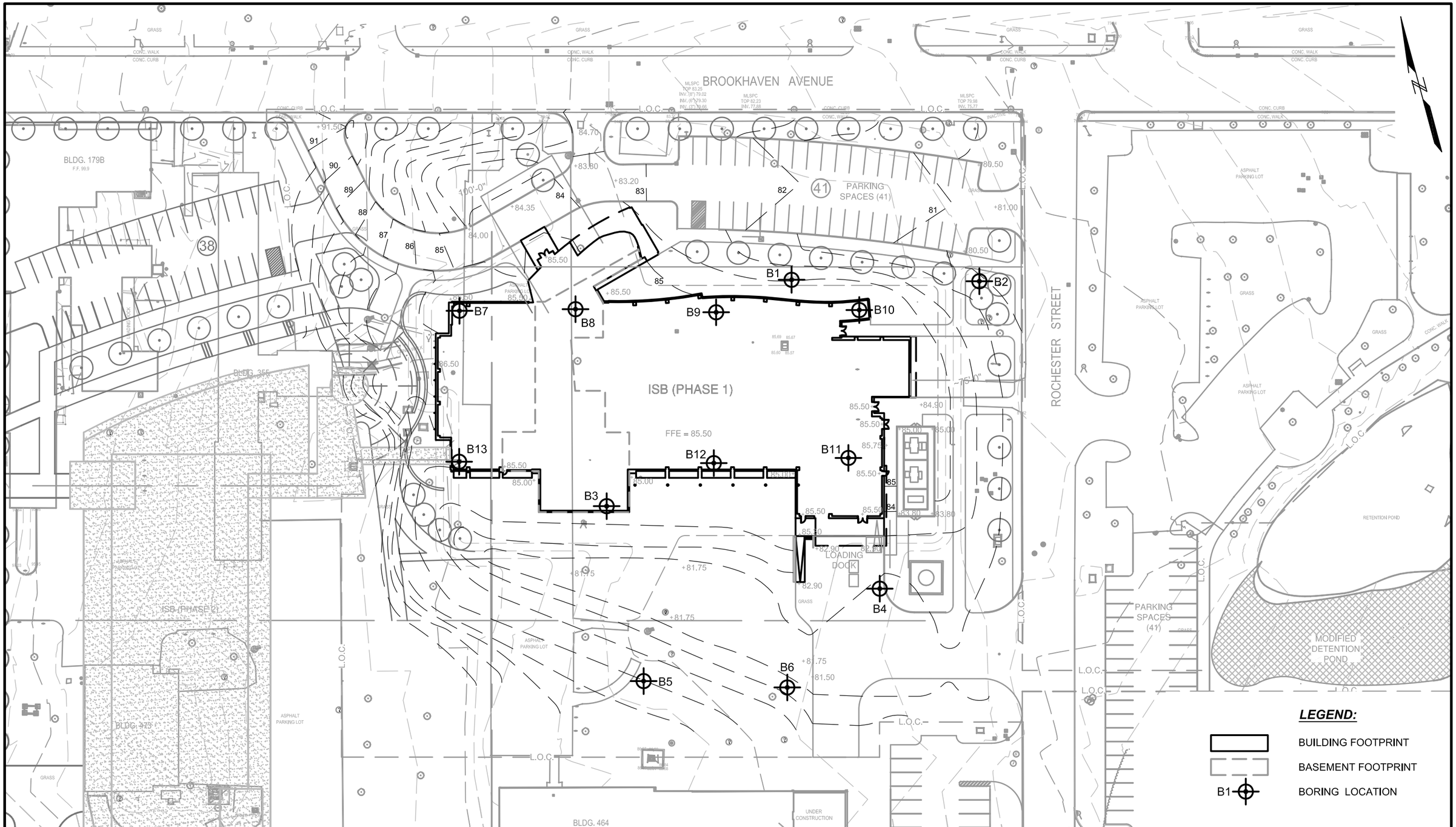
SOURCE: Map created with TOPO! ® ©2003 National Geographic (www.nationalgeographic.com/topo)

0 2000 4000

SCALE, FEET

INTERDISCIPLINARY SCIENCE BUILDING-1 BROOKHAVEN NATIONAL LABORATORY UPTON, NEW YORK	GEI Consultants	**SITE LOCATION MAP**
HDR ARCHITECTURE, INC. ALEXANDRIA, VIRGINIA	Project 080830	August 2009 Figure 1

I:\GEI\Brookhaven National Laboratory\080830\ISB Title1-III Design Report\Figures\Brookhaven ISB Location Map.CDR



NOTES:

1. PLAN BASED ON DRAWING PROVIDED BY HDR ARCHITECTURE, INC. ON AUGUST 10, 2009
2. BORING LOCATIONS WERE FIELD LOCATED BY TAPING FROM EXISTING SITE FEATURES.

0 60 120

SCALE, FEET

INTERDISCIPLINARY SCIENCE BUILDING-1
BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK

HDR ARCHITECTURE, INC.
ALEXANDRIA, VIRGINIA

GEI Consultants

Project 080830

EXPLORATION LOCATION PLAN

August 2009 Figure 2

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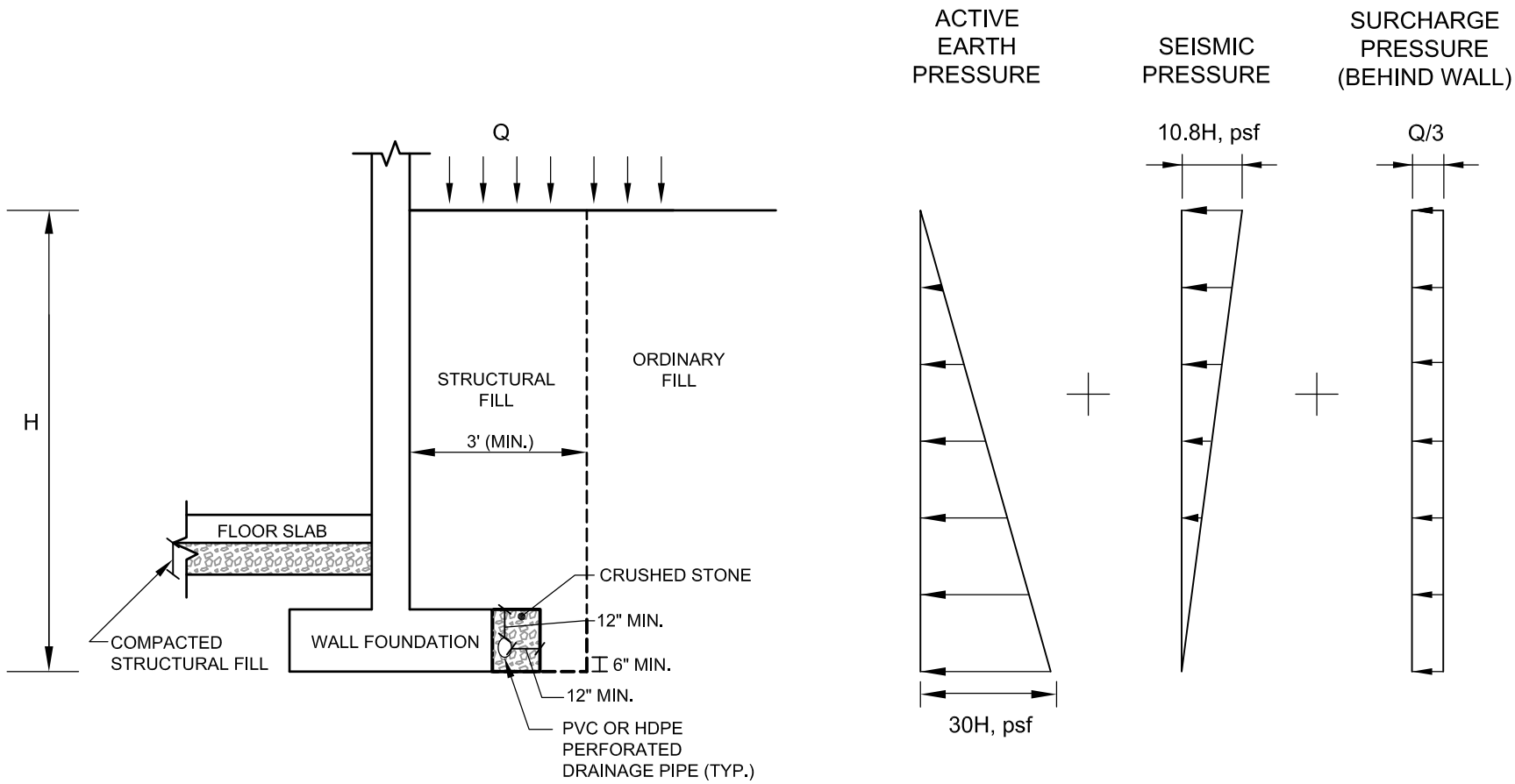

NOTES

(1) EARTH PRESSURES ASSUME WALL IS NOT RESTRAINED AND CAN ROTATE OR TRANSLATE.

(2) CONNECT DRAINAGE PIPE TO STORM DRAIN SYSTEM.

(3) Q=VERTICAL SURCHARGE PRESSURE BEHIND WALL.

(4) ASSUME A MINIMUM 200 psf LATERAL EARTH PRESSURE ON PORTIONS OF THE WALL WHERE THE RESULTING EARTH PRESSURE CALCULATED ABOVE IS LESS THAN 200 psf.

INTERDISCIPLINARY SCIENCE BUILDING-1 BROOKHAVEN NATIONAL LABORATORY UPTON, NEW YORK	GEI Consultants	**RECOMMENDED ACTIVE LATERAL EARTH PRESSURES FOR UNRESTRAINED WALLS**
HDR ARCHITECTURE, INC. ALEXANDRIA, VIRGINIA	Project 080830	August 2009 Figure 3

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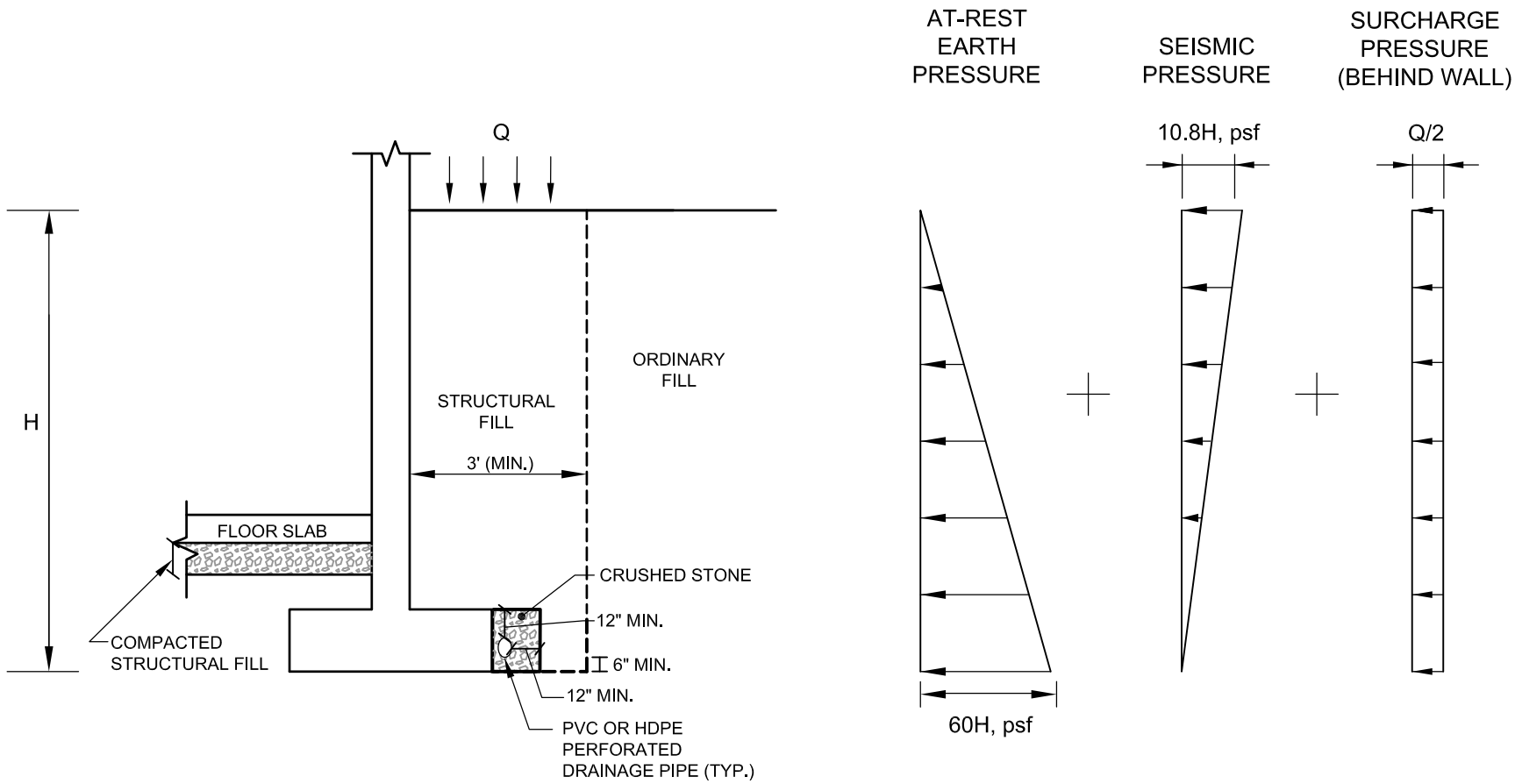


NOTES

(1) EARTH PRESSURES ASSUME WALL IS RESTRAINED FROM MOVEMENT.

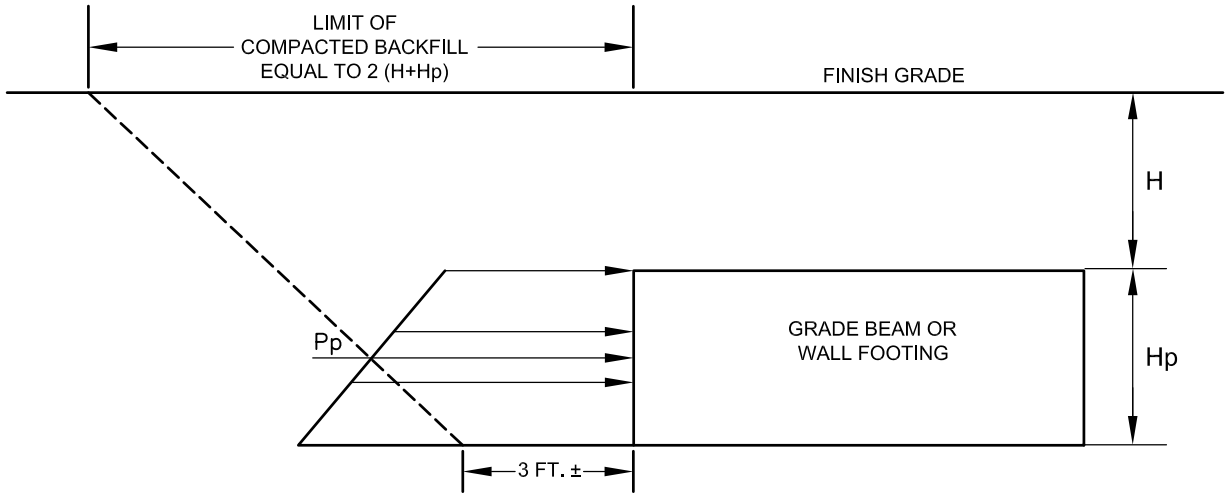
(2) CONNECT DRAINAGE PIPE TO STORM DRAIN SYSTEM.

(3) Q=VERTICAL SURCHARGE PRESSURE BEHIND WALL.

(4) ASSUME A MINIMUM 200 psf LATERAL EARTH PRESSURE ON PORTIONS OF THE WALL WHERE THE RESULTING EARTH PRESSURE CALCULATED ABOVE IS LESS THAN 200 psf.

INTERDISCIPLINARY SCIENCE BUILDING-1 BROOKHAVEN NATIONAL LABORATORY UPTON, NEW YORK	GEI Consultants	**RECOMMENDED AT-REST LATERAL EARTH PRESSURES FOR RESTRAINED WALLS**
HDR ARCHITECTURE, INC. ALEXANDRIA, VIRGINIA	Project 080830	August 2009 Figure 4

I:\GEI\Brookhaven National Laboratory\080830\ISB Title1-III Design Report\Figures\ BNL ISB-LATERAL PRESSURE.dwg \Aug 12, 2009



$$Pp_{all} = \frac{1}{2}\left[\frac{1}{3}\,Kp - Ka\right]\gamma e\,(2H \times Hp + Hp^2)$$

BACKFILL TYPE	γe (lb./cf)	Kp	Ka	Pp_{all} (lb./ft.)
COMPACTED GRANULAR FILL	125	3.69	0.27	$60\ (2H \times Hp + Hp^2)$

NOTES

Pp_{all} = ALLOWABLE PASSIVE RESISTANCE

γe = EFFECTIVE SOIL UNIT WEIGHT

Kp = ALLOWABLE PASSIVE RESISTANCE

Ka = EFFECTIVE SOIL UNIT WEIGHT

ASSUMES GROUNDWATER BELOW BOTTOM OF FOOTING OR WALL.

AT BELOW–GRADE WALLS, Hp EQUALS HEIGHT OF WALL BELOW FLOOR SLAB OR ADJACENT GROUND SURFACE, AND H EQUALS 0.

INTERDISCIPLINARY SCIENCE BUILDING-1 BROOKHAVEN NATIONAL LABORATORY UPTON, NEW YORK	GEI Consultants	**RECOMMENDED PASSIVE EARTH PRESSURES**
HDR ARCHITECTURE, INC. ALEXANDRIA, VIRGINIA	Project 080830	August 2009 Figure 5

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Appendix A

Test Boring Logs

Boring Location

NORTHING: _____ **EASTING:** _____ **STATION:** _____ **OFFSET:** _____
HORIZONTAL DATUM: _____ **STATION CENTERLINE:** _____
VERTICAL DATUM: BNL 94 **ESTIMATED GROUND SURFACE ELEVATION (FT):** 84.0
LOCATION: See Figure 2

BORING

B1

Drilling Information

DATE START / END: 3/26/2008 - 3/26/2008 **TOTAL DEPTH (FT):** 22.0
CONTRACTOR: New England Boring Contractors **DRILLER:** Trent Roe **LOGGED BY:** Amy Hare
EQUIPMENT: B53 Mobile Drill Rig **BORING METHOD:** Hollow Stem Auger
AUGER ID/OD: 4.25 in / N/A **CASING ID/OD:** N/A / N/A **CORE INFO:** _____
HAMMER TYPE: Safety Hammer **HAMMER WEIGHT (lbs):** 140 **HAMMER DROP (inch):** 30
WATER LEVEL DEPTHS (ft): _____
GENERAL NOTES: _____

ABBREVIATIONS:
ID = Inside Diameter; OD = Outside Diameter; Pen. = Penetration Length; Rec. = Recovery Length
bpf = Blows per Foot; mpf = Minute per Foot; S = Split Spoon; DP = Direct Push Sample
U = Undistrubed Tube Sample; C = Rock Core; V = Field Vane Shear; SC = Sonic Core
WOR = Weight of Rods; WOH = Weight of Hammer; RQD = Rock Quality Designation; OVM = Organic Vapor Meter
Q_u = Pocket Penetrometer Strength; S_v = Pocket Torvane Shear Strength; F_v = Field Vane Shear Strength; NA, NM = Not Applicable, Not Measured

Elev. (ft)	Depth (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	Sample Description & Classification	H_2O Depth	Remarks
			S-1	X	0 to 2	24/11	2-2-3-4		(0-0.3) WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% fines; ~20% organics, dark brown, TOPSOIL.		
			S-2	X	2 to 4	24/7	3-2-2-2		(0.3-2) SILTY SAND (SM); 58% fine to coarse sand, 38% fines, 4% fine gravel, moist, orangeish brown, FILL.		
80			S-3	X	4 to 6	24/10	2-2-7-15		(2-4) SILTY SAND (SM); ~80% sand, fine to coarse, ~15% fines, ~5% gravel, fine to coarse; moist, orangeish brown, coal fragments. FILL.		
	5								(4-4.3) WIDELY GRADED SAND WITH SILT (SW-SM); ~80% sand, fine to coarse, ~10% gravel, fine, ~10% fines; orangeish brown, roots, FILL.		Driller notes occasional cobbles during drilling
			S-4	X	6 to 8	24/11	21-27-24-24		(4.3-6) WIDELY GRADED SAND WITH SILT (SW-SM); ~80% sand, fine to coarse, ~10% gravel, fine, ~10% fines; tan, roots, FILL.		
75			S-5	X	8 to 10	24/16	15-10-13-15		(6-8) WIDELY GRADED SAND WITH SILT (SW-SM); ~80% sand, fine to coarse, ~10% gravel, fine, ~10% fines; tan, SAND.		
	10		S-6	X	10 to 12	24/14	5-4-5-5		(8-10) WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~5% gravel, fine, ~5% fines; tan, orange brown sand lense @ 15". SAND.		
									(10-15) WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% gravel, fine; tan, orange brown sand lense @ 7". SAND.		
70											
	15		S-7	X	15 to 17	24/13	4-5-9-11		(15-20) WIDELY GRADED SAND (SW); ~90% sand, medium to coarse, ~10% gravel, fine; tan, orange sand lense @ 4". SAND.		
65											Driller notes occasional cobbles during drilling
	20		S-8	X	20 to 22	24/16	10-13-19-25		(20-22) NARROWLY GRADED SAND (SP); ~90% sand, fine to medium, ~10% gravel, fine to coarse; tan, lenses @ 3", 5.5", &7". SAND.		
									End of Boring at 22 feet Filled with cuttings upon completion		

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

CLIENT: HDR Architecture
PROJECT NAME: BNL ISB Geotechnical Investigation
CITY/STATE: Upton, New York
GEI PROJECT NUMBER: 080830-*-1000

GEI Consultants
GEI Consultants, Inc.
455 Winding Brook Drive
Glastonbury, CT 06033
(860) 368-5300

Boring Location

NORTHING: _____ **EASTING:** _____ **STATION:** _____ **OFFSET:** _____
HORIZONTAL DATUM: _____ **STATION CENTERLINE:** _____
VERTICAL DATUM: BNL 94 **ESTIMATED GROUND SURFACE ELEVATION (FT):** 83.0
LOCATION: See Figure 2

BORING

B2

Drilling Information

DATE START / END: 3/26/2008 - 3/26/2008 **TOTAL DEPTH (FT):** 22.0
CONTRACTOR: New England Boring Contractors **DRILLER:** Trent Roe **LOGGED BY:** Amy Hare
EQUIPMENT: B53 Mobile Drill Rig **BORING METHOD:** Hollow Stem Auger
AUGER ID/OD: 4.25 in / N/A **CASING ID/OD:** N/A / N/A **CORE INFO:** _____
HAMMER TYPE: Safety Hammer **HAMMER WEIGHT (lbs):** 140 **HAMMER DROP (inch):** 30
WATER LEVEL DEPTHS (ft): _____
GENERAL NOTES: _____

ABBREVIATIONS:
ID = Inside Diameter; OD = Outside Diameter; Pen. = Penetration Length; Rec. = Recovery Length
bpf = Blows per Foot; mpf = Minute per Foot; S = Split Spoon; DP = Direct Push Sample
U = Undistrubed Tube Sample; C = Rock Core; V = Field Vane Shear; SC = Sonic Core
WOR = Weight of Rods; WOH = Weight of Hammer; RQD = Rock Quality Designation; OVM = Organic Vapor Meter
Q_p = Pocket Penetrometer Strength; S_v = Pocket Torvane Shear Strength; F_v = Field Vane Shear Strength; NA, NM = Not Applicable, Not Measured

Elev. (ft)	Depth (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	Sample Description & Classification	H_2O Depth	Remarks
			S-1		0 to 2	24/19	2-5-6-4		(0-0.75) WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~10% fines; ~20% organics, dark brown, TOPSOIL.		
			S-2		2 to 4	24/8	7-8-7-6		(0.75-2) SILTY SAND (SM); ~75% sand, fine to coarse, ~20% fines, ~5% gravel, fine; orangeish brown, lenses at 13, 15 & 17". FILL.		
80									(2-2.5) WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~5% gravel, fine, ~5% fines; brown, FILL.		Driller notes occasional cobbles during drilling
			S-3		4 to 6	24/20	2-3-5-10		(2.5-4) SILTY SAND (SM); ~70% sand, fine to coarse, ~20% fines, ~10% gravel, fine; orangeish brown, FILL.		
	5		S-4		6 to 8	24/16	14-20-24-27		(4-4.5) SILTY SAND (SM); ~70% sand, fine to coarse, ~20% fines, ~10% gravel, fine; orangeish brown, FILL.		Driller notes occasional cobbles during drilling
75			S-5		8 to 10	24/10	21-19-18-16		(4.5-6) NARROWLY GRADED SAND (SP); 94% fine to coarse sand, 4% fines, 2% fine gravel, tan, SAND.		
	10		S-6		10 to 12	24/14	3-4-5-6		(6-8) WIDELY GRADED SAND WITH SILT (SW-SM); ~80% sand, fine to coarse, ~10% gravel, fine, ~10% fines; tan, SAND.		
									(8-10) WIDELY GRADED SAND WITH GRAVEL (SW); ~80% sand, fine to coarse, ~15% gravel, fine, ~5% fines; tan, SAND.		
70									(10-15) WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~10% gravel, fine to coarse, rounded; tan, lense @ 9". SAND.		
	15		S-7		15 to 17	24/17	4-6-7-7		(15-20) WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~10% gravel, fine to coarse, rounded; tan, lense @ 6 & 8". SAND.		
65											
	20		S-8		20 to 22	24/16	7-9-12-13		(20-22) WIDELY GRADED SAND (SW); ~100% sand, fine to coarse; tan, lenses @ 45 degrees, ~ 5 to 7 of them between 9-12". SAND.		
60									End of Boring at 22 feet Filled with cuttings upon completion		

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

CLIENT: HDR Architecture
PROJECT NAME: BNL ISB Geotechnical Investigation
CITY/STATE: Upton, New York
GEI PROJECT NUMBER: 080830-*-1000

GEI Consultants
GEI Consultants, Inc.
455 Winding Brook Drive
Glastonbury, CT 06033
(860) 368-5300

Boring Location

NORTHING: _____ **EASTING:** _____ **STATION:** _____ **OFFSET:** _____
HORIZONTAL DATUM: _____ **STATION CENTERLINE:** _____
VERTICAL DATUM: BNL 94 **ESTIMATED GROUND SURFACE ELEVATION (FT):** 86.0
LOCATION: See Figure 2

BORING

B3

Drilling Information

DATE START / END: 3/27/2008 - 3/27/2008 **TOTAL DEPTH (FT):** 42.0
CONTRACTOR: New England Boring Contractors **DRILLER:** Trent Roe **LOGGED BY:** Amy Hare
EQUIPMENT: B53 Mobile Drill Rig **BORING METHOD:** Cased Boring
AUGER ID/OD: N/A / N/A **CASING ID/OD:** 4 in / N/A **CORE INFO:** _____
HAMMER TYPE: Safety Hammer **HAMMER WEIGHT (lbs):** 140 **HAMMER DROP (inch):** 30
WATER LEVEL DEPTHS (ft): _____
GENERAL NOTES: _____

ABBREVIATIONS:
ID = Inside Diameter; OD = Outside Diameter; Pen. = Penetration Length; Rec. = Recovery Length
bpf = Blows per Foot; mpf = Minute per Foot; S = Split Spoon; DP = Direct Push Sample
U = Undistrubed Tube Sample; C = Rock Core; V = Field Vane Shear; SC = Sonic Core
WOR = Weight of Rods; WOH = Weight of Hammer; RQD = Rock Quality Designation; OVM = Organic Vapor Meter
Q_p = Pocket Penetrometer Strength; S_v = Pocket Torvane Shear Strength; F_v = Field Vane Shear Strength; NA, NM = Not Applicable, Not Measured

Elev. (ft)	Depth (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	Sample Description & Classification	H_2O Depth	Remarks
85			S-1	X	0 to 2	24/18	5-6-6-7		(0-0.5) WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~10% fines; ~20% organics, dark brown, TOPSOIL.		
			S-2	X	2 to 4	24/12	6-8-14-15		(0.5-2) SILTY SAND (SM); ~75% sand, fine to coarse, ~15% fines, ~10% gravel, fine; brown, FILL.		
			S-3	X	4 to 6	24/7	7-11-13-14		(2-3) WIDELY GRADED SAND WITH SILT (SW-SM); ~80% sand, fine to coarse, ~10% gravel, coarse, ~10% fines; grayish tan, SAND. (3-6) NARROWLY GRADED SAND WITH SILT (SP-SM); 80% fine to coarse sand, 14% fine gravel, 6% fines, tan, SAND.		Driller notes occasional cobbles during drilling
	5										
80			S-4	X	6 to 8	24/14	13-11-11-13		(6-8) WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, fine to coarse, ~5% fines; tan, lense @ 7". SAND.		
			S-5	X	8 to 10	24/12	10-9-8-8		(8-8.5) WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, fine to coarse, ~5% fines; tan, SAND.		
	10		S-6	X	10 to 12	24/18	7-8-9-10		(8.5-10) WIDELY GRADED SAND (SW); ~90% sand, medium to coarse, ~10% gravel, fine to coarse; tan, SAND.		
75									(10-15) WIDELY GRADED SAND WITH GRAVEL (SW); ~80% sand, medium to coarse, ~20% gravel, coarse, rounded; tan, SAND.		
	15		S-7	X	15 to 17	24/8	10-11-13-20		(15-20) WIDELY GRADED SAND WITH GRAVEL (SW); ~80% sand, fine to coarse, ~15% gravel, fine to coarse, rounded, ~5% fines; tan, sample wet due to drilling. SAND.		
70											
	20		S-8	X	20 to 22	24/9	15-16-21-23		(20-25) WIDELY GRADED SAND WITH GRAVEL (SW); ~80% sand, fine to coarse, ~15% gravel, fine to coarse, rounded, ~5% fines; tan, sample wet due to drilling. SAND.		
65											

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

CLIENT: HDR Architecture
PROJECT NAME: BNL ISB Geotechnical Investigation
CITY/STATE: Upton, New York
GEI PROJECT NUMBER: 080830-*-1000

GEI Consultants
GEI Consultants, Inc.
455 Winding Brook Drive
Glastonbury, CT 06033
(860) 368-5300

Boring Location

NORTHING: _____ **EASTING:** _____ **STATION:** _____ **OFFSET:** _____

HORIZONTAL DATUM: _____ **STATION CENTERLINE:** _____

VERTICAL DATUM: BNL 94 **ESTIMATED GROUND SURFACE ELEVATION (FT):** 86.0

LOCATION: See Figure 2

BORING

B3

Elev. (ft)	Depth (ft)	Casing Pen. (bpf) or Core Rate (mpf)	SAMPLE INFORMATION: Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	GRAPHIC LOG	Sample Description & Classification	H_2O Depth	Remarks
60	25		S-9		25 to 27	24/8	12-12-13-15			(25-30) WIDELY GRADED SAND WITH GRAVEL (SW); ~80% sand, fine to coarse, ~15% gravel, fine to coarse, rounded, ~5% fines; tan, sample wet due to drilling. SAND.		
55	30		S-10		30 to 32	24/10	9-11-12-13			(30-35) WIDELY GRADED SAND WITH GRAVEL (SW); ~90% sand, fine to coarse, ~5% gravel, fine, rounded, ~5% fines; tan, lense @ 4". sample wet due to drilling. SAND.		
50	35		S-11		35 to 37	24/3	7-8-11-14			(35-40) WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% fines; tan, sample wet due to drilling. SAND.		Driller notes few cobbles and occasional boulders during drilling
45	40		S-12		40 to 42	24/9	25-41-49-58			(40-42) WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% fines; tan, sample wet due to drilling. SAND.		
40	45									End of Boring at 42 feet Filled with cuttings and grouted top ten feet upon completion		
35	50											

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

CLIENT: HDR Architecture
PROJECT NAME: BNL ISB Geotechnical Investigation
CITY/STATE: Upton, New York
GEI PROJECT NUMBER: 080830-*-1000

GEI Consultants

GEI Consultants, Inc.
455 Winding Brook Drive
Glastonbury, CT 06033
(860) 368-5300

Boring Location

NORTHING: _____ **EASTING:** _____ **STATION:** _____ **OFFSET:** _____
HORIZONTAL DATUM: _____ **STATION CENTERLINE:** _____
VERTICAL DATUM: BNL 94 **ESTIMATED GROUND SURFACE ELEVATION (FT):** 83.0
LOCATION: See Figure 2

BORING

B4

Drilling Information

DATE START / END: 3/27/2008 - 3/27/2008 **TOTAL DEPTH (FT):** 41.0
CONTRACTOR: New England Boring Contractors **DRILLER:** Trent Roe **LOGGED BY:** Amy Hare
EQUIPMENT: B53 Mobile Drill Rig **BORING METHOD:** Hollow Stem Auger
AUGER ID/OD: 4.25 in / N/A **CASING ID/OD:** N/A / N/A **CORE INFO:** _____
HAMMER TYPE: Safety Hammer **HAMMER WEIGHT (lbs):** 140 **HAMMER DROP (inch):** 30
WATER LEVEL DEPTHS (ft): ▽ 39.00 3/27/2008
GENERAL NOTES: _____

ABBREVIATIONS:
ID = Inside Diameter; OD = Outside Diameter; Pen. = Penetration Length; Rec. = Recovery Length
bpf = Blows per Foot; mpf = Minute per Foot; S = Split Spoon; DP = Direct Push Sample
U = Undistrubed Tube Sample; C = Rock Core; V = Field Vane Shear; SC = Sonic Core
WOR = Weight of Rods; WOH = Weight of Hammer; RQD = Rock Quality Designation; OVM = Organic Vapor Meter
Q_p = Pocket Penetrometer Strength; S_v = Pocket Torvane Shear Strength; F_v = Field Vane Shear Strength; NA, NM = Not Applicable, Not Measured

Elev. (ft)	Depth (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	Sample Description & Classification	H_2O Depth	Remarks
			S-1		0 to 2	24/18	3-5-9-10		(0-0.2) WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~10% fines; ~20% organics, dark brown, TOPSOIL.		
			S-2		2 to 4	24/14	10-7-10-13		(0.2-1.2) SILTY SAND (SM); ~70% sand, fine to coarse, ~20% fines, ~10% gravel, fine to medium; dark brown, FILL. (1.2-2) SILTY SAND (SM); ~80% sand, fine to coarse, ~15% fines, ~5% gravel, fine; orangeish brown, FILL.		Driller notes occasional cobbles during drilling
80											
	5		S-3		4 to 6	24/8	6-10-12-13		(2-2.4) WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% fines, ~5% gravel, fine; orangeish brown, SAND.		
			S-4		6 to 8	24/11	15-14-13-13		(2.4-4) WIDELY GRADED SAND (SW); ~80% sand, fine to coarse, ~10% gravel, fine, ~10% fines; brown, SAND.		
75			S-5		8 to 10	24/16	9-9-8-8		(4-6) WIDELY GRADED SAND (SW); ~80% sand, fine to coarse, ~10% gravel, fine, ~10% fines; grayish brown, SAND. (6-6.5) WIDELY GRADED SAND (SW); ~80% sand, fine to coarse, ~10% gravel, fine, ~10% fines; brown, SAND.		
	10		S-6		10 to 12	24/14	5-6-8-10		(6.5-8) NARROWLY GRADED SAND WITH SILT (SP-SM); 84% fine to coarse sand, 11% fine gravel, 5% fines, orangeish brown, SAND. (8-10) WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, fine, ~5% fines; tan, SAND.		
70									(10-15) WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, fine, ~5% fines; tan, lense @8". SAND.		
	15		S-7		15 to 17	24/8	28-21-10-12		(15-20) WIDELY GRADED SAND (SW); ~90% sand, medium to coarse, ~10% gravel, fine; tan, SAND.		
65											
	20		S-8		20 to 22	24/9	17-29-24-21		(20-25) WIDELY GRADED SAND (SW); ~90% sand, medium to coarse, ~10% gravel, fine; tan, lens @ 7". SAND.		
60											

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

CLIENT: HDR Architecture
PROJECT NAME: BNL ISB Geotechnical Investigation
CITY/STATE: Upton, New York
GEI PROJECT NUMBER: 080830-*-1000

GEI Consultants
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455 Winding Brook Drive
Glastonbury, CT 06033
(860) 368-5300

GEOTECHNICAL BORING LOG 02 ISB BORING LOGS.GPJ GEI DATA TEMPLATE.GDT 4/9/08

Boring Location

NORTHING: _____ EASTING: _____ STATION: _____ OFFSET: _____

HORIZONTAL DATUM: _____ STATION CENTERLINE: _____

VERTICAL DATUM: BNL 94 ESTIMATED GROUND SURFACE ELEVATION (FT): 83.0

LOCATION: See Figure 2

BORING

B4

Elev. (ft)	Depth (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	GRAPHIC LOG	Sample Description & Classification	H_2O Depth	Remarks
	25		S-9		25 to 27	24/16	12-18-24-27			(25-30) NARROWLY GRADED SAND (SP); ~90% sand, fine to medium, ~5% gravel, fine to coarse, ~5% fines; tan, 4 lenses between 14-15". SAND.		
55												
	30		S-10		30 to 32	24/15	14-18-20-23			(30-35) WIDELY GRADED SAND (SW); ~90% sand, fine to medium, ~5% gravel, fine to coarse, ~5% fines; tan, SAND.		
50												
	35		S-11		35 to 37	24/15	9-14-20-24			(35-37) NARROWLY GRADED SAND (SP); ~95% sand, fine to medium, ~5% fines; tan, SAND.		
			S-12		37 to 39	24/16	23-24-28-34			(37-39) NARROWLY GRADED SAND (SP); ~95% sand, fine to medium, ~5% fines; tan, lense @ 10". SAND.		
45											▽	
			S-13		39 to 41	24/7	24-23-28-23			(39-41) NARROWLY GRADED SAND (SP); ~95% sand, fine to medium, ~5% fines; wet, tan, SAND.		
	40											
										End of Boring at 41 feet Filled with cuttings and grouted top ten feet upon completion		
40												
	45											
35												
	50											
30												

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

CLIENT: HDR Architecture
PROJECT NAME: BNL ISB Geotechnical Investigation
CITY/STATE: Upton, New York
GEI PROJECT NUMBER: 080830-*-1000

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Glastonbury, CT 06033
(860) 368-5300

Boring Location

NORTHING: _____ EASTING: _____ STATION: _____ OFFSET: _____
HORIZONTAL DATUM: _____ STATION CENTERLINE: _____
VERTICAL DATUM: BNL 94 ESTIMATED GROUND SURFACE ELEVATION (FT): 86.0
LOCATION: See Figure 2

BORING

B5

Drilling Information

DATE START / END: 3/26/2008 - 3/26/2008 TOTAL DEPTH (FT): 22.0
CONTRACTOR: New England Boring Contractors DRILLER: Trent Roe LOGGED BY: Amy Hare
EQUIPMENT: B53 Mobile Drill Rig BORING METHOD: Hollow Stem Auger
AUGER ID/OD: 4.25 in / N/A CASING ID/OD: N/A / N/A CORE INFO: _____
HAMMER TYPE: Safety Hammer HAMMER WEIGHT (lbs): 140 HAMMER DROP (inch): 30
WATER LEVEL DEPTHS (ft): _____
GENERAL NOTES: _____

ABBREVIATIONS: ID = Inside Diameter; OD = Outside Diameter; Pen. = Penetration Length; Rec. = Recovery Length; bpf = Blows per Foot; mpf = Minute per Foot; S = Split Spoon; DP = Direct Push Sample; U = Undistrubed Tube Sample; C = Rock Core; V = Field Vane Shear; SC = Sonic Core; WOR = Weight of Rods; WOH = Weight of Hammer; RQD = Rock Quality Designation; OVM = Organic Vapor Meter; Q_u = Pocket Penetrometer Strength; S_v = Pocket Torvane Shear Strength; F_v = Field Vane Shear Strength; NA, NM = Not Applicable, Not Measured

Elev. (ft)	Depth (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	GRAPHIC LOG	Sample Description & Classification	H_2O Depth	Remarks
85			S-1		0 to 2	24/8	6-10-67-8			(0-0.5) SILTY SAND (SM); ~85% sand, fine to coarse, ~15% fines; ~10% organics, black, FILL. (0.5-0.6) CONCRETE; FILL.		Driller notes occasional cobbles during drilling
			S-2		2 to 4	24/12	5-3-4-6			(0.6-2) WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~10% fines; orangeish brown, FILL. (2-3) SILTY SAND (SM); ~75% sand, fine to coarse, ~20% fines, ~5% gravel, fine; orangeish brown, FILL.		
	5		S-3		4 to 6	24/18	7-14-11-10			(3-6) WIDELY GRADED SAND WITH SILT (SW-SM); ~80% sand, fine to coarse, ~10% gravel, ~10% fines; dark tan, SAND.		Driller notes occasional cobbles during drilling
80			S-4		6 to 8	24/13	10-10-11-11			(6-8) NARROWLY GRADED SAND (SP); 89% fine to coarse sand, 7% fine gravel, 4% fines, tan, lenses @ 3 & 10". SAND.		
			S-5		8 to 10	24/16	7-6-7-8			(8-10) WIDELY GRADED SAND (SW); ~95% sand, medium to coarse, ~5% fines; tan, lenses throughout. SAND.		
	10		S-6		10 to 12	24/16	3-3-4-6			(10-15) WIDELY GRADED SAND (SW); ~95% sand, medium to coarse, ~5% fines; tan, SAND.		
75												
	15		S-7		15 to 17	24/16	6-8-9-9			(15-20) WIDELY GRADED SAND (SW); ~95% sand, medium to coarse, ~5% fines; moist, tan, lense @ 7". SAND.		
70												
	20		S-8		20 to 22	24/16	6-8-9-15			(20-22) WIDELY GRADED SAND (SW); ~95% sand, medium to coarse, ~5% fines; tan, 4 lenses between 12-13". SAND.		
65												
										End of Boring at 22 feet Filled with cuttings upon completion		

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

CLIENT: HDR Architecture
PROJECT NAME: BNL ISB Geotechnical Investigation
CITY/STATE: Upton, New York
GEI PROJECT NUMBER: 080830-*-1000

GEI Consultants
GEI Consultants, Inc.
455 Winding Brook Drive
Glastonbury, CT 06033
(860) 368-5300

GEOTECHNICAL BORING LOG 02 ISB BORING LOGS.GPJ GEI DATA TEMPLATE.GDT 4/9/08

Boring Location

NORTHING: _____ EASTING: _____ STATION: _____ OFFSET: _____
HORIZONTAL DATUM: _____ STATION CENTERLINE: _____
VERTICAL DATUM: BNL 94 ESTIMATED GROUND SURFACE ELEVATION (FT): 84.0
LOCATION: See Figure 2

BORING

B6

Drilling Information

DATE START / END: 3/26/2008 - 3/26/2008 TOTAL DEPTH (FT): 22.0
CONTRACTOR: New England Boring Contractors DRILLER: Trent Roe LOGGED BY: Amy Hare
EQUIPMENT: B53 Mobile Drill Rig BORING METHOD: Hollow Stem Auger
AUGER ID/OD: 4.25 in / N/A CASING ID/OD: N/A / N/A CORE INFO: _____
HAMMER TYPE: Safety Hammer HAMMER WEIGHT (lbs): 140 HAMMER DROP (inch): 30
WATER LEVEL DEPTHS (ft): _____
GENERAL NOTES: _____

ABBREVIATIONS:
ID = Inside Diameter; OD = Outside Diameter; Pen. = Penetration Length; Rec. = Recovery Length
bpf = Blows per Foot; mpf = Minute per Foot; S = Split Spoon; DP = Direct Push Sample
U = Undistrubed Tube Sample; C = Rock Core; V = Field Vane Shear; SC = Sonic Core
WOR = Weight of Rods; WOH = Weight of Hammer; RQD = Rock Quality Designation; OVM = Organic Vapor Meter
Q_p = Pocket Penetrometer Strength; S_v = Pocket Torvane Shear Strength; F_v = Field Vane Shear Strength; NA, NM = Not Applicable, Not Measured

Elev. (ft)	Depth (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	Sample Description & Classification	H_2O Depth	Remarks
			S-1		0 to 2	24/20	2-4-7-12		(0-1.4) SILTY SAND (SM); ~75% sand, fine to coarse, ~20% fines, ~5% gravel, fine; ~20% organics, dark brown, FILL.		
			S-2		2 to 4	24/12	9-10-11-10		(1.4-2) WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% fines, ~5% gravel, fine; orangeish brown, FILL. (2-4) SILTY SAND (SM); 68% fine to coarse sand, 21% fines, 11% fine gravel, dark orangeish brown, FILL.		
80			S-3		4 to 6	24/14	3-4-2-2		(4-5) SILTY SAND (SM); ~80% sand, fine to coarse, ~15% fines, ~5% gravel, fine; orangeish brown, FILL.		
	5		S-4		6 to 8	24/11	2-2-5-12		(5-6) SILTY SAND (SM); ~65% sand, fine to coarse, ~35% fines; orangeish brown, FILL. (6-6.2) SILTY SAND (SM); ~65% sand, fine to coarse, ~35% fines; orangeish brown, piece of wood @ 6.2'. FILL.		Driller notes occasional cobbles and boulders during drilling
			S-5		8 to 10	24/4	18-30-28-28		(6.2-8) WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, fine to coarse, ~5% fines; tan, SAND.		
75			S-6		10 to 12	24/17	8-10-12-13		(8-10) WIDELY GRADED SAND WITH SILT (SW-SM); ~80% sand, fine to coarse, ~10% gravel, fine to coarse, ~10% fines; gray, SAND. (10-15) WIDELY GRADED SAND WITH GRAVEL (SW); ~80% sand, fine to coarse, ~15% gravel, fine to coarse, rounded, ~5% fines; tan, SAND.		
	10										
70											
	15		S-7		15 to 17	24/15	5-8-12-10		(15-20) WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% gravel, fine to coarse, rounded; tan, lenses @ 4 & 9". SAND.		
65											
	20		S-8		20 to 22	24/11	10-19-16-15		(20-22) WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~10% gravel, fine to coarse, rounded; tan, 2" piece of gravel at 3", lenses 7 to 9. SAND.		
									End of Boring at 22 feet Filled with cuttings upon completion		

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

CLIENT: HDR Architecture
PROJECT NAME: BNL ISB Geotechnical Investigation
CITY/STATE: Upton, New York
GEI PROJECT NUMBER: 080830-*-1000

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Glastonbury, CT 06033
(860) 368-5300

GEOTECHNICAL BORING LOG 02 ISB BORING LOGS.GPJ GEI DATA TEMPLATE.GDT 4/9/08

Boring Location

NORTHING: _____ **EASTING:** _____ **STATION:** _____ **OFFSET:** _____
HORIZONTAL DATUM: _____ **STATION CENTERLINE:** _____
VERTICAL DATUM: BNL 94 **ESTIMATED GROUND SURFACE ELEV. (FT):** 89.0
LOCATION: See Figure 2

BORING

B7

Drilling Information

DATE START / END: 7/20/2009 - 7/20/2009 **TOTAL DEPTH (FT):** 22.0
CONTRACTOR: New England Boring Co of CT **DRILLER:** Trent Roe **LOGGED BY:** Steven Hawkins
EQUIPMENT: Truck **BORING METHOD:** Hollow Stem Auger
AUGER ID/OD: 3.25 in / 4 in **CASING ID/OD:** N/A / N/A **CORE INFO:** _____
HAMMER TYPE: Safety Hammer **HAMMER WEIGHT (lbs):** 140 **HAMMER DROP (inch):** 30
WATER LEVEL DEPTHS (ft) 7/20/2009 Not Encountered
GENERAL NOTES: _____

ABBREVIATIONS:
ID = Inside Diameter; OD = Outside Diameter; Pen. = Penetration Length; Rec. = Recovery Length
bpf = Blows per Foot; mpf = Minute per Foot; S = Split Spoon; DP = Direct Push Sample
U = Undistrubed Tube Sample; C = Rock Core; V = Field Vane Shear; SC = Sonic Core
WOR = Weight of Rods; WOH = Weight of Hammer; RQD = Rock Quality Designation; OVM = Organic Vapor Meter
Q_v = Pocket Penetrometer Strength; S_v = Pocket Torvane Shear Strength; F_v = Field Vane Shear Strength; NA, NM = Not Applicable, Not Measured

Elev. (ft)	Depth (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	GRAPHIC LOG	Sample Description & Classification	H_20 Depth	Remarks
										(0'- 0.5') ASPHALT; Includes sub-base material.		
			S-1		0.5 to 2	18/15	5-4-2			(0.5'- 2') SILTY SAND (SM); ~60% sand, fine to coarse, ~30% fines, ~10% gravel, fine to coarse, subrounded; coal refuse, max. size 1 in., moist, orangeish brown, FILL.		
			S-2		2 to 4	24/16	2-2-4-4			(2'- 4') SILTY SAND (SM); ~65% sand, fine to medium, ~30% fines, ~5% gravel, fine to coarse, rounded; max. size 1 in., moist, orangeish brown, FILL.		
85			S-3		4 to 6	24/17	4-7-9-11			(4'- 4.1') SILTY SAND (SM); ~65% sand, fine to medium, ~30% fines, ~5% gravel, fine to coarse, rounded; max. size 1 in., moist, orangeish brown, FILL.		
	5											
			S-4		6 to 8	24/13	9-10-12-16			(4.1'- 6') NARROWLY GRADED SAND (SP); ~83% sand, mostly fine to medium, ~13% gravel, fine, rounded, ~4% fines; max. size 0.75 in., moist, light brown.		
										(6'- 8') WIDELY GRADED SAND WITH SILT (SW-SM); ~80% sand, fine to coarse, ~10% gravel, fine to coarse, rounded, ~10% fines; max. size 1.5 in., dry, light brown.		
80												
	10		S-5		10 to 12	24/17	8-9-10-13			(10'- 12') NARROWLY GRADED SAND (SP); ~90% sand, fine to medium, ~5% gravel, fine to coarse, rounded, ~5% fines; max. size 1 in., dry, tan.		
75												
	15		S-6		15 to 17	24/17	7-10-11-15			(15'- 17') WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~5% gravel, fine, rounded, ~5% fines; max. size 0.5 in., dry, tan.		
70												
	20		S-1		20 to 22	24/15	7-12-15-18			(20'- 22') WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, fine to coarse, rounded, ~5% fines; max. size 1.25 in., dry, tan, Dark colored layering.		
										Backfilled with drill cuttings upon completion.		

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

CLIENT: HDR Architecture, Inc.
PROJECT NAME: BNL ISB Final Design
CITY/STATE: Upton, New York
GEI PROJECT NUMBER: 080830-1-1101

GEI Consultants
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455 Winding Brook Drive
Glastonbury, CT 06033
(860) 368-5300

GEOTECHNICAL BORING LOG 02 FINAL DESIGN BORINGS.GPJ GEI DATA TEMPLATE.GDT 8/12/09

Boring Location

NORTHING: _____ **EASTING:** _____ **STATION:** _____ **OFFSET:** _____
HORIZONTAL DATUM: _____ **STATION CENTERLINE:** _____
VERTICAL DATUM: BNL 94 **ESTIMATED GROUND SURFACE ELEV. (FT):** 86.5
LOCATION: See Figure 2

BORING

B8

Drilling Information

DATE START / END: 7/20/2009 - 7/20/2009 **TOTAL DEPTH (FT):** 42.0
CONTRACTOR: New England Boring Co of CT **DRILLER:** Trent Roe **LOGGED BY:** Steven Hawkins
EQUIPMENT: Truck **BORING METHOD:** Hollow Stem Auger
AUGER ID/OD: 3.25 in / 4 in **CASING ID/OD:** N/A / N/A **CORE INFO:** _____
HAMMER TYPE: Safety Hammer **HAMMER WEIGHT (lbs):** 140 **HAMMER DROP (inch):** 30
WATER LEVEL DEPTHS (ft) ▽ 40.00 7/20/2009 2:10 pm 7/20/2009 2:10 pm 7/21/2009 12:54 pm
GENERAL NOTES: _____

ABBREVIATIONS:
ID = Inside Diameter; OD = Outside Diameter; Pen. = Penetration Length; Rec. = Recovery Length
bpf = Blows per Foot; mpf = Minute per Foot; S = Split Spoon; DP = Direct Push Sample
U = Undistrubed Tube Sample; C = Rock Core; V = Field Vane Shear; SC = Sonic Core
WOR = Weight of Rods; WOH = Weight of Hammer; RQD = Rock Quality Designation; OVM = Organic Vapor Meter
Q_v = Pocket Penetrometer Strength; S_v = Pocket Torvane Shear Strength; F_v = Field Vane Shear Strength; NA, NM = Not Applicable, Not Measured

Elev. (ft)	Depth (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	Sample Description & Classification	H_20 Depth	Remarks
									(0'- 0.5') ASPHALT; Includes sub-base material.		
			S-1		0.5 to 2	18/12	9-11-12		(0.5'- 1') SILTY SAND (SM); ~70% sand, fine to coarse, ~20% fines, ~10% gravel, fine, subrounded; max. size 0.75 in., dry, brown, FILL.		
85											
			S-2		2 to 4	24/15	8-11-26-35		(1'- 2') NARROWLY GRADED SAND WITH SILT (SP-SM); ~85% sand, fine to medium, ~10% fines, ~5% gravel, fine, rounded; max. size 0.75 in., dry, light brown.		
			S-3		4 to 6	24/24	20-34-19-18		(2'- 4') NARROWLY GRADED SAND WITH SILT (SP-SM); ~85% sand, fine to medium, ~10% fines, ~5% gravel, fine, rounded; max. size 0.75 in., dry, light brown.		
	5										
			S-4		6 to 8	24/17	18-17-16-16		(4'- 6') WIDELY GRADED SAND WITH SILT AND GRAVEL (SW-SM); ~70% sand, fine to medium, ~20% gravel, fine to coarse, subrounded, ~10% fines; max. size 1.5 in., dry, light brown.		
80									(6'- 8') NARROWLY GRADED SAND WITH SILT (SP-SM); ~75% sand, fine to coarse, ~15% gravel, fine to coarse, rounded, ~10% fines; max. size 1.5 in., dry, light brown.		
	10		S-5		10 to 12	24/14	6-6-7-7		(10'- 12') WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, fine to coarse, rounded, ~5% fines; roots, max. size 1 in., moist, light brown, Pink coloring.		
75											
	15		S-6		15 to 17	24/15	14-8-9-13		(15'- 17') NARROWYLY GRADED SAND (SP); ~86% sand, mostly fine to medium, ~13% gravel, fine, rounded, ~1% fines; max. size 0.75 in., moist, tan, Rust colored lenses near top of sample.		
70											
	20		S-7		20 to 22	24/6	15-16-14-15		(20'- 22') WIDELY GRADED SAND WITH GRAVEL (SW); ~70% sand, fine to coarse, ~25% gravel, fine to coarse, subrounded, ~5% fines; max. size 1.5 in., moist, tan.		
65											

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

CLIENT: HDR Architecture, Inc.
PROJECT NAME: BNL ISB Final Design
CITY/STATE: Upton, New York
GEI PROJECT NUMBER: 080830-1-1101

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GEOTECHNICAL BORING LOG 02 FINAL DESIGN BORINGS.GPJ GEI DATA TEMPLATE.GDT 8/12/09

Boring Location

NORTHING: _____ **EASTING:** _____ **STATION:** _____ **OFFSET:** _____

HORIZONTAL DATUM: _____ **STATION CENTERLINE:** _____

VERTICAL DATUM: BNL 94 **ESTIMATED GROUND SURFACE ELEV. (FT):** 86.5

LOCATION: See Figure 2

BORING

B8

Elev. (ft)	Depth (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	GRAPHIC LOG	Sample Description & Classification	H_20 Depth	Remarks
60	25		S-8		25 to 27	24/18	10-14-12-17			(25'- 27') WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, fine to coarse, rounded, ~5% fines; max. size 1 in., moist, tan.		
55	30		S-9		30 to 32	24/18	10-16-22-32			(30'- 32') WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~5% gravel, fine, rounded, ~5% fines; max. size 0.75 in., moist, tan.		
50	35		S-10		35 to 37	24/16	7-13-20-24			(35'- 37') WIDELY GRADED SAND WITH SILT (SW-SM); ~85% sand, fine to coarse, ~10% fines, ~5% gravel, fine, subrounded; max. size 0.5 in., moist, tan, 4 inch zone of very moist brown sand from 7-11.		
45	40		S-11		40 to 42	24/18	10-15-17-18			(40'- 42') WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~5% gravel, fine, subrounded, ~5% fines; max. size 0.5 in., wet, light brown.	▽	
40	45									Temporary monitoring well installed. Well abandoned in place by cutting PVC below ground surface and grouting.		
35	50											

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

CLIENT: HDR Architecture, Inc.
PROJECT NAME: BNL ISB Final Design
CITY/STATE: Upton, New York
GEI PROJECT NUMBER: 080830-1-1101

GEI Consultants

GEI Consultants, Inc.
455 Winding Brook Drive
Glastonbury, CT 06033
(860) 368-5300

GEOTECHNICAL BORING LOG 02 FINAL DESIGN BORINGS.GPJ GEI DATA TEMPLATE.GDT 8/12/09

Boring Location

NORTHING: _____ **EASTING:** _____ **STATION:** _____ **OFFSET:** _____
HORIZONTAL DATUM: _____ **STATION CENTERLINE:** _____
VERTICAL DATUM: BNL 94 **ESTIMATED GROUND SURFACE ELEV. (FT):** 85.5
LOCATION: See Figure 2

BORING

B9

Drilling Information

DATE START / END: 7/21/2009 - 7/21/2009 **TOTAL DEPTH (FT):** 22.0
CONTRACTOR: New England Boring Co of CT **DRILLER:** Trent Roe **LOGGED BY:** Steven Hawkins
EQUIPMENT: Truck **BORING METHOD:** Hollow Stem Auger
AUGER ID/OD: 3.25 in / 4 in **CASING ID/OD:** N/A / N/A **CORE INFO:** _____
HAMMER TYPE: Safety Hammer **HAMMER WEIGHT (lbs):** 140 **HAMMER DROP (inch):** 30
WATER LEVEL DEPTHS (ft) 7/21/2009 Not Encountered
GENERAL NOTES: _____

ABBREVIATIONS:
ID = Inside Diameter; OD = Outside Diameter; Pen. = Penetration Length; Rec. = Recovery Length
bpf = Blows per Foot; mpf = Minute per Foot; S = Split Spoon; DP = Direct Push Sample
U = Undistrubed Tube Sample; C = Rock Core; V = Field Vane Shear; SC = Sonic Core
WOR = Weight of Rods; WOH = Weight of Hammer; RQD = Rock Quality Designation; OVM = Organic Vapor Meter
Q_v = Pocket Penetrometer Strength; S_v = Pocket Torvane Shear Strength; F_v = Field Vane Shear Strength; NA, NM = Not Applicable, Not Measured

Elev. (ft)	Depth (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	GRAPHIC LOG	Sample Description & Classification	H_20 Depth	Remarks
85			S-1		0.5 to 2	18/16	5-5-6			(0'- 0.5') ASPHALT; Includes sub-base material.. (0.5'- 2') SILTY SAND (SM); ~70% sand, fine to coarse, ~25% fines, ~5% gravel, fine, subrounded; max. size 0.75 in., moist, brown, FILL.		
			S-2		2 to 4	24/15	4-8-9-10			(2'- 4') WIDELY GRADED SAND WITH SILT (SW-SM); ~80% sand, fine to coarse, ~10% gravel, fine to coarse, rounded, ~10% fines; max. size 1 in., moist to dry, light brown.		
			S-3		4 to 6	24/14	18-22-23-25			(4'- 6') WIDELY GRADED SAND WITH SILT (SW-SM); ~80% sand, fine to coarse, ~10% gravel, fine to coarse, rounded, ~10% fines; max. size 1.5 in., moist to dry, tan, Cobble at top of sample.		
80	5		S-4		6 to 8	24/16	20-17-17-21			(6'- 8') NARROWLY GRADED SAND WITH GRAVEL (SP); ~79% sand, mostly fine to medium, ~17% gravel, fine to coarse, subrounded, ~4% fines; max. size 1 in., dry, tan.		
75	10		S-5		10 to 12	24/17	5-5-6-8			(10'- 12') NARROWLY GRADED SAND (SP); ~85% sand, fine to coarse, ~10% gravel, fine to coarse, subrounded, ~5% fines; max. size 1 in., dry, tan.		
70	15		S-6		15 to 17	24/18	8-10-13-17			(15'- 17') NARROWLY GRADED SAND (SP); ~90% sand, fine to medium, ~5% gravel, fine, rounded, ~5% fines; max. size 0.5 in., dry, tan.		
65	20		S-1		20 to 22	24/16	12-16-18-26			(20'- 22') WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, fine, rounded, ~5% fines; max. size 0.75 in., dry, tan.		
										Backfilled with drill cuttings upon completion.		

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

CLIENT: HDR Architecture, Inc.
PROJECT NAME: BNL ISB Final Design
CITY/STATE: Upton, New York
GEI PROJECT NUMBER: 080830-1-1101

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(860) 368-5300

GEOTECHNICAL BORING LOG 02 FINAL DESIGN BORINGS.GPJ GEI DATA TEMPLATE.GDT 8/12/09

Boring Location

NORTHING: _____ **EASTING:** _____ **STATION:** _____ **OFFSET:** _____
HORIZONTAL DATUM: _____ **STATION CENTERLINE:** _____
VERTICAL DATUM: BNL 94 **ESTIMATED GROUND SURFACE ELEV. (FT):** 85.5
LOCATION: See Figure 2

BORING

B10

Drilling Information

DATE START / END: 7/21/2009 - 7/21/2009 **TOTAL DEPTH (FT):** 22.0
CONTRACTOR: New England Boring Co of CT **DRILLER:** Trent Roe **LOGGED BY:** Steven Hawkins
EQUIPMENT: Truck **BORING METHOD:** Hollow Stem Auger
AUGER ID/OD: 3.25 in / 4 in **CASING ID/OD:** N/A / N/A **CORE INFO:** _____
HAMMER TYPE: Safety Hammer **HAMMER WEIGHT (lbs):** 140 **HAMMER DROP (inch):** 30
WATER LEVEL DEPTHS (ft) 7/21/2009 Not Encountered
GENERAL NOTES: _____

ABBREVIATIONS:
ID = Inside Diameter; OD = Outside Diameter; Pen. = Penetration Length; Rec. = Recovery Length
bpf = Blows per Foot; mpf = Minute per Foot; S = Split Spoon; DP = Direct Push Sample
U = Undistrubed Tube Sample; C = Rock Core; V = Field Vane Shear; SC = Sonic Core
WOR = Weight of Rods; WOH = Weight of Hammer; RQD = Rock Quality Designation; OVM = Organic Vapor Meter
Q_v = Pocket Penetrometer Strength; S_v = Pocket Torvane Shear Strength; F_v = Field Vane Shear Strength; NA, NM = Not Applicable, Not Measured

Elev. (ft)	Depth (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	GRAPHIC LOG	Sample Description & Classification	H_20 Depth	Remarks
85			S-1		0 to 2	24/19	1-3-8-8			(0'- 0.7') SILTY SAND (SM); ~60% sand, fine to medium, ~40% fines; roots, moist, dark brown, TOPSOIL.		
			S-2		2 to 4	24/20	8-13-10-8			(0.7'- 2') SILTY SAND (SM); ~65% sand, fine to medium, ~30% fines, ~5% gravel, coarse, rounded; max. size 1 in., moist, brown, FILL. (2'- 4') SILTY SAND (SM); ~50% sand, fine to medium, ~45% fines, ~5% gravel, coarse, rounded; coal, max. size 1 in., moist, brown, FILL.		
			S-3		4 to 6	24/6	8-10-13-15			(4'- 6') SILTY SAND (SM); ~50% sand, fine to medium, ~45% fines, ~5% gravel, coarse, rounded; coal, max. size 1 in., moist, brown, FILL, Cobble stuck in sampler tip.		
80	5		S-4		6 to 8	24/16	17-19-23-32			(6'- 8') WIDELY GRADED SAND WITH SILT (SW-SM); ~80% sand, fine to coarse, ~10% gravel, fine, rounded, ~10% fines; max. size 0.75 in., dry, tan.		
75	10		S-5		10 to 12	24/13	5-9-9-8			(10'- 12') WIDELY GRADED SAND WITH SILT (SW-SM); ~80% sand, fine to coarse, ~10% gravel, fine to coarse, rounded, ~10% fines; max. size 2 in., dry, tan.		
70	15		S-6		15 to 17	24/16	5-6-8-10			(15'- 17') NARROWLY GRADED SAND (SP); ~85% sand, fine to medium, ~10% gravel, fine to coarse, rounded, ~5% fines; max. size 1 in., dry, tan.		
65	20		S-7		20 to 22	24/15	6-7-8-8			(20'- 22') WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~5% gravel, fine, rounded, ~5% fines; max. size 0.5 in., dry, tan.		
										Backfilled with drill cuttings upon completion.		

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

CLIENT: HDR Architecture, Inc.
PROJECT NAME: BNL ISB Final Design
CITY/STATE: Upton, New York
GEI PROJECT NUMBER: 080830-1-1101

GEI Consultants
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Glastonbury, CT 06033
(860) 368-5300

GEOTECHNICAL BORING LOG 02 FINAL DESIGN BORINGS.GPJ GEI DATA TEMPLATE.GDT 8/12/09

Boring Location

NORTHING: _____ **EASTING:** _____ **STATION:** _____ **OFFSET:** _____
HORIZONTAL DATUM: _____ **STATION CENTERLINE:** _____
VERTICAL DATUM: BNL 94 **ESTIMATED GROUND SURFACE ELEV. (FT):** 85.0
LOCATION: See Figure 2

BORING

B11

Drilling Information

DATE START / END: 7/21/2009 - 7/21/2009 **TOTAL DEPTH (FT):** 22.0
CONTRACTOR: New England Boring Co of CT **DRILLER:** Trent Roe **LOGGED BY:** Steven Hawkins
EQUIPMENT: Truck **BORING METHOD:** Hollow Stem Auger
AUGER ID/OD: 3.25 in / 4 in **CASING ID/OD:** N/A / N/A **CORE INFO:** _____
HAMMER TYPE: Safety Hammer **HAMMER WEIGHT (lbs):** 140 **HAMMER DROP (inch):** 30
WATER LEVEL DEPTHS (ft) 7/21/2009 Not Encountered
GENERAL NOTES: _____

ABBREVIATIONS:
ID = Inside Diameter; OD = Outside Diameter; Pen. = Penetration Length; Rec. = Recovery Length
bpf = Blows per Foot; mpf = Minute per Foot; S = Split Spoon; DP = Direct Push Sample
U = Undistrubed Tube Sample; C = Rock Core; V = Field Vane Shear; SC = Sonic Core
WOR = Weight of Rods; WOH = Weight of Hammer; RQD = Rock Quality Designation; OVM = Organic Vapor Meter
Q_v = Pocket Penetrometer Strength; S_v = Pocket Torvane Shear Strength; F_v = Field Vane Shear Strength; NA, NM = Not Applicable, Not Measured

Elev. (ft)	Depth (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	GRAPHIC LOG	Sample Description & Classification	H_20 Depth	Remarks
			S-1		0 to 2	24/20	3-14-23-35			(0'- 0.3') SILTY SAND (SM); ~70% sand, fine to coarse, ~30% fines; roots, moist, brown, TOPSOIL. (0.3'- 2') SILTY SAND WITH GRAVEL (SM); ~65% sand, fine to coarse, ~20% fines, ~15% gravel, fine to coarse, subrounded; max. size 1 in., moist, brown, FILL.		
			S-2		2 to 4	24/14	13-12-13-17			(2'- 4') WIDELY GRADED SAND WITH SILT AND GRAVEL (SW-SM); ~70% sand, fine to coarse, ~20% gravel, fine to coarse, rounded, ~10% fines; max. size 1.5 in., moist to dry, light brown.		
			S-3		4 to 6	24/18	16-26-26-25			(4'- 6') WIDELY GRADED GRAVEL WITH SAND (SW-SM); ~71% sand, mostly fine to medium, ~22% gravel, fine to coarse, subangular, ~7% fines; max. size 1 in., dry, light brown.		
80	5		S-4		6 to 8	24/18	20-19-18-18			(6'- 8') WIDELY GRADED SAND WITH SILT (SW-SM); ~80% sand, fine to coarse, ~10% gravel, fine to coarse, subangular, ~10% fines; max. size 1.5 in., dry, light brown.		
75	10		S-5		10 to 12	24/16	8-8-11-16			(10'- 12') WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~5% gravel, fine, rounded, ~5% fines; max. size 0.5 in., dry, tan.		
70	15		S-6		15 to 17	24/14	7-13-14-17			(15'- 17') WIDELY GRADED SAND WITH GRAVEL (SW); ~80% sand, fine to coarse, ~15% gravel, coarse, rounded, ~5% fines; max. size 1.5 in., dry, tan.		
65	20		S-1		20 to 22	24/13	13-20-23-26			(20'- 22') WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, fine, rounded, ~5% fines; max. size 0.5 in., dry, tan.		
										Backfilled with drill cuttings upon completion.		

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

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PROJECT NAME: BNL ISB Final Design
CITY/STATE: Upton, New York
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GEOTECHNICAL BORING LOG 02 FINAL DESIGN BORINGS.GPJ GEI DATA TEMPLATE.GDT 8/12/09

Boring Location

NORTHING: _____ **EASTING:** _____ **STATION:** _____ **OFFSET:** _____
HORIZONTAL DATUM: _____ **STATION CENTERLINE:** _____
VERTICAL DATUM: BNL 94 **ESTIMATED GROUND SURFACE ELEV. (FT):** 85.0
LOCATION: See Figure 2

BORING

B12

Drilling Information

DATE START / END: 7/21/2009 - 7/21/2009 **TOTAL DEPTH (FT):** 22.0
CONTRACTOR: New England Boring Co of CT **DRILLER:** Trent Roe **LOGGED BY:** Steven Hawkins
EQUIPMENT: Truck **BORING METHOD:** Hollow Stem Auger
AUGER ID/OD: 3.25 in / 4 in **CASING ID/OD:** N/A / N/A **CORE INFO:** _____
HAMMER TYPE: Safety Hammer **HAMMER WEIGHT (lbs):** 140 **HAMMER DROP (inch):** 30
WATER LEVEL DEPTHS (ft) 7/21/2009 Not Encountered
GENERAL NOTES: _____

ABBREVIATIONS:
ID = Inside Diameter; OD = Outside Diameter; Pen. = Penetration Length; Rec. = Recovery Length
bpf = Blows per Foot; mpf = Minute per Foot; S = Split Spoon; DP = Direct Push Sample
U = Undistrubed Tube Sample; C = Rock Core; V = Field Vane Shear; SC = Sonic Core
WOR = Weight of Rods; WOH = Weight of Hammer; RQD = Rock Quality Designation; OVM = Organic Vapor Meter
Q_v = Pocket Penetrometer Strength; S_v = Pocket Torvane Shear Strength; F_v = Field Vane Shear Strength; NA, NM = Not Applicable, Not Measured

Elev. (ft)	Depth (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	Sample Description & Classification	H_20 Depth	Remarks
			S-1		0 to 2	24	2-14-23-36		(0'- 0.3') SILTY SAND (SM); ~70% sand, fine to coarse, ~30% fines, ~0% gravel; roots, moist, brown, TOPSOIL.		
			S-2		2 to 2.5	6/3	100		(0.3'- 2') SILTY SAND WITH GRAVEL (SM); ~65% sand, fine to coarse, ~20% fines, ~15% gravel, fine to coarse, subrounded; Concrete at 2 feet, max. size 1.25 in., dry, brown, FILL. (2'- 4') Concrete.		
			S-3		4 to 6	24/15	15-20-15-21		(4'- 4.3') Concrete. (4.3'- 6') WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, fine to coarse, subangular, ~5% fines; max. size 1.5 in., dry, tan.		
80	5		S-4		6 to 8	24/18	25-22-23-20		(6'- 8') NARROWLY GRADED SAND WITH GRAVEL (SP); ~68% sand, mostly fine to medium, ~28% gravel, fine to coarse, subrounded, ~4% fines; max. size 1.5 in., dry, tan.		
75	10		S-5		10 to 12	24/14	9-10-10-13		(10'- 12') WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, fine to coarse, subrounded, ~5% fines; max. size 1 in., dry, tan.		
70	15		S-6		15 to 17	24/4	18-19-20-22		(15'- 17') WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, fine to coarse, subrounded, ~5% fines; max. size 1 in., dry, tan, Cobble in sampler tip.		
65	20		S-7		20 to 22	24/2	24-25-33-37		(20'- 22') NARROWLY GRADED SAND (SP); ~95% sand, fine to medium, ~5% fines, ~0% gravel; dry, light brown.		
									Backfilled with drill cuttings upon completion.		

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

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GEOTECHNICAL BORING LOG 02 FINAL DESIGN BORINGS.GPJ GEI DATA TEMPLATE.GDT 8/12/09

Boring Location

NORTHING: _____ **EASTING:** _____ **STATION:** _____ **OFFSET:** _____
HORIZONTAL DATUM: _____ **STATION CENTERLINE:** _____
VERTICAL DATUM: BNL 94 **ESTIMATED GROUND SURFACE ELEV. (FT):** 89.8
LOCATION: See Figure 2

BORING

B13

Drilling Information

DATE START / END: 7/21/2009 - 7/21/2009 **TOTAL DEPTH (FT):** 22.0
CONTRACTOR: New England Boring Co of CT **DRILLER:** Trent Roe **LOGGED BY:** Steven Hawkins
EQUIPMENT: Truck **BORING METHOD:** Hollow Stem Auger
AUGER ID/OD: 3.25 in / 4 in **CASING ID/OD:** N/A / N/A **CORE INFO:** _____
HAMMER TYPE: Safety Hammer **HAMMER WEIGHT (lbs):** 140 **HAMMER DROP (inch):** 30
WATER LEVEL DEPTHS (ft) 7/21/2009 Not Encountered
GENERAL NOTES: _____

ABBREVIATIONS:
ID = Inside Diameter; OD = Outside Diameter; Pen. = Penetration Length; Rec. = Recovery Length
bpf = Blows per Foot; mpf = Minute per Foot; S = Split Spoon; DP = Direct Push Sample
U = Undistrubed Tube Sample; C = Rock Core; V = Field Vane Shear; SC = Sonic Core
WOR = Weight of Rods; WOH = Weight of Hammer; RQD = Rock Quality Designation; OVM = Organic Vapor Meter
Q_v = Pocket Penetrometer Strength; S_v = Pocket Torvane Shear Strength; F_v = Field Vane Shear Strength; NA, NM = Not Applicable, Not Measured

Elev. (ft)	Depth (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	Sample Description & Classification	H_20 Depth	Remarks
			S-1		0 to 2	24/6	2-7-4-3		(0'- 0.25') SILTY SAND (SM); ~70% sand, fine to coarse, ~30% fines; roots, moist, brown, TOPSOIL. (0.25'- 2') SILTY SAND (SM); ~55% sand, fine to coarse, ~40% fines, ~5% gravel, coarse, subangular; max. size 1 in., moist, brown, FILL.		
			S-2		2 to 4	24/10	5-5-8-9		(2'- 4') WIDELY GRADED SAND WITH SILT AND GRAVEL (SW-SM); ~64% sand, fine to coarse, ~27% gravel, fine to coarse, subrounded, ~9% fines; max. size 1.5 in., dry, brown, FILL.		
85	5		S-3		4 to 6	24/16	13-21-13-20		(4'- 6') WIDELY GRADED SAND WITH SILT (SW-SM); ~80% sand, fine to coarse, ~10% gravel, fine to coarse, rounded, ~10% fines; max. size 1.25 in., dry, brown.		
			S-4		6 to 8	24/17	20-22-25-21		(6'- 7') SILTY SAND (SM); ~75% sand, fine to coarse, ~15% fines, ~10% gravel, fine to coarse, subrounded; max. size 1.25 in., dry, brown. (7'- 8') WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, fine, rounded, ~5% fines; max. size 0.75 in., dry, tan.		
80	10		S-5		10 to 12	24/10	17-20-22-24		(10'- 12') WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~5% gravel, fine, rounded, ~5% fines; max. size 0.75 in., dry, tan.		Pushed cobble
75	15		S-6		15 to 17	24/3	20-30-16-18		(15'- 17') WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~5% gravel, fine, rounded, ~5% fines; max. size 0.75 in., dry, tan.		
70	20		S-7		20 to 22	24/17	11-17-18-17		(20'- 22') WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~5% gravel, fine, rounded, ~5% fines; max. size 0.75 in., dry, tan.		
									Backfilled with drill cuttings upon completion.		

Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.

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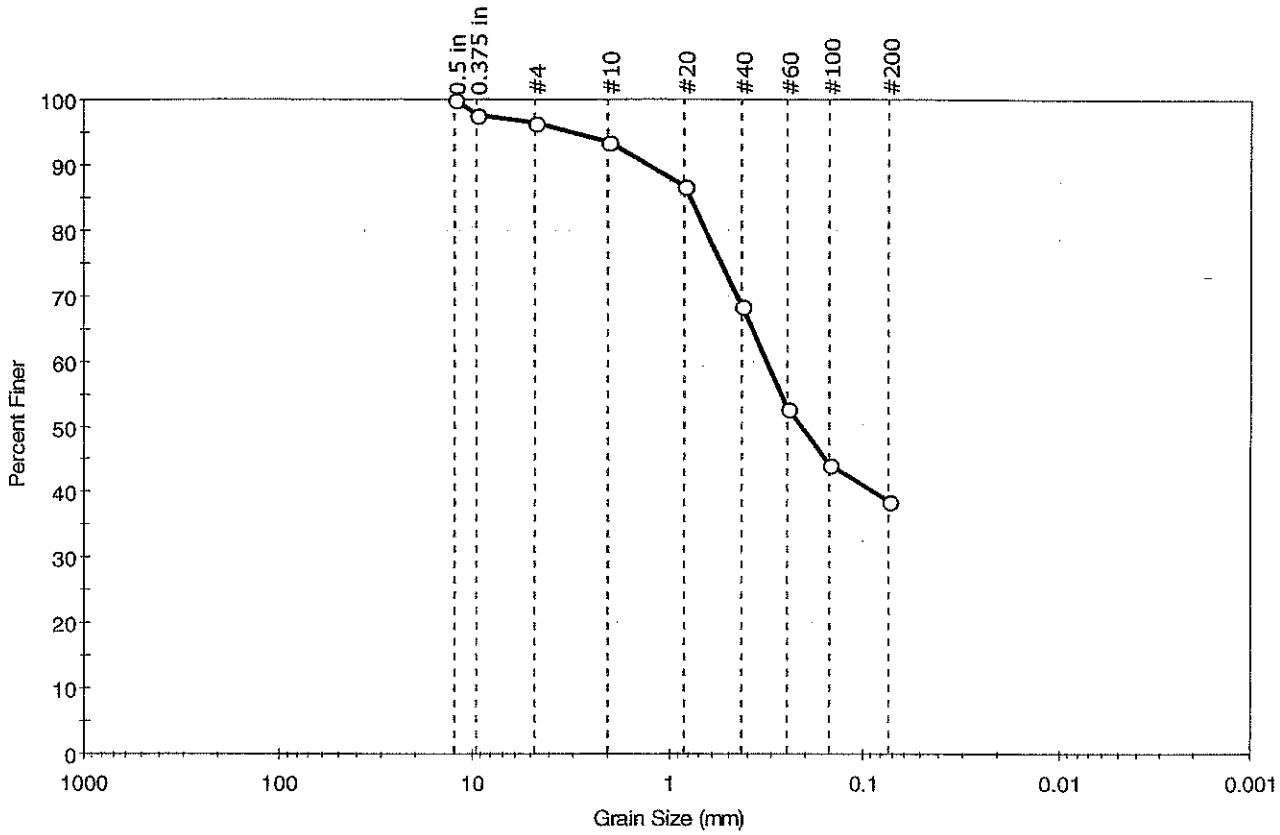
Appendix B

Results of Laboratory Testing

GeoTesting express
a subsidiary of Geocomp Corporation

Client:	GEI Consultants, Inc.		
Project:	Brookhaven National Lab - ISB		
Location:	Upton, NY	Project No:	GTX-8096
Boring ID: B-1	Sample Type: bag	Tested By:	ap
Sample ID:S-1	Test Date: 04/07/08	Checked By:	jdt
Depth : 0-2 ft	Test Id: 128825		
Test Comment:	---		
Sample Description:	Moist, dark reddish brown silty sand		
Sample Comment:	---		

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	3.7	57.7	38.6

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Compiles
0.5 in	12.50	100		
0.375 in	9.51	98		
#4	4.75	96		
#10	2.00	93		
#20	0.84	87		
#40	0.42	68		
#60	0.25	53		
#100	0.15	44		
#200	0.074	39		

Coefficients

D_{85} =0.7899 mm	D_{30} =N/A
D_{60} =0.3190 mm	D_{15} =N/A
D_{50} =0.2117 mm	D_{10} =N/A
C_u =N/A	C_c =N/A

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

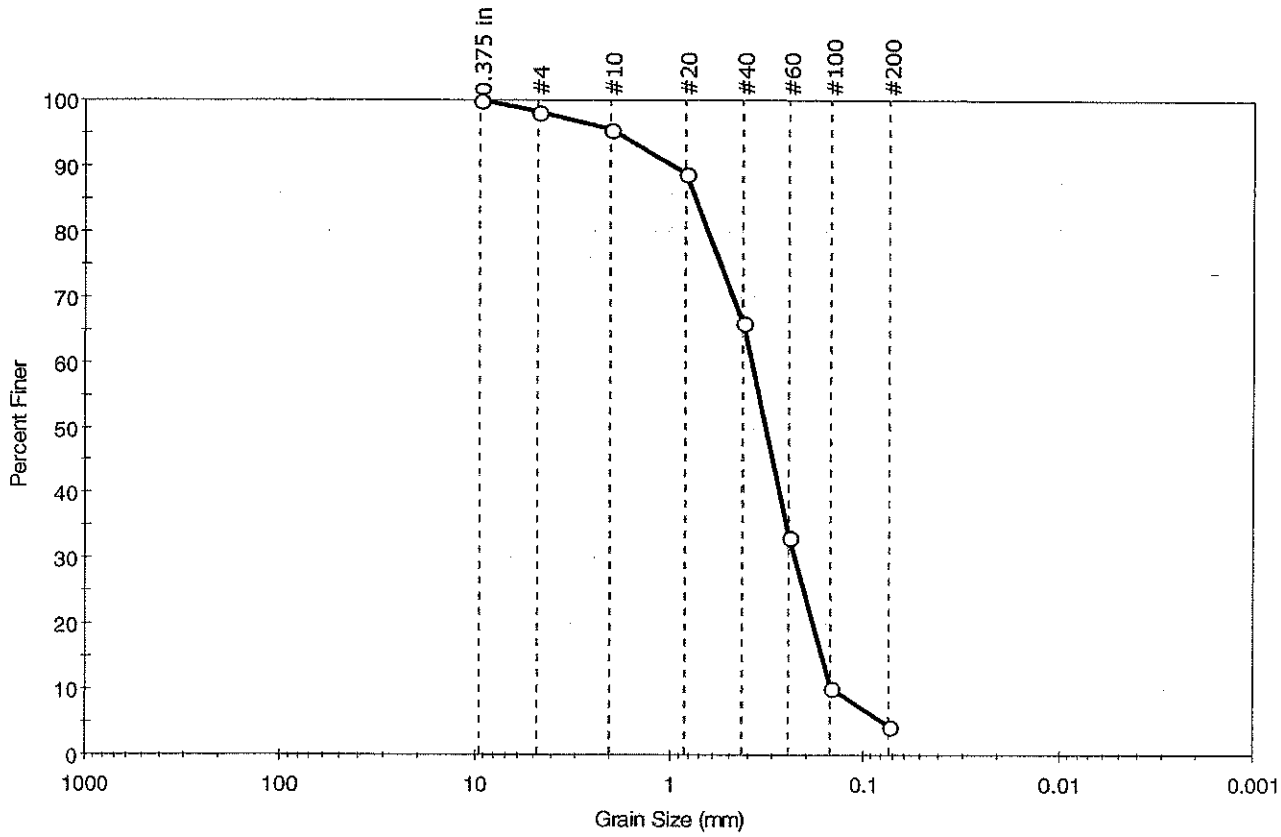
Sand/Gravel Hardness : HARD

printed 4/9/2008 11:56:45 AM

GeoTesting express
a subsidiary of Geocomp Corporation

Client:	GEI Consultants, Inc.		
Project:	Brookhaven National Lab - ISB		
Location:	Upton, NY	Project No:	GTX-8096
Boring ID: B-2	Sample Type: bag	Tested By:	ap
Sample ID:S-3	Test Date: 04/07/08	Checked By:	jdt
Depth : 4-6 ft	Test Id: 128826		
Test Comment:	---		
Sample Description:	Moist, yellow sand		
Sample Comment:	---		

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	1.8	93.7	4.5

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.51	100		
#4	4.75	98		
#10	2.00	95		
#20	0.84	89		
#40	0.42	66		
#60	0.25	33		
#100	0.15	10		
#200	0.074	4		

Coefficients

D_{85} =0.7493 mm	D_{30} =0.2323 mm
D_{60} =0.3850 mm	D_{15} =0.1652 mm
D_{50} =0.3277 mm	D_{10} =0.1413 mm
C_u =2.725	C_c =0.992

Classification

ASTM Poorly graded sand (SP)

AASHTO Fine Sand (A-3 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

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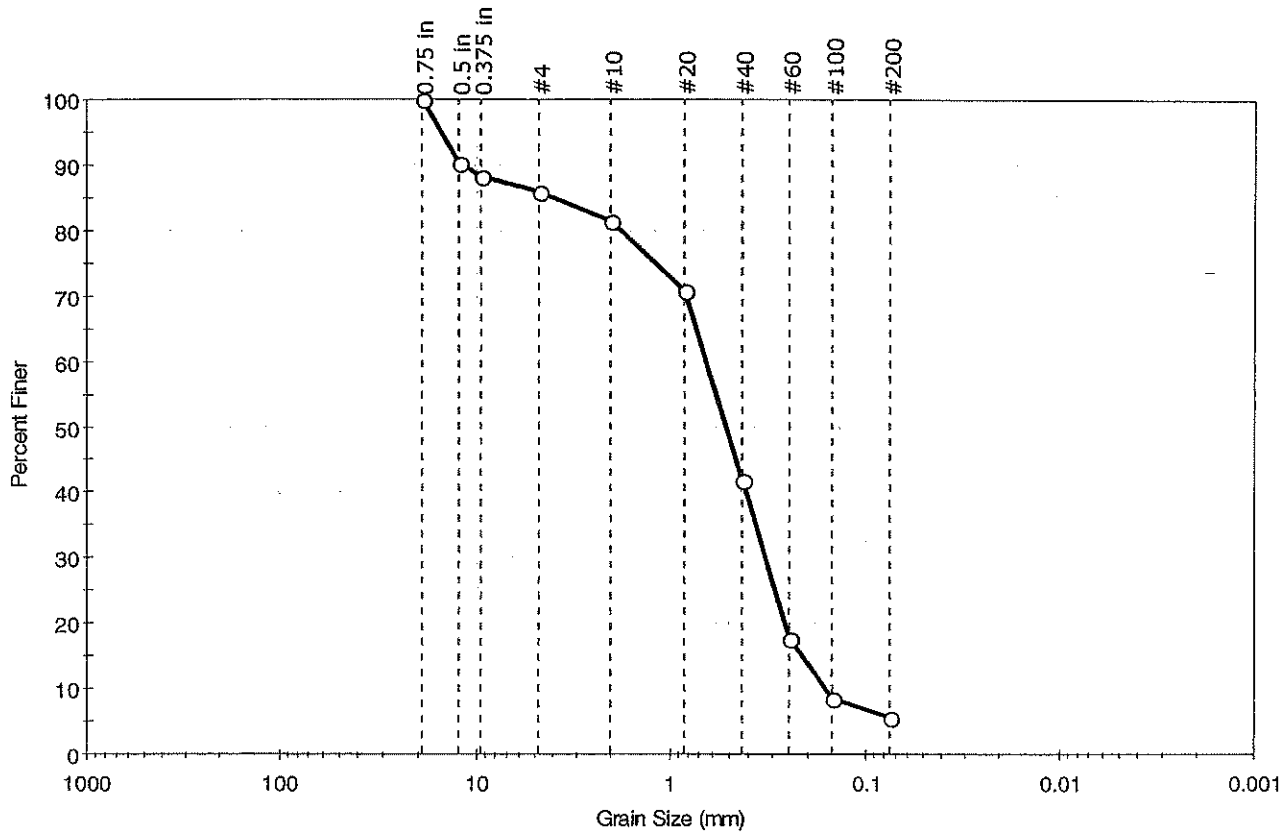
GeoTesting express
a subsidiary of Geocomp Corporation

Client:	GEI Consultants, Inc.		
Project:	Brookhaven National Lab - ISB		
Location:	Upton, NY	Project No:	GTX-8096
Boring ID: B-3	Sample Type: bag	Tested By:	ap
Sample ID:S-3	Test Date: 04/07/08	Checked By:	jdt
Depth : 4-6 ft	Test Id: 128827		
Test Comment:	---		
Sample Description:	Moist, very pale brown sand with silt		
Sample Comment:	---		

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	14.2	80.1	5.7

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	90		
0.375 in	9.51	88		
#4	4.75	86		
#10	2.00	81		
#20	0.84	71		
#40	0.42	42		
#60	0.25	18		
#100	0.15	9		
#200	0.075	6		

Coefficients

D_{85} =4.0928 mm	D_{30} =0.3280 mm
D_{60} =0.6532 mm	D_{15} =0.2155 mm
D_{50} =0.5154 mm	D_{10} =0.1611 mm
C_u =4.055	C_c =1.022

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

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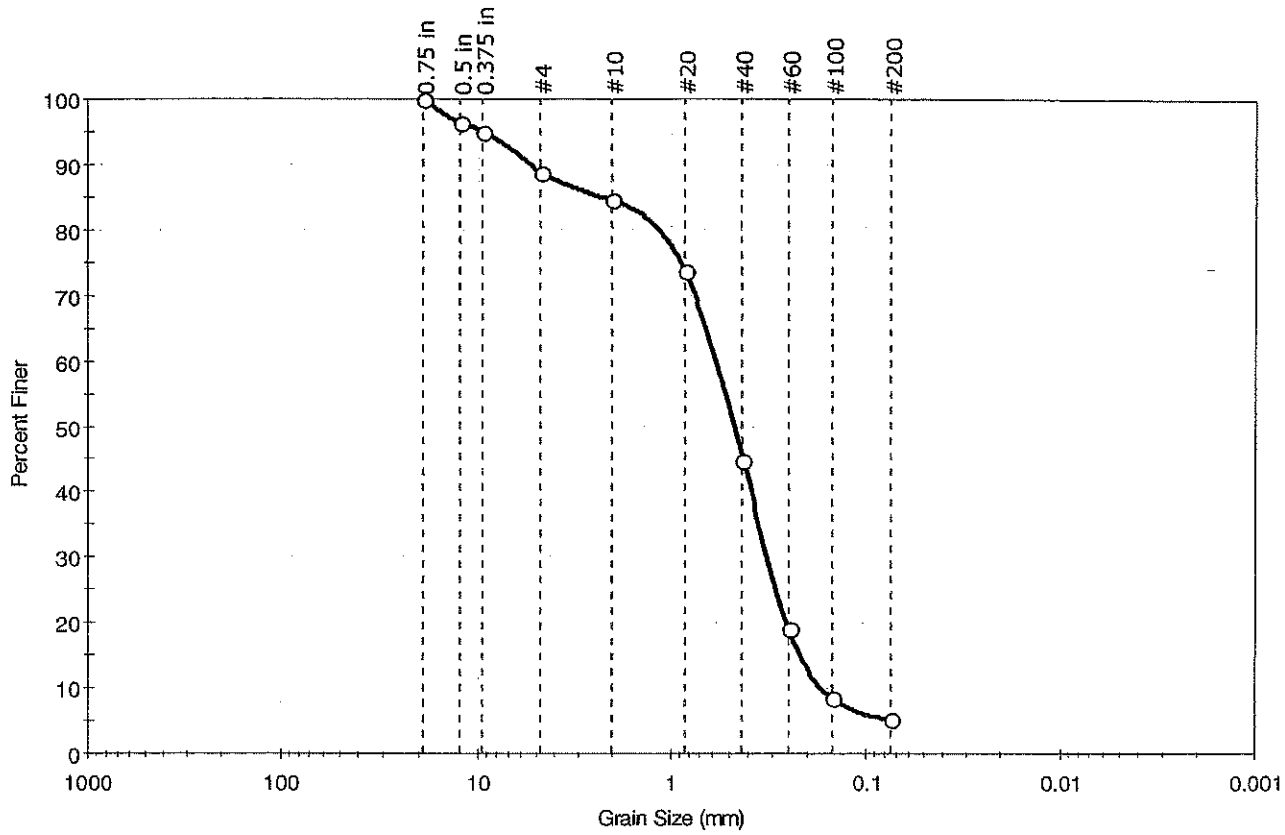
GeoTesting express
a subsidiary of Geocomp Corporation

Client:	GEI Consultants, Inc.		
Project:	Brookhaven National Lab - ISB		
Location:	Upton, NY	Project No:	GTX-8096
Boring ID: B-4	Sample Type: bag	Tested By:	ap
Sample ID:S-4	Test Date: 04/07/08	Checked By:	jdt
Depth : 6-8 ft	Test Id: 128828		
Test Comment:	---		
Sample Description:	Moist, reddish yellow sand with silt		
Sample Comment:	---		

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	11.2	83.6	5.2

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	96		
0.375 in	9.51	95		
#4	4.75	89		
#10	2.00	85		
#20	0.84	74		
#40	0.42	45		
#60	0.25	19		
#100	0.15	9		
#200	0.075	5		

Coefficients

D_{85} = 2.2032 mm	D_{30} = 0.3130 mm
D_{60} = 0.6078 mm	D_{15} = 0.2048 mm
D_{50} = 0.4794 mm	D_{10} = 0.1599 mm
C_u = 3.801	C_c = 1.008

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

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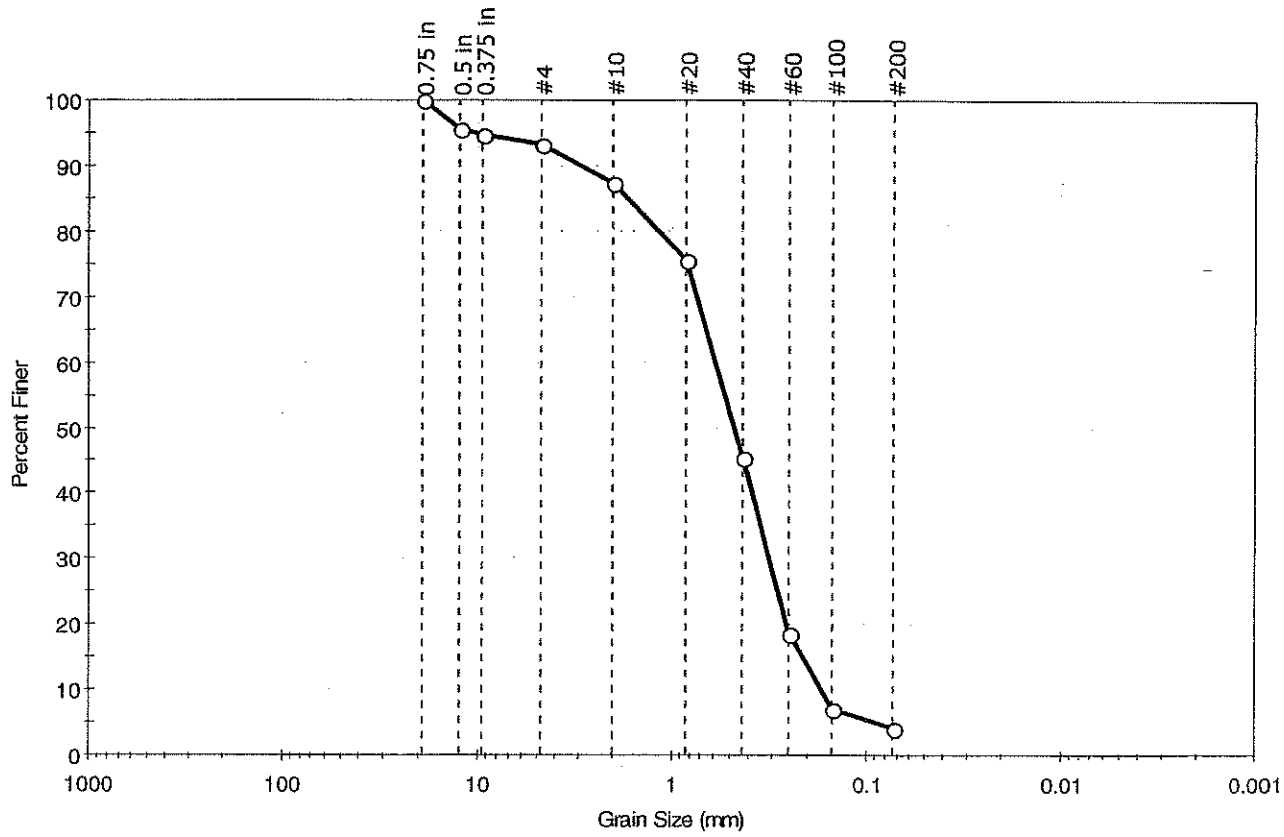
GeoTesting express
a subsidiary of Geocomp Corporation

Client:	GEI Consultants, Inc.		
Project:	Brookhaven National Lab - ISB		
Location:	Upton, NY	Project No:	GTX-8096
Boring ID: B-5	Sample Type: bag	Tested By:	ap
Sample ID:S-4	Test Date: 04/07/08	Checked By:	jdt
Depth : 6-8 ft	Test Id: 128829		
Test Comment:	---		
Sample Description:	Moist, very pale brown sand		
Sample Comment:	---		

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	6.7	89.2	4.1

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	96		
0.375 in	9.51	95		
#4	4.75	93		
#10	2.00	87		
#20	0.84	75		
#40	0.42	45		
#60	0.25	19		
#100	0.15	7		
#200	0.074	4		

Coefficients

D_{85} =1.6791 mm	D_{30} =0.3135 mm
D_{60} =0.5921 mm	D_{15} =0.2135 mm
D_{50} =0.4719 mm	D_{10} =0.1710 mm
C_u =3.463	C_c =0.971

Classification

ASTM Poorly graded sand (SP)

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

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GeoTesting express
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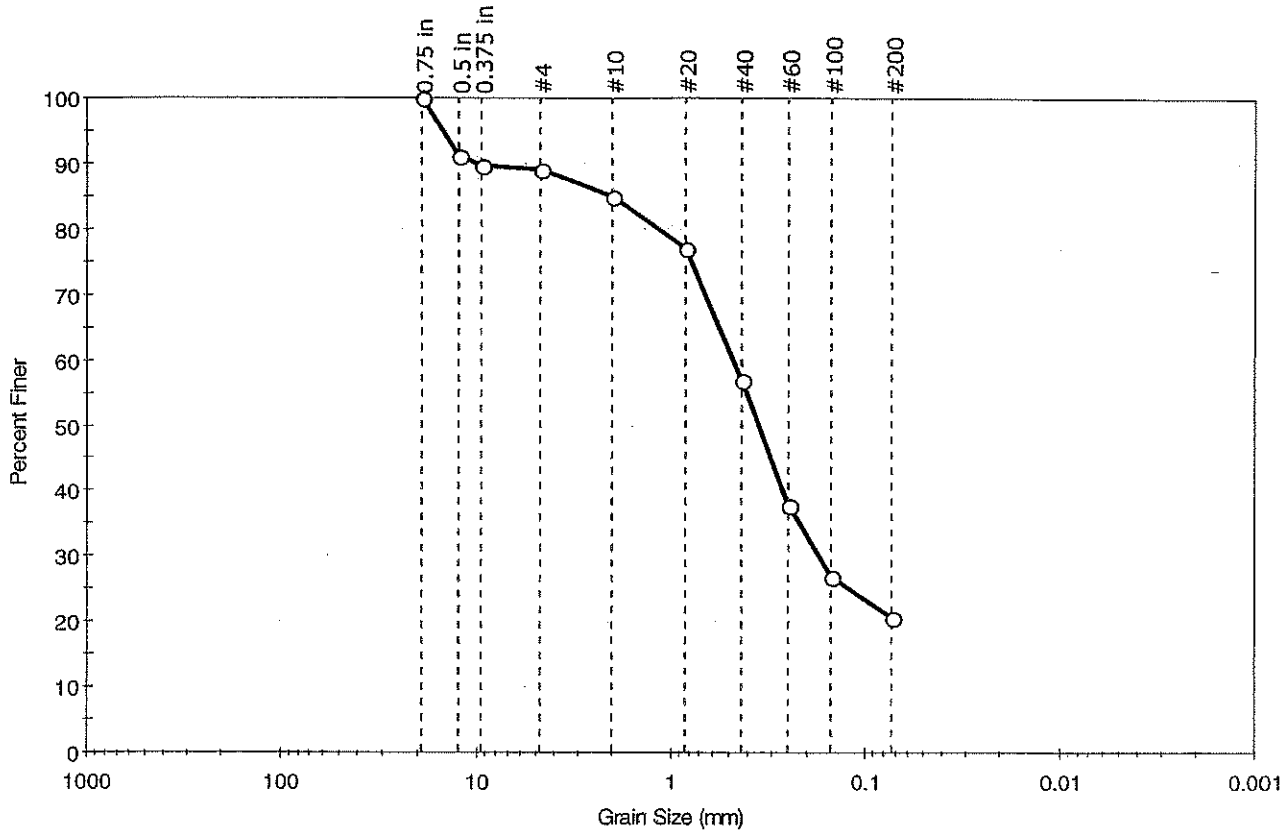
Client:	GEI Consultants, Inc.		
Project:	Brookhaven National Lab - ISB		
Location:	Upton, NY	Project No:	GTX-8096
Boring ID: B-6	Sample Type: bag	Tested By:	ap
Sample ID:S-2	Test Date: 04/07/08	Checked By:	jdt
Depth : 2-4 ft	Test Id: 128830		
Test Comment:	---		
Sample Description:	Moist, dark yellowish brown silty sand		
Sample Comment:	---		

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	10.8	68.5	20.7

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	91		
0.375 in	9.51	90		
#4	4.75	89		
#10	2.00	85		
#20	0.84	77		
#40	0.42	57		
#60	0.25	38		
#100	0.15	27		
#200	0.074	21		

Coefficients

D_{85} = 2.0054 mm D_{30} = 0.1733 mm
D_{60} = 0.4709 mm D_{15} = N/A
D_{50} = 0.3499 mm D_{10} = N/A
C_u = N/A C_c = N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

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GeoTesting express
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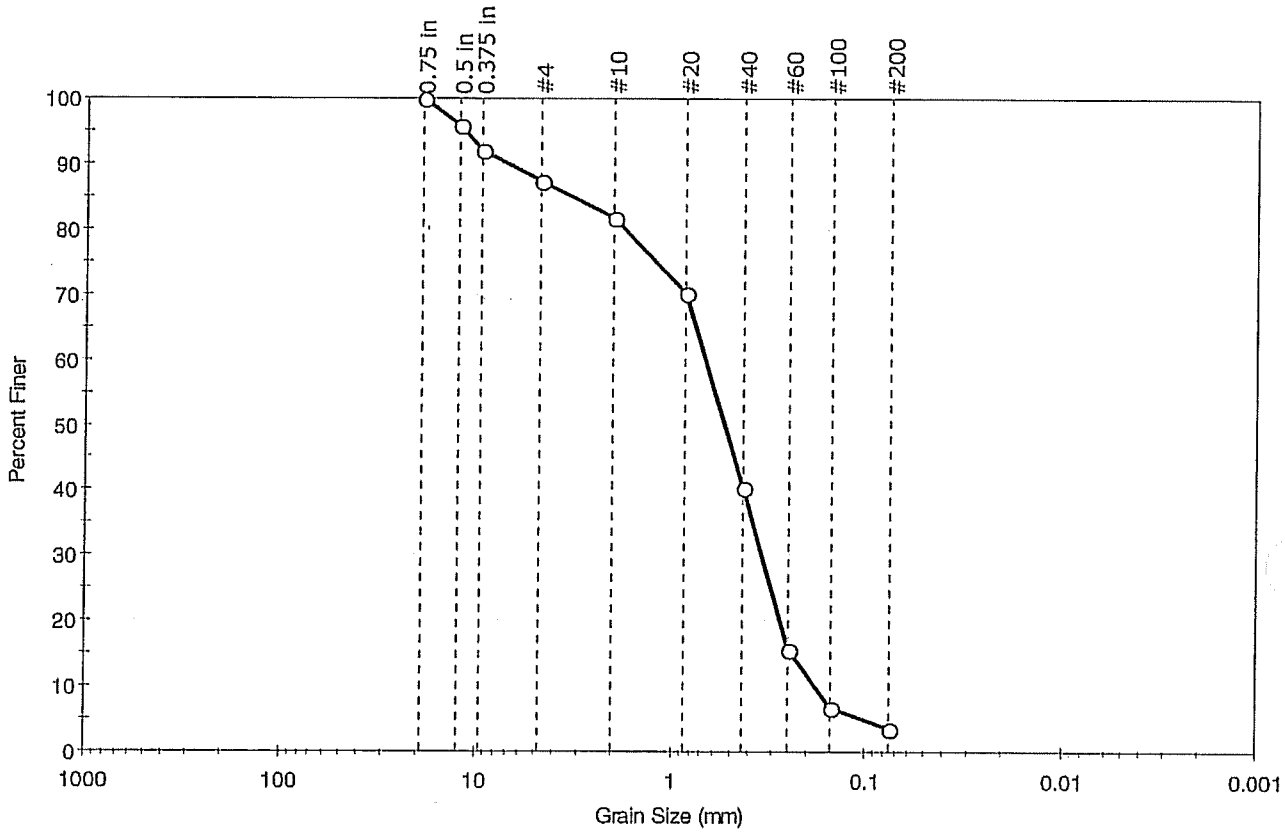
Client:	GEI Consultants, Inc.		
Project:	Brookhaven ISB Final Design		
Location:	Upton, NY	Project No:	GTX-9209
Boring ID: B-7	Sample Type: jar	Tested By:	jbr
Sample ID:S-3	Test Date: 08/03/09	Checked By:	jdt
Depth : 4.0-6.0 ft	Test Id: 158380		
Test Comment:	---		
Sample Description:	Moist, pale brown sand		
Sample Comment:	---		

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	12.7	83.6	3.7

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	96		
0.375 in	9.50	92		
#4	4.75	87		
#10	2.00	82		
#20	0.85	70		
#40	0.42	40		
#60	0.25	16		
#100	0.15	7		
#200	0.075	4		

Coefficients

D_{85} =3.3589 mm D_{30} =0.3401 mm
D_{60} =0.6696 mm D_{15} =0.2411 mm
D_{50} =0.5309 mm D_{10} =0.1809 mm
C_u =3.701 C_c =0.955

Classification

ASTM Poorly graded sand (SP)

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

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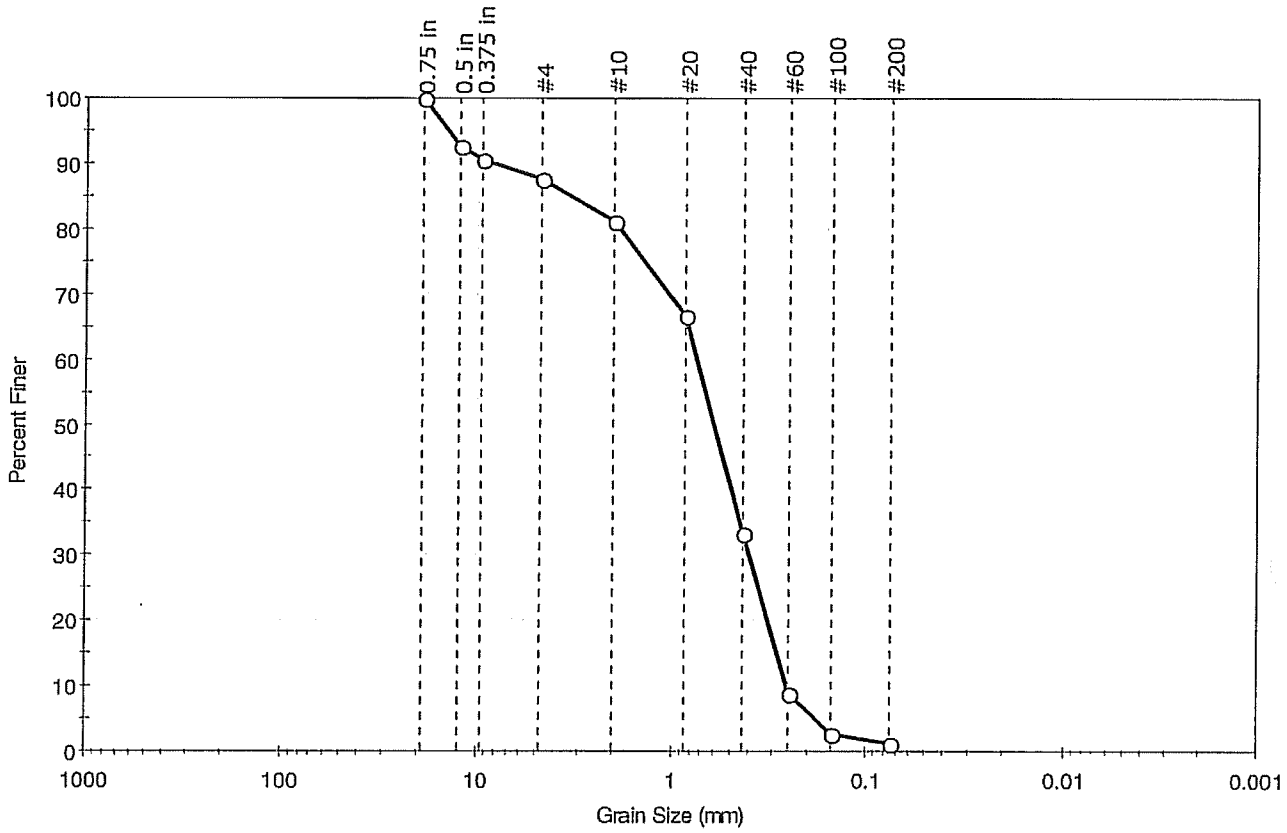
GeoTesting express
a subsidiary of Geocomp Corporation

Client:	GEI Consultants, Inc.		
Project:	Brookhaven ISB Final Design		
Location:	Upton, NY	Project No:	GTX-9209
Boring ID: B-8	Sample Type: jar	Tested By:	jbr
Sample ID:S-6	Test Date: 08/03/09	Checked By:	jdt
Depth : 15.0-17.0 ft	Test Id: 158381		
Test Comment: ---			
Sample Description: Moist, pale brown sand			
Sample Comment: ---			

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	12.4	86.3	1.3

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	93		
0.375 in	9.50	91		
#4	4.75	88		
#10	2.00	81		
#20	0.85	67		
#40	0.42	33		
#60	0.25	9		
#100	0.15	3		
#200	0.075	1		

Coefficients

D_{85} =3.3163 mm D_{30} =0.3956 mm
D_{60} =0.7386 mm D_{15} =0.2859 mm
D_{50} =0.6004 mm D_{10} =0.2566 mm
C_u =2.878 C_c =0.826

Classification

ASTM Poorly graded sand (SP)

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

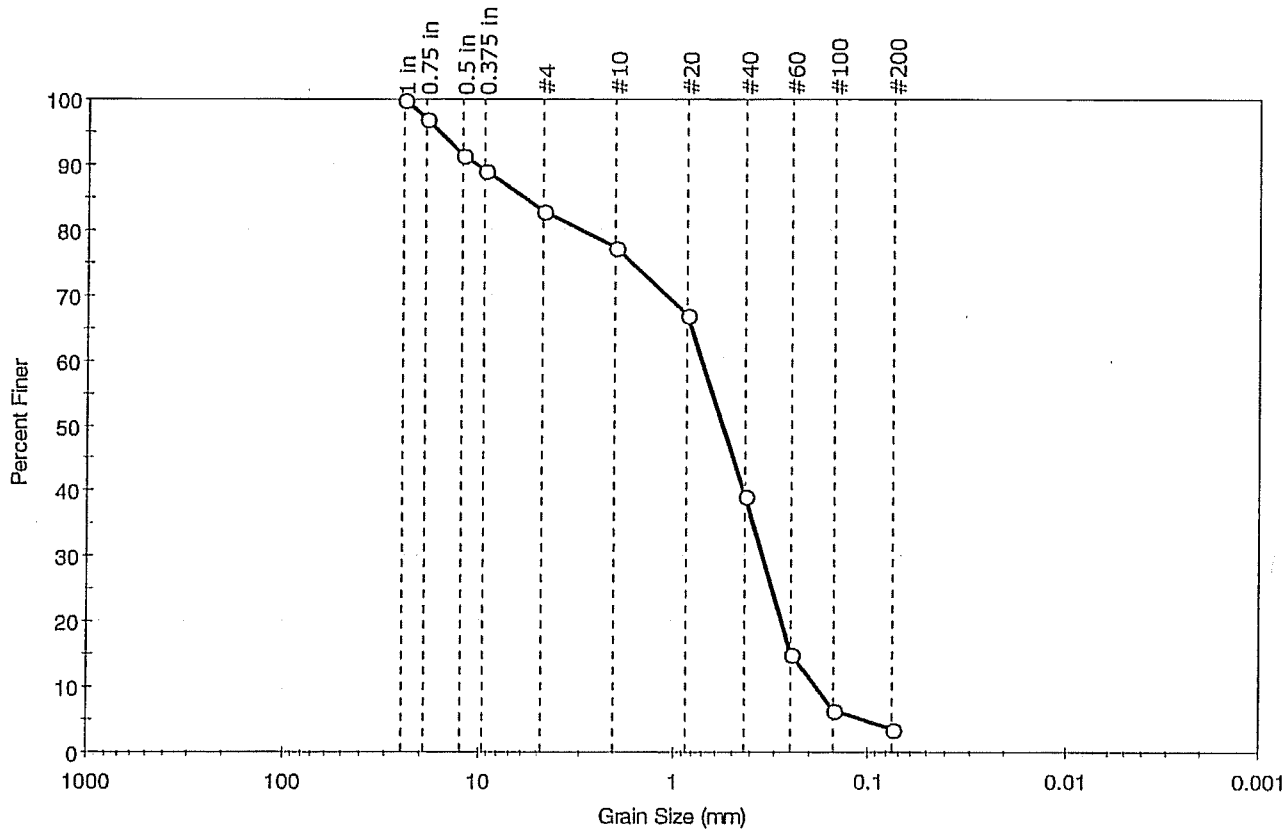
Sand/Gravel Hardness : HARD

printed 8/7/2009 8:35:33 AM

GeoTesting express
a subsidiary of Geocomp Corporation

Client:	GEI Consultants, Inc.		
Project:	Brookhaven ISB Final Design		
Location:	Upton, NY	Project No:	GTX-9209
Boring ID: B-9	Sample Type: jar	Tested By:	jbr
Sample ID:S-4	Test Date: 08/03/09	Checked By:	jdt
Depth : 6.0-8.0 ft	Test Id: 158382		
Test Comment: ---			
Sample Description:	Moist, pale brown sand with gravel		
Sample Comment:	---		

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
--	17.2	79.1	3.7

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	97		
0.5 in	12.50	91		
0.375 in	9.50	89		
#4	4.75	83		
#10	2.00	77		
#20	0.85	67		
#40	0.42	39		
#60	0.25	15		
#100	0.15	6		
#200	0.075	4		

Coefficients

D_{85} = 6.0506 mm D_{30} = 0.3476 mm
D_{60} = 0.7147 mm D_{15} = 0.2495 mm
D_{50} = 0.5571 mm D_{10} = 0.1856 mm
C_u = 3.851 C_c = 0.911

Classification

ASTM Poorly graded sand with gravel (SP)

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

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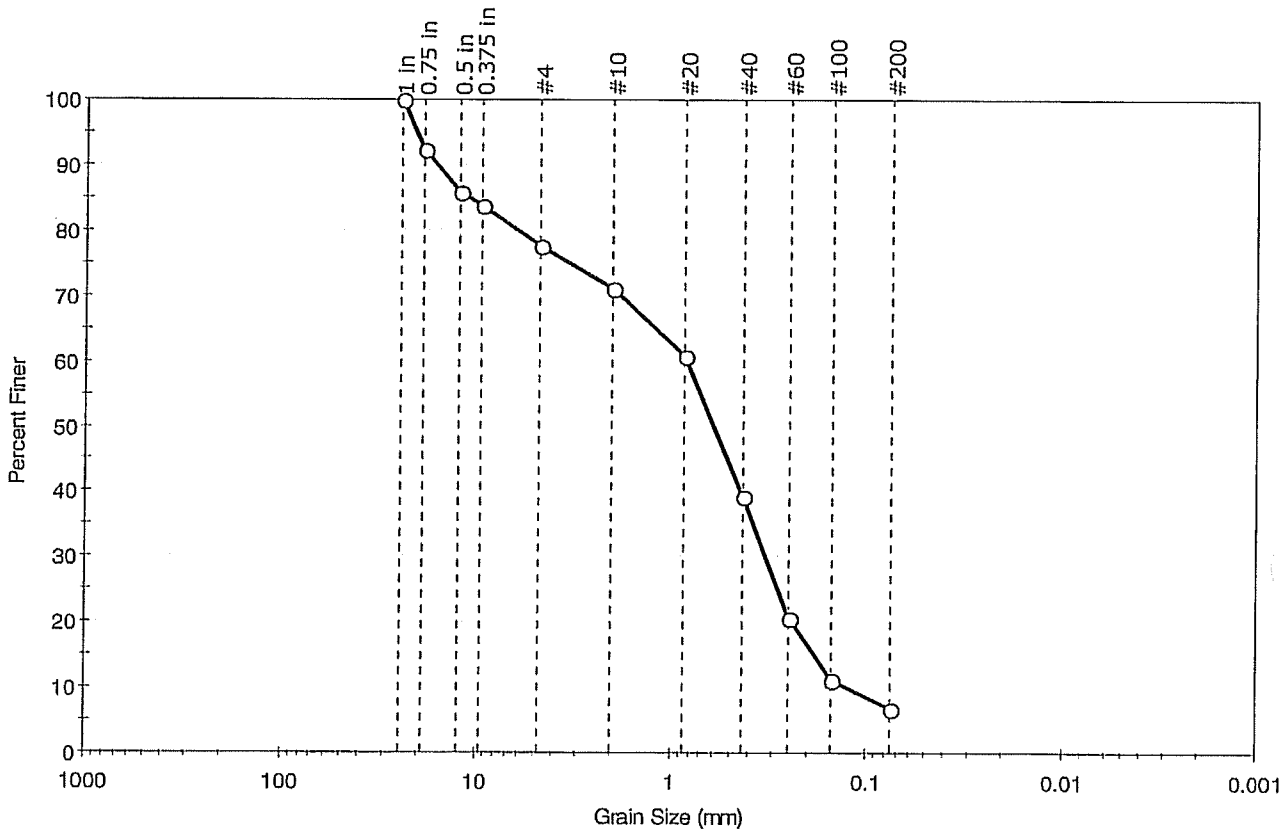
GeoTesting express
a subsidiary of Geocomp Corporation

Client:	GEI Consultants, Inc.		
Project:	Brookhaven ISB Final Design		
Location:	Upton, NY	Project No:	GTX-9209
Boring ID: B-11	Sample Type: jar	Tested By:	jbr
Sample ID:S-3	Test Date: 08/05/09	Checked By:	jdt
Depth : 4.0-6.0 ft	Test Id: 158953		

Test Comment: ---
Sample Description: Moist, light yellowish brown sand with silt and gravel
Sample Comment: ---

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	22.5	70.8	6.7

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	92		
0.5 in	12.50	86		
0.375 in	9.50	84		
#4	4.75	78		
#10	2.00	71		
#20	0.85	61		
#40	0.42	39		
#60	0.25	21		
#100	0.15	11		
#200	0.075	7		

Coefficients

D_{85} =11.1592 mm D_{30} =0.3261 mm
D_{60} =0.8316 mm D_{15} =0.1832 mm
D_{50} =0.6016 mm D_{10} =0.1228 mm
C_u =6.772 C_c =1.041

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

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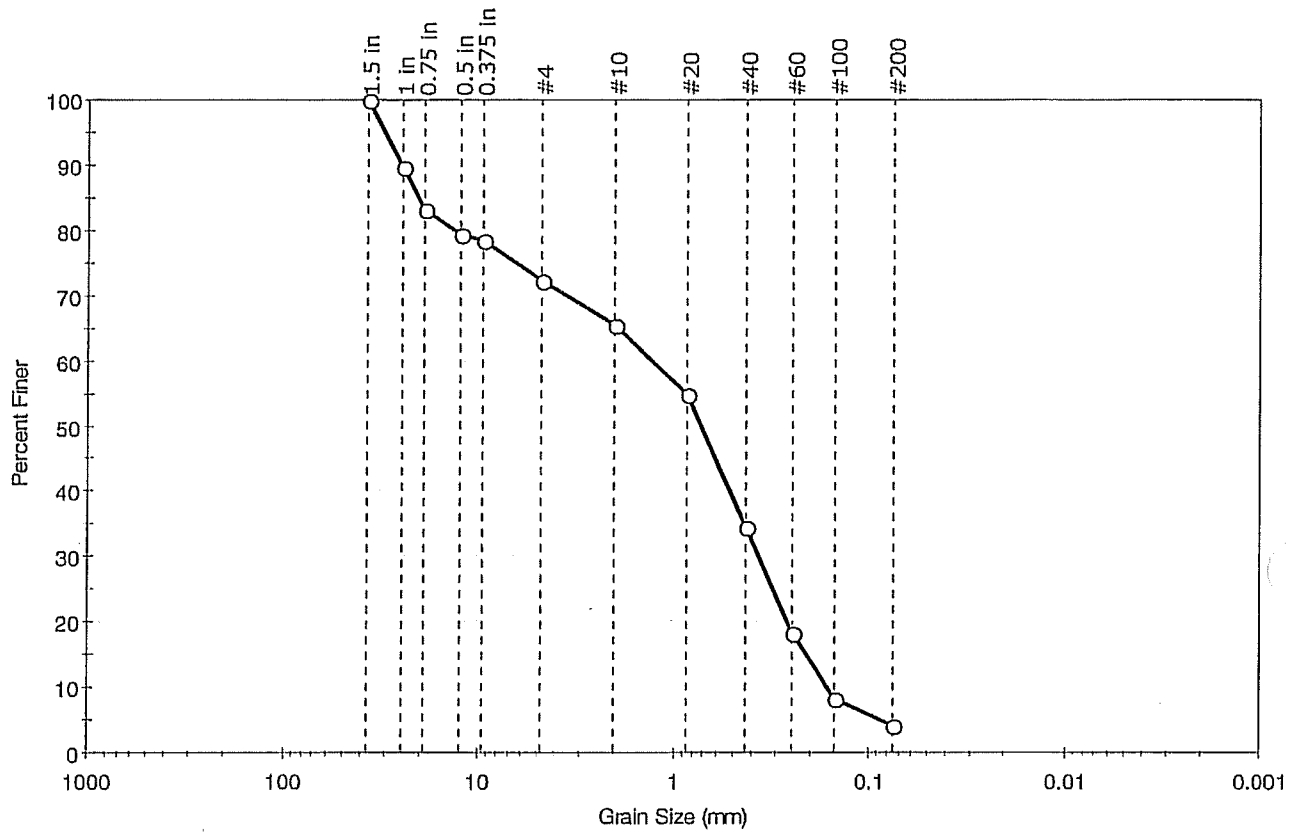
GeoTesting express
a subsidiary of Geocomp Corporation

Client:	GEI Consultants, Inc.		
Project:	Brookhaven ISB Final Design		
Location:	Upton, NY	Project No:	GTX-9209
Boring ID: B-12	Sample Type: jar	Tested By:	jbr
Sample ID:S-4	Test Date: 08/05/09	Checked By:	jdt
Depth : 6.0-8.0 ft	Test Id: 158954		
Test Comment:	---		
Sample Description:	Moist, light yellowish brown sand with gravel		
Sample Comment:	---		

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	27.7	68.2	4.1

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1.5 in	37.50	100		
1 in	25.00	90		
0.75 in	19.00	83		
0.5 in	12.50	79		
0.375 in	9.50	79		
#4	4.75	72		
#10	2.00	65		
#20	0.85	55		
#40	0.42	35		
#60	0.25	18		
#100	0.15	8		
#200	0.075	4		

Coefficients

D_{85} = 20.4477 mm	D_{30} = 0.3666 mm
D_{60} = 1.2988 mm	D_{15} = 0.2112 mm
D_{50} = 0.7225 mm	D_{10} = 0.1635 mm
C_u = 7.944	C_c = 0.633

Classification

ASTM Poorly graded sand with gravel (SP)

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

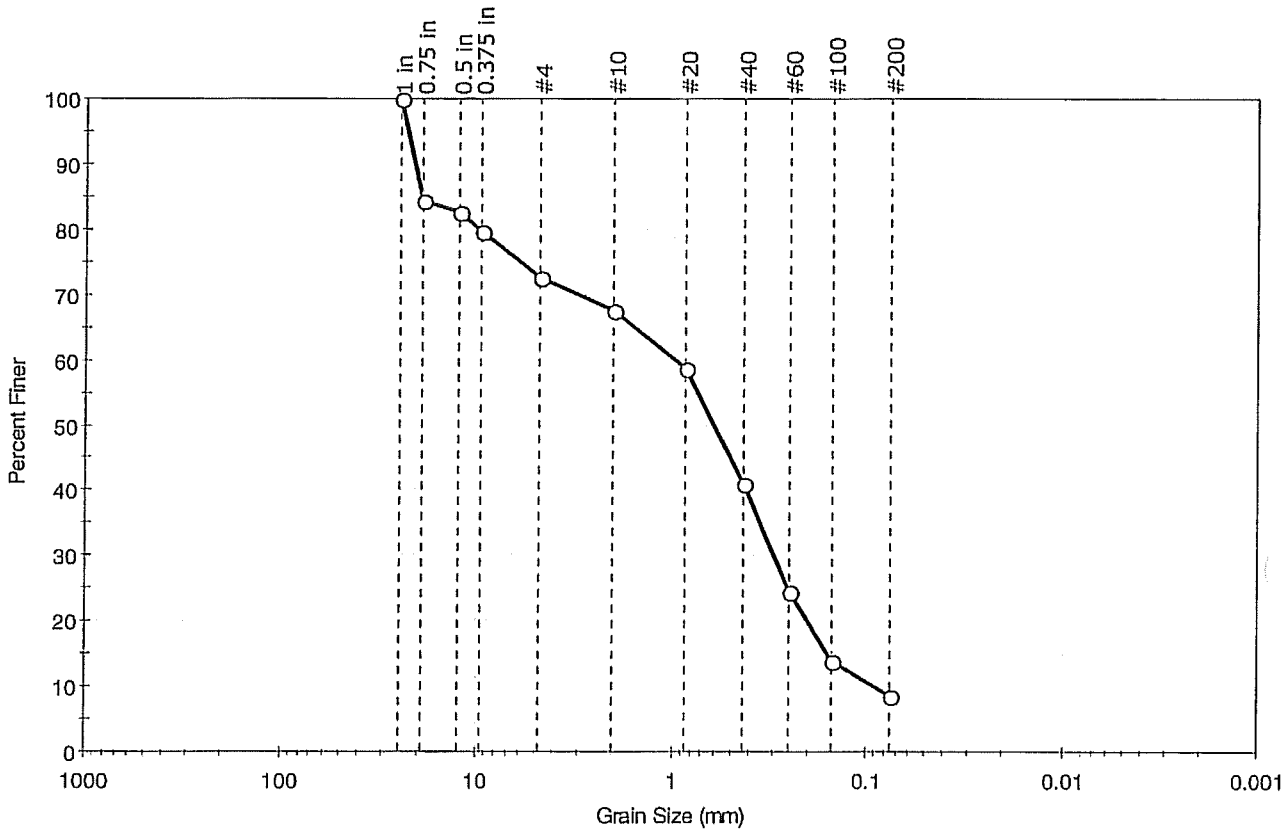
Sand/Gravel Particle Shape : ROUNDED

Sand/Gravel Hardness : HARD

GeoTesting express
a subsidiary of Geocomp Corporation

Client:	GEI Consultants, Inc.		
Project:	Brookhaven ISB Final Design		
Location:	Upton, NY	Project No:	GTX-9209
Boring ID: B-13	Sample Type: jar	Tested By:	jbr
Sample ID:S-2	Test Date: 08/03/09	Checked By:	jdt
Depth : 2.0-4.0 ft	Test Id: 158385		
Test Comment:	---		
Sample Description:	Moist, pale brown sand with silt and gravel		
Sample Comment:	---		

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	27.4	63.9	8.7

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	84		
0.5 in	12.50	83		
0.375 in	9.50	80		
#4	4.75	73		
#10	2.00	68		
#20	0.85	59		
#40	0.42	41		
#60	0.25	24		
#100	0.15	14		
#200	0.075	9		

Coefficients

D_{85} = 19.2460 mm	D_{30} = 0.2987 mm
D_{60} = 0.9653 mm	D_{15} = 0.1576 mm
D_{50} = 0.6051 mm	D_{10} = 0.0894 mm
C_u = 10.798	C_c = 1.034

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

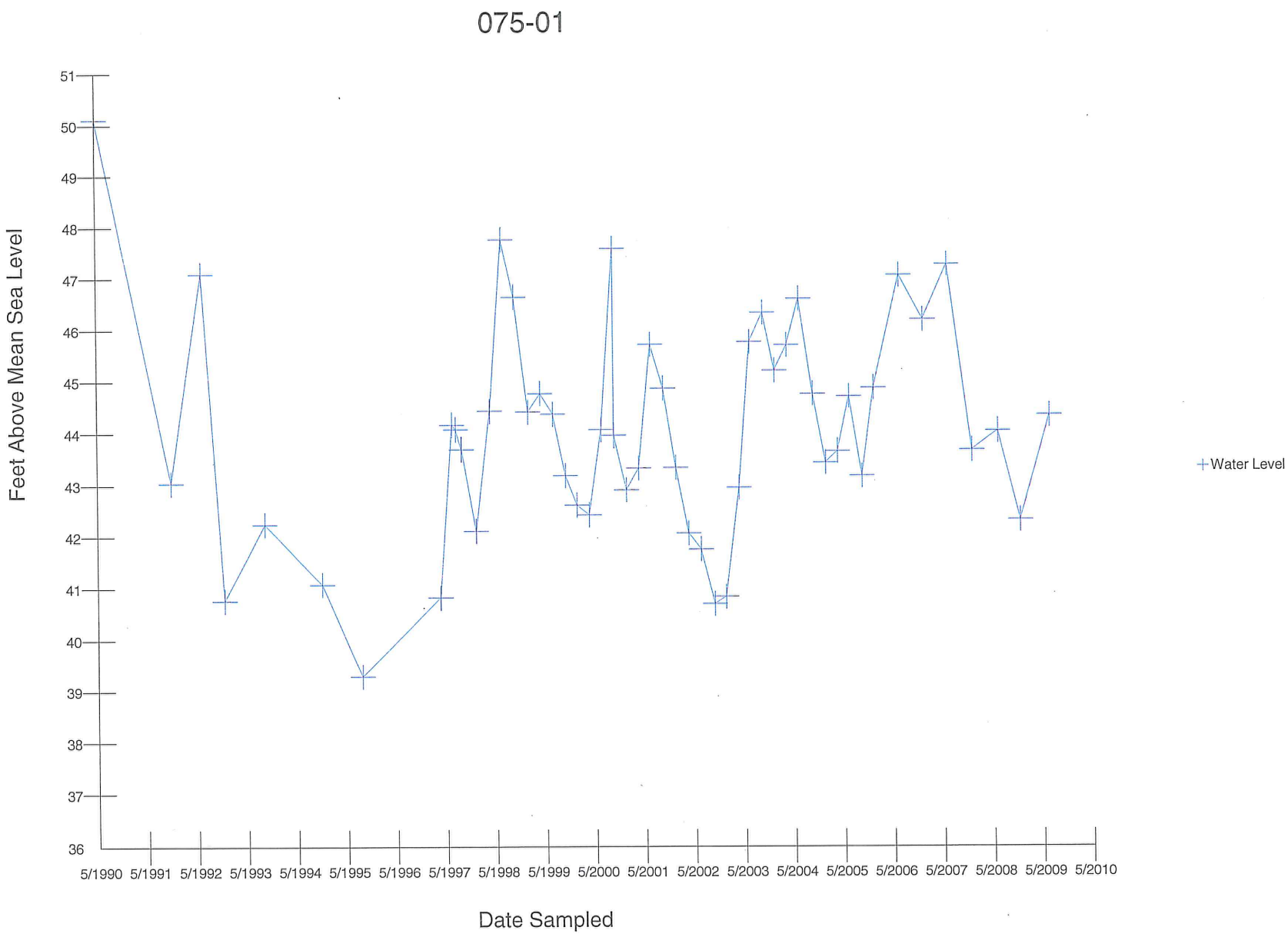
Sample/Test Description

Sand/Gravel Particle Shape : ROUNDED

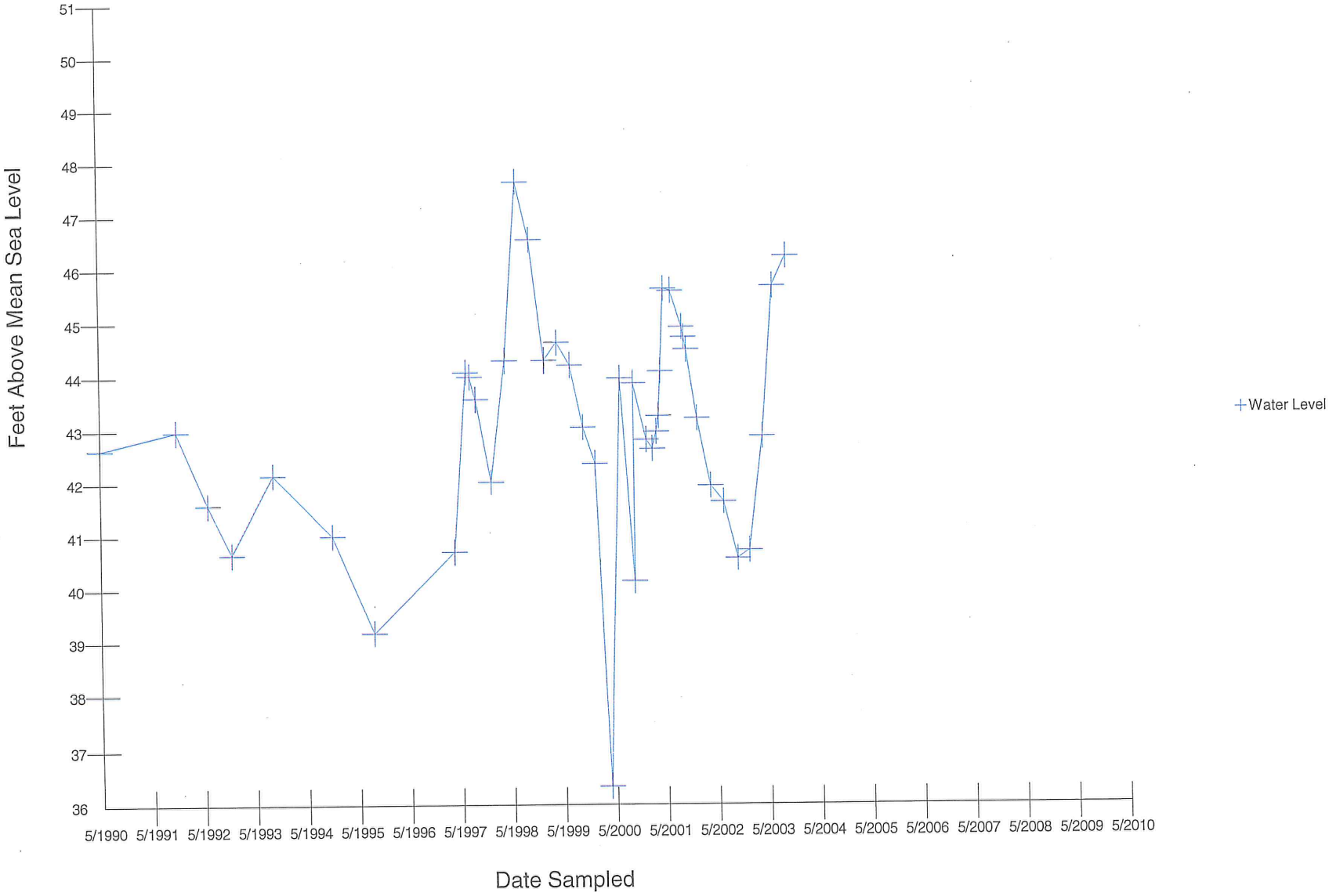
Sand/Gravel Hardness : HARD

Appendix C

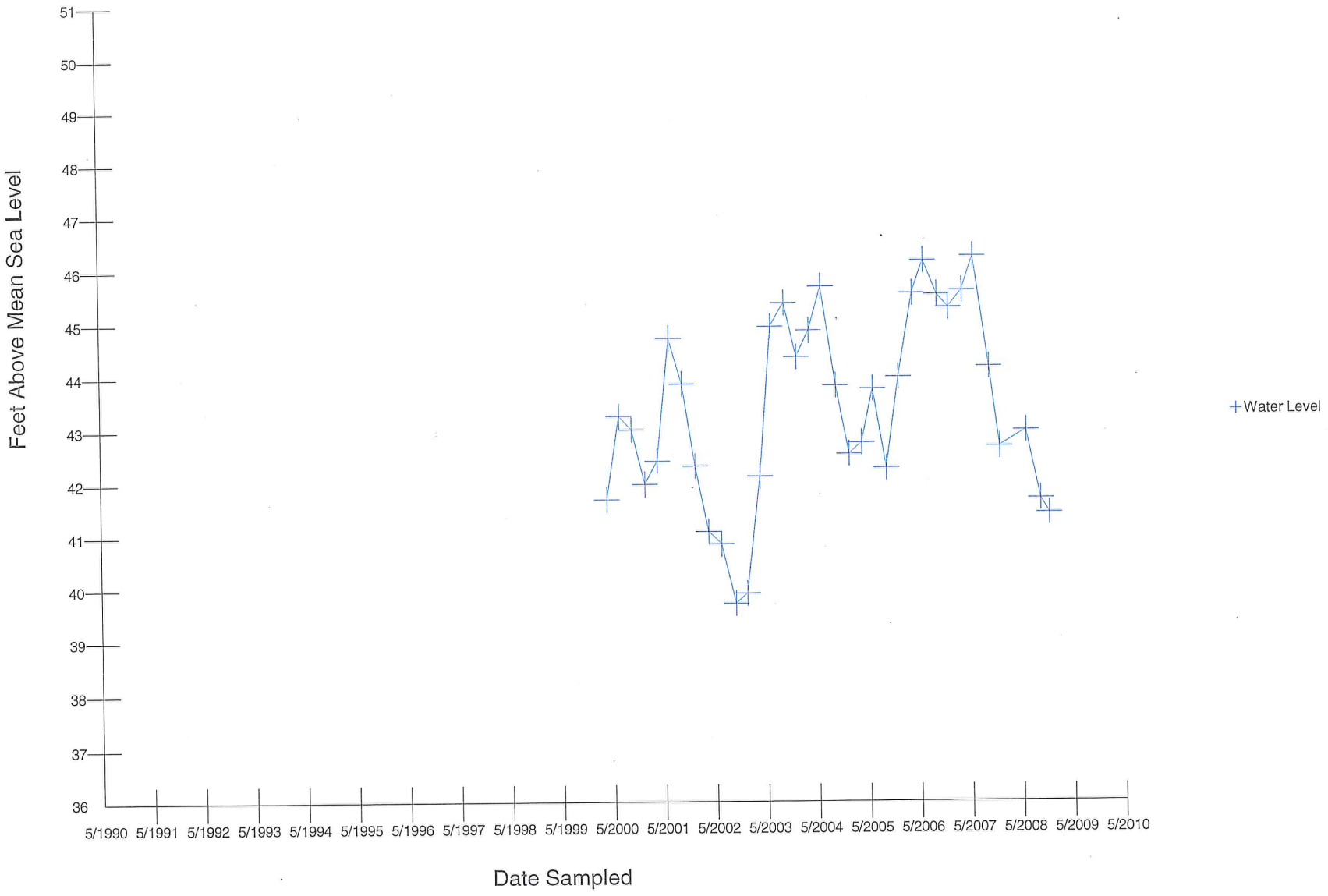
Groundwater Level Measurements Provided by BNL


075-01
Feet Above Mean Sea Level
51
50
49
48
47
46
45
44
43
42
41
40
39
38
37
36
5/1990
5/1991
5/1992
5/1993
5/1994
5/1995
5/1996
5/1997
5/1998
5/1999
5/2000
5/2001
5/2002
5/2003
5/2004
5/2005
5/2006
5/2007
5/2008
5/2009
5/2010
Date Sampled
Water Level

075-02


Feet Above Mean Sea Level
51
50
49
48
47
46
45
44
43
42
41
40
39
38
37
36
5/1990
5/1991
5/1992
5/1993
5/1994
5/1995
5/1996
5/1997
5/1998
5/1999
5/2000
5/2001
5/2002
5/2003
5/2004
5/2005
5/2006
5/2007
5/2008
5/2009
5/2010
Date Sampled
Water Level

085-160


Feet Above Mean Sea Level
51
50
49
48
47
46
45
44
43
42
41
40
39
38
37
36
5/1990
5/1991
5/1992
5/1993
5/1994
5/1995
5/1996
5/1997
5/1998
5/1999
5/2000
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5/2002
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5/2005
5/2006
5/2007
5/2008
5/2009
5/2010
Date Sampled
Water Level

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