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GENERAL CONDITIONS

THE CCWF PHASE II EXPANSION IS COMPRISED OF TWO NEW CHILLERS AND ASSOCIATED PUMPS, PIPING, AND ANCILLARY EQUIPMENT. THIS EQUIPMENT IS CONTROLLED BY A REDUNDANT PAIR OF PLCs COMMUNICATING TO REMOTE RACKS IN BOTH EXISTING AND NEW AREAS OF BUILDING 600, 600A, AND THE COOLING TOWERS. SUPERVISORY CONTROL AND MONITORING IS ACHIEVED THROUGH A WONDERWARE HUMAN MACHINE INTERFACE (HMI) WHICH COMMUNICATES OVER CONTROLNET TO THE REDUNDANT PLC PAIR, AND THROUGH VARIOUS NETWORKS (OHV, ETHERNET, CONTROLNET, ETC.) TO OTHER EQUIPMENT.

THE PROVISION OF ALL HARDWARE, INSTALLATION THEREOF, AND WIRING CONNECTIONS TO PROVIDE A COMPLETE AND FUNCTIONING SYSTEM AS DEFINED BY THE CONTRACT DOCUMENTS IS INCLUDED WITHIN THIS CONTRACT. I/O FUNCTIONALITY CHECKS, WITNESSED BY THE OWNER/OWNER'S ENGINEER ARE ALSO PART OF THIS CONTRACT. DEVELOPMENT, INSTALLATION, DEBUGGING, AND COMMISSIONING OF PLC AND WONDERWARE PROGRAMMING IS BY OTHERS. THE SEQUENCES HEREIN ARE INTENDED FOR REFERENCE PURPOSES, AND MAY SERVE TO INFORM AND ASSIST IN THE PROPER SELECTION, INSTALLATION, AND WIRING OF THE HARDWARE REQUIRED BY THE CONTRACT DOCUMENTS.

REFER TO DRAWING 11707-M622 FOR DETAILS OF THE CONTROL SYSTEM ARCHITECTURE.

THE REDUNDANT PLC PAIR CONTROLS BOTH THE NEW AND THE EXISTING CHILLED WATER SYSTEMS. THE NEW AND EXISTING CHILLED WATER SYSTEMS CAN OPERATE SIMULTANEOUSLY WITH NEW AND EXISTING EQUIPMENT ON THE CHILLED WATER LOOP OPERATED IN A LEAD/LAG FASHION TO EQUALIZE EQUIPMENT OPERATING TIME. ALL PRIMARY CHILLED WATER PUMPS, EXISTING AND NEW, WILL BE ON A SINGLE LEAD/LAG ROTATION, AND ALL SECONDARY PUMPS, EXISTING AND NEW, WILL BE ON A SINGLE LEAD/LAG ROTATION, I.E. ANY CHILLER MAY OPERATE WITH ANY PRIMARY CHILLED WATER PUMP, AND WITH ANY SECONDARY CHILLED WATER PUMP. EACH SYSTEM IS ALSO ABLE TO OPERATE WHEN THE OTHER IS NOT IN OPERATION, PROVIDED THAT KEY INSTRUMENTS (PT-550, PT-504, PT-401A) ARE FUNCTIONING.

THE NEW AND EXISTING CONDENSER WATER SYSTEMS ARE NOT INTER-CONNECTED, AND LEAD/LAG OPERATION OF THE CONDENSER WATER PUMPS AND COOLING TOWER CELLS WILL BE ON SEPARATE ROTATIONS, ONE ROTATION FOR THE EXISTING EQUIPMENT AND ONE FOR THE NEW. ANY NEW CONDENSER WATER PUMP CAN OPERATE WITH ANY NEW COOLING TOWER CELL.

IF A CHILLER, PUMP, OR COOLING TOWER FAN UNIT FAILS TO START, OR A FLOW CONTROL VALVE FAILS TO OPEN, AN ALARM IS GENERATED AND START OF THE NEXT UNIT IS AUTOMATICALLY INITIATED, AS APPROPRIATE. IF AN OPERATING CHILLER, PUMP, COOLING TOWER FAN OR FLOW CONTROL VALVE FAILS, AN ALARM IS GENERATED AND START OF THE NEXT UNIT IS AUTOMATICALLY INITIATED, AS APPROPRIATE. SUCCESSFUL START/OPERATION IS DETERMINED PER THE FOLLOWING:

DEVICE	PROOF OF START/OPERATION
VALVE:	LIMIT SWITCH
CHILLER:	HARDWIRED RUN SIGNAL
PRIMARY CHILLED WATER PUMP:	DIFFERENTIAL PRESSURE SWITCH
SECONDARY CHILLED WATER PUMP:	FLOW SWITCH
COOLING TOWER FAN:	HARDWIRED RUN SIGNAL
CONDENSER WATER PUMP:	HARDWIRED RUN SIGNAL

MANAGEMENT OF CHILLED WATER STORAGE CHARGE AND DISCHARGE CYCLES REQUIRES OPERATOR JUDGMENT BASED ON THE OUTSIDE AIR TEMPERATURE FORECAST AND ANTICIPATED PROCESS COOLING LOAD.

THE CONTROL SYSTEM PROVIDES THE FOLLOWING MONITORING AND CONTROL FUNCTIONS:

1. CHILLER START/STOP CONTROL.
2. MONITORING OF CHILLER INLET, DISCHARGE, AND BYPASS WATER TEMPERATURES.
3. CONTROL OF CHILLER INLET WATER TEMPERATURE, ACHIEVED BY MODULATION OF TEMPERATURE CONTROL VALVE (TCV-653 OR TCV-654).
4. CONTROL FLOW THROUGH THE CHILLERS VIA 2-POSITION INLET VALVES, AND MONITORING OF CHILLER INLET AND BYPASS WATER FLOWS (FT-645, FT-646, FT-691 AND FT-692).
5. PRIMARY CHILLED WATER PUMP START/STOP CONTROL.
6. PRIMARY CHILLED WATER PUMP ON/OFF STATUS.
7. SECONDARY CHILLED WATER PUMP START/STOP/SPEED CONTROL (VFD DRIVES).
8. SECONDARY PUMP SPEED CONTROL BASED ON BUILDING COOLING LOAD AS IMPLIED BY THE CHILLED WATER DISTRIBUTION SUPPLY AND RETURN SYSTEM DIFFERENTIAL PRESSURE.
9. SECONDARY CHILLED WATER PUMP ON/OFF/SPEED STATUS.
10. CHILLED WATER RETURN BACK-PRESSURE VALVE CONTROL (PV-504) IN SEQUENCE WITH EXISTING VALVES PV-502 AND PV-503.
11. MONITORING OF ALL ANCILLARY CHILLED WATER LOOP INSTRUMENTS, INCLUDING PRIMARY CHILLED WATER PUMP PRESSURE DIFFERENTIAL SWITCHES, SECONDARY CHILLED WATER PUMP INLET PRESSURE SWITCHES AND OUTLET FLOW SWITCHES, AND CHILLER INLET/OUTLET DIFFERENTIAL PRESSURE SWITCH.
12. COOLING TOWER CELL BYPASS VALVE CONTROL (MOV-714) AND MONITOR POSITION.
13. COOLING TOWER CELL VALVE CONTROL AND MONITOR POSITION.
14. COOLING TOWER FAN START/STOP/SPEED CONTROL (VFD DRIVES).
15. COOLING TOWER FANS ON/OFF/SPEED STATUS.
16. CONDENSER WATER PUMP START/STOP/SPEED CONTROL (VFD DRIVES).
17. CONDENSER WATER PUMP ON/OFF/SPEED STATUS.
18. MONITORING/CONTROL OF ALL ANCILLARY CONDENSER WATER SYSTEM INSTRUMENTS, INCLUDING TEMPERATURE, CONDUCTIVITY, MAKE-UP VALVE/FLOW, BLOW-DOWN VALVE/FLOW, SUMP LEVEL, AND CONDENSER WATER SUPPLY AND RETURN PRESSURE.
19. DATA LOGGING OF INDIVIDUAL CHILLER TONS, AND PERTINENT SYSTEM TEMPERATURES AND PRESSURES ON A 15 MINUTE CYCLE.
20. DISPLAY SYSTEM GRAPHICS, WITH CONTROL POINTS ANNOTATED AT PERTINENT POINTS IN THE DISPLAYS. THE EXISTING HMI SCHEMATIC SCREENS WILL BE MODIFIED TO ADD THE NEW CHILLERS, PRIMARY PUMPS, SECONDARY PUMPS, CONDENSER WATER PUMPS, AND COOLING TOWER CELLS. APPROPRIATE TEMPERATURES, VALVES, FLOW RATES, PRESSURES, STATUS, AND INDICATION OF CHILLED WATER STORAGE TANK CHARGE OR DISCHARGE CYCLE WILL BE ANNOTATED ON THE SCHEMATICS.

REAL-TIME CALCULATION AND HISTORICAL DATA LOGGING ON A 15 MINUTE CYCLE OF THE FOLLOWING SYSTEM PARAMETERS ARE TO BE MODIFIED TO INCLUDE THE NEW CHILLER SYSTEM DATA:

1. TOTAL SYSTEM COOLING LOAD GPM AND TONS.
2. CHILLED WATER GPM AND TONS TO BUILDINGS.
3. CHILLER GPM AND TONS.
4. NUMBER OF CHILLERS OPERATING.

SEQUENCE OF OPERATION FOR INSTRUMENT AIR SYSTEM

THE SYSTEM OPERATOR, THROUGH THE PLC, SHALL START AND STOP THE INSTRUMENT AIR COMPRESSOR (IA-3). THE PLC SHALL ALSO MONITOR THE ON/OFF STATUS OF THE AIR COMPRESSOR AND MONITOR A COMMON ALARM FROM THE COMPRESSOR.

THE INSTRUMENT AIR DRYER (AD-3) SHALL BE HARDWIRED INTERLOCKED TO THE AIR COMPRESSOR. TO OPERATE WHENEVER THE AIR COMPRESSOR IS ENERGIZED, THE PLC SHALL MONITOR THE ON/OFF STATUS OF THE AIR DRYER. THE TWO-POSITION VALVE (FV-777) SHALL BE INTERLOCKED OPEN WHENEVER THE AIR DRYER IS ENERGIZED.

WHENEVER THE AIR COMPRESSOR IS STARTED BY THE PLC, THE RECIRCULATION PUMP (RP-1) SHALL BE AUTOMATICALLY STARTED BEFORE THE COMPRESSOR IS STARTED AND THE TWO-POSITION ISOLATION VALVE (FV-790) SHALL BE OPENED. WHEN THE PRESSURE DIFFERENTIAL SWITCH (PDS-789) PROVES FLOW, THE AIR COMPRESSOR SHALL BE STARTED. WHEN THE COMPRESSOR IS STARTED, THE THREE-WAY MIXING VALVE (FV-788) SHALL BE MODULATED TO MAINTAIN A 95 DEG F DISCHARGE WATER TEMPERATURE FROM THE AIR COMPRESSOR, AS SENSED AT TEMPERATURE ELEMENT (TE-780).

SEQUENCE OF OPERATIONS FOR CHILLED WATER SYSTEM

1. MODES OF OPERATION

TWO MODES OF OPERATION ARE POSSIBLE: HMI SEMI-AUTOMATIC AND HMI MANUAL. IN SEMI-AUTOMATIC, CHILLER SELECTION WILL BE OPERATOR-CONFIRMED VIA THE HMI TERMINALS, AND PRIMARY PUMPS, SECONDARY PUMPS, CONDENSER PUMPS, AND TOWER CELLS WILL START AUTOMATICALLY BASED ON LEAD/LAG ROTATION. IN HMI MANUAL, SELECTION OF NEXT CHILLER, PRIMARY CHILLED WATER PUMP, SECONDARY CHILLED WATER PUMP, CONDENSER WATER PUMP, AND TOWER CELL WILL BE OPERATOR-CONTROLLED. LOCAL HAND/OFF/AUTO STATIONS ARE ABLE TO OVERRIDE THE PRIMARY CHILLED WATER PUMPS.

2. GENERAL START/STOP SEQUENCE

THE NUMBER OF OPERATING CHILLERS IS DETERMINED BY OPERATOR JUDGEMENT BASED ON THE CHILLED WATER DISTRIBUTION SYSTEM DEMAND AND THE CHILLED WATER STORAGE SYSTEM CHARGE AND DISCHARGE CYCLE. BTU LOAD CALCULATION ALSO INDICATES THE REQUIRED NUMBER OF OPERATING CHILLERS.

ON A SYSTEM START COMMAND FROM THE HMI, A CHILLER GROUP, CONSISTING OF A CHILLER, CONDENSER WATER PUMP, PRIMARY CHILLED WATER PUMP, AND COOLING TOWER CELL, SHALL START AND STOP PER THE FOLLOWING SEQUENCE:

- GENERAL AUTOMATIC OPERATION OF COOLING TOWER FANS AND VALVES
- TOWER BY-PASS VALVE MOV-714 AUTOMATICALLY OPENS WHEN CONDENSER WATER TEMPERATURE FALLS BELOW 71F (ADJUSTABLE) AND CLOSES ABOVE 73F (ADJUSTABLE).
 - IN SEMI-AUTOMATIC MODE, TOWER CELL FANS AUTOMATICALLY STOP WHEN THE BYPASS VALVE IS OPEN.
 - IN SEMI-AUTOMATIC MODE, TOWER CELL FANS START WHEN CONDENSER WATER TEMPERATURE IS GREATER THAN 78F, AND THE FAN SPEED MODULATES TO MAINTAIN 85F. THE TOWER CELL FANS STOP WHEN CONDENSER WATER TEMPERATURE IS LESS THAN 73F.
 - IN SEMI-AUTOMATIC MODE, TOWER CELL FANS STOP WHEN A COOLING TOWER CELL IS COMMANDED TO STOP.

FIRST CHILLER TO START

- OPEN CONDENSER WATER ISOLATION VALVES FOR THE LEAD CHILLER (FV-732 OR FV-733).
- WHEN A FLOW PATH THROUGH THE TOWER CELL IS CONFIRMED (EITHER BYPASS OR ISOLATION VALVE OPEN AND CHILLER CONDENSER ISOLATION VALVE OPEN), START LEAD CONDENSER WATER PUMP AT 50% SPEED (ADJUSTABLE).
- OPEN CHILLED WATER ISOLATION VALVE FOR THE LEAD CHILLER (FV-649 OR FV-650).
- CHILLER ON-LINE STATUS IS DETERMINED BY STATUS OF ITS CHILLED WATER ISOLATION VALVE LIMIT SWITCH.
- START LEAD PRIMARY CHILLED WATER PUMP; IN SEMI-AUTOMATIC MODE, PRIMARY PUMPS AUTOMATICALLY START AND STOP ON A LEAD/LAG BASIS, TO MATCH THE NUMBER OF ON-LINE CHILLERS.
- START THE LEAD CHILLER WHEN A FLOW PATH IS CONFIRMED THROUGH THE CHILLED WATER SYSTEM, AND THE CHILLED WATER AND CONDENSER WATER PUMPS ARE PROVEN ON.
- WHEN THE TOWER BYPASS VALVE MOV-714 CLOSES
 - o TOWER CELL FLOW ISOLATION VALVE (MOV-715 OR 716) FOR THE LEAD CELL AUTOMATICALLY OPENS WHEN THE TOWER BYPASS VALVE FV-714 CLOSES
 - o TOWER CELL DRAIN VALVE (FCV-800 OR 801) FOR THE LEAD CELL AUTOMATICALLY CLOSES WHEN THE ISOLATION VALVE (MOV-715 OR 716) OPENS.
 - o A TIME DELAY ALLOWS FOR CLOSING OF THE BYPASS AND OPENING OF THE ISOLATION VALVES.
- LEAD CELL FAN STARTS AT MINIMUM SPEED, 35% (ADJUSTABLE) WHEN CONDENSER WATER REACHES 78F.
- WHEN THE CONDENSER WATER TEMPERATURE REACHES 85 F (ADJUSTABLE):
 - o INCREASE CONDENSER WATER PUMP SPEED TO 90% OVER A PERIOD OF 5 MINUTES (ADJUSTABLE)
 - o INCREASE CELL FAN SPEED AS REQUIRED TO MAINTAIN 85F CONDENSER WATER SUPPLY TEMPERATURE TO CHILLER.
- CHILLED WATER RETURN TEMPERATURE CONTROL VALVE (TCV-653 OR TCV-654) MODULATES TO MAINTAIN THE RETURN WATER TO THE CHILLER AT 52F (ADJUSTABLE).
- THE CHILLER LOADS AND UNLOADS TO MAINTAIN A CONSTANT 42F (ADJUSTABLE) CHILLED WATER SUPPLY TEMPERATURE.

SECOND CHILLER TO START

- OPEN TOWER CELL FLOW ISOLATION VALVE (MOV-715 OR 716) FOR THE SECOND TOWER CELL.
- TOWER CELL DRAIN VALVE (FCV-800 OR 801) CLOSES AUTOMATICALLY.
- START CONDENSER WATER PUMP AND RAMP UP TO CURRENT OPERATING SPEED OF THE RUNNING CONDENSER WATER PUMP OVER A PERIOD OF 5 MINUTES (ADJUSTABLE).
- WHEN CONDENSER WATER PUMP REACHES CURRENT OPERATING SPEED, OPEN CONDENSER WATER ISOLATION VALVE FOR THE SECOND CHILLER (FV-732 OR FV-733).
- START LEAD PRIMARY CHILLED WATER PUMP; IN SEMI-AUTOMATIC MODE, PRIMARY PUMPS AUTOMATICALLY START AND STOP ON A LEAD/LAG BASIS, TO MATCH THE NUMBER OF ON-LINE CHILLERS. CHILLER ON-LINE STATUS IS NORMALLY DETERMINED BY STATUS OF ITS CHILLED WATER ISOLATION VALVE LIMIT SWITCH. SPECIAL LOGIC REQUIRES THE PRIMARY PUMP TO START BEFORE THE ISOLATION VALVE OPENS ON START OF SECOND CHILLER.
- OPEN CHILLED WATER ISOLATION VALVE FOR THE SECOND CHILLER.
- START THE SECOND CHILLER WHEN A FLOW PATH IS CONFIRMED THROUGH THE CHILLED WATER SYSTEM, AND THE CHILLED WATER AND CONDENSER WATER PUMPS ARE PROVEN ON.
- CHILLED WATER RETURN TEMPERATURE CONTROL VALVE (TCV-653 OR TCV-654) MODULATES TO MAINTAIN THE RETURN WATER TO THE CHILLER AT 52F (ADJUSTABLE).
- THE CHILLER LOADS AND UNLOADS TO MAINTAIN A CONSTANT 42F (ADJUSTABLE) CHILLED WATER SUPPLY TEMPERATURE.

SECONDARY CHILLED WATER PUMP START

SECONDARY CHILLED WATER PUMPS OPERATE INDEPENDENT OF THE NUMBER OF CHILLERS, OPERATING IN PARALLEL WITH THE EXISTING CHILLED WATER STORAGE TANK. OPERATION IS DESCRIBED IN THE SECONDARY CHILLED WATER SECTION BELOW.

FIRST CHILLER TO STOP

- STOP THE CHILLER
- WHEN CHILLER HAS CONFIRMED STOPPED, CLOSE THE CHILLED WATER ISOLATION VALVE
- STOP THE PRIMARY CHILLED WATER PUMP
- CLOSE THE CONDENSER WATER ISOLATION VALVE
- STOP THE CONDENSER WATER PUMP
- CLOSE THE COOLING TOWER CELL FLOW ISOLATION VALVE (MOV-715 OR 716)
- THE TOWER CELL FAN STOPS AND THE TOWER CELL DRAIN VALVE (FCV-800 OR 801) OPENS WHEN THE TOWER ISOLATION VALVE CLOSES

SECOND CHILLER TO STOP

- STOP THE CHILLER
- STOP THE PRIMARY CHILLED WATER AND CONDENSER WATER PUMPS
- CLOSE THE CHILLED WATER AND CONDENSER WATER ISOLATION VALVES
- CLOSE THE COOLING TOWER CELL FLOW ISOLATION VALVE (MOV-715 OR 716)
- THE TOWER CELL FAN STOPS AND THE TOWER CELL DRAIN VALVE (FCV-800 OR 801) OPENS WHEN THE TOWER ISOLATION VALVE CLOSES
- COOLING TOWER BYPASS VALVE MOV-714 OPENS WHEN CONDENSER WATER TEMPERATURE FALLS BELOW 71F

SECONDARY PUMP STOP

- STOP THE NEXT IN ROTATION SECONDARY CHILLED WATER PUMP WHEN THE SPEED OF THE OPERATING PUMPS IS LESS THAN 40% FOR 5 MINUTES (ADJUSTABLE)
- STOP THE LAST SECONDARY PUMP MANUALLY.

3. CHILLERS

CHILLERS SHALL BE STARTED AND STOPPED MANUALLY TO PROVIDE ADEQUATE CHILLED WATER SUPPLY TO THE CENTRAL CHILLED WATER DISTRIBUTION SYSTEM, AND CHARGE THE CHILLED WATER STORAGE TANK AS REQUIRED SO AS TO MINIMIZE THE NUMBER OF CHILLERS OPERATING DURING ON-PEAK HOURS. CHILLERS LOAD AND UNLOAD AUTOMATICALLY TO MAINTAIN A CONSTANT 42F CHILLED WATER SUPPLY TEMPERATURE.

4. PRIMARY CHILLED WATER PUMPS

ONE PRIMARY CHILLED WATER PUMP SHALL RUN FOR EACH CHILLER THAT IS RUNNING; THIS IS ACHIEVED AUTOMATICALLY BY THE CONTROL SYSTEM WHICH STARTS AND STOPS THESE PUMPS TO MATCH THE NUMBER OF OPERATING CHILLERS. THE PRIMARY CHILLED WATER PUMPS SHALL BE OPERATED IN ROTATION; THE FIRST PUMP STARTED SHALL BE THE FIRST PUMP SHUT DOWN.

EACH PRIMARY CHILLED WATER PUMP IS EQUIPPED WITH A SLOW-OPENING/CLOSING DISCHARGE VALVE THAT ALSO ACTS AS A CHECK VALVE. WHEN STARTING A PUMP, THE SOLENOID VALVE ON THE PUMP VALVE SHALL BE ENERGIZED, THE PUMP STARTER SHALL BE ENERGIZED SIMULTANEOUSLY, THE PUMP CONTROL VALVE SHALL OPEN AT A RATE OF 2 MINUTES FROM FULLY CLOSED TO FULLY OPEN. A LIMIT SWITCH ON THE PUMP CONTROL VALVE SHALL INDICATE THAT IT HAS OPENED.

WHEN SHUTTING DOWN A PRIMARY CHILLED WATER PUMP, THE SOLENOID VALVE ON THE PUMP DISCHARGE CONTROL VALVE IS DE-ENERGIZED FIRST, THE VALVE SHALL SLOWLY CLOSE AT A RATE OF 4 MINUTES FROM FULLY OPEN TO FULLY CLOSED. WHEN THE VALVE'S OPEN LIMIT SWITCH SHOWS THAT IS NO LONGER OPEN, THEN THE PUMP STARTER SHALL BE DE-ENERGIZED.

5. PRIMARY CHILLED WATER PUMP BYPASS VALVE

PRIMARY PUMP BYPASS CONTROL VALVE PDV-550 SHALL BE CONTROLLED BY A PID BLOCK TO LIMIT THE DIFFERENTIAL PRESSURE MEASURED AT PDT-550 TO 40 PSID. THE SETPOINT (40 PSID) IS 5 PSID ABOVE THE NORMAL DIFFERENTIAL PRESSURE ACROSS THE PRIMARY CHILLED WATER PUMPS. PDV-550 SHALL BE CLOSED DURING MOST OPERATING CONDITIONS.

6. CHILLED WATER RETURN TEMPERATURE CONTROL

CHILLED WATER RETURN TEMPERATURE CONTROL VALVES TCV-653 AND TCV-654 MODULATE TO MAINTAIN THE RETURN WATER TEMPERATURE AT 52 F (ADJUSTABLE) TO EACH CHILLER, THUS ENABLING THE CHILLER TO PRODUCE 42F CHILLED WATER. THE RETURN WATER TEMPERATURE SHALL BE REDUCED TO MINIMIZE THE LOAD ON CHILLERS OPERATING DURING ON-PEAK HOURS. BYPASS CHILLED WATER FLOW IS MEASURED BY FT-691 AND FT-692.

7. SECONDARY CHILLED WATER PUMPS

SECONDARY CHILLED WATER PUMPS OPERATE INDEPENDENT OF THE NUMBER OF CHILLERS OPERATING IN ORDER TO SATISFY THE CENTRAL CHILLED WATER SYSTEM DEMAND. SECONDARY PUMPS ARE DRIVEN BY VFD MOTORS, AND START AND STOP IN SEQUENCE AS REQUIRED TO MAINTAIN OPERATING SPEED BETWEEN 40% AND 85% OF MAXIMUM SPEED. SECONDARY CHILLED WATER PUMP VFD SPEED IS CONTROLLED BY A PID LOOP TO MAINTAIN A CONSTANT DIFFERENTIAL PRESSURE (ADJUSTABLE) BETWEEN THE CHILLED WATER SUPPLY AND RETURN (PT-504 MINUS PT-401A). THE OUTPUT OF THE PID LOOP DRIVES ALL OPERATING VFD PUMPS AT THE SAME SPEED.

- SECONDARY CHILLED WATER PUMPS START IN LEAD/LAG ROTATION TO EQUALIZE ALL OPERATING PUMPS.
- THE NUMBER OF OPERATING SECONDARY PUMPS IS BASED ON TOTAL CHILLED WATER FLOW, WITH THE COMMON PUMP SPEED OF THE SECONDARY PUMPS ADJUSTED TO SATISFY THE CENTRAL CHILLED WATER DISTRIBUTION SYSTEM DEMAND AS INDICATED BY THE PRESSURE DIFFERENTIAL BETWEEN THE CHILLED WATER SUPPLY AND RETURN (PT-504 MINUS PT-401A).
- WHEN A FLOW PATH (CHILLER INLET VALVE OPEN) IS CONFIRMED THROUGH THE CHILLED WATER SYSTEM, START THE SECONDARY CHILLED WATER PUMP(S) AND RAMP UP SPEED TO MAINTAIN THE PRESSURE DIFFERENTIAL BETWEEN THE CHILLED WATER SUPPLY AND RETURN AT 45 PSID (ADJUSTABLE).

8. SECONDARY CHILLED WATER PUMP BYPASS

A SECONDARY PUMP BYPASS VALVE (FCV-404) MODULATES TO LIMIT THE SECONDARY PUMP DISCHARGE PRESSURE AS INDICATED BY PT-401A. THIS BYPASS IS ONLY REQUIRED WHEN THE FLOW RATE IS LESS THAN MINIMUM TURNDOWN CAPACITY WHEN A SINGLE PUMP IS IN OPERATION. THE SECONDARY PUMP DISCHARGE PRESSURE SETPOINT SHALL BE EQUAL TO THE CHILLED WATER RETURN PRESSURE PLUS 5 PSIG, PLUS THE CHILLED WATER SUPPLY AND RETURN DIFFERENTIAL PRESSURE SETPOINT USED TO CONTROL THE SECONDARY PUMP SPEED.

9. CHILLED WATER RETURN BACK PRESSURE CONTROL

A NEW BACK PRESSURE CONTROL VALVE, PV-504, SHALL BE OPERATED TO CONTROL THE UPSTREAM GAUGE PRESSURE MEASURED AT PT-504 TO 45 PSIG (ADJUSTABLE), IN ORDER TO PROVIDE 5 PSIG POSITIVE PRESSURE FOR AIR VENTING AT THE HIGH POINT IN THE CHILLED WATER DISTRIBUTION SYSTEM. PV-504 IS MODULATED ALONG WITH VALVES PV-502 AND PV-503 BY A COMMON PID BLOCK TO CONTROL THE PROCESS VARIABLE PT-504. OPERATION OF VALVE PV-501 IS UNCHANGED. PV-501 IS NORMALLY OPEN.

10. CHILLED WATER MAKEUP CONTROL

CHILLED WATER MAKEUP IS CONTROLLED BY THE EXISTING CONTROL LOGIC TO MAINTAIN THE WATER LEVEL IN THE CHILLED WATER STORAGE TANK AS FOLLOWS:

MAKEUP WATER CONTROL VALVE LCV-453 OPERATES TO CONTROL THE LEVEL IN THE CHILLED WATER STORAGE TANK AS INDICATED BY LEVEL TRANSMITTER LT-511. LCV-453 SHALL OPEN BELOW 70 - 0 AND CLOSE ABOVE 70" - 2". THE LOW LEVEL ALARM SHALL BE SET AT 69" - 9", AND THE HIGH LEVEL ALARM AT 70" - 4". EXISTING EXPANSION TANK SHALL BE VALVED OFF. EXPANSION TANK FUNCTIONS ARE ACCOMPLISHED BY BACK PRESSURE VALVES PV-502, PV-503, PV-504 AND THE CHILLED WATER STORAGE TANK.

11. STORAGE TANK CHARGE AND DISCHARGE

CHILLED WATER STORAGE PARAMETERS ARE CONTROLLED AND MONITORED BY EXISTING CONTROL LOGIC AS FOLLOWS:

THE STORAGE TANK IS CHARGED OR DISCHARGED AUTOMATICALLY AT A RATE EQUAL TO THE DIFFERENTIAL FLOW BETWEEN THE PRIMARY AND SECONDARY PUMP FLOW RATE. THE TANK IS CHARGED WHEN PRIMARY PUMP FLOW EXCEEDS SECONDARY FLOW AND DISCHARGED WHEN SECONDARY FLOW EXCEEDS PRIMARY FLOW. THE DIFFERENTIAL FLOW RATE IS CONTROLLED BY THE OPERATOR BASED ON THE NUMBER OF CHILLERS OPERATING RELATIVE TO THE DISTRIBUTION SYSTEM COOLING LOAD.

CHILLED WATER FLOW THROUGH A CHILLER IS AT CONSTANT VOLUME, WHEN A CHILLER IS OPERATED WITH A SYSTEM COOLING LOAD OF LESS THAN THE CHILLER CAPACITY, WATER IS DRAWN FROM THE TOP OF THE STORAGE TANK TO SUPPLEMENT THE CHILLED WATER RETURN FROM THE BUILDINGS. THE CHILLER INLET WATER TEMPERATURE IS THEREFORE A BLEND THE LOAD ON THE CHILLER IS A FUNCTION OF THE TEMPERATURE DIFFERENTIAL BETWEEN THE ENTERING AND LEAVING WATER. IF THE ENTERING WATER TEMPERATURE IS LESS THAN 52 F, THE CHILLER WILL AUTOMATICALLY UNLOAD TO PRODUCE A CONSTANT 42 F LEAVING WATER TEMPERATURE. THE CHILLED WATER SUPPLY TO THE STORAGE TANK IS EQUAL TO THE RATE OF WITHDRAWAL.

DAILY CHILLED WATER STORAGE CHARGE AND DISCHARGE CYCLES ARE OPERATOR-CONTROLLED BASED ON ANTICIPATED COOLING TON-HOURS REQUIRED FOR THE 24 HOUR PERIOD. THE DAILY TON-HOUR REQUIREMENT IS ESTIMATED BASED ON THE MAXIMUM AND MINIMUM DAILY TEMPERATURE FORECAST AND ANTICIPATED PROCESS LOAD. OPERATORS START/STOP THE CHILLERS VIA THE HMI'S BASED ON HISTORICAL 24 HOUR LOAD PROFILE DATA AND SYSTEM OPERATION FOR THE FORECAST DAILY TEMPERATURE RANGE. THE SCREEN DATA MAY BE USED BY THE OPERATOR TO COMPARE THE CURRENT TANK CHARGE AND DISCHARGE RATES TO THE 24 HOUR HISTORICAL DATA CORRESPONDING TO THE FORECAST MAXIMUM AND MINIMUM DAILY OUTSIDE AIR TEMPERATURE.

ONE CHILLER SHOULD BE OPERATED CONTINUOUSLY DURING THE 9 HOUR ELECTRIC PEAK DEMAND PERIOD UNLESS THE SYSTEM TOTAL COOLING LOAD IS LESS THAN ABOUT 30 PERCENT OF FULL LOAD. A COOLING LOAD OF LESS THAN 30 PERCENT OF ONE CHILLER CAPACITY CAN BE SATISFIED BY OPERATING THE SECONDARY PUMPS TO CIRCULATE CHILLED WATER FROM THE STORAGE TANK WITHOUT PASSING THROUGH A CHILLER.

THE INTENT IS TO STORE A SUFFICIENT AMOUNT OF CHILLED WATER DURING OFF PEAK HOURS TO ALLOW A MINIMUM OF TWO CHILLERS TO BE TURNED OFF DURING ON-PEAK HOURS. THE STORAGE TANK SHOULD BE CHARGED TO CAPACITY EACH NIGHT. IDEALLY, THE CHILLED WATER FLOW RATE IN AND OUT OF THE STORAGE TANK SHOULD NOT EXCEED 6,000 GPM IN ORDER TO MAINTAIN STRATIFICATION BETWEEN THE CHILLED WATER SUPPLY AND RETURN. HOWEVER, THE TANK HAS PERFORMED SUCCESSFULLY AT FLOW RATES UP TO 9,000 GPM.

12. CONDENSER WATER PUMP CONTROL

EACH CHILLER STARTS ONLY AFTER CONDENSER WATER AND PRIMARY CHILLED WATER FLOWS ARE PROVEN. WHEN A CHILLER IS SELECTED TO START, ONE CONDENSER WATER PUMP STARTS IN A LEAD/LAG FASHION. ON STARTING OF THE FIRST CHILLER, THE CONDENSER WATER PUMP STARTS AT 50% SPEED (ADJUSTABLE) AND OPERATES AT THIS SPEED UNTIL THE CHILLER STARTS OR CONDENSER WATER TEMPERATURE REACHES 85 F, AFTER WHICH IT RAMP UP TO 90% SPEED (ADJUSTABLE) OVER A PERIOD OF 5 MINUTES (ADJUSTABLE). ON START OF A CHILLER WHEN ONE IS ALREADY OPERATING, THE CONDENSER WATER PUMP STARTS AT THE CURRENT SPEED AT WHICH THE OPERATING PUMP IS RUNNING.

13. CONDENSER WATER TEMPERATURE CONTROL

TOWER BY-PASS VALVE MOV-714 OPENS AND CLOSES, COOLING TOWER CELLS CTC-5 AND CTC-6 CYCLE ON AND OFF IN SEQUENCE, AND TOWER FAN SPEEDS MODULATE TO MAINTAIN THE COLD WELL WATER TEMPERATURE BETWEEN 85 F AND 65 F AT TE-724.

ON STARTING OF THE FIRST CHILLER, THE SYSTEM IS STARTED UP TO BYPASS THE TOWER, ONCE THE CONDENSER WATER TEMPERATURE EXCEEDS AN ADJUSTABLE TRIP POINT (71F), BYPASSING STOPS AND WATER FLOWS OVER THE CELL. A TOWER CELL FLOW VALVE (MOV-715 OR 716) IS OPENED AND BY-PASS VALVE MOV-714 CLOSES WHEN THE TEMPERATURE AT TE-724 IS ABOVE 71 F. THE CELL FAN SPEED MODULATES TO MAINTAIN AN 85 F COLD WELL TEMPERATURE AT TE-724. WHEN THE COLD WELL TEMPERATURE AT TE-724 IS LESS THAN 71 F, BY-PASS VALVE MOV - 714 OPENS AND TOWER CELL FLOW VALVE (MOV-715 OR -716) CLOSES. SOLENOID VALVE FCV-800 OPENS WHENEVER MOV-715 IS CLOSED AND CLOSES WHEN MOV-715 IS OPEN. SOLENOID VALVE FCV-801 OPENS WHENEVER MOV-716 IS CLOSED AND CLOSES WHEN MOV-716 IS OPEN.

THE NUMBER OF OPERATING CELLS SHALL NOT EXCEED THE NUMBER OF OPERATING CONDENSER WATER PUMPS WHEN BY-PASS VALVE MOV-714 IS CLOSED OR THE NUMBER OF OPERATING CONDENSER WATER PUMPS MINUS ONE WHEN BY-PASS VALVE MOV-714 IS OPEN.

THERE IS NO AUTOMATIC REVERSING OF FANS. IN WINTER, NON-OPERATIONAL FANS ARE MANUALLY PERIODICALLY RUN IN REVERSE TO PREVENT FREEZING.

14. CONDENSER WATER BLOWDOWN CONTROL

CONDENSER WATER CONDUCTIVITY CONTROL VALVE CV-731 IS OPENED TO BLOW DOWN CONDENSER WATER FROM THE NEW COOLING TOWER. CO-ORDINATED WITH CHEMICAL FEED TO MAINTAIN CONDENSER WATER CONDUCTIVITY, AS MEASURED BY AT-739, AT SET POINT CV-731 IS A TWO-POSITION VALVE. BLOWDOWN IS INTERLOCKED SO THAT THE BLOW DOWN AND CHEMICAL FEED CANNOT OPERATE SIMULTANEOUSLY.

15. CONDENSER WATER MAKE-UP CONTROL

MAKEUP WATER CONTROL VALVE LV-734 OPERATES TO CONTROL THE LEVEL IN THE CONDENSER WATER COLD WELL, AS MEASURED BY LEVEL SWITCH ASSEMBLY LS-763. LV-734 SHALL OPEN BELOW 73"-6" AND CLOSE ABOVE 74"-0". THE LOW LEVEL ALARM SHALL BE SET AT 73"-0" AND THE HIGH LEVEL ALARM AT 77"-0". LT-762 IS USED FOR MONITORING AND DISPLAY PURPOSES ONLY.

16. ABNORMAL OPERATION

ABNORMAL OPERATION IS CHARACTERIZED BY A MAJOR LEAK IN THE CHILLED WATER DISTRIBUTION SYSTEM, OPERATION WITH THE STORAGE TANK OUT OF SERVICE, OR OPERATION WITH THE PRIMARY PUMPS OUT OF SERVICE.

CHILLED WATER DISTRIBUTION SYSTEM LEAK DETECTION IS CARRIED OUT BY EXISTING LOGIC AS FOLLOWS:

MAKE-UP WATER IS CONTROLLED OVER A 2 INCH DIFFERENTIAL IN THE STORAGE TANK WATER LEVEL WHICH IS EQUAL TO APPROXIMATELY 7,600 GALLONS.

THE LEAKAGE RATE OF THE UNDERGROUND CEMENT LINED DUCTILE IRON CHILLED WATER DISTRIBUTION SYSTEM IS APPROXIMATELY 20 GPM.

THE 2 INCH MAKE-UP WATER SUPPLY TO THE STORAGE TANK WILL DELIVER 50 GPM AT A REASONABLE VELOCITY OF 4.8 FPS.

ACCURACY OF THE DIFFERENTIAL LEVEL CONTROL IS + 0.25 INCH.

AN ALARM SHALL BE INITIATED INDICATING A CHILLED WATER SYSTEM LEAK WHENEVER THE TANK WATER LEVEL FALLS 0.5 (ADJUSTABLE) INCH OR MORE DURING A 15 MINUTE TIME PERIOD.

THE MAXIMUM VOLUME OF LEAKAGE BEFORE AN ALARM SOUNDS RANGES BETWEEN 1,900 GAL TO 2,350 GAL, DEPENDING ON WHETHER THE MAKE-UP WATER VALVE IS CLOSED OR OPEN.

STORAGE TANK OR PRIMARY CHILLED WATER PUMPS OUT OF SERVICE.

THE PROCEDURE USED TO OPERATE THE CCWF WITH THE STORAGE TANK OUT OF SERVICE IS AS FOLLOWS:

SET THE TANK OFF LINE BIT IN THE PLC CODE.

THE CHILLED WATER SYSTEM SHALL RETURN TO THE ORIGINAL OPERATING CONFIGURATION IN THE EVENT THAT THE PRIMARY PUMPS ARE OUT OF SERVICE.

STOP SECONDARY PUMPS, AND CHILLERS/PRIMARY PUMPS.

DISABLE PRIMARY PUMPS.

CLOSE SHUT OFF VALVES ON STORAGE TANK CHILLED WATER SUPPLY AND RETURN CONNECTIONS TO ISOLATE THE TANK FROM THE SYSTEM. TANK BY-PASS VALVE REMAINS CLOSED.

OPEN THE 24 INCH BY-PASS, IN PUMPHOUSE BUILDING 600A, BETWEEN THE 36-INCH CHILLED WATER RETURN UPSTREAM OF THE BACK PRESSURE VALVES AND DOWNSTREAM OF THE PRIMARY PUMPS. CLOSE SHUTOFF VALVES UPSTREAM OF THE BACK PRESSURE VALVES.

OPEN VALVE ON EXPANSION TANK IN CCWF BUILDING 600 TO PLACE THE EXPANSION TANK BACK IN SERVICE. CLOSE SECONDARY PUMP BY-PASS VALVE AT 24 INCH CHILLED WATER SUPPLY AND OPEN VALVE AT 36 INCH CHILLED WATER RETURN.

OPERATOR SHALL START/STOP CHILLERS AND SECONDARY PUMPS VIA THE OPERATORS CONSOLE TO MAINTAIN FLOW RATE THROUGH THE CHILLERS ABOVE MINIMUM REQUIRED FOR STABLE CHILLER OPERATION.

SECONDARY PUMP SPEED CONTROL BY THE MASTER PID BLOCK REMAINS UNCHANGED. SECONDARY CHILLED WATER PUMP SPEED IS CONTROLLED BY THE MASTER PID BLOCK TO MAINTAIN A CONSTANT DIFFERENTIAL PRESSURE (ADJUSTABLE) BETWEEN THE CHILLED WATER SUPPLY AND RETURN (PT-504 MINUS PT-401-A).

SATELLITE CHILLER PLANT

TWO CHILLERS IN THE BUILDING 555 SATELLITE CHILLER PLANT ARE MANUALLY RUN TO MAINTAIN A STEADY STATE CONDITION. THESE CHILLERS SUPPLY THE SAME CHILLED WATER CHILLER AND DRAW FROM THE SAME CHILLED WATER RETURN HEADER AS THE CCWF CHILLERS.

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