SECTION 16350A

SHORT-CIRCUIT/COORDINATION/ARC FLASH STUDY

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 16010 - General Electrical Requirements

B. Section 16025 – Electrical Systems

C. Section 16050 – Basic Materials and Methods

D. Section 16100 – Motor Control

E. Section 16312 – Load Center Unit Substation- Double Ended

F. Section 16316 – Medium Voltage Metal Clad Switchgear

G. Section16318 - Medium Voltage Metal Enclosed Switchgear

H. Section 16320 – Power Transformer

I. Section 16400 – Distribution Equipment

1.2 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.

1.3 DESCRIPTION OF WORK

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.

A. 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.

B. 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.

C. 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.

D. Contractor must submit as-built system data for inclusion in a final study report prior to equipment startup.

E. Contractor shall install arc flash PPE labels prior to startup. BNL standard labels will be provided for Contractor's use.

1.4 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

1.5 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.

1.6 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

2.1 (Not applicable)

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

High Voltage Fuses

Prot Dev	Func Name	Connected Bus	Voltage	Manufacturer	Type	Description	Cartridge	Cartridge Size	Trip
SUB 600B 2B	Phase	SUB 600B S	13,800	S&C	SM-5, 14.4kV	3E- 2-400E Standard Speed	SM-5, 400E	400	400
SUB 600B 5B	Phase	SUB 600B N	13,800	S&C	SM-5, 14.4kV	3E- 2-400E Standard Speed	SM-5, 400E	400	400
SWGR-600-2 I	Phase	SWGR-600-2	4,160	CUTLER-HAMMER	CLS-1, -2, -22,	2R-26R	CLS, 12R	230	230
SWGR-600-2 I	Phase	SWGR-600-2	4,160	CUTLER-HAMMER	CLS-1, -2, -22,	2R-26R	CLS, 12R	230	230
SWGR-600-2 I	Phase	SWGR-600-2	4,160	CUTLER-HAMMER	CLS-1, -2, -22,	2R-26R	CLS, 12R	230	230
SWGR-600-2 I	Phase	SWGR-600-2	4,160	CUTLER-HAMMER	CLS-1, -2, -22,	2R-26R	CLS, 12R	230	230
SWGR-600-2 I	Phase	SWGR-600-2	4,160	CUTLER-HAMMER	CLS-1, -2, -22,	2R-26R	CLS, 12R	230	230
SWGR-600-2 I	Phase	SWGR-600-2	4,160	CUTLER-HAMMER	CLS-1, -2, -22,	2R-26R	CLS, 12R	230	230

Electronic Relays

Prot Dev	Func Name	Connected Bus	Manufacturer	Class Desc.	CT Ratio	Segments				
600-TRNF-51	Ground		GE	745	200 : 5	W1 Ground OC PU	Definite Time 4.00			
600-TRNF-51	Ground		GE	745	200 : 5	W1 Ground OC PU	Definite Time 4.00			
SWGR-600-2 5	Phase	SWGR-600-2	C-H	Digitrip MV	500 : 5	LTPU 1.0	LTD, I2t 6.0	STPU 2.25	STD 0.2	INST 17.5
SWGR-600-2 5	Phase	SWGR-600-2	C-H	Digitrip MV	500 : 5	LTPU 1.0	LTD, I2t 6.0	STPU 2.25	STD 0.2	INST 17.5
SWGR-600-2 5	Ground	SWGR-600-2	C-H	Digitrip MV	50 : 5	GF LTPU 0.1	GF LTD, Flat 0.2	GF STPU 0.1	GF STD 0.05	GF INST 0.5
SWGR-600-2 5	Ground	SWGR-600-2	C-H	Digitrip MV	50 : 5	GF LTPU 0.1	GF LTD, Flat 0.2	GF STPU 0.1	GF STD 0.05	GF INST 0.5
SWGR-600-2 5	Phase	LS SWGR-600-	GE	750	1,200 : 5	Phase OC PU 1	Ext Inverse 2.00	Phase Inst OC PU	Phase Inst OC Delay	
SWGR-600-2 5	Phase	LS SWGR-600-	GE	750	1,200 : 5	Phase OC PU 1	Ext Inverse 2.00	Phase Inst OC PU	Phase Inst OC Delay	
SWGR-600-2 5	Neutral		GE	750	1,200 : 5	Neutral OC PU 0.16	Definite Time 2.00			
SWGR-600-2 5	Neutral		GE	750	1,200 : 5	Neutral OC PU 0.16	Definite Time 2.00			

Static Motor Relays

Prot Dev	Func Name	Connected Bus	Manufacturer	Class Desc.	CT Ratio	FLA	Segments			
SWGR-600-2 5	Ground	SWGR-600-2	GE	469	50 : 5	137	GF PU	0.1		
SWGR-600-2 5	Ground	SWGR-600-2	GE	469	50 : 5	137	GF PU	0.1		
SWGR-600-2 5	Ground	SWGR-600-2	GE	469	50 : 5	137	GF PU	0.1		
SWGR-600-2 5	Ground	SWGR-600-2	GE	469	50 : 5	137	GF PU	0.1		
SWGR-600-2 5	Ground	SWGR-600-2	GE	469	50 : 5	137	GF PU	0.1		
SWGR-600-2 5	Ground	SWGR-600-2	GE	469	50 : 5	137	GF PU	0.1		
SWGR-600-2 5	Phase	SWGR-600-2	GE	469	200 : 5	137	O/L PU	1.15	O/L Curves	5
SWGR-600-2 5	Phase	SWGR-600-2	GE	469	200 : 5	137	O/L PU	1.15	O/L Curves	5
SWGR-600-2 5	Phase	SWGR-600-2	GE	469	200 : 5	137	O/L PU	1.15	O/L Curves	5
SWGR-600-2 5	Phase	SWGR-600-2	GE	469	200 : 5	137	O/L PU	1.15	O/L Curves	5
SWGR-600-2 5	Phase	SWGR-600-2	GE	469	200 : 5	137	O/L PU	1.15	O/L Curves	5
SWGR-600-2 5	Phase	SWGR-600-2	GE	469	200 : 5	137	O/L PU	1.15	O/L Curves	5

Project: CCWF II
Central Chilled Water Facil
ADJUSTABLE LOW VOLTAGE CIRCUIT BREAKER SETTINGS

DESIGNATION		FRAME			TRIP UNIT								
								SETTINGS					
Location/Name	Function	AMPS	MFR	TYPE/MODEL	AMPS	Description	TYPE/MODEL	L.T. P.U.	L.D. TIME	S.D. P.U.	S.D. TIME	I2T	INST P.U.
DP-2, DP-2 CB-1	Phase	125	CUTLER-HAMMER	CHKD	125	LSI, 70-400A Fixed Plug	CHKD, RMS 310	Fixed	Fixed	8	200 ms	Out	Fixed
LS SUB-600-2N CB 5-2, SUB-600-2N CB 5-2	Phase	4,000	CUTLER-HAMMER	DSII-840	4,000	LSI, 100-5000A	DSII, Optim 750/1050	1	2	2.3	0.2	Out	12
LS SUB-600-2N CB 5-2, SUB-600-2N CB 5-2	Ground	4,000	CUTLER-HAMMER	DSII-840	4,000	GF, 200-5000A	DSII, Optim 750/1050	0.25	0.2			Out	
LS SUB-600-2S CB 1-2, SUB-600-2S CB 1-2	Phase	4,000	CUTLER-HAMMER	DSII-840	4,000	LSI, 100-5000A	DSII, Optim 750/1050	1	2	2.3	0.2	Out	12
LS SUB-600-2S CB 1-2, SUB-600-2S CB 1-2	Ground	4,000	CUTLER-HAMMER	DSII-840	4,000	GF, 200-5000A	DSII, Optim 750/1050	0.25	0.2			Out	
SUB-600-2N, SUB-600-2N CB 4-1	Phase	1,600	CUTLER-HAMMER	DSII-616	1,600	LSI, 100-5000A	DSII, Optim 750/1050	1	11	5	0.1	Out	12
SUB-600-2N, SUB-600-2N CB 4-1	Ground	1,600	CUTLER-HAMMER	DSII-616	1,600	GF, 200-5000A	DSII, Optim 750/1050	0.25	0.1			Out	
SUB-600-2N, SUB-600-2N CB 4-2	Phase	1,600	CUTLER-HAMMER	DSII-616	1,600	LSI, 100-5000A	DSII, Optim 750/1050	1	11	5	0.1	Out	12
SUB-600-2N, SUB-600-2N CB 4-2	Ground	1,600	CUTLER-HAMMER	DSII-616	1,600	GF, 200-5000A	DSII, Optim 750/1050	0.25	0.1			Out	
SUB-600-2N, SUB-600-2N CB 4-3	Phase	1,600	CUTLER-HAMMER	DSII-616	1,600	LSI, 100-5000A	DSII, Optim 750/1050	1	3	4	0.1	Out	12
SUB-600-2N, SUB-600-2N CB 4-3	Ground	1,600	CUTLER-HAMMER	DSII-616	1,600	GF, 200-5000A	DSII, Optim 750/1050	0.25	0.1			Out	
SUB-600-2N, SUB-600-2N CB 4-4	Phase	1,600	CUTLER-HAMMER	DSII-616	1,600	LSI, 100-5000A	DSII, Optim 750/1050	1	4	4	0.1	Out	12
SUB-600-2N, SUB-600-2N CB 4-4	Ground	1,600	CUTLER-HAMMER	DSII-616	1,600	GF, 200-5000A	DSII, Optim 750/1050	0.25	0.1			Out	
SUB-600-2N, SUB-600-2N CB 5-3	Phase	1,600	CUTLER-HAMMER	DSII-616	1,600	LSI, 100-5000A	DSII, Optim 750/1050	1	4	4	0.1	Out	12
SUB-600-2N, SUB-600-2N CB 5-3	Ground	1,600	CUTLER-HAMMER	DSII-616	1,600	GF, 200-5000A	DSII, Optim 750/1050	0.25	0.1			Out	
SUB-600-2S, SUB-600-2S CB 1-3	Phase	1,600	CUTLER-HAMMER	DSII-616	800	LSI, 100-5000A	DSII, Optim 750/1050	1	2	4	0.1	Out	12
SUB-600-2S, SUB-600-2S CB 1-3	Ground	1,600	CUTLER-HAMMER	DSII-616	800	GF, 200-5000A	DSII, Optim 750/1050	0.25	0.1			Out	
SUB-600-2S, SUB-600-2S CB 2-1	Phase	1,600	CUTLER-HAMMER	DSII-616	1,600	LSI, 100-5000A	DSII, Optim 750/1050	1	2	2.5	0.1	Out	12
SUB-600-2S, SUB-600-2S CB 2-1	Ground	1,600	CUTLER-HAMMER	DSII-616	1,600	GF, 200-5000A	DSII, Optim 750/1050	0.25	0.1			Out	
SUB-600-2S, SUB-600-2S CB 2-2	Phase	1,600	CUTLER-HAMMER	DSII-616	1,600	LSI, 100-5000A	DSII, Optim 750/1050	1	2	3	0.1	Out	12
SUB-600-2S, SUB-600-2S CB 2-2	Ground	1,600	CUTLER-HAMMER	DSII-616	1,600	GF, 200-5000A	DSII, Optim 750/1050	0.25	0.1			Out	

DESIGNATION		FRAME			TRIP UNIT								
								SETTINGS					
Location/Name	Function	AMPS	MFR	TYPE/MODEL	AMPS	Description	TYPE/MODEL	L.T. P.U.	L.D. TIME	S.D. P.U.	S.D. TIME	I2T	INST P.U.
SUB-600-2S, SUB-600-2S CB 2-3	Phase	1,600	CUTLER-HAMMER	DSII-616	1,600	LSI, 100-5000A	DSII, Optim 750/1050	1	3	4	0.1	Out	12
SUB-600-2S, SUB-600-2S CB 2-3	Ground	1,600	CUTLER-HAMMER	DSII-616	1,600	GF, 200-5000A	DSII, Optim 750/1050	0.25	0.1			Out	
SUB-600-2S, SUB-600-2S CB 2-4	Phase	1,600	CUTLER-HAMMER	DSII-616	1,600	LSI, 100-5000A	DSII, Optim 750/1050	1	9	5	0.1	Out	12
SUB-600-2S, SUB-600-2S CB 2-4	Ground	1,600	CUTLER-HAMMER	DSII-616	1,600	GF, 200-5000A	DSII, Optim 750/1050	0.25	0.1			Out	
SUB-600-2S, SUB-600-2S CB 3-2	Phase	4,000	CUTLER-HAMMER	DSII-840	4,000	LSI, 100-5000A	DSII, Optim 750/1050	0.80	2	2.5	0.2	Out	12
SUB-600-2S, SUB-600-2S CB 3-2	Ground	4,000	CUTLER-HAMMER	DSII-840	4,000	GF, 200-5000A	DSII, Optim 750/1050	0.25	0.2			Out	

Thermal Magnetic Molded Cases

Prot Dev	Func Name	Connected Bus	Voltage	Manufacturer	Type	Frame Desc.	Frame	Sensor	Segments	
DP-2 CB-2	Phase	DP-2	480	CUTLER-HAMMER	HFD	HFD	100	100	Fixed	0.00
DP-2 CB-3	Phase	DP-2	480	CUTLER-HAMMER	HFD	HFD	100	100	Fixed	0.00
DP-2 CB-6	Phase	DP-2	480	CUTLER-HAMMER	HFD	HFD	25	25	Fixed	0.00
DP-2 CB-7	Phase	DP-2	480	CUTLER-HAMMER	HFD	HFD	15	15	Fixed	0.00
DP-3 CB-4	Phase	DP-3	480	CUTLER-HAMMER	HFD	HFD	20	20	Fixed	0.00
DP-3 MCB	Phase	LS DP-3 MCB	480	CUTLER-HAMMER	HFD	HFD	200	200	Fixed	0.00
LP-2 MCB	Phase	LS LP-2 MCB	480	CUTLER-HAMMER	HFD	HFD	100	100	Fixed	0.00
MLC-2 MCB	Phase	LS MLC-2 MC	208	CUTLER-HAMMER	BAB, 3-Pole	BAB	60	60	Fixed	0.00
RP-4 MCB	Phase	LS RP-4 MCB	208	CUTLER-HAMMER	BAB, 3-Pole	BAB	70	70	Fixed	0.00
RP-5 MCB	Phase	LS RP-5 MCB	208	CUTLER-HAMMER	BAB, 3-Pole	BAB	50	50	Fixed	0.00
RP-6 MCB	Phase	LS RP-6 MCB	208	CUTLER-HAMMER	BAB, 3-Pole	BAB	80	80	Fixed	0.00
RP-U MCB	Phase	LS RP-U MCB	208	CUTLER-HAMMER	BAB, 3-Pole	BAB	100	100	Fixed	0.00

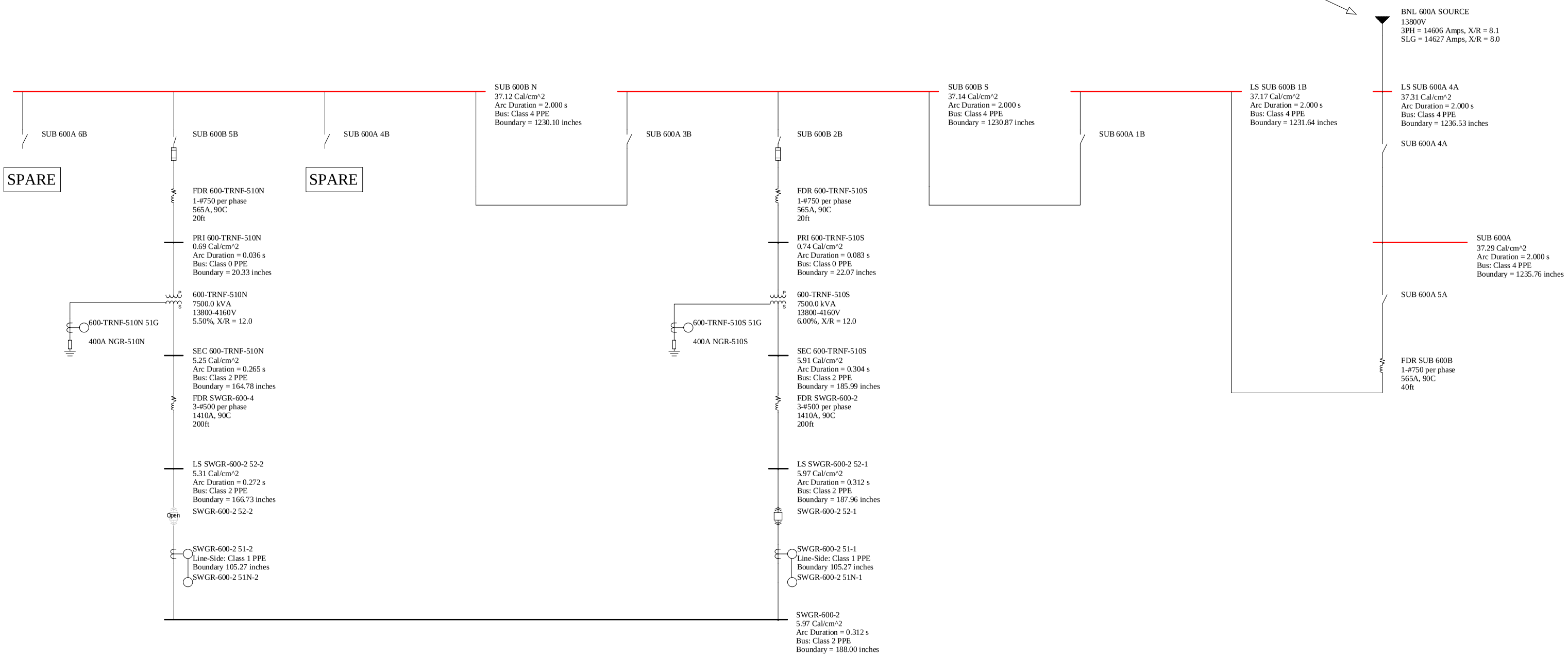
Low Voltage Fuses

Prot Dev	Func Name	Connected Bus	Voltage	Manufacturer	Type	Description	Cartridge	Cartridge Size	Trip
FUSE FDS A	Phase	FDS AD-3	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	5	5
FUSE FDS E	Phase	FDS EF-10	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	10	10
FUSE FDS E	Phase	FDS EF-6	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	1	1
FUSE FDS E	Phase	FDS EF-7	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	18	18
FUSE FDS E	Phase	FDS EF-8	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	18	18
FUSE FDS E	Phase	FDS EF-9	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	10	10
FUSE FDS H	Phase	FDS HWP-2	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	2	2
FUSE FDS M	Phase	FDS MOV 714	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	2	2
FUSE FDS M	Phase	FDS MOV 715	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	2	2
FUSE FDS M	Phase	FDS MOV 716	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	2	2
FUSE FDS M	Phase	FDS MOV 717	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	2	2
FUSE FDS M	Phase	FDS MOV 718	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	2	2
FUSE FDS M	Phase	FDS MOV 719	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	2	2
FUSE FDS R	Phase	FDS RP-6	208	BUSSMANN	FRN-R, 250V Class	1-600A	FRN-R	80	80
FUSE VFD C	Phase	BW-600-4 FDS 1	480	GOULD SHAWMUT	AJT, 600V Class J	15-600A	AJT	400	400
FUSE VFD C	Phase	BW-600-4 FDS 2	480	GOULD SHAWMUT	AJT, 600V Class J	15-600A	AJT	400	400
FUSE VFD C	Phase	BW-600-5 FDS 1	480	GOULD SHAWMUT	AJT, 600V Class J	15-600A	AJT	400	400
FUSE VFD C	Phase	BW-600-5 FDS 2	480	GOULD SHAWMUT	AJT, 600V Class J	15-600A	AJT	400	400
FUSE VFD C	Phase	BW-600-5 FDS 3	480	GOULD SHAWMUT	AJT, 600V Class J	15-600A	AJT	400	400
FUSE VFD C	Phase	BW-600-6 FDS 1	480	GOULD SHAWMUT	AJT, 600V Class J	15-600A	AJT	200	175
FUSE VFD C	Phase	BW-600-6 FDS 2	480	GOULD SHAWMUT	AJT, 600V Class J	15-600A	AJT	200	175
FUSE VFD C	Phase	BW-600-6 FDS 3	480	GOULD SHAWMUT	AJT, 600V Class J	15-600A	AJT	200	175
FUSE VFD C	Phase	BW-600-6 FDS 4	480	GOULD SHAWMUT	AJT, 600V Class J	15-600A	AJT	200	175
FUSE VFD C	Phase	BW-600-6 FDS 5	480	GOULD SHAWMUT	AJT, 600V Class J	15-600A	AJT	200	175
FUSE VFD C	Phase	BW-600-7 FDS 1	480	GOULD SHAWMUT	AJT, 600V Class J	15-600A	AJT	200	200
FUSE VFD C	Phase	BW-600-7 FDS 2	480	GOULD SHAWMUT	AJT, 600V Class J	15-600A	AJT	200	200
FUSE VFD C	Phase	BW-600-7 FDS 3	480	GOULD SHAWMUT	AJT, 600V Class J	15-600A	AJT	200	200
FUSE VFD C	Phase	BW-600-7 FDS 4	480	GOULD SHAWMUT	AJT, 600V Class J	15-600A	AJT	200	200
FUSE VFD C	Phase	BW-600-7 FDS 5	480	GOULD SHAWMUT	AJT, 600V Class J	15-600A	AJT	200	200
MCC-600-3 F	Phase	MCC-600-3	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	1	1
MCC-600-3 F	Phase	MCC-600-3	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	1	1
MCC-600-3 F	Phase	MCC-600-3	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	3	3
MCC-600-3 F	Phase	MCC-600-3	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	2	2
MCC-600-3 F	Phase	MCC-600-3	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	2	2
MCC-600-3 F	Phase	MCC-600-3	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	2	2
MCC-600-3 F	Phase	MCC-600-3	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	2	2
MCC-600-3 F	Phase	MCC-600-3	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	2	2
MCC-600-3 F	Phase	MCC-600-3	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	2	2
MCC-600-3 F	Phase	MCC-600-3	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	1	1

Prot Dev	Func Name	Connected Bus	Voltage	Manufacturer	Type	Description	Cartridge	Cartridge Size	Trip
MCC-600-3 F	Phase	MCC-600-3	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	10	10
MCC-600-3 F	Phase	MCC-600-3	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	1	1
MCC-600-3 F	Phase	MCC-600-3	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	15	15
MCC-600-3 F	Phase	MCC-600-3	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	1	1
MCC-600-3 F	Phase	MCC-600-3	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	1	1
MCC-600-3 F	Phase	MCC-600-3	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	1	1
MCC-600-3 F	Phase	MCC-600-3	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	18	18
MCC-600-3 F	Phase	MCC-600-3	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	10	10
MCC-600-3 F	Phase	MCC-600-3	480	GOULD SHAWMUT	AJT, 600V Class J	15-600A	AJT	200	200
MCC-600-4 F	Phase	MCC-600-4	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	30	30
MCC-600-4 F	Phase	MCC-600-4	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	60	60
MCC-600-4 F	Phase	MCC-600-4	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	60	60
MCC-600-4 F	Phase	MCC-600-4	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	30	30
MCC-600-4 F	Phase	MCC-600-4	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	30	30
MCC-600-4 F	Phase	MCC-600-4	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	30	30
MCC-600-4 F	Phase	MCC-600-4	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	125	125
MCC-600-4 F	Phase	MCC-600-4	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	60	60
MCC-600-4 F	Phase	MCC-600-4	480	GOULD SHAWMUT	AJT, 600V Class J	15-600A	AJT	400	300
MCC-600-4 F	Phase	MCC-600-4	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	18	18
MCC-600-4 F	Phase	MCC-600-4	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	60	60
MCC-600-4 F	Phase	MCC-600-4	480	GOULD SHAWMUT	AJT, 600V Class J	15-600A	AJT	400	300
MCC-600-4 F	Phase	MCC-600-4	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	30	30
MCC-600-4 F	Phase	MCC-600-4	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	30	30
MCC-600-4 F	Phase	MCC-600-4	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	10	10
MCC-600-4 F	Phase	MCC-600-4 FD	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	60	60
MCC-600-4 F	Phase	MCC-600-4 FD	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	60	60
MCC-600-4 F	Phase	MCC-600-4 FD	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	60	60
MCC-600-4 F	Phase	MCC-600-4 FD	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	60	60
MCC-600A-2 l	Phase	MCC-600A-2	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	1	1
MCC-600A-2 l	Phase	MCC-600A-2	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	1	1
MCC-600A-2 l	Phase	MCC-600A-2	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	175	175
MCC-600A-2 l	Phase	MCC-600A-2	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	175	175
MCC-600A-2 l	Phase	MCC-600A-2	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	175	175
MCC-600A-2 l	Phase	MCC-600A-2	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	175	175
MCC-600A-2 l	Phase	MCC-600A-2	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	175	175
MCC-600A-2 l	Phase	MCC-600A-2	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	1	1
MCC-600A-2 l	Phase	MCC-600A-2	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	1	1
MCC-600A-2 l	Phase	MCC-600A-2	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	20	20
MCC-600A-2 l	Phase	MCC-600A-2	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	6	6
MCC-600A-2 l	Phase	MCC-600A-2	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	1	1
MCC-600A-2 l	Phase	MCC-600A-2	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	1	1
MCC-600A-2 l	Phase	MCC-600A-2	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	1	1

Prot Dev	Func Name	Connected Bus	Voltage	Manufacturer	Type	Description	Cartridge	Cartridge Size	Trip
MCC-600A-2	l Phase	MCC-600A-2	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	20	20
MCC-600A-2	l Phase	MCC-600A-2	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	60	60
MCC-600A-2	l Phase	MCC-600A-2	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	1	1
MCC-600A-2	l Phase	MCC-600A-2 F	480	BUSSMANN	FRS-R, 600V Class	1-600A	FRS-R	60	60
MCC-600A-2	l Phase	LS MCC-600A-	480	BUSSMANN	KRP-C, 600V Class	601-6000A	KRP-C	800	800

Available fault current at the 13.8kV SUB 600A Bus
3-Ø=14,606A, X/R=8.1, SLG=14,627, X/R=8.0.
Data taken from the PTW Backup Project file for
B-600, dated 03/26/09.



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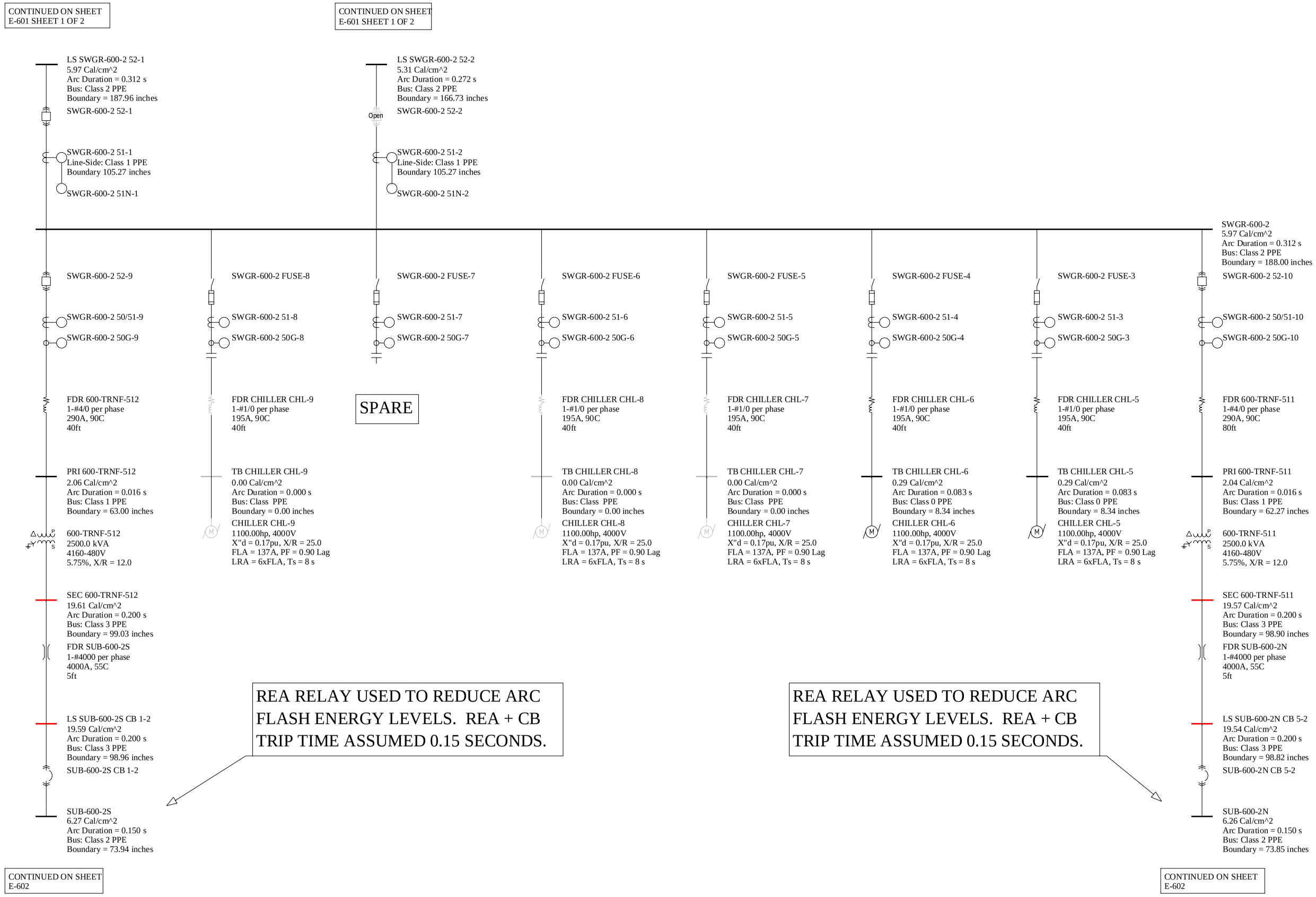

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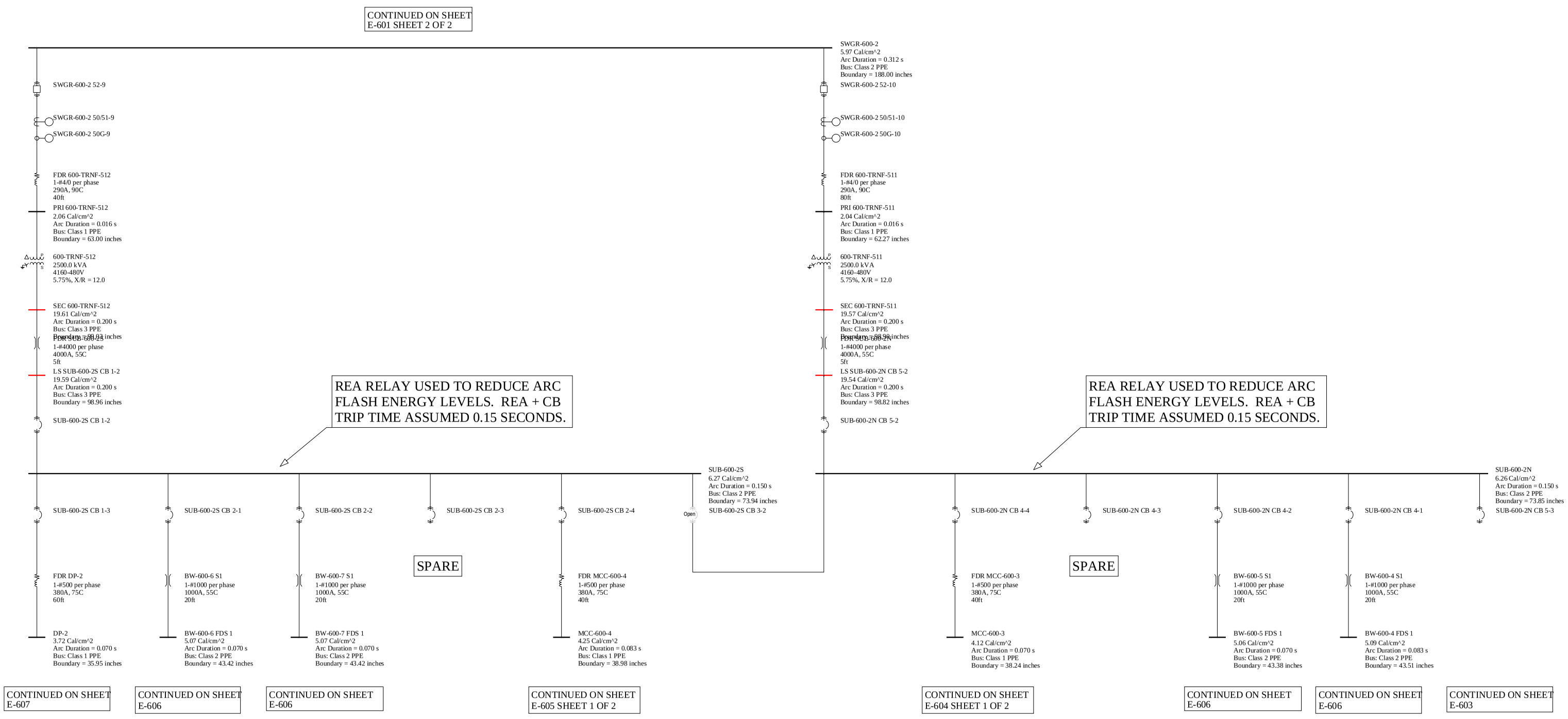

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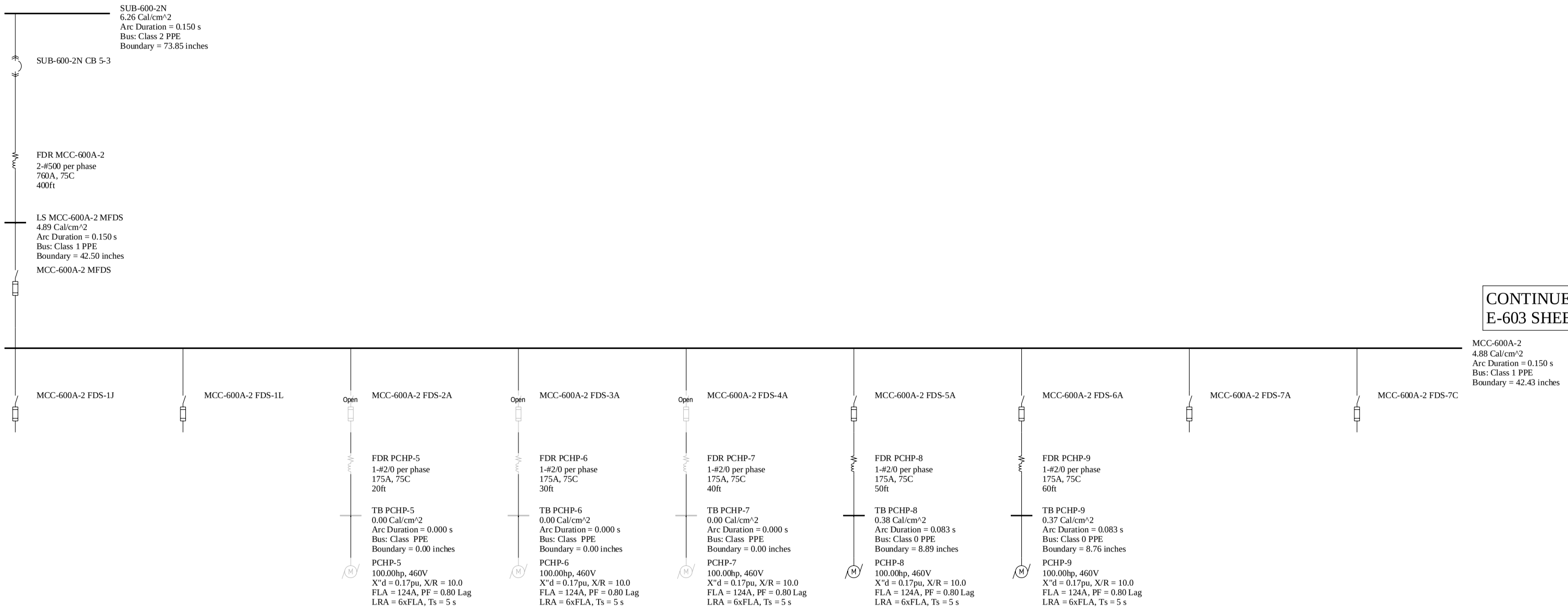

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Central Chilled Water Facility Phase II
Arc Flash Results - Base Project
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CONTINUED ON SHEET
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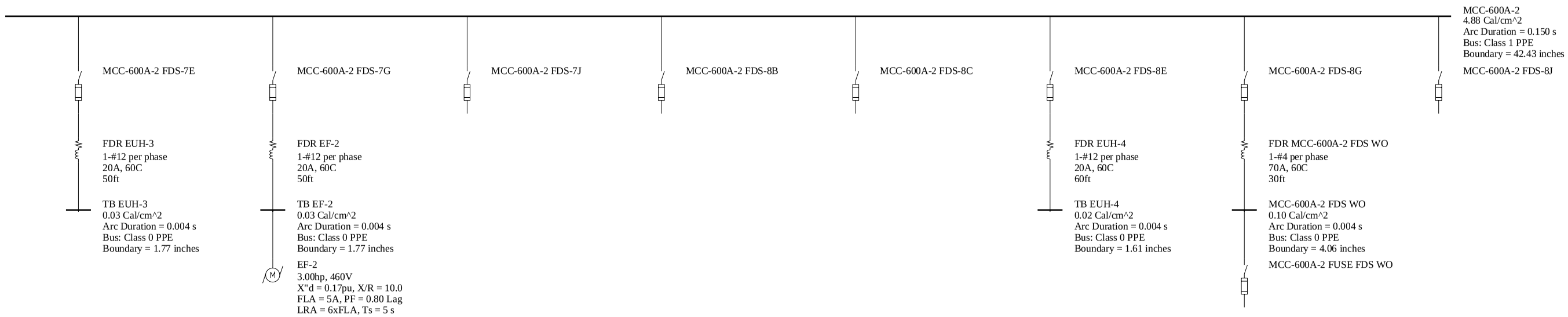

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SUB-600-2N
6.26 Cal/cm^2
Arc Duration = 0.150 s
Bus: Class 2 PPE
Boundary = 73.85 inches
SUB-600-2N CB 4-4

FDR MCC-600-3
1-#500 per phase
380A, 75C
40ft

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E-605 SHEET 2 OF 2

MCC-600-3
4.12 Cal/cm^2
Arc Duration = 0.070 s
Bus: Class 1 PPE
Boundary = 38.24 inches

MCC-600-3 FDS-1E

MCC-600-3 FDS-1G

MCC-600-3 FDS-1J

FDR ACU-2 SUPPLY FAN
1-#12 per phase
20A, 60C
50ft

TB ACU-2 SUPPLY FAN
0.03 Cal/cm^2
Arc Duration = 0.004 s
Bus: Class 0 PPE
Boundary = 1.82 inches

ACU-2 SUPPLY FAN
1.00hp, 460V
X"d = 0.17pu, X/R = 10.0
FLA = 2A, PF = 0.80 Lag
LRA = 6xFLA, Ts = 5 s

MCC-600-3 FDS-1L

FDR FDS HWP-2
1-#12 per phase
20A, 60C
80ft

FDS HWP-2
0.02 Cal/cm^2
Arc Duration = 0.004 s
Bus: Class 0 PPE
Boundary = 1.40 inches

FUSE FDS HWP-2

FDR HWP-2
1-#12 per phase
20A, 60C
10ft

TB HWP-2
0.02 Cal/cm^2
Arc Duration = 0.004 s
Bus: Class 0 PPE
Boundary = 1.32 inches

HWP-2
0.75hp, 460V
X"d = 0.17pu, X/R = 10.0
FLA = 2A, PF = 0.80 Lag
LRA = 6xFLA, Ts = 5 s

MCC-600-3 FDS-2A

FDR FDS MOV 715
1-#12 per phase
20A, 60C
200ft

FDS MOV 715
0.01 Cal/cm^2
Arc Duration = 0.004 s
Bus: Class 0 PPE
Boundary = 0.84 inches

FUSE FDS MOV 715

FDR MOV 715
1-#12 per phase
20A, 60C
10ft

TB MOV 715
0.01 Cal/cm^2
Arc Duration = 0.004 s
Bus: Class 0 PPE
Boundary = 0.82 inches

MOV 715
1.00hp, 460V
X"d = 0.17pu, X/R = 10.0
FLA = 2A, PF = 0.80 Lag
LRA = 6xFLA, Ts = 5 s

MCC-600-3 FDS-2C

FDR FDS MOV 716
1-#12 per phase
20A, 60C
225ft

FDS MOV 716
0.00 Cal/cm^2
Arc Duration = 0.004 s
Bus: Class 0 PPE
Boundary = 0.93 inches

FUSE FDS MOV 716

FDR MOV 716
1-#12 per phase
20A, 60C
10ft

TB MOV 716
0.00 Cal/cm^2
Arc Duration = 0.004 s
Bus: Class 0 PPE
Boundary = 0.91 inches

MOV 716
1.00hp, 460V
X"d = 0.17pu, X/R = 10.0
FLA = 2A, PF = 0.80 Lag
LRA = 6xFLA, Ts = 5 s

MCC-600-3 FDS-2E

FDR FDS MOV 717
1-#12 per phase
20A, 60C
250ft

Open

FDS MOV 717
0.00 Cal/cm^2
Arc Duration = 0.000 s
Bus: Class PPE
Boundary = 0.00 inches

Open

FUSE FDS MOV 717

FDR MOV 717
1-#12 per phase
20A, 60C
10ft

TB MOV 717
0.00 Cal/cm^2
Arc Duration = 0.000 s
Bus: Class PPE
Boundary = 0.00 inches

MOV 717
1.00hp, 460V
X"d = 0.17pu, X/R = 10.0
FLA = 2A, PF = 0.80 Lag
LRA = 6xFLA, Ts = 5 s

MCC-600-3 FDS-2G

FDR FDS MOV 718
1-#12 per phase
20A, 60C
275ft

FDS MOV 718
0.00 Cal/cm^2
Arc Duration = 0.000 s
Bus: Class PPE
Boundary = 0.00 inches

Open

FUSE FDS MOV 718

FDR MOV 718
1-#12 per phase
20A, 60C
10ft

TB MOV 718
0.00 Cal/cm^2
Arc Duration = 0.000 s
Bus: Class PPE
Boundary = 0.00 inches

MOV 718
1.00hp, 460V
X"d = 0.17pu, X/R = 10.0
FLA = 2A, PF = 0.80 Lag
LRA = 6xFLA, Ts = 5 s

MCC-600-3 FDS-2J

FDR FDS MOV 719
1-#12 per phase
20A, 60C
300ft

FDS MOV 719
0.00 Cal/cm^2
Arc Duration = 0.000 s
Bus: Class PPE
Boundary = 0.00 inches

Open

FUSE FDS MOV 719

FDR MOV 719
1-#12 per phase
20A, 60C
10ft

TB MOV 719
0.00 Cal/cm^2
Arc Duration = 0.000 s
Bus: Class PPE
Boundary = 0.00 inches

MOV 719
1.00hp, 460V
X"d = 0.17pu, X/R = 10.0
FLA = 2A, PF = 0.80 Lag
LRA = 6xFLA, Ts = 5 s

MCC-600-3 FDS-2L

FDR FDS MOV 714
1-#12 per phase
20A, 60C
300ft

FDS MOV 714
0.00 Cal/cm^2
Arc Duration = 0.004 s
Bus: Class 0 PPE
Boundary = 0.81 inches

FUSE FDS MOV 714

FDR MOV 714
1-#12 per phase
20A, 60C
10ft

TB MOV 714
0.00 Cal/cm^2
Arc Duration = 0.004 s
Bus: Class 0 PPE
Boundary = 0.80 inches

MOV 714
1.00hp, 460V
X"d = 0.17pu, X/R = 10.0
FLA = 2A, PF = 0.80 Lag
LRA = 6xFLA, Ts = 5 s

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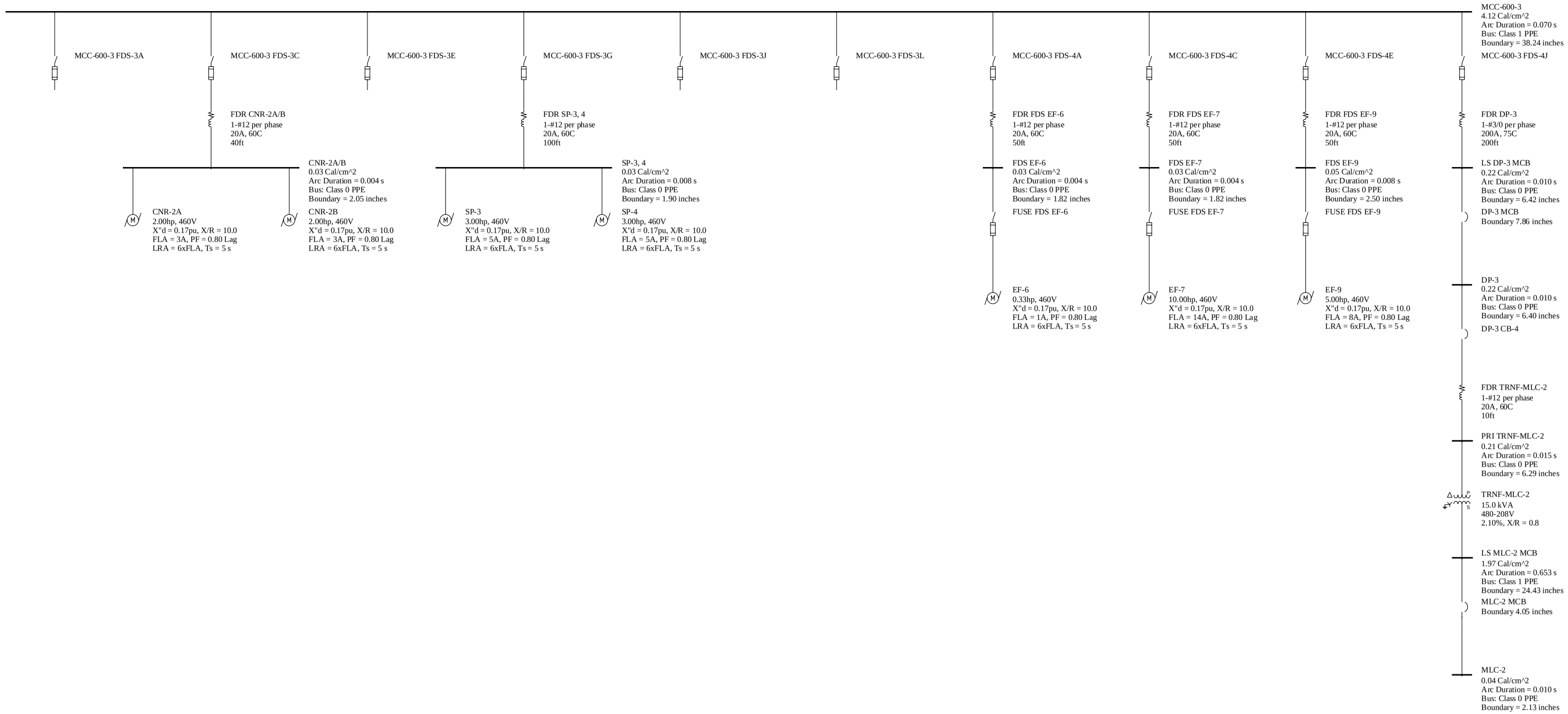

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Arc Flash Results - Base Project
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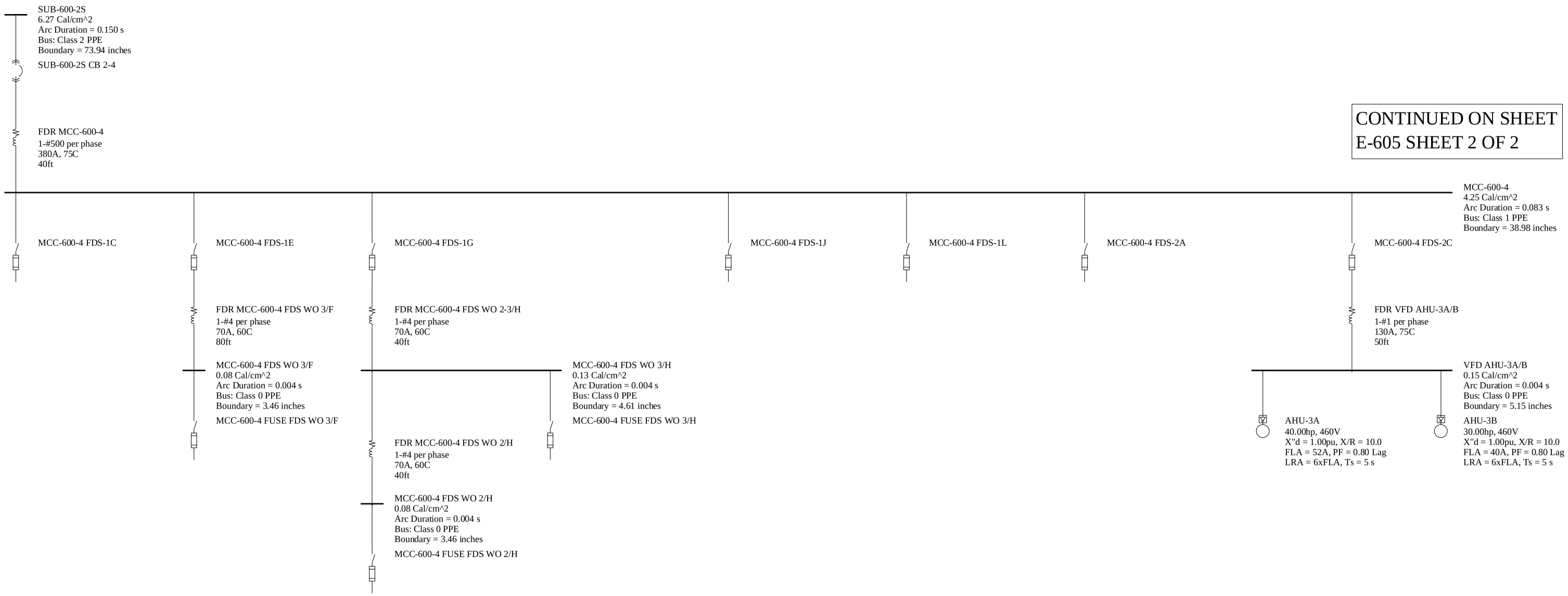

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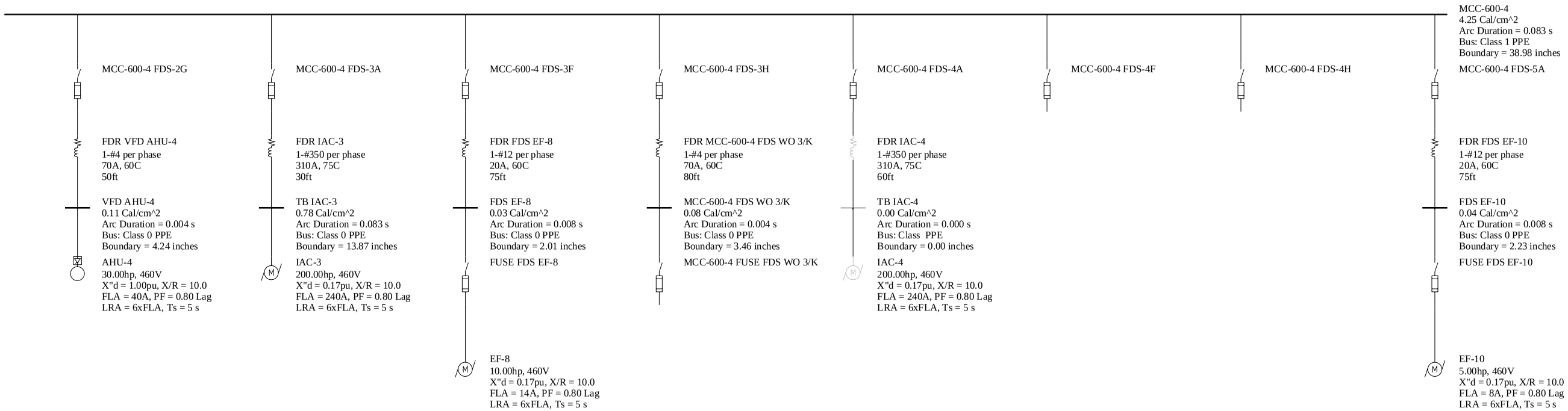

Central Chilled Water Facility Phase II
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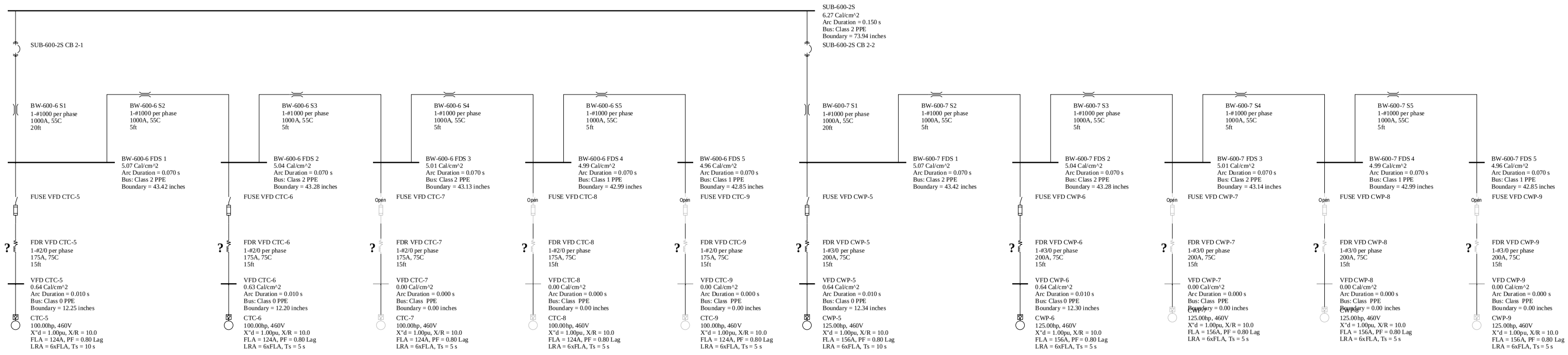

Central Chilled Water Facility Phase II
Arc Flash Results - Base Project
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SOLID STATE TRIP UNIT WITH ADJUSTABLE L-S-I FUNCTIONS REQUIRED TO MEET BNL ARC FLASH CRITERIA

SUB-600-2S
6.27 Cal/cm^2
Arc Duration = 0.150 s
Bus: Class 2 PPE
Boundary = 73.94 inches

SUB-600-2S CB 1-3

FDR DP-2
1-#500 per phase
380A, 75C
60ft

DP-2
3.72 Cal/cm^2
Arc Duration = 0.070 s
Bus: Class 1 PPE
Boundary = 35.95 inches

DP-2 CB-1

FDR T45 RP-4, 6
1-#4 per phase
70A, 60C
50ft

PRI T45 RP-4, 6
0.36 Cal/cm^2
Arc Duration = 0.014 s
Bus: Class 0 PPE
Boundary = 8.73 inches

T45 RP-4, 6
45.0 kVA
480-208V
4.20%, X/R = 2.0

SEC T45 RP-4, 6
1.00 Cal/cm^2
Arc Duration = 0.200 s
Bus: Class 0 PPE
Boundary = 16.18 inches

FDR RP-4
1-#4 per phase
70A, 60C
10ft

LS RP-4 MCB
0.97 Cal/cm^2
Arc Duration = 0.200 s
Bus: Class 0 PPE
Boundary = 15.82 inches

RP-4 MCB
Line-Side: Class 3 PPE
Boundary 60.58 inches

RP-4
0.05 Cal/cm^2
Arc Duration = 0.010 s
Bus: Class 0 PPE
Boundary = 2.55 inches

FDR FDS RP-6
1-#1 per phase
130A, 75C
10ft

FDS RP-6
0.98 Cal/cm^2
Arc Duration = 0.200 s
Bus: Class 0 PPE
Boundary = 15.96 inches

FUSE FDS RP-6

FDR RP-6
1-#1 per phase
130A, 75C
15ft

LS RP-6 MCB
0.26 Cal/cm^2
Arc Duration = 0.066 s
Bus: Class 0 PPE
Boundary = 7.17 inches

RP-6 MCB
Boundary 6.78 inches

RP-6
0.05 Cal/cm^2
Arc Duration = 0.010 s
Bus: Class 0 PPE
Boundary = 2.52 inches

DP-2 CB-2

FDR LP-2
1-#1 per phase
130A, 75C
10ft

LS LP-2 MCB
0.63 Cal/cm^2
Arc Duration = 0.013 s
Bus: Class 0 PPE
Boundary = 12.18 inches

LP-2 MCB
Boundary 14.83 inches

LP-2
0.62 Cal/cm^2
Arc Duration = 0.013 s
Bus: Class 0 PPE
Boundary = 12.10 inches

DP-2 CB-3

FDR LP-3
1-#6 per phase
55A, 60C
100ft

INPUT UPS-600-1
0.18 Cal/cm^2
Arc Duration = 0.016 s
Bus: Class 0 PPE
Boundary = 5.64 inches

UPS-600-1

OUTPUT UPS-600-1
0.08 Cal/cm^2
Arc Duration = 2.000 s
Bus: Class 0 PPE
Boundary = 4.80 inches

FDR RP-U
1-#1 per phase
130A, 75C
10ft

LS RP-U MCB
0.08 Cal/cm^2
Arc Duration = 2.000 s
Bus: Class 0 PPE
Boundary = 4.80 inches

RP-U MCB
Boundary 4.80 inches

RP-U
0.08 Cal/cm^2
Arc Duration = 2.000 s
Bus: Class 0 PPE
Boundary = 4.80 inches

DP-2 CB-6

FDR T15 RP-5
1-#10 per phase
30A, 60C
10ft

PRI T15 RP-5
0.43 Cal/cm^2
Arc Duration = 0.014 s
Bus: Class 0 PPE
Boundary = 9.70 inches

T15 RP-5
15.0 kVA
480-208V
2.10%, X/R = 0.8

SEC T15 RP-5
3.48 Cal/cm^2
Arc Duration = 1.095 s
Bus: Class 1 PPE
Boundary = 34.54 inches

FDR RP-5
1-#10 per phase
30A, 60C
10ft

LS RP-5 MCB
3.79 Cal/cm^2
Arc Duration = 1.331 s
Bus: Class 1 PPE
Boundary = 36.34 inches

RP-5 MCB
Line-Side: Class 1 PPE
Boundary 34.32 inches

RP-5
0.03 Cal/cm^2
Arc Duration = 0.010 s
Bus: Class 0 PPE
Boundary = 2.05 inches

DP-2 CB-7

FDR FDS AD-3
1-#12 per phase
20A, 60C
100ft

FDS AD-3
0.08 Cal/cm^2
Arc Duration = 0.022 s
Bus: Class 0 PPE
Boundary = 3.46 inches

FUSE FDS AD-3

FDR AD-3
1-#12 per phase
20A, 60C
10ft

TB AD-3
0.03 Cal/cm^2
Arc Duration = 0.008 s
Bus: Class 0 PPE
Boundary = 1.79 inches

AD-3
1.00hp, 460V
X"d = 0.17pu, X/R = 10.0
FLA = 2A, PF = 0.80 Lag
LRA = 6xFLA, Ts = 5 s

Central Chilled Water Facility Phase II
Arc Flash Results - Base Project
E-607

Date: 04/10/09

Revision 0