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IMPLEMENTATION OF RELIABLE AND SAFE PRIMARY AND BACKUP POWER SUPPLY SYSTEMS FOR MUNICIPAL FACILITIES

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PRIMARY POWER SYSTEM SAFETY

- Safety During Maintenance
- Arc Flash
- Safer Equipment
- Intelligent Motor Control
- Equipment Safety: How to Protect your Equipment
- Reliability
- Maintenance



BACKUP POWER SYSTEM SAFETY

- Typical Backup Power Supply Installation
- Backup Power Supply System Sizing
- Transfer Switch Equipment
- Generator Fuel Supply
- Reliability
- Maintenance



SAFETY DURING MAINTENANCE



- Personal awareness
- De-energize equipment prior to opening doors
- Lock out/Tag out
- Ensure that enclosure doors are closed and properly latched

MAINTENANCE ON ENERGIZED EQUIPMENT

- Continuous operation plants, vital systems
- Workers must be aware of both electrical shock hazard and arc flash hazard



ARC FLASH: WHAT IS IT?

- Two concerns when working with electricity-
 1. Shock Hazard
 2. Arc Flash Hazard
- During a fault (short circuit) an explosion of energy is released through an electrical arc
- Only a hazard if equipment is energized



Arc Flash

ARC FLASH: WHAT IS IT?

- Arc Flash is typically caused by human error (dropping a wrench/tool), equipment malfunction, or occupation of equipment by wildlife.
- Fault Current
- Clearing Time
- Fault Current + Clearing Time = Incident Energy
 - Incident Energy is quantified in calories/cm²
- Where does an arc flash hazard exist?
 - At any point within an electrical system. It becomes a point of concern primarily on 480V and above.



HOW DANGEROUS IS ARC FLASH?



- Dozens of reported fatalities and thousands of serious injuries due to Arc Flash in the past 50 years
- NFPA categorizes potential arc flash by Hazard Risk Categories (0, 1, 2, 3, 4) corresponding to different levels of Incident Energy
- Each Hazard Risk Category carries a minimum amount of Personal Protective Equipment (PPE) that must be worn when working on the equipment

ARC FLASH FACTS

- The core of the arc flash can reach temperatures of 35,000 °F in 1/1000 of a second. That is roughly four times the temperature of the sun.
- The rapid expansion of copper and the surrounding atmosphere causes a pressure wave that can propel shrapnel at speeds of 700 miles per hour.
- The sound wave can exceed 140 to 165dB; permanently damaging hearing to anyone in the vicinity.
- 480V equipment can produce some of the highest fault current and can have a worse Hazard Risk Category than similar high-voltage equipment due to the longer response time of protective equipment.



ARC FLASH ANALYSIS

Purpose: To classify the Hazard Risk Category of electrical equipment (corresponds to PPE)

Process: Utilize software to accurately model electrical equipment to simulate how it will respond under a fault condition

Results: Equipment labels identifying safety hazard for each piece of protective equipment

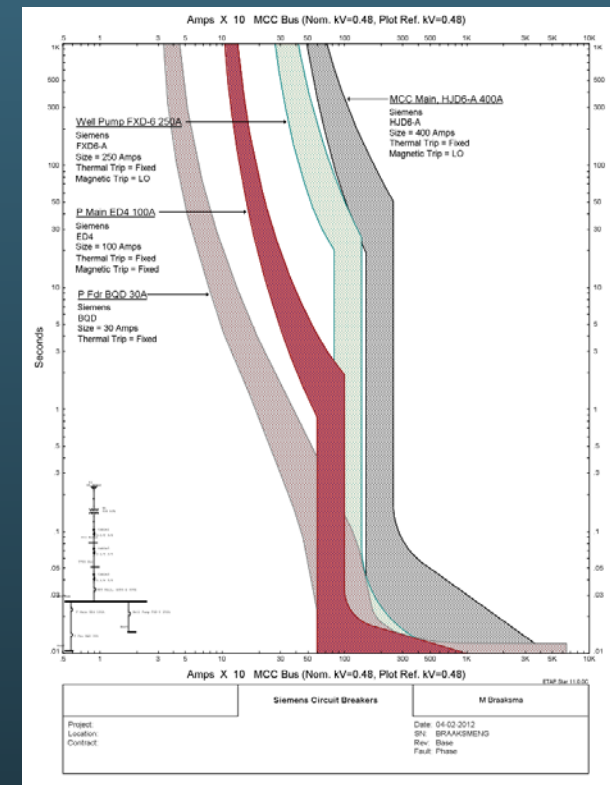


HOW TO IDENTIFY ARC FLASH HAZARD?

- Short circuit study will determine the fault current
- Coordination study will identify the clearing time of each protective device
- With these two studies it is possible to identify the Hazard Risk Category of each bus within a system

HOW TO MINIMIZE ARC FLASH HAZARD?

- Adjustable circuit breaker settings (instantaneous trip, short term trip, long-term trip).
- Installing modern, user-programmable protection equipment.
- Reducing in-rush current of motors by installing VFDs instead of Across-The-Line starters. By reducing in-rush current it is possible to reduce the Utility Transformer and the Feeder Breaker, resulting in less available fault current and faster clearing times.

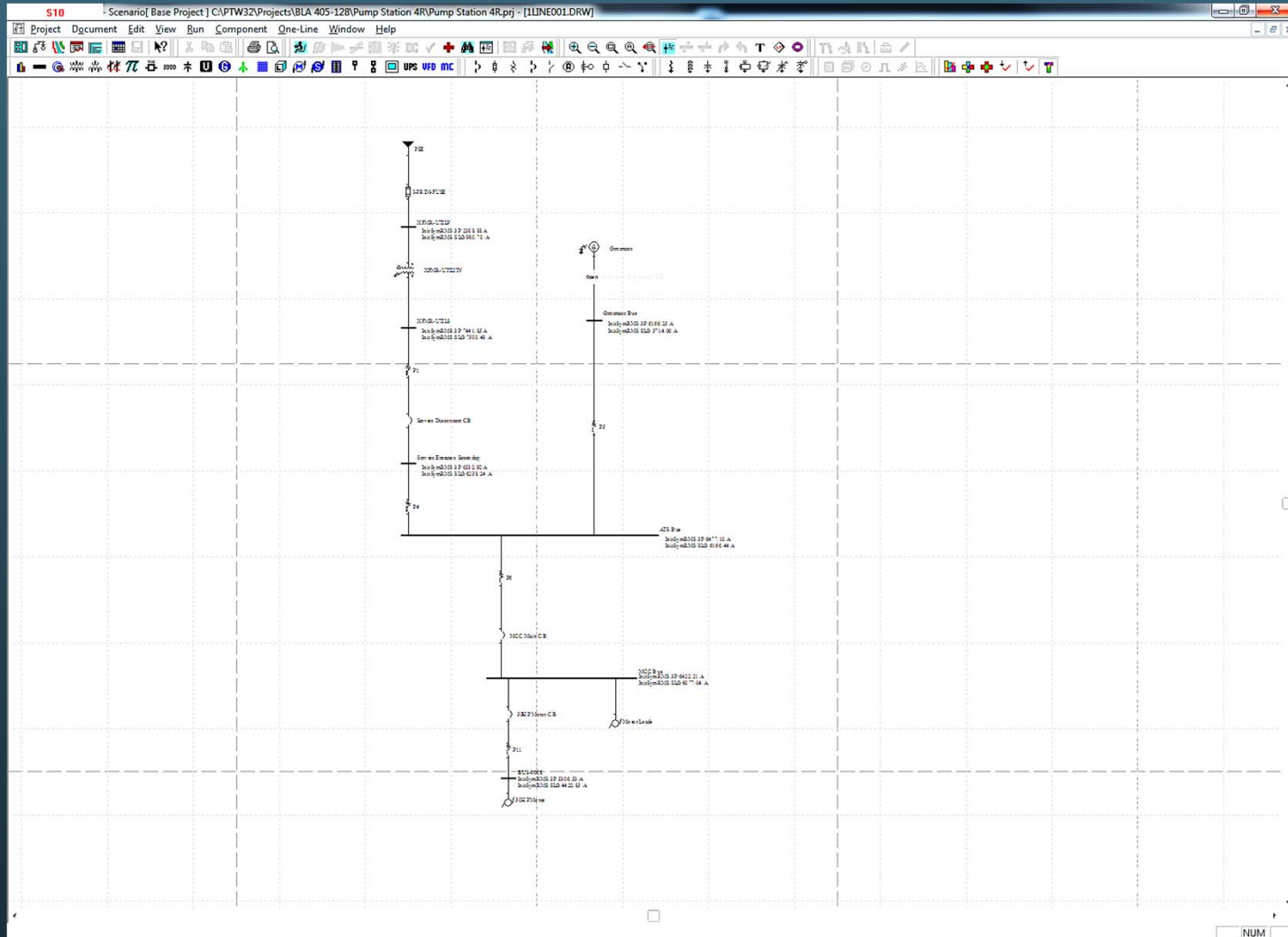


STEPS OF AN ARC FLASH ANALYSIS

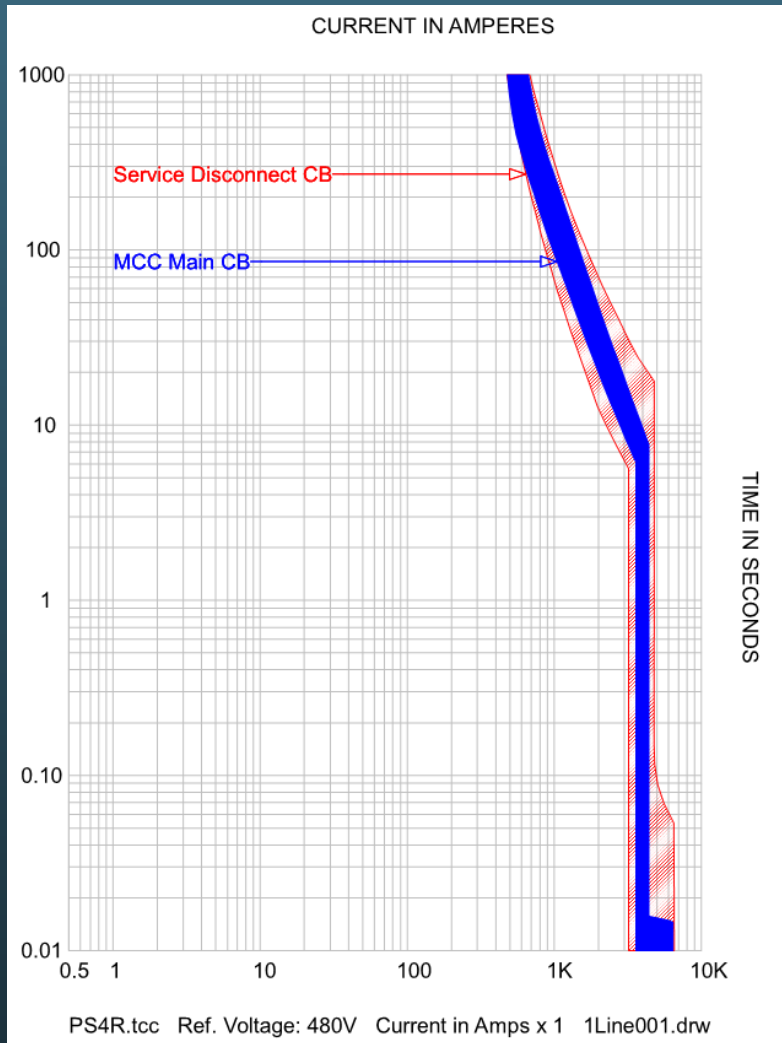
- Information gathering (substantial)
- Software modeling of electrical system
- Short Circuit Study (under worse case scenario)
- System Coordination Study (Clearing Time)
- Fault Current + Clearing Time = Arc Flash Hazard



SHORT CIRCUIT STUDY



SYSTEM COORDINATION STUDY




Time-Current Characteristic Curve Example

480V 400 Amp Thermal-Magnetic Circuit Breakers

The TCC Curve is used to identify Clearing Time based on the Available Fault Current

ARC FLASH ANALYSIS RESULTS

- Hazard Risk Category (HRC) identified for each piece of equipment.
- HRC minimized where possible with existing equipment.
- Equipment improvement suggestions for even further HRC reductions.

 WARNING	
Arc Flash and Shock Hazard	
Appropriate PPE Required	
117 in	Flash Hazard Boundary
26 cal/cm²	Flash Hazard at 18 in
Level 4	Arc-rated shirt & pants + arc-rated coverall + arc-rated arc flash suit
480 VAC	Shock Hazard when cover is removed
00	Glove Class
42 in	Limited Approach
12 in	Restricted Approach
1 in	Prohibited Approach
Location:	ATS Bus



ARC FLASH: SAFER EQUIPMENT



- Ensure that ALL doors on electrical equipment are properly closed and latched.
- Ensure that proper instruction is given to those around you. Electrical doors and cabinets should not be opened unless absolutely necessary.

ARC FLASH: SAFER EQUIPMENT

Allen Bradley ArcShield Motor Control Centers incorporate several innovative design features that enable them to mitigate an arc flash event in a safer manner than a conventional MCC.

- 1) Spring loaded latches: in the event of an arc flash the doors can open slightly to vent gas.
- 2) Arc resistant cooling baffles: prevent the arc flash from “escaping” through the traditional cooling vent and fan.
- 3) Automatic “shutters” close off the main bus plug-in stab openings. By limiting access to the 480V bus it minimizes the chance of an object (tool, wildlife, loose conductor) causing a fault.



PERSONNEL SAFETY: REMOVING THE ELECTRICIAN FROM THE EQUIPMENT



- Intelligent motor control is a quicker, easier, and faster way to transfer information.
- Intelligent motor control reduces the amount of wiring between MCCs and Telemetry Panels.
- Several protocols are in use: DeviceNet, Profibus, ControlNet, Ethernet/IP.

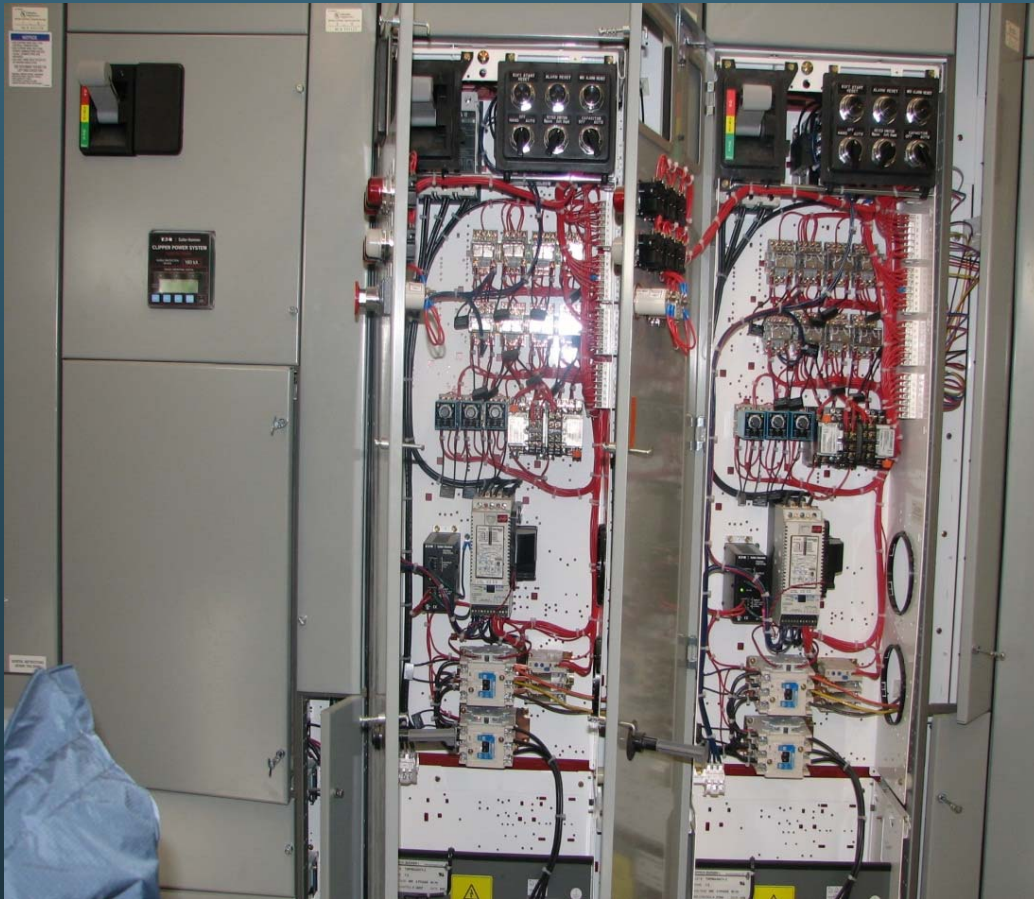
PERSONNEL SAFETY: REMOVING THE ELECTRICIAN FROM THE EQUIPMENT

How can networking make your electrical system safer?

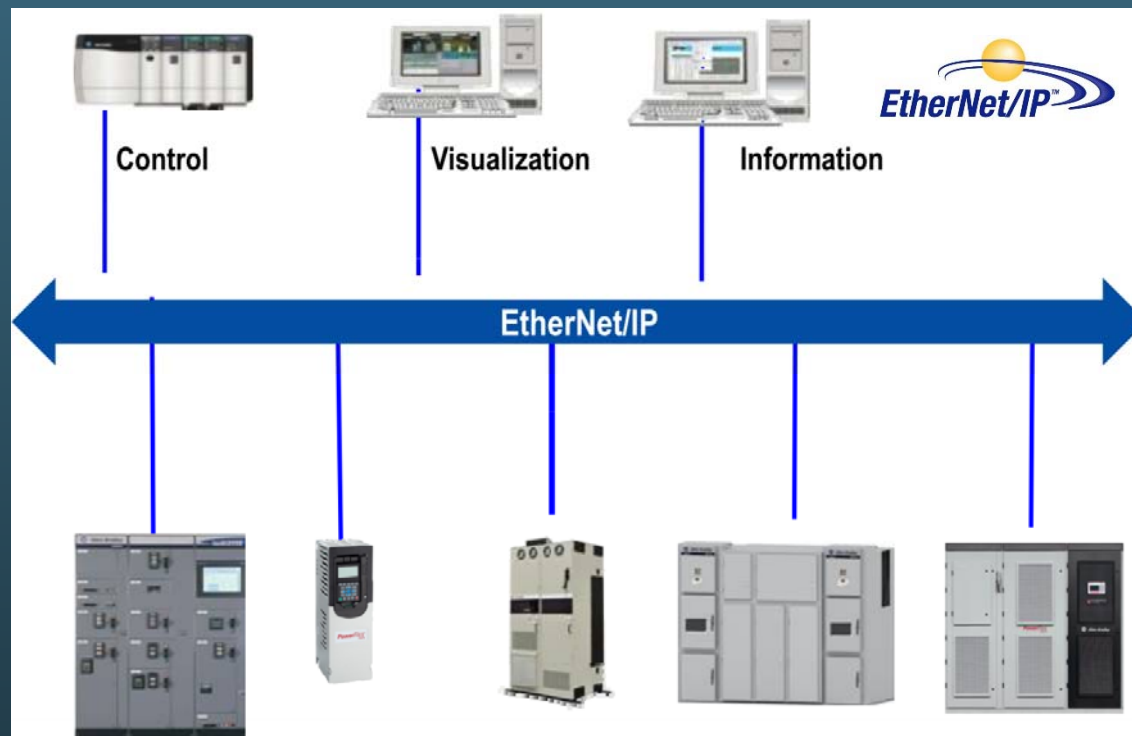
- Arc Flash/Electrical Shock are only a hazard if a worker is near or inside electrical equipment.
- By utilizing Ethernet/IP networking it is possible to reduce a number of common points-of-failure (relays/control wiring) within an MCC.
- By using Ethernet/IP much of the traditional troubleshooting/repair can be done on an off-site computer without opening an MCC door.



ELECTROMECHANICAL VS. INTELLIGENT MOTOR CONTROL



INTELLIGENT MOTOR CONTROL WITH ETHERNET/IP



- Over 60% of MCCs shipped today are networked using one of the various protocols.
- Costs between traditional (hard wired) MCCs and networked MCCs typically break even at 5 sections.

EQUIPMENT SAFETY: HOW TO PROTECT YOUR ELECTRICAL SYSTEM

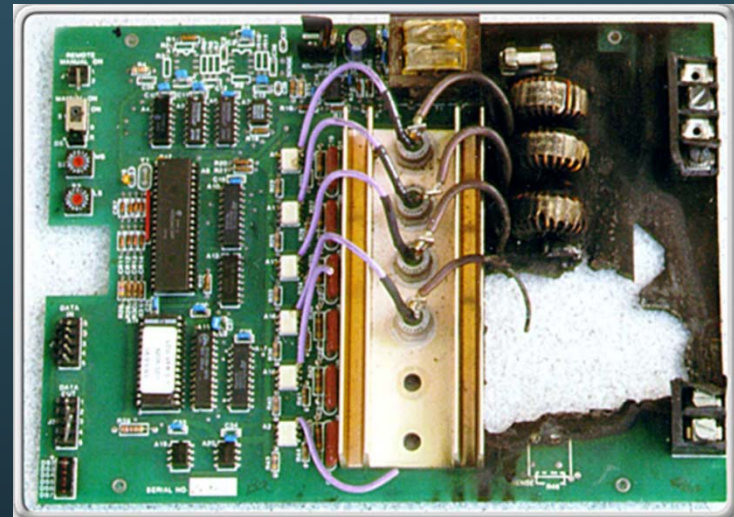
- Transients become an issue as VFDs and other electronic equipment grow in popularity.
- Transients can damage electrical equipment throughout the system (VFDs, PLCs, Soft-starters, Power Meters, etc.)
- Transients are passed down through the Utility Transformer from other areas of the distribution system, as well as produced by equipment that may be internal to your electrical system.



PREVENT TRANSIENTS FROM DAMAGING YOUR SYSTEM

Surge Protection

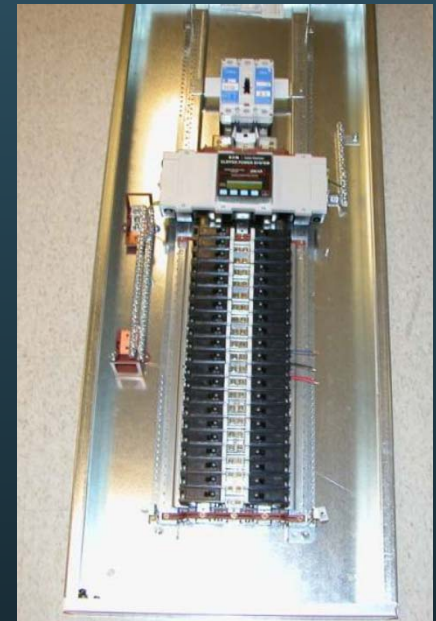
- Lead length is monumentally important to the effectiveness of a surge protector. **Manufacturers rate surge protectors based on 6" of lead length.**
- Several installations exist that can minimize lead length.
 - Side mounted
 - Internally mounted
 - Bus mounted



SURGE PROTECTION INSTALLATION

6,000V Surge on a 120V Panel

Installation	Lead Length	Let-Through Voltage
Side Mounted SPD	36"	520V
Internally Mounted SPD	6"	358V
Bus Mounted SPD	Zero	325V



LOCATIONS FOR SPD TYPES

Type 1

Before service disconnect (A)

Type 3 (Type 1 and 2 permitted)

Point of use
Minimum 30 feet of conductor between service disconnect and SPD

Type 2 (Type 1 permitted)

After service disconnect (B)

Type 2 (Type 1 permitted)

Point of use, Branch Panels & Distribution Panels (C & D)



A Before Service Disconnect

Eaton SPD Series (with basic package), CVX or SP1
Any kA Rating



B After Service Disconnect

Eaton SPD Series (all packages)
≥ 800A = 250 kA to 300 kA
< 800A = 160 kA to 200 kA



C Distribution Panels / MCC's

Eaton SPD or SPV Series
80 kA to 160 kA



D Branch/Sub Panel's

Eaton SPD, SPV or CVX Series
50 kA to 120 kA



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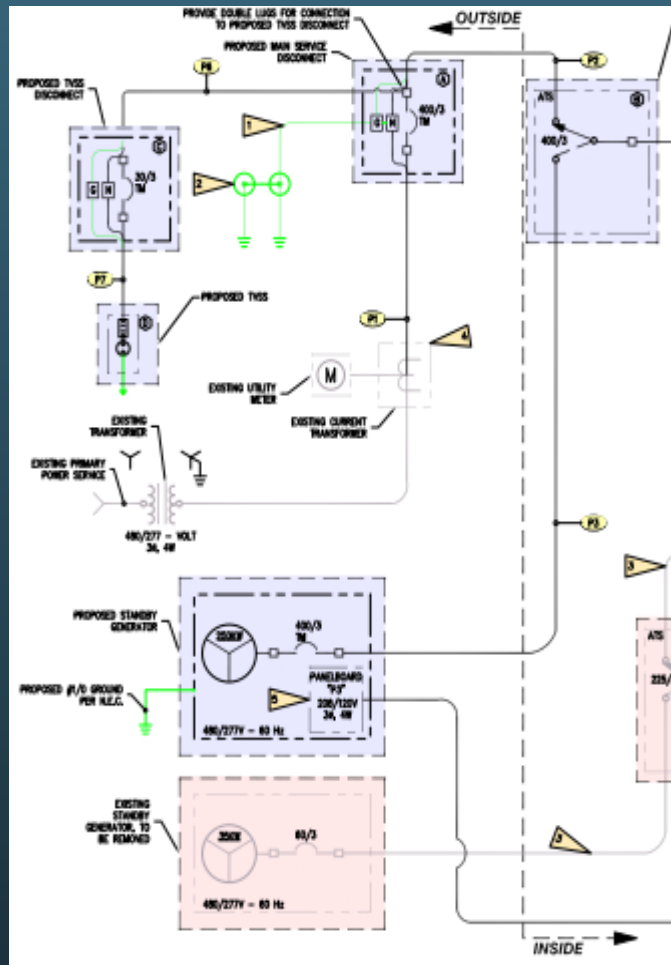
BACKUP POWER SUPPLY SYSTEM INSTALLATION CRITERIA

Projects involving a backup power supply usually fit one of the following criteria:

- Existing facility that has no existing backup power supply connected to the power distribution system.
- Existing facility only has a connection available for a portable generator.
- Facility has an existing permanent generator that is not large enough to provide backup power to the entire facility.
- Proposed facility where a generator will be included in the construction of the facility.



BACKUP POWER SUPPLY SYSTEM INSTALLATION CRITERIA



- Integration of generator and automatic transfer switch into an existing power distribution system.
- Identify space to locate the generator and transfer switch.
- Outdoor Generator Installations – Provide access and protection for the generator.
- Indoor Generator Installations – Generator cooling, exhaust, and fuel provisions.

SELECTING THE RIGHT GENERATOR

- Visit facility and take inventory of all electrical loads and equipment.
- Review as-built drawings to identify electrical load demand factors and calculations.
- Operate facility at maximum load and monitor power usage.



SELECTING THE RIGHT GENERATOR

- Review 1 years worth of utility bills to estimate usage (only applies to facilities that are charged for demand loads)
- Review operational requirements of equipment.
- Perform electrical load calculations and use generator sizing software to determine the required generator size.



AUTOMATIC TRANSFER SWITCH INSTALLATION AND INTEGRATION

- The automatic transfer switch monitors utility power and sends the start signal to the generator after utility power is lost. After the generator is operational, the transfer switch transfers the facility power to the generator.
- After utility power has returned for a programmed period of time, the transfer switch switches the facility back to utility power.
- The transfer switch also controls the cool down operation of the generator and the periodic exercising of the generator.
- Several time delay settings are integrated into the transfer switch control for transferring between utility and backup power.



AUTOMATIC TRANSFER SWITCH INSTALLATION AND INTEGRATION



- Provide proper overcurrent protection on both sides of the transfer switch.
- Locate the transfer switch to minimize conduit and conductor installation lengths to reduce cost.
- Provide adequate space and working clearances around the transfer switch. Transfer switches are a common source for arc flash and creating transients in the power system.

GENERATOR FUEL SUPPLY

Diesel Versus Natural Gas/Propane Fueled Generators:

- Diesel fueled generators are the most common.
- Natural gas fueled generators rely on availability from the gas utility which may not be available at all times. A main break resulting from an earthquake is one example.
- Natural gas and propane fueled generators are comparable in cost to diesel fueled generators up to about 150 kW depending on the manufacturer. The cost can be almost double for natural gas and propane fueled generators above 150 kW.

GENERATOR FUEL SUPPLY

Determining Fuel Storage Requirements:

- A standard sub-base generator fuel tank allows for 24 hours of fuel storage.
- After the long term power outages in winter of 2006, more utilities are requesting at least 3 days of fuel storage. Utilities had difficulty getting fuel trucks to facilities to refuel generators due to diesel fuel demand.



GENERATOR FUEL SUPPLY

Determining Fuel Storage Requirements:

- Important that utilities must monitor fuel consumption and be aware of how much fuel is in each generator at all times. 3 days of fuel storage won't do much good if the tank only has 12 hours of fuel remaining.



GENERATOR FUEL SUPPLY

International Fire Code Compliance:

- Fuel tank installations require a fuel tank permit and are subject to review by the local fire department to determine if it is in compliance with the international fire code.
- We have found that fire code requirements can be interpreted differently in different jurisdictions.
- Not paying attention to fire code requirements during design can lead to change orders during design for fuel tank modifications.
- Request a plan review during design by the fire marshal, City permitting department, or County permitting department.



GENERATOR FUEL SUPPLY

Common Fire Code Issues:

- Venting
- Distance from openings in buildings (5 feet) and property lines (15 feet).
- Fuel fill requirements such as drop tubes, overfill prevention, and spill containment.
- Fuel level monitoring (low, high (90%), and high-high (95%))
- Leak detection monitoring.
- Impact protection (vehicle, gunfire, and explosions)



RECOMMENDED ASSESSMENT AND MAINTENANCE OF ELECTRICAL SYSTEMS

- Visual assessment of electrical distribution equipment, instrumentation and telemetry equipment, and backup generators
- Equipment age
- Spare part availability
- Thermography testing of electrical equipment including circuit breakers, motor starters, transformers, transfer switches, and electrical terminations



RECOMMENDED ASSESSMENT AND MAINTENANCE OF ELECTRICAL SYSTEMS

- Conductor continuity testing
- Grounding system electrode testing
- Review of National Electrical Code (NEC) compliance for each facility
- Arc flash hazard warning compliance



VISUAL ASSESSMENT

Evaluate of condition of both exterior and interior of electrical equipment on a regular basis. Interior evaluation requires de-energizing of equipment.

- Equipment and conductor corrosion
- Water damage to equipment
- Accumulation of dust or dirt in the equipment
- Identify potential arcing or shock hazards
- Pest infestation
- Damaged or inoperable equipment
- Loose terminations
- Missing labels
- Missing documentation



VISUAL ASSESSMENT: PEST INFESTATION AND CORROSION



Corrosion at
conductor
termination

Pump control panel
with rodent
infestation and
damage to wiring

VISUAL ASSESSMENT: ARCING AND SHOCK HAZARD

Variable
frequency drive
enclosure with
burn damage
indicating arcing
inside enclosure



THERMOGRAPHY TESTING

- A thermography analysis (infrared electrical/mechanical inspection) identifies hot spots for electrical equipment, conductors, and terminations which can provide the Owner with advanced notice of which equipment may soon fail or requires maintenance.
- This is a more in depth assessment of the equipment and identifies problems that can't be seen with a visual assessment.

THERMOGRAPHY TESTING

Existing City owned pad-mount transformer. A thermography test performed on the transformer indicated that the transformer may soon fail.



New pad-mount transformer



SDMVERS Data Processing Division TCF 9181

Customer: TERRY ADVANCED ELECTRICAL TESTING Co. JAMES WA Location: OUTDOOR
 Sub Name: WPA 2 Unit No. Unit

NAMEPLATE DATA

Manufacturer	Model Number	Transformer Type	Transformer	Rating	Phase	Additional Equipment
GE	1500VA	1500VA	1500VA	1500VA	3	1500VA
Primary Voltage	240	Secondary Voltage	120	Impedance	5.75%	Temperature Class
Secondary Voltage	120	Impedance	5.75%	Temperature Class	150C	Power Available

WINDING INFORMATION

UNIT	LEVEL	SAMPLE TEMP	TOP TEMP	RY	FRONT	LEADS	DATE	SERVICE
010000	100000							

ADDITIONAL INFORMATION

Reason for Test:

FIELD SCREEN TEST DATA

DATE	SERVICE	NOV	BY	DEL BY	DEL VOLT	DEL CUR	SP-INDIC	WINDING	REMARK
01/00/00	100000	000000	000000	000000	1.0000	0.0000	000000	000000	000000

ANALYSIS COMMENT

DATE: PCT BY: WIGHT

LEGAL POWER FACTOR

DATE	BY	TIME
01/00/00	000000	00:00:00

NOV 10 10:00 AM '00

Example thermography test report for transformer



RECOMMENDED ASSESSMENT AND MAINTENANCE OF BACKUP POWER SYSTEMS

- Visual inspection
- Review and log total hours of operation
- Review maintenance history
- Perform a load bank test annually to verify performance at different kilowatt ranges. This provides insight into whether the generator is having performance issues.
- Mechanical inspection of the generator by a generator service representative or utility maintenance crew
- Perform regularly scheduled service of the generator (similar to a vehicle)



BACKUP GENERATOR SYSTEM ASSESSMENT

Existing Generator



- Existing direct natural gas fuel supply from utility was unreliable in the event of a gas main break or shutoff from the utility.
- Generator was inadequately sized to provide backup power for all critical facility electrical loads.

Replacement Generator and Fuel System



- New generator adequately sized for providing backup power to entire facility.
- New diesel fuel tank containing 1 weeks supply of fuel in the event of a prolonged power outage.

QUESTIONS?

- Lock out/Tag out
- Arc Flash Analysis
- Personal Protective Equipment (PPE)
- Networked MCCs (Ethernet/IP)
- Surge Protection
- Backup Power Systems
- Reliability, Assessment, and Maintenance

