An Overview of Electrical System Components for Mission Critical Facilities: Part 1

by

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A. Introduction

This course is developed to provide a course on the function of Electrical System components for Mission Critical facilities. This course along with part-1 and part-2 covers from Utility service to the rack level electrical distribution standard practice for mission critical facilities. This course is also "introductory" in nature in that it will cover basic functions of different electrical systems. This course may be considered a good refresher course for those who work in the mechanical/electrical engineering field and already have a familiarity with Mission critical facilities systems.

The learning objectives of this course will be a high level review of electrical systems as they relate to Mission critical facilities, and to learn about good engineering practices for electrical systems of mission critical facilities and how they affect performance.

This course is intended to be useful to individuals at all levels of experience as well as a topic of interest to the full variety of those of an engineering (civil, mechanical, electrical, etc.), architectural, and/or facilities management background. As a result, some basics will be touched upon that may seem rudimentary to some, but for others will be useful to hear for the first time or as a refresher. Regardless, it should be valuable to establish this information and have it in one place for the reader's reference.

The reader of this course should be able to use the tools gained to have an even greater understand of Electrical system applications for Mission Critical facilities.

B. General

The electrical distribution system for Mission Critical facilities requires that all contamination and potential contamination from other loads within the facility be eliminated. Accordingly, the design development must reflect this requirement. A separate dedicated feeder directly from the main service entrance to the Mission Critical facility's distribution system should be provided. This feeder will be dedicated to the critical equipment loads. Similarly, the ground should be to a single central grounding point. This should be the single point where interconnected parts of the critical facilities' grounding system are connected to other ground connectors, which extend beyond and outside of the Mission Critical facility.

C. Utility Service

Public utilities are typically a reliable source of general power. The utility distribution system allows rerouting of source when outages occur; however, a failure at the utility entrance to the site can result in a complete outage. It is for this reason that a second utility feeder on a distinct route is recommended. Additionally, should a substation outage occur, even separate feeders would be useless; therefore, it is recommended that whenever possible, the second feeder be fed from a separate substation. It is preferred that overhead exposure (pole-mounted conductors) be avoided to reduce disruption of service commonly caused by animals, weather, or automobiles; however, the end user generally has no control over this.

D. Service Transformer

The electrical power transmitted by the utility is generally at a higher voltage than is used on the site. A transformer is used to step down the transmission voltage to the voltage used throughout the site. This transformer may be utility-owned or owned by the customer. In either case, as in all equipment, there will eventually be a failure and requirement for repair and/or replacement. At that point, the power will be out for the facility. The recommendation is to have the separate utility feeder supply a separate transformer and thereby have redundancy established. There should be an automatic transfer/bypass capability between the source supply to the transformers. Both the transformers and all switches should be located inside the facility in separate fire-rated areas or vaults to avoid the potential for damage or vandalism.

E. Main Service Switchgear

Each service transformer should be fed from separate high voltage switches. These switches will be connected to alternate high voltage feeders. A normally open tie switch should connect the separate 480V buses and be interlocked to prevent both switches from being closed at the same time.

The secondary voltage from the service transformers should feed separate main switchboards located in separate fire-rated rooms. The switchboards should be interconnected to allow automatic transfer to the standby power system. This concept eliminates the single point of failure of equipment, feeder, and source at all points.

F. Alternate Power Source

In the event utility service is unavailable, an alternate power source such as standby generators should be included. The generator power plant should be sized to support both the critical load and the environmental support systems and infrastructure (lights) to maintain the operational environment. By using standby generators, the interruption resulting from a utility source service or transformer failure is reduced to the time it takes to get the generators online. The generator voltage should be the same as the service transformer secondary.

The generator paralleling switchboard allows the generators to operate concurrently, feeding a common bus for capacity and redundancy. The generator plant can feed each main switch. Should it be desirable, the paralleling switch could also be set up to co-generate with the utility and thereby gain cost savings/avoidance.

In order to exercise the generator plant and/or to test an individual generator after repair or maintenance, a test switchboard should be included. This switchboard would be connected to a load bank and enable testing of the generators and UPS systems under simulated load. The test bus also would allow the redundant generator to support a failed generator in the event the generator paralleling bus is out of service.

G. Transfer of Source

There are two ways to achieve the transfer of power between normal (utility) and standby (generator) sources. When the generator is isolated from the utility when supporting the critical loads of facility, either an automatic transfer switch or paralleling switchgear with motorized circuit breakers can be used.

Paralleling Switch

While synchronizing with the utility can be an effective way to avoid costs and maximize the return on investment, it is important to recognize the primary justification for a standby generator for Critical facility is not energy savings, but operational reliability. The costs associated with critical facility downtime are generally sufficient to justify the capital costs without including energy savings. The only advantage to using a synchronizing switchgear is the ability to support loads other than the critical facility with "excess" generator capacity.

The synchronizing gear allows the generator to run in the same phase and voltage characteristics as the utility; thereby sharing the load and decreasing the amount of power consumed from the utility. The utility generally requires safety devices to disconnect the generator from service if the generator becomes out of sync with the utility. The Critical facility operation would require that in the event of power failure, only critical facility loads be supported by the generator. This will require motorized breakers to load the critical facility and off load other facility loads. It will also allow the generator to be isolated from the utility when utility power is off. This is necessary since at times, when utility service is disrupted, it often is an "on again-off again" scenario. Such alternating between utility and generator must be avoided and the isolation will allow time for the utility service to be stabilized before returning to the utility grid. During such time only Critical facility loads should be connected. This will avoid any overloading of the generator from unrelated facility loads.

Automatic Transfer Switch (ATS)

The automatic transfer switch provides the smooth transfer of load to the alternate source (generator) whenever the utility power characteristics are out of tolerance. It allows for the complete isolation from utility and is the most common way the standby generator systems are connected. It is important when using an automatic transfer switch that full isolation bypass capability is provided. This feature allows the automatic portion of the switch to be manually bypassed for repair and/or maintenance. The ATS should be equipped with open transition time between the opening of the utility source contacts and the closing of the generator source contacts to prevent paralleling of the differing sources.

Figure 5.6.1: Standard Transfer Switch

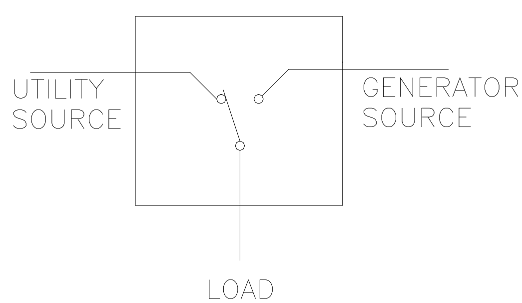
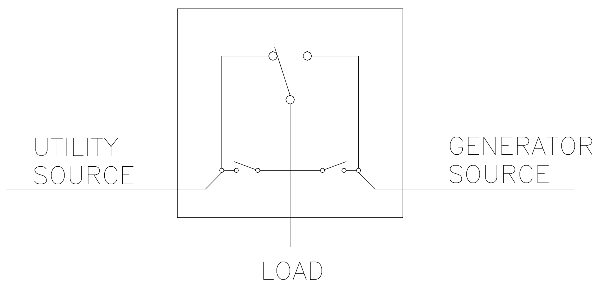
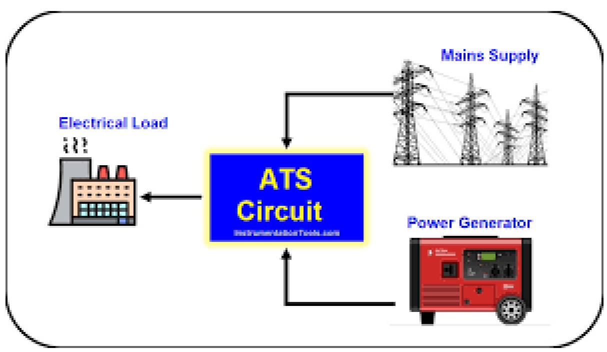


Figure 5.6.2: Transfer Switch with Isolation Bypass





The single disadvantage to the ATS is that the generator will only generate power to support the load connected to the ATS. This eliminates the ability to effectively use "excess" generator capacity. However, many would not consider this a disadvantage at all since the primary and often only reason for the generator is to provide power for the Critical Facility when utility source is unavailable.

H. Test Switchboard

In order to exercise the generator plant and/or to test an individual generator after repair or maintenance, a test switchboard should be included. This switchboard would be connected to a load bank and enable testing of the generators and UPS systems under simulated load. The test bus also would allow the redundant generator to support a failed generator in the event the generator paralleling bus is out of service.

I. GENERAL ELECTRICAL DISTRIBUTION

In order to isolate the Mission Critical facility power source from other facility loads, it is recommended that segregated distribution panels be installed. These distribution panels should separately feed the Critical Facility loads and other loads, such as air conditioning systems, lighting, and general-purpose receptacles. The segregated feeders to the Critical Facility electrical distribution system shall be provided with a full (parity) sized ground, equal to that required for the phase conductors. These feeders should be sized to handle the full load of the Critical Facility equipment based upon the ultimate design load. The feeders to the other critical loads should be sized to include the maximum A/C power requirements, based upon the ultimate configuration, along with the lighting and other incidental loads.

Ground fault protection shall be limited to protect the critical loads from nuisance tripping during activation of ground fault protection. This is especially applicable to parallel UPS configurations. All input Ground Fault Interruption (GFI) protection to UPS systems should be properly analyzed to determine that the GFI would not inhibit the UPS system functionality. Any UPS circuits extending beyond the Critical facility envelope shall be ground fault protected.

In order to limit single points-of-failure, the electrical distribution system should be designed using redundant distribution from alternate main switchboards. This distribution will allow the critical power distribution system to achieve redundancy for both power and HVAC systems. When necessary, the distribution panelboard will contain a kirk key arrangement or manual transfer switch to avoid simultaneous energization from different sources. Critical equipment such as critical facility, critical facility A/C units, chillers, and other environmental equipment should be fed from alternate sources to achieve a true dual bus topology. The term dual bus topology should be understood to include multiple bus configurations that achieve the same intent.

The feeders to the Mission Critical facility UPS and its distribution panels should consist of three phase conductors and a full-sized insulated ground conductor. All feeders should consist of cable in conduit, and both ends of the conduit should be connected and grounded. All cable should be copper and code type THHN/THWN. The feeders to 208Y/120-volt distribution and branch circuit panels serving any 120-volt circuits should have neutrals sized equal to the current ratings of the phase conductors.

All panelboards shall be constructed in accordance with code requirements and NEMA standard with UL rating. All bus shall be copper. Over current protection shall be provided. The panelboards shall have a short circuit current rating equal to or greater than the integrated equipment rating. Over current protection should be provided. A complete Short Circuit Coordination Study should be conducted and published. All circuit breakers should be tested to the NETA testing standards for circuit breakers to confirm compliance to the settings of the coordination study. An Arc Flash Analysis should also be included with the appropriate warning labels on all panels and switchboards.

Labels should be installed on all electrical panels to signify where the panels are fed, panel voltage, and designation. All circuit breakers in the panels should be labeled with their destination. Labels should be installed below the ceiling grid depicting important equipment/ devices in the ceiling and below the raised floor so that personnel can quickly find equipment/ devices.

J. TRANSIENT VOLTAGE SURGE SUPPRESSION (TVSS) (SPD)

Powerful, high speed, high-energy electrical spikes and surges threaten sensitive electronic equipment used in Critical facility, offices, and warehouses. Lightning, electrical short circuits, large motors, mechanical equipment, and elevators can all create surges that contribute to the degradation of microprocessor circuitry. Through magnetic induction, a lightning discharge two miles from an exposed overhead electrical line can produce a 20-thousand-volt surge. Electric utility distribution systems interconnect many different types of loads. The feeder and capacitor switching, used to control these circuits, cause disturbances. Large motors and machinery cause distortion to the power system due to the load of the motors. Electrical and electronic equipment can create smaller voltage fluctuations called noise.

Transient Voltage Surge Suppressors (TVSS) or Surge Protection Devices (SPD), when installed at critical panelboards and main switchgear, can provide additional protection from internal and external electrical surges. The TVSS device should be installed on the secondary side of the building transformer where high-energy spikes can be shunted to ground.

K. LIGHTNING PROTECTION

Lightning is an electrical discharge originating in the atmosphere that contains enormous amounts of energy. Each stroke may contain a peak current of 100,000 amperes and voltage up to 100,000,000 volts over a period of 30 to 50 microseconds. The most destructive lightning may contain up to ten such strokes resulting in a total duration approaching one second. The result of a lightning strike can be structural damage, ignition of combustibles and/or electrical system damage.

A lightning protection system is designed to intercept the lightning flash and dissipate it harmlessly to ground while at the same time protecting the structure from induced lightning currents and transient voltage surges. The exterior system consists of air terminals, ground terminations and down conductors. The interior system consists of loop conductors, bonding conductors, and other devices to achieve equalization of ground potential within the structure. Lightning protection system design should comport with UL standards for Master Label systems.