Section 9: Power Distribution Equipment

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Introduction

Power Distribution Equipment is a term generally used to describe any apparatus used for the generation, transmission, distribution, or control of electrical energy. This section concentrates upon commonly-used power distribution equipment: Panelboards, Switchboards, Low Voltage Motor Control Centers, Low Voltage Switchgear, Medium Voltage Power and Distribution Transformers, Medium Voltage Metal Enclosed Switchgear, Medium Voltage Motor Control Centers, and Medium Voltage Metal-Clad switchgear. Each has its own unique standards and application guidelines, and one facet of good power system design is the knowledge of when to apply each type of equipment and the limitations of each type of equipment. All of these equipment described herein are typically custom-engineered on a per-order basis.

NEMA enclosure types

One common characteristic of all of the equipment types covered in this section is that they are all enclosed for safety. The enclosures for enclosed equipment generally follow the guidelines set forth in NEMA 250-2003 [1], and, although this standard is intended for equipment less than 1000 V, this is true of medium voltage power equipment also.

The most common NEMA enclosure types are described as follows [1]:

Type 1: Enclosures constructed for indoor use to provide a degree of protection to personnel against access to hazardous parts and to provide a degree of protection of the equipment inside the ingress of solid foreign objects.

Type 3R: Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (falling dirt and windblown dust); to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (rain, sleet, snow); and that will be undamaged by the external formation of ice on the enclosure.

Type 4: Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (falling dirt and windblown dust); to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (rain, sleet, snow, splashing water, and hose directed water); and that will be undamaged by the external formation of ice on the enclosure.

Type 4X: Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (windblown dust); to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (rain, sleet, snow, splashing water, and hose directed water); that provides an additional level of protection against corrosion; and that will be undamaged by the external formation of ice on the enclosure.

Type 5: Enclosures constructed for indoor use to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection of the equipment inside the enclosure against the ingress of solid foreign objects (falling dirt and settling airborne dust, lint, fibers, and flyings); and to provide a degree of protection with respect of harmful effects on the equipment due to the ingress of water (dripping and light splashing).

Type 12: Enclosures constructed (without knockouts) for indoor use to provide a degree protection to personnel against access to hazardous parts; to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (falling dirt and circulating dust, lint, fibers, and flyings); and to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (dripping and light splashing).

Panelboards

Table 9-1: Quick reference – Panelboards

Available voltage ratings	120-600 V
Available current ratings	30-1200 A
Available short-circuit ratings	Through 200 kA
Major industry standards	UL 50, UL 67, CSA C22.2 No. 29, CSA C22.2 No. 94, NEMA PB 1, Federal Specification W-P-115C, NEC
Typical enclosure types	1, 3R, 5, 12
Primary NEC requirements	Article 408

Panelboards are the most common type of power distribution equipment. A panelboard is defined as "a single panel or group of panel units designed for assembly in the form of a single panel, including buses and automatic overcurrent devices, and equipped with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall, partition, or other support; and accessible only from the front" [2]. It typically consists of low voltage molded-case circuit breakers arranged with connections to a common bus, with or without a main circuit breaker. Figure 9-1 shows typical examples of panelboards.

Figure 9-1: Panelboards

Panelboards are used to group the overcurrent protection devices for several circuits together into a single piece of equipment. In small installations they may serve as the service equipment. The NEC [2] divides panelboards into two categories:

Lighting and Appliance Branch-Circuit Panelboard: A panelboard having more than 10 percent of its overcurrent devices protecting lighting and appliance branch circuits.

Power Panelboard: A panelboard having 10 percent or fewer of its overcurrent devices protecting lighting and appliance branch circuits.

Lighting and appliance branch-circuit panelboards are limited to a maximum of 42 overcurrent devices, excluding mains. UL 67 [3] designates Class CTL *Panelboard* as the marking for appliance and branch circuit panelboards; CTL stands for "circuit limiting." In some manufacturer's literature lighting and appliance branch-circuit panelboards for residential or light commercial use are referred to as loadcenters.

Panelboards are available with built-in main devices or as *main lugs only* (MLO). The NEC [2] requires appliance and branch circuit panelboards to be individually protected on the supply side by not more than two main circuit breakers or two sets of fuses having a combined rating no greater than the rating of the panelboard. Lighting and appliance branch circuit panelboards are not required to have individual protection if the feeder overcurrent device is no greater than the rating of the panelboard. Power panelboards must be protected by an overcurrent device with a rating not greater than that of the panelboard [2].

Various methods for attaching the circuit breakers to the panelboard bus are available, such as plug-on, bolt on, etc. The circuit breakers are typically purchased separately. Often, *the enclosure*, interior, and trim assemblies for the panelboard itself are purchased separately as well. This is typically true of larger panelboards and gives a great deal of flexibility with regard to use of the same interior with different enclosures and trims.

Panelboards are available with a number of accessories. *Subfeed lugs* allow taps directly from the panelboard bus without the need for overcurrent devices. Circuit breaker locking devices allow locking of circuit breakers in the open or closed position (note that the breakers will still trip on an overcurrent condition). Various types of trims are available, with various locking means available for trims that are equipped with doors.

Switchboards

Table 9-2: Quick reference – Switchboards

Available voltage ratings	120-600 V
Available current ratings	800-5000 A
Available short-circuit ratings	Through 200 kA
Major industry standards	UL 891, NEMA PB 1, NEC
Typical enclosure types	1, 3R
Primary NEC requirements	Article 408

The definition of a switchboard is “a large single panel, frame, or assembly of panels on which are mounted on the face, back, or both, switches, overcurrent and other protective devices, buses, and usually instruments” [2]. Switchboards are free-standing equipment, unlike panelboards, and are generally accessible from the rear as well as from the front. They may consist of multiple sections, connected by a common through-bus. Unlike panelboards, the number of overcurrent devices in a switchboard is not limited.

Switchboards generally house molded case circuit breakers or fused switches. They are generally the next level upstream from panelboards in the electrical system, and in some small to medium-size electrical systems they serve as the service equipment. Figure 9-2 shows an example of a switchboard.

Figure 9-2: Switchboards

Switchboards are available with a main circuit breaker or fusible switch, or as main-lugs only. The available ampacities and multi-section availability makes them more flexible than panelboards. They are generally available utilizing either copper or aluminum bussing, and with a variety of bus plating options. Custom bussing for retrofit applications is also possible.

Switchboard circuit breakers may be *stationary-mounted* (also referred to as *fixed-mounted*), where they can be removed only by unbolting of electrical connections and mounting supports, or *drawout-mounted*, where they can be without the necessity of removing connections or mounting supports. It is possible to insert and remove drawout devices with the main bus energized. The section which contains the main circuit breaker(s) or service disconnect devices is referred to as a *main section*. A section containing branch or feeder circuit breakers is referred to as a *distribution section*.

Devices mounted in the switchboard may be either *panel mounted* (also referred to as *group mounted*), where they are mounted on a common base or mounting surface, or *individually mounted*, where they do not share a common base or mounting surface. Individually mounted devices may or may not be in their own compartments. A device which is segregated from other devices by metal or insulating barriers and which is not readily accessible to personnel unless special means for access are used is referred to an *isolated device*. Figure 9-3 shows examples of sections with group-mounted individually-mounted device.

The main through-bus is often referred to as the *horizontal bus*. The bussing in a section which connects to the through-bus is referred to as the *section bus* (also known as *vertical bus*). The bussing that connects the section bus to the overcurrent devices is referred to as the *branch bus*. Section and branch busses may be smaller than the main through-bus; if this is the case UL 891 [2] gives the required section bus size as a function of the number of overcurrent devices connected to it.

a.) b.)

Figure 9-3:

a.) Group-mounted devices

b.) Individually-mounted devices

Switchboards are available with a number of accessories, including custom-engineered options such as utility metering compartments, automatic transfer schemes, and modified-differential ground fault for switchboards with multiple mains. However, the internal barriering requirements are minimal.

Low voltage motor control centers

Table 9-3: Quick reference – Low voltage motor control centers

Available voltage ratings	120-600 V
Available current ratings	600-2500 A
Available short-circuit ratings	Through 100 kA
Major industry standards	NEMA ICS-18, UL 845, NEC
Typical enclosure types	1, 3R, 12
Primary NEC requirements	Article 430

A motor control center (MCC) is defined as “a floor-mounted assembly of one or more enclosed vertical sections typically having a common power bus and typically containing combination motor control units” [5].

Motor control centers are used to group a number of combination motor controllers together at a given location with a common power bus. Figure 9-4 shows an example of a motor control center.

Figure 9-4: Low voltage motor control center

MCCs are classified into two classes by [5] and [6]:

Class I Motor Control Centers: Mechanical groupings of combination motor control units, feeder tap units, other units, and electrical devices arranged in an assembly.

Class II Motor Control Centers: A Class I motor control center provided with manufacturer-furnished electrical interlocking and wiring between units, as specifically described in overall control system diagrams supplied by the user.

MCC wiring is classified by [5] and [6] into three types:

Type A Wiring: User (field) load and control wiring are connected directly to device terminals internal to the unit; provided on Class I MCCs only.

Type B Wiring: User (field) control wiring is connected to unit terminal blocks; the field load wiring is connected either to power terminal blocks or directly to the device terminals.

Type C Wiring: User (field control wiring is connected to master terminal blocks mounted at the top or bottom of vertical sections which contain combination motor control units or control assemblies; the field load wiring is connected to master power terminal blocks mounted at the top or bottom of vertical sections or directly to the device terminals.

MCCs generally consist of a common power bus and a vertical bus for each section to which combination motor controllers are plugged on. The individual plug-in units are often referred to as *buckets* and may be inserted and removed with the main bus energized so long as the disconnecting device for the individual unit is open. A vertical *wireway* is supplied internal inter-unit connections and field connections within each section.

MCCs offer the opportunity to group several motor starters together in one location with a space-efficient footprint vs. individual control cabinets, and like switchboards are available with many options. Removable plug-on units allow quick change-outs if spare units are kept on hand for the most common sizes of starters in the facility. Low voltage soft-starters and variable-speed drives may also be mounted within MCCs.

Low voltage switchgear

Table 9-4: Quick reference – Low voltage switchgear

Available voltage ratings	120-600 V
Available current ratings	1600-5000 A
Available short-circuit ratings	Through 200 kA
Major industry standards	ANSI/IEEE C37.20.1, ANSI/IEEE C37.51, NEMA SG-5, CAN/CSA C22.2 NO 31-M89, UL 1558
Typical enclosure types	1, 3R

Low voltage switchgear, more properly termed *metal – enclosed low voltage power circuit breaker switchgear*, is defined per [7] as "LV switchgear of multiple or individual enclosures, including the following equipment as required:

- Low voltage power circuit breakers (fused or unfused) in accordance with IEEE Std. C37.13-1990 or IEEE C37.14-1999
- Bare bus and connections
- Instrument and control power transformers
- Instruments, meters, and relays
- Control wiring and accessory devices

Low voltage power switchgear is the preferred equipment for medium to large industrial systems where the advantages of low voltage power circuit breakers, discussed in Section 7, can be utilized to enhance coordination and reliability. It is typically used as the highest level of low voltage equipment in a facility of this type and, if the utility service is a low voltage service, the service entrance switchgear as well. Figure 9-5 shows an example of low voltage switchgear.

Low voltage switchgear, although it performs the same functions and has comparable availability of voltage and ampacity ratings as switchboards, represents a different mode of development from switchboards and is, in general, more robust, both due to the construction of the switchgear itself and due to the characteristics of low voltage power circuit breakers vs. molded-case circuit breakers. For this reason it is preferred over switchboards where coordination, reliability, and maintenance are a primary concern.

Figure 9-5: Low voltage Switchgear

Low voltage switchgear is compartmentalized to reduce the possibility of internal fault propagation. ANSI C37.20.1 [7] requires each breaker to be provided with its own metal-enclosed compartment. Optional barriers are usually available to separate the main bus from the cable terminations, forming separate bus and cable compartments within a section, as well as side barriers to separate adjacent cable and bus compartments.

All low voltage switchgear is required to pass an AC withstand test of 2.2 kV for one minute [7].

As with switchboards, low voltage switchgear is available with many options. The options are generally more numerous than those for switchboards due to the nature of switchgear service conditions.

Medium voltage power and distribution transformers

Table 9-5: Quick reference – Medium voltage power and distribution transformers

Available primary voltage ratings	2400 - 38 kV
Available secondary voltage ratings	120 - 15 kV
Available kVA ratings	Through 10,000 kVA
Major industry standards	ANSI/IEEE C57 Series (All Types) UL 1562 (Dry and Cast-Resin Types)
Typical enclosure types	1, 3R

Medium voltage power and distribution transformers are used for the transformation of voltages for the distribution of electric power. They can be generally classified into two different types:

Dry-Type: The windings of this type of transformer are cooled via the circulation of ventilating air. The windings may be one of several types, including Vacuum Pressure Impregnated (VPI), Vacuum Pressure Encapsulated (VPE), and Cast-Resin. The Cast-Resin types generally are more durable and less likely to absorb moisture in the windings than the VPI or VPE types. In some cases the primary windings are cast-resin and the secondary windings are VPI or VPE.

Liquid-Filled: The windings of this type of transformer are cooled via a liquid medium, usually mineral oil, silicone, or paraffinic petroleum-based fluids.

Liquid-filled units have a generally low in first-cost, but the requirements in NEC [2] Article 450 must be reviewed to insure that installation requirements can be adequately met, and maintenance must be taken under consideration since fluid levels should be monitored and the condition of the fluid examined on a regular basis. They have an expected service life of around 20 years. VPE and VPI dry-type transformers also generally have low first-costs, have longer lifetimes than liquid-filled units, and are much easier than liquid-filled types to install indoors; however, consideration should be given to the absorption of moisture by the windings if these are used outdoors. Installed indoors, these have expected service lifetimes of around 30 years. Cast-resin, dry-type transformers have generally high first-costs compared to the other types, but have the same installation requirements as dry-type transformers and have the longest expected service life (around 40 years).

Enclosure styles may also be divided into two basic types: *pad-mounted*, which is a totally-enclosed type generally mounted outdoors and with specific tamper-resistance features to prevent inadvertent access by the general public, and *unit substation* type, which is an industrial-type enclosure suitable for close-coupling into an integrated unit substation lineup with primary and secondary equipment (note that unit substation-style transformers may also be equipped with cable termination compartments as well).

Figure 9-6 shows typical examples of medium voltage power and distribution transformers.

Medium voltage power and distribution transformer capacities may be increased with the addition of fans. Cooling types are listed as AA (ambient air) for dry-type transformers without fans, and AA/FA (ambient air/forced air) for dry-type transformers with fans, for an increase of 33% in kVA capacity. The cooling type for a liquid-filled transformer is listed as OA for units without fans, OA/FA for units with fans, with an increase of 15% kVA capacity for units 225-2000 kVA, and 25% for units 2,500-10,000 kVA. “FFA” (future forced air) options are usually available for both dry and liquid-filled types, although experience has shown that the fans are almost never added in the field.

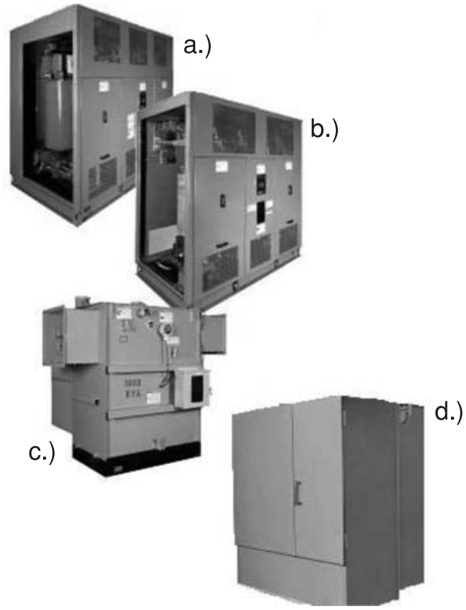

Figure 9-6: Medium Voltage Power and Distribution Transformers

a.) Cast-Coil Dry Type with Unit Substation-Style Enclosure

b.) VPI Dry-Type with Unit Substation-Style Enclosure

c.) Liquid-Filled Type with Unit Substation-Style Enclosure

d.) Dry-Type with Pad-Mounted Enclosure

Table 9-6 gives typical BIL levels for medium voltage power and distribution transformers. These apply to both the primary and secondary windings. Table 9-7 gives typical design temperature rises.

Table 9-6: Typical BIL levels for medium voltage power and distribution transformers

kV class	VPI/VPE dry-type BIL (kV)	Liquid-filled and cast-resin dry-type BIL (kV)
1.2	10	30
2.5	20	45
5.0	30	60
7.2	30	60
8.7	45	75
15.0	60	95
25.0	110	125
35.0	N/A*	150

* *VPI/VPE dry-type transformers are typically not available above 25.0 kV Class*

Table 9-7: Typical design temperature rises for medium voltage power and distribution transformers (over A 30˚C average/ 40˚C maximum ambient)

Transformer type	Temperature rise (˚C)
VPI/VPE dry-type	80, 115, or 150
Cast-coil dry-type	80 or 115
Liquid-filled	55/65 or 65

Impedance levels vary; the manufacturer must be consulted for the design impedance of a specific transformer. In general, units 1000-5000 kVA typically have 5.75% impedance ± 7.5% tolerance.

Medium voltage power and distribution transformers are typically available with several types of accessories, including connections to primary and secondary equipment, temperature controllers and fan packages, integral fuses for transformers with padmount-style enclosures, etc.

Medium voltage metal-enclosed interrupter switchgear

Table 9-8: Quick referencee: Medium voltage metal-enclosed switchgear

Available voltage ratings	2400 V - 38 kV
Available current ratings	600 - 2000 A
Available short-circuit ratings	Through 65 kA
Major industry standards	ANSI/IEEE C37.20.3
Typical enclosure types	1, 3R

Metal-enclosed power switchgear is defined by [8] as “a switchgear assembly enclosed on all sides and top with sheet metal (except for ventilating openings and inspection windows) containing primary power circuit switching or interrupting devices, or both, with buses and connections and possibly including control and auxiliary devices. Access to the interior of the enclosure is provided by doors or removable covers.” Metal-enclosed interrupter switchgear is defined by [8] as “metal-enclosed power switchgear including the following equipment as required:

- Interrupter switches
- Power fuses (current-limiting or noncurrent- limiting)
- Bare bus and connections
- Instrument Transformers
- Control wiring and secondary devices

Metal-enclosed interrupter switchgear is typically used for the protection of unit substation transformers and as service-entrance equipment in small- to medium- size facilities. Figure 9-7 shows an example of metal-enclosed interrupter switchgear.

Figure 9-7: Metal-enclosed interrupter switchgear

As with all fusible equipment, overcurrent protection flexibility is limited, however with current-limiting fuses this equipment has high (up to 65 kA rms symmetrical) short-circuit interrupting capability. The load interrupter switches in this class of switchgear are designed to interrupt load currents only, and may use air as the interrupting medium or SF_6. They may be arranged in many configurations of mains, but ties, and feeders as required by the application.

This type of switchgear is frequently used as the primary equipment of a unit substation line-up incorporating primary equipment, a transformer, and secondary equipment.

Table 9-9 shows the BIL levels of metal-enclosed interrupter switchgear, per [8]. The power frequency withstand is a one-minute test value. Momentary (10 cycle) and short-time (2s) current ratings are also assigned for this type of switchgear.

Table 9-9: Voltage withstand levels for metal-enclosed interrupter switchgear, per [8]

Rated Maximum Voltage (kV)	Power Frequency Withstand (rms) (kV)	Impulse Withstand (kV)
4.76	19	60
8.25	36	95
15.0	36	95
27.0	60	125
38.0	80	150

Internal barriering requirements for medium voltage areas within the switchgear are minimal. All low voltage components are required to be separated by grounded metal barriers from all medium voltage components. Interlocks are required to prevent access to medium voltage fuses while their respective switch is open and to prevent closing their respective switch while they are accessible. In the rare case that this type of switchgear contains drawout devices, shutters must be provided to prevent accidental contact with live parts when the drawout element is withdrawn.

Available options for this type of switchgear include shunt trip devices for the switches, motor operators for the switches, blown fuse indication, etc. Relaying of any type, including voltage relaying, must be carefully reviewed to avoid exceeding the limits of the switches. The application of overcurrent relaying to this type of switchgear is not recommended unless a short-circuit interrupting element is included, such as a vacuum interrupter.

Medium voltage motor control centers

Table 9-10: Quick referencee: Medium voltage motor conrol centers

Available voltage ratings	2400 V – 7.2 kV
Available current ratings	Through 3000 A
Available short-circuit ratings	Through 50 kA
Major industry standards	NEMA ICS-3, UL 347
Typical enclosure types	1, 3R

Medium voltage motor controllers are used to control the starting and protection for medium voltage motors. They generally utilize vacuum contactors rated up to 400 A continuous, in series with a non-load-break isolation switch and R-rated fuses, fed from a common power bus. The motor starting methods in Section 8 are all generally supported, including soft-start capabilities. Class E2 units per [9], which employ fuses for short-circuit protection, are generally the most common. Figure 9-8 shows a typical example of a medium voltage MCC.

Medium voltage MCCs are generally available with a number of options depending upon the manufacturer, including customized control and multi-function microprocessor-based motor protection relays. The contactors are generally of roll-out design to allow quick replacement.

Above 7200, metal-clad switchgear is generally used for motor starting.

Figure 9-8: Medium voltage MCC

Medium voltage metal-clad switchgear

Table 9-11: Quick referencee: Medium voltage metal-clad switchgear

Available voltage ratings	2400 V – 38 kV
Available current ratings	Through 3000 A
Available short-circuit ratings	Through 50 kA
Major industry standards	ANSI/IEEE C37.20.2
Typical enclosure types	1, 3R

Metal-clad switchgear is defined by [10] as “metal-enclosed power switchgear characterized by the following necessary features:

- The main switching and interrupting device is of the removable (drawout type) arranged with a mechanism for moving it physically between connected and disconnected positions and equipped with self-aligning and self-coupling primary disconnecting devices and disconnectable control wiring connections.
- Major parts of the primary circuit, that is, the circuit switching or interrupting devices, buses, voltage transformers, and control power transformers, are completely enclosed by grounded metal barriers that have no intentional openings between compartments. Specifically included is a metal barrier in front of, or a part of, the circuit interrupting device to ensure that, when in the connected position, no primary circuit components are exposed by the opening of a door.
- All live parts are enclosed within grounded metal compartments.
- Automatic shutters that cover primary circuit elements when the removable element is in the disconnected, test, or removed position.
- Primary bus conductors and connections are covered with insulating material throughout.
- Mechanical interlocks are provided for proper operating sequence under normal operating conditions.
- Instruments, meters, relays, secondary control devices, and their wiring are isolated by grounded metal barriers from all primary circuit elements with the exception of short lengths of wire such as at instrument transformer terminals.
- The door through which the circuit interrupting device is inserted into the housing may serve as an instrument or relay panel and may also provide access to a secondary or control compartment within the housing

Medium voltage metal-clad switchgear is generally used as the high-level distribution switchgear for medium- to large-sized facilities. It is also the preferred choice for service entrance equipment for these types of facilities. Figure 9-9 shows an example of metal-clad switchgear.

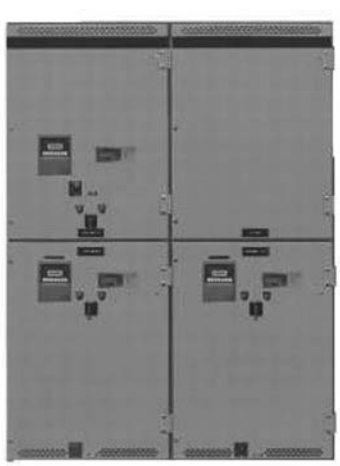

Figure 9-9: Metal-clad switchgear

Metal-clad switchgear uses high-voltage circuit breakers, as described in Section 7, fed from a common power bus. It is configurable in many different arrangements of main, bus tie, and feeder devices to suit the application. Relays are usually required since the circuit breakers generally do not have integral trip units. This type of switchgear is the preferred means for accomplishing automatic transfer control and complex generator paralleling applications; the control may be placed in the switchgear itself or in a separate panel, depending upon the application and specific end-user preferences.

The construction requirements per [10] insure that metal-clad switchgear is the safest type of switchgear in terms of operator safety.

The BIL and withstand voltage requirements for this switchgear are the same as for metal-enclosed switchgear as given in table 9-9 above.

This type of switchgear has many options available to suit the application, such as electric racking for circuit breakers, ground and test units that allow the grounding/testing of stationary contacts with a circuit breaker withdrawn, etc.

References

[1] Enclosures for Electrical Equipment (1000 Volts Maximum), NEMA Standards Publication 250-2003.

[2] The National Electrical Code, NFPA 70, The National Fire Protection Association, Inc., 2005 Edition.

[3] UL Standard for Safety for Panelboards, UL 67, Underwriters Laboratory, Inc., November 2003.

[4] UL Standard for Safety for Switchboards, UL 891, Underwriters Laboratories, Inc., February 2003.

[5] UL Standard for Safety for Motor Control Centers, UL 845, Underwriters Laboratories, Inc., August 2005.

[6] Motor Control Centers, NEMA Standards Publication ICS 18-2001

[7] IEEE Standard for Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear, IEEE Std. C37.20.1-2001, October 2002.

[8] IEEE Standard for Metal-Enclosed Interrupter Switchgear, IEEE Std. C37.20.3-2001, August 2001.

[9] Industrial Control and Systems: Medium Voltage Controllers Rated 2001 to 7200 Volts AC, NEMA Standards Publication ICS 3-1993.

[10] IEEE Standard for Metal-Clad Switchgear, IEEE Std. C37.20.2-1999, July 2000.