

The Application of Switchgear and Switchboards

by Jerry Milton, GE Systems Engineer

One important element of good power system design is the proper selection of the distribution equipment. The choice of using either switchgear or switchboards must be based on many different criteria and the design of the power system requires thought be given to each one. Following are insights into just a few of the differences to help in making those decisions.

Standards and Testing

Switchgear and switchboard structures are built and tested to different standards: Switchgear to ANSI standard C37.20.1, UL standard 1558, and NEMA standard SG-5, switchboards to NEMA PB-2, and UL-891. Switchgear incorporates only low-voltage power circuit breakers (LVPCB) which conform with ANSI C37.13, NEMA SG-3 and are listed per UL-1066, whereas switchboards may include any combination of protective devices including insulated case (ICCB), molded-case circuit breakers (MCCB) listed per UL-489, fusible switches listed per UL-508 and 977 and power circuit breakers listed to UL-1066.

Unfused switchgear is short circuit tested at 15% power factor for a full 30 cycles, while switchboards are tested at 20% power factor for only 3 cycles. The higher 30-cycle delay time and lower power factor test point require the switchgear structure, including bus, be built to withstand harsher electrical and mechanical stresses for a longer time. Because of the limited 3-cycle short circuit test duration applied to most switchboards, all of its protective devices must have instantaneous trip functions to maintain the UL 891 label, limiting selectivity between its main and feeder circuits.

Switchboard testing is based on system nominal voltage rating levels (i.e. 240V, 480V, 600V). Switchgear standards, however, recognize actual conditions may vary beyond that and stipulate maximum voltage levels at nominal plus 5.8% (i.e. 480V nom, 508V max). Dielectric tests are also different: switchboard tests are limited to twice rated voltage plus 1000V phase-to-phase and phase-to-ground (i.e. 240V system = 1480V test); switchgear is tested to 2200V in all cases.

Structures

Switchgear and individually compartmented switchboards require rear access for terminating incoming line and outgoing feeder cables. Group-mounted switchboards, however, are typically front-access-only for incoming line and feeder cables. As a result, switchboards 45" deep or less can be placed with their rear against a wall. The largest feeder that may be group mounted is a 1200 amp molded case breaker. In group-mounted switchboards, feeders rated above 1200 amps will be individually mounted. Generally, switchgear and individually compartmented switchboards take more space than group-mounted switchboards. GE switchgear and individually compartmented switchboards offer an insulated and isolated bus system. This option can significantly reduce the opportunity for arcing type faults to occur on the bus or to ground and should be considered when safety from such faults is of high concern.

Protective Devices

In switchgear all protective devices are drawout and individually mounted as well as individually compartmented. Switchboard protective devices may be group-mounted or individually compartmented. Individually compartmented switchboards have each breaker positioned behind its own door and barrier-isolated from surrounding devices; these are also identified as AV3 Access and Power Break 2 Switchboards. Some switchboards may incorporate a combination of individually mounted as well as group mounted protective devices. In these cases the individually mounted devices are not individually compartmented.

Low voltage power circuit breakers can be manufactured with or without an instantaneous trip, because of their 30-cycle short-time test rating. Though MCCB and ICCB protective devices may have short-time ratings, they are insignificant compared to those available on LVPCB's. The frame sizes available for LVPCBs are 800, 1600, 2000, 3200, 4000 and 5000A; for ICCB's are 800, 1600, 2000, 2500, 3000, 4000 amps; while for molded case circuit breakers they include 100, 150, 225, 250, 400, 600, 800, 1200 amps.

All breakers undergo testing for single-pole as well as multi-pole interrupting capability. The single-pole test is especially significant for ungrounded applications where any individual pole could be called on to clear a double line-to-ground fault. While other breakers have very limited single-pole ratings, often a small fraction of the multi-pole rating, which could result in failure in ungrounded applications if misapplied, LVPCB's are tested to interrupt 87% of their 3-phase bolted fault rating on a single pole. Single-pole should not be confused with single-phase. Single phase actually involves two poles, but single pole interruption involves only one pole and the fault current is driven by line-to-line voltage. A diagram of this is shown in figure 1. The fault shown on the diagram is a line-to-ground-to-line fault, which would depend on the clearing capability of only one single pole. If the impedance is sufficiently low, this current will approach the bolted line-to-line fault value.

Steel-framed LVPCB's have heavy-duty metal frames specially designed for ease of maintenance. Plastic-enclosed breakers are either sealed or must be disassembled to access its operating mechanisms making them more difficult to maintain.

LVPCB's are rated to carry 100% of their nameplate full load rating continuously, as are ICCB's and HPC switches. Standard rated molded case circuit breakers will carry 80% of their nameplate rating continuously or 100% non-continuously. Non-continuous is defined as a period of three hours or less. Certain molded case circuit breakers can be obtained as 100% rated. In all cases, molded case, insulated case, and LVPCB's are rated with the capability to fully interrupt a fault up to 100% of their short circuit rating. The short circuit ratings may vary significantly at different voltage levels.

The LVPCB is often referred to as an air circuit breaker. The term 'air' identifies the medium in which the arc is interrupted. An arc may also be interrupted in SF6, oil, or vacuum. Technically a molded case or insulated case breaker is also an "air" circuit breaker. Each should be properly identified by the specifier to assure that the user is supplied the correct device.

Application Consideration 1: System Grounding

When selecting the type of equipment, the grounding method of the electrical system must be considered. Molded case and insulated case circuit breakers are only suitable for solidly grounded distribution systems. This is due to their relatively low single pole interrupting ratings.

A molded case breaker with a 65kA multi-pole interrupting capability could be reduced to its 8.7kA single pole rating if that becomes the circuit limitation, a possibility of significant concern. The corner delta grounded system warrants special care since the first ground is already purposefully established. As discussed previously, low voltage power circuit breakers have much higher single pole interrupting ratings and, in most instances, may be successfully applied on these systems. Because of the critical nature of these applications, and the limitations of the protective devices available, the short-circuit studies performed for these systems should always include adequate phase fault configurations to help in selecting the proper protective devices with suitable three-phase and single-pole ratings.

Application Consideration 2: System Coordination

Here we must investigate the level of selectivity between protective devices required. LVPCB's can be built without an instantaneous trip function. This is true for the main as well as the feeder breakers. Without an instantaneous the main, feeders, and possible other downstream devices can more fully coordinate with each other. But besides switchgear there is a second option; recall that GE's individually compartmented switchboards are also available with 30 cycle withstand ratings. Thus it is possible to affect a much greater level of selectivity between LVPCB's in switchgear or between LVPCB's and ICCB's or MCCB's in individually compartmented switchboards. Since these switchboards have a 30-cycle short circuit rating, the UL 891 listing can still be applied. Group-mounted switchboards, on the other hand, must use protective devices that all incorporate instantaneous trip functions. In the presence of a high current fault exceeding the instantaneous set points, all devices could operate immediately, compromising the continuous flow of power. Fortunately there are many options available to the design engineer.

Application Consideration 3: Size and Accessibility

Size is always an important consideration. Some applications are so space restrictive that only group-mounted switchboards can be used. If the equipment must be backed against a wall eliminating rear access, the only choice may be group-mounted switchboards with front accessible terminations. Switchgear sections range from 22" to 38" wide and 60" to 81" deep. Individually mounted switchboard sections range from 22" to 38" wide and 50" to 74" deep. Special applications could require somewhat different dimensions. Group mounted switchboards may have main sections up to 45" wide and group mounted distribution sections of 40" to 45" wide and a depth of about 45" maximum. Because group mounted switchboards use molded case breakers as feeders, the density may be greater and the overall width much less. Applications requiring higher levels of reliability, maintainability and remote operation must be designed to contend with rear access of that gear and in compliance with NEC 110.26 and 110.34.

Application Consideration 4: Economics

In most applications economics are an important consideration. The primary consideration is often the initial cost. Generally speaking, group mounted switchboards are the least costly. Individually mounted switchboards can cost between 15 and 50% more than group mounted switchboards, depending on the number and type of devices required. Switchgear is typically more expensive than the individually mounted switchboards, but it may have certain features that preclude the use of any other equipment.

Application Consideration 5: Match The Project's Need

There are projects that will require the use of switchgear, others that will preclude its use. For instance, the continuity of power needs in a middle school are not as critical as in a health care facility or steel mill. A switchboard with its size and cost advantage may be well suited for the first while the unsurpassed reliability and maintainability offered by the switchgear may offer no viable alternative for the latter projects. A thorough knowledge of the customer's needs and the demands of the customer's process is key in matching the proper equipment with the project.

Conclusion

Many options are available within each subcategory of gear. The proper selection of whether to use switchboards or switchgear requires knowledge of each type of equipment as well as consideration of the power system, coordination, economics, size, and application needs. For a more in-depth discussion of these subjects and others contact your local GE Systems Engineer.

Application References (*Including guide-form specs)

Switchgear (*AKD-10)	DET-196
Low voltage power circuit breakers (*Wave-Pro)	DET-167
Switchboards (*Spectra)	GET-8032
Switchboards (Power Break 2)	DET-118
Switchboards (AV3 Access)	DET-138

Diagram Showing Single Pole Interruption of a Fault

