Power/Vac® Switchgear

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Introduction

The purpose of this newsletter is to provide the reader with an overview of the basic features and construction types for the Power/Vac line of medium voltage metal-clad switchgear equipment offered by GE. More detailed information can be found in the Power/Vac Application Guide GET-6600G, which can be access via the web link found on the last page of this document.

For more than 30 years, Power/Vac has provided the industry with one of the most reliable and durable metal-clad switchgear designs available. The heart of this gear is the breaker utilizing vacuum interrupter technology. The interrupter consists of a pair of butt contacts, surrounded by a vapor-condensing shield, a bellows through which one of the contacts moves, all of which is sealed in an air-tight enclosure under vacuum. Applications include maximum RMS voltages of 4.76, 8.25 and 15 kV, with a nominal RMS voltage class of 4.16, 7.2, and 13.8 kV respectively. This type of switchgear is designed, assembled, and tested to meet applicable ANSI, IEEE, and NEMA standards. Many of these standards are listed below.

- ANSI C37.04 — AC Power Circuit Breaker Rating Structure
- ANSI C37.06 — Preferred Ratings of Power Circuit Breakers
- ANSI C37.09 — Test Procedures for Power Circuit Breakers
- ANSI C37.010 — Application Guide for Power Circuit Breakers
- ANSI C37.11 — Power Circuit Breaker Control Requirements
- ANSI C37.20.2 — Metal-Clad Switchgear Assemblies
- ANSI C37.100 — Definitions for Power Switchgear
- NEMA SG-2 — High Voltage Fuses
- NEMA SG-4 — Power Circuit Breakers
- NEMA SG-5 — Power Switchgear Assemblies

Basic Application Conditions

Usual service conditions include ambient temperature ranges of –30°C to 40°C (-22°F to 104°F), maximum altitude of 1000m (3300 ft), and standard bus temperature rise of 65°C above an ambient of 40°C for a maximum hot spot of 105°C. If the gear will be applied at higher altitudes or elevated ambient temperatures, then voltage and/or current correction factors must be applied. See GET-6600G, Section 3, Table 3-6 for further details.

Basic Layouts

Power/Vac metal-clad switchgear combines the advantage of metal-clad construction's safety and flexibility with the benefits of the vacuum interrupter's reliability, low maintenance, and reduced breaker size and weight.

Power/Vac standard offering is a 2 high breaker stacking configuration and utilizes basic modular construction in one basic vertical size, which is 36" wide and 95" high for the standard indoor unit.

There are 12 standard Power/Vac layout combinations for breakers and auxiliary units. Some of the most common configurations include: a 1200A breaker stacked above a 1200A breaker, a 1200A breaker stacked above a 2000A breaker, an auxiliary unit either above or below a 1200A breaker, an auxiliary unit above a 2000A or 3000A breaker, or auxiliary units mounted in the top and bottom cubicle. The auxiliary units are VT's (voltage transformers) and CPT's (control power transformers). Some of these auxiliary units can be double stacked in a single cubicle depending upon the size of the device needed.

Power/Vac also offers a 3500A and 4000A breaker for indoor construction, with the 4000A device requiring fan cooling. When used in outdoor construction, the 4000A breaker is not available and the 3500A must be de-rated to a maximum of 3250A. Also, in standard outdoor construction, equipment heaters are included in each vertical section.

Circuit Breaker Selection

A circuit breaker's function and intended use are established in ANSI C37.100-1992. The breaker is used to carry and switch load current and to interrupt short circuit current when required. The fundamental rule for selecting the proper circuit breaker is that the ratings of the breaker must be equal to or exceed the calculated duty requirements for the connected loads.

When Power/Vac breakers were originally developed around 1975, they were designed and tested to ANSI C37.06 and ANSI C37.09, the standards that were applicable at that time. These standards were based on a constant MVA structure and specified a voltage range factor "K" to be greater than 1. The "K" factor is a ratio used to express the relationship between the applied voltage and the short circuit capabilities of medium voltage breakers. The predominant interrupting technologies at that time were air magnetic and oil, and they exhibited short circuit capabilities which varied significantly as the applied voltage changed, and thus the "K" factor > 1.0 was used.

The short circuit or interrupting rating of a breaker is a measure of its ability to interrupt a symmetrical fault current, expressed in kA (thousands of amps), with a given contact parting time, specified system X/R ratio, and a specified maximum voltage.

MVA (millions of volt amps), as applied to breakers, was first used to match a breaker's capability to the size of the transformer to which it was connected.

MVA= voltage x short circuit rating x $\sqrt{3}$
Example: 15 kV x 18 kA x 1.732 = 467.7 MVA or 500 MVA Class

In 1997, the ANSI C37.06 Standard "Preferred Ratings and Related Required Capabilities" were revised to acknowledge the fact that vacuum and SF6 technologies have nearly constant interrupting capabilities over a range equal to or less than the maximum rated voltage of the breaker. This changed reflected the move to harmonize the IEC and ANSI/IEEE standards, and present ratings based on "constant kA" basis instead of the earlier rating of "constant MVA".

In 2000, the ANSI C37.06 standard was changed to match the IEC short circuit ratings. The updated short circuit ratings were changed to 20 kA, 25 kA, 31.5 kA, 40 kA, 50 kA, and 63 kA.

The Close and Latch rating is the breakers ability to close in on a short circuit, and stay closed for a period of 10 cycles. Based on the 2000 standard, the close and latch rating was changed from a RMS value to a Peak value. The peak rating is 2.6 times the maximum short circuit rating. To express this value in RMS, the standard now uses 1.55 times the maximum short circuit rating to get the value. For example, a 40 kA short circuit rating would have a 104 kA peak close and latch rating or a 62 kA RMS rating.

Power/Vac circuit breakers are 100% rated and have no continuous overload rating. Most breakers are available with interrupt ratings of 5 cycles or 3 cycles. If the lineup of gear will be capable of paralleling sources, whether manual or automatically controlled, the entire lineup and breakers must be rated for the total available fault current from both power sources.

Fast bus transfer (FBT) is an option used when there is a need for transferring from a normal power source bus to an emergency or alternate power source upon failure of the normal source of power, and you need this done as quickly as possible without paralleling sources. This transfer is typically completed within a maximum of 3 cycles or 50 milliseconds. It is only available on 1200A, 2000A, and 3000A breakers that utilize 125VDC or 250 VDC control voltages. The breakers do not have to be rated for 3 cycle interrupting because the interrupting speed does not impact the amount of dead bus time, which is the critical factor.

There are several other applications that are considered special duty conditions. These conditions include: repetitive switching duty, arc furnace switching, reactor switching, capacitor switching, and the fast bus transfer as previously described. When the Power/Vac breaker is used in one of these conditions, the breaker's maximum ampacity may have to be de-rated, and it may also require increased maintenance procedures to keep it functioning properly.

Control Power

One of the more important considerations in switchgear design is selecting the control power source. It must be a reliable source of control power that will, at all times, maintain a voltage at the terminals of all electrically operated devices, and must be within the operating voltage range of these devices. The voltage ranges are established by ANSI C37.06 standards. It must provide tripping power for all the circuit breakers during protective relay operation and should be capable of closing the breakers without direct manual operation. Source of control power can be any of the following: 48 VDC, 125 VDC, 250 VDC, 120 VAC, and 240 VAC. Three common control power configurations are: an AC power source used for control and tripping power, a DC power source used for control and tripping power, or a combination of an AC power source used for control power and a DC power source used for tripping power.

When an AC power source is used for control and tripping, the breaker tripping power is generated from capacitors contained within the trip device, which are fed from a rectified AC source. The GE/ITI Automatic Charging Capacitor Trip Device (CTDB-6) is used to trip circuit breakers and lockout relays when AC control power is used. This device includes batteries, that when fully charged, will maintain a charge for a minimum of 3 days after the AC power source has been interrupted. During normal operation, the batteries are trickle charged from the AC voltage source.

When a DC power source is used, you need to take into consideration all the breaker operation requirements, such as closing coil current, tripping coil current, charge motor inrush current, and charge motor run current. In addition, determine if some or all of the breakers could trip simultaneously due to the programmed functions of the various relays included in the system. Then calculate the DC load under normal operation, the DC load during a shutdown, and the momentary DC load that may occur during a fault condition. These factors will then be used to properly size a bank of batteries needed to carry the DC load. The most common types of batteries used are lead acid and nickel-cadmium.

When an AC power source is used for control power and a DC power source is used for the tripping power, the current loads need to be split appropriately so that the AC and DC systems can be adequately sized. In this arrangement, you may also want to consider a UPS backup system so that the system will still have control power if the utility source fails.

System Protection

The type of relay protection must be considered when configuring the switchgear. Main and tie breakers typically include phase over current protection with time delay (51), and are normally furnished without an instantaneous protection (50) so they can be coordinated with downstream feeder devices.

Feeder breakers typically include phase over current protection with time delay (51) along with instantaneous protection (50). These settings should be set low enough so that the combination of the two settings provides protection below the conductor short circuit heating limit. When the feeder breaker is supplying a transformer, the requirements of the National Electrical Code determine the range of pickup values for the time over current protection function. When the feeder breaker is supplying a motor, there are several additional protective features that must be included. These features are discussed in detail in Section 6 of GET-6600G Power/Vac Application Guide.

Bus differential is another level of protection that should be considered in the overall switchgear protection scheme. This type of protection provides a way to identify internal bus faults by monitoring the incoming and outgoing currents on the main bus, and comparing their values. With bus differential systems, the faults internal to the switchgear are usually detected much quicker, and as a result may be able to reduce the level of incident energy released during a fault condition. This may also reduce the Personal Protective Equipment (PPE) that is required to work on the system due to the reduced potential energy levels. The appropriate PPE levels can be determined by completing an Arc Flash study on the system.

Current transformers with standard window type openings are available from 50:5 to 5000:5 amperes ratios. There are Standard and High Accuracy class CT's as specified by IEEE C37.20.2-1999. However, the High Accuracy class CT’s require twice the mounting space due to the larger size of the device. See the chart below for the Single Ratio CT’s.

CT Ratio	Standard Accuracy Class		CT Ratio	High Accuracy Class
50:5 to 100:5	C10		50:5	C10
150:5 to 250:5	C20		100:5	C20
300:5 to 400:5	C50		150:5 to 250:5	C50
500:5 to 800:5	C100		300:5 to 500:5	C100
1000:5 to 5000:5	C200		600:5 to 800:5	C200
			1000:5 to 5000:5	C400

Every medium voltage AC power system is subject to transient voltages in excess of the normal operating voltages. Surge arresters limit the crest voltage of a voltage surge. If you want these devices included in your equipment, make sure you specify them either on your one line diagram or in your specification section for this gear.

Construction Types

The basic construction types for this gear are: indoor, indoor drip proof, outdoor no aisle, outdoor protected aisle, and outdoor common aisle.

The indoor construction (Nema 1) consists of one or more vertical sections that are mounted side by side, and connected mechanically and electrically together to form a complete lineup of equipment. Each vertical section is a self-supporting structure of 11 gauge steel used for the front doors, top, side and rear covers. It is bolted together with reinforced gussets. The indoor drip proof construction type includes a sloped roof with overhangs on each end to prevent dripping liquids from entering the top of the switchgear.

The breakers are removable from the equipment by means of a portable lifting device (lift truck). An optional lower compartment rollout breaker design is available on Indoor and Outdoor Protected Aisle construction.

Outdoor construction (Nema 3R) begins with the basic indoor equipment, and is weatherproofed by gasketing and sealing the end and rear covers, adding filters to ventilation louvers, and adding a sloped weatherproof roof. Four strip heaters are mounted in each vertical section to guard against internal condensation. The microprocessor based relays that are typically installed in this gear are designed for a maximum of 90-95% non-condensing humidity. If the conditions where the outdoor gear will be located could exceed the relay's environmental rating, then a power house should be considered.

For outdoor non-walk in units, a full height, gasketed, lockable door is provided on the front of the unit. For the protected aisle walk in units, a 75-inch deep weatherproof aisle is added to the basic outdoor unit. For the outdoor common aisle walk in unit, the 75-inch aisle is included in the middle of the structure with the compartment doors entering into the common area.

The main bus is completely enclosed by grounded metal barriers and feeds the upper and lower compartments in the vertical section. All main bus joints use tin plating as a standard, and silver plating as an option. Connections utilize (2) ½-inch Grade 5 plated steel bolts per joint. Provision for future extensions of the main bus is standard. All main bus joints are insulated with pre-formed vinyl boots secured by nylon hardware. The standard bus supports have strength suitable to withstand forces caused by a 50 kA RMS symmetrical fault (80 kA asymmetrical, 130 kA peak), with additional bracing used to meet the highest symmetrical rating of 63 kA. Bus bars are insulated with flame retardant, track resistant epoxy applied in a fluid-dipped process to a thickness that withstands the dielectric tests specified by ANSI C37.20.2. The bus bracing, or equipment momentary rating, is equal to the breaker close and latch rating as previously discussed.

Transition sections between Power/Vac and motor control equipment, switches, transformers, and other equipment are to be furnished by the vendor of the connecting equipment. When transitions are required, the Power/Vac gear is typically provided with horizontal bus that is extended 10 inches beyond the side panel to allow for mating equipment to bolt up to this piece of gear. (See Section 7, Figures 7-17 thru 7-20 Power/Vac Application Guide GET-6600G for these details.)

Power/Vac switchgear is provided with mechanical interlocks to inhibit moving the breaker into or out of the "Connected" position when the breaker contacts are in the closed position. Interlocks prevent the breaker from closing unless the primary disconnects are fully engaged, or the breaker is in the "Test/Disconnect" position. Closing springs are automatically discharged when the breaker is moved between the "Connected" and the "Test" positions, or when it is inserted into or withdrawn from the compartment. Control power transformer primary fuses, whether located on the CPT or on the separate rollout try, are not accessible unless the CPT primary and secondary circuits are open.

There is an optional motor driven remote racking device which can be used to move the circuit breaker between the disconnected and connected position instead of the normal hand operated crank. This remote racking device has a hand held operator station that is located at the end of a 30-foot cable. This allows the operator to move up to 30 feet away from the front of the gear while racking the breaker in and out, and reduces the potential exposure to arc flash conditions should a short circuit occur during this racking procedure.

Finally, if the switchgear will be mounted on a raised housekeeping pad, there are strict guidelines that must be adhered to for the breaker lift truck to work properly. The pad must not extend more than 3 inches beyond the front of the switchgear, and be no more than 7 inches tall. Otherwise, the breaker lift truck will not properly engage the breaker and it will not be able to be removed from the gear. (See Section 7, Figure 7-12, Power/Vac Application Guide, GET-6600G.)

References

Power/Vac® Application Update Issue No. 1	October 21, 2002
Power/Vac® Application Update Issue No. 3	February 14, 2003
Power/Vac® Application Update Issue No. 4	June 20, 2003
Power/Vac® Product Family Application Guide	GET-6600G Sept. 2008

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