LET'S BE PACIFIC™

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Federal Pacific Integrates Vacuum Switch and Controls into Metal-Enclosed Switchgear for Frequent Switching Application

Figure 1. Federal Pacific Metal-Enclosed Switchgear in a four (4) bay configuration features (from left) two incoming switch-only bays for primary-selective service (and also serve as the line side visible disconnect for the vacuum switch), a bay containing a vacuum switch and a switch/fuse feeder bay that provides circuit protection for the load circuit as well as providing a load-side visible disconnect for isolating the vacuum switch when maintenance service is required.

With the design flexibility not offered by many manufacturers, Federal Pacific holds a unique position in the market for metal-enclosed switchgear of all types. Federal Pacific has the willingness, the capability and the expertise to develop sophisticated circuits employing unique capabilities for application specific project requirements. A case in point is the 15kV Metal-Enclosed Switchgear that is the subject of this newsletter.

The basic project requirement for this particular assembly of Metal-Enclosed Switchgear is (1) to provide primary-selective service for an installation at a major industrial facility so it can be served from either of two power sources. Other major design criteria established for the switchgear assembly include: (2) to provide a reliable, long-life load-switching solution on a specific frequently switched circuit within the industrial complex; (3) to provide protection against single phasing on the incoming and on the load circuit; (4) to provide over-current protection for the load circuit; (5) to provide real-time voltage and current measurement on the incoming line circuits; (6) to provide real-time power monitoring conditions of the load circuit; and (7) to provide a secure sequential switching scheme to avoid inadvertent operator errors during maintenance and operation of the switchgear. The various solutions implemented in the switchgear to provide all of the foregoing project requirements are discussed in the subsequent paragraphs of this newsletter.

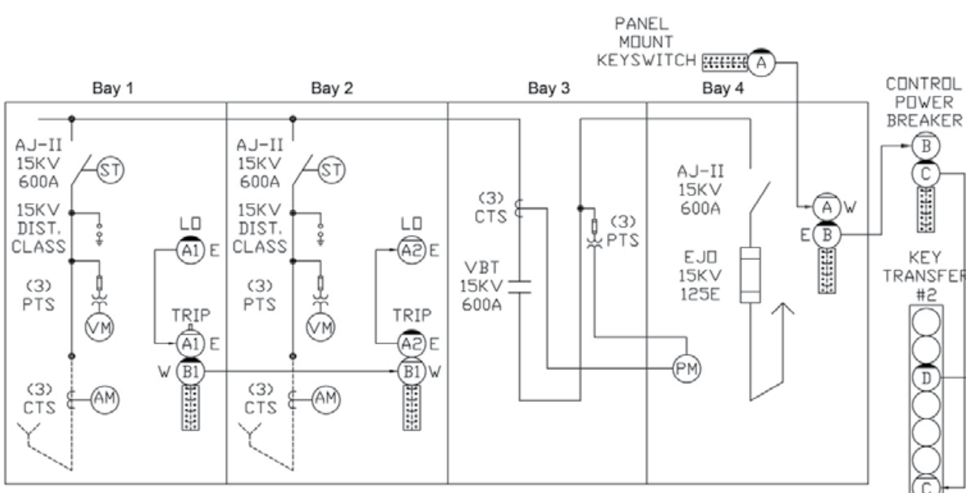

Figure 2. One-line diagram of lineup pictured in Figure 1 is illustrated above.

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Primary-Selective Service

Primary-selective service is developed to provide an alternate, redundant back-up power source to critical loads in the event the preferred (normal) source requires maintenance, becomes overloaded, or is lost. In the switchgear assembly of this newsletter, the configuration is deemed a common-bus configuration because there is one continuous main bus and only one of the two incoming power sources (Bay 1 and Bay 2 in Figure 1) is utilized at any given time. If there were a tie switch in the lineup between the two power sources allowing both switches to be utilized to serve a portion of the main bus, the system would be deemed a split-bus primary- selective scheme.

With the common-bus primary-selective scheme, the switch associated with the preferred (normal) source (Bay 1) is closed, serving the load, and the switch associated with the alternate (backup) source (Bay 2, which is pictured in Figure 3) is open. The alternate source can be a standby generator, in which case there is typically, but not always, provisions to prevent both switches to be closed at the same time. In some cases, with suitable control functions, the sources can be temporarily paralleled so there is no outage to the load during the return transfer to the preferred source.

Figure 3. Pictured above is Bay 2, which includes the incoming switch for the alternate (backup) source. Insets show (at top) screen over the switch that is encountered when the enclosure door is opened and (at bottom) the analog voltmeter and ammeter with selector switch, allowing a real-time verification of the condition of the incoming power source. Bay 1, which includes the incoming switch for the preferred (normal) source is similar.

Frequent Switching Requirement

Typical load interrupter switches have limited capability when it comes to frequent switching or switching of capacitive or inductive loads. For capacitive and inductive loads, the duty is difficult because the high-rate of rise of the recovery voltage means the prestrike that occurs when switches are closed is initiated more quickly (than if it is switching load current) and, therefore, lasts longer until the switch contacts, are fully closed, which results in greater wear on the contacts with each operation. Similarly, when contacts part on opening the arc stays engaged longer as the contacts have to separate further before the necessary dielectric is established. Circuits that require frequent switching are also problematic for load-interrupter switches because of the contact wear that occurs with each load-switching operation.

For these circuits with difficult switching parameters or where frequent switching is required, vacuum interrupters are the answer. The vacuum environment helps control the arc, minimizes the arcing time because the operation is very fast (typically about 3 cycles) and the contacts are extremely close to begin with so there is less distance to travel before complete contact engagement (or separation) has occurred (i.e. less arcing time), and the vacuum retards metal erosion from the contacts.

With these exceptional characteristics, vacuum interrupters can typically provide many thousands of operations before contact wear may become an issue. On the other hand, industry standards for load-interrupter switches require operations totaling less than a hundred operations when energized.

For this lineup of Federal Pacific Metal-Enclosed Switchgear, the Joslyn 15kV, 600amp VBT vacuum interrupter was selected. See Figure 4. The VBT is capable of performing over 100 load-switching operations per day. And, the product literature indicates that it is capable of 100,000 operations before maintenance is required. The capability of the VBT makes it well suited for the anticipated frequent switching requirements at the customer's installation.

The VBT is mounted in Bay 3 from the left. The associated controls are installed in a low-voltage control compartment that is mounted in the switchgear bay door and is isolated from high voltage.

Figure 4. Pictured above is Bay 3, which includes the VBT vacuum interrupter switch for frequent sustained switching of the load circuit. Inset at top (on right above) shows dual, hinged screens allowing separate access to the vacuum interrupter (at bottom in photo at left) and to VTs and CTs (at top in the photo at left. Inset at bottom (on right above) is a view of the interior of the low-voltage compartment mounted in the Bay 3 compartment door and containing the control circuit for the vacuum interrupter; the green/red position indicating lamps for the vacuum interrupter; and the voltage indicator with multiple color-coded LED-type indicating lamps to show presence/absence of voltage on each phase and ground.

Protection for Single Phasing

To avoid single phasing of three-phase loads, Federal Pacific has developed an economical package for tripping circuits open when one or two phases are lost. If a three-phase load is "single phased" (typically the loss of one phase), the equipment may run slower, causing overheating with potential damage to insulation and eventually to the equipment itself.

To avoid the effects of potential single-phase conditions, Federal Pacific installed Auto-jet®II Load-Interrupter Switches equipped with the shunt-trip feature in each of the incoming switch-only bays and in the load-feeder bay. See Figures 2 and 5. An auxiliary switch on each load-interrupter switch provides position indication plus contacts for opening and closing the switches. A voltage transformer on each phase of each switch provides the means to determine if voltage is present and also provides control power for the relays.

The shunt-trip feature is activated by first closing the switch using the manual handle and then charging the switch-operating mechanism to a stored-energy condition using the manual handle.

The loss of voltage is detected by the Federal Pacific provided power monitoring relay that, on detection of a loss of voltage, initiates the signal to trip open the associated switch. The switches also can be manually tripped open.

As there is potential for either of the incoming switches to be open, surge arresters are provided in each incoming section. These 15kV MCOV arresters provide protection against the doubling of voltage that will occur at an open gap from a traveling wave form, such as from lightning or switching surges.

Figure 5. Pictured above is Bay 4, which includes the feeder switch and current-limiting fuses for switching and protection of the load feeder circuit. Inset (at top right) shows steel perforated screen that is encountered over the switch when the enclosure door is opened and that allows access to the fuses without exposure to the switch terminals; and (at bottom right) the digital power monitoring meter that allows real-time display of the various circuit parameters. The power monitor is mounted on a hinged, bolted panel in a low-voltage compartment that is isolated from high voltage. The operating handle on this bay is painted red to differentiate it from the handles of the incoming switches.

Over-Current Protection for Load Circuit

The switchgear assembly includes one switch/fuse load-feeder circuit that provides switching and protection of the load circuit and there is potential for high fault currents in the event a short circuit occurs. The VBT vacuum interrupter is a load switching device, accommodating currents up to 600 amperes. But, its fault interrupting rating is limited to 4,000 amperes. Therefore, an additional protective device is necessary to handle currents exceeding the 4ka capability of the vacuum interrupter.

For this protection application, current-limiting fuses have been selected. See Figure 5. The fast action (less than 0.25cycles, i.e. approximately 4 milliseconds) will substantially limit the thermal damage to insulation and mechanical stress to all components, cable and equipment in the short-circuit path. The current-limiting fuses furnished are capable of protecting circuits to 50,000 amperes symmetrical, although the available fault-current at the installation may be of a lower value.

The switchgear assembly carries a rating of 25,000 amperes symmetrical. But, since the current-limiting fuses are so fast acting, the switchgear can be applied in conjunction with the current-limiting fuses at installations with higher available fault current. The necessary restriction is that the interrupting response of the current-limiting fuses must limit the let-through current to a value less than the short-circuit rating of the switchgear assembly. The bus, which is silver-plated copper, is fully insulated with heat-shrink sleeve material and booted at bus connections.

Real-Time Voltage and Current Measurement

Current transformers on each phase in each incoming termination compartment provide input to an ammeter with selector switch for local indication of the real-time load current to the switchgear. See Figure 3. They are mounted in a rear-termination compartment as the two incoming lines are arranged for top-rear cable entry.

Voltage transformers on each phase in each incoming bay are also provided with a selector switch for local indication of the real-time operating system voltage. The fused VTs are partitioned among barriers in a section at the bottom of the bay.

The sets of analog voltmeters, ammeters and associated selector switches are housed in low-voltage compartments that are isolated from high voltage. A low-voltage compartment for each set of meters and switches is mounted in the door of each incoming bay. The low-voltage compartments provide security for the meters and easy access for inspection.

Real-Time Power Monitoring for Load Circuit

The switchgear is equipped with a digital Rockwell PM3000 that provides configurable real-time power quality data, harmonics analysis, high-speed oscillography, and sub-metering via a variety of communication protocols all in a compact package. See Figure 5. This allows the customer to measure and monitor energy use for its major manufacturing process. Energy-intensive equipment is required in the manufacturing process and the power monitor allows the customer to develop data on:

- Load Profiling
- Demand Management
- Cost Allocation
- Distribution System Monitoring
- Emergency Load Shedding
- Power System Control

This data can then be used to establish an energy efficiency program to reduce overall manufacturing costs.

The power monitoring unit, which is mounted in Bay 4 (at right), develops the information from voltage and current input provided by the CTs and PTs that are located in Bay 3 (from left).

Secure Sequential Switching Scheme

In industrial settings, in particular, insuring correct lock-out tag-out procedures to permit maintenance operations on electrical circuits is important not only for the proper and continued operation of the manufacturing process, but also for the safety of the workers. In Federal Pacific Metal-Enclosed Switchgear, access to the interior of bays containing switches is prevented by mechanical interlocks that prevent opening the door unless the switch is open. This mechanical interlock, therefore, also prevents access to fuses unless the associated switch is open. In this four-bay lineup, there are additional security features to insure safe sequential operation of equipment in the switchgear and of equipment external to the switchgear.

Key interlocks are provided (1) on the operating handles of the incoming switches in Bay 1 and Bay 2 and (2) on the shunt-trip function of those incoming switches. This system pairs of key interlocks insures that only one of the incoming switches can be closed at a given time to prevent paralleling of the two associated incoming power circuits. This system of interlocks also makes certain that the scheme of the manual handles cannot be bypassed by operation of the Manual Shunt-Trip Levers. See Figure 3.

Key interlocks are also provided to prevent opening the feeder switch unless associated devices external to the switchgear are appropriately configured. See Figure 6. This involves (1) an external panel-mounted key interlock, (2) key interlocks on the manual operating handle of the feeder switch, (3) an external key interlock mounted on a control-power breaker and (4) a key interlock on a key-transfer block. The operating sequence for these interlocks is as follows:

(a) Perform the function necessary to release key (A);
(b) Take key (A) to open the feeder switch, which releases key (B);
(c) Take key (B) to open the control-power breaker, which releases key (C);
(d) Take key (C) to the transfer block, which releases key (D);
(e) Take key (D) to perform additional functions associated with isolation of the switchgear assembly and the opening of the control-power breaker.

The switchgear assembly also includes red and green position indicating lamps for the VBT plus a Grace Engineered Products Voltage Indicator. The lamps and indicator are separately mounted on the door of Bay 3. See Figure 4.

The red/green lamps show, respectively, the closed/open positions of the VBT. The voltage indicator shows the presence/absence of voltage on each phase and ground on the load side of the VBT. The voltage indicator displays a different color for each phase and ground. Thus, maintenance personnel use the indicator to further verify that the VBT vacuum interrupter has opened and that there is no voltage on any phase of the downstream open circuit. The color coding will help them identify which phase (or ground) is the problem circuit and has voltage still present. All lamps on the voltage indicator must be extinguished for a shock hazard not to exist. Nevertheless, for redundancy, safe practice dictates that all circuits still be tested for voltage and grounded before work is performed.

Design and Operating Flexibility

Federal Pacific's ability to provide the design requirements for switching and protection applications at large industrial facilities is an important asset in the successful penetration of the metal-enclosed switchgear market. The additional flexibility to provide complex security features makes that ability even more beneficial to potential customers. The particular switchgear assembly featured in this newsletter, while not the most functionally sophisticated, demonstrates some of Federal Pacific's abilities. Federal Pacific was also able to supply a similar, but more complex seven-bay lineup to the same customer for a facility located off shore.

Show Federal Pacific's expertise off to potential clients in your territory. This newsletter will help you in that promotion.

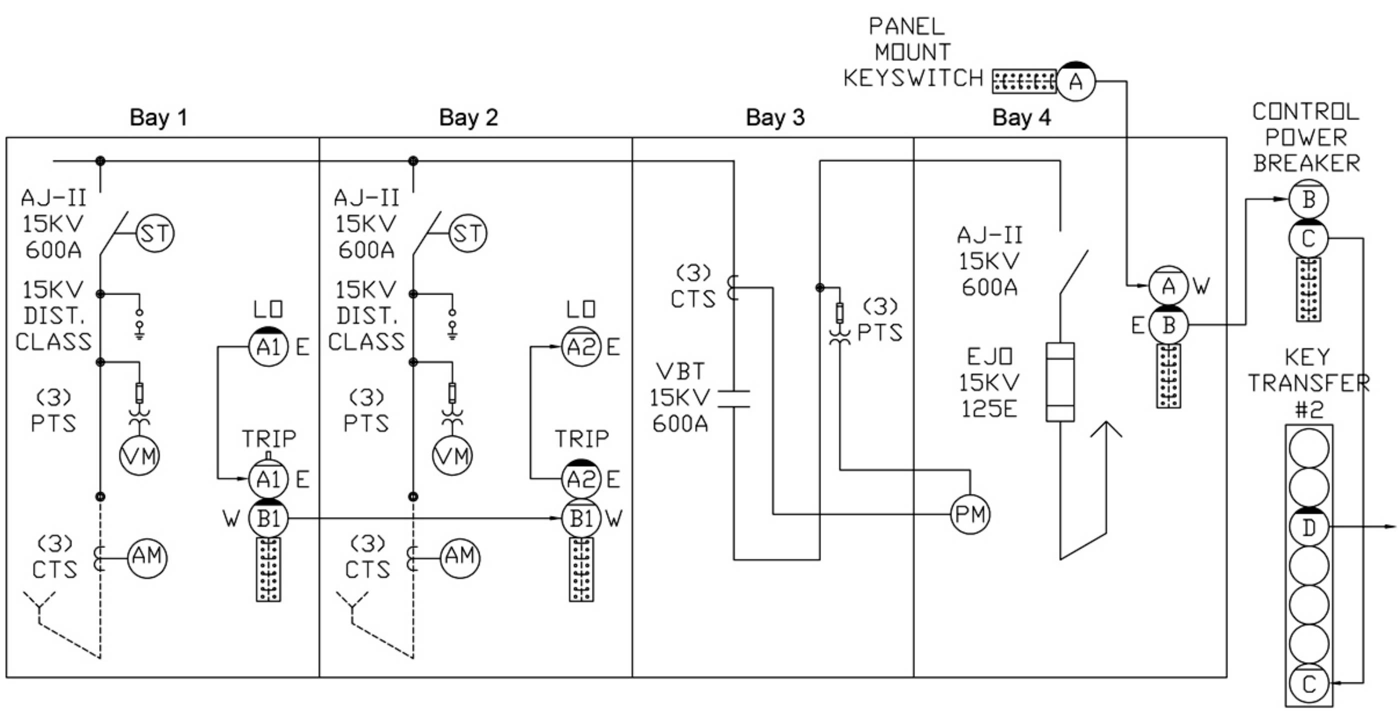

Figure 6. Key interlock scheme insures appropriate sequential operation to avoid paralleling of switches in Bays 1 and 2 and an orderly procedure to follow when it is necessary to perform maintenance.

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