LET'S BE PACIFIC™

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Fixed-Mounted Vacuum Circuit Breaker with Series-Connected Auto-jet® Switch for Isolation and Visible Disconnect

Figure 1. This 10-bay lineup of 38kV Metal-Enclosed Switchgear provides switching and protection at a major installation in the Northeast. The switchgear assembly includes: a billing metering compartment, a cable-entrance compartment, a main-circuit breaker compartment with Auto-jet® Switch as a visible disconnect, utility metering bay, customer metering bay and six (6) fused-switch feeder bays.

Recently, IEEE Standard C37.20.3 "IEEE Standard for Metal-Enclosed Load Interrupter Switchgear" was revised to expand the utilization of vacuum circuit breakers in metal-enclosed switchgear. This arrangement, vacuum circuit breakers in combination with fused load-interrupters, has been produced for many years but there was no formal standard recognizing the acceptability of such a pairing. Federal Pacific too has been offering this arrangement for many years. One such lineup was featured in the November 2013 "Let's Be Pacific", which included a drawout circuit breaker. The switchgear assembly featured in this news letter is a ten (10) bay, outdoor 38kV lineup that includes a fixed-mounted circuit breaker in series with a disconnect switch that provides visible isolation for the circuit breaker. In addition, the lineup includes a utility metering bay with a bay for meter panels, a customer metering bay with a control-power transformer and six (6) bays with fused load-interrupter switches. This extensive power-distribution switchgear assembly provides switching and protection at a large industrial complex. There are many benefits to this combination of having a circuit breaker on the incoming and fused load-interrupter switches on the feeder circuits.

Advantages of Combining A Fixed-Mounted Vacuum Circuit Breaker with a Visible Disconnect and Fused Load-Interrupter Switches

1. Circuit-breaker load-switching capability exceeds that of typical load-interrupter switches and therefore is better suited for handling the continuous current associated with multiple load-feeder circuits.
2. Circuit-breaker short-circuit interrupting rating often exceeds the capability of fuses especially at voltages in excess of 15kV.
3. Circuit-breakers have much greater frequent switching capability, into the thousands of operations, far in excess of what load-interrupter switches are capable of performing.
4. Circuit breaker time-current characteristics are readily adjusted to coordinate with multiple fuses (or other protective devices) when in series.
5. Circuit breakers are readily reset following a fault without requiring direct exposure to energized components as is typically required when handling fuses.
6. Fixed-mounted circuit breakers eliminate exposure to the potential arc-flash hazard associated with "racking" drawout breakers in and out.
7. High-speed tripping on fault currents allows use of circuit breakers in arc-flash mitigation schemes that will minimize the effects of an arc flash.
8. Vacuum circuit breakers can be readily configured to be operated from a remote location, such as using a handheld controller, outside the arc-flash boundary to minimize exposure to any potential arc-flash hazard and thereby reduce the caloric exposure to personnel so that PPE suitable for the short-circuit current available at the location is reduced in recognition that the function is being performed from a distance that is outside the arc-flash boundary.
9. Federal Pacific's Portable Remote Operating Mechanism (PROM) can be applied on the visible disconnect so that opening and closing the visible disconnect can also be performed outside the arc-flash boundary.
10. Federal Pacific's PROM can also be used on load-interrupter switches so they too can be operated from a distance outside the arc-flash boundary, reducing required PPE and minimizing exposure to any arc-flash hazard.
11. Using vacuum circuit breakers on the incoming and fuse load-interrupter switches on the load feeders makes for one of the most economical metal-enclosed switchgear assemblies compared to a metal-clad switchgear assembly comprised of all circuit breakers.
12. Fused load-interrupter switches take up much less floor space than is typically required for circuit breakers.

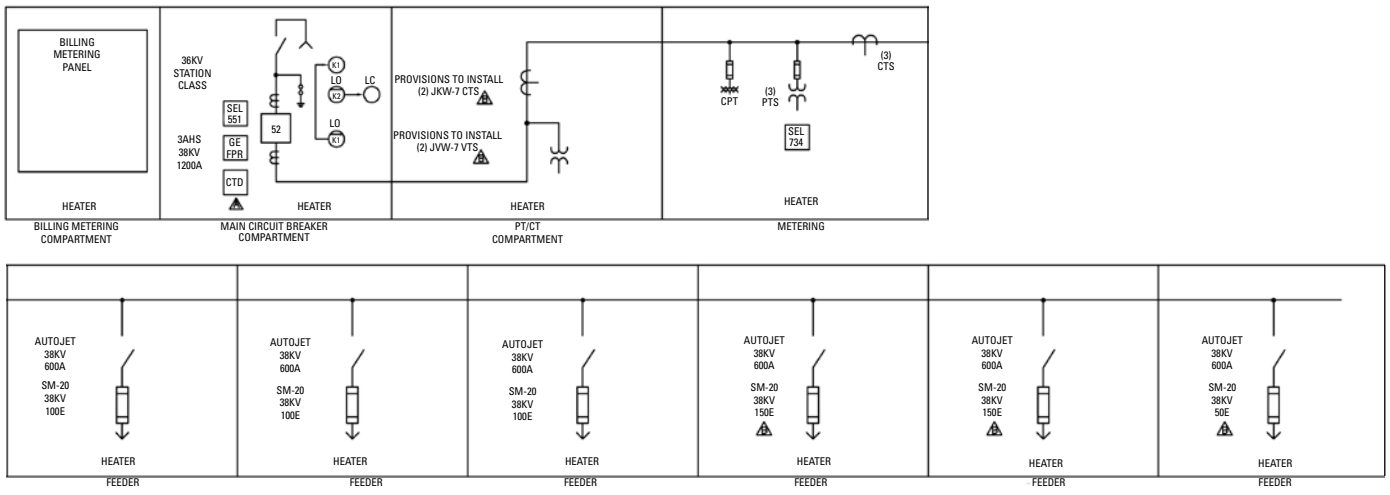

Figure 2. The one-line diagram for the ten (10) bay 38kV switchgear assembly is illustrated above in two sections. At top is the incoming section comprised of the main-incoming circuit breaker with its visible disconnect, capacitive-trip device and relaying; a utility metering bay with provisions for metering transformers to be provided and installed by the serving utility; a customer metering bay with VTs, CTs and a single-phase control-power transformer (wired phase-to-phase) to supply power for the auxiliary components in the assembly, including relays and strip heaters; and six (6) feeder bays containing fused load-interrupter switches — each switching and protecting a 5,000kVA, 34.5kV/4.16kV delta/wye-grounded transformer.

Relays and Controls

1. SEL 551 – Overcurrent and Reclosing Relay

- **Comprehensive Overcurrent Protection**
  Phase, negative-sequence, residual ground, and neutral overcurrent protection in a compact package. Complete set of instantaneous, definite-time, and time-overcurrent elements.
- **Reclosing**
  Program up to four shots of reclosing with sequence coordination logic for coordination with downstream reclosers.

SEL 551

2. SEL 734 – Advanced Revenue Metering Control

- **Accurate Metering**
  Exceeds ANSI C12.20 0.2 class accuracy at unity power factor with bidirectional, full four-quadrant energy metering for generation, interchange, transmission, distribution, or industrial applications.
- **Load Profile Data Collection**
  Collect billing data with a simple-to-use load profile recorder that captures years of data.
- **Synchronized Phasor Measurement**
  Measure instantaneous voltage and current angles in real time to improve system operation with synchrophasor information.
- **Transformer and Line-Loss Compensation**
  Enter transformer nameplate and line impedance information directly into the meter to automatically compensate for transformer or line losses and move the billing point.
- **Time-of-Use (TOU) Metering**
  Provides flexible, time-differentiated energy and demand registers with multiple day types, rates, seasons, and a 20-year programmable calendar.
- **Predictive Demand**
  The predictive demand function monitors accumulated demand and alarms when the demand exceeds a user-defined limit. The SEL-734 can then shut down loads or peak-shave with generation to avoid demand charges. The predictive demand alarm is available through Modbus, DNP3, Mirrored Bits® communications, or the front-panel LEDs.
- **Preventive Maintenance**
  Allows a user to track relay exposure to extreme environmental conditions by monitoring and alarming at high ambient temperatures
- **Arc Flash Mitigation**
  It is equipped with multiple setting groups and two user definable inverse-curves – Flex Curves A and B for fast and reliable arc-flash detection and breaker operation
- **Temperature Monitoring**
  Continually monitors ambient temperature around the relay and alarms when device is exposed to extreme temperatures
- **Advanced Device Health Diagnostics**
  These diagnostic tests monitor for conditions that could impact and present device status via SCADA communications and front panel display

SEL 734

3. GE Multilin 350 Feeder Protection System

- **Preventive Maintenance**
  Allows a user to track relay exposure to extreme environmental conditions by monitoring and alarming at high ambient temperature
- **Arc Flash Mitigation**
  It is equipped with multiple setting groups and two user definable inverse-curves – Flex Curves A and B for fast and reliable arc-flash detection and breaker operation
- **Temperature Monitoring**
  Continually monitors ambient temperature around the relay and alarms when device is exposed to extreme temperatures
- **Advanced Device Health Diagnostics**
  These diagnostic tests monitor for conditions that could impact and present device status via SCADA communications and front panel display

GE Multilin 350

Figure 3. Bay 1

Figure 4. Bay 2 – Screens Closed

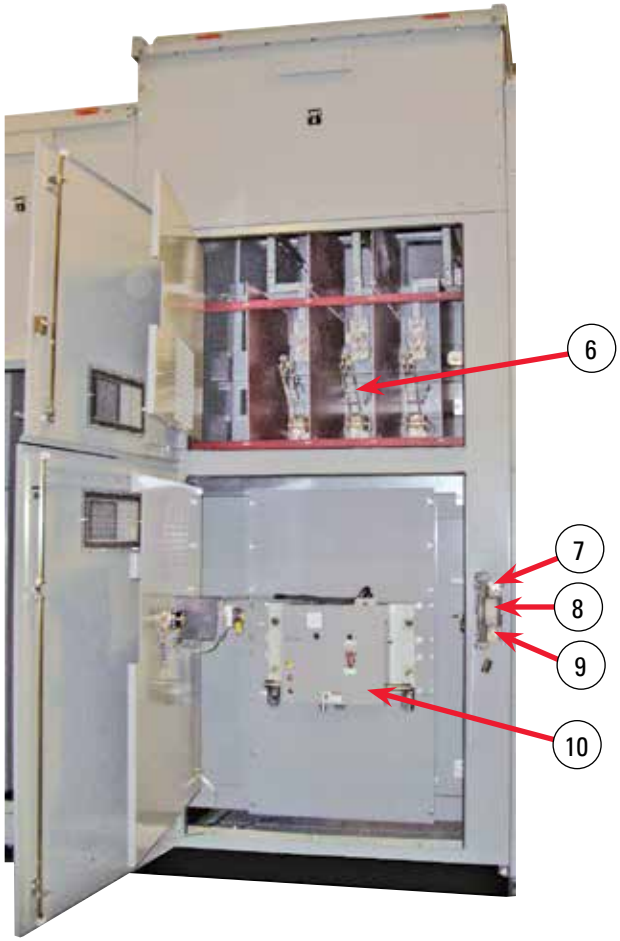

Figure 5. Bay 2 – Screens Open

Features:

1. Bay 1 includes Duplex Receptacle, Lamp with Light Switch and provisions to accommodate revenue billing meters.
2. Strip Heater and Thermostat
3. Overcurrent & Reclosing Relay (SEL 551)
4. Feeder Protection Relay (GE Multilin 350 Relay)
5. Breaker Control Switch
6. Disconnect Switch
7. Key Interlock – Prevents opening disconnect unless circuit breaker is open
8. Disconnect-Switch Operating Handle
9. Key Interlock prevents closing Disconnect Switch if the associated compartment door is open
10. Vacuum Circuit Breaker

Bay 2 is the incoming bay for the switchgear assembly and has a rear termination compartment for cable entry. Surge Arresters, 36kV Station Class, are mounted in the termination compartment and are connected in the circuit between the disconnect switch and the circuit breaker. Sensing CTs are on the upstream side of the circuit breaker for input to the GE Multilin 350 and on the downstream side for input to the SEL 551 relay.

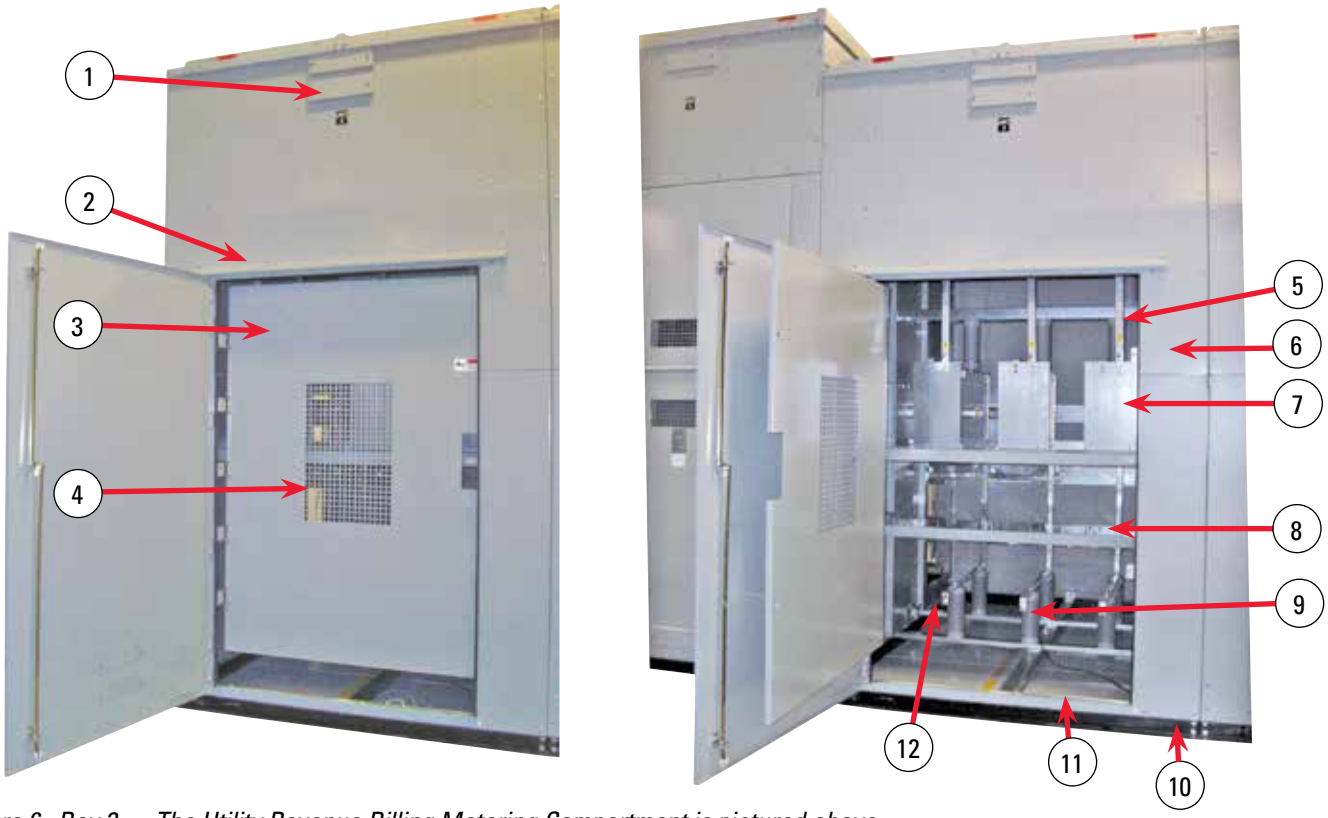

Figure 6. Bay 3 — The Utility Revenue Billing Metering Compartment is pictured above.

Features:

1. Ventilation louvers to support air circulation are provided at the top and bottom at the front and rear of each bay.
2. Rain shield is provided above each door to divert moisture that may run down the front of the unit.
3. A full-length screen isolates the interior as a second barrier to prevent inadvertent contact with internal components.
4. The screen perforations allow inspection of the interior without exposure to the energized VTs, CTs and bus.
5. Silver-plated copper bus is provided throughout the switchgear assembly.
6. The bay includes mounting provisions for the VTs and CTs that will be supplied and installed by the serving utility. The utility prescribes the bus configuration and positioning for the metering transformers.
7. The three large plates viewed in the center of the bay opening, which are removable, represent the mounting location for the CTs and are installed to support the bus during shipment and are to be removed when the CTs are set.
8. The VTs will mount on the horizontal channel that is located below the CTs. The VT mounting channel includes weld studs that are positioned to match the bolt-hole pattern in the VT-mounting plate.
9. Federal Pacific cycloaliphatic epoxy insulators are used for bus supports throughout the switchgear assembly
10. A heavy coal-tar coating is provided on the channel base along the full length of the switchgear assembly to further inhibit corrosion
11. Silver-plated ground bus is continuous throughout the switchgear assembly across the front of every door opening.
12. Grounding balls are provided above and below the metering transformers.

Figure 7. Bay 4 — The Customer Metering Bay with an Advanced Metering Relay is pictured above and in inset below.

Features:

1. Solid, full-height inner screen isolates energized components in the interior
2. Low-voltage compartment isolates the metering relay from energized components
3. SEL 734 Revenue Metering Control is mounted on the door in an isolated low-voltage compartment.
4. Metering CTs are mounted at the top of the compartment
5. Fused VTs for metering are mounted on a channel at the bottom of the compartment.
6. A single-phase, fused 11.5kVA control-power transformer (connected phase-to-phase) provides control power to relays, heaters and other auxiliary equipment in the switchgear assembly.

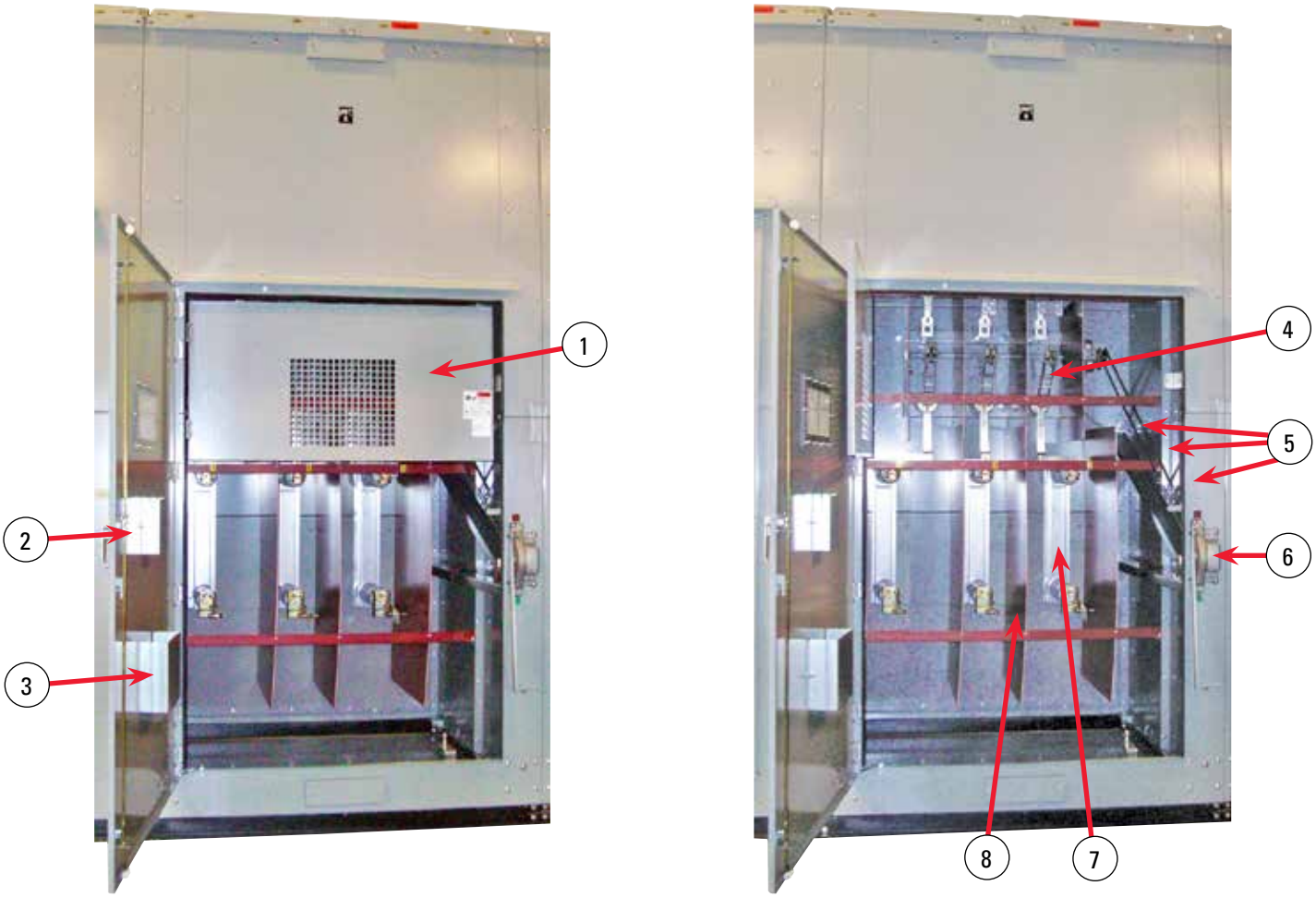

Figure 8. Typical Feeder Bay (Bays 5 to 10) is pictured above.

Features:

1. Perforated partial screen over switch isolates energized bus at top to allow changing fuses
2. Instruction manual holder
3. Storage compartment for spare fuse units
4. 38kV, 600-ampere Auto-jet® load-interrupter switch
5. Chain-coupled operating handle
6. Cast-aluminum cover over operating mechanism with steel switch-operating handle and grip
7. Federal Pacific fuse mountings accommodate SM-20 power fuses
8. NEMA-grade red GPO-3 fiberglass barriers provide isolation phase-to-phase and phase-to-ground for group-operated switch and for fuses

Switchgear Ratings

Short-Circuit:	
Circuit-Breaker Interrupting	31,500 amps rms sym
Fuse Interrupting	8450 amps rms sym
Withstand	8450 amps rms sym
Withstand Duration	2 Seconds
Momentary	13,520 amps rms asym
Rated Continuous Current	
Main Bus Continuous	1200 amperes
Circuit Breaker	1200 amperes
Disconnect Switch	1200 amperes
Load-Interrupter Switches	600 amperes
SM-20 Fuses	200 amperes
Rated Maximum Voltage	38kV
Rated Frequency	60Hz
Basic Insulation Level	150/200kV BIL*
Rated Power Frequency Withstand	80kV
Fault Closing	
Circuit Breaker	31,500 amps rms sym
Load-Interrupter Switches	25,000 amps rms sym

*The bay containing the vacuum circuit breaker and visible disconnect is rated 150kV BIL.

Specifications

Enclosure: NEMA 3R Outdoor-Style

Category: B – Install in Locations Accessible to Qualified Persons Only

Material: 11-Gauge Steel

Finish: ANSI 61 (Powder Coatings)

Doors: Three-Point Door Latch

Interlocks: Mechanical Interlocks to Prevent Access to Interior Unless Switch is Open are Provided on Doors to Fused-Switch Feeder Bays

Key Interlocks are Provided on Main Circuit Breaker and Disconnect Switch per Description Below.

Barriers: NEMA Grade GPO-3 Red Fiberglass for Switches and Fuse Mountings

Bus: Main Bus – Tin-Plated Copper

Ground Bus – Tin-Plated Copper

Shipping Weight: Approximately 31,000 pounds

Key Interlock Scheme

The key interlock scheme has been developed to (1) Prevent opening of the disconnect switch until the main vacuum circuit breaker is open and (2) prevent opening the door to the disconnect-switch compartment until the disconnect switch is open. Conversely, (3) the disconnect switch cannot be closed when the associated compartment door is open and (4) the disconnect switch cannot be closed if the main vacuum circuit breaker is closed. To accomplish this functionality, key interlocks are installed (a) on the main-vacuum circuit breaker, (b) two on the disconnect switch, one locking the disconnect open and the other locking the disconnect closed and (c) on the disconnect-switch compartment door.