

Electric Utility Grade.....

Generator Switchgear

With IEEE C37.013 ...

...Circuit Breakers

**Rated 1200 Amperes to 6300 Amperes
&
Paralleling Switchgear**

**For: Gas Turbine Generators
Steam Turbine Generators
Diesel Electric Generators
Hydro Electric Generators
Combined Cycle Plants
etc...**

With Optional *PACsafe* Arc Resistant Switchgear Construction



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ANSI

ISO 9001-2000

IEC

Facilities in Great Neck, New York and Mount Vernon, Ohio

ABOUT PACS: PACS Industries, Inc., is a leading manufacturer in the USA of Generator Switchgear, using vacuum circuit breakers that conform to, and were tested to IEEE C37.013. Since the late 1990's, PACS has manufactured hundreds of Model PVHA 4,000 Ampere-6,000 Ampere Generator Switchgears for use with Gas Turbine Generators, in the 100–125 MVA range. These Generator Switchgears are in successful use throughout the United States, Canada, Saudi Arabia, and elsewhere.

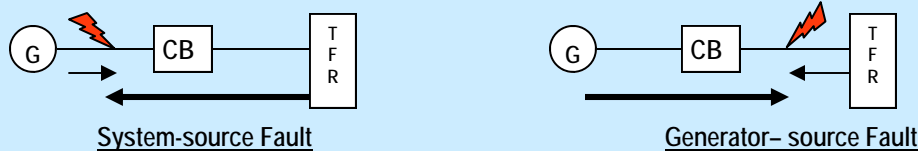
The PACS Model PVHA Generator Switchgear units utilize Vacuum Circuit Breaker modules, that have been Type Tested to relevant requirements of IEEE C37.013. The Circuit Breaker modules are manufactured into drawout truck assemblies, and into metalclad drawout switchgear and are Type Tested by PACS in accordance with IEEE C 37.20.2. The circuit breakers and switchgear also conform to the Type Test requirements of IEC 56 (circuit breakers) and IEC 298 (switchgear). These are truly World Class products.

About C37.013: In 1997, the IEEE developed a Standard entitled "C37.013-1997, IEEE Standard For AC High-Voltage Generator Circuit Breakers Rated on a Symmetrical Current Basis". The purpose of this Standard was to set parameters that would consider the severe operating capabilities required for Generator Circuit Breakers. This standard was intended for central plant generator ratings of 6300 Amperes and up, and was generally written around fixed SF6 insulated circuit breakers with hydraulic operators.

In recent years, hundreds of smaller generators have been installed, in the range of 1200 Amperes to 6000 Amperes. Realizing that many of the same severe withstand parameters required for larger generators, applied to smaller generators as well, the IEEE has been preparing a supplement to C37.013, specifically covering circuit breakers for smaller generators to the 100 mVA range, in which Vacuum Interrupters are used. Until recently, the only circuit breakers available for smaller generators, have been standard distribution type circuit breakers, but these do not have the robust characteristics required by IEEE C37.013.

PACS has available a complete product line of generator switchgear, including generator circuit breakers from 1200 Amps to 6300 Amps. Designed and Type Tested to the relevant standards of IEEE C37.013.

There are significant operating differences between standard distribution circuit breakers, and C37.013 generator circuit breakers, which we will summarize below.



Referring to the one-line representations above, there are important issues over safely interrupting short circuit faults in a generator circuit which cannot be normally handled by distribution class circuit breakers.

In a System-source Fault, the generator circuit breaker must interrupt the usually very high system short circuit current contributions, which the low transformer and connecting bus impedances do not limit. Not only must the circuit breaker interrupt the symmetrical short circuit current, but the usually very high percentage of DC component, can force the asymmetrical short circuit to higher values. As an illustration, assuming a DC component of 75%, and using the formula $I_a = \text{Sqrt}(2 \times \%DC \times \%DC + 1) \times I$, a 50 kA symmetrical fault would result in a 70 kA asymmetrical fault that the generator breaker must safely interrupt.

In a Generator-source Fault, the question of safely interrupting the fault becomes more complex due to the "Delayed Current Zeroes" effect of the system. This is caused by the very high X/R (Inductance to Resistance) Ratio of the system, that can cause the asymmetrical component of the short circuit current to exceed 100%. The effect of this very high DC component, is to cause the first zero crossover to be delayed by several cycles. Since circuit breakers depend upon zero crossover to interrupt short circuit currents, this delay in interrupting time requires that the circuit breaker be sturdy enough to withstand the additional effects of arcing, electrical, mechanical, and thermal forces for a longer time.

Out-Of-Phase Switching Capabilities. The circuit breaker must also withstand possible out-of-phase switching, that could occur with poor synchronization, or accidental closure across unsynchronized voltage and frequency between the generator and line.

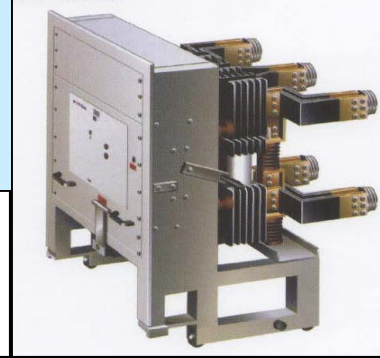
110 kV BIL Capability. It is possible for the generator voltage to vary, and as it comes up to speed with the circuit breaker open. This could impress voltages up to 2.5 times rated voltages across the circuit breaker. It is for that reason that C37.037 requires a 110kV BIL rating, as well as a higher Power Frequency Rating of the generator circuit breaker.

Transient Recovery Voltage (TRV). During the instant of contact interruption, the dielectric strength across the interrupter gap reduces to a minimum, creating voltages as high as double the line-to-line voltages, across the gap. This is called the Transient Recovery Voltage. With generators in particular, this TRV spikes very rapidly in the range of 3.5 kV–4.0 kV per microsecond. The generator circuit breaker must withstand this TRV rate-of-rise, and attempt to interrupt the current, at the first current zero intercept. The rate-of-rise of the TRV is measured by the Rate of Rise of Recovery Voltage (RRRV). This is as compared with distribution circuit breakers that are designed to handle TRV values of only 0.4 to 1kV per microsecond.

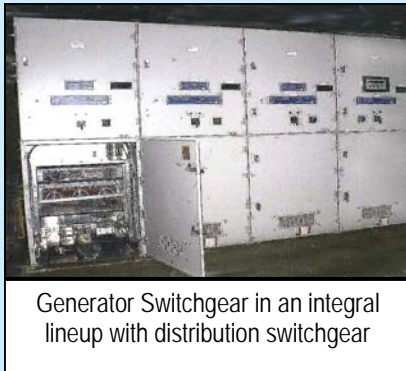


Model PHVX
 Generator Circuit breaker.
 Full metalclad construction including drawout circuit breakers.
 1,200 Amperes to 3,000 Amperes

Model PVAH
 Generator Circuit breaker.
 Full metalclad construction including drawout circuit breakers.
 4,000 Amperes to 6,000 Amperes



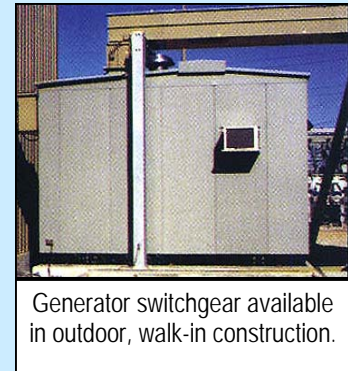
Grounding Switches or Test Trucks Available
 Remote Circuit Breaker Racking Available



Generator Switchgear in an integral lineup with distribution switchgear



Typical PHVX drawout breaker.



Generator switchgear available in outdoor, walk-in construction.

Circuit Breakers per IEEE C37.013. Switchgear per IEEE C37.20.2 or IEC 298

Circuit Breaker IEEE C37.013 Ratings *		PACS PHVX Switchgear	PACS PVAH Switchgear
* IEEE data selected for small generators	For 50C Ambient Multiply by 0.93 > For 55C Ambient multiply by 0.87 >	To 3,150 Amps @ 40C Amb	4,000-6,000 Amps @ 40C Amb
Maximum Voltage	15.5 kV	15.5 - 17.5 kV	15.5 - 17.5 kV
Operating Voltage	13.8 kV	13.8 kV	13.8 kV
Rated Frequency	50 & 60 HZ	50 & 60 HZ	50 & 60 HZ
Lightning Impulse BIL	110 kV	95 or 110 kV	95 or 110 kV
Short Circuit Current (K = 1)	25-63 kA (1 Sec)	25, 31.5, 50 kA (3 Sec)	40, 50, 63 kA (3 Sec)
Close & latch Peak (10 cy)	SC times 2.74	SC times 2.74	SC times 2.74
Power Frequency, AC	50 kV	38-50 kV	38-50 kV
TRV (contact us for 4.0 us)	3.5 kV/microsecond	3.5 kV/microsecond	3.5 kV/ microsecond (**)
Out-of-Phase Switching	50% x SC Amps	50% x SC Amps	50% x SC Amps (**)
Max DC Component	75%	75%	75% (**)
Mechanical Endurance	500 Full load, plus maintenance after SC	10,000 FL, 100 SC operations	10,000 FL, 100 SC operations
Rated Interrupting Time	60-90ms	90ms	90ms
Duty Cycle	CO-30 min-CO	CO-30 min-CO	CO-30 min-CO
	1.5	1.5	1.5 (**)

Avoid Arc-Flash ⚡ Failures

PARTIAL DISCHARGE ANALYZERS:

The best way to avoid a destructive electrical Arc-Fault blast is through preventive means. **PACSafe** Types KRIES & MAY continuously monitors live bus bars for corona and voltage, and detects deteriorating insulation systems. Level adjustments include warning or shut-down set-points, allowing repairs, avoiding Arc-Flash explosions. Can be fed to a computer for long time analysis & event recording.

For retrofit of existing switchgear, or new switchgear.



ARC-MITIGATION SYSTEM:

In the event that an Arc-Flash does occur in switchgear, it is imperative that the fault source be disconnected as quickly as possible, to avoid or mitigate damage to equipment or personnel.

The **PACSafe** Type VAMP Arc Detection system, immediately senses a light flash in a switchgear cubicle when an Arc-Flash occurs, and simultaneously senses for Rate-of-Rise of current. A signal is sent to targeted breaker trip coils, bypassing Protective relays, tripping in as low as 57ms, mitigating Arc-Fault damage. This compares to over 300 ms trip time in Selective Coordination relay systems. Damage to the switchgear is proportional to the time duration of the Arc-Fault. The shorter the duration, the less damage will occur.

For retrofit of existing switchgear, or new switchgear.



ARC-RESISTANT SWITCHGEAR

PACSafe Arc-resistant switchgear is available, designed and tested in accordance with IEEE C37.20.7 standards. PACS has successfully tested single high and 2 high switchgear, to 15kV and 50 kA short circuit, IEEE Types 1, 2, 1C & 2C, at the KEMA laboratories. The **PACSafe** Arc-Resistant designs include available top mounted Collector Plenums, to safely duct the Arc-Fault flames, heat, pressure, smoke & debris out of the switchgear room, into a safe disposal area. For new & replacement applications. Contact us regarding other Voltage ranges.



PACS Industries, Inc., is a leading independent manufacturer of Switchgear in the USA, in ratings from 600 Volts to 40.5 kV. PACS also manufactures Power and Control Centers (PCC), which are factory fabricated buildings including required interior Switchgear, Controls, etc. PACS has developed a total **PACSafe** system which includes continuous, live Partial Discharge Monitoring of bus bars, an Arc Detection System to mitigate the destructive effects of an Arc-Fault, and Arc-resistant Switchgear, to contain the effects of an Arc-fault, to help safeguard personnel.