THOMSON TECHNOLOGY®
A Subsidiary of Regal-Beloit Corporation
POWER & CONTROL

CIRCUIT BREAKER SIZING

ENGINEERING BRIEF

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A) Generator Breaker Sizing

For minimal generator protection, one must consider two classes of overcurrent conditions when sizing generator circuit breakers:

1) Overload Protection (a slight overcurrent of long duration):

Typically protection is afforded by the long time tripping device (thermal element of thermal-mag or long time in a solid-state trip breaker). Since the thermal element's temperature rise (or solid state equivalent) in a breaker generally approximates the temperature rise in the generator windings (including pre-heating and ambient temperature considerations), it will provide fairly good protection, if sized closely to generator output. If the thermal trip is over-sized, protection is minimal (See B).

2) Short Circuit Protection (a large overcurrent, hopefully of short duration):

Breakers with magnetic trips (or solid-state equivalent) are usually applied to give short circuit protection, but since the available fault current of the generator (sustained) is usually lower than the magnetic trip setpoint, they are often useless. If a solid state breaker is used it may be possible to size one to trip on a short circuit, but only if it trips at less than 300% of the generators output, and if the generator has sustained short circuit output capacity (i.e. PMG, SBO, or equivalent).

A "short time" trip (i.e. an instantaneous trip that has a very short time-delay) is okay, since the generator should provide 300% current for at least 10 seconds without damage (much longer than the trips' time delay).

As an alternative, a generator may be equipped with an undervoltage shutdown. Single phase sensing should be adequate, as all phases will collapse on a solid short circuit. This is a low cost but effective method of protection, and does not require a generator with fault current sustaining capability.

Caution must be exercised when attempting to sense short circuits with a current sensing relay because:
- the generator may not have sustained short circuit output.
- if the generators output voltage is used to power the current sensing relay, that voltage will not be available during a short circuit condition, and the relay might not operate.

B) Breaker Sizing Example (for long-time trip)

Suppose the generator is rated at 313 amps output. The breaker should be a 300A (as opposed to a 350A) because:

1) If the generator is loaded to 350A (which will likely occur in one leg only, thus not causing an engine overload), heat generated in the generator winding would be:

$$\frac{350}{313} \times \frac{350}{313} \times 100\% = 125\% \text{ of rated thermal capacity, i.e. likely burnout.}$$

or even worse, if loaded to 1.2 X 350A.
(i.e. the current at which the breaker would trip in 1-2 hours), then:

$$\frac{420}{313} \times \frac{420}{313} \times 100\% = 180\% \text{ of rated thermal capacity, i.e. definite burnout.}$$

2) If a 300A trip is chosen, you can still load the generator at 100% at:

$$\frac{313}{300} \times 0.8 = .835 \text{ PF}$$

Therefore is PF = .835 or higher, you are not limiting the genset's (as opposed to the alternator's) output.

C) The "80% Rule" & Standby Generator Breakers

1) Thermal Mag - technically (according to code) the maximum continuous current is 80%, but you must consider:
   (a) The generator is a standby, therefore it is not continuous.
   (b) The generator is not likely to run at 100% load @ PF = 0.8.

   Note - using an oversize frame will not help, since the trip is the limiting factor, e.g. a 600AF/400AT is continuous rated 320A.

2) Solid State Trip (i.e. no heat-producing thermal element) - which is also rated 100% (some are not), then there is no problem.

   CONCLUSION: - The "80% rule" is not useable on a standby unless you use a 100% rated solid-state trip breaker.

D) Breakers for A Generator Which Must Provide Overload

1) "Continuous" Rated:

   A generator with an overload rating of 10% for one or two hours (i.e. "continuous rated") can generally be used with a standard thermal-mag or solid state breaker.

The breaker should be rated for approximately full load current. Since the breaker will typically trip in 1 - 2 hours at 110% load, it allows the reserve capacity of the generator to be used, but will trip if it is run continuously at overload.

2) "Standby Rated":

A generator with no overload rating (i.e. rated as "standby" or "continuous standby, with no overload, for duration of outage") is generally not able to be protected by a standard thermal-mag or solid state breaker of any description. Since the breaker must be sized to handle the full load current continuously, and since the breaker will only trip on some overload (which the generator cannot supply) it is apparent that protection is not possible. In this case either:

(a) the breaker must be sized for the normal continuous rating, which will prevent the generator from running continuously at the standby rating, or;

(b) other means must be used to protect the generator (e.g. high winding temperature shutdown), or;

(c) it must be deemed acceptable to have no real protection (in the case of a standby unit, this may be a consideration).

NOTE - This information is generalized, and is provided for general consideration only. Specific applications should be considered in depth to determine required protection.