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TechTopics No. 17

Main bus continuous current ratings

The continuous current ratings of bus bars used for main bus and connections in medium-voltage metal-clad switchgear are determined by the requirements of ANSI/IEEE standard C37.20.2-1999. This standard requires that the bus conductors used in a switchgear design pass a continuous current test (often referred to as a "temperature-rise" or "heat-run" test). The temperature rise at the end of the test must not exceed the limits established by the standard, as summarized in Table 1. The test must continue until the temperature rise of all points monitored is less than 1 °C in one hour, considered to be the time at which temperature rise has stabilized.

Table 1: Temperature rise limits in switchgear

Application	Temperature rise limit
Buses and connections with silver-surfaced or tin-surfaced connecting joints	65 °C

In addition, the bus system must successfully pass the short-circuit tests specified in the standard. The short-time withstand current test verifies that the bus system can carry the rated short-time withstand current for two seconds, which imposes the most severe thermal stress on the conductors, joints and supports. The momentary withstand-current test subjects the bus system to the maximum offset current (e.g., the close and latch peak-current rating of the associated circuit breakers) during a test period of 10 cycles, which tests the mechanical strength of the bus system.

Some user specifications request that bus bars be sized based on current density – typically 1,000 A/in^2 (and sometimes as low as 750 A/in^2). Notice that the requirements of the ANSI/IEEE standards do not stipulate a particular current density.

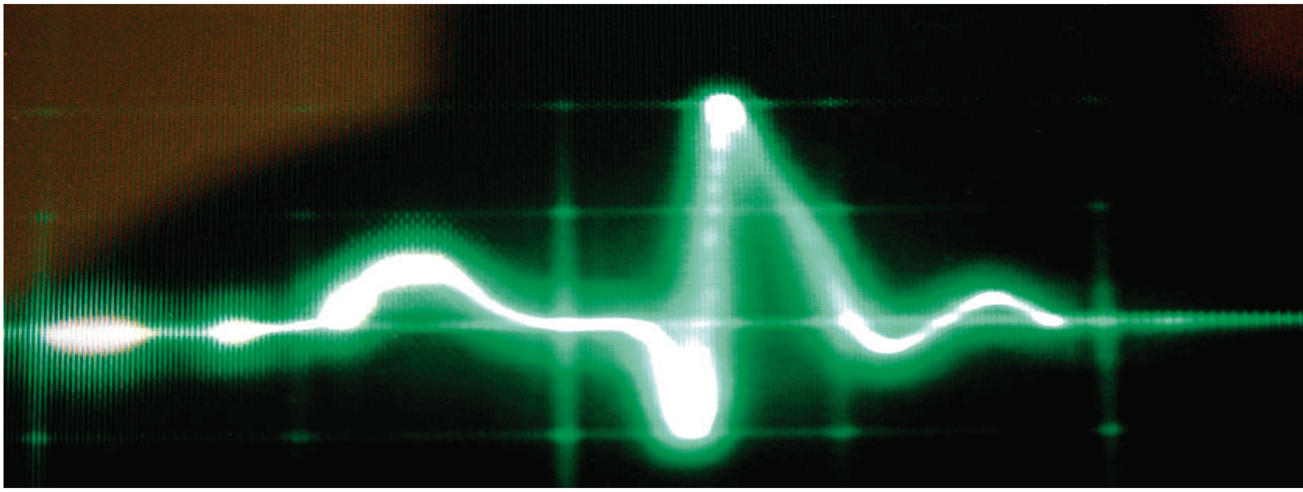
The underlying philosophy of the standards is to establish performance requirements, rather than setting an arbitrary "formula" for determining the size or quantity of bus bars. User specifications calling for a limit on current density are obsolete. Originally, they may have had some validity when many installations were custom built at the installation site or in a local fabrication shop.

Such assemblies seldom had the benefit of rigorous design testing conducted to verify the integrity of the design, and usually had relatively low-continuous current and short-circuit current ratings.

Our experience is that the allowable current density varies widely, depending on a number of factors that can affect temperature rise. Some of these include:

- Continuous current rating; the law of diminishing returns applies to the sizing of bus bars, in other words, as the continuous current rating increases, the current density of the bus will ordinarily decrease
- Size and shape of bus bars; a thicker bus bar is not as efficient as a narrow bus bar, and a single thick bar is not as efficient as multiple bus bars (of equal total cross-sectional area) with space between the bus bars
- Configuration of the bus; bars arranged with the wide dimension oriented vertically are more efficient than when the bars are oriented horizontally
- Spacing between bars of the same phase; bars spaced farther apart are more efficient
- Proximity to magnetic materials; steel bus-compartment barriers or other magnetic-enclosure elements can dramatically affect temperature rise, particularly for higher continuous current ratings

Answers for infrastructure.



- Spacing between bars of differing phases; proximity effects can increase the apparent resistance of a conductor, and thus, its temperature rise
- Air flow in the vicinity of the bus; improving air flow around the bus will remove heat at a higher rate, thus decreasing temperature rise
- Proximity to other sources of heat; for example, circuit breakers
- Emissivity of the bus; bare bus bars that are covered with a dark or dull coating will exhibit a lower temperature rise
- Presence of insulation and type of insulation; conformal insulation (such as fluidized-bed epoxy) decreases the temperature rise compared to a bare bus bar, whereas non-conformal insulation (such as loose fitting sleeves) may increase temperature rise.

Table 2 gives a brief review of the sizes of bus bars used for various main bus continuous current ratings in Siemens types GM-SG and GM-SG-AR (up to 15 kV) and GM38 (up to 38 kV) metal-clad switchgear. In each case, the design tests validate temperature rise performance within the 65 °C limit in the standards.

Table 2: Main bus sizes

Type of equipment		Main bus continuous current rating		
		1,200 A	2,000 A	3,000 A
Types GM-SG and GM-SG-AR switchgear (up to 15 kV)	Quantity bus size	One 0.25 X 4	One 0.38 X 6	Two 0.38 X 6
	Current density	1,200 A/in^2	889 A/in^2	667 A/in^2
Type GM38 switchgear (up to 38 kV)	Quantity bus size	One 0.25 X 4	One 0.50 X 5	Two 0.50 X 6
	Current density	1,200 A/in^2	800 A/in^2	500 A/in^2

This table illustrates that current density is not a valid criterion for sizing of bus bars. For low continuous current ratings, a current density requirement of 1,000 A/in^2 would result in a bus larger than required by temperature rise performance. For higher bus continuous current ratings, the current density criterion (1,000 A/in^2) would result in a bus bar that would fail to meet temperature rise requirements by a substantial margin.

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