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TechTopics No. 31

Solar radiation correction factors

Medium-voltage metal-clad switchgear and outdoor high-voltage circuit breakers have ratings that are based on application under “usual service conditions,” as defined in the applicable standards. Essentially, the “usual service conditions” defined in the ANSI standards encompass:

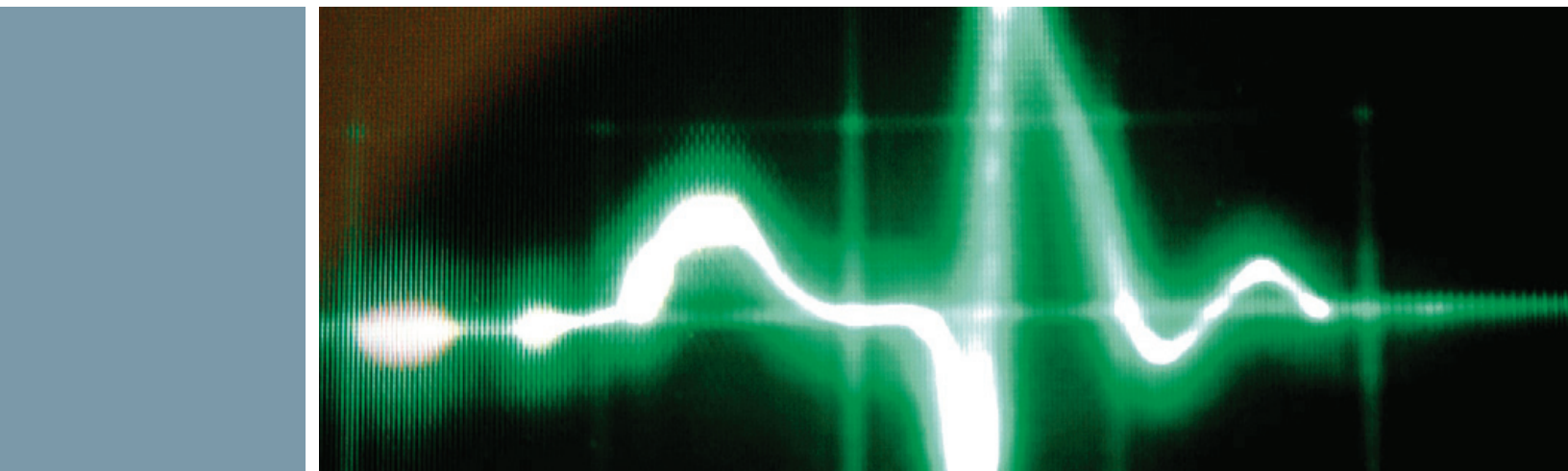
- Ambient temperature within the range of -30°C to $+40^{\circ}\text{C}$
- Altitude 1,000 m (3,300 ft) or below
- No significant solar radiation
- No significant adverse environmental considerations (e.g., corrosive fumes, dust, excessive humidity and the like).

This issue of TechTopics discusses the adjustments required for applications subject to significant solar radiation. ANSI/IEEE C37.24-2003, “Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal-Enclosed Switchgear,” discusses the issues relevant to evaluating the adjustment required to account for solar radiation. This application guide is used not only for medium-voltage metal-clad switchgear, but also for outdoor high-voltage circuit breakers. Since the medium-voltage control standards do not deal with this issue, we would suggest that the principles of ANSI/IEEE C37.24 are also appropriate for medium-voltage controller applications.

When applied outdoors, the temperatures inside electrical equipment are affected by solar radiation, wind and the external ambient temperature, as well as by the loading on the equipment. In general, the equipment is rated on the basis of a maximum ambient temperature of 40°C , and is rated on the basis that the temperature rise is due entirely to heat release resulting from the current loading.

The impact of solar radiation varies by geographic location, degree of exposure to sunlight, time of day and season. As ANSI/IEEE C37.24 discusses, it is not economical to design electrical equipment with custom ratings to correspond with a particular set of solar radiation conditions. For similar reasons, it is usually not appropriate to design for all the influences to simultaneously fall into their most adverse ranges (e.g., maximum ambient temperature, highest load current, maximum solar radiation, zero wind, etc.). Therefore, it is the responsibility of the user to determine appropriate solar radiation correction factors for the particular installation.

If the factors affecting the equipment internal temperature only reach their “worst case” conditions for a few hours per day, and only on a few days per year, the increase in temperature inside the unit probably only has a minor effect on the useful life of the equipment. This subject is discussed in TechTopics No. 15.



Using the concepts discussed therein, we see that one hour of operation with an internal temperature 10 °C higher than the limits of the standards is approximately equivalent to two hours of operation at the limiting temperature of the standards. Thus, operating for four hours per day for 10 days per year at these conditions would cause a decrease of expected life of the order of $4 \times 10 \times (2-1) = 40$ hours, or a bit over a day and a half per year. In the overall “scheme of things,” such a decrease in life would not normally be considered significant.

Historically, the standard color for outdoor electrical equipment was ASA No. 24 dark blue-gray. In recent years, it has become much more common to use ANSI 61 light gray or ANSI 70 sky gray. The color of the enclosure makes very little difference with respect to dissipation of the heat generated internally (e.g., due to the current loading), but light color exterior finishes reflect a larger share of incident solar radiation, thus decreasing internal temperature rise due to solar radiation.

In the 1950s, studies were done by several manufacturers, and these indicated that the maximum internal temperature rise for a dark (black) enclosure due solely to solar radiation is about 15 °C. In contrast, the data suggests that the temperature rise due to solar radiation for a light gray enclosure would be only about half as great.

A word of caution here is appropriate. The data suggests that the decrease in temperature rise due to use of a light color may be completely overcome when the enclosure is dirty. Therefore, it is recommended that allowance for reduced temperature due to the use of light color enclosure color be used only with caution.

The basic technique employed in ANSI/IEEE C37.24 is to assume that the maximum temperature rise due to solar radiation is 15 °C. To maintain the equipment within its temperature limits, the continuous current capability must be adjusted whenever the ambient temperature exceeds $40 \text{ °C} - 15 \text{ °C} = 25 \text{ °C}$. The application guide contains tables of 30-year monthly normal maximum temperature for a large number of locations in the U.S. and Canada.

The recommended adjustment for solar radiation is to decrease the continuous current capability by approximately one percent for each °C that the 30-year monthly normal maximum temperature exceeds 25 °C. Thus, in a location in which the 30-year monthly normal maximum temperature is 35 °C (e.g., Austin, Texas), a solar radiation correction factor of 0.90 would be appropriate.

This issue of TechTopics provides only a brief summary of the discussions in ANSI/IEEE C37.24. The reader is encouraged to review the complete version of ANSI/IEEE C37.24, which is available from IEEE.

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