Altitude De-rating of Components Placed in the Switchgear Enclosure

September 20, 2012

As a dielectric — dry air works satisfactorily. However as the altitude at which we apply our electrical equipment increases, the effectiveness of the dielectric property decreases. An increased altitude also decreases the continuous current carrying capability of electrical equipment due to the reduced thermal conductivity of the lower density air. In the past, we have discussed the altitude de-rating factors for switchgear (see PTB #25). This Powell Technical Brief will explain how altitude de-rating effects the installation of medium voltage fuses, surge arresters, current transformers, voltage transformers, control power transformers and relays.

Fuse De-rating

The fuse de-rating is a function of the ability of the fuse to clear a fault and achieve a dielectric across the fuse element gap faster than the system voltage across the fuse can be established. This de-rating would be applicable for non-sealed fuses like expulsion fuses and current limiting fuses, where the outside air is the insulating means used to isolate the line and faulted load. Any fuse that depends on air at atmospheric pressure for its insulating and cooling medium will have a higher temperature rise and a lower dielectric withstand and need to be de-rated for altitude exceeding 3300 ft per the IEEE Std C37.40, section 2.3, Table 1.

When the dielectric strength of the fuse is de-rated, the application engineer is often required to choose a fuse of higher voltage class. The fuse interruption at higher voltages will result in higher arc voltages than the maximum fuse voltage rating. The maximum permissible overvoltages for various rated maximum voltages are listed in ANSI C37.46, Table 5. However, most of the fuse manufacturers design for the peak arc voltage to be around three times that of the rated maximum fuse voltage. The peak of the arc voltage depends on the voltage applied across the fuse and the peak arc voltage should not exceed the system and equipment insulation levels (BIL).

An alternate solution is the hermetically sealed fuse, which does not require de-rating of the internal operating mechanism. Note that hermetically sealed fuses are both expensive and may have a long delivery time. Care must also be taken to confirm that the outer creepage distance is acceptable within the de-rated values.

Surge Arrester De-rating

The most common type of surge arrester that we use today is the gapless metal oxide arrester. These arresters are sealed and the outside air plays a part in the external surface creepage distance of the housing. The outer surface has a certain creepage distance that prevents the surge arrester housing from tracking across the surface of the arrester. Powell Technical Brief # 59 describes the acceptable surface creepage distance for various voltage levels. The insulated conductor distances can only be used if an insulating boot properly covers the ferrule at the top of the arrester.

Powell Industries, Inc.
PO Box 12818
Houston, TX • 77217

Tel: 713.944.6900 • Fax: 713.947.4453
www.powellind.com
info@powellind.com

Altitude De-rating of Components Placed in the Switchgear Enclosure

Standard arresters are designed to operate at altitudes that do not exceed 6000 ft. Special arresters are required for altitude of 6001 – 12000 ft and for altitudes of 12001 – 18000 ft. It may also be necessary to have special arresters manufactured with a standard duty cycle arrester in a housing with higher creep levels to maintain the desired discharge level of the arrester and the required creep distance.

A special caution when applying de-rated higher voltage current limiting fuses. Each fuse has a characteristic such that the peak arc voltage generated would be around three times that of the rated maximum fuse voltage. The transients that result from applying a higher voltage class fuse due to altitude de-rating can often result in the surge arrester conducting during a fuse interruption. This should be avoided for line side station class and intermediate class arresters as the conducting impedance of these arresters is so low that when conducted during a fault will cause serious damage. So consider installing distribution class arresters for this application which have higher conducting impedance.

Current Transformer De-rating

When installing CTs at higher altitudes, the dielectric strength and the thermal current rating factor are affected due to reduced air density. The dielectric strength rating (BIL) needs to be de-rated as per IEEE Std C57.13, section 4.2, Table 1. This de-rating may require the use of higher insulation level current transformer with the appropriate primary current and the ratio to maintain the desired secondary current. The thermal current rating factor de-rating is required only when the temperature limits are exceeded while carrying the continuous current. The thermal current rating factor needs to be de-rated by 0.3% for every 330 ft.

Voltage and Control Power Transformer De-rating

The basic impulse insulation level (BIL) and the thermal volt-ampere (VA) rating of the VT and CPT are affected at higher altitudes. The BIL rating of the VT and CPT needs to be de-rated as per IEEE Std C57.13, section 4.2, Table 1. This de-rating may require the use of a higher voltage class transformer with the appropriate primary voltage and the ratio to maintain the desired secondary voltage. Always consult with the manufacturer before applying the VT and CPT at higher altitudes (greater than 3300 ft) for de-rated value of thermal VA rating and the iron core wattage loss of the transformer.

For example: Given a line-up of switchgear operating at 4.16kV at an altitude of 10,000 feet, the appropriate choice is a voltage transformer with a primary voltage of 4200 Volts and a secondary of 120 Volts. The transformer would have a nominal voltage class of 8.7kV with a BIL at sea level of 75kV. When the 80% de-rating factor is applied due to the altitude, this VT has a BIL of 60kV.

Powell Industries, Inc.
PO Box 12818
Houston, TX • 77217

Tel: 713.944.6900 • Fax: 713.947.4453
www.powellind.com
info@powellind.com

Altitude De-rating of Components Placed in the Switchgear Enclosure

Relay De-rating

The application of relay at altitude higher than 5000 ft is considered as an unusual service condition and need to be de-rated for dielectric strength and maximum ambient temperature of the relay as per IEEE Std C37.90, section 4.2.1.1 , 4.2.1.2 and Table 1, Table 2. However, consult with the relay manufacturer for your specific application.

Samala Santosh Reddy, P.E.
R&D Engineer

Michael Wactor, P.E.
Technical Director – CPD

Powell Industries, Inc.
PO Box 12818
Houston, TX • 77217

Tel: 713.944.6900 • Fax: 713.947.4453
www.powellind.com
info@powellind.com