Applying Switchgear Utilizing Sealed Interrupting Devices at High Altitudes

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Basis of Altitude Related Corrections

Air density (temperature and pressure) varies from one location to another. Because it is a major factor in the dielectric strength of air, most electrical equipment is tested using the standard reference atmosphere, also referred to as the normal temperature and pressure at sea level (NTP*) to obtain consistency in test results. Correction factors may then be used to apply the design in other locations. Switchgear that depends on air for an insulating and cooling medium will have a higher temperature rise and a lower dielectric withstand capability when operated at altitudes above sea level.

Mathematically, corrections to these ratings apply immediately as you elevate from sea level, however historically air insulated equipment has shown enough design margin to be applied at altitudes up to 1000m (3300ft) with no correction factors applied. At elevations above 1000m, the rated power frequency withstand voltage, the lightning impulse withstand voltage, and the rated continuous current for the assemblies should be reviewed and may require adjustment by the altitude correction factors found in applicable design standard. It is important to note that for any insulation not exposed to ambient atmospheric pressure, the dielectric characteristics are not affected by changes in altitude and no special precautions need to be taken. An example of this type of internal insulation can be found on a sealed vacuum interrupter.

Corrections for continuous current

Corrections to the rated continuous current based on altitude can be quite confusing. De-rating factors are provided in many equipment standards containing application advice that seems contradictory. It is stated in the high voltage circuit breaker application guide that de-rating circuit breakers for altitude is generally thought to be unnecessary because the ambient temperature at altitudes above 1000m is significantly lower than the normal 40°C maximum. This is not necessarily correct for indoor rated equipment. The continuous current capability of any device is based on the ambient air temperature surrounding the device; indoor equipment may be in a significantly warmer environment that the outside air, even at higher altitudes. For indoor equipment, the de-rating assessment can only be made based on the equipment room temperature, not the environmental conditions outside the building.

* NTP is defined as temperature = 20°C, atmospheric pressure = 101.3kPa (14.7psi), humidity = 11 g/m^3.

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Corrections for dielectric withstand

The dielectric capabilities of all switchgear components using air as the primary insulating medium will be affected by the changes in air pressure experienced at higher altitudes. Specifically, the Basic Impulse Level (BIL) and Power Frequency Withstand ratings must be reduced as altitude increases. While some components such as sealed interrupters are unaffected internally by decreased air pressure, the external surface insulation of these devices may experience similar reductions in capability. In applications above 1000 m the use of surge arresters to keep transients voltages below the adjusted levels should be considered.

Surge arrester selection should be coordinated such that:

1. The maximum Discharge Voltage of the arrester is approximately 20% lower than the de-rated BIL for the equipment.
2. The Maximum Continuous Operating Voltage (MCOV) for the arrester is equal to or greater than the actual, not a de-rated value, maximum continuous system voltage for the equipment.

Corrections for rated voltage

Air pressure affects the dielectric capability of the air and therefore affects the interrupting capability of contacts in open air. The air pressure in a sealed interrupter, such as a vacuum interrupter, is unaffected by changes in air pressure and will not be affected by changes in altitude. It is not necessary to de-rate the maximum voltage rating for devices using sealed interrupters based on elevation.

Refer to IEEE C37.100.1 Annex B for a detailed explanation of how the de-rating factors were obtained and applied.

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