

Dewpoint measurement in SF₆ gas-insulated switchgear

Sulfur Hexafluoride (SF₆) is an inert insulating gas of high dielectric strength and thermal stability. The electric power industry uses SF₆ to insulate high voltage lines, circuit breakers and other equipment used in electricity transmission and distribution. Dewpoint measurement is an important part of SF₆ equipment maintenance.

SF₆ is a greenhouse gas, with a global warming potential 23900 times that of CO₂. For this reason, the gas is used sparingly and recycled.

Moisture in SF₆

Power switching or load current interruption in a switchgear results in arcing between two contact points. The insulation properties of SF₆ control effectively the arc formation. Under the influence of an arc, a small portion of SF₆ gas dissociates into its atomic constituents sulfur and fluorine, then again recombining naturally into SF₆.

However, in the presence of moisture, the SF₆ reformation is disturbed and secondary decomposition products such as highly corrosive hydrogen fluoride (HF) start to form. These weaken the insulation properties of SF₆ and may cause rapid deterioration of a high-voltage switchgear.

In order to avoid the formation of unwanted secondary decomposition products, the amount of water vapor in the system should be kept at minimum.



Operating environment

A typical dewpoint range for servicing the SF₆ equipment is -50...-20 °C. Pure SF₆ may be even drier. The most typical operating pressure within the switchgears is 3...8 barg, but dewpoint measurement can also be performed at atmospheric pressure.

The industry also uses ppm units, especially ppm_w (parts per million by weight) to indicate humidity. For SF₆, the conversion between ppm_v and ppm_w is

$$\text{ppm}_w = \text{ppm}_v / 8.1$$

Performing the measurement

Typically, dewpoint measurement in the switchgear is done at 5-8 years intervals by specialized SF₆ servicing companies.

The measurement can either be performed at system or atmospheric pressure. The conventional dewpoint measurement technique (chilled mirror) has typically been restricted to measurement at atmospheric pressure due to rather high liquefaction temperatures of pressurized SF₆.

Standards

IEEE standard guides for moisture measurement and control in SF₆ Gas-Insulated Equipment (IEEE std 1125 -1993).

International standards specify the recommended maximum moisture content in circuit breakers.

IEC 376 specifies the limit for new gases to be introduced into the GIE compartment as 120 ppm_v / T_d = -40 °C.

The US standard ASTM D2472-92 states 71 ppm_v / T_d = -45 °C.

Pure SF₆ contains very little moisture. A typical moisture limit set by SF₆ gas manufacturers is -60 °C T_d.

Moisture limit recommendations of the gas-insulated equipment (GIE) vary between 70 ... 810 ppm_v, corresponding to -45 ... -22 °C T_d in the atmospheric pressure, or -29 ... -3 °C T_d in 5 bar_g pressure.

Products for measuring dewpoint in SF₆

The Vaisala DRYCAP[®] Hand-held Dewpoint Meter DM70 with the DMP74C probe is optimized for measuring the dewpoint in SF₆ gas. The sensor purge feature of DM70 allows fast response in low dewpoints, and only a small amount of SF₆ is needed for sampling. Fast response time is especially important because of the environmental restrictions on SF₆ release to atmosphere. The instrument outputs several measurement quantities, including e.g. dewpoint temperature, ppm_w, ppm_v, and even dewpoint temperature calculated from gas pressure to atmospheric pressure.

A 10m extension cable between the MI70 indicator and the DMP74C probe is useful for measurement points that locate high up from ground level.

The DSC74B and DSC74C sampling cells are optimized for measurement in the SF₆ gas insulated equipment, and it

enables measurement at both gas system and atmospheric pressure. The sampling cells also enable collecting and recycling SF₆ when measuring in atmospheric pressure.

Regardless of dewpoint measurement technology, it is to be noted, that SF₆ combustion gases such as HF should not be present when making the measurement. The industry standard is typically to ensure these gases are not present in notable quantities before performing dewpoint measurement. In a well serviced switchgear, the presence of HF is very rare. Combustion gases may appear in places where the gear is heavily burdened and short circuits commonly take place.