



GEAFOL – cast-resin dry-type transformers

Behavior in fire, toxicology of the fumes and
of the oxidative pyrolysis products

Power Transmission and Distribution

SIEMENS

The tests and their results – Summary

Cast-resin dry-type transformers can, almost without exception, take the place of the askarel-filled transformers that have been called into question for ecological and toxicological reasons. The way the GEAFOL cast-resin dry-type transformer behaves in fire under internal and external exposure to energy and the possible toxicity of its combustion gases and pyrolysis products were the matters under investigation.

Short-circuit tests in the high-power test laboratory of the “Forschungsgemeinschaft Mannheim-Rheinau” (a research association)

Test set-up

Short-circuit arcs were generated across all three high-voltage windings of an 800-kVA GEAFOL cast-resin transformer at normal operating temperature. The short-circuit power was limited to 150 MVA.

Test result

After two short-circuit arcs lasting for 0.5 and 2.0 seconds, the transformer exhibited surface damage caused by the effects of exposure to the arcs. Following cleaning of the surface, its operating characteristics would not have been restricted.

Conclusion

Even at normal operating temperature, the GEAFOL cast-resin transformer is not flammable when exposed to high-energy arcs; surface arcs do not lead to any form of permanent restriction in its operating characteristics.

Fire behavior tests with examinations of fumes conducted at the “Brandhaus” (fire test building) of the “Allianz-Zentrum für Technik GmbH”

Test set-up

With the aid of another 800-kVA GEAFOL cast-resin transformer, the first step involved exposing limb W to external exposure to flame, the fire being built of dry pinewood. This was followed by limb U also being exposed to such flame, but this time with propane gas. The flame temperatures ranged from 800 to 1,200° C. The duration of the test with wood was 44 minutes; in line with the temperature characteristic measured during this test, the source of the fire in the gas-flame test was switched off after 30 minutes. The fumes that arose were scanned in “on-line” mode at intervals of 4 s and evaluated by mass spectrometry in the range from m/e (mass/load) = 12 to m/e = 650.

Test results

■ As was to be expected, the insulating materials of the HV and LV windings ignited under the prolonged influence of the high external flame temperatures (up to 1,200° C) and caused a strong flare, in particular due to the stack effect caused by axial cooling ducts. The outer surface of the HV winding exhibited burn marks only at the actual area of exposure to the flames. Flame transmission to the adjacent limb was only slight. After the wood had burned away or after the gas burner had been switched off, the flames went out of their own accord.

- In order to analyze the fumes, all those masses between m/e = 12 and m/e = 650 were registered that demonstrated a characteristic curve proportional to the temperature of the fire and had more than one peak during the course of the fire.
- 99% of the gases given off during combustion contained the components of the air (N_2 , O_2 , Ar and CO_2).
- The progression of the fire can be tracked by following the intensity of the molecular ion for CO_2 .
- Apart from CO_2 (taken as being 100%), the combustion gases were found to contain only the hydrocarbon gases presented in the table in the publication E50001-U413-A105-X-7600 entitled “Fire and the cast-resin dry-type transformer”.
- The total concentration of hydrocarbons was less than 120 ppm.
- Carbon monoxide (CO), that cannot be distinguished from N_2 by mass spectrometry, was found by means of gas chromatography to be present in a concentration of almost 3%.

Conclusion

When a GEAFOL cast-resin dry-type transformer is involved in a fire with an external source, this does not lead to any appreciable exacerbation of the fire. Under the test conditions described, only a minimal concentration of hydrocarbon gases was measured in the fumes given off, in addition to the common fume components such as CO and CO_2 ; due to their low concentration, there are no specific hazards to be expected from these gases, which could from this point of view exacerbate the externally ignited fire.



Investigations into the pyrolysis products of the cast-resin molding for GEA FOL transformers with regard to 2,3,7,8-TCDF and 2,3,7,8-TCDD conducted by CIBA-GEIGY (Vantico), Basle, Switzerland

Test set-up

The cast-resin was combusted in the BAYER-ICI-SHELL apparatus and the combustion products that arose were collected in a filter and in methanol as an absorption solution. The extract from the filter was combined with the absorption solution. Known quantities of TCDF and TCDD were added to an aliquot (sample with addition). Subsequently, the two test solutions, one with and one without addition, were purified by column chromatography and chromatographed on a capillary column with electrochemical detection (EC).

Test result

At a level of 0.05 µg/g (= 0.05 ppm), no 2,3,7,8-TCDF and 2,3,7,8-TCDD was detected in the pyrolysis products of the cast-resin molding.

Special test to verify fire behavior class

Test set-up

In a special chamber, a simulated transformer limb was tested simultaneously with

- Flames from a trough full of spirit,
- Radiated heat from a vertical heater and
- Reflected heat from a metal screen behind the coil.

The test criteria are maximum emitted gas temperature, its time characteristic and smoke density.

Test result

Verification was provided of categorization in the highest behavior class F1 to IEC 60076-11.

Overall results

The tests conducted with four different matters in mind demonstrated that GEA FOL cast-resin dry-type transformers are not flammable when exposed to high-energy arcs and that they are self-extinguishing under external exposure to flame once the source of the fire is removed. Horizontal flame transmission was not observed. The analysis of the combustion gases and the oxidative pyrolysis of the cast-resin molding demonstrate that no toxic components worthy of mention are given off over and above the fume components commonly given off in fires. The transformer fulfills all requirements for classification in fire class F1. This result was actually expected, because the components of the cast-resin molding, the insulating materials used and their chemical reactions when exposed to flame give no indication of critical toxicities.

Please also read the scientific paper on this subject entitled "Fire and the cast-resin dry-type transformer" (E50001-U413-A105-X-7600).

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