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Gutachten

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(Kurzfassung)

Gegenstand: **Bewertung der Wirksamkeit von flammenhemmenden Abdeckungen bei Mineralölbränden in abflusslosen, wannenförmigen Auffangräumen unter Transformatoren**

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Die Kurzfassung des Gutachten besteht aus 4 Seiten und einer Anlage.

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Expert's Report (abbreviated version)

1. Grounds

Mineral oil is used for cooling and insulating transformers in electrical switching and transformer substations. Collecting chambers without drains are generally installed underneath the transformers in order to prevent mineral oil from seeping into the soil in the event of a leak. In view of the relatively low flash point and the high operating temperature of the oil, there is danger of the oil igniting in the event of a leak.

In order to prevent any fire spreading to neighbouring transformers and reduce as far as possible any damage to the environment by combustion products, covers are placed on the collecting chambers which, in the event of a leak, allow the oil to flow without hindrance into the collecting basin while at the same time restricting the fire to the collecting chamber and simultaneously preventing its spread.

The suitability of a special cover - "flame-retardant gratings" - manufactured by the company PcP. was examined in several preliminary trials and a multi-phase original fire test.

2. Test item

Mineral oil

- Insulating oil on a mineral oil basis to DIN 57370, parts 1 and 2
- Calorific value: approx. 42,700 KJ/kg
- Flash point to DIN 51758 138 up to 148°C; boiling temperature or initial boiling point at 290°C; thermal decomposition from 340°C
- Operating temperature in transformer 60- 90 °C

Covers

- Flame-retardant covers manufactured by PcP
- Panels type LHD-153 und LHD-99
- U-shaped panel sections on perforated galvanised sheet steel 3 mm thick (ÜP 240 – StW 22)

- Standard height of the panels 35 mm, width and length according to requirements
- Diameter of perforation holes 7mm, approx. 1065 holes per sq.m., i.e. approx. 4.1% of the surface is open
- Flow rate of 660 l per min. for mineral oil at a temperature of 90°C through 1 sq.m. covering surface

Collecting chambers

The form and collecting capacity of the drain-free mineral oil collecting chambers is adapted to suit the size of the respective transformer platform and the volume of oil in the transformers.

The collecting chambers are trough-shaped and usually consist of several sections linked by connecting holes at the base for level compensation.

3. Original fire test

3.1. Test methods

- a) Oil is collected in a collecting chamber equipped with flame-retardant covers. Using various burning solids (wood and paper), as well as a burning fluid (mineral oil), attempts are made to ignite the oil from outside.
- b) Burning oil flows from a typical transformer height onto covers placed over a collecting chamber.

3.2. Description of test process

1000 l mineral oil were heated to a temperature of 98°C in a reservoir. The mineral oil was then ignited using an igniting agent (5 l Isopropanol). After burning for one minute, the oil reservoir was tipped over automatically.

Approx. 950 l burning mineral oil were channelled over guiding plates onto the covers of the collecting chamber within 3 minutes and 30 seconds. The burning oil poured onto the covers from a height of 960 mm and over a width of 2000 mm.

The majority of the mineral oil immediately seeped through the holes in the covers and collected on the base of the collecting chamber. The fire on the surface of the covers extinguished in just a short period ($t < 5$ sec.) after the flow of burning oil came to an end. In the course of the test, an intermittent emergence of white mineral oil vapour through the covers was observed.

In individual cases, stray flames (length < 0.5 m) emerged through the covers shortly after the emergence of mineral oil vapour. The duration of flame emergence in these cases was between 2 and 7 seconds. In all, however, this occurrence was only observed 5 times during the test period of 63 minutes. Fig. 1 and 2 illustrate the test procedure at chosen moments.

3.3 Test results

Upon extinguishing the fire on the surface of the covers (directly after the tipping process was completed), temperatures at intervals of 200 mm along the surface were measured at between 70° and 85°C during the complete test duration; brief temperature peaks of 200°C were reached during the few occasions of flame penetration. These temperatures, however, are not sufficient to ignite combustible solids.

As soon as the burning mineral oil had entered the collecting chamber underneath the covers, the oxygen concentration in the chamber dropped immediately from 21% by volume to values between 3 and 4% by volume. This very low mean concentration is indicative of an extremely under-ventilated fire or pyrolytic decomposition processes with oxygen starvation.

4. Evaluation of test results

Flammability

The covers used to cover collecting chambers beneath transformers form an additional mechanical protection measure against larger burning objects falling from above (hole diameter 7 mm). Consequently, ignition of the mineral oil is only possible if sufficient quantities of highly inflammable fluids such as alcohol or petrol are added and ignited.

Fire behavior of mineral oil in the event of transformer leakage

A flow rate of at least 600 l mineral oil (temperature 90°C) through a covering surface of one square metre within one minute was recorded in preliminary tests. This is similar to the flow rate of water at 15°C. Taking into account this result, it can be assumed that a quantity of burning mineral oil approx. thirteen times larger would flow through the 22.5 sq.m. of covers used in the test without problem within 3 min. 30 sec, representing a flow rate of burning mineral oil through the grating holes of approx. 47,000 l or 13,500 l per min. The permeability rate of the covers is therefore sufficient under all circumstances to prevent any burning mineral oil from flowing over the edges of the collecting chamber.

For a duration of just 20 seconds in the main test, there were localised occurrences of after-burning of mineral oil residue on the surface of the covers after the flow of burning mineral oil had ceased. Upon contact with the covers, the burning oil flowed through the holes into the collecting chamber where it spread evenly over the floor of the chamber. Ambient air can only gain access to the collecting chamber through the holes in the covers and some gaps between the covers and the sides of the chamber.

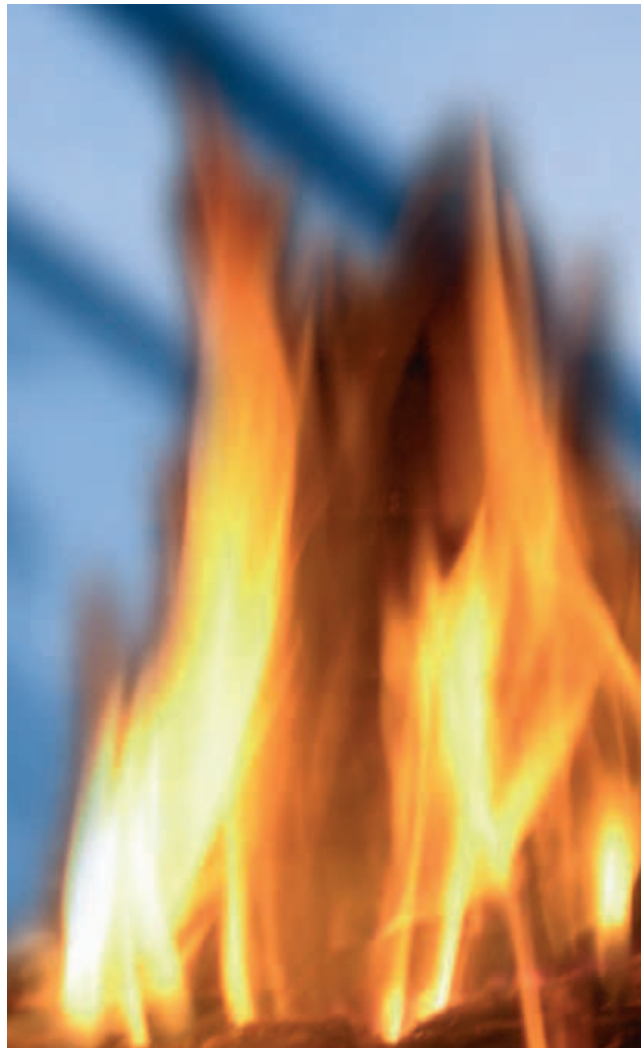
The maximum surface area available for subsequent in-take of fresh air is approx. 10% of the total surface. For this reason, combustion of the mineral oil is only possible to an extremely limited extent due to the lack of oxygen and, consequently, it would be better described as pyrolytic decomposition.

The occasional emergence of hot gases at temperatures below 200°C does not represent any significant risk for surrounding areas or the environment.

Effect of the covers

Summing up, it can be said that adequate drainage through the covers into the collecting chamber is guaranteed even with larger quantities of oil. Emergence or spraying of burning mineral oil is not to be expected. In order to take into account the possibility of all the mineral oil in a transformer leaking out within a matter of just a few seconds, it is recommended for safety reasons that the covers are positioned at least 100 mm below the upper edge of the collecting chamber in order to avoid any burning oil spraying out.

The LHD® "flame retardant gratings" of the company PCP, as used in the test guarantee a high degree of fire protection-related safety in the event of damage to a transformer with leakage of larger quantities of burning mineral oil because of their high permeability rating on the one hand and the restriction of air supply to the collecting chamber underneath the covers on the other. Consequently, their use can be recommended for the intended purpose. In an installed state, the effect of the covers can be described as flame or fire retardant.



A handwritten signature in blue ink, appearing to read 'I. Kotthoff'.

Dipl.-Phys. I. Kotthoff

Head of Original Fires Technical Dept

Test layout principle

Starting position prior to start of tipping process
1000 l Mineral oil
Initial temperature 90°C

