Fire testing for transformer pit fire protection

ABSTRACT

Transformer pits are conventionally filled with rocks in order to achieve passive fire safety in the event of an oil leak from the transformer. Other solutions also exist but there is no well defined test method that allows an assessment of the fire performance. In this brief article, such a test is presented together with test results for an alternative system where profile planks are used instead of rocks.

KEYWORDS

transformer pit, transformer oil, transformer fire, profile plank, experimental measurements

On the use of alternatives to rocks for passive fire protecton

1. Introduction

Burning transformer oil that has been ignited due to a transformer rupture can be a large problem and the fire can cause huge damage to the surroundings. To handle the leaking oil, a transformer is often placed above a concrete pit (transformer pit) to capture all the leaking oil. If the leaking oil is ignited, the fire can effectively be extinguished by using different systems in the transformer pit. The traditional way of improving the fire safety of transformer stations is to fill the transformer pit with rocks. The purpose of these rocks is that, in the event of an incident involving leaking and burning of transformer oil, the oil should be cooled as it comes into contact with the stones and that the limited amount of oxygen would help to avoid a long lasting fire when the oil runs into the transformer pit. Stone filled transformer pits can make it hard for service personnel to work on the transformer. It can also be expensive to sanitise the stones after the oil leak. An alternative to filling the pit with stones is to cover it with a profile plank. A profile plank is in this case a product based on a steel grid that is a kind of floor inside the transformer pit. The steel grid needs to have holes that will drain the leaking oil down into the transformer pit. The tested product is shown in Figure 1. This solution has the advantage

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Burning transformer oil that has been ignited due to a transformer rupture can be an extensive problem and the fire can cause huge damage to the surroundings

of allowing the entire volume of the pit to be available for rainwater and for any oil, instead of having most of the volume filled with stones. Another advantage is that it is easier to perform service work on the transformer station with a smooth profile plank as the base instead of stones. It is also easier to clean and restore the transformer pit after an oil leak.

Today no technologically neutral description of the requirements for extinguishing burning oil in a transformer pit is available. Swedish standard SS 421 01 01 [1] states:

"Preferably arrangements that contribute to extinguishing the fire in the leaked liquid shall be used, for example the use of a layer of stones (approximately 300 mm deep and with a grain size of about 40/60 mm) that extinguishes the burning liquid that enters the layer."

A search through the literature, both national and international standards and guidelines, finds that several documents describe the problems of burning oil, but none of them state specific requirements for fire extinguishing [2-6]. Rather, the documents typically contain guidelines similar to the translated citation from SS 421 01 01 above. SP Fire Research has, therefore, performed fire tests simulating a transformer failure by tipping burning transformer oil into a transformer pit covered by profile planks.

2. Experimental method

The test setup is shown in Figure 1. The transformer pit was 4 m long, 3 m wide and 1 m deep. Instrumentation consisted of thermocouples at various heights above and below the profile plank, and gas sampling probes mounted 5 cm below the plank. The oil was stored in a tippable trailer and heated by means of an LPG burner. Detailed information about the tests can be found in [7] and [8]. Three tests were carried out, see Table 1.

Table1. Diagnosis methods and related problems

Test No.	Scenario
1	With the oil heated to 90 °C.
2	With the oil heated to 90 °C. The transformer pit had been filled with water down to a depth of 19 cm to represent rainwater.
3	With the oil heated to 140 °C.

Figure 1: The transformer pit covered with the profile planks. Instrumentation consists of thermocouples and gas sampling probes. The tippable trailer on the left was used to contain the oil while being heated.

A new alternative for passive fire protection of transformer pits has been tested

3. Results and discussion

Figure 2 shows a series of pictures from Test 2, where it can be seen that the flames were self-extinguished within a few seconds after tipping the burning oil into the transformer pit. The burning oil was self-extinguished. The self-extinguishing occurred mainly due to the low oxygen level in the transformer pit as shown in Figure 4. It is important to remember that other fire scenarios and operational factors need to be studied regarding different safety solutions for transformer pits. Examples of operational factors are the reduction of oil drainage rate due to different construction solutions and debris, the cost of maintenance and the cleaning cost after an eventual oil leakage or fire. In this study no reference test using classic rocks instead of profile planks was performed. Such a comparison can be found in reference [9].

Figure 3 shows how the temperature rises rapidly as the burning oil contacts the profile plank. The flames disappear quickly and the temperature above the plank falls back to a low level. Beneath the planks the temperatures remain at elevated values for a longer period of time. For Tests 1 and 2 this is primarily due to the limited ventilation through the grating, but in Test 3 (in which the oil was heated to 140 °C) there was some heat release for about two minutes.

Figure 4 shows the oxygen concentration which quickly falls to low levels beneath the planks and helps to extinguish the fire.

Figure 2: A series of pictures from Test 2. The time lapse in minutes and seconds can be seen on the display in the bottom right hand corner of the pictures. It can be seen that the flames are extinguished within a few seconds of tipping the burning oil into the pit.

The result shows that solutions other than transformer pits filled with rocks are promising

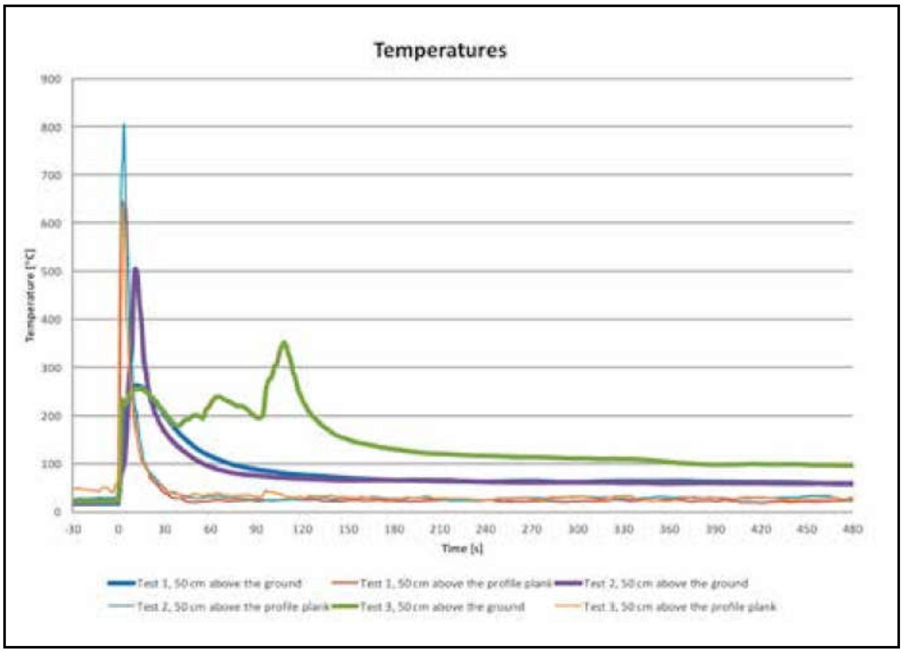

Figure 3: Temperatures in the centre of the pit, 50 cm above the bottom (i.e. beneath the planks), and 50 cm above the planks.

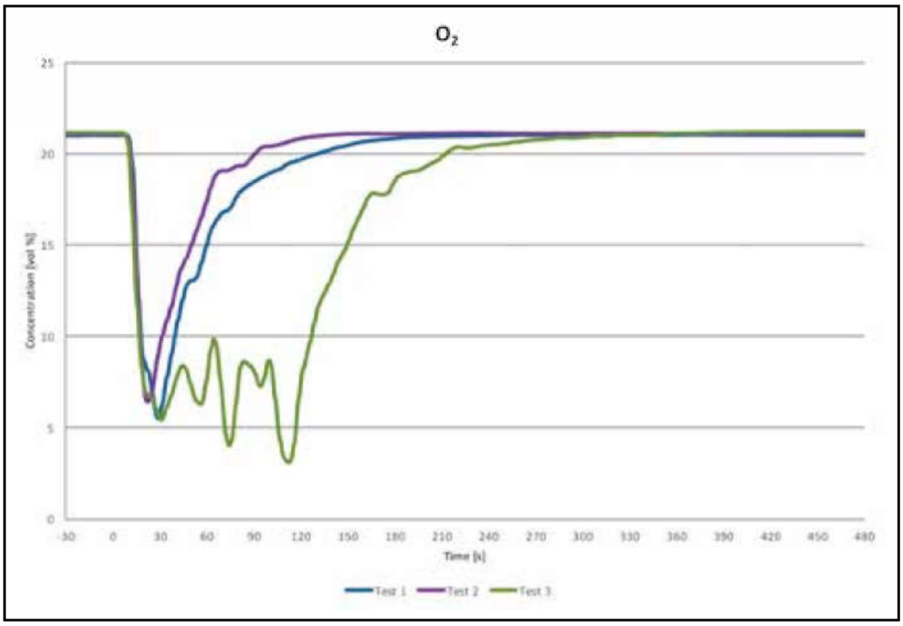

Figure 4: Oxygen concentration in the centre of the pit, 5 cm below the planks.

Conclusion

In summary, a method has been developed to evaluate the fire protection performance of covered and/or filled transformer pits. The result for the particular profile planks that were tested shows that the flames above the planks are self-extinguished within a few seconds.

References

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