Full-scale Fire Suppression Tests of a Power Transformer in an Indoor Installation with Water Mist Systems

Myung Bae Kim*, Yong Shik Han, Byung Il Choi

Thermo-fluid System Department, Korea Institute of Machinery & Materials, P.O. Box 101, Yusong, Taejon, 305-343, Korea

Dong Cheol Lee, Young Hwan Choi, Soon Cheol Noh

Namseoul T/C, Korea Electric Power Corporation

Abstract

Full-scale fire suppression tests of an indoor-power-transformer are carried out with water mist systems in view of fire extinguishment. Fire incidents are carefully investigated with the analysis of cause in order to make the most realistic test procedures. Based on that, six fire test scenarios are built. All the tests are performed with two kinds of water mist systems, the low and high pressure system. Test results show dramatic difference in oxygen decrease between both systems. In general the high pressure system demonstrates obviously the better performance in fire extinguishments.

1. Introduction

Water mist has been viewed as a possible alternative to gaseous suppression systems for use in electrical equipment rooms. Even though potential applications include telecommunication facilities, control rooms, computer rooms and a power transformer, developments in these areas are limited. The present study deals with full-scale fire tests of a power transformer in an indoor installation with two kinds of water mist systems, a low pressure and a high pressure system. A room, 10x10x10m, contains the transformer that is as big as about 7% of the room. The transformer that converts 154kV to 22.9kV with 60MVA is filled with dielectric oil that cools the transformer core.

According to an incident scenario[1], the core heats to be approximately 700 °C due to a short circuit inside the transformer, which leads to heat transfer from the core to the dielectric oil. Then at one time the oil starts to vaporize, and the internal pressure is built up and finally the pressure will exceed a certain limit. It can be, therefore, assumed that fire occurs from leak of the heated oil through ruptured

Corresponding Author- Tel.: +82-42-868-7329; *Fax*: +82-42-868-7355
E-mail address: mbkim@kimm.re.kr

Fig.1 Damaged part of transformers

Fig.2 Fire incidents in transformers

parts of the external plate, piping and fittings of the transformer. Damaged part of transformers was illustrated in Fig.1 and fire incidents in Fig. 2.

From the above review three kinds of fire types were suggested. Two spray fires, three pool fires and one cascade fire. The total six fire scenarios were summarized in Table 1 and Fig. 3.

2. Fire extinguishments tests

Table 1. Fire scenarios for the transformer

Symbol	Fire type	Fire origin	Remarks
S-01M	Spray fire (1MW)	1m above the mock-up	Full-cone(120^o), diesel oil 0.03kg/s, 8.5bar
S-06M	Spray fire (6MW)	1m above the mock-up	Full-cone(80^o), diesel oil 0.16kg/s, 8.0bar
L-10M	Pool fire (10MW)	Floor around the corners of the mock-up	0.6X1.4m, 4ea, heptane
U-06M	Pool fire (6MW)	Top surface of the mock-up	0.6X1.4m, 2ea, heptane
L-01M	Pool fire (1MW)	Floor under the mock-up	0.6X0.7m, heptane
C-12M	Cascade fire (12MW)	Front side of the mock-up	Heptane

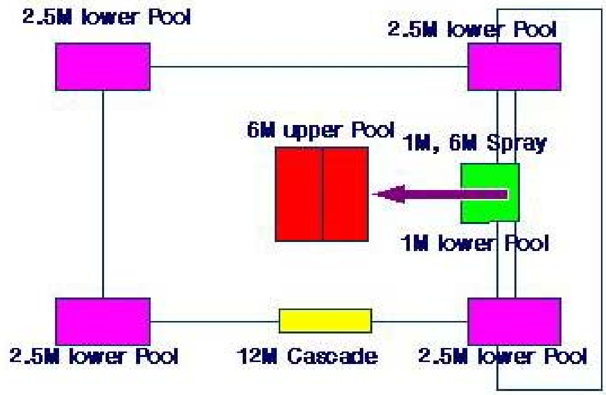

Fig. 3 Top View of the mock-up with each fire
(L-10M is consisted of 4 pool fires at the 4 corners of the mock-up at floor level)

To optimize the nozzle configuration we carried out experiments with seven kinds of nozzle lay-out, and the best one among them was depicted in Fig. 4.

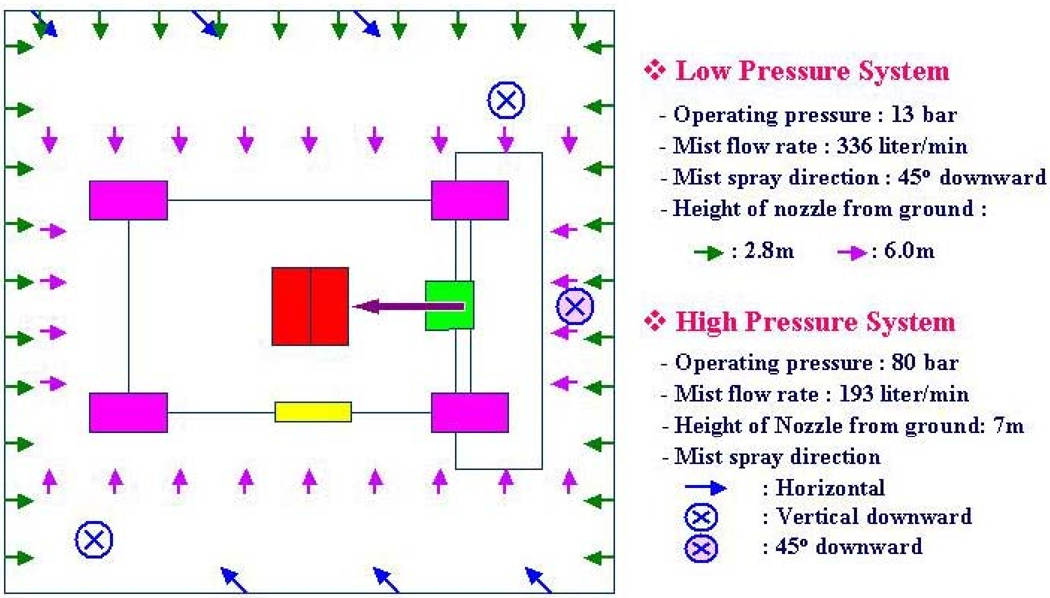

Fig. 4 Nozzle configuration

About 71 extinguishment tests were performed for seeking the best configuration and for consistency of experimental data[2]. Experimental results were described here for 6MW spray fire(S-06M). As seen from Fig. 5, the extingishment time of the high pressure system was much smaller than the low pressure system. A thermocouple was installed near to the fire source to distinguish fire extinguishment.

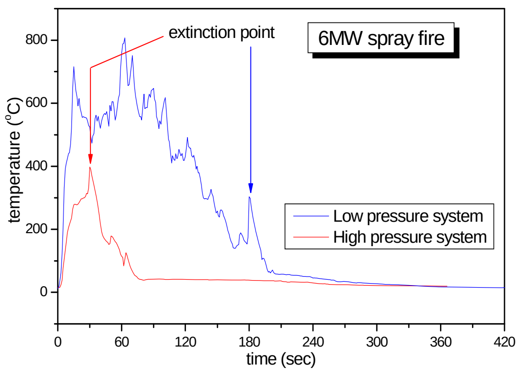

Fig. 5 Fire extinction time in S-06M

This remarkable difference between both systems could be analyzed from the obvious trends of oxygen concentration in Fig.6 and vertical temperature distribution in a fire room in Fig. 7.

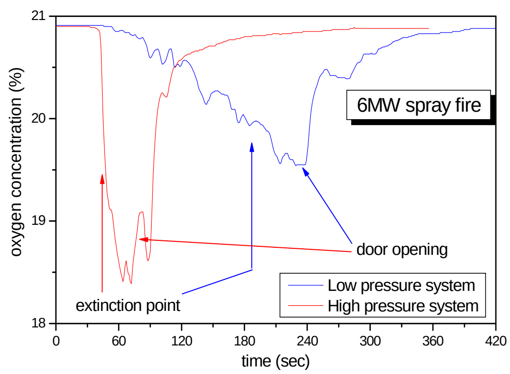

Fig. 6 Oxygen concentration in S-06M

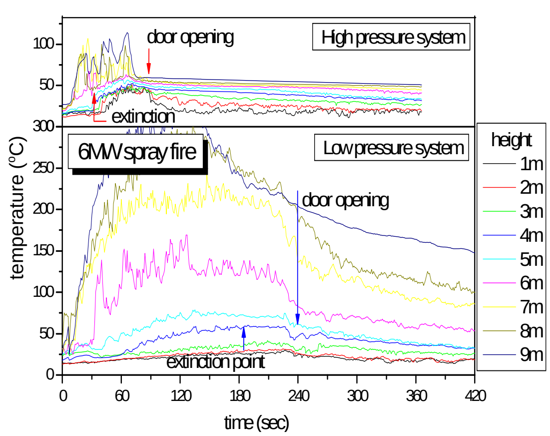

Fig. 7 Temperature distribution with height in S-06M

Fire extinguishment times of both systems were presented in Table 2, where the high pressure system had a better performance as compared with the low pressure system.

Table 2. Fire extinguishment time (sec)

Fire scenario	High pressure	Low pressure
S-01M	40	44
S-06M	30	122
L-10M	429	1084
U-06M	431	509
L-01M	956	Fail to suppress
C-12M	113	205

3. Conclusions

As stated before the high pressure system shows generally the better performance than the low pressure system for the indoor-power-transformer. From the test results of the fire scenario S-06M, remarkable differences between both systems are observed, and those can be represented by two facts. One is decrease of oxygen concentration, and the other is averaged temperature of the fire room. The high pressure system reveals the typical advantages of fine water mist protection that are oxygen displacement and cooling due to fine droplets.

References

1. Analysis of transformer incidents, Korea Electric Power Corporation, 2003.
2. Fire extinguishment tests with water mist systems, KIMM report BSG154-1059.M, 2004.