RESULTS OF EXTRA FIRE TESTS ON A TRANSPORT CONTAINER FOR UF_6

S. KOBAYASHI, H. YAMAKAWA, M. YASUDA, Y. ESASHI
Central Research Institute of Electric Power Industry,
Abiko, Chiba, Japan

Abstract

RESULTS OF EXTRA FIRE TESTS ON A TRANSPORT CONTAINER FOR UF_6.

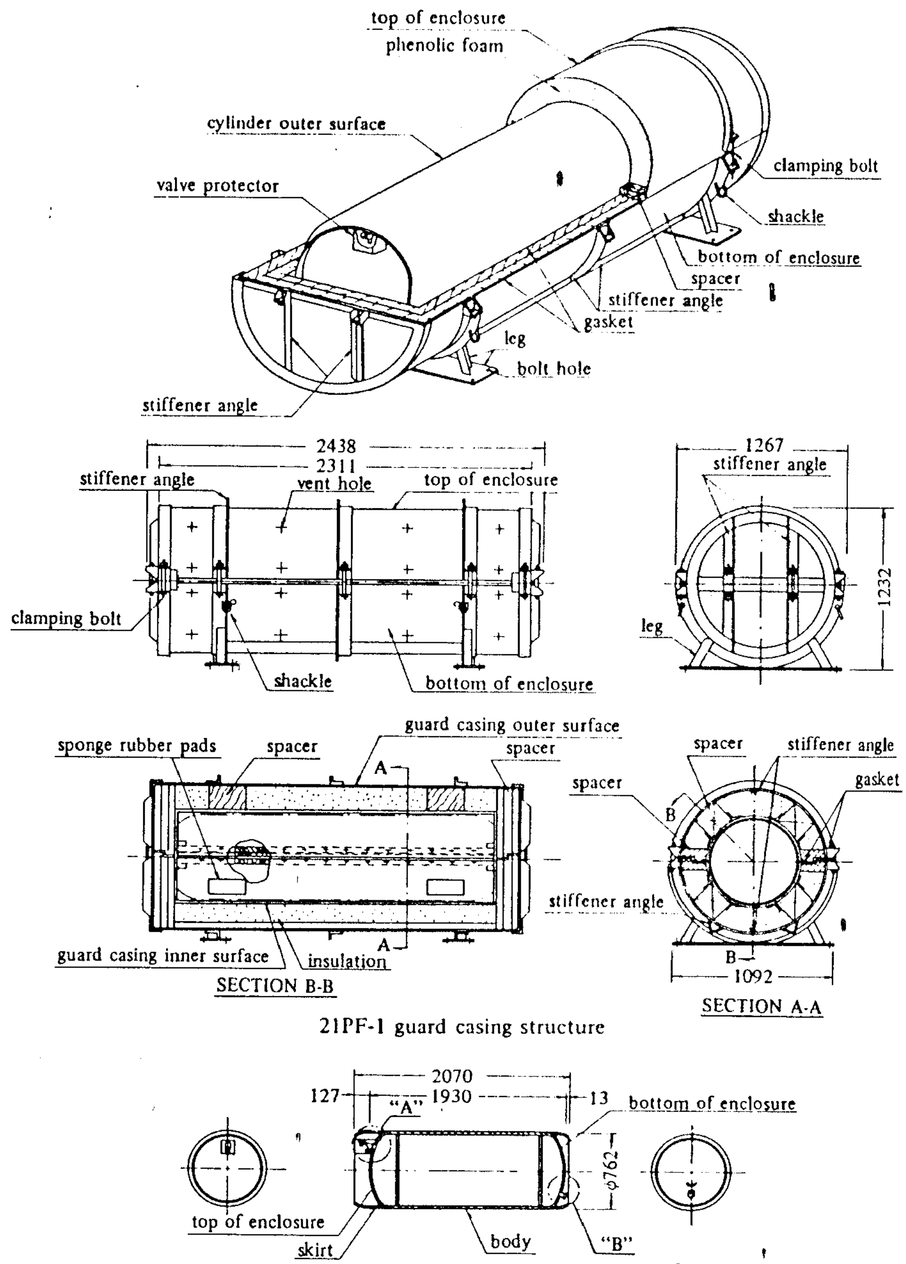
The Central Research Institute of Electric Power Industry, under a contract with the Science and Technology Agency of Japan, conducted tests more severe than those required by regulations on the container used to transport UF_6 in order to obtain various data on its behaviour under severe heat conditions. The fire test conditions were as follows: test I: 800°C-60 min; test II: 1000°C-30 min; test III: 800°C-long period test. Before these extra fire tests, preliminary tests were carried out, using a partial-scale model, to investigate the properties of phenolic foam, which was supposed to burn out under test conditions. Finite element analysis was used for the numerical analysis and to simulate the irreversible properties of phenolic foam and the heat effects of the gas generated from the phenolic foam (which fills the space between the cylinder and guard casing). The main results are: (1) In the 800°C-60 min and 1000°C-30 min tests, the increase in temperature on the outer surface of the 30B cylinder was small and no change in leakage characteristics was found. In the 800°C-long period test, it took almost 4 h for the container to reach 120°C on the cylinder surface and during this period no change in seal leakage characteristics was found. (2) In the fire test, it was observed that the heat flux (which flows into the cylinder) was not the only one flowing toward the guard casing; there was also a heat effect caused by gas generated from the phenolic foam. (3) The fire resistance capacity of the container depends on the carbonizing speed of phenolic foam and this speed in turn depends on the particular temperature at the time. (4) The results of the numerical analysis of heat generation effects from phenolic foam agree well with the results of the fire resistance tests.

1. INTRODUCTION

The container used to transport uranium hexafluoride (UF_6) is designed to maintain its integrity under the 800°C-30 min fire resistance test condition. However, the Central Research Institute of Electric Power Industry, under a contract with the Science and Technology Agency of Japan, has conducted tests more severe than those defined in the regulations in order to obtain data on the container behaviour under severe heat conditions. The fire test conditions were as follows:

- Test I: 800°C-60 min.
- Test II: 1000°C-30 min.
- Test III: 800°C-long period test.

This paper describes the results of the above tests, in which the integrity of the UF_6 container was confirmed, and also demonstrates the good agreement between the experiments and numerical simulations.



21PF-1 guard casing structure

30B cylinder structure

FIG. 1. UF_6 transport container structure (dimensions in mm).

2. FEATURES OF THE UF_6 CONTAINER

The UF_6 transport container used in the extra fire tests has the following features:

- Maximum length: 2.44 m.
- Maximum width : 1.27 m.
- The container consists of a 30B cylinder full of UF_6 and guard casings.
- The guard casing contains phenolic foam between the inner and outer shells.
- In the fire tests, the 30B cylinder was filled with iron balls, simulating the effect of heat capacity on UF_6.

The container is shown in Fig. 1.

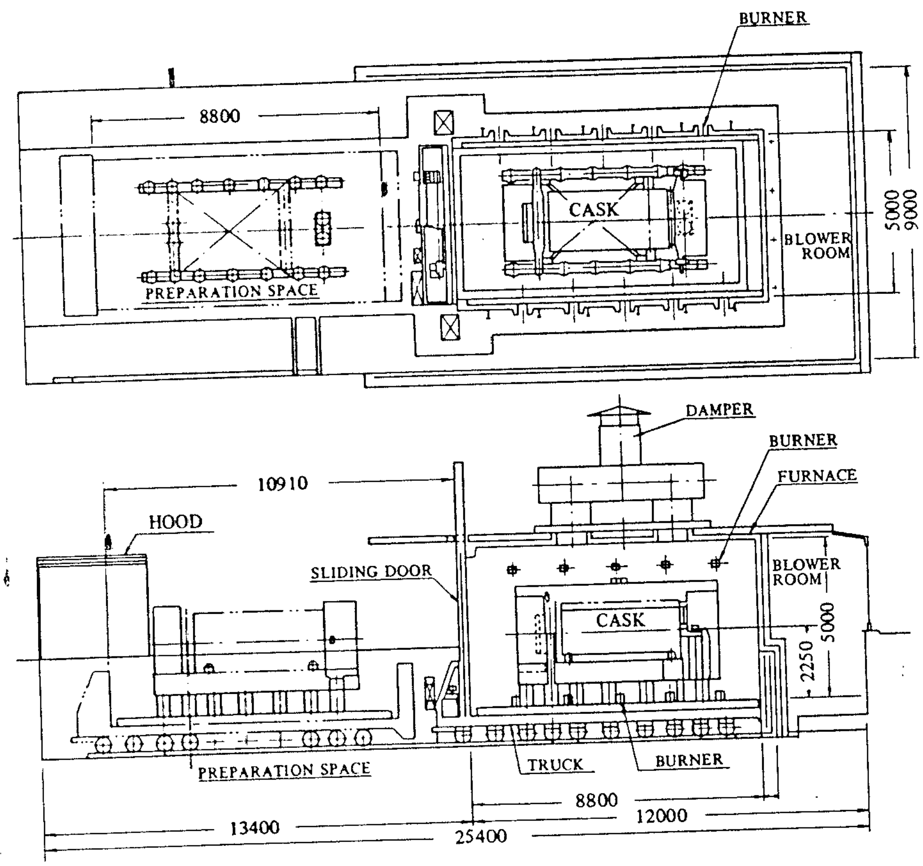


FIG. 2. Test furnace at the Yokosuka Laboratory (dimensions in mm).

3. THE EXTRA FIRE TESTS

The extra fire tests of the transport container were carried out at the Yokosuka Laboratory of the Central Research Institute of Electric Power Industry.

Yokosuka Laboratory has a fire test furnace, 9 m drop test equipment, pressure, shielding and heat transfer test devices, and a computer system to store and analyse the results. This equipment is used for the tests carried out according to IAEA Regulations.

The fire test furnace (Fig. 2) is 5 m wide, 8.5 m long and 5 m high and is capable of maintaining a furnace wall temperature of over 1000°C for a 100 t class cask. The specimen was put into the furnace, which had been pre-heated to 900°C and was burned for the periods and at the temperatures stated earlier. The temperatures of the container and the environment were measured at more than 200 points, data from the test being stored in a cassette tape recorder for analysis. It was concluded that the integrity of the UF_6 transport container (the 30B cylinder and guard casing) was maintained.

Before the extra fire tests, preliminary tests were carried out, using a scale model, to understand the properties of phenolic foam, which was supposed to burn out under test conditions.

4. NUMERICAL ANALYSIS

One of the main purposes of this study was to establish a simulation method for the behaviour of the transport container under severe heat conditions. While the phenolic foam acted as thermal isolation material, its behaviour was found to be temperature dependent. In fact, it did not show the same characteristics under conditions of rising or falling temperatures. Thus, in order to estimate the behaviour of the container, it was necessary to simulate its performance while in a fire.

The temperature-dependent properties of phenolic foam were thus determined by 'identification analysis' of the fire test for the partial models. The finite element analysis program HI-CASK, based on MARC (the CRAY version) was used for the numerical analysis and for simulating the irreversible properties of phenolic foam and the heat effects caused by gas generated from the foam (which fills the space between the cylinder and the guard casing). It was concluded that the numerical results showed good agreement with the experiments, after taking into account the effects mentioned above.

5. RESULTS

The three fire resistance tests carried out on the 21PF1 container also involved leakage tests, which were conducted before and after those tests. The results are described below.

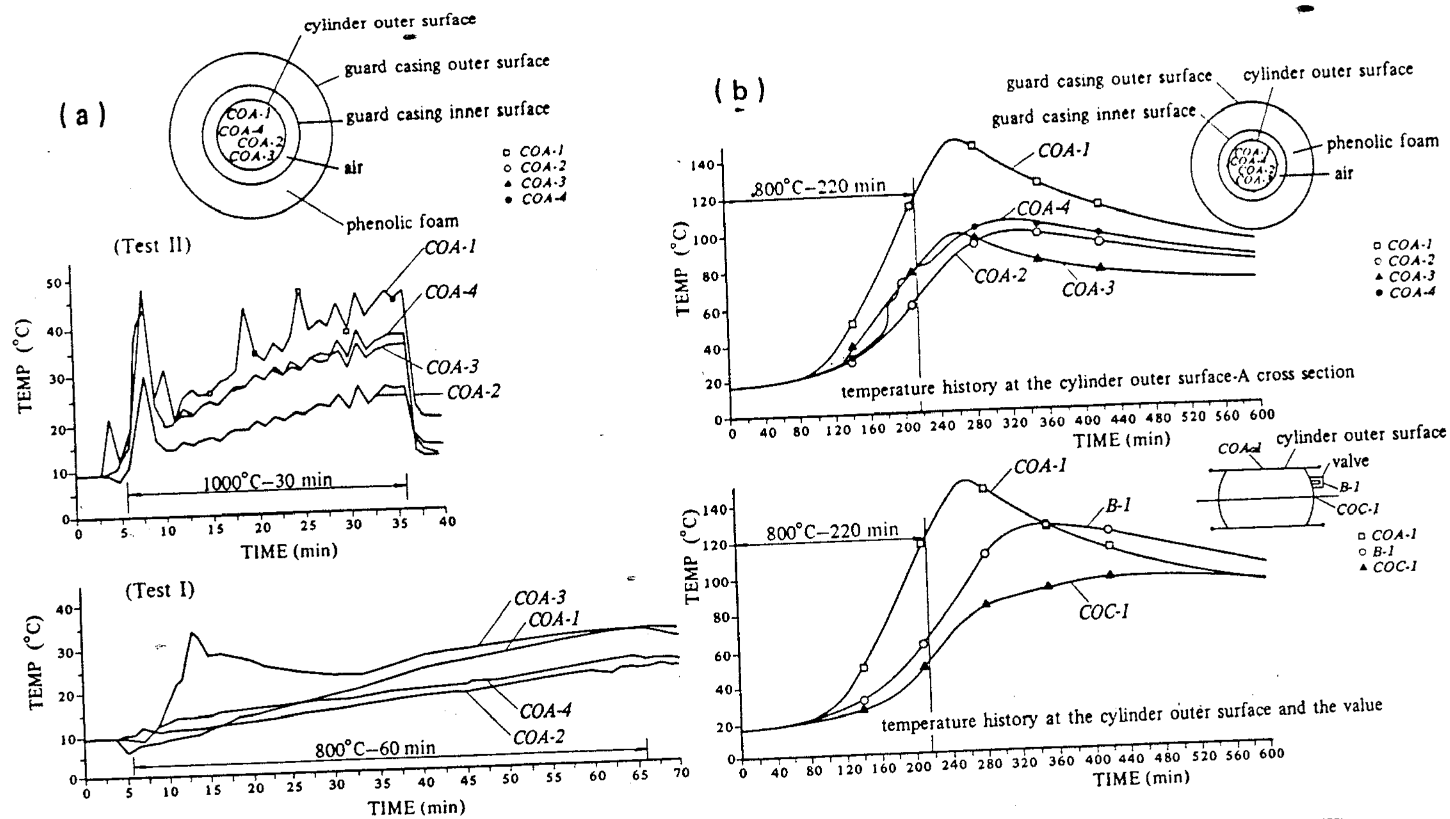


FIG. 3. Temperature ranges at (a) the outer surface of the cylinder, (b) the container during the long time period fire test (test III).

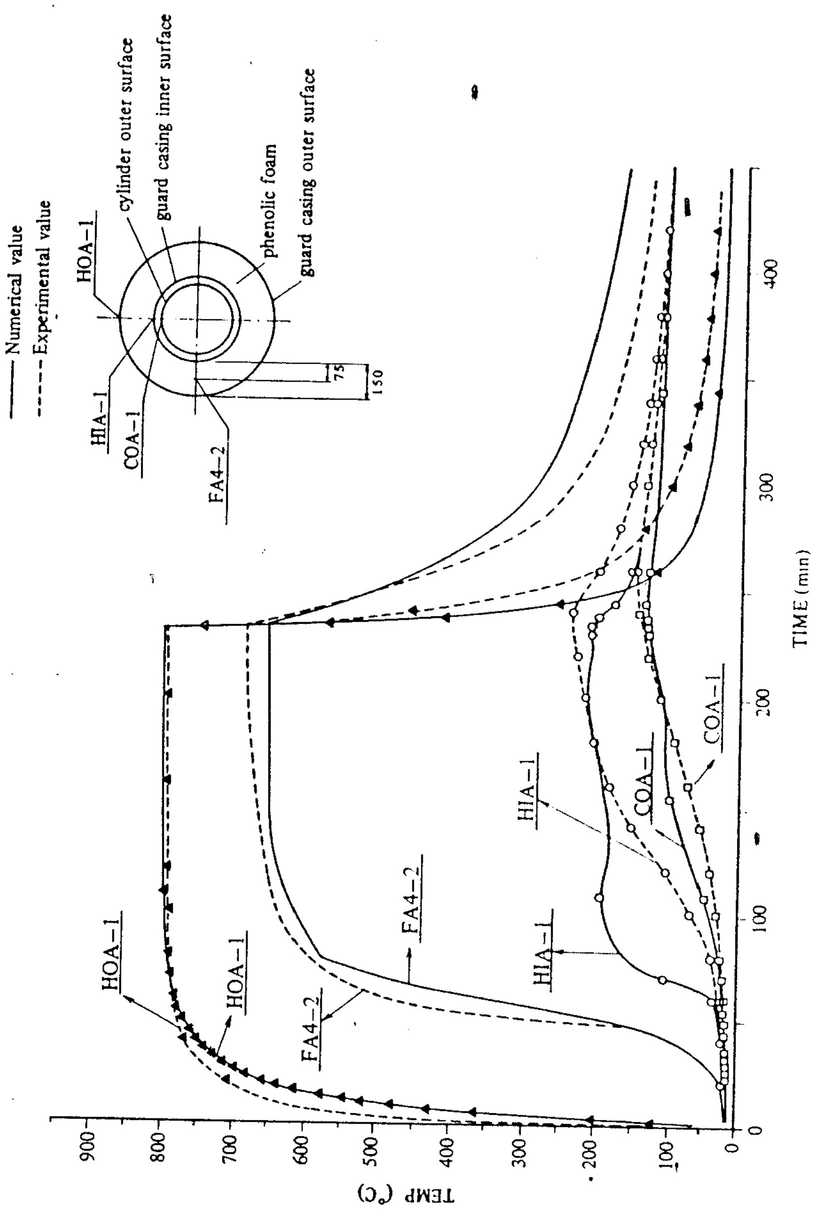


FIG. 4. Results of the limit fire test and the numerical analysis for test III (dimensions in mm).

(1) In the 800°C-60 min and 1000°C-30 min fire resistance tests, the increase in temperature on the outer surface of the 30B cylinder was small and no change in leakage characteristics was found. During the 800°C-long period fire resistance test, it took almost 4 h for the container to reach 120°C on the cylinder surface and during this period no change in seal leakage characteristics was found. (The temperature ranges of the container during the 800°C-long period fire test are shown in Fig. 3.)

(2) In the tests, it was found that the heat flux which flows into the cylinder was not the only one flowing toward the guard casing; there were also heat effects from the gas generated from the phenolic foam.

(3) The fire resistance capacity of the container depended on the carbonizing speed of the phenolic foam and this speed depended, in turn, on the temperature at particular instances of time and conditions.

(4) The results of the numerical analysis, taking into consideration the heat generation effects from the phenolic foam, agree well with the results of the fire tests (see also Fig. 4).