DEMONSTRATION OF THE TN 1300 TRANSPORT-/STORAGE CASK PERFORMANCE

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Abstract

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The TN 1300 is a large capacity transport-/storage cask for LWR fuel. Its performance has been tested by heat transfer experiments with electrical heaters and by cask loading operations with active fuel in a power plant. The loading operations included temperature measurements, leak testing and vacuum drying of the cavity. The tests showed the adequacy of the design and of the procedures for handling the cask in a power station.

INTRODUCTION

After the Type B(U) tests for the TN 1300 transport-/storage cask had been completed successfully with a 1/3 scale model, a test and demonstration programme was performed in three steps:

(1) Heat transfer experiments with electrical heaters
(2) Demonstration of cask loading and temperature measurements under active conditions
(3) Demonstration of an improved vacuum drying operation.

TEST OBJECT

For all experiments an original full size TN 1300 cask (PWR version) was used. It has a capacity of twelve PWR assemblies (burnup 42 000 MW·d/t, 3.5% enrichment, 2.5 years cooling time). Its features were described in [1] and are briefly summarized below:

— Authorized thermal power — 50 kW
— Principal dimensions — 2500 mm diameter, 6000 mm length
— Cask body of ductile cast iron
— Double lid system with metallic seals
— Total weight 120 t.

HEAT TRANSFER EXPERIMENTS

The heat transfer experiments were performed by the GKSS research centre in Geesthacht under contract with Transnuklear. The purpose of these experiments was to check the calculation methods and assumptions. To be more specific it was aimed at obtaining heat transfer coefficients of the fins in horizontal and vertical cask orientations, finding the influence of the filler gas and the pressure, and demonstrating the behaviour of the cask components under operational temperatures.

It was necessary to have a special lid with penetrations for the gas pipes and measurement cables. Decay heat was simulated by 11 heating elements and one complete dummy element. Each heating element consisted of 32 heating tubes with a heated length of 3.9 m. To simulate the friction resistance for convective heat transfer of a real fuel assembly, horizontal metal sheets were installed. The dummy element was built of original PWR assembly parts; each of the 236 tubes was heated electrically. The electrical power over the heated length was constant. Altogether 130 thermocouples were attached.

TABLE I. HEAT TRANSFER EXPERIMENT PROGRAMME

Cask orientation	Filler gas type	Filler gas pressure (mbar abs)	Thermal power (kW)
Vertical	air	500	15
Vertical	air	5500	37.5
Vertical	air	5/500/1000	50
Vertical	helium	500	37.5/50
Vertical	helium	500	4 inner elements with 5.4 8 outer elements with 3.5
Horizontal	helium	500	37.5/50
Horizontal	air	500	50

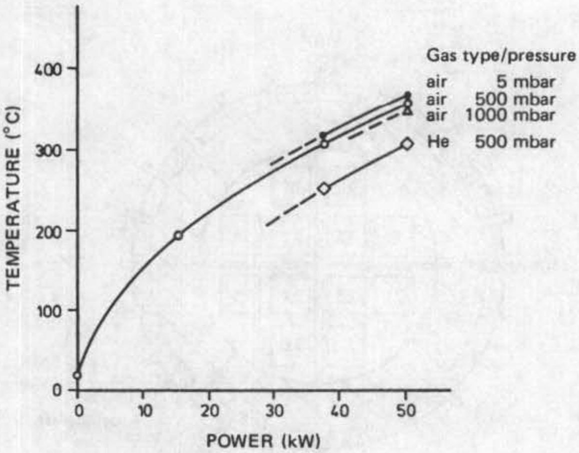

FIG. 1 TN 1300 heat transfer test — maximum fuel rod temperature.

Table I shows an overview of the test programme. The cask was tested horizontally (transport) and vertically (storage) with heat loads of 15, 37.5 and 50 kW. As filler gas, air and helium were used and the internal gas pressure was varied (5 mbar, 500 mbar, and in one case 1000 mbar).

Some of the important results were:

(1) Overall heat dissipation characteristics are not much dependent on cask orientation.
(2) Filler gas pressure has only a very limited influence on fuel rod temperature (Fig. 1). This confirms that convective heat transfer in the cavity is not important.
(3) Because of the heat conduction, the filler gas type has the expected strong influence on maximum fuel rod temperature.
(4) The upper limit of 390°C rod temperature (storage condition) is not achieved, even under vacuum drying conditions (5 mbar air pressure).

HOT DEMONSTRATION

In June 1984 the cask was loaded with 12 PWR assemblies at the Biblis power station of Rheinisch-Westfälisches Elektrizitätswerk AG (RWE) to demonstrate procedures and measure data important for the performance of the cask during storage. It was a joint venture of Transnuklear, RWE and Deutsche Gesellschaft für

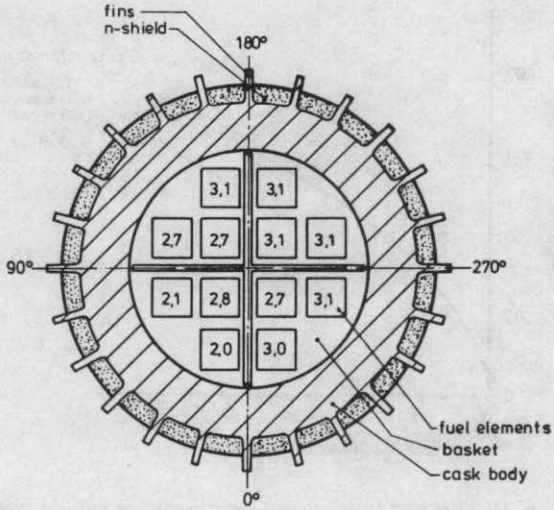

FIG. 2 TN 1300 hot demonstration — Thermal power distribution in the basket.

Wiederaufarbeitung von Kernbrennstoffen mbH, Hannover. The programme comprised the following parts:

- — Instrumentation of the cask with thermocouples
- — Transfer of the cask in the containment pool and loading
- — Instrumentation of the loaded assemblies with thermocouple rods in the control rod tubes
- — Helium leak tests and vacuum drying
- — Transient and steady state temperature measurements of the cask, basket and fuel assemblies
- — Cooldown under typical PWR conditions and unloading.

The heat power of the assemblies ranged from 2.0 to 3.1 kW, the total heat load of the cask was 33.6 kW with an average axial peaking factor of 1.17. To get maximum temperatures, the three assemblies with the maximum decay heat were put into one quarter of the basket (Fig. 2). Readings were taken through all the steady state and transient phases of the programme (heating up, vacuum drying, helium filling, cooling down for unloading). Figure 3 gives the temperature development before draining and during drying and helium flooding. A maximum pin temperature of 332°C was found. One can see the very important influence of the filler gas. Classical procedures were applied for the other measurements.

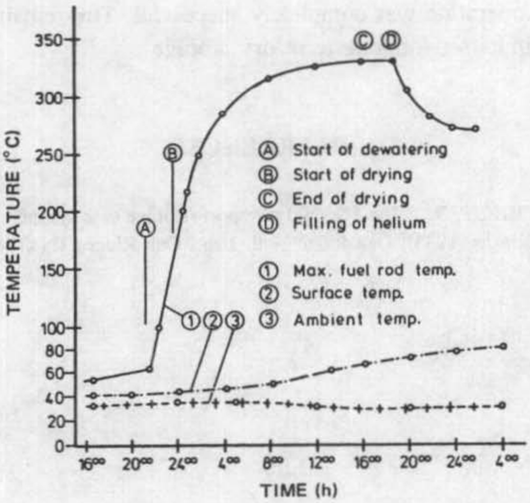

FIG. 3 TN 1300 hot demonstration — main temperatures.

Some of the important results are:

(1) Temperature measurements agreed with the predictions and thus confirmed the adequacy of design calculations.
(2) Analysis of gas samples confirmed that there was no loss of fuel rod integrity.
(3) The handling of the TN 1300 in the power station is without problems and the cask components such as the lid, seals and basket worked well.
(4) The residual humidity values and the procedure used for humidity measurement were unsatisfactory.

IMPROVED DRYING PROCEDURE

After a careful review and modification of the drying procedures the cask drying operation was repeated in an additional test. The most important improvements in the drying procedure were:

- Washing of the inner cavity with demineralized water to reduce the boric acid content
- Decreasing the pressure to 0.3 mbar during the final stage of drying operation to remove water absorbed on the surfaces
- Reliable measurement of residual humidity by use of calibrated equipment and high volume gas sampling.

The drying operation was completely successful. The remaining moisture was well below the limits set for long term dry storage.

REFERENCES

[1] KEESE, H., CHRIST, R., "The TN 1300 transport-/storage cask system", PATRAM '83 (Proc. Symp. New Orleans, 1983), Oak Ridge Natl. Lab., Oak Ridge, TN (1983).