THE SINGLE SNR FUEL ASSEMBLY CONTAINER (ESBB) TO TRANSPORT UNIRRADIATED SNR 300 FUEL ASSEMBLIES

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SUMMARY

In this paper a new type B(U) package design is presented. The Single SNR Fuel Assembly Container (ESBB) is designed for the transport and storage of a single SNR 300 fuel assembly. This package is the main component for the future interim storage of the fuel assemblies in heavy storage casks. Its benefits are that it is compatible with the Category I transport system of Nuclear Cargo + Service (NCS) used in Germany and that it can be easily handled at the current storage locations as well as in an interim storage facility.

In total 205 fuel assemblies are currently stored in Hanau, Germany and Dounreay, U. K.. Former studies have shown, that heavy transport and storage casks can be handled there only with considerable efforts. But the required category I transport to an interim storage is not reasonably feasible. To overcome these problems the ESBB was designed. It consists of a stainless steel tube with welded bottom, a welded plug as closure system and shock absorbers. 26 packages at maximum can be transported in one batch with the NCS security vehicle.

The safety analysis shows that the package complies with IAEA 1996. Standard calculations methods and computer codes like HEATING 7.2 (Childs 1993) have been used for the analysis. Criticality safety assessment is based on conservative assumptions as required in IAEA 1996. Drop tests carried out by BAM will be used to verify the design. These tests are scheduled for mid 1998.

For the validation of the design prototypes have already been manufactured. Handling tests show that the design complies with the requirements. Preliminary drop tests show that the certification drop tests will be passed positively.

INTRODUCTION

The 205 fuel assemblies manufactured for the SNR 300 fast breeder reactor are currently stored in Hanau, Germany and in Dounreay, U. K.. Because the SNR project was given up in 1991 the assemblies are not irradiated. Due to contractual reasons the fuel has to be removed from both storage locations. Various studies (not published) regarding storage of the SNR fuel assemblies in heavy storage casks have shown that the transport of the fuel assemblies from these current storage locations to an interim storage facility is crucial.

EARLIER WORK

In a series of studies the handling of heavy transport and storage casks at the current storage locations as well as the transport of these casks to an interim storage facility was examined. The result of these studies was as follows:

- both current storage locations are not designed for handling such heavy transport and storage casks;
- to achieve adequate physical protection during loading, extensive additional measures are required;
- there is no experience regarding transport of Category I material in such heavy transport and storage casks by rail;
- the implementation of the required physical protection measures for the rail transport is extremely costly.

The conclusion was drawn, that the transport of SNR 300 fuel assemblies from the current storage locations to an interim storage facility in transport and storage casks is not reasonably feasible.

In an other study the transport of the fuel assemblies in the existing transport container for fresh SNR 300 fuel assemblies was investigated. The use of this container raised no problems concerning handling and transport as it had been designed for that purpose and already been used for transports. But the required unloading of the container in an interim storage facility and handling of an unpacked fuel assembly is not within the scope of the license of an interim storage facility.

FUEL ASSEMBLIES

Basic data of the fuel assemblies are given in Table 1. In total the 205 fuel assemblies contain approx. 1600 kg of Plutonium. Special care must be taken with respect to the source terms. Compared to other unirradiated fuel thermal power as well as dose rate are considerably high. Furthermore, the source terms are increasing with time, the reason is the build-up of Am-241. Some of the values given in Table 1, e.g. for thermal power, are based on the highest Am-241 reached in some 10 years.

length	3690 - 3700 mm
shape of cross section	hexagonal
max. diameter	131 mm
length of active zone	950 mm
length of breeder zones (each)	400 mm
number of fuel pins	166
diameter of fuel pins	6 mm
cladding material	stainless steel
mass of U + Pu + Am per assembly	27 kg
max. mass of Pu per assembly	9.6 kg
max. mass of Am-241 per assembly	1.0 kg
max. thermal power	225 W
total mass	140 kg

Table 1: Basic Data of SNR 300 Fuel Assemblies

THE SINGLE SNR FUEL ASSEMBLY CONTAINER

In order to solve the problems mentioned before NCS developed the "Single SNR Fuel Assembly Container" (ESBB). The main characteristics of this container are

- licensed as type B(U) package;
- easy handling at each of the current storage locations;
- transport with the NCS security vehicle licensed for transport of category I material;
- the loaded container itself will be loaded at an interim storage facility into the interim storage cask used for mechanical and physical protection (see Figure 1).

THE DESIGN

The design of the ESBB with its content is shown in Figure 2. It consists of a stainless steel tube (1), a welded bottom (2), a welded plug (3) at the top side and shock absorbers (4, 5) at both ends of the container. The plug is equipped with a coupling (6) for filling the cavity with Helium after loading. This coupling is covered by a welded plug (7) when presented for transport.

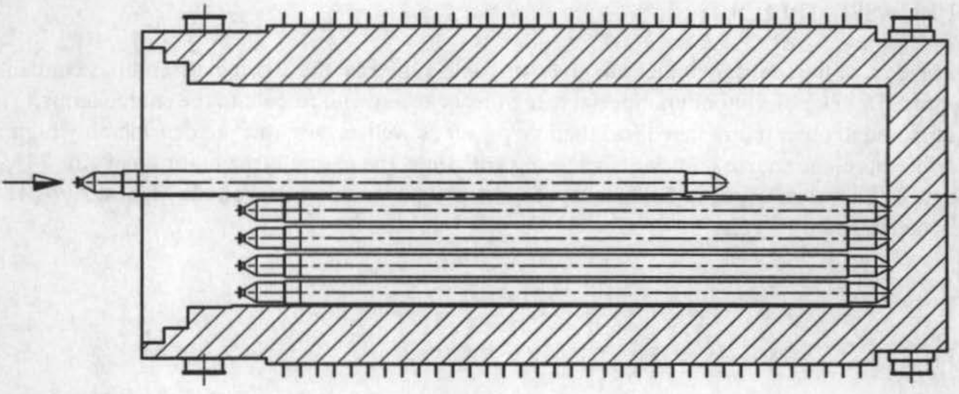

Figure 1: Interim Storage of SNR Fuel Assemblies in Heavy Storage Casks

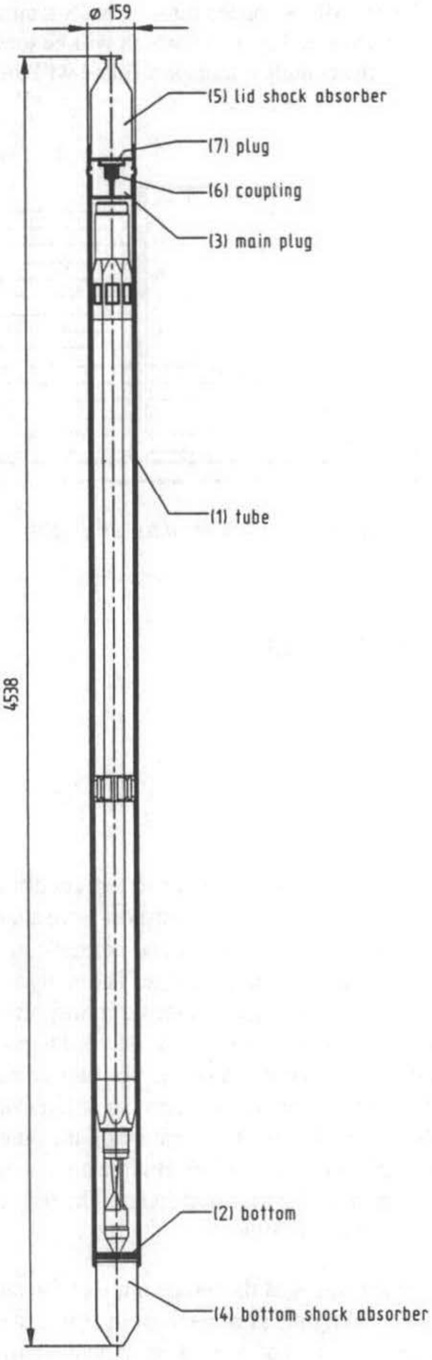

Figure 2: The Design of the ESBB

For transport a maximum of 26 ESBB will be loaded into the NCS security vehicle. For that purpose a transport frame was designed (see Figure 3), which will be loaded within a protected building. Before transport the complete transport frame will then be loaded into the security vehicle.

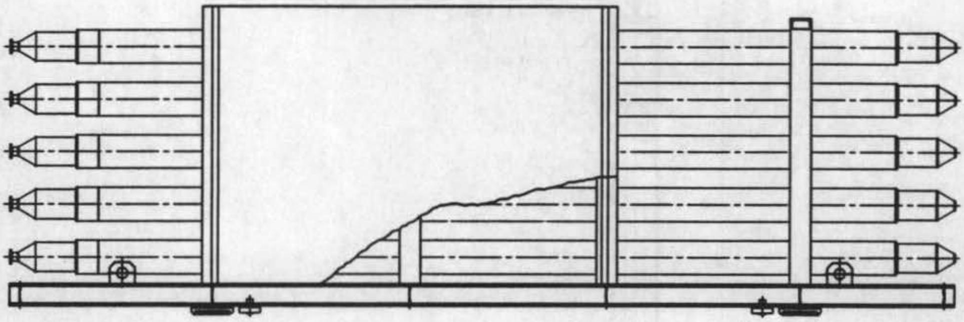

Figure 3: Transport Frame for max. 26 ESBB

SAFETY ANALYSIS

Basically the following safety analysis was applied:

- analysis of mechanical safety
- thermal analysis
- analysis of activity release rates
- dose rate calculations
- criticality safety assessment

The analysis of the mechanical safety comprised normal and test conditions. For normal conditions handling, loading and unloading as well as transport were analysed. This analysis included also the tests for demonstrating ability to withstand normal conditions of transport. All calculated results were well within the acceptable range. The analysis of the tests for demonstrating the ability to withstand accidental conditions of transport was restricted to a rough estimate. Because of economic considerations it was decided to prove the mechanical safety of the package by drop testing. The thermal analysis was carried out with the computer code HEATING 7.2 (Childs 1993). Under normal transport conditions (ambient temperature 38°C, no insolation) according to IAEA 1996 the temperature on the outer surface of the package exceeds the limit of 85°C given in IAEA 1996. But the area with this high temperature is covered during transport by the transport frame. The temperature of the readily accessible surface is below the limit of IAEA 1996.

The result of the transient calculations was, that the temperature of the outer surface of the package rises to almost 800°C. The leaktightness of the container is not affected by that temperature because the containment consists of no gaskets. A temperature of about 600°C was calculated for the cladding. The leaktightness of the fuel pins is not affected by this temperature because the properties of the special material of the cladding are even at this temperature range considerably good.

Activity release calculations are mainly based on two assumptions. First, the ESBB has a leak-rate of 1 x 10^{-8} Pa m^3 s^{-1}. This leak rate is verified by drop tests and checked before each transport. Second, the fuel pins have a leak rate of 6.7 x 10^{-10} Pa m^3 s^{-1} which was checked after manufacture and verified in former tests for normal and accidental drop test conditions.

For the dose rate photon and neutron sources have to be considered. Photon dose rates were calculated with the computer code QAD (Litwin et al. 1994). For the calculation of neutron dose rates the simplified model of a line source was used and the container was neglected as shielding. The total dose rate calculated was below 10 mSv/h at the surface, about two third resulting from the photon source and one third from the neutron source.

For transport 26 ESBB at maximum will be loaded into the NCS security vehicle. Calculations showed, that there is a need for additional shielding. Therefore neutron and gamma ray shielding will be attached to the transport frame, the thickness depending on the date of transport. Please remember, that the neutron and photon source terms of the assemblies are increasing with time for some more ten years. With this additional shielding the requirements of IAEA 1996 are fulfilled.

The criticality analysis comprised the analysis of the single package, an array of five times "N" of undamaged packages and an array of two times "N" of damaged packages. "N" was derived to be 13. With respect to Table X of IAEA 1996 max. 26 packages can then be transported under exclusive use.

For the calculations the computer code SCALE (SCALE 1995) was used. Paras. 677 to 682 of IAEA 1996 were considered for the calculations. The array of two times "N" damaged packages resulted in the highest reactivity. For this model water inleakage into the package and the fuel assembly has been assumed, the diameter of the package was reduced by 8 mm representing plastic deformation after drop testing and the shock absorbers were not taken into account. In all cases the neutron multiplication factor k_{eff} did not exceed 0.95, including 2 standard deviations.

TESTING OF THE PACKAGE

Drop testing of the package will be carried out by the "Bundesanstalt für Materialprüfung und -forschung (BAM)" in its test centre in Lehre. The test program was prepared by BAM and comprises the tests listed in Table 2.

Some preliminary small scale tests with a 1:5 scale model were carried out by NCS in order to determine the general behaviour of the container. For these tests a simplified model was used without shock absorbers. The tests showed following results:

- After a 9 m horizontal drop (Table 2, test no. 3) the specimen showed plastic radial deformations of max. 1 mm. The longitudinal axis was bent by 3 mm.
- After an 8 m vertical drop (Table 2, test no. 2) with the same specimen used for the horizontal drop the plug was deformed by max. 1.2 mm. This drop was much more severe than a 9 m drop test of a specimen equipped with shock absorbers.
- After a 9 m slap down drop (Table 2, test no. 4) with a second specimen there were plastic deformations on the plug and bottom sides and the longitudinal axis was bent by 9.4 mm.

- Liquid penetration tests were carried out on both specimens after the drops. These checks showed no indication of cracks.

Test No.	Drop Height	Drop Orientation	Target
1	9 m	vertical bottom	IAEA
2	9 m	vertical plug	IAEA
3	9 m	horizontal	IAEA
4	9 m	slap down	IAEA
5	1 m	horizontal	IAEA/bar
6	1 m	oblique	IAEA/bar

Table 2: Test Program for the ESBB

A further preliminary drop test with a 1:1 scale model was carried out representing drop no. 1 of Table 2. Following results could be observed:

- the bottom shock absorber was deformed by 97 mm, the deformation was symmetrical to the centreline of the packaging;
- the deceleration of the packaging was max. 350 g;
- the foot part of the fuel assembly was deformed, but taking into consideration results of earlier tests a damage of the fuel pins could be excluded;
- the bottom plate as well as the welding seam between container body and bottom was not affected by the drop; liquid penetration tests showed no indication of cracks.

The remaining tests are scheduled for mid 1998. The small scale preliminary tests as well as the preliminary original scale test described above indicate that the certification tests will show the compliance of the design of the ESBB with the requirements of IAEA 1996 for type B(U) packages.

REFERENCES

Childs, K. W.: HEATING 7.2 Users Manual, ORNL/TM-12262, Oak Ridge National Laboratory, Oak Ridge, 1993

IAEA: Regulations for the Safe Transport of Radioactive Material, 1996 Edition, ST-1, International Atomic Energy Agency, Vienna, 1996

Litwin, K. A., Gauld, I. C., Penner, G. R.: Improvements to the Point Kernel Code QAD-CGGP: A code Validation and User's Manual Code, RC-1214, COG-94-05, Whiteshell Laboratories, Pinawa, 1994

SCALE: A Modular Code System foı Performing Standardized Computer Analysis for Licensing Evaluation, NUREG/CR-0200, Rev. 5 (ORNL/NUREG/CSD-2/R5), Vols. I, II and III (draft September 1995)