Licensing of LLW Final Storage Casks as Transport Casks of Type IP for Fissile Radioactive Materials

W. Bergmann (1), R. Baumann (2) and H. Grunau (3)

(1) Nuclear Cargo + Service GmbH, Rodenbacher Chaussee 6, D-63457 Hanau, Germany
(2) Siemens AG Decommissioning Projects, P.O.B. 110060, D-63434 Hanau, Germany
(3) Eisenwerk Bassum mbH, P.O.B. 1145, D-27201 Bassum, Germany

1. Introduction

In 1995 Siemens AG decided to stop the manufacture of fuel assemblies in Hanau and to decommission the Uranium and MOX plant. Since this time about 70.000 tons of radioactive contaminated materials have either been recycled or prepared for final storage in the planned repository Konrad.

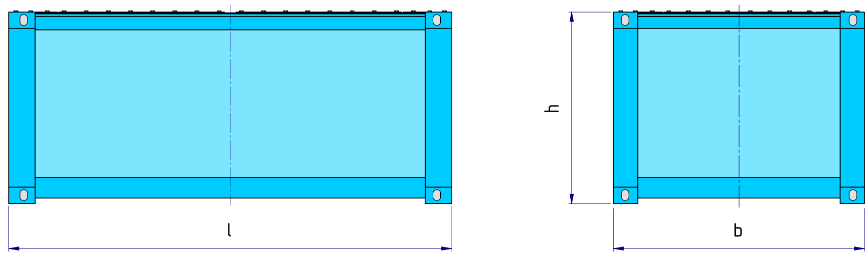
Up to now about 750 of a totally expected number of about 1200 so-called "KONRAD-Containers" are loaded and stored in an intermediate storage facility at Nuclear Cargo + Service GmbH in Hanau (see Fig. 1).

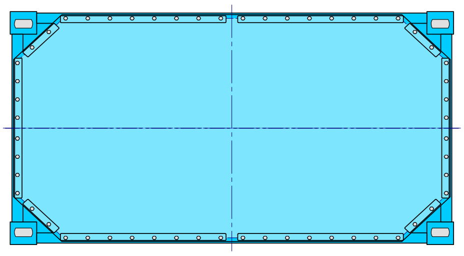
Fig. 1: NCS interim storage facility with Type IV and Type VI packages

2. Description of the package

2.1. Description of the packaging

The requirements for containers to be stored in the repository Konrad are defined in [1]. In this document the acceptable dimensions and the allowable content are specified.
In the case of Siemens AG Hanau essentially two types of containers were used, which are called Steel Container Type IV and Type VI. They are shown in the picture below (Fig. 2).





Type	l (mm)	b (mm)	h (mm)	Tare wt. (kg)	Gross wt. (kg)
Type IV	3000	1700	1400	1900	20000
Type VI	2000	1600	1700	1200	15500

Fig. 2: Dimensions and masses of the Type IV and Type VI packages

Typically the rectangular containers consist of carbon steel with wall thickness 5 mm (bottom, lid) and 3 mm (body) reinforced at the inside by welded in ribs. The lid is fastened by 44 screws and sealed to the body by an elastomer gasket. A special heavy coating on the inside and outside guarantees a life time of at least 40 years for interim storage. The maximum gross weight of the container is up to 20 tons.

2.2 Description of the allowable content

The allowable content consists of solid, non burnable uranium contaminated wastes in bulk condition (LSA-II), cemented uranium/plutonium contaminated solid, non burnable wastes (LSA-III) or a mixture of both.
The following pictures Fig. 3 show a steel container Type VI during cementing of 200 l drums.

Fig. 3: Cementing of 200 l drums in a Type IV package

According to [1] the following limits for the fissile materials per package (enrichment U-235 $\leq$ 5 wt.%) are valid for the different container types.

	Type IV	**Type VI**
Total mass U-235 (g)	850	425
Total mass Pu-239 (g)	180	110
Total mass Pu-241 (g)	90	55

The maximum allowable concentration of fissile material in the content is according to [1] 50 g per 0.1 m³.
These requirements were defined by taking into regard the analyses for criticality safety in the storage facility.
In the transport regulations [2] the mass limit per consignment for excepted packages is given by the equation:

$$\frac{mass\ of\ U-235\ (g)}{X} + \frac{mass\ of\ other\ fissile\ material}{Y} \langle 1$$

with X = 400 g and Y = 250 g in this case.
In addition a concentration limit of 5 g of fissile material per 10 l volume has to be kept.

Whereas most of the steel containers loaded by Siemens would have observed the consignment limits, the measuring equipment used to determine the fissile material concentration in the containers, which is a high standard equipment, was not able to proof a concentration limit as precise as 5 g per 10 l.

Therefore the material in the containers has to be looked upon as fissile material and consequently the steel containers have to be licensed according to the transport regulations as IP-2 packages for fissile radioactive material for transport by road and rail.

3. Safety analysis

3.1. Mechanical behaviour

A comparison is made for the differing mechanical requirements toward the containers under normal operation/transport conditions and accident conditions during storage and transport

	Storage	**Transport**
Low temperature for material properties	-20°C	-40°C
Normal operating / transport conditions	No special requirements	• Free drop test, height 0,3 m • Stacking test
Accidental conditions	• Free drop test height 5 m[2)]	• Free drop test, height 9 m[1)] • Drop test onto the bar, height 1 m[1)]

1) For demonstration of criticality safety only
2) For packages of type ABK II

The comparison shows that the general requirements for low temperature properties of the packaging materials are different.
Whereas the storage requirements only look at low temperatures down to -20°C the transport regulations require a -40°C limit.
Because the steel containers were originally designed and manufactured according to the storage requirements consequently the temperature during transport was limited in the certificate of approval to -20°C.

To demonstrate the mechanical behaviour under normal conditions of transport and accidental storage conditions the following drop tests were performed under several drop orientations.

Container Type	**Type IV (bulk) (ABK I)**	**Type IV (cemented) (ABK II)**	**Type VI (cemented) (ABK II)**
<u>Normal conditions</u> Drop test height	0,8 m 0,3 m		--
<u>Accidental conditions</u> Drop test height	--	5 m	5 m

The result of these tests was that as required for IP-2 packages no loss or dispersal of radioactive material and no dose rate increase of more than 20 % takes place.

The following picture Fig. 4 shows the steel container Type IV before the drop from 5 m height.

Fig. 4: Type IV package before 5 m horizontal drop test

The drop test also confirmed that the storage requirements under accidental conditions were met.
No drop tests were performed to demonstrate the condition of the packages under accidental transport conditions for criticality analyses (see also chapter 3.3).

3.2. Thermal behaviour

Whereas the storage requirements assume a fire of 800°C and 1 h duration the transport regulations only require an 800°C fire for 0.5 h. Therefore the accident scenario for storage covers the requirements of the transport regulations.
HEATING [3] calculations for the different steel container types and tests with cemented 200 l drums showed that the fire cause no unacceptable release of radioactive materials in a storage accident.

3.3. Criticality safety

The criticality safety of the individual package in isolation under normal conditions of transport and under accidental conditions is always guaranteed due to the limited mass of fissile material, which is less than the “safe mass” (≤ 45 % of the “critical mass”).

Under normal conditions of transport for a number “N” of N = 1 (Type IV) respectively N = 2 (Type VI) for five times “N” criticality safety is guaranteed by the limitation of the concentration of the fissile material to 50 g per 0.1 m³. Calculations for the repository Konrad result in a k_{eff}-value of less than 0.6 for an infinite array of packages.

For an array of two times of “N” under accidental conditions it is demonstrated for the allowable content in bulk condition (only Type IV) that the fissile inventory of two packages if conservatively arranged as a sphere with an optimum moderated homogeneous UO_2-H_2O mixture is criticality safe. The resulting k_{eff}-value is 0.9625 which is acceptable for this very conservative model.

For the allowable content in cemented form in the packages Type IV and VI it is also assumed that the fissile inventory of two (Type IV) respectively four (Type VI) packages is arranged as a sphere consisting of an optimum moderated homogeneous UO_2/PuO_2-H_2O mixture. In addition to the loading in bulk condition for the cemented material a maximum concentration of 2 x 50 g = 100 g (Type IV) respectively 4 x 50 g = 200 g (Type VI) per 0.1 m³ of the fissile material is taken into regard. The maximum value of k_{eff} is calculated for the Type VI package with 0.6658 for this case.

4. Handling, maintenance and periodic inspections

Handling, maintenance and periodic inspections are performed in accordance with instructions released by the expert of the German competent authority BAM.

After loading of the packages and before storage in the NCS interim storage facility the packages are inspected and especially the sealing areas and the coating are checked for any visual damages.

Because the coating guarantees that no corrosion will occur during interim storage no regular inspections of each package is required but only a random inspection.

The periodic inspection of these packages is not performed in regular intervals as usual in Germany for transport containers but an inspection is only performed when the packages are removed from the NCS interim storage facility to be transported to the repository for final storage. Among others these inspections include an exchange of the elastomer gaskets if the interim storage time exceeds 10 years.

5. Literature

[1] Bericht ET-TB-79
Anforderungen an endzulagernde radioaktive Abfälle (Endlagerbedingungen, Stand: Dezember 1995) - Schachtanlage Konrad -
Bundesamt für Strahlenschutz (BfS), Salzgitter, Dezember 1995

[2] Regulations for the Safe Transport of Radioactive Material 1996 Edition (Revised)
No. TS-R-1 (ST-1, Revised)
International Atomic Energy Agency (IAEA), Vienna, 2000

[3] K. W. Childs
Heating 7.2 User`s Manual
ORNL/NUREG/CSD-2/V2/R6
Oak Ridge, Tn, September 1998