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# MULTIPURPOSE CONTAINER CONSTRUCTION FOR TRANSPORTING RADIOACTIVE MATERIALS

F. GULYÁS, J. OZORAI, F. TAKÁTS
ERÖTERV, Budapest,
Hungary

S. STANDKE, R. DIERSCH, M. WEISS
BIF, Freiberg,
German Democratic Republic

## Abstract

MULTIPURPOSE CONTAINER CONSTRUCTION FOR TRANSPORTING RADIOACTIVE MATERIALS.

Within the scope of the design and development work connected with the Hungarian nuclear power station construction programme, the Power Station and Network Engineering Co. (ERÖTERV) has developed a complex system for the neutralization of low and intermediate level radwaste produced in the power plant. The thin wall, multilayer container to be described was designed with a view to transportation aspects of a complex liquid waste system requiring the development of a large size container (package). It lends itself to the safe transport of radioactive materials – in the first place of liquid and solidified wastes from nuclear power stations, as well as of decommissioning wastes and of other dangerous industrial materials. The final aim of the development activity was to produce a container series consisting of several, multipurpose members.

## 1. DESIGN AND FUNCTIONING OF THE CONTAINER DESIGN

A schematic drawing of the container is to be seen in Fig. 1. The container vessel (1) is a thin-wall, cylindrical steel tank with a welded flat bottom and a flat cover with bolted connection. The tank (barrel) (2) containing the radioactive material or a radioactive object is centrally supported by an inner basket (4) within the container vessel. The basket (4) is suspended by springs (5) from an external basket (3) supported by the outer container wall. The free inside container space is filled with granular matter (quartz sand) (9) which provides safety. The air distribution box (7) arranged at the tank bottom is connected by an elastic hose to an air inlet valve (6) built into the outer container wall. Lifting, moving and fastening of the container is accomplished by means of lifting lugs (10). Depending on its design and application, the container can be also fitted with a tank (barrel) grasping appliance (8).

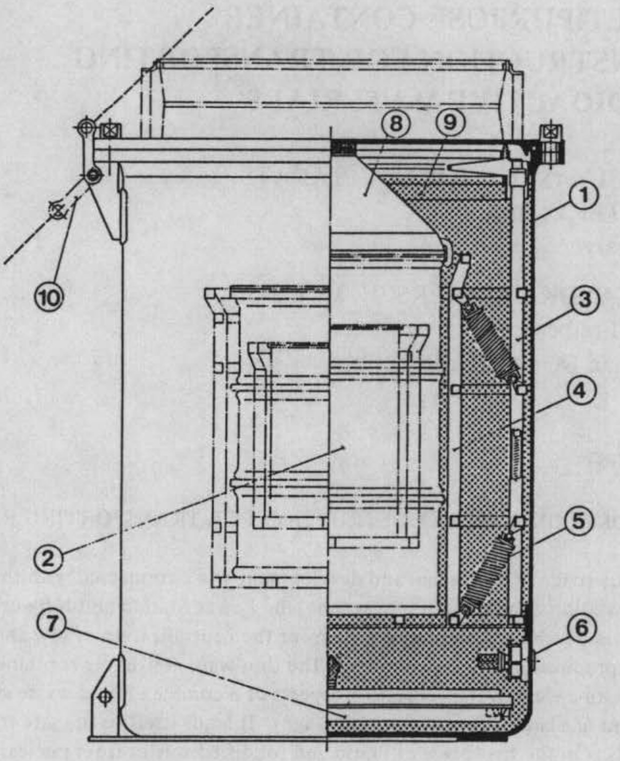

*FIG. 1. Schematic drawing of the container:*
*1 – container vessel; 2 – tank (or barrel);*
*3 – external basket; 4 – inner basket;*
*5 – spring suspension; 6 – air inlet valve;*
*7 – air distributor; 8 – grasping appliance;*
*9 – sand filling; 10 – lifting and fastening lug.*

## 2. FUNCTIONING

The functioning of the container is based on fluidizing its granular filling. For the insertion and removal of the tank containing radioactive material or of a radioactive object, compressed air has to be fed into the container. Air injected through the inlet valve into the air distributor is discharged from the latter through its felt distribution material with a uniform velocity distribution, thus fluidizing the granular filling. Spillage of fluid sand is prevented by the anti-dust (plastic and hemp) stub extending above the cover edge.

After the air injection is completed, the granular matter gets back into its static condition. This granular filling (for containers for active materials the filling is classified quartz sand) provides the basic radiation protection of the container,

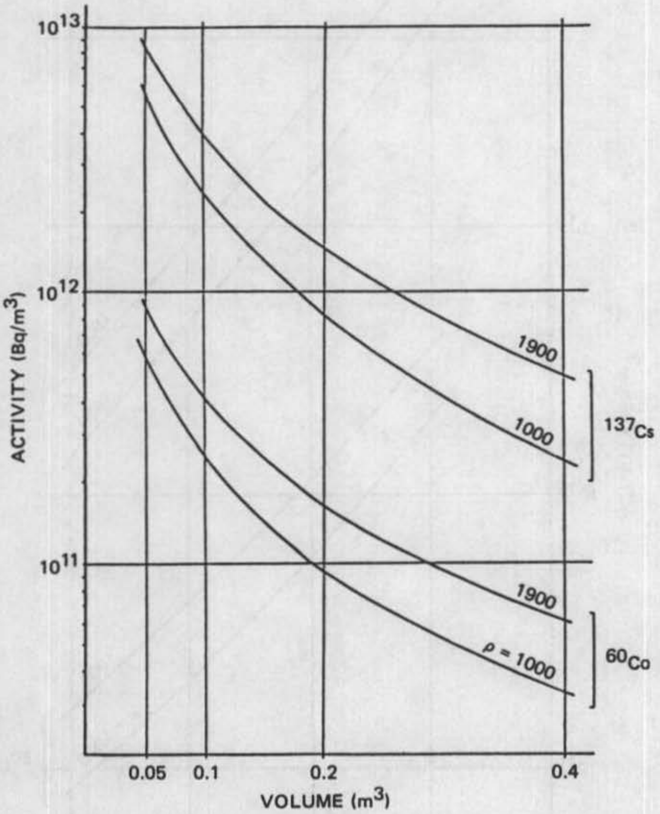

*FIG. 2. Permissible specific activity as a function of the volume of radioactive material to be transported within a container of 0.4 $m^3$ useful volume.*

attenuates dynamic forces resulting from transport or accidents and finally provides thermal insulation for the inner tank. Also the liquid absorbing property of the granular matter may be of advantage in specific cases.

In addition to its simple design and functioning as outlined above, the container has the advantage that it can be manufactured by conventional mechanical techniques. The construction does not require materials of special quality, e.g. the container vessel is made of medium grade structural steel.

## 3. TRANSPORTABLE RADIOACTIVE MATERIAL

The strength properties of the construction (see Section 4) are essentially provided by the container vessel serving as a structural skeleton and by its granular

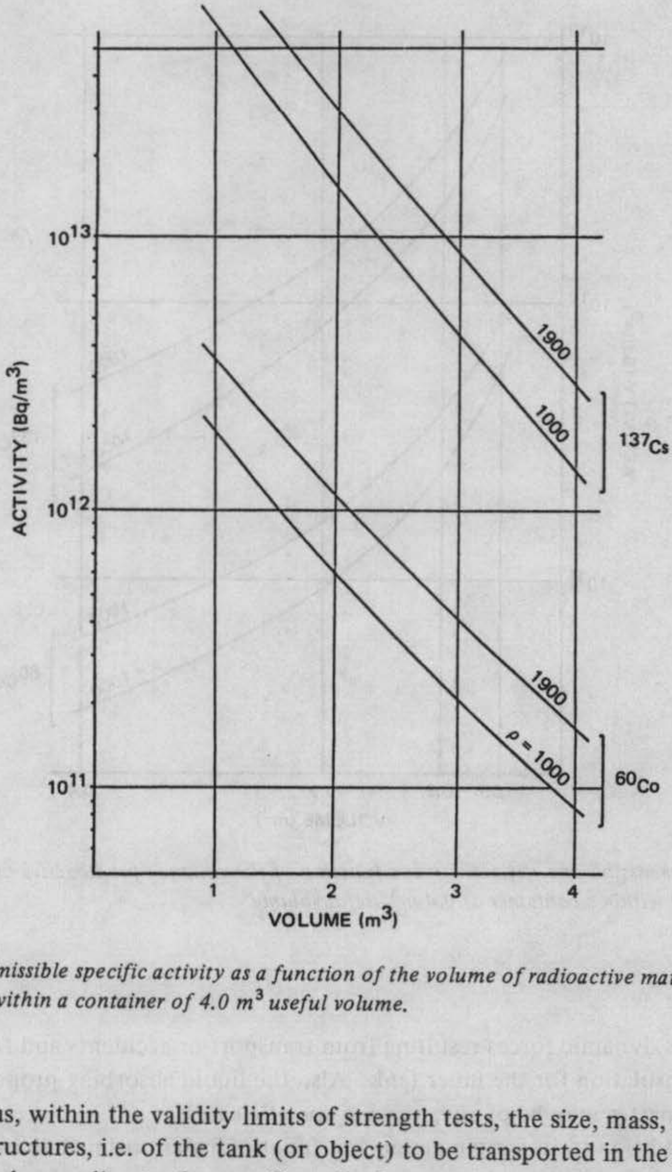

*FIG. 3. Permissible specific activity as a function of the volume of radioactive material to be transported within a container of 4.0 m³ useful volume.*

filling. Thus, within the validity limits of strength tests, the size, mass, and shape of inside structures, i.e. of the tank (or object) to be transported in the container can be varied according to the specific task. In accordance with the above, under specific geometry and radiation protection conditions the permissible activity of material to be transported within the container is determined by radiation level limits.

The permissible specific activity as a function of the volume of radioactive material to be transported within the already completed first and last standard size container of the series is shown in Figs 2 and 3 for two characteristic energies and material densities. Curves were calculated on the basis of 0.1 mSv/h radiation level at a distance of 1 m from the container surface.

TABLE I. CONTAINER DATA AND RESULTS OF STRENGTH TESTS WITH A SINGLE LAYER WALL CONSTRUCTION

| Container size / Main parameters | | | Container for the transport of a 0.4 m$^3$ barrel | | Container for the transport of a 4.0 m$^3$ tank | |
|---|---|---|---|---|---|---|
| | | | Original | 1:3 model | Original | 1:4 model |
| Diameter (mm) | | | 1250 | 417 | 2400 | 600 |
| Height (mm) | | | 1775 | 590 | 3028 | 768 |
| Wall thickness (mm) | | | 12 | 4 | 32 | 8 |
| Weight (kN) | | | 46.80 | 1.77 | 295.35 | 4.65 |
| 1 m drop | Impact force (kN) | *onto* | | | | |
| | | cover | 1125 | 125 | 2789 | 174 |
| | | mantle | 765 | 85 | 1600 | 100 |
| | | bottom | 1071 | 119 | 2656 | 166 |
| | Deformation (mm) | *onto* | | | | |
| | | cover | 57.9 | 19.3 | 86 | 21.5 |
| | | mantle | 78 | 26 | 112 | 28 |
| | | bottom | 67.5 | 22.5 | 100 | 25 |
| 9 m drop | Impact force (MN) | *onto* | | | | |
| | | cover | 58.1 | 6.5 | – | – |
| | | mantle | 45.9/36.2 | 5.1/- | 59.5/49.1 | 3.72/3.07[a] |
| | | bottom | 51.2 | 5.74 | 119 | 7.44[a] |
| | | cover edge | 27.4 | 3.04 | 16.0 | 1.0[a] |
| | | bottom edge | 23.0 | 2.56 | – | – |
| | Deformation (mm) | *onto* | | | | |
| | | cover | 3 | 1 | – | – |
| | | mantle | 21/42 | 7/14 | 44 | 11 |
| | | bottom | 10 | 3.3 | 4 | 1 |
| | | cover edge | 147 | 49 | 104 | 26 |
| | | bottom edge | 196 | 65 | – | – |

[a] Values calculated from acceleration measurement.

TABLE II. CONTAINER DATA AND RESULTS OF 1 m DROP WITH A SANDWICH WALL CONSTRUCTION

| Main parameters \ Container size | | Container for the transport of a 0.4 $m^3$ barrel | | Container for the transport of a 4.0 $m^3$ tank | |
|---|---|---|---|---|---|
| | | Original | 1:3 model | Original[a] | 1:3 model |
| Diameter (mm) | | 1300 | 440 | 2800 | 1490 |
| Height (mm) | | 1840 | 520 | 3200 | 1729 |
| Thickness of sandwich wall layers (mm) | | 5 + 50 + 3 | 2 + 18 + 1 | 14 + 100 + 9.5 | 7 + 50 + 5 |
| Weight (kN) | | 45.23 | 1.67 | ~300 | 43.00 |
| Onto mantle | Impact force (kN) | 384 | – | 1313 | 363 |
| | Deformation (mm) | 114 | – | 196 | – |
| Onto cover | Impact force (kN) | 584 | 60.9 | 1877 | 520 |
| | Deformation (mm) | 75.9 | 25.9 | 151 | 79.5 |

[a] No final data.

The first member of the series was designed for the insertion of a barrel of maximum 0.4 $m^3$ (Fig. 2), while the last one is suited for the transport of tanks of a maximum volume of 4.0 $m^3$ (Fig. 3).

The fundamental geometrical parameters are:

| | | |
|---|---|---|
| – Maximum volume of active material ($m^3$) | 0.4 | 4.0 |
| – Container diameter (mm) | 1250 | 2400 |
| – Height of container (mm) | 1775 | 3028 |

## 4. PACKAGE SAFETY OF THE CONTAINER

With a view to a multipurpose design, development activity was aimed at the compliance with specifications for B(U) type packages. Testing of the equipment

TABLE III. TEMPERATURE VARIATIONS AND DISTRIBUTION IN THE CONTAINERS DURING THERMAL TEST

| Time (min) | Measured temperatures of the model test (°C) | | | Calculated temperature variations in the containers (°C) | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Environment | Container transporting a 0.4 $m^3$ barrel | | Container transporting a 4.0 $m^3$ tank | |
| | Environment | Surface of container vessel | Surface of inner tank | | Surface of container vessel | Barrel surface | Surface of container vessel | Tank surface |
| 0 | 38 | 38 | 38 | 38 | 38 | 38 | 38 | 38 |
| 10 | 1020 | 780 | 38 | 800 | 577 | 38 | 430 | 38 |
| 20 | 925 | 920 | 38 | 800 | 788 | 38.2 | 699 | 38 |
| 30 | 750 | 770 | 39 | 800 | 792 | 38.6 | 783 | 38.1 |
| 60 | 40 | 280 | 39 | 38 | 230 | 40.6 | 341 | 38.5 |
| 120 | 38 | 135 | – | – | – | – | – | – |
| 240 | – | – | – | 38 | 49 | 52.5 | 82 | 42.7 |
| 480 | – | – | – | 38 | 41 | 59 | 46 | 47.4 |
| 1080 | – | – | – | 38 | – | – | 40.2 | 51.7 |

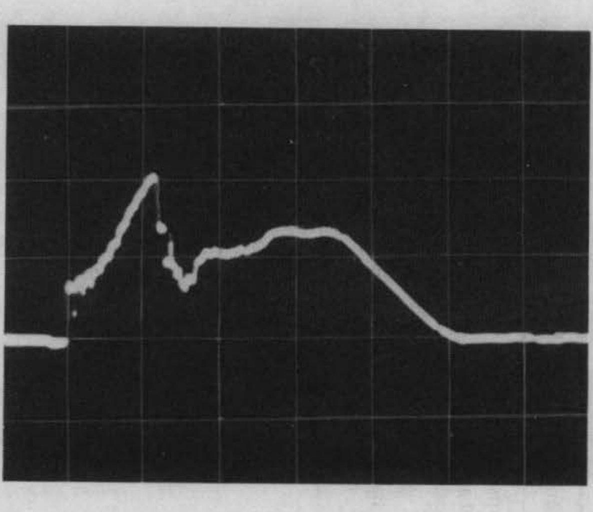

*FIG. 4. Force–time signals for the 1 m drop of a 1:6 model.*

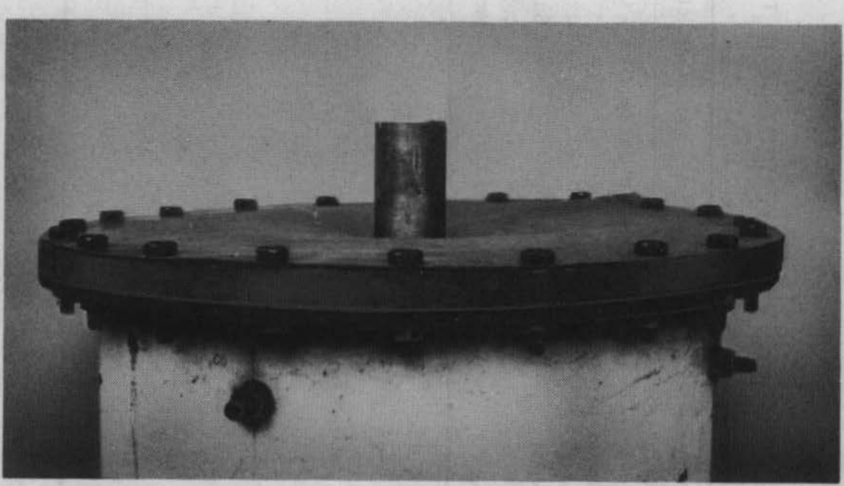

*FIG. 5. Photograph of 1:3 model with sandwich cover after 1 m drop test.*

for accident impacts was performed at and expertise was given by Brennstoffinstitut Freiberg (GDR).

Owing to the heterogeneous character of the structure, the working programme of the Freiberg Institute was on the one side directed to safety verification and on the other to the experimental determination of an optimum wall thickness for the container vessel to prevent its piercing (1 m drops). Models of different scales

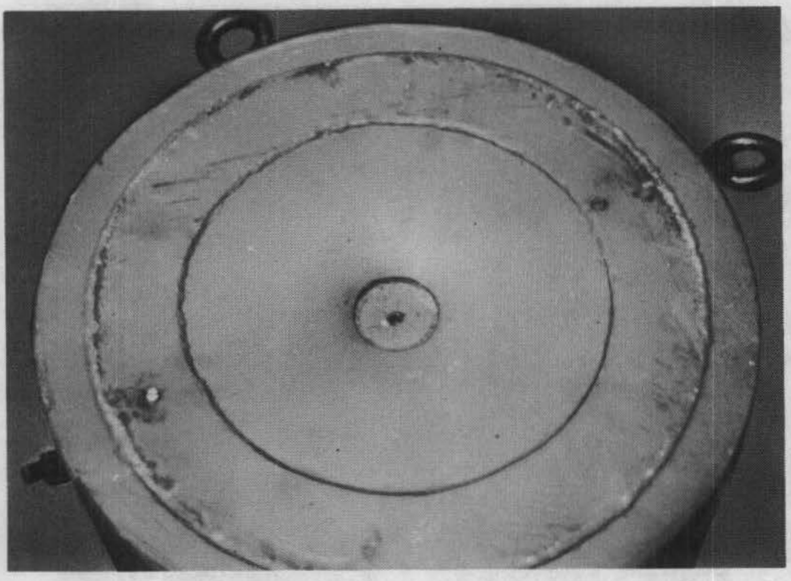

*FIG. 6. Bottom deformation of a single layer model after the 1 m drop (1:3 model).*

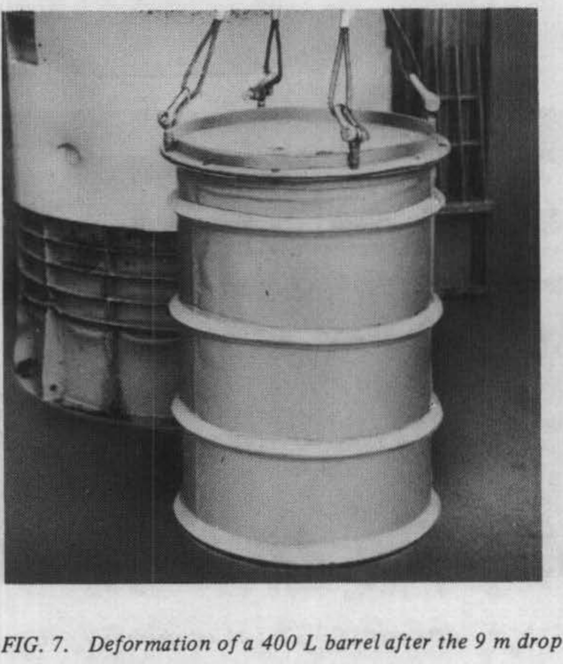

*FIG. 7. Deformation of a 400 L barrel after the 9 m drop.*

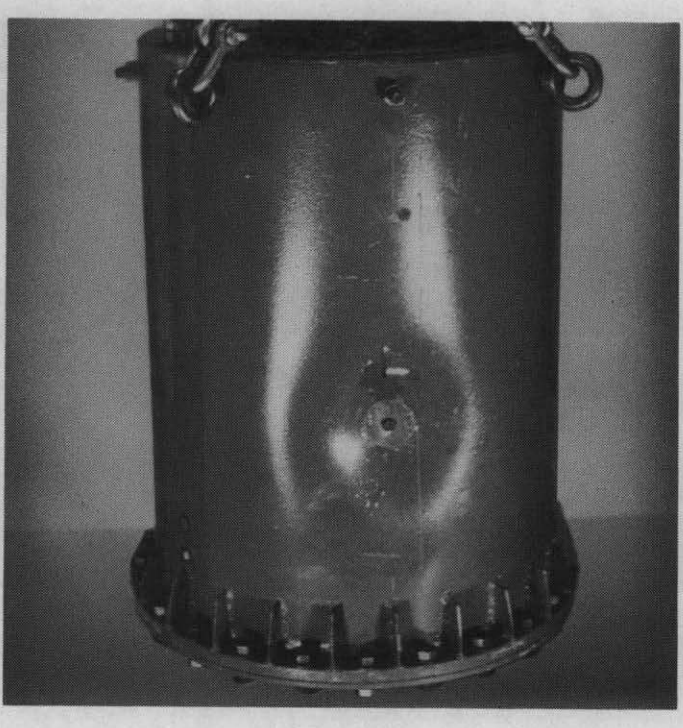

*FIG. 8. Mantle deformation of a 1:3 model after the 1 m drop.*

*FIG. 9. Deformation of a 1:4 model after the 9 m drop.*

(1:6, 1:4, 1:3, 1:2) were completed for the tests. Several of them served for modelling the whole construction while others were designed to simulate only the structural details being tested. All the models were to represent a maximum load application, with a maximum size and maximum mass inner tank.

Wall thickness tests were carried out with two approaches:

- single layer steel walls,
- sandwich walls, where the intermediate layer between the external and internal steel plates consists of synthetic resin concrete (sand–resin).

Characteristic test data for container strength and thermal behaviour are summarized in Tables I, II and III. 'Model' results were obtained by testing models with significant parameters similar to those of the original containers. Typical test situations are illustrated by Figs 4–9.

The following conclusions can be reached from the test results:

(1) The thin-wall design with granular filling has a high energy absorbing capacity; impact forces are low.

(2) Even with small wall thicknesses the wall structure resists in both alternatives the stress resulting from a 1 m drop onto a bar.

(3) Leaktightness of the tank or barrel containing radioactive materials was preserved after the drop and thermal tests.

(4) Sand-tightness is provided by the cover of the thin-wall container without any special shock protection design.

(5) Sand filling provides efficient thermal insulation; during the thermal tests the temperature rise of the tank (barrel, object) placed into the container did not exceed 20–30 K.