Programme to Develop a Large Transport Container for Transportation of Large Pieces of Contaminated Equipment and Medium Level Waste

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I. AIM OF THE STUDY

The partial or complete dismantling of research and development laboratories, facilities for the production of isotopes, installations for the manufacture of fuel elements in reprocessing plants will be required after a few decades of operation.

Some of the equipment in these facilities, such as glove boxes, ventilation piping, filters are too large to be packed in the presently available type A or B packages. Consequently, their transport is carried out in the frame of special licences delivered by the competent authorities on the basis of studies to be submitted and of special provisions with a view to ensure an equivalent safety.

In most of the cases the irradiation levels resulting from the beta/gamma contamination and/or the activation of structural elements of these installations are low and do not require heavy shielding.

The study now in progress, which consists of at least three phases, aims at the design of a large container for the transport of alpha wastes and/or large pieces resulting from the dismantling of installations. It will have an equivalent resistance to that of the type B packages.

The container should be suitable for transport by rail, road and sea.

II. BASIC OPTIONS

In the frame of the first phase of this study an inventory was made of the nuclear facilities in Europe which could be involved in this project. Subsequently a questionnaire on the following subjects was sent to them :

- dimensions, weight, activity level of the pieces and wastes to be transported;
- transport means used at present time;
- allowed dose rates during these transports;
- assessment of future needs.

Upon conclusion of the first phase, some preparatory choices have been made on the basis of the results obtained with the international survey as well as of the information on a few large containers already available in the United States and in Europe.

More particularly, these choices concern the maximum mass of the container type, its volume, the containment of the radioactive contents and the location of the radiological protection.

II.1. The maximum mass of the container

The total train weight of the transport system is limited to 38 tons on road (or 44 tons for certain countries).

Deducting the weight of the truck and of the semitrailer, the maximum total weight load of the large container is limited to 25 tons.

It should be reminded that the transport of wastes can also be carried out by rail and by sea. The concept of the large ISO container of 20 ft is perfectly adapted to these various ways of transport. The design of the large container should meet the specifications of the ISO containers, including corn-castings with a view to ensuring their bolting in a normalized way for classical transport means.

II.2. The containment

The containment must be controllable before shipment and must maintain its tightness during the whole transport irrespective of any condition (altitude, temperature, possible radiolysis of the wastes, etc.). Its location at the walls of the large container would present important drawbacks, such as :

- tightness barrier very close to outside incidents and aggressions;
- tightness seals at the door difficult to control and to protect during the loading and unloading operations;
- possible contamination spread over the whole inside of the large container.

Consequently, the idea of seperate containment was considered. It consists in putting the containers containing the wastes of the contaminated pieces into internal racks, the shape and dimensions of which can be adapted to the nature and dimensions of the objects to be transported.

This equipment, standardized and easy to handle, would be reusable. In the case of cylindrical containment vessels, these would be put in to parallelepiped racks providing for the best connection to the inside walls of the large container and allowing their stowing.

II.3. The radiological protection

Certain wastes can contain isotopes producing dose rates (gamma and/or neutron). It should be determined how an optimum radiological protection of workers can be ensured during the loading and unloading operations, taking into account that the transport standards should be met.

A radiological protection at the internal support structures (caissons or racks) has been chosen, because it has the advantage of an optimized weight when they are required. On the other hand, the radiological protection can be removed when not required.

III. DESIGN DEVELOPMENT

III.1. Punch test - design of the outer shell

III.1.1. Objective

From initial experiments, it clearly appears that the 1 m high drop test represents the most difficult problem to be solved.
The external container shell must withstand appreciable load.
Deformation of the shock absorbing materials must be limited to avoid any damage to the containment system, and to avoid a too great reduction in the usable volume.

III.1.2. To satisfy that objective, two resistant components were defined :

- a lining supporting the load $P_{(x,y)}$
- an orthotropic beam grid supporting displacement $d_{(x,y)}$

$$P(x,y) \cdot d_{(x,y)} \geq E_{(x,y)}$$

Example :
when the drop test occurs in the middle of a large side of the package:
$x = 1/2\ L$
$y = 1/2\ l$
$P_{(1/2L,1/2l)} \cdot d_{(1/2L,1/2l)} \geq 245{,}000$ J

III.1.3. With a view to demonstrating the punch withstanding, two requirements were to be met :

- to avoid the construction of the whole packaging at scale 1,
- to take into account at scale 1, the behaviour of special materials.

The problem will be solved analyzing a three-part structure (figure 1):
research (a) a horizontal grid composed of two sets of crosswise tubes, identical to those of the beam frame, on a 1/4 scale,
research (b) a complete 1/1 scale beam frame,
research (c) a portion of the lining including shock absorbing materials.

- research (a) carried out with a punch of 130 mm diameter (scale 1/4) shows the importance to have at the nodes of the beam grid, a sufficient quantity of material withstanding not only the bending phenomena but also shearing phenomena.

- research test (b) was performed with the help of non-linear finite elements code. After trying different sections of beams, for the chosen 160 x 80 x 6 mm steel shape, the ultimate loading of 2,000 KN is obtained with a maximal displacement of 20 cm. Bending energy reaches more than 259,000 Joules. Stress remains on an acceptable level (5 % maximum) but induces the general collapse.

- research (c) was carried out with 3 different shock absorbing materials : Kevlar, honeycomb and alloyed aluminium. The three tests compared in table 1 demonstrate the importance of the shearing resistance; it is for this criterium that aluminium sheet was preferred.

Description (scale 1/1)	Weight	Load max.	Displacement max.	Energy max.
Aluminium honeycomb 75 mm thick + "CORTEN" sheets 2 x 3 mm thick	109 kg/m^2	80.10^3 daN	100 mm	46300 J
Aluminium honeycomb 20 mm thick + aluminium sheets 1 x 30 mm thick, 1 x 12 mm thick	121 kg/m^2	270.10^3 daN	50 mm	85300 J
Kevlar 180 plies 48 mm thick laminated with epoxy cemented to AE24 sheets (4 mm thick)	105 kg/m^2	145.10^3 daN	90 mm	86400 J
Alloyed aluminium (2017) 45 mm thick	118 kg/m^2	454.10^3 daN	27 mm	99500 J

Table 1 : Characteristics at scale 1/1 of the different tested linings (section between fixed supports)

That is why after these three analyses, it has been decided to select only one withstanding element machined from an alloyed aluminium thick plate and constituted by (figure 2) :

- a lining plate,
- a rectangular aluminium bar.

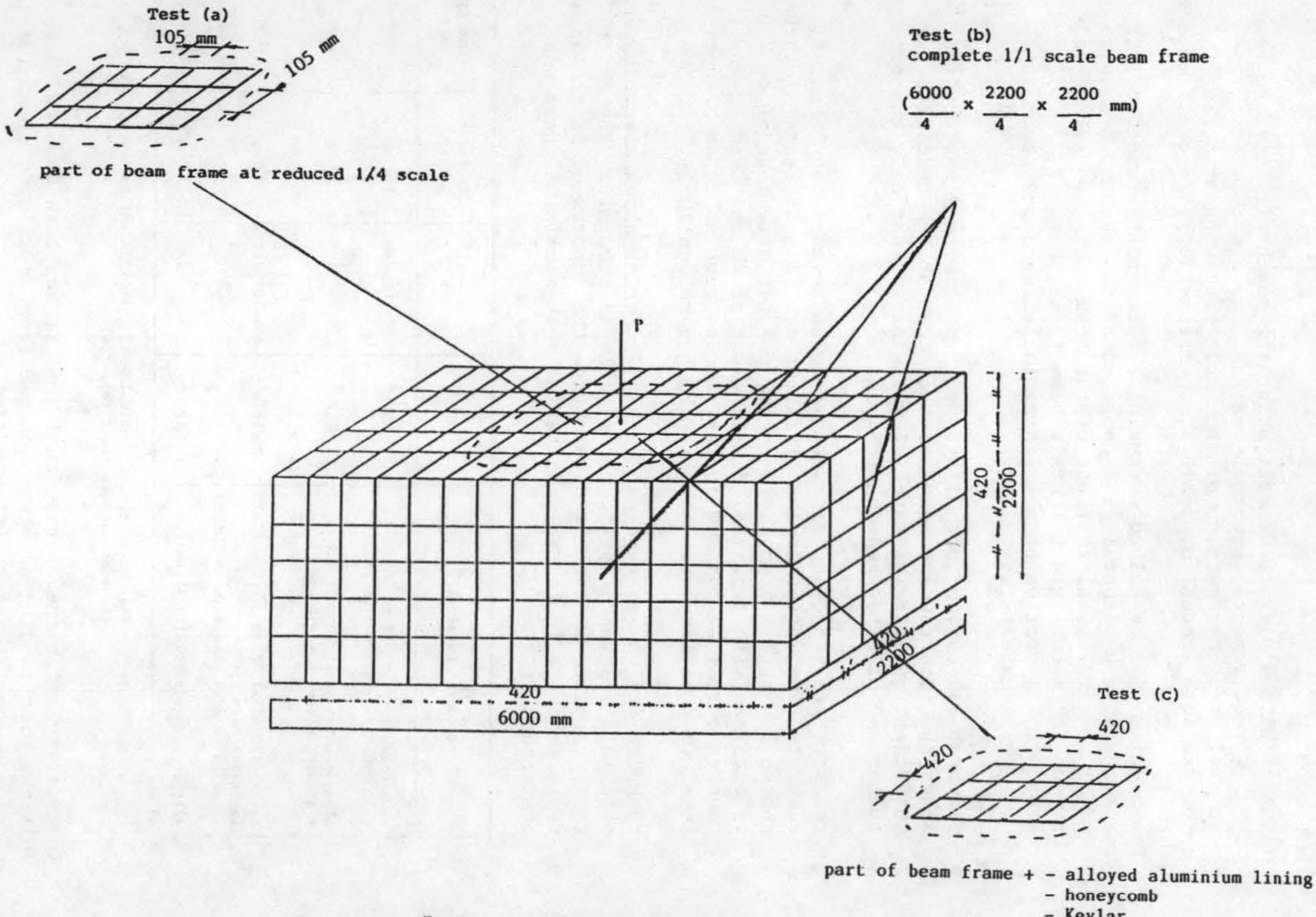

Figure 1 : 20' ISO-container structure

This aluminium plate will be welded by electron beam.

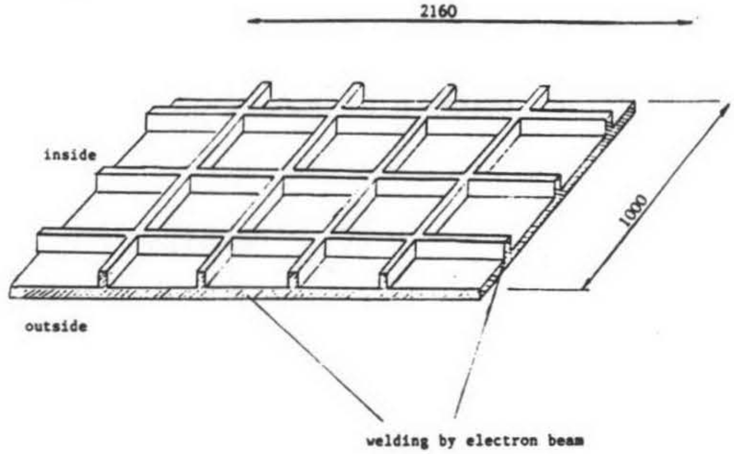

Figure 2 : Aluminium plate

III.2. 9 m high drop test

Having designed the necessary stiffness of the structure for the punch test, it appears that this structure doesn't strain enough within the framework of a 9 m high drop and that decelerations on the containment system would be too high.
That is why two shock absorbing systems were added (figure 3).

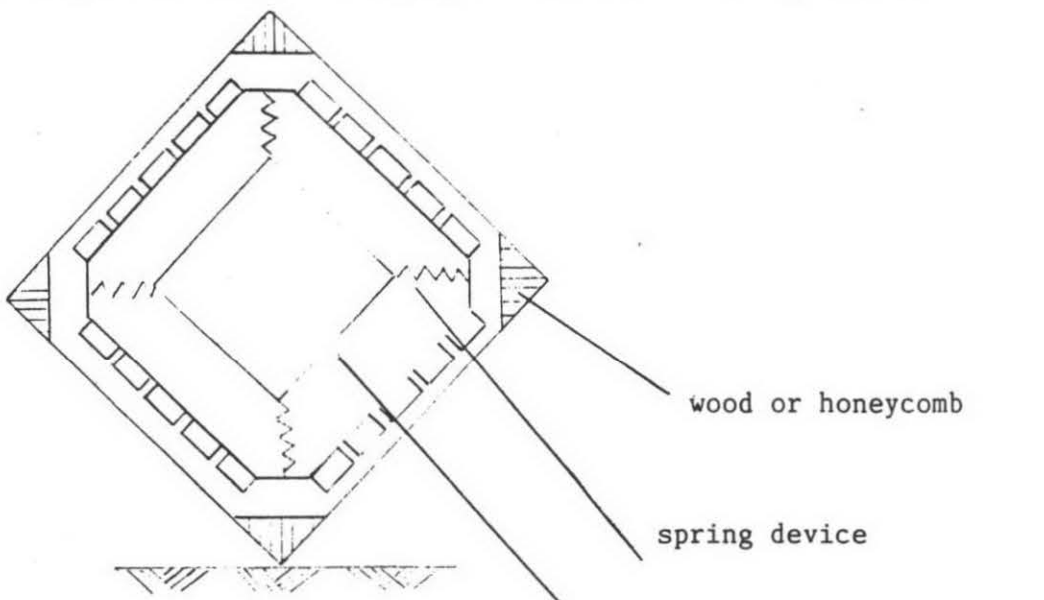

Figure 3 : Two shock absorbing systems

This solution, with the help of calculation by finite elements, can evaluate during the shock, the stresses transmitted by the spring device on the internal structure. These stresses can be considered as static loads and make the design of the internal structure and the containment system easier.

III.3. Fire test

III.3.1. General characteristics

From the outset of the study, tests on the fire behaviour were performed with structural elements of the packaging uncompletely defined. One example of this test is given in figure n° 4. This figure shows a strengthened corrugated steel structure.

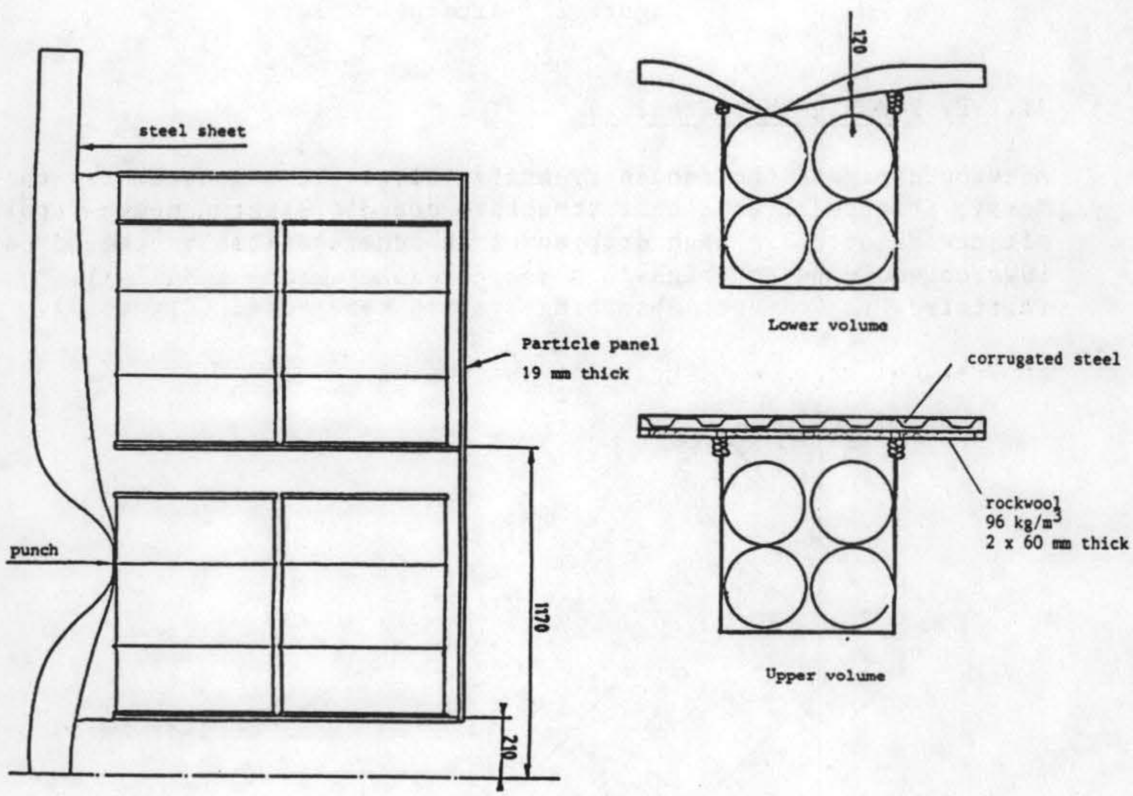

Figure 4 : Position of the drums near the lining

The distance between the outer shell and the drum is defined by the maximum admissible collapsing of the packaging.

III.3.2. Simulation method

As shown in figure 1, a caisson was built and used to contain and position the drums. As a result thermal leaks from the cold face of the lining and around drums are minimized and can be considered as a conservative assumption.

III.3.3. Results

Temperature variations at various points in the caisson were monitored by 23 thermocouples. The maximum temperature reached at the punch test location was 110° C. The waste in the drums remained undamaged. It can be concluded that the results indicate satisfactory safety margins. When the final design is considered to meet punch test requirements, thermal control calculation or model testing will be performed.

IV. DEVELOPMENT IN THE FUTURE

After performing the finite elements calculation, and knowing energy levels absorbed by the different elements of the structure a study of all the details (stowing, hinges of the doors) will be pursued during 1990 and construction drawings for a reduced scale model will be initiated.

In 1991 the model will be built and tested.

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