Steel Wood Concept of a Plutonium Air Transport Packaging

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INTRODUCTION

The CEA CESTA developped for COGEMA a plutonium air transport packaging project. The japanese company PNC "Power Reactor and Nuclear Fuel Development Corporation" joined this program. The main technical constraints applied by COGEMA to the design of the packaging are basically of two kinds :

Compliance with regulations :

. AIEA type B

. USNRC NUREG 0360
- impact test (130 m/s),
- puncture test,
- kerosen fire test during one hour (among the test series).

These regulations make the qualification of packagings for air transport of plutonium conditional on various sequential and individual tests designed to assess three parameters : containment, external radiation level and subcriticality.

Constraints specific to the La Hague reprocessing plant :

It will be recalled that the loading of transport packagings at La Hague is carried out in automated, robot-equipped facilities : BST1 for UP2, BSI for UP3. The feature of these facilities is that, for safety and security reasons, operating staff are not allowed to work in contact with the packagings. As a result, these must meet extremely stringent design and tolerance criteria to ensure compatibility with the robots.

Because of this situation, the FS68 - plutonium air transport packaging - design is based on the FS47, a recently developped type B(U) fissile packaging used for road transport of PUO2 from BST1 and BSI ; the FS68 requires only minimal alteration on BST1 and BSI machinery.

The guiding principles for the overall definition of the FS68 PU02 air transport packaging were :

- use of a compact packaging called DV73, directly derived from the FS47, in which the neutronic and thermal shield (compound + plaster) has been replaced by a redwood shock absorber to reduce its mass and improve its mechanical properties ; in a second step, its length has been reduced (and consequently the FS68 capacity) to decrease the FS68 overall weight ;

- lodging the DV73 in a protective shell lined with absorbing wood and equipped with closure systems at both ends. The protective shell and its contents have been designed to protect the DV73 during regulation mechanical and thermal tests. It was decided not to use advanced material for this study.

Although the behaviour of the FS68 packaging to the other tests has been studied, the improvement of the packaging high speed impact strength was the main subject of the three years developement programmes.

This paper is focused on this mechanical aspect and presents some interesting solutions.

DEVELOPMENT

The research performed from august 1985 to june 1988 has been of an entirely practical nature and can be roughly divided into five phases :

- simple calculations, preliminary design
- design of 6 different concepts
- selection and design of 3 concepts
- selection and design of a reference concept
- improvement of the reference concept

Each phase naturally comprised the construction of 1/5 or 1/4 scale models, the running of tests, and the analysis of these tests prior to continuation of the program.

COGEMA has preferred to conduct the tests on reduced scale models, which are less expensive and much faster to build than full-scale models. This approach was intended to allow a choice of options based on a maximum number of experimental confirmations. Full-scale tests will be reserved for packaging qualification.

The initial part of the program therefore involved designing a certain number of solutions to permit the development of a reference configuration complying with the required standards.

This procedure was based on studies and tests that enabled COGEMA to :

- validate a general concept
- refine that concept through special, performance - enhancing features.

These scale model tests have been performed in a CEA test site : The Centre d'Etudes Scientifiques et Techniques d'Aquitaine CEA/CESTA/TEE at Le Barp.

Two facilities for reproducing impact conditions have been used :

- compressed-air guns from 50 to 300 mm in diameter

- high-speed firing system : this system uses cable guidance and is fitted with a carrier-vehicle stopping device that enables the dummy to impact the rigid target independently (see figure 1).

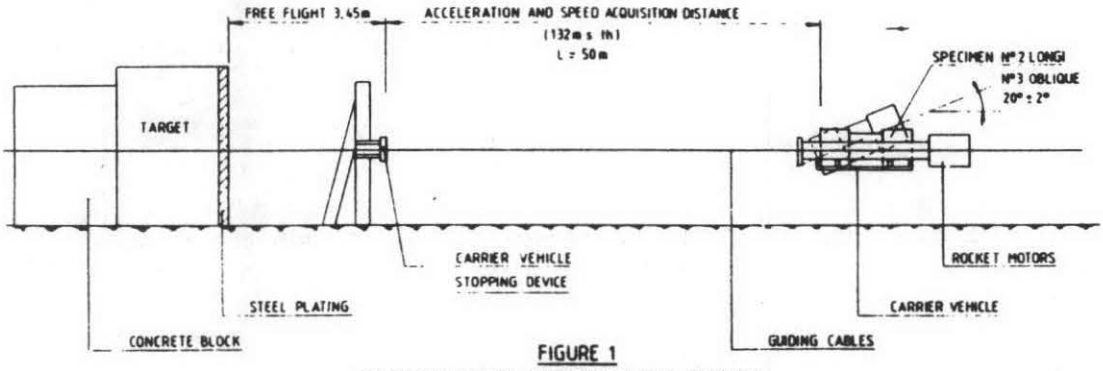


FIGURE 1
DIAGRAM OF THE CEA/CESTA/TEE FACILITY

The feasibility of a full-scale impact test has already been demonstrated during a test performed in the Centre d'Essais des Landes (CEL at Biscarosse) on a dummy-weight. A type of equipment which could be used is shown on the figure 2.

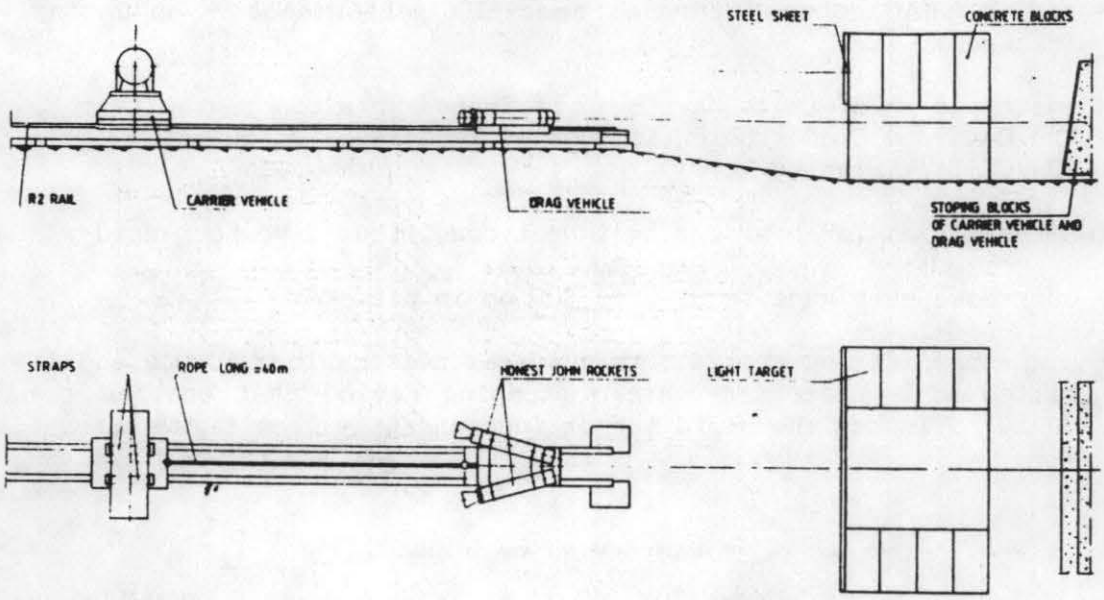


FIGURE 2
C.E.L. TEST FACILITY
FS 68 PACKAGING. TRANSVERSAL IMPACT TEST

Although essentially engaged in military programs, both Test Centers also serve for civilian programs. Because of their know-how and powerful resources, the centers are used by many French and foreign manufacturers in a wide range of fields, including aeronautics and space, transportation, and mechanical engineering.

AXIAL SHOCK ABSORBING SYSTEM

Before giving a general description of the packaging, we present now the selected solution for the axial shock absorbing system :

at both ends of the packaging, the shock absorbing system is composed of :

- an end-plug made of redwood whose central fibers lie parallel to the main axis of the packaging. Peripheral fibers lie perpendicular to the main axis,
- a removable cover made of stainless steel and reinforced with a composite fiber winding. The use of rigid covers limits the deformations and folds of the outer shell and plays a great part in the correct work of redwood as shock absorber.

The figures 3 and 4 show the work of the cover in axial and oblique impact test.

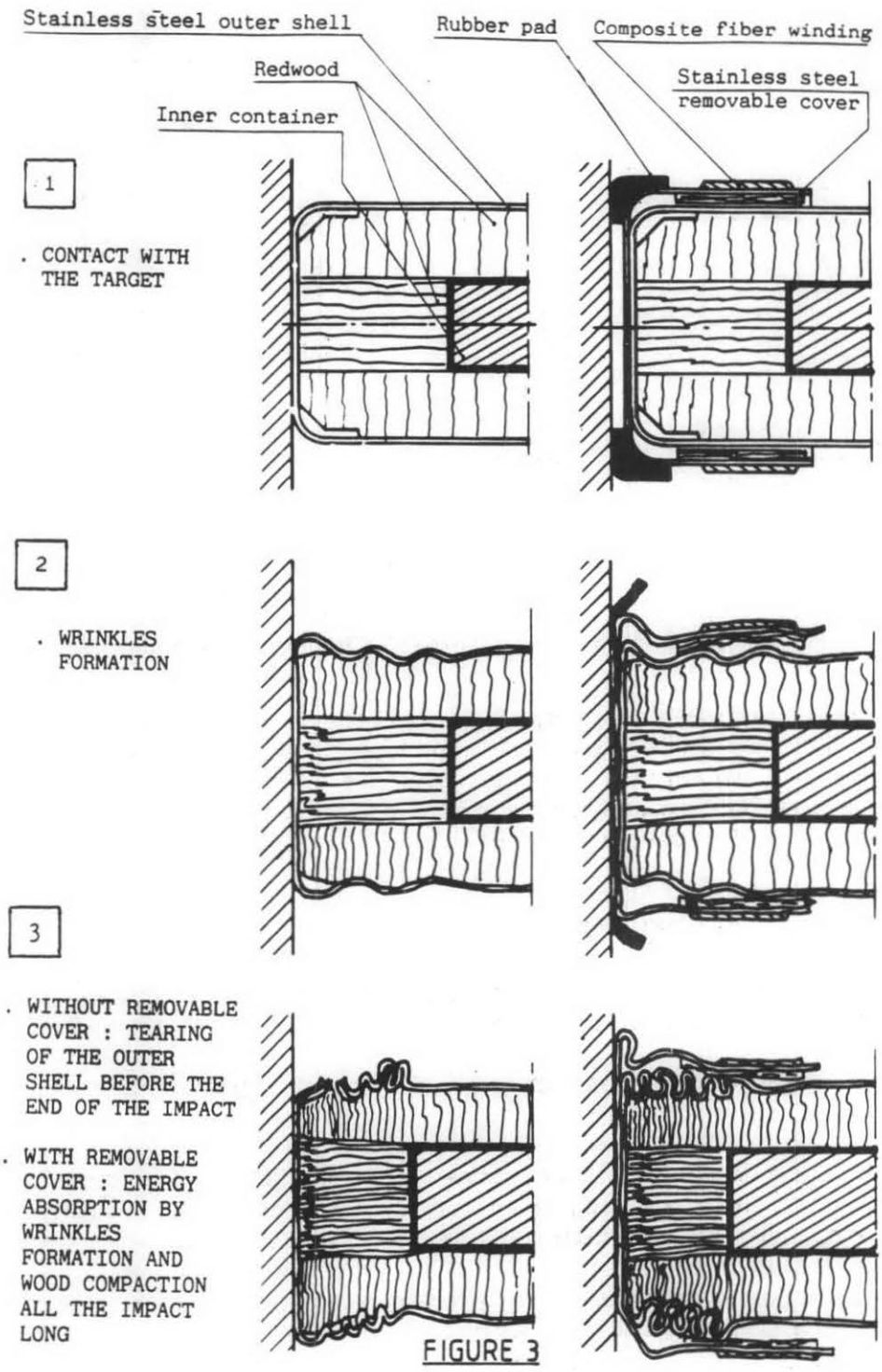
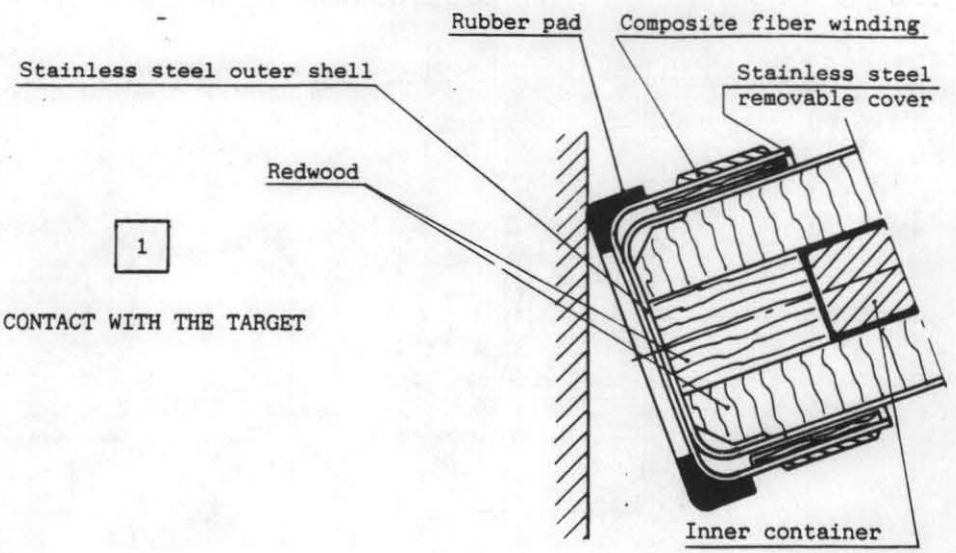
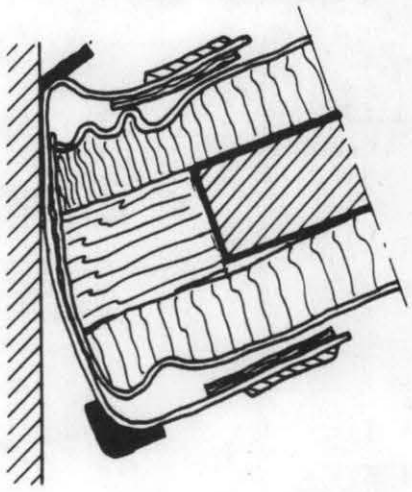

Stainless steel outer shell
Rubber pad
Composite fiber winding
Redwood
Stainless steel
removable cover
Inner container
1
. CONTACT WITH THE TARGET
2
. WRINKLES FORMATION
3
. WITHOUT REMOVABLE COVER : TEARING OF THE OUTER SHELL BEFORE THE END OF THE IMPACT
. WITH REMOVABLE COVER : ENERGY ABSORPTION BY WRINKLES FORMATION AND WOOD COMPACTION ALL THE IMPACT LONG

FIGURE 3



1

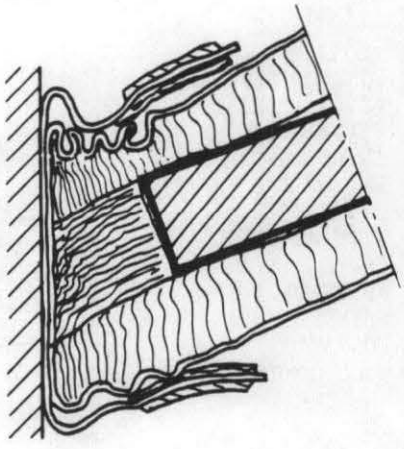
CONTACT WITH THE TARGET



2

. WRINKLES FORMATION

. RADIAL WOOD COMPACTION
BEFORE AXIAL WOOD



3

ENERGY-ABSORPTION BY :

. WRINKLES FORMATION ON
THE OUTER SHELL

. WOOD COMPACTION

FIGURE 4

GENERAL DESCRIPTION OF THE FS68 PACKAGING

The FS68 packaging, in its last reference configuration, is composed of :

- a removable inner module, the DV73, which houses the containment vessel with the material to be transported,
- a wood-based protective shell.

The packaging shown in figure 5 has the following basic characteristics :

- Approximate overall dimensions :
  . length 1 755 m
  . diameter 1 140 m (without frame)
- Total mass when loaded, without frame : approx 1 800 kg

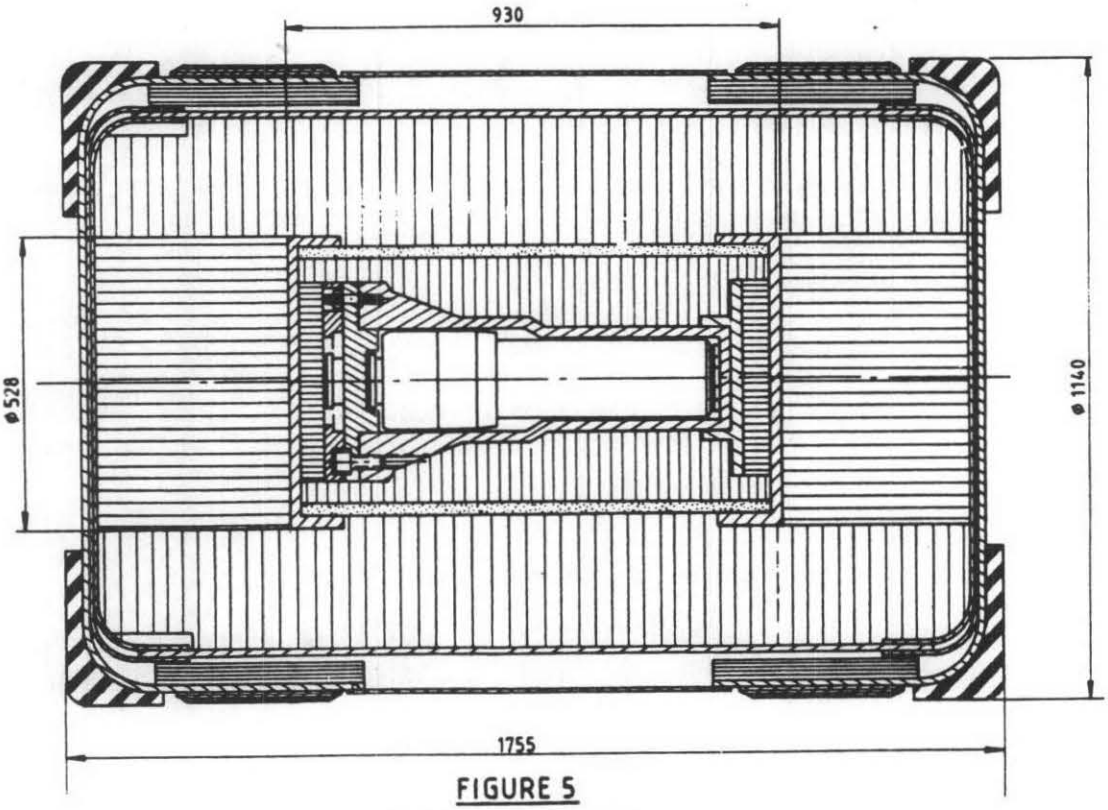


FIGURE 5
FS-68 PACKAGING

The protective shell is cylindrical and comprises the following sub-assemblies :

- a casing composed of :

  . a stainless-steel course closed at both ends by flat lids. They are fastened to the course by screws.

  . a redwood filling bonded by section and divided into two parts:
    . a main cylindrical part with radially-directed fibers
    . two end-plugs described above.

- removable covers at both ends.

The DV73 is a streamlined version of the FS47 packaging from which its design is directly derived. The DV73 is cylindrical and comprises two parts : the body and the closure system.

The body is composed of an outer course and an internal containment vessel, both of stainless steel. These two parts are separated by a redwood course whose fibers are radially directed.

The stainless-steel lid is fastened to the internal containment vessel by 8 studs and 8 screws, and is fitted with a viton double sealing joint allowing a leaktightness test before shipping.

The handling grip at the center of the lid houses a sampling system for placing the internal cell under negative pressure.

An axial neutron shield is fastened on the inside of the lid.

A fixture attached to the lid allow remote handling of the DV73.

The FS68 concept is mainly based on redwood mechanical characteristics. It is the reason why redwood must be selected at purchasing time according to :
- density
- moisture
determining acceptable wood quality.

All the FS68 scale models already tested have been manufactured with selected redwood having a high crushing plateau (40/50 MPa) on 70 % of its initial length.

CONCLUSION

The results of the reduced-scale test make it reasonable to expect that this packaging will meet the required acceptance conditions. However, these results need to be confirmed by a complete full-scale test series.