DESIGN & APPROVAL TESTING OF THE TRANSHIELD-20 TYPE-B ISO CONTAINER FOR DRUMMED PCM & OTHER WASTE

A P Gaffka & G Lawrence

AEA Technology, Harwell, Oxfordshire, OX11 0RA, United Kingdom

INTRODUCTION

This paper summarises the design and approval resting of the Transhield-20 Type-B container in a programme that began in 1991 when the UKAEA anticipated a long-term requirement to transport 200-l drums of PCM waste between its sites. This resulted in the design of two packagings : the Nupak-200 [Gaffka & Lawrence, Patram '95], and the Transhield-20, a full-height 20' Type -B ISO container which has recently been adapted to carry heavy 500-l drums.

The Transhield-20's construction is based upon the steel space-frame and resin-bonded cork construction proven on the earlier Nupak design. The container was subjected to extensive drop-testing at AEA Technology's site at Winfrith, Dorset to qualify it to carry up to 3kg of fissile material.

OVERVIEW OF THE TECHNOLOGY

The Transhield-20 container comprises an outer structure, which provides the primary impact and thermal protection, and a 5.5m x 1.9m diameter stainless steel containment vessel. This is loaded from one end either with carousels or a purpose-built frame. All loading operations can be performed with a fork-lift truck and are inherently safe because the drums are not required to be lifted higher than about one metre. Its overall dimensions are 6178mm long x 2442mm wide x 2716mm high in accordance with ISO standards [Figure 1].

The containment vessel is surrounded with resin-bonded cork for insulation and protection, and the assembly is built into a cross-braced space-frame made of box-section steel. The container has a sheet steel outer skin and external door which is hinged on its top edge, hydraulically operated and mechanically locked in the open position. The twistlock corner castings were standard supply for operation down to -40° C, although the attachment welds were assessed to the 10g criterion in accordance with the IAEA guidelines.

The package was dropped several times from 9m (and above), and its thermal performance in the damaged state was assessed by finite element analyses supported by data from the actual fire test performed on the similarly-constructed prototype Nupak-200.

The Transhield-20 provides a very strong and highly adaptable Type-B packaging for transporting bulk quantities of intermediate-level drummed waste and other hazardous goods. Its inspection and maintenance requirements are straightforward, and it can be accommodated in facilities capable of handling ISO containers.

PAYLOAD VARIANTS

Transhield-20 is currently designed to carry either :

(i) 30-off 200-l drums (maximum individual weight of 137kg) in 5 Mk-I type carousels with a maximum package fissile content of 725g, or

(ii) 25-off 200-l drums (maximum individual weight of 178kg) in 5 Mk-II type carousels with a maximum package fissile content of 3000g, or

(iii) up to 10-off "heavy" 200-l drums (~360 kg) or up to 5-off 500-l drums supported on a special dual-purpose frame (with a fissile content limit of 250g fissile material).

The essential difference between the Mk-I and Mk-II carousels is that the Mk-I carousel provides containment for a batch of six drums, whereas the Mk-II carousel provides individual containment for each of its five drums. [Figures 2a, 2b & 2c refer.]

DESIGN FEATURES AND SOME STRUCTURAL ASPECTS

The skeletal frame is made from welded rolled-hollow-section (RHS) box-members, and corrugated steel panels of 4mm - 6mm thickness which are welded between the main spans. The packaging has a top-hinged outer which can only be opened using the pair of powered by a pair of hydraulically-operated rotary actuators. It is secured further by six hydraulically-actuated steel bolts.

The inner containment vessel, which is designed to the BS 5500 as a category 1 pressure vessel, comprises a 12.5 mm thick stainless steel domed-end tube with access via the opposite end. The resin-bonded cork wrapping has a minimum thickness of 75mm. The inner door, which weighs 1600 kg, also uses cork for insulation and is clad in 3mm thick stainless steel. Its feet are located on a pair of hydraulically-driven telescopic arms of rectangular-section which drive the door parallel to the major axis of the container to provide the interface with the fork-lift truck.

An air sampling and depressurisation system is provided on the inner door and protected during transport by a special plug. The vessel is sealed at the single opening face by a pair of continuous elastomeric double 'o-rings' which are held by annular trapezoidal grooves within the removable inner door. A pair of rails run the length of the containment vessel at approximately '4-o'clock' and '8-o'clock' positions. These help secure the carousels during transport. Stresses in the package tie-downs were assessed under the action of (+/-) 10g, 5g, and 4g accelerations, and were evaluated in accordance with BS 2573 Part 1 (1983).

MATERIALS DEVELOPMENT WORK

Component bench tests were performed to verify the performance of the resin-bonded cork in its capacity to act as a thermal barrier and absorb mechanical energy during impact. Its strength over the -40°C to +70°C temperature range and its performance when subjected to burning were also assessed. Model tests on resin-bonded cork panels were undertaken to assess their impact performance under punch conditions.

IMPACT TESTING FOR APPROVAL

A full-scale prototype Transhield-20 container was subjected to two series of tests (in 1995 & 1996) under drop conditions that were either equal to, or in excess of, the current IAEA SS6 regulations. These were supplemented with theoretical analyses, other experimental tests and suppliers' data to provide a comprehensive justification for the integrity of the packaging.

In the first series of tests the package was subjected to four 0.3m corner free-drop impacts, one 0.3m free-drop base impact, one 9m free-drop end impact [Figure 3] and one 1m free-drop punch puncture onto the end face.

Two designs of carousel were proposed for operational duty. These permit fissile limits of 725g (in 30 drums) and 3,000g (in 25 drums). The contents configuration for tests performed on the prototype were a close representation of what is expected in service.

Very minor damage was sustained in the 0.3m free drops onto the hollow corner sections of the box which knocked-back, at most, by 44mm. The 0.3m drop onto the base had no noticeable effect.

The worst case pressure loading was calculated using the maximum internal operating pressure of 1.84 bar (absolute), so that the pressure differential across the containment vessel in the worst case of ambient pressure reduction to 0.25 bar is 1.59 bar (gauge). In this condition, the maximum stress in the containment vessel occurs in the flange when the door is fully-bolted.

The selection of the worst case orientation for the 9m free-drop centred on two areas : the potential for relative movement of the sealing faces leading to reduced compression in the o-ring seals, and the possibility that the elastomeric material could degrade if exposed to excessive temperatures during a fire.

During all impact testing the vessel was pressurised to 3 bar (gauge) in order to ensure that the regulatory requirements were exceeded by an adequate safety margin. Following each test, this pressure was held for several hours, with no evidence of deformation of either the containment vessel or its door. The resulting leak-rate never exceed the prescribed criterion of 1×10^{-7} bar cm^3 s^{-1}

In order to maximise the damage caused by the punch impaling into the packaging, the package was inclined at 5° and the CoG off-set from the point of impact to maximise "wrenching" and better predict the direction of slap-down. [Figure 4]. In the event the package remained upright and did not fall over.

THERMAL PERFORMANCE ASSESSMENT

The packaging's ability to protect its contents from the effects of a fire were assessed by finite element methods modelling the damaged state of the box following impact testing. This work is reported in more detail in an accompanying Patram '98 paper (Fry, 1997).

To ensure that the worst case had been identified, the effect of gross damage to the outer packaging resulting from the removal of a single panel in the vicinity of the inner vessel door flange and seals was analysed.

Surprisingly, this condition does not generate an environment which is as demanding for the seals as is the case where the punch has penetrated the insulation at the rear-end centre of the packaging. This is where the outer box protection is weakest and the inner vessel dome end presents a relatively flat surface. The contents are very well insulated by the excellent resin-bonded cork.

It was decided that the evaluation of the packaging's thermal performance under accident conditions would be undertaken using computer analyses based on finite element codes, supported by the knowledge of the previous fire testing performed on Nupak-200. This was because it is extremely difficult, if not impossible, to generate and sustain a surface temperature of 800°C from an open pool fire on large containers [Fry, 1995]. In the analysis, an internal heat load of 280W was maintained throughout.

The insulating effect of the cork prevents the temperature rise in the area of the seals rising above 94°C, which is well below the maximum permitted operating temperature (120°C) of the EPDM seals.

Transhield-20's containment vessel is designed to comply with the requirements of BS5500 as a category 1 pressure vessel code for both an internal pressure of 3 bar gauge and an external pressure of 2 bar gauge, and thus adequately fulfils the external pressure criterion for water immersion.

SOME OPERATIONAL ASPECTS

The container is operated most efficiently when permanently fixed to a flatbed trailer, where it requires a headroom of about 6m from the ground to accommodate the raising of the outer door. Each carousel is designed to be handled with a fork-lift truck and is loaded by placing it on the fixed rails that run the length of the unit.

Analysis of the vessel's atmosphere can be performed using the Air Sample System which uses a quick-release coupling that is protected during transit. This feature is also used to allow the vessel to de-/re-pressurise by venting to atmosphere through a control valve.

The packaging undergoes annual and five-yearly maintenance.

CONCLUSION

The Transhield-20 Type-B(U)F packaging is a versatile ISO container that can carry a range of intermediate-level waste forms either in drums or other types of bulk containment. The fissile material capability of 3kg provides considerable flexibility for a range of operations.

ACKNOWLEDGEMENT

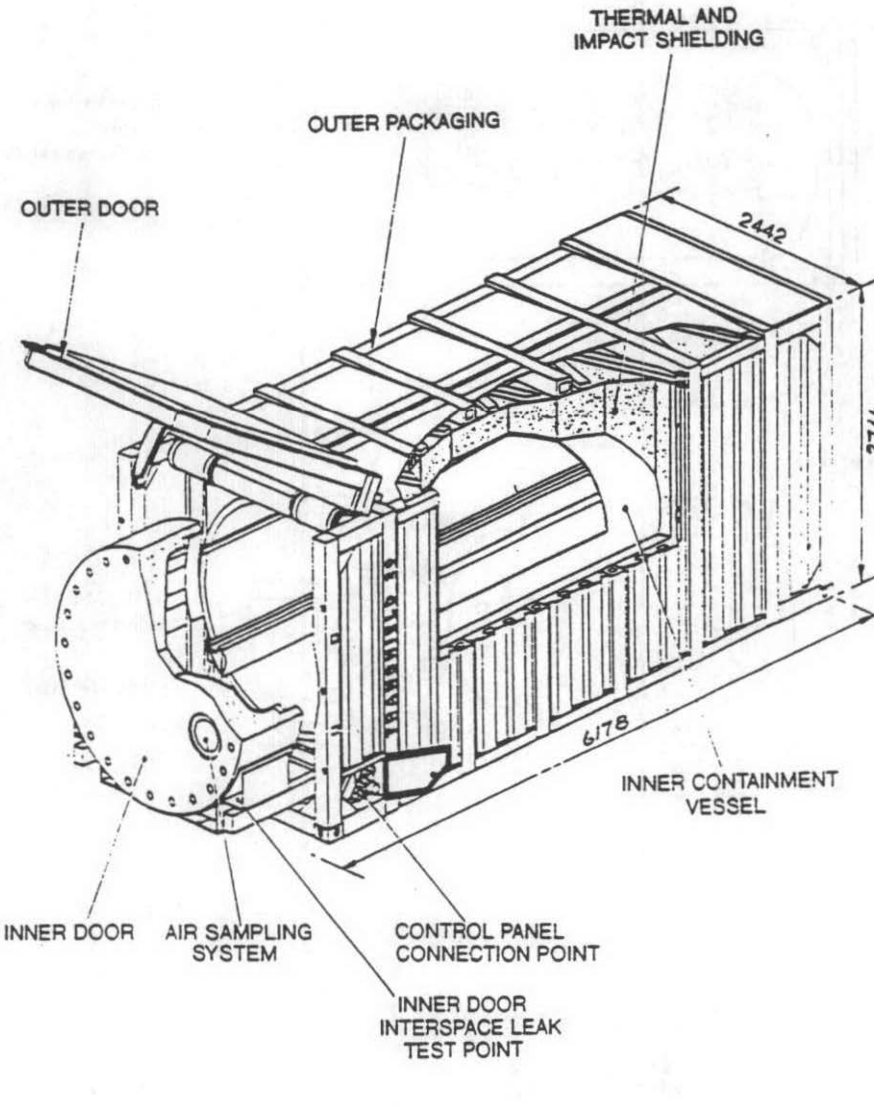
AEA Technology plc is grateful for the support given by UKAEA throughout this project to achieve certification of the current variants of Transhield-20.

REFERENCES

Fry. 1995 : "The use of CFD for modeling pool fires". Proceedings of the 11th PATRAM conference. Las Vegas, USA, December 1995

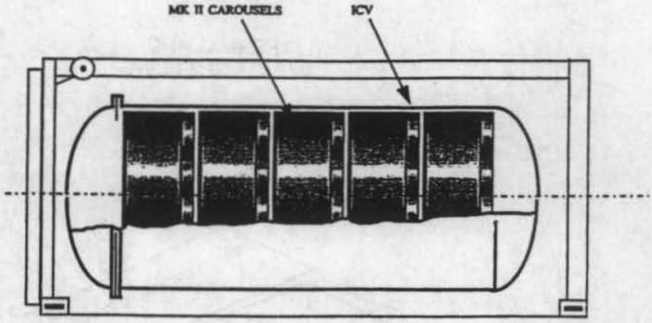
Fry & Gillard. 1995 : "Thermal analysis of the Transhield-20 container" Paper to be presented at the 12th PATRAM conference. Paris, France. May 1998.

Gaffka & Lawrence. 1995, "Design and Testing of a Transport Package System for PCM". Proceedings of the 11th PATRAM conference. Las Vegas, USA. December 1995



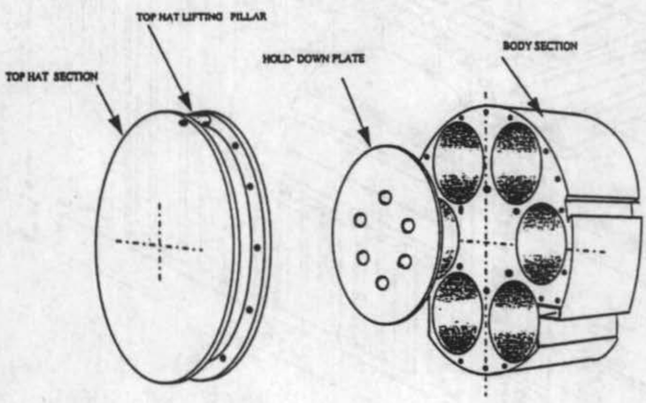
Transhield-20 schematic cut-away drawing

Figure 1



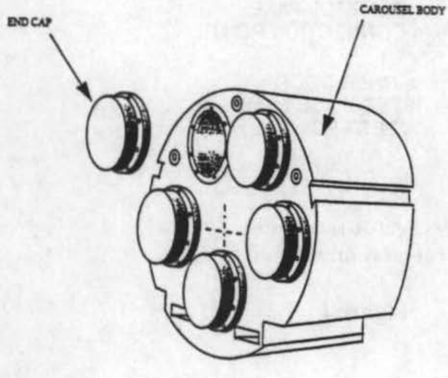
Side elevation
cut-away
of theTranshield-20

Figure 2(a)



The Mk-I
6-drum carousel

Figure 2(b)

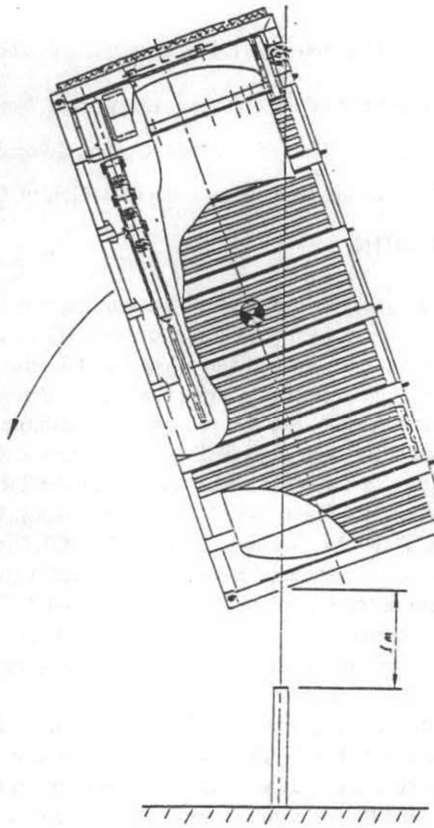


The Mk-II
5-drum carousel

Figure 2(c)

9m end-drop preparation

Figure 3



Attitude for the punch test

Figure 4