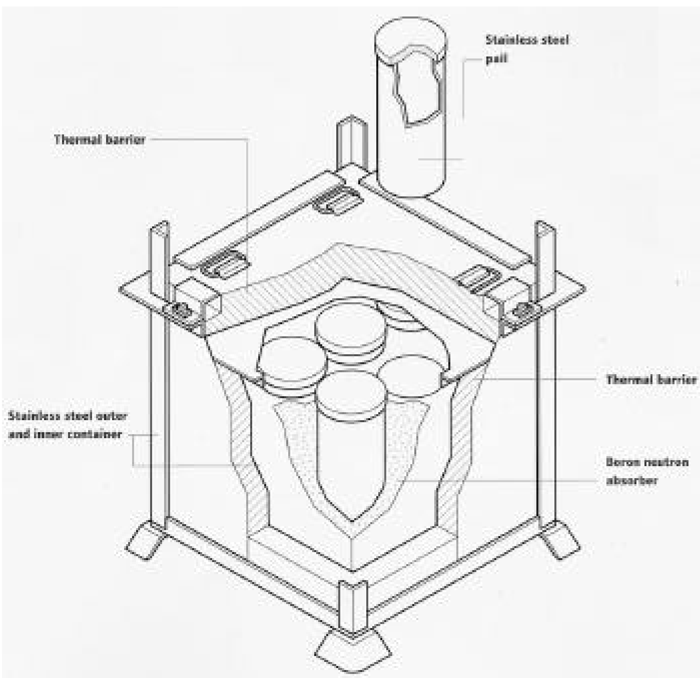
THE TYPE 3516 POWDER PACKAGE
EXPERIENCES FROM CONCEPT TO PROCUREMENT

Howard G Whittaker
Westinghouse NFBU-Transport
Springfields, Salwick, Preston
Lancashire UK PR4 OXJ

INTRODUCTION

The 3516 package is a stainless steel container for the transport of radioactive powders – primarily UO2. It comprises of 9 stainless steel 3544 pails supported in stainless steel tubes in a 3x3 array surrounded by a boronated resin as a neutron absorber. This assembly is held in an inner stainless steel box with a bolted lid surrounded by a layer of thermal insulation. This is contained within a secondary stainless steel container with an easily removable lid.



The dimensions of the container and each pail are given in the tables below

3516 Package Dimensions	
Width:	1062
Height:	908 (2 high 1716)
Unladen weight: (incl empty pails)	450kg
Capacity (as 5% UO2)	243kg

Dimensions in mm unless stated

3544 Pail Dimensions	
Diameter (lid):	243
Diameter (pail):	220
Height:	489
Capacity (as 5% UO2)	27kg

The following paper briefly covers some of the key stages in the development of this package leading to its current operational use within Westinghouse NFBU.

CONCEPT AND JUSTIFICATION

When the 1985 IAEA Safety Series 6 Regulations for the Safe Transport of Nuclear Material were introduced in the late eighties, BNFL realised it would have difficulties with our 1660 transport container. This package was a 1973 design comprising a metal drum surrounded by an iroko timber outer and was used to transport powders, pellets and residues. At that time we

knew that the container could continue in use under the "Grandfathering" clauses in the regulations, but we would be unable to purchase replacements. In addition we had carried out tests and knew that the wooden components would have problems with new fire test requirements, which prevented artificial cooling. A number of other containers available at that time for transporting the same types of material were also encountering difficulties with the regulators and having restrictions placed on them. BNFL had a business need for a reliable transport solution. It was therefore decided to design our own package, primarily for up to 5% enriched powders but which, at a later date, could be adapted for other contents, such as pellets. Additionally we would not be in a situation where a third party owned the design and could let certification lapse at any time. The design brief was to improve upon all existing packages by maximising the payload, minimising the handling, improving the ease of transport and be completely compliant with the latest regulations.

DESIGN PROCESS

This was an ideal opportunity to create something quite novel for powder transport. The initial stage of design was to talk to all of the people who would be handling the package. The package was aimed at a single internal customer with powder loading taking place in our new oxide fuel complex. The result of the discussions was that the size of pail was of utmost importance and should be similar to the existing type 1610 (the inner pail of the 1660 container) and BUJ type pails. This would allow existing plants to continue operations with the minimum of modification. Once this was established the next step was to get as many pails in an ISO freight container as possible. Initial thoughts were to have a circular drum type overpack similar to the BUJ design. This idea was not favoured by our transport personnel who pointed out that these drum type packages had to be loaded onto odd shaped pallets, which did not fit ideally into an ISO container. The result was that we were shipping large amounts of empty space around the world with the load braced with timber, which being of a useful size very rarely seemed to find its way home. Additionally, at the time the design was being considered the normal maximum road weight for a load was 38 tonne within the UK. This encouraged us to have the lightest container possible with the maximum of contents. Consideration of the required thermal insulation concluded that it was much more efficient to protect multiple containers rather than individual. This led directly to the multi-tube vision

All of the above factors together with the internal size limitations of an ISO container set the outer dimensional limits for our new package. BNFL had a lot of experience with square/ cuboid containers and it seemed logical to make good use of this, deriving a new design to fit snugly into the ISO with the minimum of wasted space. We had now arrived at a situation where we had a concept of a cuboid container which needed to be sized to be easily handled in and out of an ISO container, stack 2 high and allow 2 containers to fit side by side.

Tests were carried out using dry cement powder which had a similar density to the uranic powder (1.6 g/cc). The result was that 27kg could be contained in each pail. At this point we had 9 pails each containing 27kg of powder within a cuboid container. The outer container size was dictated by the ISO container dimensions. We therefore needed to obtain insulation material with the correct properties which would fit between the two. We eventually chose a calcium silicate based sheet thermal insulator.

The next stage of the design, once overall sizes had been established, was to decide on materials for manufacture. This proved to be very simple; use a grade of stainless steel which would negate all of the previous problems associated with brittle fracture at -40C, and give a container with a long working life with the minimum of maintenance and ease of decontamination. Throughout the design stage our criticality experts had been kept up to date with our work and we were aware that some form of neutron absorber would be necessary to carry this quantity of powder in a single package. Our initial thoughts were to make use of boronated steel as dividers for the pails. A proposal was made to the criticality section who promptly told us that for the level of boron present we would have to introduce a substantial amount of moderator into the package. This forced us to insert a high-density polyethylene block in place of the central pail. This increased the weight of the package and decreased the contents, although this was still superior to existing packages.

A test package was manufactured in order to carry out some in-house drop tests. This was to get a feel for any weak points in the package with a view to corrective action before the design was finalised. Even before testing, two problems became apparent. One was that boronated steel was not readily available so a substitute normal grade of steel was used. Second was that our in-house target for testing, although substantial could not be described as unyielding as described in the regulations. In order to compensate for this the drop heights were all increased by a nominal 10%. The prototype container was subsequently tested to the full range of tests as detailed in IAEA SS6 1985 for a Type A Fissile package with the exception of the fire test. The option to fire test was not available at this stage

The main problems were with the steel lattice. As there was no restraint for the circular pails apart from this lattice they were relatively free to move. This caused distortion of the dividers which allowed the lid closures to contact each other causing damage. In addition the steel lattice distorted due to the impacts (see fig left).

The good news was that the outer containment stayed in place and appeared to have sustained no more than the minimal deflections anticipated with the range of tests carried out.

While these tests were taking place discussions were in hand with several experts on boronated steel. It was becoming obvious that boronated steel does not lend itself to welding, and unless strips were left un-boronated, severe embrittlement would occur. In addition the new container had to be cost effective and the boronated steel was proving difficult to source and very expensive. This effectively forced a complete review of the inner container design.

Fortuitously one of our other design teams was working with a proprietary material formed

from resin, which is homogeneously loaded with boron material to act as a neutron absorber. It is mixed, poured as a liquid into the inner steel container and sets hard. Using this material within the secondary containment we had a rigid support for the pails, having the same circular profile as the pails. This restricted the movement of pails within the package, thus preventing them from contacting each other during the drop testing. In addition absorbent packing materials discs were placed between each pail and the inner lid. A second series of tests with a re-designed inner (see fig left) showed the resin to be very rigid and resilient. This protected the inner package and pails from damage during testing.

So we had now arrived at our finished design which comprised;

1) Stainless steel cuboid outer containment with easily removable lid.
2) Approximately 95mm of thermal/impact resistant material.
3) Stainless steel inner containment.
4) Solidified boron laden resin core with integral thin walled steel tubes for pails.
5) Stainless steel pails (9 off).

TESTING

The regulatory testing was carried out in accordance with the requirements of IAEA Safety Series 6 1985 edition (as amended 1990) for a Type A Fissile package in the following sequence.

STACKING TEST

An applied load of 4.2 tes was left for 24hrs without any detectable damage

PENETRATION TEST

A 6kg bar was dropped onto the lid flange resulting in a small indentation

0.3 METRE CORNER DROPS

Drops onto each corner resulting in minor damage to upright angle and lid flange

1.2 METRE DROP (WORST ATTITUDE)

Drop onto top edge resulting in further distortion of angles and flanges, and slight buckling of lid and sides.

9 METRE DROP (WORST ATTITUDE)

Drop onto same edge as before (see figs below) resulting in distortion and partial cracking

of a non-containment weld between angles and flange. There was further bowing of the package faces.

1m PUNCH TEST
After consultation with the competent authority representative it was decided to attempt to dislodge the lid adjacent to a damaged centre bolt. This resulted in near failure of centre bolt and failure of 2 corner bolts but the remaining 9 bolts held and the lid remained secure and did not appear to allow any entry into the package.

FIRE TEST
Open pool fire above 800deg C for minimum 30minutes resulting in fragmentation of the edges

of the insulation material. On inspection there was slight sooting on the inside of the inner lid but no other noticeable effect on the pails or contents. The maximum internal temperatures varied from 60deg C in the centre to 116deg C adjacent to the 9m impact zone. This was well within the operating scope of the pail seals. There was no damage to the neutron absorbing material.

In addition to the above tests, a sealed pail was successfully subjected to a differential pressure test in order to satisfy paragraph 534 of Safety Series 6.

PREPARATION OF SAFETY CASE

Our package design approval applications are entitled Design Safety Reports (DSR), known elsewhere as Safety Analysis Reports (SAR). They are prepared to a specific format as outlined in an applicants guide produced by the UK Competent Authority, the Department of Transport, Local Goverment and the Regions (DTLR). The DSR for the 3516 was prepared in accordance with the 1985 applicants guide and comprised of three major sections.

a) The formal application briefly covering each of the points required by the applicant’s guide.
b) The criticality assessment prepared by our criticality safety section
c) The independent test report produced by AEA technology.

One item not contained in the DSR was any mathematical modelling. At the time we had limited capability in this area and it was our understanding the DTLR were unlikely to accept computer analysis except as a reinforcement of physical tests

LICENCING

Following production of the DSR, a submission was made to the UK DTLR for a licence for the 3516 as a Type A Fissile package. There followed a series of questions and responses between the various experts at the DTLR and BNFL until certification as an AF was granted. Following this the approval has been subsequently validated in a number of other countries including Spain and Sweden

We consider our working relationship with DTLR to be excellent. It is based on an open exchange of information and involvement with projects from their very inception. Representatives from the DTLR had attended all of the tests, both unofficial and official. We also find the availability of the DTLR for comment and advice on regulatory interpretation a significant aide to our work.

PROCUREMENT & MANUFACTURE

Once a licence had been obtained, tenders were put out to approved manufacturers. There was a business requirement for several hundred 3516 packages.

The choice of manufacturer was based on several factors. Cost was an obvious consideration. However the selected company also had experience of producing containers for the nuclear industry which enabled an immediate appreciation of the importance of quality issues. They were also solely a fabricator of stainless steels which avoided the problems sometimes associated with cross-contamination by carbon steels.

All stages of manufacture were subject to an agreed production route which detailed the exact quality plan for every stage of construction including material batches, welding techniques etc.

The fabrication of the steel components were very straightforward. Each of the parts was of relatively simple construction, providing no new technical challenges to the manufacturer.

Most of the challenge came from the preparation and pouring of the boron resin. The resin for the test containers had been cast by a specialist firm who had used this material extensively. However for efficiency reasons for the large quantities involved, the steel fabricator directly mixed and poured the resin. This was a new material for them. A new industrial mixer was purchased and commissioned. A development programme for the preparation and pouring of the resin was instigated at the fabricators in order to promote familiarisation with the product. This continued until both the operators felt confident and the correct material specification was consistently achieved. Analysis proved homogeneity throughout the wet mix and the hardened cast.

An important learning point from the work was for more consideration at the design stage, of the requirements of volume production. Specified fabrication details on the drawings which suit small scale manufacture can lead to inefficiencies when the work is scaled up to a production line. The need to apply to the regulators for minor changes to licenced packages makes any change extremely time consuming and potentially expensive.

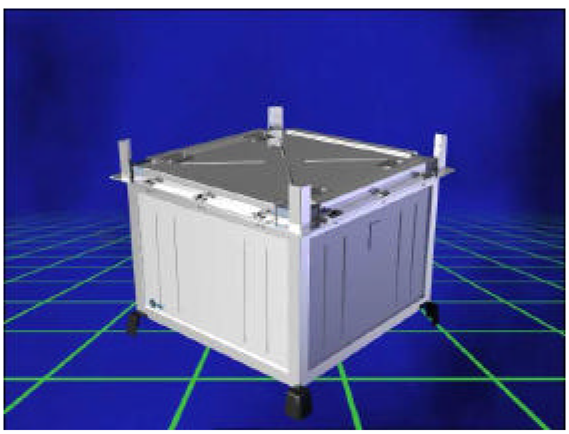
MAINTENANCE AND QUALITY RECORDS

The design of the container is such that it can be completely broken down into it's individual components. This gives the advantage of being able to fully inspect all of the internal parts during maintenance, giving assurance that no unseen corrosion has taken place, as is possible with completely sealed units. The fact that all of the ferrous parts are stainless steel should prevent most types of corrosion.

The pails, inner container, and outer container are individually numbered allowing interchangeability without losing traceability. All components including the resin have complete quality records both from their original manufacture and any subsequent maintenance.

SUMMARY

The 3516 development and procurement programme has given Westinghouse an efficient, durable UO2 powder transport container which is fully compliant with the latest regulations. There is considerable scope for development of new inner containers to take different types of material. Work is currently underway to develop a system to take fuel pellets.



ABSTRACT

THE BNFL TYPE 3516 POWDER PACKAGE – EXPERIENCES FROM CONCEPT TO PROCUREMENT

The need for a new design of container for the international transport of uranic powders became evident to BNFL due to an increasing series of issues with existing licenced containers. There were a mixture of business, regulatory, and operational drivers. Consequently BNFL Fuel Group (now Westinghouse UKFB) designed a completely new 9 pack stainless steel AF package which contained many new features and innovations.

Throughout a period of several years the container has progressed through a series of distinct phases until recently being brought into operational use.

These stages were:

Concept and justification
Design
Testing
Preparation of Safety Case
Licencing
Procurement
New materials
Manufacture
Maintenance Programmes

Each of the stages brought their own challenges and learning points, some unique to this type of package others of a more general nature. These are considered and discussed and key issues expanded upon.