THE DEVELOPMENT OF A NEW PACKAGE FOR THE TRANSPORT OF MIXED OXIDE (MOX) FUEL IN EUROPE

P Purcell, A R Cory

BNFL Transport Section, Risley, Warrington, UK

SUMMARY

BNFL are developing a new package for the transport of MOX fuels to European LWR utilities. This package is to comply with the 1996 edition of the IAEA Transport Regulations these having, in some respects, more stringent requirements than the 1985 edition. The capability to deliver fuel to all utilities has been one of the prime functional objectives and has led to a package design capable of delivering a wide range of PWR and BWR MOX fuel assembly types. In order to achieve this, the package design incorporates a flexible operational system that ensures the MOX fuel may be unloaded at utilities with minimal plant modifications being required.

MOX fuels with heat outputs and gamma/neutron radiation emissions not experienced with new UO2 fuels may be transported and operated with minimum dose uptake to personnel due to the shielded module design. Where required, a utility may retain the module to provide radiological protection to operators until the fuel assembly is loaded into the reactor.

This paper gives details of the functional specification of the package, its development and outlines the resulting design.

INTRODUCTION

Testing of MOX fuels in reactors have taken place from the early days of the industry and in the past 10 years or so that such fuels have approached the performance of conventional UO2 fuels. Its use has increased enormously over the past few years and will continue to do so, given the potential for many reactors to take up to 30% of MOX fuel in the core.

The capability to manufacture MOX fuel assemblies has expanded rapidly in most companies involved with fuel fabrication. BNFL is no exception and after operating a development facility for some years is now in the process of commissioning a much larger MOX fuel fabrication facility known as the Sellafield MOX Plant (SMP) with the potential output of 120 tonnes of heavy metal per year, of which a significant proportion is intended for European customers.

A major feature of the new fuel fabrication plant is the SMP export facility designed for loading MOX fuel assemblies into transport packages. Presently rail transport is not an option for transporting MOX fuel from Sellafield to continental Europe because of the constraints on transporting category one materials by rail in mainland Europe.
As a consequence of the flexibility required to deliver to a range of customer receipt facilities and in order to transport the planned MOX fuels, which will have greater heat outputs and radiation emissions than currently the case, in 1996 BNFL initiated development of a new MOX transport package. This will comply with the 1996 IAEA Transport Regulations and be capable of carrying any fuel assembly from the new fabrication plant. This paper discusses the development of the package which is designated **EUROMOX**.

INITIAL DEVELOPMENT

The starting point for the development of any new package for the transport of nuclear material is a functional specification which in broad terms should give details on the following;

- Applicable site and transport safety standards
- Parameters of the nuclear materials to be carried
- Parameters of export and receipt facilities

With MOX fuel classed as Category 1 material, civil security aspects must also be considered, these becoming a significant feature of the EUROMOX development. The current practice with smaller MOX packages is to fit them into a secure container which incorporates systems that extend the time to gain forced access. It is intended that the EUROMOX is transported in a new design of secure container specifically to carry the new packages. The design of the secure container is an implicit and influential part of the EUROMOX development, this is known as the **EUROSEC.**

Within Europe potential users of MOX fuels cover a wide range of LWR fuel types and sizes and many different fuel receipt facilities in respect of lifting capacity and handling space. A prime requirement of the EUROMOX functional specification was full compliance with the SMP Export Facility and as many reactor fuel receipt facilities as practical. To determine the operational parameters of fuel receipt facilities a number of visits were arranged to reactor sites, these providing fundamental data for the flask functional specification. In parallel, an optimisation study was conducted considering a range of payloads, this study focusing on the resulting weights and dimensions of the EUROSEC.

Following site surveys and optimisation studies an initial specification was prepared which formed the basis of the design process, a number of the principal functional specifications are given below;

- Compliance with the B(U)F standards of the 1996 IAEA Transport Regulations, which due to the activity content being above 10^5 A2 requires the containment to be capable of withstanding 200 metres immersion with no rupture (IAEA SS6 para 657)

- The payload capacity of the EUROMOX is one PWR or two BWR fuel assemblies.

- The loaded EUROMOX weight not to exceed 5000kg loaded with one PWR or two BWR fuel elements.

- The EUROMOX must fit into a secure container (EUROSEC) whose dimensions do not exceed those of a standard ISO transport container

- The target payload capacity of the EUROSEC to be four PWR or eight BWR fuel assemblies.

- The EUROMOX is to be capable of transporting PWR fuel elements up to 230mm cross-section and 5metre length and BWR fuel upto 140mm cross-section and 4.5 metre length.

- Lifting points to comply with UK, NII and relevant European site standards

- Dose uptake to operators at export and receipt facilities to be minimised.

The requirement to withstand 200metres immersion dictated that a cylindrical containment shell with a thick base and lid was essential and this became the constant feature of all design concepts. A number of concepts evolved and each was reviewed against the functional specification with the result that the following was selected for further development;

The fuel assembly fits into a shielded module which incorporates individual clamps at the grid positions. The module acts as a support to the fuel and can be withdrawn from the containment shell both horizontally and vertically. Outside the containment shell is a layer of thermal insulating material through which pass a number of heat conducting webs to allow heat to pass from the fuel to the outer surfaces.

This design concept was selected because it offered operational flexibility, lowest weight and the greatest radiological protection to personnel.

CONCEPT DEVELOPMENT

Development of the shielded module proved to be a significant feature of this project, and involved input from the fuel designers, SMP export facility designers, customers, and BNFL Technical Services who provided criticality, shielding, thermal and vibration analysis. A total of 10 fuel module variants were required to cover the complete range of fuel lengths and cross-sections, all with common design features and capable of fitting into the EUROMOX containment system. It is proposed that when MOX fuel requirements are specified an appropriate shielded module design is selected and potentially optimised to suit their needs, for example in respect of operational and handling features. Where necessary the module may be retained on site until the fuel is loaded in order to provide radiological protection to operators.

The shielded module has to be capable of fitting both vertically and horizontally into the EUROMOX containment system and then be clamped into position by an end operated actuation system. This capability has to suit all the module designs and is achieved by allowing clamping arrangements to be interchangeable.

Containment is provided by a stainless steel shell with a flat base and lid. The base is welded to the shell, the lid is retained by 16 bolts into an external flange welded to the shell. Lid sealing is provided by dual elastomeric seals fitted into grooves in the lid. An interspace between the seals is used to demonstrate seal integrity. The thickness of the shell and the end closures was determined by the need to comply with the 200m immersion requirement with due consideration to the weight consequences from over specifying thickness

A major consideration consequent from the relatively thin containment shell was the susceptibility to damage both from 9 metre and punch impacts. Protection from damage resulting from a 9metre impact onto a rigid target is provided by detachable shock absorbers fitted to each end of the containment system, each designed to give low decelerations. To determine damage from punch penetration, a scale model was used which examined the consequences of horizontal drops on to a punch aimed at mid length. Initial tests indicated that the punch would penetrate the cladding and dent the containment system. Punch protection was then incorporated into the handling frame and subsequent tests indicated only slight distortion of the containment shell occurred.

The EUROMOX is a light package with the potential to reach high temperatures in a fire accident due to low thermal inertia. This puts the lid seals at risk and hence containment integrity. Assessment of the EUROMOX concept indicated this was the case and a thermal shield was incorporated into the lid shock absorber. Thermal protection of the main body is provided by a layer of insulating material clad by a thin stainless steel shell. Webs pass through this layer from the outer cladding to the containment shell to ensure heat transfer under normal conditions. These are designed to limit heat input during a fire by severing thermal contact when the cladding reaches 200 degrees. This occurs within 3 to 5 minutes from commencement of the fire.

Under normal transport conditions it is essential to ensure temperature limits on fuel pins are not exceeded. Assessments at the early stages of development showed this could be achieved without resorting to external finning. Heat from the fuel reaches the external package surface by a combination of thermal radiation, conduction and convection, all of which were optimised during the development process.

Transport of the MOX fuel assembly within prescribed conditions is an essential requirement to limit inertia loadings during normal transport and damage from induced vibrations. Detailed handling procedures have been developed to minimise inertial loadings and assurance is given by the EUROMOX being fitted with load transducers recording accelerations experienced during transport and handling. To ensure the fuel does not become damaged by vibration the EUROMOX containment system is dynamically isolated by strategically located anti vibration mountings.

The transport frame is an integral feature of the EUROMOX. Fabricated from aluminium alloy for lightness it has been developed to serve several functions whilst allowing free dissipation of heat. The frame incorporates pivot points for tilting operations and allows EUROMOX packages to be stable when stacked. Attachment features on the frame allow units of two or four packages to be joined and handled together as a unit. The frame incorporates protection plates on each face to limit punch damage.

DESIGN DESCRIPTION

Development of the EUROMOX and EUROSEC is nearing completion with all functional specification being either achieved or improved upon. The attached figures illustrate the current design of the EUROMOX;

Figure 1 Flask Assembly And Sectional Elevation

Figure 2 Typical PWR Fuel Element Module

Figure 3 Typical SectionThrough Flask For 230 Sq PWR Fuel Assemble

FUTURE PROGRAMME

The development work is currently nearing completion with drop testing work programmed to take place early in 1999. This will involve drop testing of a full size prototypes.

During 1999 safety cases will be consolidated and submissions made to the competent authorities.

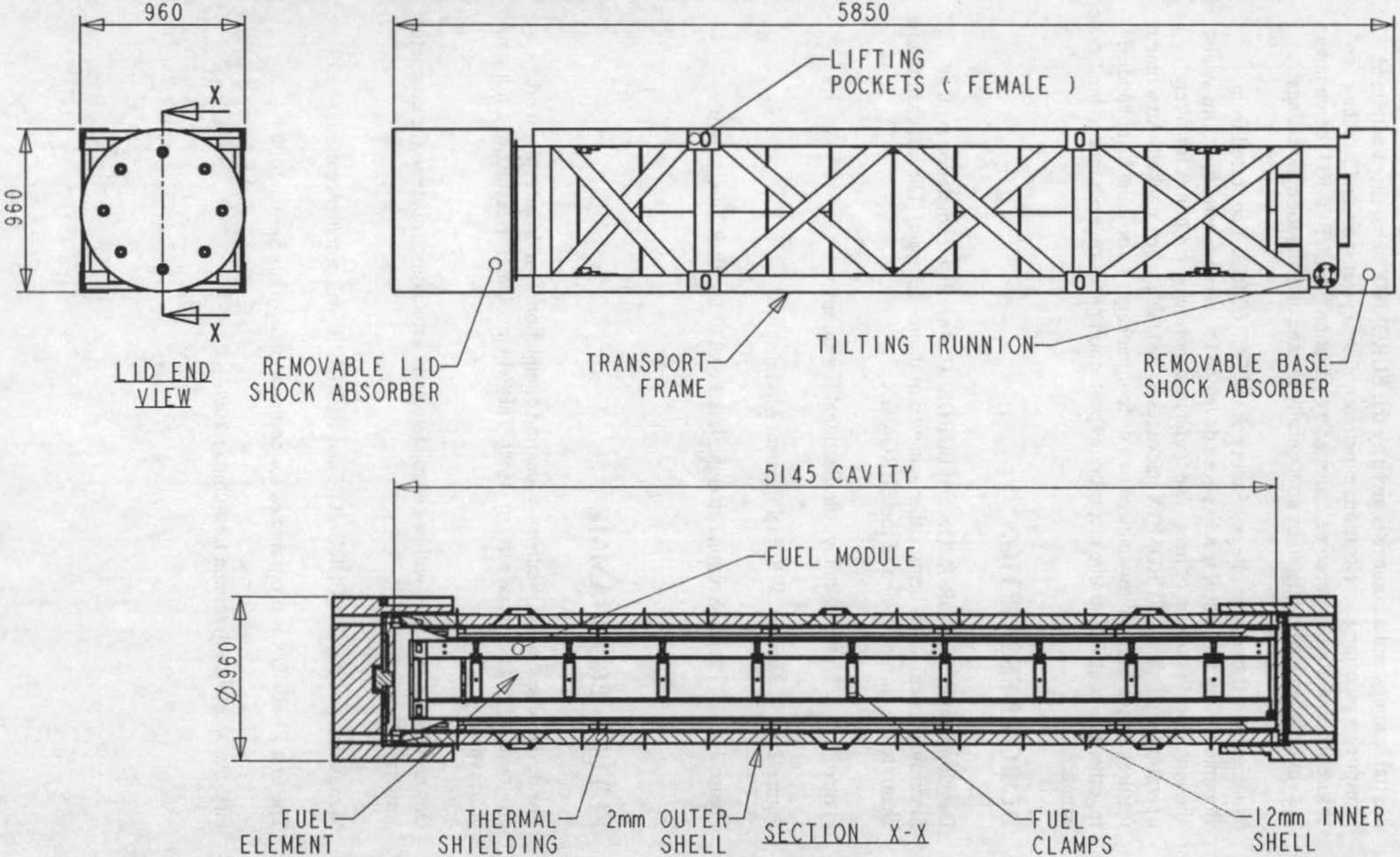
Manufacture of the first EUROMOX and EUROSEC will commence during 1999

The first EURMOX is programmed for commissioning trials Spring 2000

First transports programmed for Summer 2000

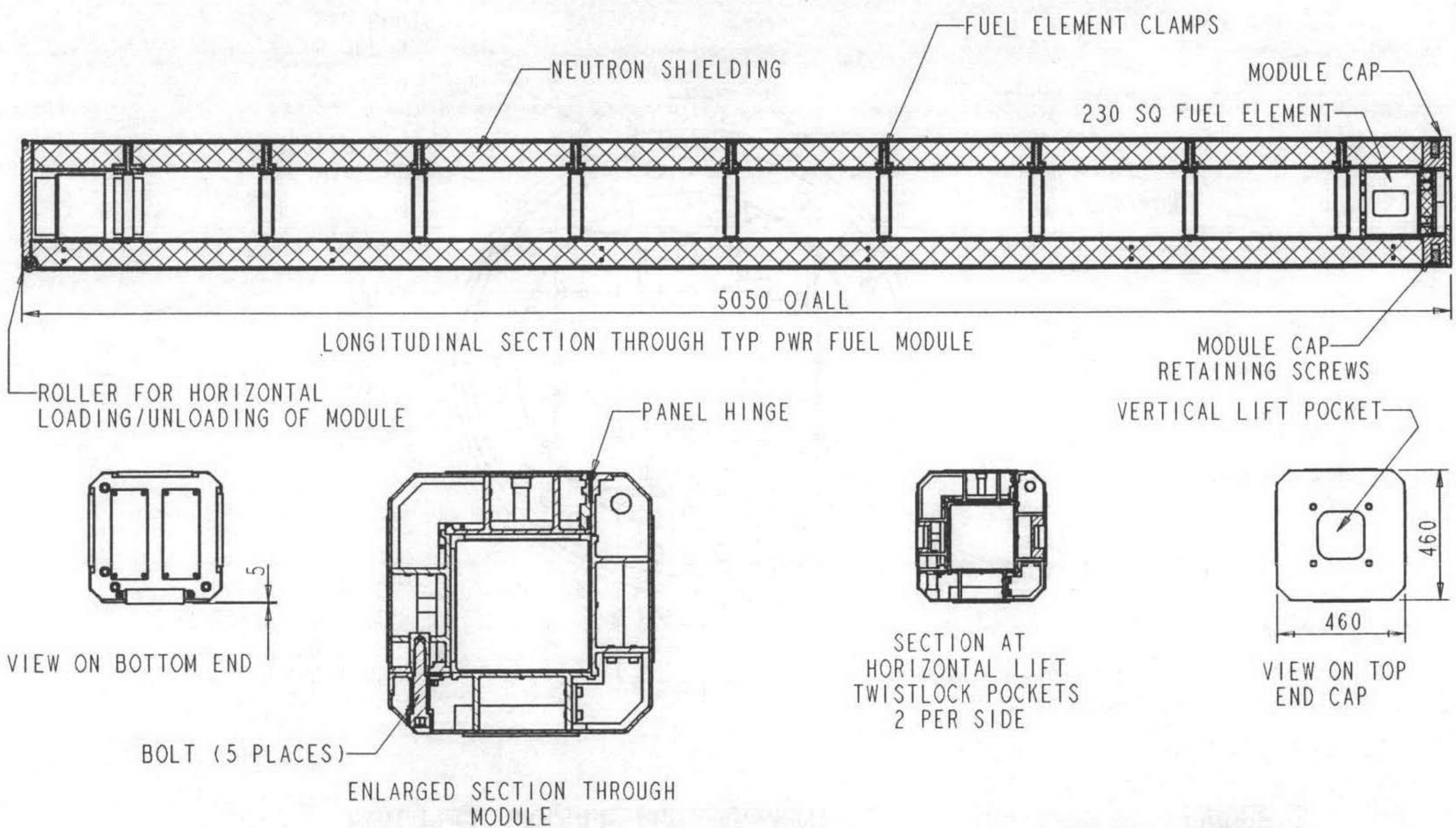
FLASK ASSEMBLY AND SECTIONAL ELEVATION

FIGURE 1



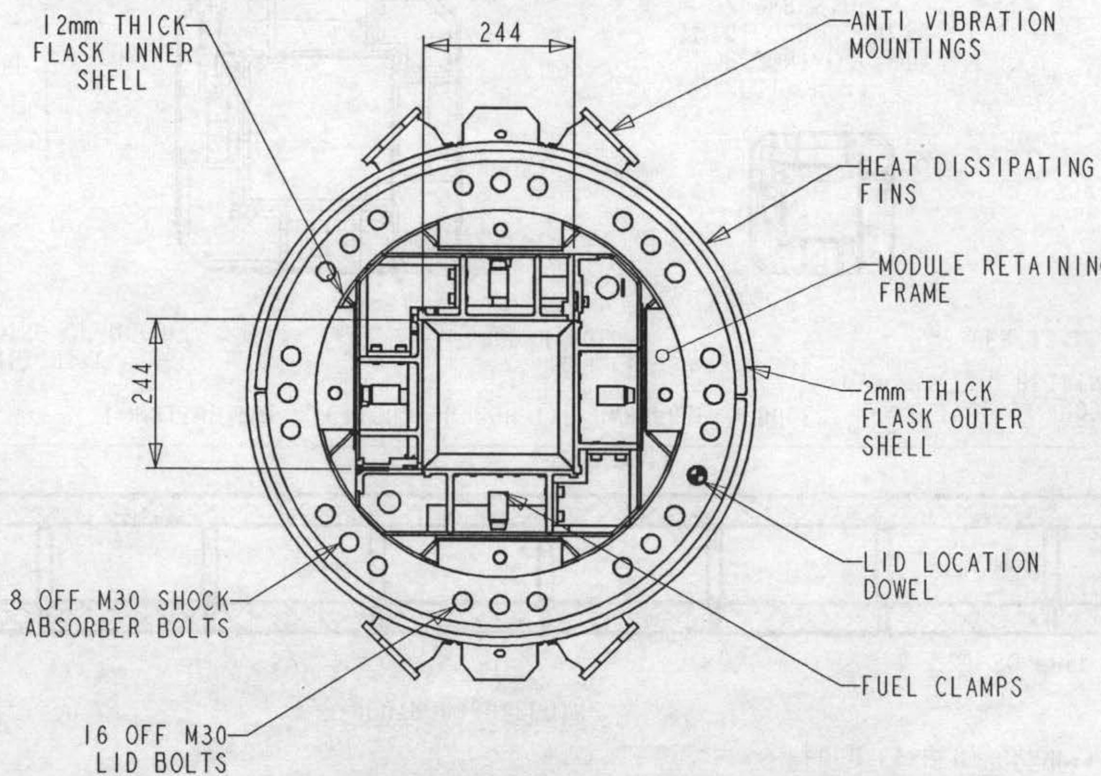
TYPICAL PWR FUEL MODULE - EUROMOX FUELS

FIGURE 2



PWR FUEL MODULE ARRANGEMENT

FIGURE 3



TYPICAL SECTION THROUGH FLASK
FOR 230 SQ. PWR FUEL ASSEMBLY

1340

SESSION 15.4

Drop Testing