BNFL WET SPENT FUEL HANDLING EXPERIENCE

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ABSTRACT

Since 1973, BNFL has handled and shipped 2,400 tons of spent LWR fuel utilizing the "wet" principle. This principle involves the use of customized sealed stainless steel vessels known as multi-element bottles (MEB's) and provides a convenient and safe method of shipping and transferring spent fuel. Significant benefits result, including a reduced overall operator dose uptake and a much reduced contamination of Receipt and Storage pools.

INTRODUCTION

1. BNFL and its subsidiary, Pacific Nuclear Transport Limited (PNTL) provides transport services between Japan and Europe, a round trip of 33,000 miles. It has its own fleet of purpose-built ships delivering spent fuel to Sellafield, in the United Kingdom and Cap de la Hague in France. A similar service from most European reactors is operated by an associated company - Nuclear Transport Limited (NTL). BNFL also operates a transport service to Sellafield from the Magnox reactor at Latina in Italy.

2. Transport of spent fuel from commercial nuclear power stations in the UK is the responsibility of the Central Electricity Generating Board and the South of Scotland Electricity Board. Transport of spent fuel from the Chapelcross nuclear power station in the South of Scotland is the responsibility of BNFL.

3. BNFL owns and operates a fleet of about one hundred and fifty casks and in the last year, 200 tons of spent ILW fuel has been shipped from Japan to Sellafield representing 74 cask journeys. In the longer term, since 1973, approximately 2,400 tons of spent ILW fuel have been shipped from Japan and Europe to Sellafield for storage and ultimate reprocessing.

4. All these shipments have been made without an incident involving any breach of containment. This outstanding safety record is due to the rigorous checks carried out at every stage of the operation and the quality of the materials and design of the casks used to carry the spent fuel.

5. Over this period of time, BNFL has developed and operated an integrated transportation and storage philosophy utilizing a "wet" sealed principle for spent LWR fuel shipped to Sellafield for storage and ultimate reprocessing. The BNFL Excellox range of "wet" spent fuel transport casks are used to transport spent LWR fuel from Japan to Sellafield. Similar generic types of "wet" casks are used for European transport.

6. The principle of "wet" and sealed fuel transport was adopted by BNFL at the onset of LWR fuel shipments as a means of conveniently and safely transferring fuel from casks to storage pools at Sellafield and to minimize cask and pool contamination.

CASK PACKAGE DESIGN

The Excellox cask and its generic developments are used for the Japanese and European shipments mentioned previously and this will now be discussed in more detail.

7. Adoption of the wet transport and storage philosophy provided benefits in transfer of fuel decay heat and a reduction of the required thickness of neutron shielding. The difficulties of ensuring retention of the water and of compliance with the IAEA fire test requirements were addressed and successfully solved.

8. Cask package design was verified by comprehensive theoretical analyses of impact, heat transfer, shielding and criticality, all performed by BNFL Engineering. The designs were validated by physical drop tests and fire tests on quarter scale cask models to demonstrate compliance with IAEA Regulations.

   All cask package designs are licensed as type BU or BA packages by the UK Competent Authority in line with IAEA Regulations.

9. The existing range of Excellox casks are thin-walled forged carbon steel of welded construction with a separate stainless steel clad lead liner which can be removed for maintenance and cleaning.

   The spent fuel is located within an inner-sealed and lidded stainless steel vessel known as a multi-element bottle (MEB). The internal structure of the MEB separates the fuel elements and incorporates a neutron poison to ensure criticality control of the contents. The MEB concept minimizes contamination of the cask internal surfaces by fuel debris and also provides a convenient means of handling at the reprocessing plant. Contamination of reprocessing storage pool water is also minimized.

   Both cask and MEB are water-filled and provided with a simple means of creating an ullage space to cater for water expansion during fire accident conditions.

   Radiation shielding is provided by the lead liner and water, heat transfer from the external cask surface

being facilitated by means of robust welded on steel fins.

10. A thick-walled cask of monolithic forged carbon steel construction is currently being developed to carry high burn-up and high initial enrichment uranium oxide and mixed oxide fuels. Drop testing of quarter scale models of this design has now been full completed and detail design is progressing towards providing the next generation of transport casks for use from 1991 onwards.

REACTOR OPERATIONS AND TRANSPORTATION

11. The cask and MEB package is transported dry to the reactor station. The cask and MEB lids are removed and the internal cavities filled with demineralized water then lowered into the reactor pool for fuel loading. Spent fuel assemblies (usually at least 12 months cooled) are loaded into the MEB compartments and the MEB lid refitted. A nitrogen ullage is created in the MEB and the MEB pressure tested by means of special adaptors in the MEB lid. The cask is refitted with its lid, raised above the pond and allowed to self-ullage by means of a simple drain and vent system. Finally, the cask lid is bolted down, the drain and vent closed and the whole package checked for contamination.

12. The package is transported to Sellafield and on arrival at the reprocessing plant, the MEB is removed from the cask and transferred to special pools to allow a further decay in the level of radioactivity prior to reprocessing. There are currently over 800 BWR and PWR MEB's stored at Sellafield containing some 2,400 tons of spent oxide fuel.

The empty casks are washed and monitored for contamination and further checks are made on casks and rail wagons before they are returned with a new empty MEB to the power stations.

The MEB concept provides an easy means of handling fuel and a consequential faster cask turnaround at the reprocessing plant, thus contributing to a lower overall level of operator dose uptake.

13. The range of equipment involved in these transportations can be summarized as:

1. Specially-designed casks with internal components (MEB's) to locate the fuel assemblies.
2. Transport frames to retain the casks in position during shipment.
3. Specially-designed lifting beams with captive locating features.
4. Specially-designed transport, ships and rail wagons in particular.

To enable the packages to be loaded, transported and unloaded various facilities are required:

1. Loading facilities at the Reactor, i. e., wet transfer into the casks and loading the casks onto road/rail transport.
2. Off-loading from road/rail and transfer to ships and the reverse at the other end of the voyage.
3. Off-loading from road/rail and transfer into storage pools.
4. Removal from storage and transfer for reprocessing (or long-term dry storage).

CASK MAINTENANCE

14. Maintaining a fleet of casks also needs careful consideration and BNFL has two specially-designed cask maintenance facilities at Sellafield, one of which is used to maintain the Excellox generic range of casks.

This is provided with a 120 ton capacity overhead crane for handling the cask. There are contamination, machining, grit blasting and painting facilities. There are also facilities for testing of lifting trunnions, pressure testing of seals, etc.

As part of the licensing procedure a full maintenance schedule is specified ranging from simple cleaning after each shipment to a full strip down grit blast and re-paint every three years. The Excellox range of casks have performed so well in service that BNFL now consider that a six-year period between refurbishments is adequate and the licensing arrangements are being changed to reflect this.

SELLAFIELD OPERATIONS

15. Since the mid-1960's, some 16 million cask miles of sea shipments have been covered without any cask ever receiving structural damage.

For overseas shipments BNFL uses a fleet of six purpose-designed ships, some of which can carry up to 28 casks. To enable safe loading/unloading of casks BNFL have built a Sea Terminal at Barrow Dock, some 35 miles from Sellafield. This involved integration with a rail link to Sellafield and the provision of a 150 ton capacity cantilever Crane.

16. An interim cask parking area is provided on the Sellafield site to accommodate the large numbers of casks delivered prior to transfer to the Thermal Oxide Reprocessing Plant (THORP) Receipt Building for fuel unloading. A rail head building with a 120 ton capacity overhead crane is provided to service this facility.

17. On delivery to the THORP Receipt Building, the casks are unloaded from the rail wagons using a 150 ton specially-designed overhead crane. This places the cask into an inlet pool in the building after it has undergone various receipt checks. A fixed masted machine which spans the pool is used to remove the cask lid and remove the MEB and place it in a storage rack.

The MEB's provide a convenient and safe method of transfer, they prevent the cask from becoming dirty by retaining any fuel element debris and they also prevent the pool water from becoming contaminated, i. e., from damaged fuel elements, etc.

18. The loaded racks are then transferred under water to the storage pool by another custom-built device which is supported from the pool wall. The racks are then finally accurately positioned in the pool by a large handling machine which will park the racks in predetermined grid positions so that they can be retrieved at a later date.

19. When the fuel is scheduled for reprocessing the MEB's are moved by the foregoing techniques in to a fuel handling pool where various items of equipment are employed to remove the fuel from the MEB's and transfer it to the reprocessing plant.

OTHER BNFL ACTIVITIES

20. In addition to the shipment of fuel from all over the world to Sellafield, there are many internal transfers of radioactive materials within the Sellafield site between the various Sellafield plants. These transfers are carried out using purpose-designed "internal transfer containers."

Although these containers are not licensed in the same manner as "off-site" casks, they are still subject to rigorous design assessment in the same manner as outlined for the Excellox casks.

They have to satisfy BNFL's internal safety standards and meet the requirements of the Nuclear Installations Inspectorate.

Many of these "internal transfer" containers have in-built hoist units and sliding gamma gates to allow remote loading and unloading of the container.

21. BNFL has also developed a range of waste containers for various forms of waste. For example, there is a vitrified residue container for heat-producing, highly-active residues which are used for long-term storage within the vitrified product store at Sellafield and for export back to the countries of origin. BNFL is currently developing and licensing a dry cask design to export and store the vitrified residue containers.

BNFL has also developed a 500 liter container for long-term storage of low heat-producing medium active waste to meet the requirements of UK NIREX Limited and to serve the needs of four different waste treatment plants in BNFL.

22. This paper is intended to give a brief insight of the experience gained by BNFL in the handling of spent fuel and to highlight that BNFL has the capability to satisfactorily solve any problem associated with the handling of radioactive materials.