Radioactive Waste Management Directorate

Packaging of PWR1 Submarine Dismantling ILW in 3m^3 Boxes
(Conceptual Stage)

Summary of Assessment Report

Issue date of Assessment Report: 27 March 2012

Introduction

Babcock Marine on behalf of the Ministry of Defence has sought Conceptual stage endorsement of proposals for the packaging of Intermediate Level Waste (ILW) from the dismantling of Pressurised Water Reactor type 1 (PWR1) equipped submarines. The PWR1 ILW consists of Reactor Pressure Vessel (RPV) and Primary Shield Tank (PST) and it is proposed that these wastes are size reduced and packaged in 3m^3 boxes.

This Assessment Report provides the basis and findings of the Conceptual stage disposability assessment by NDA Radioactive Waste Management Directorate (hereafter RWMD) for packages of PWR1 ILW. The assessment has been carried out through the Disposability Assessment process, whereby RWMD examines the disposability of proposed waste packages by assessment against standards and specifications set out in WPS/310 and WPS/315, Specifications for side lifting and corner lifting variants of 3 cubic metre Box Waste Package and the reference ILW disposal concept. This concept has been developed as part of the programme to implement geological disposal for the UK's higher activity wastes. Further information on the Letter of Compliance process is available elsewhere1.

Background

Babcock Marine is providing advice to the Ministry of Defence (MoD) on decommissioning the existing nuclear powered submarine fleet. These consist of 23 Pressurised Water Reactor (PWR) type 1 reactor equipped submarines and four PWR type 2 equipped submarines. Some of the PWR type 1 equipped submarines and all of the PWR type 2 submarines are still in service and will not be decommissioned for several decades. The PWR type 2 submarines are likely to be in service for up to thirty years. There are currently eleven submarines ready for final dismantling, with a further five in various stages of final de-fuel and de-equipment operations.

RWMD (and formerly Nirex) has had a number of previous interactions regarding the disposal of submarine reactor dismantling wastes, which has led to the current developed disposal strategy. The current disposal strategy for the redundant submarines is to dismantle them and dispose of the resulting materials through non-active, low level and higher activity (Intermediate Level) waste disposal routes. The current baseline waste packaging strategy involves the size reduction of the RPV and PST, and subsequent packaging as Intermediate Level Waste (ILW). Wastes would be loaded into 3m^3 boxes and encapsulated utilising a cementitious grout. The packages would be stored until a Geological Disposal Facility (GDF) for the UK's higher activity wastes becomes available. The 3m^3 boxes would then be consigned, along with civil ILW, for geological disposal.

[1] NDA, Guide to the Letter of Compliance Process, NDA Document WPS/650, March 2008

In order to progress the dismantling of the submarines, Babcock Marine has sought advice from the Nuclear Decommissioning Authority (NDA) Radioactive Waste Management Directorate (RWMD) on the disposability of proposed waste packages using the Letter of Compliance (LoC) disposability assessment process. This is to ensure that the higher activity radioactive waste will be packaged in compliance with RWMD requirements as currently foreseen. Babcock Marine is seeking an Assessment Report and a Conceptual stage Letter of Compliance. The submission provided to RWMD addresses the dismantling and packaging of waste from the entire PWR1 equipped fleet. PWR2 equipped submarines have not been included in the current submission, subsequently ILW from only the 23 PWR1 submarines are addressed.

This Assessment Report provides the basis and findings of the conceptual stage disposability assessment by NDA RWMD for packages of PWR1 submarine dismantling ILW.

Waste packaging proposal and scope of assessment

The waste addressed by these proposals forms part of UK Radioactive Waste Inventory waste streams 7G102 & 7G104, Short-Lived ILW from Decommissioning Submarines and Long-Lived ILW from Decommissioning Submarines, respectively.

The wastes derive from the operation of the UK nuclear powered submarine fleet and consist of ILW in the RPV and PST, which will have been exposed to heavy neutron irradiation and activation during the service lifetime of each submarine. The extent of neutron irradiation and activation will vary from submarine to submarine and will depend on the individual reactor operating histories, which include the replacement of cores during refurbishment operations. In some cases the replacement cores were of differing design.

The RPV consists of an external cylindrical shell with an ellipsoidal base. The RPV shell has four nozzles that connect it to the primary cooling circuit and a series of integral internal thermal shields of varying thicknesses, a core barrel and additional internal furniture. Details of the construction steels were provided. The RPV sits within the PST which is filled with water. The PST acts as a biological shield between the reactor and the operators. The inner wall of the PST is shaped to provide a pocket in which the RPV is suspended.

It is proposed that RPV and PST components would be size-reduced into smaller sections using a purpose built cell at the dockyard, and then the sections loaded into existing design $3m^3$ stainless steel boxes. Size reduced components would be remotely placed into the $3m^3$ box waste container, which may contain suitable furniture to ensure the accurate placement of the individual pieces. Any swarf or particulate generated (including any crud that flakes off from components) during the cutting phase would be gathered using a vacuum system and packaged into a suitable small container for transfer to the box. The submission proposes that there is the potential to immobilise these fines in grout or a polymer separately before adding the small container to the boxes along with the solid steel sheets for encapsulation.

In addition to the proposal to encapsulate wastes in $3m^3$ boxes, an option considered by this assessment is packaging in a non-encapsulated form. This may be justified by the solid nature of the steel waste materials.

Assessed radionuclide inventories were developed based on the submission inventories for a “Representative Boat”. These data were enhanced by RWMD, and then decayed to 2040, the earliest date assumed for transport to a GDF. Taking into account the basis of the average (of all RPV/PST components) and maximum (inner RPV components) contents described above, has provided a best estimate average waste package and best estimate maximum inventory waste package. A set of upper bound radionuclide inventories were also provided, which additionally take into account a factor of 2 uncertainty in the inventory modelling. For the purposes if this assessment the upper bound average and maximum values were used.

Outcome of assessment

Compliance with Waste Package Specification

The Generic Waste Package Specification (GWPS) and the more detailed Waste Package Specifications (310 & 315/WPS) for mid-side and corner lifting variants of the 3m3 box detail a number of features of waste packages, and quantitative limits that are necessary in order for the packages to be compatible with transport to and disposal in a GDF. These features and limits have been derived from the geological disposal concept as it is currently envisaged, including certain aspects of the IAEA Transport Regulations. It is therefore necessary (but not sufficient, because other requirements of the packaging and the packaging process also need to be satisfied) to confirm that the $3m^3$ box packages are consistent with the WPS.

The proposed waste package used will be based on a generic $3m^3$ box which is one of a list of containers described in the Disposal System Specification (DSS) as waste packages with standardised features. As it is within the DSS, the $3m^3$ box is considered within the scope of the GDF design.

The features and quantitative limits covered by the WPS that are relevant to the PWR1 Submarine dismantling ILW waste packages have been evaluated and in all cases either the requirements are met, or the submission provides a commitment to deliver relevant documentation that will meet the specifications. It should also be noted that the inventory for the Representative Boat assumes a decay period to the earliest time of transport (2040) of 33 years, although shorter periods of decay may be tolerable due to large margins of safety identified in this assessment.

Calculated dose rates and heat output are within specified limits. Surface contamination has not been quantified in the assessment but a commitment is made to meet the requirements of the specification at the time of transport.

The submission states that a $3m^3$ box meeting the requirements of the waste package specifications will be used and that waste containers will be filled to comply with the mass limit requirement, which is that the gross package mass shall not exceed 12,000 kg.

Gas generation will be within the defined limit and any toxic, flammable and radioactive gases including C14 bearing methane, radon and tritium are present in insignificant quantities. An engineered vent will be required for the management of any gas and particulate activity

Radionuclides are predominantly present as activated precursor elements in steel and measures will be taken to separate and immobilise crud and swarf in smaller containers. Waste will be dry with particular emphasis on the potential traps for liquid. Ullage will be minimal in the case of encapsulated waste packages.

Quantities of fissile nuclear material are below significant levels and do not present a criticality safety risk. The anticipated levels of nuclear material are below levels of concern from safeguards and security perspectives.

Quality management arrangements will be applied to all aspects that affect product quality and specific arrangements will be agreed with RWMD. Waste package data and information will be recorded regarding all relevant details of the manufacture of each waste package.

Compliance with concepts for a Geological Disposal Facility

The packaging proposals are consistent with meeting handling, storage and disposal system design and safety requirements as currently foreseen. This compliance is however, based on a number of assumptions and commitments made in the absence of specific detail, for example the assessment is based on a generic $3m^3$ box design. The validity of these assumptions will need to be confirmed at interim stage.

Conclusions

The proposed packaging of PWR1 Submarine Dismantling ILW has been assessed and it is concluded that it raises no major disposability issues based on encapsulation of the waste in a $3m^3$ box of similar design to a $3m^3$ box that has previously been endorsed. Provided that the proposed waste packages are packaged in a manner that meets the requirements of the relevant waste package specification, and any requirements that may apply to the specific box design as developed, the resulting waste packages are expected to be disposable. The proposal can therefore be endorsed at Conceptual Stage.

Proposals for disposal of non-encapsulated PWR1 Submarine Dismantling waste in a $3m^3$ box of similar design to a previously endorsed box can also be endorsed at Conceptual stage. This is on the assumption that the small fraction of dispersible material, crud and cutting swarf, is immobilised using a small-scale encapsulation process or a robust inner container within the package. Considering the development work that is likely to be required to justify non-encapsulation, especially for packaging in boxes developed for encapsulated waste, a waste encapsulation process may be the least onerous option.

It is noted that the assessment has not considered the packaging of the PWR2 design of reactor. Challenges from this waste may arise from differences in the radionuclide inventory associated with higher irradiation or much shorter periods of decay. Separate assessment would be required to support packaging of this waste before endorsement can be provided.