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Developing a new waste route for the transport of UK spent sealed sources for long term storage

Stephen Middleton
International Nuclear Services (INS) Ltd, Warrington, UK, WA3 6GR

Abstract

There is an ongoing requirement to manage redundant radioactive sealed sources used in medical, educational and commercial operations. In the UK, these sealed sources are collected and consolidated by specialist agencies prior to onward transport to a Nuclear Licensed site for long term storage. Over recent years there has been a reduction in the number of suitably licensed transport packages and available storage/disposal sites in the UK. This has resulted in a backlog of temporarily stored sealed sources.

In 2014 International Nuclear Services (INS) identified an opportunity to re-use an existing fleet of transport packages (1648C) that had originally been used to transfer specific Intermediate Level Waste (ILW) from Chapelcross NPP for storage at Sellafield. The re-use of the 1648C package for the transport of sealed sources directly to the Sellafield site for long term storage and disposal brings a number of safety and operational benefits to the management of redundant sealed sources in the UK.

This paper describes how INS has developed a new waste route for the transport of the used sealed sources for long term storage and disposal in the UK. In particular it discusses the challenges associated with assessing the existing 1648C transport package design against the requirements of the IAEA Transport Regulations when considering such a diverse waste composition.

Introduction

In the UK, redundant Sealed Radioactive Sources (SRS) used in medical, academic and commercial operations are collected and consolidated in significant quantities by specialist Source Collection Agencies (SCA). The SCA process the sources to remove inactive components and produce an Intermediate Level Waste (ILW) stream for onward consignment to a Nuclear Licensed site for secure long term storage.

The number of facilities in the UK capable of receiving SRS ILW for long term storage has reduced over recent years as ageing Nuclear Licensed Sites progress their decommissioning programmes. In addition to this, the number of licensed packages available to transport SRS has reduced significantly. Uncertainty around the interpretation of the IAEA Regulations for the Safe Transport of Radioactive Material, updated in 2012 [1], is thought to have led to a number of Transport Package licences not being re-submitted for renewal in the UK. Paragraphs 617 and 648 of the Transport Regulations place the emphasis on the package designer to demonstrate compliance with the radiation level limits. This can become difficult to demonstrate, as in the case with consolidated SRS ILW, where the maximum permitted contents cannot always be well defined at the design stage of the transport package. As a result, there are less transport packages available to the SCA and a number that are available are not compatible with the facilities at the long term storage site. These problems have significantly impacted the SCA, reduced their capability for accepting new business and produced a backlog of temporarily stored SRS ILW at their facilities.

The UK's Nuclear Decommissioning Authority (NDA) asked INS to assist it in establishing possible solutions to alleviate this problem. In 2014 INS identified an opportunity to develop the use of the existing 1648C transport package to consign SRS ILW directly to the secure Miscellaneous Beta Gamma Waste Store (MBGWS) at Sellafield.

This paper describes the main aspects of the new waste route that INS established utilising the 1648C package. It also discusses the challenges of re-licensing an existing transport package to accommodate this type of varying inventory.

Sealed Radioactive Source (SRS) waste stream

SRS are used in a wide range of industrial, medical and academic devices. Eventually SRS reach the end of their useful life. If the SRS cannot be repatriated or recycled then it is deemed disused and has to be prepared for long term storage and ultimate disposal. There are a number of reasons why SRS become disused [2]:

(a) Activity decay – Activity becomes too low for the source to be useful.
(b) Damaged – Sources become physically damaged or leak and so need to be replaced.
(c) Obsolete equipment – Sources contained in equipment that has reached the end of its useful life.
(d) Alternative technology – Alternative methods or equipment are adopted as a replacement.
(e) Change in priorities – Specific research or projects that are completed or terminated.

(f) Orphan sources – Sources that are not under regulatory control for example, due to being abandoned or transferred without proper authorisation.

Table 1 shows some examples of the various types of applications for SRS and the typical dimensions of the sources contained within the devices [3].

Table 1 Examples of Use and Typical Dimensions of Some Sealed Sources [3]

Sealed Sources	Dimensions
Co-60 teletherapy source	20mm diameter x 30mm length cylinder
Co-60 gamma sterilization source	11mm diameter x 450mm length
Sr-90 Radioisotope Thermoelectric Generator (RTG) source	Up to 100mm diameter x 200mm length
Industrial gamma radiography sources	Up to 7mm diameter x 15mm length; flexible tail up to 200mm length
High Dose Rate (HDR) remote afterloading brachytherapy sources	*Modern sources:* Up to 2mm diameter x 15mm length; flexible tail up to 300mm length
	Older sources: Spherical; approx. 3mm diameter, activity: Cs-137
High energy gamma industrial gauging sources	Typically cylindrical capsules: 3-12mm diameter x 5-15mm length
Neutron industrial gauging sources	3 or 4-6mm diameter x 12mm length or 8-20mm x 12-30mm length
Gamma and neutron oil well logging sources	*Gamma sources:* 8-20mm diameter x 14-40mm length
	*Neutron sources:*15-25mm diameter x 25-60mm length
Low energy fixed industrial gauging sources	10-15mm diameter x 7-15mm height
Permanent implant and Low Dose Rate (LDR) brachytherapy seed sources	Less than 1mm diameter x less than 5mm length
Eye plaques	3-15mm diameter x 7-10mm height
Low energy gamma analytical sources	Various sizes and shapes

In the UK, SCA provide commercial services to receive or collect large numbers of disused SRS from owners around the country. The SCA process SRS by identifying the nuclides, measuring the dose rates and contamination levels and segregating the sources into the required waste streams for disposal as ILW. Where it is practical, the shielding, packaging and ancillary equipment is removed from the source and designated as LLW or exempt material to reduce the ILW waste volume.

The wide range of devices and applications in which SRS have historically been used results in a varied ILW stream in terms of shape, size, isotope type and activity. For the SCA, transporting individual or very small numbers of SRS to long term storage sites is neither operationally or commercially viable. They therefore have a requirement for generic transport packages licensed to accommodate a range of size and radioactive contents.

The varying nature of the SRS waste stream poses a challenge in developing the contents specification when licensing a generic transport package. Often the required information is not

available at the design stage of a package or, if a package is available for potential use, it becomes impractical to change the contents section of its Design Safety Report for every transport. As a result, a suitable bounding case has to be developed to determine the allowable contents to satisfy the IAEA Transport Regulations [1].

Re-use of the 1648C Transport Package

The 1648C package was originally designed and licensed as a Type B(M) in 1993 specifically for the road transportation of ILW from the Chapelcross NPP to the MBGWS. By 2013 Chapelcross NPP no longer had a use for the package and plans were proposed to decommission their fleet of six flasks and associated transport and handling equipment.

Since 2008, INS has acted as the Design Authority for the 1648C package and therefore has an in-depth knowledge of its specification and design intent. Following a request received from the NDA to assist in finding solutions to the transportation and long term storage of SRS ILW in the UK, INS proposed the re-use of the 1648C.

The 1648C package is a cylindrical flask comprising of a stainless steel lid and an aluminium shock absorber. It is designed to be transported in the vertical plane and is approximately 1.3m tall by 1m wide with a wall thickness of 232mm. Its laden weight is approximately 4 tonnes. An inner "disposable" liner with a capacity of 28 Litres is used to carry the ILW inside the package. The package and liner are compatible with the receipt and handling facilities at the MBGWS at Sellafield. On receipt of the package at MBGWS, the liner is removed in a cell and transferred into a vault for secure long term storage.

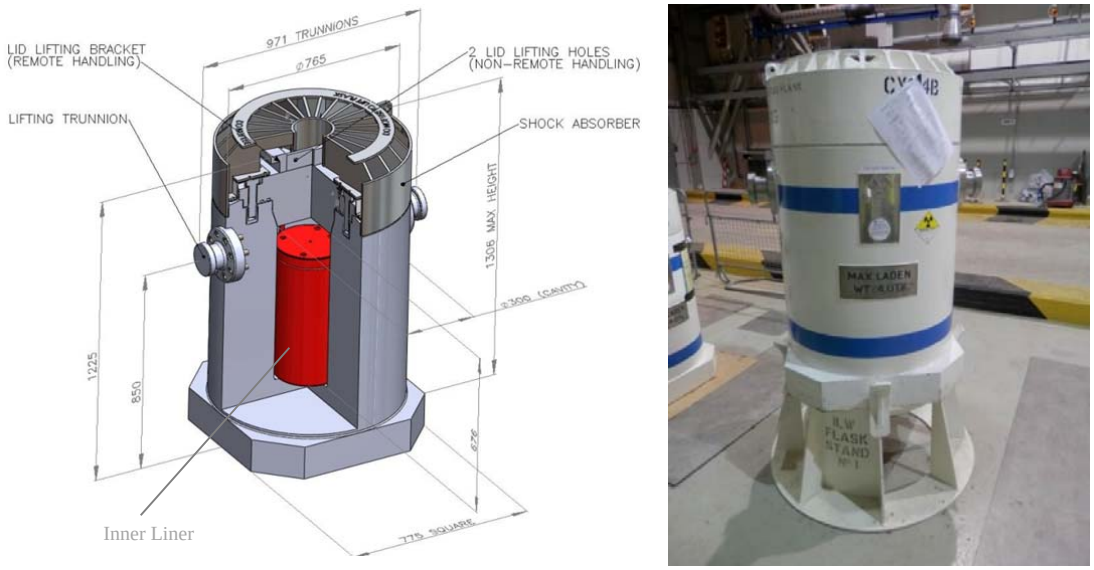

Figure 1 The 1648C Transport Package

In addition to the significant cost benefits of not having to design a new transport package from first principles, the use of the 1648C for the transport of SRS ILW offers a number of other benefits:

(a) The package has a relatively large payload allowing potentially large numbers of SRS to be carried in it.
(b) The package had originally been designed and licensed as a Type B(M) package and so was physically robust and provided substantial inherent shielding.
(c) The existing fleet of packages were available for use, still licensed as Type B(M) packages, their Lifetime Quality Records (LQRs) and maintenance records were up to date and fully documented.
(d) The package was already compatible with the existing long term Storage facility and maintenance facility at Sellafield and so removed the need and significant cost to re-design the plant infrastructure.
(e) Because the package was already compatible with the long term storage facility (MBGWS) at Sellafield it negated the need to pass through an interfacing plant to re-package the waste stream into a compatible flask prior to receipt (as has been the case with some previous historical operations involving SRS).
(f) Some of the transport and ancillary handling equipment still existed and could be re-used.
(g) The flask, with very minor operational adjustments, could be handled at the SCA sites.

Licensing Challenges

It is critical to the SCA operations to have access to packages that can accommodate mixed loads with varying inventories of a wide range of radioactive isotopes. Developing the contents section of a Package Design Safety Report (PDSR) for such a wide list of potential Isotopes posed a significant challenge. INS worked with the Criticality Dose Shielding Assessment (CDSA) team of Sellafield Ltd to develop a bounding case for the shielding assessment to allow an extensive list of Isotopes to be carried in the 1648C.

The IAEA transport regulations [1] place the emphasis on the package Design Authority, and not the Consignor, to demonstrate compliance to radiation limits. Specifically;

Para 617: "*A package shall be so designed that it provides sufficient shielding to ensure that, under routine conditions of transport and with the maximum radioactive contents that the package is designed to contain, the radiation level at any point on the external surface of the package would not exceed the values specified in paras 516, 527 and 528, as applicable, with account taken of paras 566(b) and 573.*"

Para 648: "*A package shall be so designed that if it were subjected to the tests specified in 719-724, it would prevent:*

(a) Loss or dispersal of the radioactive contents;

(b) *More than a 20% increase in the maximum radiation level at any external surface of the package*"

It can be relatively straightforward to demonstrate compliance with these requirements by analysis where the size, form and activity of the contents is fixed and known in advance. This is not the case for the varying nature of waste streams produced from disused SRS collected and processed by the SCA.

To address the requirements of Para 617, INS and the CDSA team developed an analysis approach for the 1648C that used a point source case. The position of the point source was chosen in a location such that the maximum dose rate was achieved at contact and 2m away from the flask and if it was to be dislodged during transport the dose rates would decrease rather than increase. This produced a maximum activity of a particular isotope that could be carried in the 1648C (Type A and Type B quantities were assessed separately). This assessment was done against the list of Isotopes detailed in Section IV, Table 2, of the IAEA transport regulations [1]. Certain fissile/ fissionable and Alpha emitting isotopes were excluded.

Perhaps the most challenging aspect to demonstrate compliance with is Paragraph 648. The varying nature of the SRS ILW, in terms of size, shape and activity, means that designing a means to fix the contents inside the package to avoid a "20% increase" in the maximum measured dose rate on the surface during the Normal Conditions of Transport (NCT) is not practically possible. Although packing densities inside the 1648C liner mean that the measured dose is extremely unlikely to change during transport, it is difficult to demonstrate in theory. To address this, INS has adopted an approach that converts the known total activity of a specific consignment into a point source. From this, a theoretical maximum surface dose is calculated for that transport. This value can then be used as the basis for the Transport Index. Due to the way that the shielding assessment has been completed to meet Para 617, the measured dose rate on the surface of the package could never increase above this value at any time during the transport. Through an ALARP justification [4], INS have presented the case that any alternative approaches to attempt to fix the contents (including sorting, further processing to allow grouting or similar, selective placing or packing of SRS in the liner, etc.) result in higher dose up-take to operators than any possible change in surface dose during transport.

Through this approach, INS has been able to generate an extensive list of allowable Isotopes (with activity limits) that could be carried in the 1648C. Acting as a Competent Body INS has issued a

Type A package certificate for the 1648C to allow the transport of UK SRS ILW by road to the MBGWS.

A Type B (M) licence application for the 1648C has been prepared by INS using the above approach and submitted to the UK's Competent Authority, the Office for Nuclear Regulation (ONR), for review and approval. The objective is that by the end of 2016 there will be a Type B (M) licence in place for the 1648C to allow higher activity SRS ILW to be transported to the MBGWS.

First Transport Operations

INS began preparations to establish the new waste route from the SCA to the MBGWS by developing and issuing a Type A Package Certificate to allow the 1648C to carry SRS ILW. The next steps saw the transfer of ownership of a fleet of 1648C and related transport equipment from Magnox Ltd and the design and manufacture of new ancillary equipment to allow more effective handling of the 1648C packages at the SCA. A key part of the preparations involved assisting the SCA in becoming approved consignors to Sellafield Ltd's MBGWS by demonstrating through assessment of their management and quality systems that they could meet the MBGWS Conditions for Acceptance (CFA). The CFA sets out the waste conditions and consignment arrangements that must be met to allow ILW to be stored at the storage facility.

In July 2015, INS, the Source Collection Agencies and Sellafield Ltd began operations to consign, transport and receive SRS ILW to MBGWS using the 1648C (Type A). Since then, four further Type A transports have been successfully completed. Figures 2 to 4 show some of the stages of operations undertaken at the SCA to load and prepare the 1648C for transport to the MBGWS.

Figure 2 The loaded 28L disposable liner being lowered into the 1648C and then loaded to the transport trailer (Type A consignment).

Figure 3 Final preparations prior to departure from the SCA

Figure 4 The Miscellaneous Beta Gamma Waste Store (MBGWS) at Sellafield, United Kingdom

INS has compiled and submitted a Type B (M) licence application for the 1648C to the UK competent Authority for consideration. The transport of higher active SRS ILW to the MBGWS can commence following an approval of a Type B (M) Package certificate.

Conclusions

1. The number of licensed packages available to transport SRS ILW and the number of facilities capable of receiving SRS ILW for long term storage has reduced over recent years in the UK. This has impacted the SCA, reduced their capability for accepting new business and produced a backlog of temporarily stored SRS ILW at their facilities.

2. After identifying the re-use of the 1648C transport package, INS have established the infrastructure to open a new waste route to transport SRS ILW to the MBGWS at Sellafield. This solution represents a safe and cost effective solution that contributes to managing secure long term storage of disused SRS in the UK.

3. The varying nature of the SRS waste stream poses a challenge in developing the contents specification when licensing a generic transport package.

4. INS have developed a bounding case approach to allow the 1648C to be relicensed as a generic Type A and Type B (M) transport package for transport of SRS ILW. A Type A Package Certificate has been issued and a Type B (M) licence application has been submitted to the UK's Competent Authority, the Office for Nuclear Regulation (ONR), for review and approval.

5. Operations have begun to consign, transport and receive SRS ILW from UK Source Collection Agencies to the MBGWS using the 1648C (Type A). Since 2015, five (Type A) transports have been successfully completed.

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