IAEA Activities in End-of-Life Management of Disused Sealed Radioactive Sources - 14648

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ABSTRACT

Once sealed sources become disused (e.g. once they cannot accomplish their intended purpose due to radioactive decay) and if they are not then managed safely and securely, they may leak, become abandoned or be lost, stolen or misused by unauthorized persons, potentially causing radiation incidents or accidents. The IAEA defines a 'disused source' as "a radioactive source that is no longer used, and is not intended to be used, for the practice for which an authorization has been granted". Best practise and IAEA guidance indicates that users should identify appropriate routes for the management and disposal of DSRS before they acquire and use radioactive sources. For low level and short-lived DSRS the use of a near surface disposal option may be possible. However, high activity and long-lived sources that have reached the end of their useful life shall be disposed of in geological disposal facilities when recycling or export options do not exist. For those countries without the capability or capacity to construct mined geological facilities, a valid option to dispose of relatively small amounts of DSRS declared as waste in a cost effective manner would be the disposal in specially engineered boreholes that can be demonstrated to be safe.

The IAEA has developed such a concept for the borehole disposal of DSRS. In relation to the demonstration of safety of borehole disposal facilities for DSRS, and with the view to assisting Member States in safely and efficiently manage DSRS, the IAEA has developed a generic post-closure radiological safety assessment (GSA) for the BDC for low activity DSRS. The outcome of the work on the GSA shows that with a suitable combination of inventory, near-field design and geological environment, the borehole disposal concept is capable of providing a safe solution for the disposal of both long-lived and short-lived radionuclides. Borehole disposal of low

activity sources is ready for implementation now, and several countries are actively characterising sites in order to develop preliminary site specific safety assessments.

INTRODUCTION

Sealed radioactive sources (SRS) are widely used for beneficial purposes throughout the world in research, industry and in medicine. In industry, common uses include non-destructive testing, radiation sterilization of health care products, modification of polymeric materials, on-line process control systems, elemental analysis of raw materials, mineral resource evaluation, food irradiation and smoke detection. In medicine, SRSs are commonly used in teletherapy and brachytherapy for the treatment of malignant diseases and for blood irradiation. The activity of these sources ranges from tens of kilobecquerels (kBq) (1 Bq = 2.7 x 10^{-11} curies (Ci)) in sources used for calibration purposes to hundreds of terabecquerels (TBq) in industrial irradiators and sources used in radiation therapy.

Once sealed sources become disused (e.g. once they cannot accomplish their intended purpose due to radioactive decay) and if they are not then managed safely and securely, they may leak, become abandoned or be lost, stolen or misused by unauthorized persons, potentially causing radiation incidents or accidents.

The IAEA defines a ‘disused source’ as “a radioactive source that is no longer used, and is not intended to be used, for the practice for which an authorization has been granted”. The IAEA has categorised disused sealed radioactive sources (DSRS) in the Categorization of Radioactive Sources Safety Guide (RS-G-1.9) which defines five categories for radioactive sources. Within this categorization system, sources in Category 1 are considered to be the most ‘hazardous’ and Category 5 are the least hazardous.

In this paper we consider Categories 1 & 2 as “high activity” sources and categories 4&5 are considered as “low activity” sources. Sources of category 3 may be of high or low activity. This distinction is important because it relates to the degree of shielding required during conditioning and the nature of the operational procedures that must be followed to ensure safety.

The widespread use of SRSs worldwide in industry and medicine provides major benefits to human society. However, the use and end of life management of radioactive materials should be planned and addressed in a holistic manner by all stakeholders involved in any part of the life cycle. Of specific relevance to this paper, best practise and IAEA guidance indicates that users should identify appropriate routes for the management and disposal of DSRS before they acquire and use radioactive sources. In relation to this, the Code of Conduct on the Safety and Security of Radioactive Sources specifically states:

" Every State should, in order to protect individuals, society and the environment, take the appropriate measures necessary to ensure…….. that the radioactive sources within its territory, or under its jurisdiction or control, are safely managed and securely protected during their useful lives and at the end of their useful lives;"

During the past decade, the IAEA has initiated a number of activities related to the safety and security of radioactive sources. These activities include, but are not limited to:

- the establishment of the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (GSR-Part 3)
- the development of safety standards and other guidance documents, including the Categorization of Radioactive Sources (RS-G-1.9, 2005), Code of Conduct on the Safety and Security of Radioactive Sources (IAEA/CODEOC/2004), and more recently, Guidance on the Import and Export of Radioactive Sources, (IAEA/CODEOC/IMP-EXP/2005)

In addition, the IAEA organized several conferences and meetings on the management of DSRS where important messages have been reiterated. For example, as a result of the IAEA International Workshop on Sustainable Management of Disused Sealed Sources - Working Towards Disposal, held in Chiang Mai, Thailand, 12-16 January 2009, it was stated:

- *A number of storage facilities have been built recently or renovated with physical protection upgrades allowing for improved control of DSRS. While storage is a necessary intermediate step, disposal is generally recognized to provide a safer and more secure*

solution for all types of radioactive sources, although very short lived sources are suitable for decay storage

- *As such, users should identify appropriate routes for the disposal of DSRSs before they acquire and use radioactive sources.*

In the International IAEA Workshop on Sustainable Management of Disused Sealed Radioactive Sources (DSRS), 11 - 15 October, 2010 in Lisbon, Portugal, it was again stated that while centralized storage is key to safe and secure management of DSRS, long-term storage is not a permanent solution and countries should be working toward a less temporary solution, such as recycling and reusing of sources, and disposal such as the borehole disposal of disused sealed sources. The Borehole Disposal of Sealed Radioactive Sources may be an attractive disposal option for many States, particularly States with relatively small inventories of radioactive waste.

Disused sources, when considered as radioactive waste, are to be managed in the same manner as other radioactive waste. Safe and proven storage technologies are available for DSRSs. However, and as noted above, storage is not a sustainable long-term strategy for dealing with DSRS. This is because there will be on-going financial obligations, there is the potential for societal instability and loss of control, capabilities and capacity to store waste safely and securely may become an issue and numerous other factors may severely disrupt storage records and storage systems. For these reasons, appropriate end-point solutions must be found and disposal of DSRS is one such way to avoid these risks.

DISPOSAL OF DSRS

For low level and short-lived DSRS the use of a near surface disposal option may be possible. However, high activity and long-lived sources that have reached the end of their useful life shall be disposed of in geological disposal facilities when recycling or export options do not exist.

The IAEA with its Safety Standards provides requirements and guidance on all steps in radioactive waste management. This includes predisposal activities as well as disposal activities. Every disposal option described in the Disposal of Radioactive Waste Specific Safety

Requirements (SSR 5) may apply to DSRS declared as waste, but the option that will be chosen depends on the nature of the disused sources.

The safe disposal of DSRS in engineered near surface disposal facilities is technically viable and has been applied in countries where the existence of other types of low and intermediate level radioactive waste justify establishing such facilities. However, in some countries the lack of near surface disposal facilities and insufficient financial and human resources makes the management and disposal of DSRS a serious challenge with potential detrimental safety and security consequences.

For those countries without the capability or capacity to construct mined geological facilities, a valid option to dispose of relatively small amounts of DSRS declared as waste in a cost effective manner would be the disposal in specially engineered boreholes that can be demonstrated to be safe.

The IAEA has developed such a concept for the borehole disposal of DSRS. Much documentation exists to inform Member States interested in exploring this option, such as IAEA-TECDOC-1644 “BOSS: Borehole Disposal of Disused Sealed Sources - A Technical Manual”. And the Safety Guide on Borehole Disposal Facilities for Radioactive Waste (Safety Standards Series No. SSG-1), which provides specific guidance on the design, construction, operation and closure of boreholes disposal facilities. This Safety Guide mainly focuses on boreholes having a diameter of not more than few hundred millimetres and a depth beyond a few tens of metres and up to a few hundred metres.

Borehole disposal facilities have a number of characteristics that enhance waste safety, cost-effectiveness, and physical security. For example, they:

- Isolate the DSRS from the human environment by placing them underground in high integrity packaging to contain DSRS for thousands of years;
- Provide direct and cost-effective access to a suitable geological environment, using readily available technology;

- Require limited land area and limited infrastructure and a short period for implementation;
- Have a small ‘footprint’ minimizing inadvertent intrusion;
- Require minimal control over the disposal site when the disposal and site restoration have been completed.

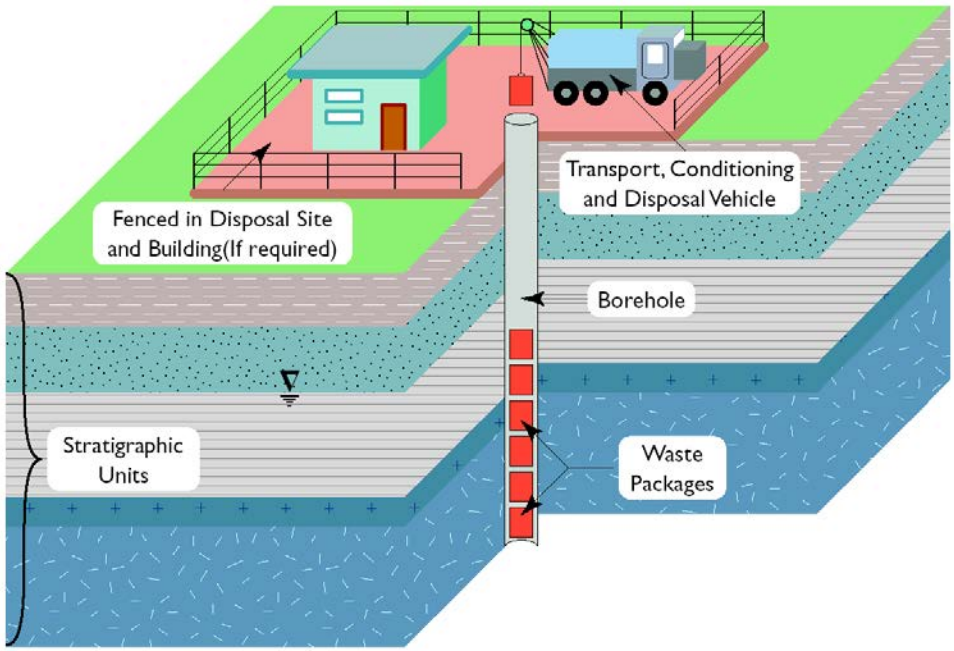

FIG. A. Schematic representation of a borehole site.

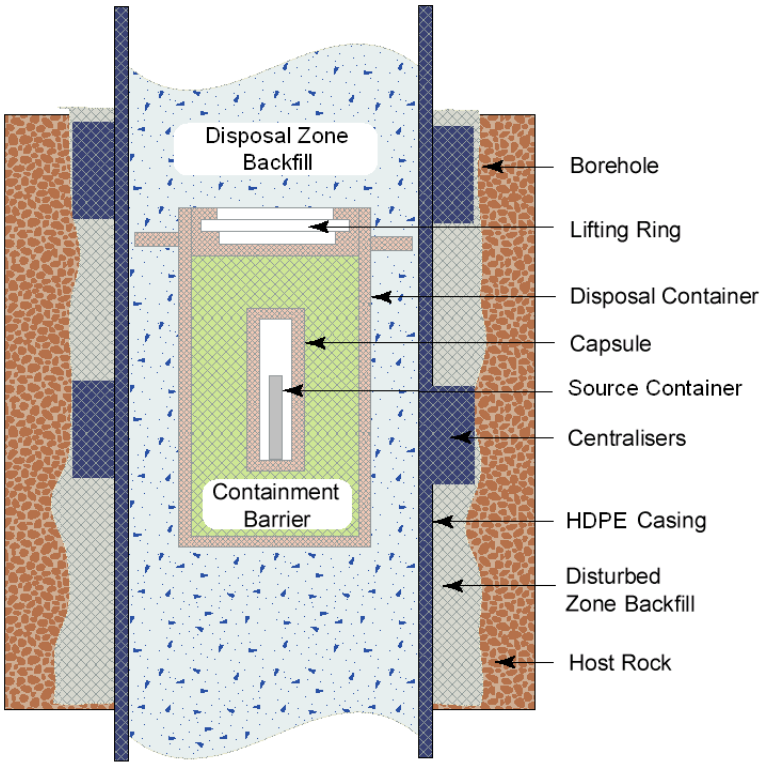

FIG. B. Illustrative section through a disposal borehole.

The borehole disposal concept (BDC) significantly depends on the integrity of the engineered barriers. The capsule and disposal canister that predominantly form the engineered barrier are made of 316L stainless steel and the design of these canisters was originally intended to accommodate DSRS of less than 110 mm in length and 15 mm in diameter. However, the length of the capsule and disposal canister can be extended and this means that the design is applicable to a wide range of source sizes.

It is a requirement of the concept that the sources are disposed at least 30 m below the ground surface in order to reduce the potential for inadvertent human intrusion or deliberate malicious attempts to retrieve the waste. The geological, hydrogeological and geochemical conditions that would be suitable for a disposal operation represent a broad spectrum of site conditions.

In relation to the demonstration of safety of borehole disposal facilities for DSRS, and with the view to contribute assisting Member states in safely and efficiently managing DSRS, the IAEA

has developed a generic post-closure radiological safety assessment (GSA) for the BDC for low activity DSRS. The GSA has been undertaken using an approach that is consistent with best international practice with the aim of ensuring that the assessment is undertaken and documented in a consistent, logical and transparent manner. The ISAM Safety Assessment Approach consists of the following key steps:

- Specification of the assessment context;
- Description of the disposal system;
- Development and justification of scenarios;
- Formulation and implementation of models; and
- Presentation and analysis of results.

Each of these steps would be applied to the site specific Safety Assessment needed for authorisation to implement the borehole disposal concept.

The outcome of the work on the GSA shows that with a suitable combination of inventory, near-field design and geological environment, the borehole disposal concept is capable of providing a safe solution for the disposal of both long-lived and short-lived radionuclides. For most radionuclides, including longer-lived radionuclides such as Ra-226, post-closure safety in theory places no limit on the DSRS radionuclide inventory that could be disposed of. However, the GSA can only be considered as a basis to facilitate the development of a BDC and the demonstration of its safety. It does not permit the Member State developing the concept to ignore the requirement to demonstrate the safety of the concept on the basis of site specific conditions. This implies the necessity that both waste management organization and regulatory body must have the capacity and capability to respectively demonstrate the safety and review the safety of the concept as part of the licensing process and in line with international safety standards. This also implies the establishment of an appropriate governmental, legal and regulatory framework in the country.

The IAEA may assist its Member States to decide whether the BDC would be a suitable disposal option for implementation in their country and, if suitable, what conditions would need to be met to ensure the safety of humans and the environment. IAEA assistance to Member States is provided through the provision of advice, training, reviews and the use of equipment and by

providing generic design and safety documentation, with the intention of building the competency and capacity of both the regulatory authority and the organisation responsible for disposal. The IAEA will also facilitate the sharing of information and experience in this field and promote regional cooperation between Member States.

CONCLUSIONS

In conclusion, Member States have a range of options to be considered when they are developing strategies for the disposal of their inventory of DSRS, and the IAEA BDC is one such option that is safe, technically viable, cost effective and secure, ensuring a sustainable solution ready for implementation now.

A Safety Case will need to be made in order to obtain regulatory approvals for DSRS disposal and the IAEA Generic Safety Assessment can be used as a framework for presenting site specific data and understanding. Currently, the GSA is applicable for a range of DSRS and environmental conditions that might exist at a disposal site, but further work is underway to broaden its applicability to high activity sources as well.

Implementation of borehole disposal of DSRS requires a national effort and the capabilities and the capacity of both the regulator and operator must be developed in parallel.

Several countries are actively characterising sites in order to develop preliminary site specific safety assessments for borehole disposal using the BDC. For the disposal of high activity sources, conditioning will be required using a mobile hot cell. The operational procedures and prototype equipment are currently under development to ensure that these gaps in the concept are filled.