23rd NUCLEAR INTER JURA 2018
4-8 November, 2018 - Abu Dhabi, United Arab Emirates

INTERNATIONAL LEGAL FRAMEWORK ON THE MANAGEMENT OF DISUSED RADIOACTIVE SOURCES

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Abstract

The paper will summarize the reviewed information and provides an up to date overall picture of the management of disused sealed radioactive sources (DSRSs) based upon the current status and trends in this field. It incorporates the most recent international legal framework, technical, financial and legal aspects and future challenges.

The objective of this report is to provide information in the handling and management of DSRSs that takes account of international experience and the guidance and principles that have been learned from that experience. It also provides an understanding of the nature of DSRSs, continues with a general description of the sealed source management process and is followed by the legal and obligations descriptions of the issues that affect the parties who are typically involved in the chain of manufacture, use and storage of radioactive sources. It also describes their typical legal responsibilities which includes regulatory and economic considerations that play an important role in the establishing and implementation of sealed source management.

Introduction

The management and characterization of disused sealed radioactive sources (DSRSs) are regularly a major topic of discussion amongst Member States of the International Atomic Energy Agency (IAEA), and the need to reinforce the nuclear legal framework in the States was frequently mentioned in different internationals meetings.

Practically all countries in the world use radioactive sources. The rays they emit can be used for many beneficial purposes, in medicine, industry and agriculture. But if sources are not controlled properly, they pose a threat to human health and the environment. Taking into account this context, the countries should develop or reinforce an effective, safe and secure control system for their radioactive sources - from the cradle to the grave. 'Cradle-to-grave' refers to the control of radioactive sources from distribution to installation, use, disuse, and through to disposal.

The applications of sealed radioactive sources have been widespread. The nature and quantity of the radionuclides utilized depend on the intended purpose. While most sources are of relatively low activity, there are many of high or very high activity. These high activity sources have been responsible for most of the radiological accidents involving loss of life or disabling injuries to the public [1].

High activity sources are utilized for various applications: for example, sources of the order of 100 TBq (several thousand curies) are used worldwide for teletherapy in radiology. Sources in the TBq–PBq range (up to tens of thousands curies) are used in research irradiators and sources of tens of PBq (several hundred thousand curies) are used for sterilization and food irradiation.

The radionuclides which have been most commonly used to produce high activity sources are Co-60, Cs-137 and Ir-192. There are also a small number of applications which use other radionuclides such as Sr-90 and Am-241 mixed with beryllium to produce neutron sources. The IAEA-TECDOC-1191, "Categorization of Radiation Sources" [2], lists the various applications for each of the radionuclides of interest, along with the likely range of activity for that application.

There is large number of high activity sealed radioactive sources in use worldwide. Due to the limited operational lifetime of sealed radioactive sources there are many that are no longer in use and require safe management.

Disused sources are defined as sources that are no longer used and there is no intention of using them again in the practices they were authorized for. Spent sources, which can no longer be used for their intended purposes as a result of radioactive decay, are a sub-set of disused sources.

If lost or not properly controlled, disused sealed sources can be a threat to human health and the environment. Exposure to large doses of radiation from an unshielded high-activity source can be lethal or cause severe radiation injury. If the source capsule is damaged, the radioactive material can be released and dispersed, resulting in contamination to the environment and potential radiological hazards for people.

Ensuring safety in the use of radiation sources and operation of related facilities is of paramount importance for the protection of people and the environment from any associated radiation risks. In order to ensure radiation safety, a cradle-to-grave system for the control of radiation sources is needed.

Such a system requires first of all that relevant laws and regulations are in place, a national infrastructure for the control of radiation sources should be established and that regulatory control activities should be implemented. The regulatory body needs sufficient resources and competent staff, while the regulatory control activities would need to include all necessary steps, from authorization to inspection and enforcement.

Code of Conduct on the Safety and Security of Radioactive Sources (CoC) and the Guidance on the Management of Disused Radioactive Sources

The 2009 annual meeting of the Code of Conduct focused explicitly on the long term management of disused sources. Other international meetings have included long and detailed discussions about challenges and concerns with disused sources. This continued attention culminated in a formal recommendation by technical experts to the IAEA´s Scientific Secretariat at the 2013 Abu Dhabi International Conference on the Safety and Security of Radioactive Sources that had encouraged to develop and implement an "additional guidance at the international level for the long-term management of disused radioactive sources” and indicated it “may form supplementary guidance to the Code of Conduct.”

Since the Abu Dhabi International Conference, the issue has arisen at each subsequent meeting of the Working Group on Radioactive Source Security in the IAEA. The draft document has also been discussed at every annual meeting of the Code of Conduct. Resolutions of the General Conference have referred to the text explicitly, beginning in 2014, and calls upon Member States to ensure adequate provision for safe and secure storage and disposition pathways for disused radioactive sealed sources.

Throughout the drafting process, Member States provided a profound level of input to the Secretariat for this guidance. The high level Member State involvement testifies to the importance placed on completing this document and providing this guidance to Member States, and to the importance placed on it by those committed to the Code.

The Guidance on the Management of Disused Radioactive Sources, was endorsed by the 61st IAEA General Conference in September 2017. The document stands as supplementary guidance to the Code of Conduct on the Safety and Security of Radioactive Sources, along with the Guidance on the Import and Export of Radioactive Sources.

The Code of Conduct and its supplementary documents foster management and protection by providing guidance on the development, harmonization and implementation of national policies, laws and regulations, as well as the promotion of international and regional cooperation among Member States.

The Guidance promotes a more rigorous radiation safety and security culture, which will be further enhanced once Member States put the recommendations of the Guidance into practice.

The Guidance, which is not legally binding, describes a variety of options for the management and protection of disused radioactive sources and outlines the responsibilities of relevant parties, including regulatory bodies. It emphasises disposal as the final management option for disused sources and encourages countries to have national policies and strategies to manage disused radioactive sources in a safe and secure manner. It also contains provisions on bilateral relations, including advice on the return of sources in cases where such arrangements have been agreed.

IAEA ROLE

Through its Safety Standards and other documents, such as the Code of Conduct on Safety and Security of Radioactive Sources and the Guidance on the Import and Export of Radioactive Sources, the IAEA provides the international requirements and recommendations for an appropriate and sustainable regulatory system for the control and management of radioactive sources. The Agency also provides various tools to assist regulatory bodies in strengthening the effectiveness of their activities, including the Self-Assessment of Regulatory Infrastructure for Safety (SARIS), the Regulatory Authority

Information System (RAIS), the Control of Sources Network (CSN) and the Radioactive Waste Management Registry (RWMR) for operators.

The IAEA also assists its Member States in implementing safe and cost-effective technologies for recovering, conditioning and storing sealed radioactive sources. Direct assistance includes:

- Search for potential orphan sources, as well as recovery and safe management of found sources;
- Recovering, characterizing and conditioning of disused sealed radioactive sources, including radium sources, lightening conductor sources and smoke detectors, for long-term storage or disposal;
- Completion of national inventories of disused sealed radioactive sources, source characterization and record-keeping; and
- Providing assistance for the repatriation or recycling of high-activity disused sealed radioactive sources.

The IAEA also helps improve national capabilities for disused sealed source management, by advising on the designs for facilities to condition and store these sources; by providing technical procedures on the handling, conditioning and storage of DSRS; and by offering training on the design of facilities and on technical procedures.

The IAEA supports Member States in the implementation of the Code of Conduct and Guidance documents through projects and information exchange. This includes a formal process that was established in 2006. The first international meeting for the exchange of experience on the implementation of the Guidance on the Management of the Disused Radioactive Sources is planned for 2020 in Vienna.

Risks associated with disused sources

In general terms, risk is the chance or probability that a person will be harmed or experience an adverse health effect if exposed to a hazard, and is a function of probability (likelihood that a certain event will occur) and consequence (extent of detrimental effects). The risks associated with exposure to DSRSs are affected by the characteristics of the source, the environment in which the source is affected, and the actions of the persons involved. Radioactive sources containing long lived radionuclides, such as 241Am or 226Ra, will still be potentially dangerous after thousands of years. Conversely, short lived radioisotopes become safe in a far shorter time. The decay of ten half-lives decreases the activity by a factor of about 1000. A teletherapy source with an initial activity of 100 TBq 60Co will decay to a safer level after 100 years, while a 137Cs source of the same activity requires 600 years and an 192Ir radiography source only four years, to decay to the same level of activity. The consequences of an accident involving exposure to an SRS are directly proportional to its activity

In the case of DSRSs, the consequences of an accident could include of one or more of the following;

- Internal and/or external contamination of individuals and associated radiation injuries (e.g. erythema, tissue damage, amputation and even death) due to excessive exposure of individuals;

- Contamination of material or the environment due to the breaching of the encapsulation and dispersion of the radioactive content of the SRS (destruction of the encapsulation, melting down with scrap, etc.);
- Economic losses due to medical treatment, accident related radiation surveillance, decontamination, dismantling, waste management and disposal, as well as costs due to loss of production capacity, monetary compensation to over exposed individuals, social expenses and the loss of use of the source itself.

Effects of Ionizing Radiation

The impact of any radiation exposure depends on the type of radiation associated with the source. When ionizing radiation imparts energy to living tissue, damage is likely to occur. The higher the intensity of incident radiation, the greater is the extent of damage. It is, therefore, the transfer or deposition of energy in living tissue that determines the extent of the damage to the tissue and, hence, the injury. The ionization of tissue can also take place as a direct consequence, as is the case with alpha and beta radiation, or indirectly, as is the case with gamma rays and neutrons. While alpha radiation has a high specific ionization characteristic, its penetration is very limited.

Gamma radiation and neutron beam ionization characteristics depend on their energy. Neutron sources (e.g. Am–Be, Ra–Be, Pu–Be) require particularly careful handling as neutrons emitted by these sources represent a more dangerous type of radiation. Moreover, when absorbed by the surrounding medium, neutrons can induce artificial radioactivity. For deterministic (non-stochastic) effects on man, there are threshold doses below which specific effects are not apparent. Whole body exposure above 3 Sv can be, and above 7 Sv is, lethal to humans. If only part of the body is exposed, the individual can survive higher doses, but the damage may be so severe that the exposed part may have to be removed. The IAEA source categorization system is based on the deterministic effects.

Category 1 sources, if not safely managed or protected securely, are likely to cause permanent injury to a person during handling, or alternatively, from contact with the sources for more than a few minutes. It would probably be fatal to be in close proximity of unshielded radioactive material for a period of a few minutes to an hour.

Category 2 sources, if not safely managed or protected securely, could cause permanent injury to a person during handling, or alternatively, from contact with the sources for a short period of time (minutes to hours). It could possibly be fatal to be in close proximity of unshielded radioactive material for a period of hours to days.

Category 3 sources, if not safely managed or protected securely, could cause permanent injury to a person during handling, or alternatively, from contact with the sources for several hours. It is very unlikely that any person in close proximity will be exposed for more than a couple of hours at such short distances.

For stochastic effects, mainly the induction of cancer and genetic effects, there is no threshold; the risk for an effect is regarded as proportional to the dose. The risk for induction of potentially lethal cancer is 2–4 × 10-2 per Sv, while for severe hereditary effects the risk is smaller, about 10-2 per Sv.

Time, distance, and shielding are the key elements of radiation protection and minimizing exposure. The radiological risk is linked with the same elements. Radiation exposure may cause more harm if people are exposed for longer times, at closer proximity, and with less shielding material between the source and the subject. These factors make it difficult to do grave harm to large numbers of people because it is difficult to put many people in close proximity to a source for a long time, and even the human body itself provides some shielding, so that a crowd somewhat shields a radioactive source. A single source, even a large one, might not have major or lasting psychosocial or economic impacts.

In the event of a damaged source, the effect on the environment may be contamination of buildings and of the general area. The high specific activity of the radioactive material in sealed sources means that the spread of as little as microgram quantities of its contents into the environment can generate a significant risk to man, thereby restricting the use of potentially contaminated buildings and areas. The cost of decontamination can be very high. Accidents with disused sources have already resulted in extensive contamination of the environment and high costs for the associated decontamination work.

General Management Issues

An effective DSRSs policy needs to outline general principles to be applied to the management of these sources through their life-cycle [4]. The policy has to be developed taking into account the technical and financial resources available in the prevalent social and political climate. Without an agreed policy it is not possible to set appropriate programmes of work and allocate the required resources to carry out the tasks for the management of DSRSs in a safe and economical manner. The policy should be reviewed on a regular basis to account for changes that could affect the management of DSRSs.

There are a number of generic policies which can be adopted by a state for the management of DSRSs. These are:

- Limiting the number of DSRSs within the territory;
- Recycling or re-use;
- Handling unexpected DSRSs storage prior to disposal.

Limiting the number of DSRSs within the territory

This policy cannot be conducted without consideration of all factors. Each application should be evaluated on a case-by-case basis to assess the benefit of using high activity sources against any disadvantages resulting from the spent source liability.

There are several possibilities which can be used to achieve this policy. These are:

- Limiting the import of high activity radioactive sources
- Requiring guarantee of return to the supplier

- Arranging transfer of existing DSRSs

Recycling or re-use

States should adopt the policy of encouraging the recycling or re-use of radioactive sources wherever possible. This can be accomplished either by utilizing the source for a different application within a country or by returning it to a supplier for re-use or recycle. Economic, environmental and safety issues involved in recycling/re-use make this issue challenging and the following are required to be evaluated:

- commercial demand for the recycled product;
- storage costs when recycling is not immediately viable;
- technical requirements for re-use, recycling and storage;
- safety and regulatory standards and requirements;
- social acceptability of the recycling and storage processes.

Member States, through international co-operation, should provide guidance, control and economic incentives for both users and suppliers to explore recycle and re-use. Conditions for which long term storage is more viable should be identified by stakeholders. The preference can be based on economic, safety or technical grounds. Source manufacturers or other source processors are likely to be in the best position to provide re-use/recycle services, and the policy in a given Member State may therefore be aided by strategies which encourage return of radioactive sources to the manufacturer.

All stakeholders will have some financial commitments in the recycling/re-using of DSRSs. Financial provisions to meet the forecasted cost should be created during the lifetime of the sources in order to meet such costs when they arise. Legal and administrative arrangements may need to be simplified if such an option is to be developed on a wider scale. International co-operation and information exchange is an important component for this issue. An overall strategy on the national and possibly the international level may be required.

These sources (often known as “lost” or “orphan” sources) occur when DSRSs are discovered unexpectedly. These DSRSs may not have supporting documentation and determination of ownership may be impossible. General policy to handle unexpected cases should be available, locally and on a national level. Of primary importance are the safety implications of discovering these DSRSs.

Typical cases of unexpected DSRSs include:

- DSRSs found in scrap metal.
- Decommissioned industrial complexes.
- Illicit trafficking.
- Abandoned equipment.
- Unintentional disposal along with conventional waste.
- DSRSs outside regulatory control (e.g. resulting from bankruptcy).

For the storage prior to disposal two alternatives have to be considered, decay storage and interim storage.

Legal, regulatory and economic considerations

The state of advancement and the nature of the legal system regarding the management of DSRSs are different in every country. Most countries' legal systems are based on producing a number of laws that state the legislator's policy. The detailed implementation of these laws is then governed by supplementary legislation including regulations and ordinances.

A number of countries have issued laws on the safe (or peaceful) use of atomic energy and laws on Radiation Protection. That law is implemented via a number of regulations that will normally include the safe use of radioactive sources and their subsequent management after the end of their operating life.

The characteristics of a national regulatory infrastructure are described in more details in an IAEA publication on the subject "*Organization and Implementation of a National Regulatory Infrastructure Governing Protection against Ionizing Radiation and the Safety of Radiation Sources*" [3].

General legal considerations for management of radioactive material

The parties involved in the manufacture, transport, use, and storage of sealed radioactive sources are responsible for the safe management of all radioactive material in their possession.

This principle applies equally to radioactive by-products and waste from the manufacturing process as it does to finished sealed sources in possession of the end user. In most cases this obligation is specified in a framework of laws and regulations under which the facility operates. Ultimately, the source material ownership is transferred to another party, or the source material is retained in a safe and secure location until it becomes non-hazardous through decay.

Typical legal obligations

Below are the parties who are typically involved in the chain of manufacture, use and storage of radioactive sources, and their typical legal responsibilities.

An Irradiation Facility typically irradiates inactive material to produce useful radioisotopes, or refines them from the by-products of other nuclear processes, and delivers the radioisotopes in bulk form to the Source Manufacturer. The Irradiation Facility is responsible for the safe operation of its facility under applicable laws and licenses, and for the safe disposition of all by-products of the production process, which may include isotopes other than those in the final product. For high activity sources that later become SHARS, Irradiation Facilities are nuclear reactors. At these facilities, radioactive waste from the irradiation process is usually conditioned and placed in an interim storage facility, all of which is intended for eventual disposal in permanent facilities.

A Source Manufacturer usually accepts ownership of the active material at time of delivery from the Irradiation Facility. The Source Manufacturer then becomes legally responsible for the safe handling of the radioactive material and for its subsequent transfer of ownership. Usually, the Source

Manufacturer encapsulates the source to specific standards or legal requirements in facilities that are designed and licensed for the purpose (e.g. hot cells and glove boxes), and subsequently sells the encapsulated source to the User. The Source Manufacturer is responsible for ensuring safe operation of its facilities under all applicable laws and licenses and for the safe disposition of all waste material from the encapsulation process. This waste material is typically transferred back to the Irradiation Facility under terms of a contract associated with the purchase of the radioactive material. The Source Manufacturer also accepts responsibility for providing a transport container that meets national and international transport laws and license requirements, and helps make delivery arrangements for the source. In addition, the Source Manufacturer is typically required to supply to the user and Regulatory Authority a source certificate that contains comprehensive information about the source such as model and serial number, radionuclide, activity, date of calibration, capsule type, special form certificate number, and manufacturer information.

An Equipment Manufacturer provides the equipment into which a source will be loaded, either before shipment to the User's site or after installation. The Equipment Manufacturer is typically required by regulations to provide to the User all information needed to safely and properly operate and maintain the equipment. This includes all relevant information about the source and source transport mechanism, including means of securing the source in a safe condition, interlocks, and how to respond in emergency conditions.

A Shipper (or Distributor), trained in the transport of dangerous goods and authorized by legal bodies, is responsible for carrying out all shipping operations in accordance with laws that pertain. The Source Manufacturer (who typically continues ownership of the source during shipping) and the Shipper therefore both have legal responsibilities during shipment operations. Insurance is usually purchased to cover costs that might arise during shipping due to possible accidents that damage the product or the environment, or cause injury to persons.

A User usually accepts ownership of the source material at time of delivery from the Source Manufacturer or importer. The User then becomes legally responsible for the safe handling of the radioactive material under all applicable laws and licenses, and for its subsequent transfer of ownership. License conditions typically require the User to securely retain a copy of the source certificate information provided by the Source Manufacturer. Although not usually required by license, the User should also ensure that it securely retains all technical information about the equipment provided by the Equipment Manufacturer. When a spent source is exchanged for a new one, this may be performed by experts from outside the User's facility, but is normally performed under the license conditions and radiation safety practices for which the User is responsible. During such an exchange the Source Manufacturer typically takes the spent source back; the exchange therefore creates no new waste issues for the User.
When the equipment is eventually decommissioned, the disposition of the final source then becomes an issue. Local decay to a safe condition is typically not practical for SHARS due to the long half-life and/or high activity of the source. The User must therefore transfer ownership of the source to another party, such as a Source Manufacturer or an Interim Storage Facility Operator. If the User stores the source prior to a formal transfer of ownership (temporary storage), the User remains responsible for the safety and security issues during the storage period.

An Interim Storage Facility Operator for a spent source provides storage of conditioned and unconditioned spent sources. The Interim Storage Facility Operator is legally responsible for safe and secure storage of the sources under its ownership, and typically operates under license conditions established by a regulatory authority. This responsibility terminates when the source has decayed sufficiently to be disposed of as non-hazardous material, or until the source is legally transferred to another organisation such as a disposal facility. As a requirement of its license, the Interim Storage Facility Operator maintains an up-to-date inventory of all sources in its possession, including all details provided by the Source Manufacturer.

A Regulatory Authority in a particular country is created and empowered by national laws.
There may be several regulatory authorities with different jurisdiction. Its legal responsibilities usually include all aspects of safety of radioactive materials, including licensing and auditing of Users and Storage Facilities, approving transport container licensing, and regulating the transport of radioactive material within the country. The Regulatory Authority has a legal obligation to protect public health through an appropriate level of diligence. Usually, it also is empowered to issue fines for infractions of licensing conditions or legal infractions, to suspend operations, or start criminal legal proceedings in extreme cases. In order to ensure a high degree of safety, a Regulatory Authority should maintain an inventory of all SHARS in its territory and ensure that the inventory is always kept up to date. To facilitate equipment decommissioning, the Regulatory Authority should also retain a copy of the technical details of the equipment containing SHARS that is pertinent to source security, removal, and transport. To support the legal obligations listed above, Member State governments should ensure that legislation is passed to create and empower a regulatory authority, and ensure that a waste management facility is established and appropriately funded.

Financial considerations: costs for transfer of radioactive material and meeting legal requirements

All parties who own radioactive material during the process of manufacturing, transporting, using, and temporary storage of DSRSs typically transfer ownership of the material to another party. Eventually, the material will reside in an Interim Storage Facility, where it will either decay to a safe level or be held pending transfer to a disposal facility.

The costs of ownership transfer of radioactive material during the manufacture and replacement of a sealed source are reflected in the purchasing price for the original and replacement sources, as this is usually the means by which the manufacturer recovers its costs. When a source is replaced, the manufacturer usually takes the spent source back as part of the transaction. However, when the equipment is eventually decommissioned, the ownership transfer of the final source in the equipment must be managed as part of the cost to the User associated with return of the facility to general use. In essence, the total ownership transfer costs are part of the total cost to the User for providing the service for which the source was purchased. For high activity sources, these services include industrial radiography, material irradiation, sterilization and cancer therapy.

Other financial considerations

Both the User and the Source Manufacturer have licensing costs and operating costs related to regulatory requirements. Regulatory Authorities issue licenses to facilities handling radioactive materials and perform inspections, and at least some of the costs of these activities are passed on to the licensee as licensing fees. Regulatory license costs for the Irradiation Facility and for the Source Manufacturer are typically built into the price of the source as delivered to the User, and the User's regulatory costs become an operating expense borne during the time of use of the source. Licensing cost of shipping containers, the costs of shipping are also passed to the user in the costs of sources and source replacements. These expenses, which are necessary to meet legal and safety requirements, become additional costs to the User.

Legal and financial problems contributing to radiological accidents

In general, Irradiation Facilities and Source Manufacturers operate under license conditions from Regulatory Authorities and the loss or mismanagement of waste material is rare.
Similarly, regulations for transport of Hazardous Goods, and radioactive material specifically, are also well developed and thus shipping operations are not known to result in radiation accidents. The principal problem appears to be related to spent sources after the decommissioning phase, i.e., when equipment use is discontinued and ownership transfer is required for the final source in the equipment. Below are some of the legal and financial conditions that contribute to the likelihood of radiological accidents in these circumstances.

Inadequate financing of the ownership transfer costs

Once equipment has been purchased and delivered, a facility might not provide for the cost of ownership transfer of the source when the equipment is eventually retired. This can be because the facility owners do not have a budgetary mechanism for accruing for a cost that will be realized only well into the future (perhaps decades) and for which the exact value can only be estimated. It could also be because the facility assumes that it can cover the ownership transfer cost out of its operating budget or as a condition of purchase of new equipment. This can lead to financial pressure when the time for ownership transfer arises, with the corresponding temptation to use less expensive options. These alternatives could result in a higher likelihood of loss of control of the spent source.

Facility bankruptcy or other unplanned closure

If (for example), a facility owner becomes insolvent, or a facility is closed due to abandonment, war, natural disaster etc., the assumed method of financing source ownership transfer may no longer be possible. Insurance or emergency funds from public agencies may be available to assist in these circumstances; otherwise, costs of ownership transfer will need to be undertaken by other institutions that may not have participated in the benefits for which the source was purchased.

Unavailability of an ownership transfer path

At the time of decommissioning of equipment, the original source manufacturer might not be in business, or might be unable to retrieve the source due to the age or condition of the equipment or changes in applicable regulations. If transfer to a storage facility operator is not practical, then the user will need to store the source safely and securely until a practical solution is available. Although this is not likely to be a high cost on a yearly basis, the storage time could exceed the ability of the facility to reliably ensure safe and secure storage, and could in fact exceed the operational life of the facility. In these situations, the cost of source ownership transfer is deferred by temporary storage, but not solved.

Inadequate regulatory oversight

In some countries, the need for radioactive material for a variety of purposes precedes the establishment of an official Regulatory Authority to oversee radiation safety. Even in cases where such an authority exists, it may not exercise oversight with appropriate diligence in all cases due to a number of problems such as inexperience of the staff or funding problems. In these cases, unsafe practices by the owners of the source could go unnoticed and may lead to radiological accidents.

Development and Use of Alternative Technologies

Radioactive sources have a variety of essential and beneficial applications. However, if they are mishandled, particularly with malicious intent, or improperly disposed of, they have the potential to cause significant damage and injury. There are numerous examples of radioactive sources being stolen or going missing. Some of those incidents caused serious harm.

International interest in, and support for, replacing high-risk radioactive sources has also been increasing. As long as these dangerous materials exist, the threat of radiological terrorism will persist. The only way to permanently reduce risk is to minimize, and where feasible, eliminate these materials.

On-going research, advancements in new technology and improvements in existing technologies have made many alternatives to radioactive sources attractive and cost effective. In some cases, there has been a strong movement to alternative technologies; this has been encouraged, at least in part, by the potential risks and liabilities posed by radioactive material. In other cases, complacency, a lack of incentives or a lack of viable alternatives have limited the movement to non-isotopic replacements.

it is necessary to take into account that before an interested party make the commitment to switch to a new technology, it is important to determine what needs to be done with the soon-to-be disused source. Some organizations made arrangements for disposal when they signed the original purchase contract, so disposal costs will not present a problem for them. However, other organizations have not made such arrangements. This means they will have to find a way to properly dispose of their oldmsources, which could be a significant and costly challenge. In fact, disposal costs can be a major reason for an organization’s reluctance to adopt alternative technologies.

If an organization is in such a position, it should contact the original source supplier to determine whether they can take the source back. The supplier may offer a return option, either for free or for a fee. It is important to know about any buyback options and be sure to ask about any additional fees, such as transportation and export permits. If the original supplier cannot help, other source suppliers may be able to accept and recover the source. Some countries have government run source recovery programmes. In some countries and whether the radioactive source is eligible. Also it is important to contact the regulator for additional options, suggestions and solutions.

Multilateral instruments and international norms have also played a significant role. The 2014 and 2016 NSS's heightened awareness of radioactive source security and the promotion of alternative technologies. At the 2016 NSS, France led a Gift Basket on Strengthening the Security of High Activity Sealed Radioactive Sources that was signed by 28 countries and Interpol. This Gift Basket contributed to raising political awareness on actions needed to promote the exchange of information on alternative technologies through many forums as well as through the auspices of the IAEA.

While alternative technologies cannot currently replace the complete spectrum of radioactive sources, for certain applications they represent a mature technology that can also offer better operational, economic, and healthcare benefits. Several states have advanced well beyond advocacy for alternative technologies and are undertaking implementation efforts to switch to non-isotopic alternatives.

Alternative technologies (such as x-rays for the replacement of cesium irradiators and linear accelerators for the replacement of teletherapy devices) are replacing radioactive sources in certain countries, resulting in permanent risk reduction. Some States work with their public and private sectors, in close coordination with national research and development efforts, in promoting the development, certification, promotion, and demonstration of innovative technologies that do not require the use of high-activity radiological sources. Non-isotopic alternative technology has become increasingly available worldwide, and some countries continue to develop and explore applications that are on par with their isotopic counterparts.

Conclusion

The most severe accidents with disused sources have occurred when the sources ended up in the hands of non-professionals who were unaware that they were dealing with radioactive material, since equipment or source holders containing disused sources may look like normal scrap. Loss of control over DSRSs can also lead to risk of loss, theft or misappropriation of the source. A new dimension to the potential hazard of disused sources is the possibility that they may be intentionally stolen for malicious use or illicit trafficking.

Past accidents have demonstrated that radiation, due to its nature and history, has a unique ability to trigger fear and anxiety in the general population. The quantity of radioactive material required to cause economic consequences does not need to be large; even a small amount could trigger huge psychological impacts. Implementation of appropriate security measures can reduce the probability of such situations occurring.

The effective and continuous regulatory and management control of radioactive sources, from cradle to grave, is of utmost importance for the prevention of radiological accidents and malicious acts with harmful radiological consequences It is important to strength the control throughout a source's entire life cycle, education and training of all stakeholders in proportion to their responsibilities, international cooperation, establishing responsibilities, improving security culture, resolve problems arising from international trade in radioactive sources, dealing with orphan radioactive sources and reinforce the interface between security and safety. The Guidelines on the management of disused sources is an ideal reference to develop or reinforce a national policy, implementing different strategies that should be adapted to the realities and national legal frameworks of the States.

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In addition to the Code of Conduct on the Safety and Security of Radioactive Sources (CoC) and the Guidance on the Management of Disused Radioactive Sources and also other international legal instruments such as the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, the European Directive 2013/59/ Euratom, the international Basic Safety Standards GSR Part 3 as well as security standards such as IAEA NSS 11 and NSS 14 were considered in this report.