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IAEA NUCLEAR ENERGY SERIES

No. NW-T-1.26

Management of Disused Ionization Chamber Smoke Detectors: Approaches and Practical Experiences

TECHNICAL REPORTS

IAEA NUCLEAR ENERGY SERIES PUBLICATIONS

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MANAGEMENT OF DISUSED IONIZATION CHAMBER SMOKE DETECTORS: APPROACHES AND PRACTICAL EXPERIENCES

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IAEA NUCLEAR ENERGY SERIES No. NW-T-1.26

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FOREWORD

The IAEA's statutory role is to "seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world". Among other functions, the IAEA is authorized to "foster the exchange of scientific and technical information on peaceful uses of atomic energy". One way this is achieved is through a range of technical publications including the IAEA Nuclear Energy Series.

The IAEA Nuclear Energy Series comprises publications designed to further the use of nuclear technologies in support of sustainable development, to advance nuclear science and technology, catalyse innovation and build capacity to support the existing and expanded use of nuclear power and nuclear science applications. The publications include information covering all policy, technological and management aspects of the definition and implementation of activities involving the peaceful use of nuclear technology. While the guidance provided in IAEA Nuclear Energy Series publications does not constitute Member States' consensus, it has undergone internal peer review and been made available to Member States for comment prior to publication.

The IAEA safety standards establish fundamental principles, requirements and recommendations to ensure nuclear safety and serve as a global reference for protecting people and the environment from harmful effects of ionizing radiation.

When IAEA Nuclear Energy Series publications address safety, it is ensured that the IAEA safety standards are referred to as the current boundary conditions for the application of nuclear technology.

IAEA Member States have been using ionization chamber smoke detectors containing sealed radioactive sources for many decades. The main benefit of smoke detectors with ionization chambers is the potential to save lives by warning of fires. Although most Member States have laid down a proper regulatory framework to control sealed radioactive sources, there is no consistent approach to the management of the disused ionization chamber smoke detectors.

This publication provides an overview of a variety of ionization chamber smoke detector models. In addition, it discusses practices for the collection, dismantling and storage of disused ionization chamber smoke detectors and radioactive waste streams resulting from their management. Various options for the safe management of disused ionization chamber smoke detectors are discussed, including advantages and disadvantages based on Member State experiences and IAEA guidance and standards.

The IAEA wishes to acknowledge the assistance provided by the contributors to drafting and review listed at the end of the publication. The IAEA officer responsible for the publication was J.C. Benitez-Navarro of the Division of Nuclear Fuel Cycle and Waste Technology.

CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

Sealed radioactive sources (SRS) are used worldwide in medicine, agriculture, industry and research, in mobile as well as stationary devices. Their use provides many benefits to millions of people, in diagnosing and treating diseases, in assuring consistent food supplies and in improving the quality of manufactured products. The IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards [1] defines an SRS as a “radioactive source in which the radioactive material is (a) permanently sealed in a capsule or (b) closely bonded and in a solid form”.

If a source is no longer needed (e.g. replaced by a different technique) or it becomes unfit for the intended application (e.g. the activity becomes too weak, the equipment containing the source malfunctions or becomes obsolete, or the source is damaged or leaking) it is considered disused. Disused sealed radioactive sources (DSRS) are typically conditioned and disposed of, if a disposal facility is available. If the disposal option is not available, conditioned DSRS might be stored under proper conditions. In some cases, the radionuclide(s) in DSRS can be recovered/recycled or more often the DSRS can be repurposed/reused for other applications. Some examples are shown in the annexes.

Smoke detectors are devices used to detect fires by sensing the smoke they cause. There are different types of smoke detectors:

— Non-ionizing: optical detectors that use a photoelectric sensor;
— Ionizing: ionization chamber smoke detectors (ICSDs) that contain SRS and share many management options with other devices containing an SRS.

Millions of all types of smoke detectors have been used in private and public places for decades and while many are still in use, large numbers of disused smoke detectors have arisen.

Until recently, ICSDs have been the most common type of smoke detectors [2]. These devices use a small amount of radioactive material, usually ^{241}Am. Other radionuclides such as ^{63}Ni, ^{85}Kr, ^{226}Ra, ^{238}Pu and ^{239}Pu have also been used.

Some facts to note for smoke detectors are:

— Householders may install one to several ICSDs in their homes, but a much larger number of ICSDs may be used as part of a fire protection system in commercial settings such as an office block, shopping mall or hotel. ICSDs installed as components of fire detection systems of this nature are not consumer products as defined in GSR Part 3 [1], since they are not made available to members of the public [2].
— The application of the provisions for exemption to consumer products are not straightforward and this has resulted in different approaches being adopted in different States [2].
— The manufacture and installation/replacement of ICSDs is decreasing overall worldwide. Switching to non-ionizing smoke detectors is increasing because some Member States perceive the use of ICSDs to be an unjustifiable risk/practice.
— Some countries have banned new installations of ICSDs and some countries banned the use of ICSDs and established a schedule for their removal and management by specialized organizations. For example, the installation of new ICSDs in Luxembourg has been prohibited since 1994 [3]. Another example is described in Annex III of the IAEA Safety Standards Series No. SSG-36, Radiation Safety for Consumer Products [2].

— Individual ICSDs were often exempted from regulatory control due to the small amount of radioactive material they contain, therefore, disposal of individual units in landfills was previously practised in many countries and is still practised in some.
— If ICSDs or their recovered DSRS are managed as radioactive waste, a limiting concentration for alpha emitters in individual radioactive waste packages for disposal into near surface repositories may preclude surface/near surface disposal, therefore disposal at depth may be an option.
— Due to the widespread use of ICSDs, the disused units are also widely distributed. Estimated numbers, locations and distribution may be very different among Member States. For example: there are over 30 000 disused ICSDs in Lithuania [4], there are more than 40 000 disused ICSDs in the centralized waste management facility in Cuba [5], more than 20 000 disused ICSDs in the centralized waste management facility in Slovakia [6] and by 2001 more than 50 000 were collected in Belgium [7] and over 200 000 ICSDs in Brazil [8]. There are about 7 million ICSDs in France in some 300 000 locations, which make their collection and management a great challenge (see Annexes I–IX).

1.2. OBJECTIVE

Ionization chamber smoke detectors contain relatively small amounts of radioactive material and pose little hazard on an individual basis, even when disposed of in landfills. However, many Member States have taken the decision to collect all or many of their country's ICSDs into one or more locations. This often leads to a volume that needs to be managed as radioactive waste. The objective of this publication is to provide an overview of the management options for the ICSDs when declared disused.

1.3. SCOPE

This publication focuses on the management of disused ICSDs at radioactive waste management facilities or at manufacturers and suppliers. The activities include some or all of the following:

— The receipt of disused ICSDs at these facilities;
— Characterization and inventory management;
— Dismantling, which includes recovery of the DSRS;
— Conditioning of associated DSRS;
— Management of secondary wastes from dismantling;
— Reuse of the DSRS;
— Recycling of recovered radionuclides (not commonly practised);
— Storage;
— Disposal;
— Record keeping at all appropriate stages.

This publication does not discuss the pros and cons of the use of optical detectors and ICSDs. The manufacture, distribution, use, maintenance, operational incidents and removal of ICSDs from service are not discussed in this publication.

1.4. STRUCTURE

This publication provides:

— The approach and examples for landfill disposal of household ICSDs as consumer products exempted from regulatory control;

— An overview of disused ICSDs once they have been collected and their subsequent long term management but does not intend to encourage the collection of household ICSDs;
— A variety of national experiences in the management of disused ICSDs;
— Examples of dismantled disused ICSDs for recovery and management of the radioactive sources.

This publication contains 7 sections and 18 annexes (with the addition of an introductory section). Section 2 presents an overview of the smoke detectors with emphasis on the characteristics and identification of ICDSs. Section 3 presents the safety and safeguards considerations in the management of disused ICSDs. The radiation protection and industrial safety related to the operations for handling disused ICSDs is also discussed in this section. Section 4 describes the management options for disused ICSDs. The approach and examples for landfill disposal of household ICSDs as consumer products exempted from regulatory control is discussed. The management of disused ICSDs after been collected at centralized processing and storage facilities is also discussed. Section 5 describes the procedures for dismantling disused ICSDs after been collected and the conditioning of the recovered radioactive sources. Sections 6 and 7 summarizes the lessons learned, conclusions and further considerations related to the management of disused ICSDs.

The annexes comprise 18 national reports that were prepared by Member State representatives in technical and consultancy meetings. These national reports provide a snapshot of the status of management disused ICSDs in the Member States.

2. OVERVIEW OF SMOKE DETECTORS

Smoke detectors are devices used to alert people to fires by sensing the smoke from fires. Commonly, smoke detectors in commercial, industrial and large residential complexes issue a signal to a central fire alarm system and are typically connected to building power with a battery backup. Household smoke detectors generally issue a local audible or visual alarm from the detector itself and may be powered only by a battery.

Smoke detectors are typically housed in a disc-shaped plastic enclosure, but the shape can vary by manufacturer or product line. The working principle in most smoke detectors is based on optical detection (via photoelectric sensor) or ionization; some use both detection methods to increase the sensitivity to smoke [9]. Sensitive alarms can be used to detect, and thus deter, smoking in areas where it is banned.

It is often difficult to visually determine the type of smoke detector (i.e. ionization, optical or dual sensor). Figure 1 demonstrates how difficult it is for the average consumer to recognize the detector type without additional information.

2.1. SMOKE DETECTORS: OPTICAL AND IONIZATION CHAMBER

2.1.1. Optical smoke detectors

Detectors incorporating an optical smoke detection mechanism rather than a radioactive source have been developed and are also available to the public as an alternative to ICSDs. An optical detector is a light sensor. When used as a smoke detector, it includes a light source (incandescent or infrared), a lens to collimate the light into a beam and a photodiode or other photoelectric sensor at an angle to the light beam. In the absence of smoke, the light passes in front of the detector in a straight line. When smoke enters the optical chamber across the path of the light beam, some light is scattered by the smoke particles, directing it to the sensor and triggering an alarm.

FIG. 1. Examples of ionization, optical and dual sensor smoke detectors.

2.1.2. Ionization chamber smoke detectors

An ICSD uses a radioactive source, typically ^{241}Am, to produce a small electric current due to ionization of the air in a chamber adjacent to the source. When smoke enters the chamber, the current decreases, which triggers an alarm. Historically, ICSDs were considered to respond more rapidly to a fast-burning fire, whereas optical smoke detectors are more suited to the detection of smouldering fires [9].

Ionization chamber smoke detectors are considered consumer products. Small amounts of radionuclides have deliberately been incorporated into these, either for functional reasons or because of particular physical or chemical characteristics (i.e. the radionuclides are essential for the product to function correctly) [9].

The standby power consumption of an ICSD is so low that a 9 V battery can provide power for months or years, making the unit independent of alternating current (i.e. building electrical system) power supply. However, batteries require regular testing and may require replacement.

Americium 241 is an alpha emitter with a half-life of 432.6 years. Alpha radiation, as opposed to beta and gamma, is used for two reasons: alpha particles have high linear energy transfer, so sufficient air particles will be ionized for the current to exist, and they have low penetrative power, meaning they will be stopped by the plastic of the smoke detector or by the air. The radiation risk associated with the amount of ^{241}Am used for this practice is sufficiently low that some Member States have exempted such usage from the radiation safety regulations. ICSDs typically include 37 kBq (1 μCi) of ^{241}Am. This provides sufficient ion current to detect smoke, while producing a very low level of radiation outside the device.

Different manufacturers have made ICSDs using small amounts of other radionuclides such as ^{63}Ni, ^{85}Kr (a gas), ^{226}Ra, ^{238}Pu and ^{239}Pu (Table 1). However, ^{241}Am remains the most commonly used radionuclide. The principles of detector operation for these other units are the same (radionuclide decay induced ionization).

The use of ICSDs is being discontinued in many countries in favour of non-ionizing smoke detectors. In many Member States the disused ICSDs are still in use and are collected, then consequently managed as DSRS.

TABLE 1. RADIONUCLIDES THAT HAVE BEEN USED IN ICSDs

Radionuclide	Half-life (years)	Main decay mode
Ni-63	98.7	Beta
Kr-85	10.75	Beta
Ra-226	1600	Alpha + progeny
Pu-238	87.74	Alpha
Pu-239	24 100	Alpha
Am-241	432.6	Alpha

Source: Library for gamma and alpha emissions (Nucléide — Lara); Laboratoire National Henri Becquerel (known as LNHB), France (National Metrology Laboratory in the field of ionizing radiation) http://www.lnhb.fr/nuclear-data/module-lara/.

2.2. IDENTIFICATION OF ICSDS

The ICSDs are usually labelled with the trefoil symbol and the word 'radioactive' to warn users of the presence of a radioactive substance, as shown in Figs 2–6. Different indicators may be used to determine if a smoke detector contains radioactive material or not; therefore, it is necessary to carefully examine the labels and markings on a smoke detector. Apart from the radiation symbol and/or the word 'radioactive,' the ICSDs can be marked as: ionization, americium, microcurie, becquerel or the abbreviations Am-241, ^{241}Am, μCi or kBq.

The IAEA has developed and implemented a publicly available database that includes a variety of ICSD models (mainly past models) [10] (Fig. 7). One purpose of the ICSD database is to present several models of ICSD and to provide details on each model's construction and the types of sealed sources they contain.

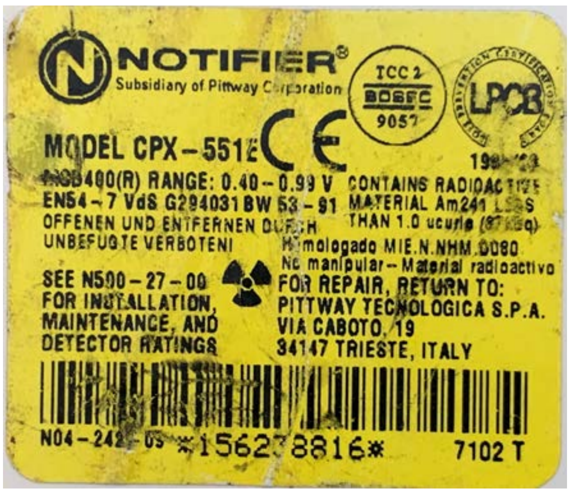

FIG. 2. ICSD Model Notifier CPX-551E yellow label with trefoil symbol and the words 'radioactive material Am241'.

FIG. 3. ICSD Model System Sensor 1400A yellow label with the trefoil symbol and the words 'radioactive material Am-241'.

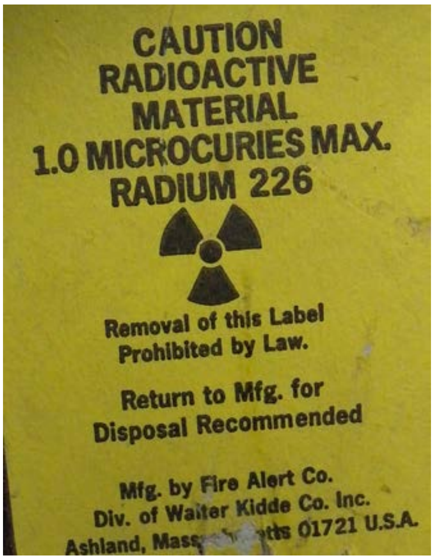

FIG. 4. ICSD Model Combustion Product Detector CPD 1212 yellow label with trefoil symbol and the words 'radioactive material … radium 226'.

FIG. 5. ICSD Model First Alert 0827 with white label showing a circled 'i' ionization symbol and the words 'americium 241, a radioactive material'.

FIG. 6. ICSD model FDS511 with white label showing the trefoil symbol and indicating the presence of 'radioactive substances… Am241'.

FIG. 7. Computer screen capture showing a portion of the ICSD Database within the IAEA Professional Network DSRSNet.

3. SAFETY AND SAFEGUARD CONSIDERATIONS FOR ICSDS

3.1. SAFETY CONSIDERATIONS

The source activity contained in an ICSD is normally greater than the exemption values given in GSR Part 3 [1]. In general, an authorization for the use of ICSDs is not required in most of Member States. An assessment of the doses that could be received by members of the public in normal use and in foreseeable accidents from an ICSD indicated that the possible doses would satisfy the exemption criteria of 10 μSv/a for normal use. In some countries (e.g. Bulgaria, Romania, Russian Federation, Serbia) an ICSD containing nuclear materials (e.g. ^{239}Pu) is subjected to authorization.

Paragraph 3.7 of GSR Part 3 [1] also states that “Notification is required for consumer products only with respect to manufacture, maintenance, import, export, provision, distribution and, in some cases, disposal.” This requirement recognizes that the use of consumer products by members of the public is effectively beyond regulatory control and no notification of use is required. However, any person or organization intending to carry out any of the practices specified in the requirement have a duty to notify the regulatory body of their intention to do so. The regulatory body may then consider whether authorization of any of these practices is necessary, taking into account the nature of the product, the associated risks and the prospective individual doses identified in the safety assessment [2].

For example, in France, ICSDs were first used in the 1940s with radium or other sources. Since 1966, the use of ICSDs in France has been forbidden in personal lodging but allowed in industrial or administrative buildings.

This justification of using ICSDs has been reassessed in France in the light of technical developments of other types of detectors. ‘Non-ionizing’ detectors now comply with the essential requirements of national standards and regulations for fire detection. Therefore, ICSDs can no longer be installed in new buildings and at the end of 2011, a transition period was defined to gradually remove the existing ICSDs (7 million detectors assigned to 300 000 installations) [11].

3.2. RADIATION PROTECTION AND INDUSTRIAL SAFETY

3.2.1. Radiation protection

Occupational exposure to radiation can occur as a result of handling, conditioning and storage of disused ICSDs. A radiation protection programme to support disused ICSD management might reflect the specific requirements of the three cases: storage as received, dismantling and recycling. In relation to exposures due to handling several ICSDs, protection and safety is required to be optimized in order that the magnitude of individual doses, the number of people exposed and the likelihood of incurring exposures all be kept as low as reasonably achievable.

Contamination control and radiation monitoring have to be carried out during and after all work.

Although in all cases the IAEA safety requirements in GSR Part 3 [1] need to be followed, there are differences related to training and retraining of workers, for example the level of training for workers performing storage as received is lower that the level of training for the workers dismantling ICSDs, which is part of the broad concept of a graded approach to hazard management. Reference [12] states:

> “DSRS management should identify the relative importance of the various activities, facilities, equipment and DSRS packages in meeting the overall safety, health, environmental, security, quality and economic requirements, with safety and environmental protection being of primary importance.

The application of management system requirements needs to be graded to deploy resources at appropriate levels…"

Workers involved in dismantling disused ICSDs have to be informed about the possible occupational and radiological hazards and can, by their own actions, contribute to protection and safety for themselves and for others at work.

Contamination control of disused ICSDs during dismantling operations is vitally important since it cannot be assumed that the radioactive sources in an ICSD are not damaged. In particular, damaged disused ICSDs have to be carefully monitored before deciding to dismantle them or manage them as-is.

In all cases, workers involved in these operations are trained and qualified in specific radiation protection procedures, which include:

— Use of personal protective equipment (PPE; e.g. mask, gloves, clothes and shoes or overshoes) the type of which depends on the tasks being performed and on the potential hazards (both radiological and conventional).
— Periodic contamination monitoring of the workplace as some old radioactive sources could be leaking and leakage may not be detected during dismantling operations.
— Design or arrangement of the workplace with materials that are easy to decontaminate, for instance no wood or porous materials.
— Simple decontamination methods, graded with the nature and level of contamination and type of material to decontaminate.
— Individual monitoring of occupational exposures, depending on the radiological risk assessment performed for the dismantling operations and the facility conditions:
  - According to the radionuclides and activity ranges of radioactive sources contained in disused ICSDs, external exposure hazard due to dismantling operations is expected to be low; thus, passive dosimetry on a monthly basis would not be necessary;
  - Internal contamination hazard might be low provided PPE are used and periodical contamination control of the workplace is performed.
— Use of radiation protection detection equipment (e.g. dose rate meters, proportional counterprobe for swipe measurement).
— Description of simple methods to minimize secondary radioactive waste, in case of contamination incident.
— Emergency plans: both an off-site plan in case of transport accident (road accident) and an on-site plan in case of fire in the facility where several disused ICSDs are stored and dismantled.
— Generation and maintenance of records related to radiation protection events in the facility.

The workers involved in dismantling operations for disused ICSDs are regularly hands-on trained, due to the various models of ICSDs and the need to get familiar with ICSD model specific procedures. The workers are also required to provide relevant information to the management and to act in a responsible manner with regard to protection and safety.

3.2.2. Industrial safety

In addition to radiological protection concerns, workers have to be informed about the non-radiological risks involved, such as repetitive strain injuries and be trained on necessary protective measures. Training on the safe use of mechanical tools to disassemble an ICSD is required. Hand tools can cause injury if used improperly. Gloves, safety shoes and glasses have to also be worn. The type of PPE depends on the tasks being performed [13].

3.3. SAFEGUARDS CONSIDERATIONS

States conclude safeguards agreements with the IAEA in order to fulfil their non-proliferation commitments in connection with the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) [14]. The IAEA applies safeguards pursuant to three types of safeguards agreements: comprehensive safeguards agreements (CSAs) and additional protocols concluded in connection with the NPT and/or treaties establishing nuclear-weapon-free zones (for ~170 States); item-specific safeguards agreements (for 3 States); and voluntary offer agreements (for the 5 nuclear-weapon States party to the NPT). All information given here is provided as general information for a generic state and all readers are encouraged to read the specific safeguards agreement(s) in force in their state.

Each non-nuclear-weapon State that is party to the NPT is required to conclude a CSA with the IAEA. A model agreement based on INFCIRC 153 (corrected) [14] is published as GOV/INF/276, Annex A [15]. The vast majority of States have concluded CSAs with the IAEA. The rest of this section focuses on the safeguards obligations related to nuclear material when used as an ionization source in ICSDs (e.g. plutonium). This situation is only present in a small fraction of ICSDs and the vast majority will have no safeguards obligations due to their use of other radioactive sources (see Table 1, above).

3.3.1. Safeguards obligations

Under a typical CSA, the State undertakes to accept IAEA safeguards in accordance with the terms of the safeguards agreement on all source or special fissionable material in all peaceful nuclear activities within the territory of the State, under its jurisdiction, or carried out under its control anywhere. The IAEA has the corresponding right and obligation to ensure that such safeguards are applied to all such material for the exclusive purpose of verifying that it is not diverted to nuclear weapons or other nuclear explosive devices.

Nuclear materials subject to safeguards are defined in Article XX of the IAEA Statute:

— Special fissionable material means “plutonium-239; uranium-233; uranium enriched in the isotopes 235 or 233…”[1];
— Source material which includes natural uranium, depleted uranium and thorium in any physical or chemical form.

States with CSAs in force are required to provide information to the IAEA about inventories and flows of all nuclear material and to facilitate access by the IAEA to conduct inspections at facilities and locations where such material is present. Therefore, when managing any plutonium sources, including ICSDs, it is important to ensure the relevant safeguards obligations under a CSA are met. This section describes these obligations in general terms. For a more complete explanation of safeguards obligations, detailed guidance is provided in the Guidance for States Implementing Comprehensive Safeguards Agreements and Additional Protocols (IAEA Services Series No. 21 [16])[2].

Nuclear material, including plutonium contained within an ICSD, continues to be subject to safeguards until such time as it is determined by the IAEA that safeguards can be terminated on such material. INFCIRC/153 (Corr.) [14] states in paragraph 11 that “safeguards shall terminate on nuclear material subject to safeguards thereunder upon determination by the Agency that it has been consumed, or

[1] While ^{238}Pu is not specifically called out in this definition, most ICSDs that use plutonium would not use pure but instead a mixture of ^{238}Pu and ^{239}Pu and would therefore be subject to safeguards.

[2] Many States have concluded an ‘additional protocol’ to their safeguards agreements. Such States undertake to provide additional information and access to the IAEA, to strengthen the effectiveness and efficiency of safeguards. States with very limited quantities of nuclear material may conclude a ‘small quantities protocol’ (known as an SQP) to their CSA, which holds in abeyance or suspends some of the safeguards procedures in Part II of the CSA.

has been diluted in such a way that it is no longer usable for any nuclear activity relevant from the point of view of safeguards, or has become practically irrecoverable."

3.3.2. Steps to take when dealing with Pu ICSDs

When one or more ICSDs with plutonium ionization sources are identified, the first action needs always to be to document the material and secure it to avoid accidental theft or mishandling (i.e. place in a locked room). Once secure, the state or regional safeguards authority needs to be contacted to verify the status of the material. It is possible that the material is in full compliance if the detectors have, for example, a transit exemption from safeguards (i.e. if it still belongs to the originating State) or if they have had safeguards on them terminated. If the material does belong to the State in which it was found, a process to add the material as an accidental gain can be completed per guidance in the Nuclear Material Accounting Handbook (see IAEA Services Series No. 15 [17]). This process is typically pursued under the guidance of the State's safeguards authority in consultation with the IAEA and is generally seen as a normal component of a safeguards programme.

In all cases, however, the main recommendation is to keep the lines of communication open among the location/facility with the item(s), the state safeguards authority and the Agency. This communication will keep everyone informed throughout the process and result in a smoother application of appropriate safeguards for the material. In every case, the steps to remember when dealing with material with an unknown safeguards burden is to secure, document, notify and declare.

4. MANAGEMENT OPTIONS FOR DISUSED ICSDS

4.1. GENERAL APPROACH

Most Member States require authorizations for the supply, transport, handling (installation, maintenance and decommissioning) of ICSDs and these operations are typically conducted by authorized workers/companies.

The basic radiation safety regulatory approaches for ICSDs are summarized in Table 2.

TABLE 2. REGULATORY APPROACHES FOR ICSDs AND DISUSED ICSDs

Example Member State (see annexes or References)	Is the (bulk) manufacture, import, installation, transport of ICSDs subject to control?	Is the use of ICSDs controlled?	Is the collection and management of disused ICSDs under regulatory control?	Installation type
Canada, United States of America[a] [18], Australia[b] [19], Argentina	Yes	No	No	Household
Canada, United States of America	Yes	No	Yes	Industrial Institutional

TABLE 2. REGULATORY APPROACHES FOR ICSDs AND DISUSED ICSDs (cont.)

Example Member State (see annexes or References)	Is the (bulk) manufacture, import, installation, transport of ICSDs subject to control?	Is the use of ICSDs controlled?	Is the collection and management of disused ICSDs under regulatory control?	Installation type
Algeria, Austria, Belarus, Belgium, Bosnia and Herzegovina, Brazil, Bulgaria, Burkina Faso, Chile, China, Côte d'Ivoire, Croatia, Cuba, Cyprus, Czech Republic, Denmark, Ecuador, Egypt, Estonia, Finland, Germany, Georgia, Ghana, Greece, Hungary, Indonesia, Islamic Republic of Iran, Latvia, Libya, Lithuania, Luxembourg, Malaysia, Mauritius, Moldova, Mongolia, Morocco, Montenegro, Nicaragua, Nigeria, North Macedonia, Philippines, Poland, Portugal, Romania, Senegal, Serbia, Slovakia, South Africa, Spain, Syrian Arab Republic, Thailand, Uruguay	Yes	No	Yes	Industrial Institutional
Slovenia	Yes	Yes (notification)	Yes	Industrial Institutional
France, Czech Republic[c] [20]	Yes and installation of new ICSDs is prohibited	No	Yes	Household Industrial Institutional
Albania, Luxembourg (since 1994)	Import and use of ICSDs is prohibited			

[a] In the United States of America, household disused ICSD management requirements vary from state to state.

[b] In Australia, radiation safety regulation of ICSD disposal depends on the quantities involved.

[c] Applies to autonomous ICSDs (ICSDs that are not a part of a central fire system).

The manufacture, export, import, installation and transport of bulk quantities of ICSDs are subject to authorization. The use of ICSDs is commonly not subject to radiation safety regulation. The collection of ICSDs from public, industrial and institutional places, as well as the further management as radioactive wastes is a common practice in many Member States.

Some Member States do not have centralized collection of households disused ICSDs since their safety assessments on the disposal of disused ICSDs in their landfills have shown that the radiological risk to the public is acceptable. Therefore, in these Member States, the disposal/management of household disused ICSDs is not subject to radiation safety regulation (Table 2).

The landfill facilities can vary considerably, both in their design and in the degree to which operations are controlled. At one extreme, operations may be carefully controlled, with prompt covering of disposed material at the end of each working day, preventing any human contact with the waste (Fig. 8). At the other extreme, such disposal might consist of little more than loose tipping onto a ground surface with final cover only being applied after some delay. In this case, consideration might be given to the possibility of scavenging as an exposure scenario (Fig. 9).

Safety assessments are required to be conducted so as "To determine the expected likelihood and magnitudes of exposures in normal operation and, to the extent reasonable and practicable, to make an assessment of potential exposures" (see GSR Part 3 [1], para. 3.31(b)). This has a particular relevance

FIG. 8. Example of a well managed landfill where daily waste emplacements are covered.

FIG. 9. A landfill where waste is not covered at the end of each day's operation (left) and waste pickers often scavenge for still-usable materials (right).

to consumer products, for which an individual dose of 10 μSv or less in a year is one of the criteria to be used in deciding on the exemption of practices from regulatory control [2]. In the case of consumer products, a review of the safety assessment could result in a decision by the regulatory body that their provision to the public no longer meets the criteria for exemption [2].

Centralized collection and dismantling of disused ICSDs is carried out by several Member States to separate the radioactive components from non-radioactive components to minimize the amount of radioactive waste for storage and/or disposal.

For the selection of the long term management of disused ICSDs, some important issues need to be considered:

- ICSDs (as consumer products) are considered to be beyond effective regulatory control after provision to members of the public. It is therefore inferred that there will be landfill disposal of ICSDs with household waste. The summary Table 2 shows that, apart from their use, the management of ICSDs (including import, transport, installation, removal, storage and disposal) is regulated in most countries.
- The accumulation of ICSDs in landfills, depending on how a landfill is operated, may pose a radiological hazard and the landfilling of ICSDs may have to be subjected to a safety assessment before implementing the practice — see GSR Part 3 [1] and SSG-36 [2] which states in paras 4.40–4.41: "…in practice States may need to place restrictions on the available disposal options for certain types of consumer product. …These restrictions may be put in place to minimize the amount of radionuclides present in the environment that are not under proper control…".
- If, after the end of their useful lifetime, consumer products are to be collected for disposal, they may need to be treated collectively as radioactive waste. In such circumstances, the safety requirements in the publications IAEA Safety Standards Series No. GSR Part 5, Predisposal Management of Radioactive Waste [21] and IAEA Safety Standards Series No. SSR-5, Disposal of Radioactive Waste [22] will apply [2].

Options for the long term management of ICSDs are related to a Member State's regulatory framework. They are:

- Disposal of intact ICSDs in landfills, for instance, by individual users.
- Storage or disposal of intact or partially dismantled ICSDs (with source chamber intact) as radioactive waste in licensed facilities and recycling or disposal of any removed, non-active components in non-regulated facilities.
- Dismantling of ICSDs (with the radioactive source recovered from the chamber) and management of the components as follows:
    - Clearance and disposal of non-radioactive components in non-radiation safety regulated facilities;
    - Storage and/or disposal of contaminated components and secondary waste in licensed facilities;
    - Conditioning, storage and/or disposal of DSRS in licensed facilities;
    - Reuse of DSRS;
    - Recycling of radionuclides recovered from DSRS.

4.2. DISPOSAL OF ICSDS IN LANDFILLS

Ionization chamber smoke detectors are available to the public as a consumer product. Consumer products are considered to be beyond effective regulatory control after provision to members of the public. The safety assessment is supposed to assume that there will be landfill disposal of consumer products with household waste. The possible doses that could arise due to exposure via various exposure pathways following such disposal have to be assessed. This assessment will estimate the total numbers of the specific consumer products that are likely to be disposed of [2].

The accumulation of consumer products at a waste disposal facility or recycling facility may present a potential radiological hazard and may have to be subject to a safety assessment — see GSR Part 3 [1] and SSG-36 [2].

The safety assessment considers the total numbers of ICSDs that are likely to be disposed of in certain period of time and the processing of the waste at the landfill then estimates the possible dose to workers at the landfill site and to members of the public who visit the landfill or live nearby. If a safety assessment demonstrates that doses to the workers at landfill facilities and members of the public are in the range of about 10 μSv/a, the regulatory body may exempt ICSDs from regulatory control. This option is followed in Canada, some states in USA and for household ICSDs in Australia.

In Australia, individual (or small numbers of) ICSDs can be safely disposed of in domestic rubbish. The amount of radioactive material in each ICSD is extremely small. From environmental and public health perspectives, the disposal of individual ICSDs with domestic rubbish does not represent any risk. When more than ten ICSDs (or more particularly, the americium-241 sources) are collected together for bulk disposal, they have to be treated as radioactive waste and the national requirements for the near-surface disposal of radioactive waste in Australia have to be met [23].

More than half a million ICSDs for domestic use were sold in Sweden on an annual basis. The number of discarded ICSDs per year was likely to be in the same range. The public was allowed to dispose their ICSDs together with domestic waste, whereas companies are allowed to dispose up to five ICSDs per month at the landfill [24]. New regulations came into power in 2008 stipulating that the discarded ICSD units from domestic use are to be collected and shipped for disassembly and the discarded ICSD units from industrial use should be handled as radioactive waste and returned to the supplier or manufacturer [25].

In the interest of harmonizing the approaches among States, some guidance on justification and application of the criteria for exemption from regulatory control for consumer products has been provided in a number of IAEA publications: IAEA Safety Standards Series No. GSG-12, Organization, Management and Staffing of the Regulatory Body for Safety [26], IAEA Safety Standards Series No. GSG-17, Application of the Concept of Exemption [27], SSG-36 [2] and GSR Part 3 [1]. The process of justification and the application of the provisions for exemption to consumer products are not straightforward, and this has resulted in different approaches being adopted in different States.

4.3. COLLECTION OF DISUSED ICSDs

4.3.1. Collection of disused ICSDs by manufacturers and recycling companies

Some states in the USA do not allow ICSDs to be disposed of with municipal waste. In this case, ICSDs that contain radioactive material can be returned to the manufacturer for disposal. There are clear instructions on how to return the ICSDs to the manufacturer (Fig. 10).

There are several companies around the world offering services for the collection and recycling of disused ICSDs (Fig. 11).

4.3.2. Centralized collection of disused ICSDs

The approach to disused ICSD management in various Member States is to recover and transfer them to a centralized collection facility or facilities, with the option to dismantle them at authorized facilities to minimize the volume of radioactive waste and recover their DSRS and condition them for long term storage and/or disposal. The non-radioactive materials (plastic, metal and electronic components) are managed according to national regulations (for recycling and disposal):

Greece collects disused ICSDs in a centralized storage facility operated by the Institute of Nuclear and Radiological Sciences & Technology, Energy & Safety of the National Center for Scientific Research 'Demokritos' [28].

In Portugal, disused ICSDs are centrally collected and managed at the Radioactive Waste Interim Storage Facility at the Nuclear and Technological Institute located in Sacavem [29].

In Spain, disused ICSDs are centrally collected and managed by Enresa which is the Spanish organization responsible for the management of radioactive waste. ICSDs are considered a type radioactive waste that, because of their characteristics, require special management [30].

Smoke Detector Disposal Information

The most common type of smoke detector used in residential homes contains a minute amount of radioactive material*. Although the amount of radioactive material contained in these detectors is so small that it does not pose a risk to human health, some localities, including Santa Barbara, do not allow them to be disposed of with municipal waste. In this case, smoke detectors that contain radioactive material can be returned to the manufacturer for disposal. When returning a smoke detector to the manufacturer, include a note that indicates that the detector is intended for disposal and mail it to the address listed on the back of the detector.

The following manufacturers/distributors of smoke detectors will take back smoke detectors that they manufacture:

MANUFACTURER/ DISTRIBUTOR	PHONE NUMBER	ADDRESS FOR RETURN	NOTES
AMERICAN SENSORS/ DICON	(800) 387 4219	Call to receive a reference number and return information	Accepts "Dicon" and "American Sensors" brands only
AMWAY CORPORATION	(616) 787-6000	7575 East Fulton Street ADA, MI 49355	No longer manufacturing smoke alarms
FIRST ALERT/ BRT	(800) 323-9005	Customer Service Department 3920 Enterprise Court Aurora, IL 60504	Accepts up to four detectors at a time
G.E. SECURITY/ ESL	(503) 692-4052	12345 Southwest Levetan Drive Tualatin, OR 97062	Will accept "ESL" brand only
HONEYWELL	(800) 328-5111	Returned Goods, Honeywell Inc. Dock 4-MN10-3860 1885 Douglas Drive Golden Valley, MN 55422	cstrcare@honeywell.com
INVENSYS/ FIREX	(800) 445-8299	Invesys Controls c/o Firex 28 C Leigh Fisher Boulevard El Paso, TX 79906	technicalservice@invensys.com
KIDDE	(800) 880-6788	1394 South 3rd Street Mebane, NC 27302	
SEARS	local number	Some Sears locations are designated collection sites	Call to find out if your local Sears will accept smoke detectors
SYSTEM SENSORS	(800) 736-7672 ext. 1	Call to receive a reference number and return information	Will accept "System Sensor" brand only
USI ELECTRIC	(800) 390-4321	7A Gwynns Mill Court Owings Mills, MD 21117	Return only detectors that say "ionization" on the back

FIG. 10. Example of information to the public on how to return disused ICSDs to the manufacturers in some states in the USA (courtesy of City of Napa, USA).

FIG. 11. Example of a company offering services of collection, recycling and disposal of ICSDs (courtesy of STEP, Germany).

In Ghana, disused ICSDs are centrally collected and managed by The National Radioactive Waste Management Centre of the Ghana Atomic Energy Commission [31].

In Switzerland, disused ICSDs are centrally collected by the Paul Scherrer Institute which operates the National Collection Center for all resulting radioactive waste from Medicine, Industry and Research in Switzerland. Waste originating from nuclear power plants is not stored at the Paul Scherrer Institute [32].

In Austria, the preferred management option for DSRS is returning them to the manufacturer. If disused sources cannot be returned to the manufacturer and recycling (i.e. reuse by a third party) is also not possible, they are centrally collected at Nuclear Engineering Seibersdorf for storage or for treatment as radioactive waste. This also includes ICSDs [33].

In Brazil, americium-241 is used in the manufacture of ICSDs. Although each device has an exempt activity (less than 10 kBq), companies that install and replace ICSDs handle tens or hundreds of them each time. So, disused ICSDs are being collected as radioactive waste [8].

In Finland, there are currently over 3 million ICSDs in use. The disposal of an individual detector into normal municipal waste was earlier considered, from the radiological point of view, as the optimum waste management option. However, the Council Directive 2002/96/EC (on waste electrical and electronic equipment) of 27 January 2003 defines disused ICSDs as waste electronic equipment subject to recycling requirements. Today, a private entrepreneur takes care of removing the radiation sources from recycled ICSDs and hands them over to an installation licensed to receive, condition and transfer radioactive waste to a central storage operated by the Radiation and Nuclear Safety Authority [34].

An increased number of household ICSDs containing Am-241 are collected at the local scrap yards as they are being replaced by photoelectric smoke detectors. The Danish Health Authority, Radiation Protection, has instructed local scrap yards to collect these with the electronic waste. That waste is subsequently collected by one of three licensed recycling companies which holds the responsibility of separating ICSDs and delivering them to the Waste Management Facility the Danish Decommissioning. Industrial ICSDs are either delivered directly to the waste management facility or returned to the manufacturer through the importing company. At the waste management facility, Am-241 sources are taken out of the ICSDs and stored in dedicated waste containers, ready for further management [35].

Section 5.1 of this publication provides a brief overview of the dismantling process for various disused ICSDs (such as solid versus gaseous SRS, single versus multiple SRS). Additional models and detailed dismantling procedures are provided in the ICSD database (see Section 2). Since the highest radiological risk to members of the public from ICSDs is the unauthorized dismantling of their ionization chambers [2], the dismantling procedures are available only to IAEA authorized users.

In recognition that many Member States may not have the radioactive waste management infrastructure to address the issue of disused ICSDs within their territory, this publication discusses:

— Components of a suitable waste management infrastructure;
— Dismantling disused ICSDs after collection (pre-collection activities are out of scope);
— Conditioning of DSRS;
— Packaging of DSRS removed from disused ICSDs;
— Storage and/or disposal of DSRS and secondary (mainly non-radioactive) waste.

The handling and dismantling of disused ICSDs and the subsequent management of their DSRS and secondary waste requires skilled workers with an appropriate level of technical knowledge and practical experience, trained and authorized to conduct such operations. Understanding of the design, construction and mounting of the source in the ICSD and the design and function of the device itself are also important considerations. The generation of radioactive waste needs to be kept to the minimum that is reasonably practicable, both in terms of activity and volume, during dismantling of the ICSDs. The DSRS and secondary waste have to be safely managed, including in the long term.

4.4. MANAGEMENT OF DISUSED ICSDS AT A CONDITIONING AND/OR STORAGE FACILITY

This section discusses the management of ICSDs that become disused or that is being replaced with non-ionizing detectors. All the relevant national regulations need to be considered and provisions made for their application.

This section presents an overview of the hazards associated with various stages of disused ICSD management. The various stages of management have to be conducted according to all applicable waste management and radiation safety regulatory requirements. There are three cases that may not be completely independent and may overlap. These three cases cover both the near term and long term management of ICSDs, unlike the options in Section 4.1 which cover only long term management. A Member State could do any or all of the following:

(a) Collect and store ICSDs as received, awaiting a decision on their further management;
(b) Collect and dismantle ICSDs and assure the long term management of both the recovered DSRS within its holder and secondary wastes;
(c) Recover the radionuclides from the recovered DSRS for recycling and assure the long term management of secondary wastes.

Options (a) through (c) above represent increasing risk of radiation exposure and, therefore, require increased radiation protection programmes.

4.4.1. Hazards associated with managing disused ICSDs

This section discusses the hazards that may be associated with the centralized collection and management of ICSDs. While applicable to all three cases (store as received, dismantling and recycling radionuclides) the hazards listed below have different risk levels. For example, radiation risks for radionuclide recycling is higher than for storage as received. In addition, not all hazards below apply to all cases, for example, damage during dismantling does not apply to material that is store as received.

Only non-routine situations associated with ICSD management, starting with their receipt at collection facilities after transport, are discussed herein. For hazards associated to transport and the corresponding preparedness, the reader might consult IAEA Safety Standards Series No. SSR-6 (Rev.1), Regulations for the Safe Transport of Radioactive Material [36], as well as IAEA Safety Standards Series No. SSG-65, Preparedness and Response for a Nuclear or Radiological Emergency Involving the Transport of Radioactive Material [37]. Information on the radiation doses that might typically be received by members of the public from normal use, incidents, misuse and disposal of ICSDs, is provided in annex V of SSG-36 [2].

(a) A damaged ICSD is received

If an ICSD is visually identified as damaged during the process of receiving multiple ICSDs, the options are:

— Check the damaged ICSD for contamination and, if no contamination is detected, dismantle the ICSD per standard operating procedures;
— If contamination is detected, (a) manage the ICSDs as radioactive waste as received or (b) if the procedures and facilities allow for its safe dismantlement, dismantle the contaminated ICSDs. Decontamination procedures for the work area may have to be carried out;
— Whether or not contamination is detected, one option is to segregate damaged ICSDs and then manage them together in a campaign.

National experience shows that receipt of damaged ICSDs is very uncommon. It is even less likely that the source has been damaged even if the ICSD is damaged. Multiple damaged ICSDs can arise from cases, for example, where they were recovered from a building that had been destroyed.

(b) An ICSD is damaged during dismantling

If an ICSD is damaged during dismantling, the SRS may or may not be damaged. Some possible response scenarios are:

— If a gaseous SRS is damaged (^{85}Kr), leave the area and wait for the air to clear according to written procedures. The standard procedure to dismantle disused ICSDs with gaseous SRS typically includes the use of a ventilated hood.
— For non-gaseous SRS, check for contamination (e.g. using a swipe test. If there is no contamination, continue with standard dismantling). If there is a spread of contamination, wrap the entire ICSDs and treat it as radioactive waste. Decontaminate the work area as needed.

(c) Risks associated with many DSRS in one package

If many DSRS are stored in one package, there is a risk of damaging the sources (e.g. by rubbing/friction on each other) and spreading contamination within the package. This can result in the spread of contamination and exposure to workers if packages are open or reopened.

In some cases, higher dose rates can be expected from packages if a large number of sources are stored (notably ^{85}Kr and ^{226}Ra).

The use of smaller, sub-packages (e.g. 1 L cans or capsules) inside the main package (e.g. a 200 L drum) can help mitigate the risks associated with having many DSRS in the main package (Fig. 12).

(d) A DSRS is lost during dismantling

Because of the design of common DSRS (small discs, foils, needles, threads) with only few millimetres in dimension, the risk of loss of a source during dismantling is not negligible. This is another reason to not remove sources from their holders; see the two options for Case B in Section 4.2, since it would be easier to locate a DSRS in its holder.

(a) (b)

FIG. 12. Examples of different container sizes for DSRS packaging: (a) small packages for future overpacking (Chile) and (b) DSRS and secondary radioactive waste in 200 L drums (Philippines).

FIG. 13. Example small tray work area design to minimize the loss of DSRS during dismantling.

The arrangement of the workplace has to be designed “to prevent the loss of, or the loss of control over, a radioactive source or other source of radiation” (para. 1.18 of GSR Part 3 [1]). For example, by using a small tray to work upon, as shown in Fig. 13.

(e) An ICSD is received without the SRS

Sometimes an ICSD that has no SRS can be received, for example, during manufacturing there was an error and the SRS was not incorporated. It is also possible that the received smoke detector is not an ICSD. There is obviously no direct health risk in the facility for this situation.

Depending on the situation and on national laws and regulations, this situation may have to be reported to the regulatory body. It reinforces that accurate record keeping is essential; see Sections 5.2.5 and 5.3.5.

(f) The number of ICSDs received does not match the number specified by the sender

Any discrepancy in the number of ICSDs is recorded. Depending on the situation and on national laws and regulations, this situation may have to be reported to the regulatory body. This further reinforces that accurate record keeping is essential.

(g) An unknown ICSD is received

In the case of receiving unknown models/types or unlabelled ICSDs, the internal structure and radionuclide/activity are not known; therefore, extra caution is needed during dismantling. Searches for supporting documentation are important to assist dismantling. A key source of information is the ICSD database [10]. Record keeping is important; for example, including photographs and drawings. In the case that a Member State encounters an ICSD which is not in the ICSD database, they are encouraged to collect all details and provide the information to the IAEA contact point for the ICSD database (under DSRSNet[3]).

[3] See: https://nucleus.iaea.org/sites/connect/DSRSpublic/Pages/default.aspx

4.4.1.1. Industrial hazards

Besides the radiological hazards and risks, there may be industrial hazards such as:

— Cuts from sharp parts (e.g. source holders, circuit plates and metal parts);
— Repetitive strain (ergonomics need to be considered);
— Injuries (e.g. hernias) from lifting heavy weights (boxes, drums) — forklifts may be required for transportation pallets;
— Damage or injuries (e.g. from falling objects);
— Inhalation of dust (from opening old or very dirty ICSDs);
— Biological and chemical hazards (e.g. ICSDs from medical use, laboratories and research facilities).

4.4.2. Collect and storage of ICSDs as received (Case A)

An option, pending further management, is to remove ICSDs from where they were installed, transfer them to a centralized collection point or multiple collection points where they are stored as received, see Fig. 14. The first actions are to review the records provided with the ICSDs, confirm the right number of ICSDs that were received and check for damage and radioactive contamination. From the operational records held at the facility (reception of radioactive waste and/or DSRS, segregation, storage records, etc.) it will be possible to gather information on the stored ICSDs, such as:

— Origin (where the ICSDs were installed);
— Manufacturer;
— Model;
— Radionuclide;
— Activity (Bq).

If no records are provided with the ICSDs, the receiver will identify the radionuclide(s) and determine or estimate their activity(ies).

If an ICSD appears seriously damaged, it will be checked for contamination, put in a plastic bag and the information recorded.

If many units of the same model of ICSD are received, it may only be necessary to record the information above and indicate that it applies to the number of units received, excluding damaged units.

Individual ICSDs might be consolidated (e.g. placed into containers). Consolidating ICSDs by model is a good practice, as it will facilitate subsequent operations (segregation, dismantlement,

FIG. 14. Example of collection of ICSDs by model in separate containers.

FIG. 15. Example of labelled drum containing ICSDs (courtesy of the National Nuclear Energy Agency, Indonesia).

source recovery, management of secondary wastes). As a minimum, records for these containers would include the following:

— Package ID;
— Package inventory (number of ICSDs, model number(s), total radionuclide inventory(ies)).

Containers have to be suitable for the conditions and duration of storage (e.g. corrosion resistant) and durable, with legible labels affixed, see Fig. 15. See Ref. [7] for additional guidance on storage.

4.4.3. Collect and dismantle ICSDs, recover DSRS within their holder (Case B)

Clear criteria are needed for implementing extra precautions over those of Case A. For example, masks may be required if ventilated hoods are not available, which might result in contamination levels being higher than expected.

The minimum requirements to be met are:

— Based on a safety assessment according to planned exposure situations, work procedures/guidance for contamination control and industrial safety and radiation protection and waste management programmes have to be developed by an authorized person or organization [1, 38].
— The establishment of designated areas for storing, dismantling and packaging. This can be a dedicated room in an existing building. Access control may only be needed to the overall workplace.
— Waste segregation procedure(s) and suitable labelled containers need to be available to separate non-radioactive waste, radioactive secondary wastes and recovered DSRS. Batteries need to be managed separately as required by local regulations.
— Records need to be kept for (see Section 5):
  • The ICSDs received, as described previously;
  • Packages with DSRS;
  • Packages with radioactive secondary wastes.
— After consolidation and packaging of the DSRS and secondary wastes, they are either stored at the dismantling site or transported to off-site storage or disposal facilities. See Section 5 for additional information.

For dismantling, there are two options: (1) The ICSDs could be dismantled down to the level of removing the source within its holder or ionization chamber; or (2) The actual source (e.g. the foil for Am or capsule for Pu) could be removed (the latter is only applicable to recycling the source's radionuclides).

FIG. 16. Tens of ^{241}Am sources within their holders removed from ICSDs.

For dismantling option 1 (Fig. 16), the spread of contamination is possible but unlikely and, therefore, radiation protection procedures are less stringent, for example only periodic contamination swipes could be taken.

For option 2, the spread of contamination is likely, therefore, more stringent radiation protection measures are needed, such as working in a glovebox, more frequent contamination checks, air monitoring, etc. Removal of foils or capsules without the intent to recycle the radionuclides may not serve to minimize volumes of radioactive wastes

A practical management option for disused ICSD sources that provides an example of specific technical procedure for handling and conditioning of ^{241}Am sources for long term storage is presented in Ref. [7]. The described management option does not rely on a complex infrastructure. For this reason, this practical approach can be implemented in every waste treatment facility including those in Member States with less developed nuclear infrastructure [7].

The National Institute for Radio-Elements in Belgium operates as a subcontractor of the national organization for the management of the radioactive waste known as ONDRAF/NIRAS for the dismantling of the DSRS including ICSDs [7]. More than 40 different types of ICSD have been dismantled in their facilities [7].

The Institute of Energy and Nuclear Research in Brazil has received thousands of disused ICSDs [39]. Over 49 000 radioactive sources have been recovered from ICSDs and are currently safely stored awaiting for a decision on their final disposal [40, 41].

The safe management of disused ICSDs in Cuba consists of dismantling the devices, recovering the radioactive sources and conditioning them for long term storage and disposal. As of 2013, over 5300 ^{241}Am sources recovered from ICSDs were conditioned in stainless steel capsules (total activity of 160 MBq) and placed within a concrete lined drum [42].

4.4.4. Collect and dismantle ICSDs, recover DSRS for recycling/disposal (Case C)

Clear criteria are needed for implementing extra precautions over those of Case B. This may require a higher level of radiation protection due to a higher risk of contamination.

- These activities need to be performed by qualified workers only using approved technology(ies) and procedures (details of the technology(ies) are out of the scope of this publication);
- Record keeping is essentially as for other cases but may include recording of any toxic or hazardous materials associated with, for example, dissolving DSRS foils to recover radionuclides.

A clear cost-benefit analysis is essential for Case C since it likely results in significant secondary waste with associated costs in addition to increased radiation and industrial hazard.

5. ICSDS DISMANTLING PROCEDURES AND LONG TERM MANAGEMENT OF RECOVERED DSRS

5.1. GENERAL DISMANTLING PROCEDURE

The steps that follow describe a general procedure for the removal of a DSRS within its holder for a generic ICSDs (Case B, see Section 4). Modification of these steps is necessary to adapt to specific models and designs.

The following does not discuss radiation and industrial protection procedures since these are discussed elsewhere in this publication. For clarification purposes, a variety of photos follow the steps below to illustrate the various stages of dismantling disused ICSDs.

(1) Select a specific number (pre-counted) of similar model ICSDs for dismantling and the relevant tools (which may be unique and specific), equipment and procedure(s);
(2) Physically examine the ICSDs to ensure that there is no damage (see Section 4.2 regarding the management of damaged units);
(3) Remove the device cover to access the ionization chamber and circuit board assembly which may require screw removal, simple twisting or breaking off the outer assembly;
(4) Remove or dismantle the ionization chamber (or cover plate) using special tools if required;
(5) Separate the DSRS within its holder or mounting plate from the circuit board if possible, or manage these together if they cannot be separated;
(6) Put the DSRS within its holder into a collection container;
(7) Destroy (cover up) any radiation symbols (e.g. trefoil or caution labels) on the non-radioactive components;
(8) Separate the non-radioactive and radioactive secondary wastes into appropriate bins (i.e. metals, plastics, batteries and electronics);
(9) Repeat this procedure for the next device in the group (see Section 6, Lessons Learned, for optimizing the workflow);
(10) After completion, ensure that the necessary information is recorded so that, for example, the total number of DSRS and total activity can be properly tracked.

In addition to this general procedure for the removal of DSRS in their holders, specific information including photographs and manufacturer specifications may be referenced as needed to ensure that the dismantling process is clearly understood and safely done.

Currently in its ICSD database, the IAEA is compiling model specific information, including dismantling procedures, that are useful for managing the wide variety of disused ICSDs that are found in Member States [10]. This information is extremely useful to groups or organizations tasked with consolidation, dismantling and packaging of disused ICSDs. Only IAEA authorized users will be able to access these dismantling procedures.

The following photographs illustrate various stages of disused ICSD dismantling, taken from actual dismantling procedures.

Step 1: Select similar ICSD models for dismantling campaigns (to work on one model at a time), see Fig. 17.
Step 2: Remove the ICSD cover to access the ionization chamber and circuit board assembly, see Fig. 18.
Step 3: Remove or dismantle the ionization chamber, see Fig. 19.
Step 4: Separate the DSRS within its holder from the circuit board (if possible), see Fig. 20.
Step 5: Put the DSRS in collection containers, see Fig. 21.
Step 6: Destroy or cover up any radiation symbols (trefoil or caution label) on the non-radioactive components, see Fig. 22.
Step 7: Separate secondary waste into appropriate bins, see Fig. 23.

(a) Model with a single SRS/radionuclide.

(b) One model that uses a ^{226}Ra or ^{241}Am SRS.


(c) Model with a single SRS, ^{85}Kr gas.

(d) Model with a single radionuclide/multiple SRS, ^{241}Am.

FIG. 17. Examples of ICSD models with different radionuclides and number of sources.

FIG. 18. *ICSDs without the plastic cover.*

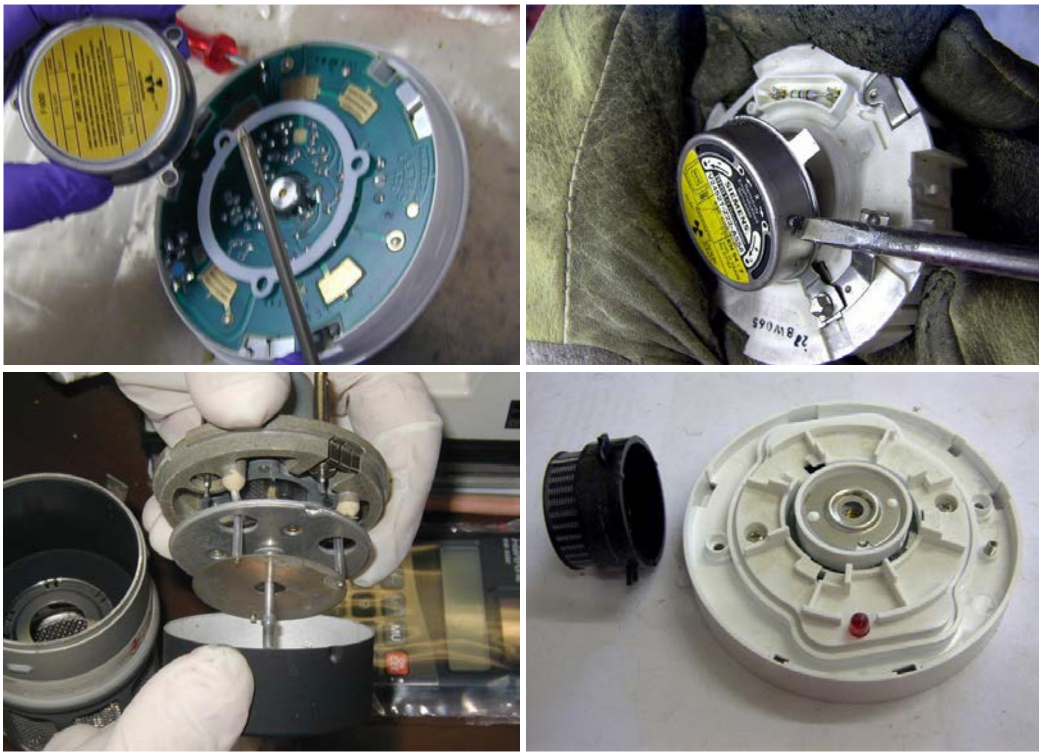

FIG. 19. *Opening the ionization chamber.*

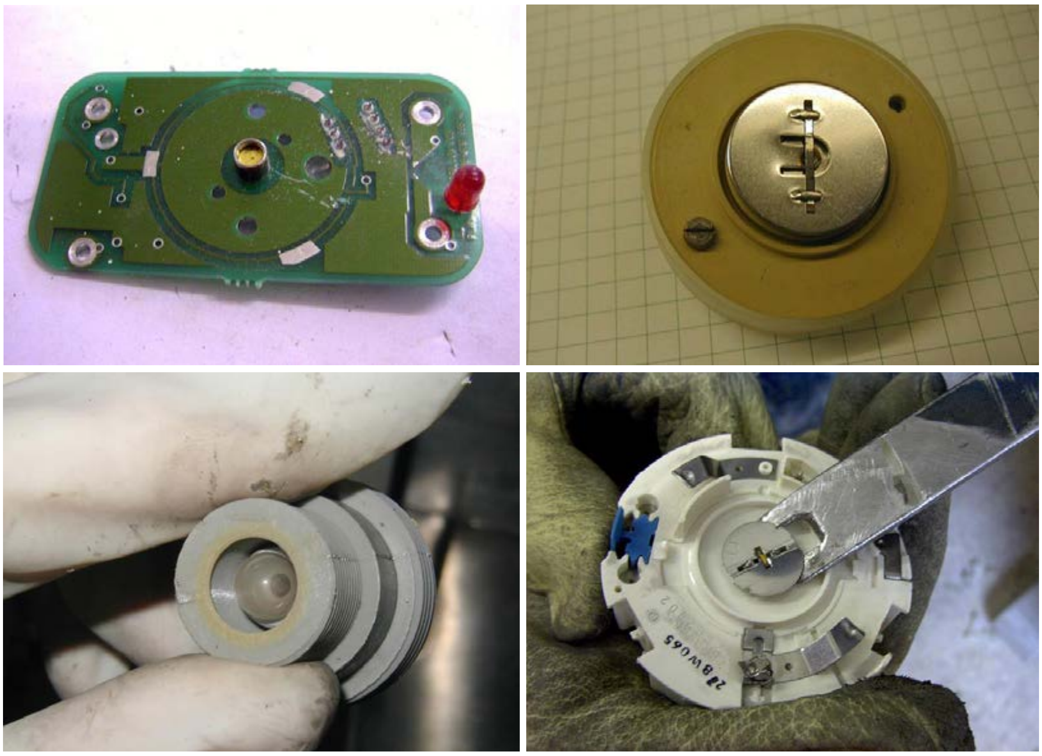

FIG. 20. The DSRS within its holder (courtesy M. Kinal, RME, Germany).

(a) (b)

FIG. 21. Examples of collection containers for DSRS: (a) appropriate collection containers after a dismantling campaign (courtesy of the Centre for Radiation Protection and Hygiene, Cuba) and (b) temporary collection container during dismantling (courtesy of the Philippine Nuclear Research Institute, Philippines).

FIG. 22. Removing the radiation symbols (courtesy of the Centre for Radiation Protection and Hygiene, Cuba).

FIG. 23. Examples of containers for secondary waste (courtesy M. Kinal, RME, Germany).

5.2. CONDITIONING AND PACKAGING

As recommended in the supplementary Guidance on the Management of Disused Radioactive Sources [43], the disused sources (recovered from the ICSDs) to be stored in a long term storage facility have to be properly conditioned as required by the regulatory body and comply with applicable acceptance criteria.

Conditioning of DSRS and radioactive secondary wastes needs to consider that waste acceptance criteria of the facilities for their future management (e.g. in disposal facilities) may not yet be specified. Uncertainty about the end point may not be used as a rationale for not taking steps to ensure that the recovered DSRS from ICSDs are managed in a safe and environmentally acceptable manner pending disposal. Conditioning requirements are normally limited to packaging requirements. Embedding DSRS in a matrix such as cement is generally not advisable. Packaging needs to allow for easy retrieval of sources at a later time, such as placing DSRS into smaller containers (e.g. stainless steel capsules) inside a main package (e.g. 200 L drums). See Fig. 24.

Best practice includes limiting package contents to a single radionuclide, such as packaging ^{241}Am DSRS separately from ^{226}Ra DSRS. Some of the various practices in Member States follow.

FIG. 24. The recovered DSRS are conditioned in a stainless steel capsule inside a concrete lined 200 L drum for storage in a retrievable manner.

Since 2012, the Slovenian agency for radioactive waste management (ARAO) has carried out dismantling of ICSDs as a regular activity. The volume reduction factor of this treatment is so significant that, despite the continuous receipt of new waste, the volume of radioactive waste in the storage facility has been only very slightly increasing [44].

Greece collected disused ICSDs in the centralized storage facility operated by the IINRASTES of the NCSR'D'. The disused ICSDs containing ^{241}Am sources are dismantled on a bench using local ventilation. Before dismantling, smear samples are taken close to the source and measured by a portable contamination monitor. If contamination is detected, the dismantling of the device needs to be performed inside a glove box [28].

Thailand recovered and conditioned over 3000 DSRS from ICSDs at the Radioactive Waste Management Center of the Thailand Institute of Nuclear Technology [45].

In Poland, the ICSDs containing plutonium sources are dismantled and the plutonium sources separately immobilized in a 1 dm^3 metal box using polyester resin. The metal boxes are subsequently placed in 50 dm^3 zinc-plated metal drum and cemented [46].

In the Philippines, examples of conditioning the ^{241}Am sources from ICSDs for different purposes (storage/disposal, as well as for removal for recycling/reuse in another country) is described in the national in Annex XIII of this publication.

5.2.1. Equipment and material

For packaging, the following may be needed:

Equipment:

— Personal dosimeters (whole body and finger ring dosimeters);
— Electronic personal dosimeter (EPD);
— Beta and gamma dose rate meter;
— Alpha contamination handheld monitor (pancake probe);
— Hand and foot/body monitor for contamination check on exiting the control area;
— Adjustable lamp;
— Labels (for transportation and storage), see Section 5.2.2;
— Crimpers or wrenches for attaching drum lids;
— Welding machine;
— Hand truck or forklift truck.

Tools:

— Tongs, various lengths;
— Forceps, various lengths;
— Tweezers, various lengths;
— Basic mechanic hand tools (set of screwdrivers, set of wrenches, set of pliers, adjustable wrenches, hex/Allen keys, hammers);
— Pipe cutter;
— Strap wrench set;
— Screw extractor set;
— Punch and chisel set;
— Lifting slings;
— Lifting shackles and clevises;
— Drill press, set of metal drill bits, standard and metric;
— Air compressor and pneumatic tool assortment;
— Battery operated screw gun;
— Battery operated drill;
— Battery operated and corded reciprocating saw;
— Metal chop saw;
— Flashlight;
— Magnifying glass;
— Pallets.

Materials:

— Lead bricks and/or lead sheets;
— Lead glass shield;
— Lead containers/pots for source segregation;
— Thick plastic sheet;
— Working tray;
— Plastic bags;
— Masking tape;
— Duct tape;
— Detergent and/or another decontamination solution;
— Lab coats, coveralls, etc.;
— Safety shoes;
— Work gloves;
— Dust masks;

— Absorbent paper;
— First aid kit;
— Smears to use for contamination surveys;
— Welding mask for welding operations;
— Negative pressure hood;
— Fire extinguisher.

Containers:

— Lead shielded long term storage containers;
— Concrete lined drums;
— Type A containers for transportation of DSRS to the storage/conditioning facility;
— Stainless steel capsules for source conditioning;
— Handling tools for capsules;
— Holder for the capsules to put into or remove from drums.

5.2.2. Marking and labelling of packages

As a minimum, each container with radioactive materials needs to have a label that indicates the information listed below or have a unique ID that references the information listed below within a record management system. Requirements specified by storage/disposal operators also need to be considered.

— A unique ID;
— Radionuclide(s) and their total activity(ies) in becquerels;
— Dose rate at surface;
— Packaging date (date package closed);
— At least one radiation warning symbol (e.g. trefoil symbol).

Durable labels, such as engraved or stamped aluminium or stainless steel panels placed in suitable positions both within (secured to small containers in the main container) and secured to the outside of the main container, are recommended for long term storage (e.g. decades).

5.2.3. Safety and security considerations

Radiological and industrial safety considerations for packaging activities fall within the overall scope of disused ICSD management described in Section 3.2. Radiation and contamination levels of packages need to be within the limits given in the IAEA transport regulations if there are plans to transport these packages [36]. Also, handling of heavy packages needs to be given special industrial safety considerations [13].

It is the responsibility of the operators of conditioning and storage facilities to meet technical and functional specifications in accordance with legislative requirements. Specific guidance on regulatory requirements for the design and operation of waste processing (including conditioning) and storage facilities is given in IAEA Safety Standards Series No. SSG-40, Predisposal Management of Radioactive Waste from Nuclear Power Plants and Research Reactors [47], IAEA Safety Standards Series No. SSG-45, Predisposal Management of Radioactive Waste from the Use of Radioactive Material in Medicine, Industry, Agriculture, Research and Education [48] and IAEA Safety Standards Series No. WS-G-6.1, Storage of Radioactive Waste [49]. The design of facilities and all operations carried out within them have to be authorized (licensed) and inspected and conditions of authorization have to be enforced by the regulatory body. Where there is a national programme for ICSD management, treatment/conditioning of ICSDs may be carried out in an existing facility or in new ones.

If it is suggested that the treatment/conditioning and storage of ICSDs is to be carried out in an existing facility, the operator would have to investigate whether the facility and planned operations with ICSDs meet the requirements of the existing licence. If the operations with ICSDs do not meet the requirements of the licence, the operator would have to conduct a safety assessment, update the safety case and submit to the regulatory body a request for the amendment of the licence — see GSR Part 5 [21]. If the treatment/conditioning and storage of ICSDs is to be carried out in a new facility, the operator[4] will have to conduct a safety assessment, develop a safety case and submit a new licence application to the regulatory body.

The security measures might be applied on a graded basis, taking into account the current evaluation of the threat, the relative attractiveness of the source and the potential consequences resulting from malicious use. The ICSDs are at the lower end of the source categorization system which is considered the least dangerous. There is no need to increase the security measures due to the collection and storage of ICSDs. However, even these sources could increase some higher dose levels (internal, external) if not properly controlled and therefore need to be kept under appropriate regulatory control. Relevant information on the security of radioactive sources can be found in Ref. [50].

Further guidance on the safety and security of radioactive sources is given in the Code of Conduct on the Safety and Security of Radioactive Sources [51].

5.2.4. Management of secondary waste

Most secondary waste would be non-radioactive and would be candidates for municipal landfill disposal, hazardous landfill disposal or recycling (e.g. plastic, metals, batteries, circuit boards).

However, during dismantling operations, dry secondary waste that is contaminated may be generated. Damp wipes may also be generated by decontamination operations. Given the extremally low activity of DSRS from disused ICSDs, it is likely that contaminated wastes would have activities below clearance levels and could be managed the same as non-radioactive waste.

Small quantities of secondary waste may have activities above the clearance levels (Refs [1, 27]). These materials need to be collected, placed and tied off in plastic bags (of minimum practical size) and managed separately from DSRS and non-radioactive secondary wastes.

As mentioned in Section 4.2, the workplace needs to be designed and arranged to minimize the risk of losing a DSRS, for example, by using a small tray to work upon while generating secondary waste.

Information typically collected during dismantling of ICSDs, the segregation of their sources and radioactive secondary wastes and their subsequent management is summarized in Section 5.2.5. Appropriate records have to be properly retained.

5.2.5. Record keeping

IAEA Safety Standards Series No. GSG-16, Leadership, Management and Culture for Safety in Radioactive Waste Management [52] provides recommendations on developing and implementing management systems for safety during all steps of radioactive waste management.

For packages of DSRS the following information is typically recorded:

— Waste package ID;
— The origin, types and quantities of ICSDs that were dismantled to recover their DSRS;
— The types and quantities of sources (e.g. 100 foils, 20 threads);
— Radionuclide(s) and their total activity(ies) in becquerels with a reference date);

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[4] In the IAEA safety standards, 'operator' means any organization or person applying for authorization or authorized and/or who is responsible for nuclear, radiation, radioactive waste or transport safety when undertaking activities or in relation to any nuclear facilities or sources of ionizing radiation. This includes, inter alia, private individuals, governmental bodies, consignors or carriers, licensees, hospitals, self-employed persons, etc.

— Dose rate at surface and at 1 m (mSv/h);
— The level of surface contamination;
— Packaging date (date package closed).

For packages of radioactive secondary waste, the following information is typically recorded:

— Waste package ID;
— Description of package contents (e.g. PPE, wipes, contaminated parts);
— Radionuclide(s) and their total activity(ies) in becquerels, typically estimated;
— Dose rate at surface and at 1 m (mSv/h);
— The level of surface contamination;
— Packaging date (date package closed).

5.3. STORAGE AND DISPOSAL OF DSRS AND SECONDARY RADIOACTIVE WASTE

The IAEA Nuclear Safety and Security Glossary [53] defines storage as "the holding of *radioactive sources*… or *radioactive waste* in a *facility* that provides for their/its *containment*, with the intention of retrieval." Though not part of the definition, Ref. [53] also notes that "*Storage* is by definition an interim measure, and the term ***[interim storage]*** would therefore be appropriate only to refer to short term temporary *storage* when contrasting this with the longer term fate of the *waste*."

The IAEA Nuclear Safety and Security Glossary [53] defines disposal as the "Emplacement of *waste* in an appropriate *facility* without the intention of retrieval." Options for disposal are near surface disposal or geological disposal. Disposal in boreholes may also be an option [54]. The regulatory and technical aspects of different disposal options are beyond the scope of this publication. Guidance on the selection of the appropriate disposal option for a given type of radioactive waste, site selection, site investigation, safety and environment assessment, design, licensing, operation, closure and monitoring of disposal facilities are given in a number of IAEA safety standards and technical publications.

5.3.1. Storage facility

Specific guidance on the storage of small amounts of radioactive waste at different stages of its management is provided in SSG-45 [48]. More detailed recommendations on regulatory requirements for the design and operation of waste processing and storage facilities are provided in SSG-40 [47] and WS-G-6.1 [49].

Storage is, by definition, an interim measure, which might be arranged on-site or at a specifically designed and constructed storage facility. For most small waste storage facilities, simple design features together with correspondingly simple operating procedures will be appropriate [49].

The storage of waste in centralized facilities rather than in a multitude of on-site facilities should be considered, since there will be opportunities to adopt more stringent safety standards and at the same time to realize economies of scale [49].

A storage facility needs to be properly designed and constructed in accordance with GSR Part 5 [21] and be licensed by the regulatory body. Requirements and guidance for storage facilities which can accommodate ICSDs as part of DSRS and radioactive wastes include:

— Waste shall be stored in such a manner so that it can be inspected, monitored, retrieved and preserved in a condition suitable for its subsequent management (Requirement 11 of GSR Part 5).
— The design of the storage facility depends on the type of radioactive waste, its characteristics and associated hazards, the radioactive inventory and the anticipated period of storage (para. 4.20 of GSR Part 5) considering, for example, the following factors:

- Physical barriers to intrusion, surveillance, high security locks, alarm systems and or trained guards, or any combination of these;
- The loading capacity of the floor;
- The provision of surfaces in the store that are smooth and non-porous, to facilitate decontamination (see Fig. 25);
- The use of appropriate markings (e.g. radiation trefoils) and the word ‘radioactive’ (see Fig. 26);
- Shielding (e.g. in the walls or as movable shielding material) and other protective devices optimized as appropriate (para. 3.49 of GSR Part 3 [1]) to ensure that the dose rate at any accessible place within or outside the store does not exceed the applicable values prescribed by the regulatory body;
- The provision of adequate loading and unloading areas to facilitate transfer of DSRS to and from the store.

— Waste packages and unpackaged waste that are accepted for processing, storage and/or disposal shall conform to criteria that are consistent with the safety case (Requirement 12 of GSR Part 5 [21]).

— The storage of DSRS has to be licensed on the basis of a safety case and safety assessment approved by the regulatory body as prescribed in GSR Part 5 [21].

— Safety documentation to be developed in support of a licence application for the storage facility per para 6.5 of WS-G-6.1 [49].

FIG. 25. Example of DSRS storage facilities with proper loading capacity floor and smooth, non-porous surface.

FIG. 26. Examples of entrance to the DSRS storage facilities marked with a trefoil symbol of ionizing radiation and the word ‘radioactive’.

(a) (b)

FIG. 27. (a) An ISO freight container used as national storage for DSRS and (b) schematic of an ISO container with a possible array of 200 L waste packages.

A large number of alternative storage facility designs may be envisaged which would meet the above criteria.

If the facility is multi-purpose, it may need to have separate areas for the receipt, conditioning and storage of the waste.

If a radioactive waste storage facility is not available, a possible option is to establish a storage facility in freight containers[5] (see Fig. 27). The use of International Organization for Standardization (usually referred as ISO) shipping containers for small inventory of waste (mainly DSRS) is also in line with para. 5.19 of WS G 6.1 [49]. Various freight containers are widely available throughout the world.

Freight containers offer a flexible, modular, low-cost method of providing a weatherproof enclosure for waste storage. They can accommodate a wide range of waste package sizes and weights. For the arrangement shown in Fig. 25 of 200 L drums stacked inside an ISO freight container, some manoeuvring would be required for carrying out periodic inspection of the stored drums. Depending on the situation, users may prefer other arrangements that require less manoeuvring for inspection. Whatever solution is found for the design of a storage facility, the facility has to be licensed on the basis of a safety case and safety assessment approved by the regulatory body as prescribed in IAEA safety requirements GSR Part 5 [21]. The safety case and safety assessment have to take account of many factors, including those related to facility siting and the possible occurrence of external hazards and events (e.g. landslips, flooding, earthquakes).

5.3.2. Storage of ICSDs as received

Storage of the disused ICSDs may be required prior to its dispatch to the processing facility for removing the radioactive sources. This storage time has to be in line with national regulatory requirements and authorization conditions and ought to be kept as short as practicable. It needs to be noted that keeping DSRS on the site without observing proper storage regulations is the most frequent cause of accidents and loss of control.

5.3.3. Storage of conditioned DSRS removed from ICSDs

Until disposal sites are available, a national storage facility for conditioned DSRS and radioactive wastes can be developed in several different ways. It needs to be stressed that most of the countries do not have final disposal facility in operation.

[5] See: https://www.iaea.org/newscenter/news/malis-journey-to-sustainable-safety-and-security-for-radioactive-sources

FIG. 28. A 440 L drum filled with ^{241}Am sources recovered from ICSDs [7].

Packages of ICSDs and those containing DSRS and secondary radioactive waste could involve interim storage where packages are held temporarily waiting for transfer to the next stage of management.

Storage implies that the waste will be disposed of in the future (i.e. storage is not a long term, end point solution). If no repository is yet available, long term storage may be required. For this purpose, the storage facility would need proper maintenance and periodic inspection of packages.

According to Ref. [7], the volume of the radioactive sources is so small compared to the overall volume of the ICSDs that volume reduction is the only responsible option for their management and storage. Given the respective volumes of the ICSDs and their radioactive source, the expected volume reduction factor (known as VRF) could vary from 500 up to 2000 [7]. As an example of storing sources removed from the ICSDs, the National Institute for Radioelements in Belgium (known as IRE) has acquired a wide experience in the field of handling, conditioning and storage of disused ICSDs mainly based on ^{241}Am sources. By 2001, more than 40 different types of ICSDs were dismantled in these facilities, representing a total amount of more than 30 000 items.

In Belgium, the ^{241}Am sources recovered from the ICSDs are placed into a 230 L stainless steel inner container fitted into a 400 L steel drum. The space between the container and the outer drum is filled with concrete to form a concrete lined drum. Into one such a container it is possible to place an amount of sources representing the dismantling of 25 000 ICSDs (see Fig. 28). In this case, the total activity inside a 400 L drum can reach up to about 3.7×10^{10} Bq of ^{241}Am (or 1 Ci) [7].

5.3.4. Disposal of recovered and conditioned DSRS

Waste disposal means the “Emplacement of *waste* in an appropriate *facility* without the intention of retrieval” [53]. A disposal facility needs to provide passive safety after its closure, meaning that no active safety or security measures are required to ensure that it maintains its isolation and containment functions [22]. Disposal facilities use a combination of natural and engineered barriers to contain and isolate radionuclides so that they do not cause an unacceptable impact to health and environmental, now or in the future [22].

Radioactive waste needs to be disposed of in a repository that is in compliance with relevant national regulations and requirements and international legal instruments, safety standards and good practices to provide for their safe, long term management. The waste will be disposed of either in existing facilities or in newly developed ones.

Guidance on the selection of the appropriate disposal option for a given type of radioactive waste, site selection, site investigation, safety and environment assessment, design, licensing, operation, closure and monitoring of disposal facilities are given in a number of IAEA safety standards and technical publications.

Requirement 20 of SSR-5 [22] states that "waste packages and unpackaged waste accepted for emplacement in a disposal facility shall conform to criteria that are fully consistent with and are derived from, the safety case for the disposal facility in operation and after closure."

For existing disposal facilities, waste acceptance criteria (WAC) approved by a regulatory body will determine which wastes can be accepted for disposal. If the disused ICSDs represents a waste stream not originally planned to be disposed of in that facility and its characteristics are not consistent with the WAC, then its acceptability for disposal has to be documented and supported by the safety assessment and consequently approved by the regulatory body. Meeting WAC implies that disposal of ICSDs waste is consistent with the performance assessment of the disposal facility.

Development of a disposal facility requires relevant infrastructure including a national waste management policy and corresponding strategy for implementation, a proper regulatory framework, as well as the financial, human and technical resources needed for such a development [55]. International implementation examples follow.

In Sweden, while developing the WAC for disposal, the ICSDs were considered [56].

In Germany the disused ICSDs are sent to the land collecting facility of Baden-Wuerttemberg (known as LSSt BW). The ICSDs are sent complete (i.e. including plastic housing) for conditioning. It is considered that separating the source from each ICSDs is not economically feasible. The ICSDs are already packed up into press drums by the waste producer. The subsequent conditioning is performed by means of high-pressure compaction generating a volume optimized product. The aim of conditioning is to transform radioactive waste into a form that is suitable for disposal in the Konrad repository [57].

5.3.5. Record keeping

The operator is responsible for establishing and maintaining a detailed record keeping system for all stages of radioactive waste management [48]. Traceable records should be created that describe and characterize the radioactive waste and the waste management activities undertaken [52]. Information generated during storage or disposal of DSRS and secondary radioactive wastes from ICSDs are:

— Waste package ID;
— Date stored or date disposed;
— Storage or disposal location (facility, coordinates).

Appropriate records are kept of the inventory of DSRS and radioactive waste in individual waste packages as described in Section 5.2.5. All information needs to be retained in duplicate at separate locations. As stated in para. 5.67 of GSG-16 [52], "The licensee should define where and how (e.g. the media to be used) the records are to be stored and this should be documented in the management system. Decisions on record keeping should take account of regulatory requirements and authorization conditions."

The IAEA technical report No. 434 [58] provides some guidance on current practices and methods for maintaining records of waste packages produced through various phases of the waste management process from waste generation through conditioning, storage and transport. The possible ways for preserving information about repositories for low and intermediate level radioactive waste and long lived radioactive waste are discussed in the IAEA publications [58, 59]. Additionally, IAEA-TECDOC-1222, Waste Inventory Record Keeping Systems (WIRKS) for the Management and Disposal of Radioactive Waste, discusses the ways for compiling and managing information about the inventories in their radioactive waste repositories [60]. These record keeping systems can be used to plan for waste receipts and to track wastes from the agreement to accept them from a generator through to their final disposal.

Tracking could include the recording of changes made to wastes such as compaction, concentration, repackaging or grouting, as well as the waste's final location.

6. LESSONS LEARNED

This section does not discuss Case C, the recycling of radionuclides from DSRS recovered from ICSDs (Section 4.4) because the recycling of radionuclides from DSRS is not commonly performed due to major drawbacks. The focus of this Section is on Cases A and B. The lessons learned, many derived from central facilities that manage ICSDs, can be summarized as follows:

— Records of the problems encountered and their solutions need to be kept. Improvements in operational activities and how they are implemented need to be recorded for upgrading future activities.
— In general, the public may not be aware that ICSDs are being collected, which complicates collection. Implementation of a public awareness campaign would be helpful.
— Applying a fee to the user in an indirect manner is seen as a preferred option to promote the collection and acceptance of ICSDs. Applying a direct fee to the user could result in the abandonment of the ICSDs due to the fees associated with management;
— Segregation by ICSD model may minimize the effort in managing them at collection points. It may also optimize interim storage at the location where they had been installed. If there may be a 'significant' time between the ICSD's removal from where they were installed and their transfer to a central collection point, the owner needs to ensure safe and secure storage conditions until the final transfer away from the premises.
— The ICSDs segregated by model and radionuclide will allow for efficient dismantling of a batch, being a repetitive process. This will simplify waste management because different radionuclides may require different waste management routes including conditioning, storage and disposal.
— After removal of the DSRS within their holders from the ICSDs, they need to be packaged into small numbered containers to allow for efficient loading of the larger waste containers and allow for repacking of materials for disposal if necessary. These sub-packages will also prevent the potential spread of contamination from any leaking or damaged sources.

7. CONCLUSIONS AND FURTHER CONSIDERATIONS

7.1. CONCLUSIONS

Ionization chamber smoke detectors have been widely used for decades to detect fires — they have saved many lives, minimized injuries and reduced property damage. However, because of their widespread use, many millions of disused ICSDs have been generated worldwide.

This publication provides general information about ICSDs, identifies a variety of models and highlights a range of management options for further consideration by Member States, supported by national experiences.

Some Member States have concluded that disused ICSDs need no specific management in relation to the presence of radioactive material and, based on the safety assessment, the landfill disposal of ICSDs with household waste is a common practice.

This report does not encourage the collection of household ICSDs classified as consumer products and exempted from regulatory control.

This report identifies and addresses an area of great interest to Member States, what actions need to be taken to deal with large numbers such as hundreds to millions of disused ICSDs already collected. This report intends to raise Member States' awareness of the challenges associated with the management of collected ICSDs.

This publication expands on collection and dismantling practices of disused ICSDs, on management of resulting DSRS and secondary radioactive wastes and considers the technical and radiological concerns associated with such practices.

It is clear that some practices (collection and dismantling of disused ICSDs) are commonly used by most Member States, while others (recovery of radionuclides from DSRS) are uncommon. In this regard, the publication offers some guidance based on practical experiences from several Member States.

7.2. FURTHER CONSIDERATIONS

Records of the problems encountered and solutions found need to be kept. Improvements in operational activities need to be recorded for upgrading future activities.

Segregation of disused ICSDs by model and radionuclide when they are removed from where they were used will minimize the effort in further management.

Dismantling of disused ICSDs in batches appears to be a more efficient approach and needs to be pursued.

Duration of short term storage at the location where ICSDs were formerly installed needs to be minimized. If this is not possible, guidance on storage requirements and conditions may be provided to the users, so the storage of the ICSDs is authorized by the regulatory body.

REFERENCES

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Annex I

INFORMATION FOR THE ANNEXES

I–1. INFORMATION

At a consultancy meeting in June 2016, participants agreed upon the following information for preparing Member States' submission for these annexes. Submissions should answer these questions:

- Does your country have ICSD manufacturers? Importers? Exporters?
- Does your country know the number of ICSDs it has (estimate, unknown, well known)?
- In your country, how are/were ICSDs:
  - Distributed (e.g. by retail sales, controlled)?
  - Installed (location and method; by consumers or by authorized workers)?
  - Removed from service (e.g. by consumers or by authorized workers)?
  - Collected (e.g. collection points or centralized collection)?
  - Recommended to be replaced (e.g. service life determined by manufacturer or by regulator)?
- What are your country's policies, regulations and impact on stakeholders?
- Are there any restrictions on the type of radionuclides in ICSDs (e.g. Ra, Pu)?
- Were there any incidents/accidents that impacted policy?
- What is your country's approach to disused ICSD management (provide an overview of what your country does or plans to do in the context of Case A, B and C)?
- Further considerations and lessons learned.

Annex II

MEMBER STATE EXPERIENCE (ALBANIA)

II–1. HISTORICAL BACKGROUND

Albania does not have any ICSD manufacturers, importers or exporters. The import of ICSDs is prohibited and there is a ban on their use.

A campaign to determine the number and types of ICSDs in Albania indicated that there are only a few ICSDs in the country, but their origins were not determined.

Based on available information, ICSDs were never distributed or installed in Albania, except for the few mentioned above. Therefore, the guidance provided in Annex 1 is not applicable (i.e. a report on where and how were they installed, how were they removed from service, how were they collected and what is the recommended service life).

II–2. POLICIES, REGULATIONS AND IMPACT ON STAKEHOLDERS

There is set of regulations on the limits for exemption and clearance based on IAEA standards. Disused ICSDs can be only managed as radioactive waste as there were no policies or regulations in the past related to ICSDs. As such, there are no associated impacts on consumers, manufacturers, suppliers, etc.). There have been no incidents or accidents related to ICSDs.

Albania does not have any formal approach to management of disused ICSDs since the problem of disused ICSDs essentially does not exist, except for the few ICSDs that were found. There are no further considerations or lessons learned regarding management of disused ICSDs.

Annex III

MEMBER STATE EXPERIENCE (ARGENTINA)

III–1. HISTORICAL BACKGROUND

In Argentina, there are no ICSD manufacturers. There are only ICSD importers.

All radioactive materials under regulation of imported origin need the corresponding import authorization. Each importer declares the total amount of radioactive material for each consignment to the Nuclear Regulatory Authority.

Each authorized ICSD importer has a radiation safety officer who maintains records of the radioactive material stored under its authority.

The use of ICSDs devices is not regulated in Argentina, due to their individual activity below the exemption limit established in Regulatory Guide AR 6. Nevertheless, ICSDs importers need regulatory authority authorization and, consequently, are under regulatory control.

There are no special requirements for distributing ICSDs, however, authorized importers have records of the distribution of radioactive material.

Ionization smoke detectors were normally installed in institutions and less so in households. They were installed either by consumers or maintenance staff in institutions.

In addition, ICSDs were removed from service either by consumers or maintenance staff in institutions. The use of ICSDs has been decreasing in Argentina during the last decades.

No special recommendation is required for service life.

III–2. POLICIES, REGULATIONS AND IMPACT ON STAKEHOLDERS

Past and present policies on ICSDs are the same — only authorized importers can import ICSDs. There is no policy or regulation on ICSDs distribution or use.

Since policies have not changed, there is no direct impact on ICSD use in Argentina.

The decline in ICSD use over time is not due to any regulatory driving force or to any incidents or accidents. The real cause is the appearance of new technology alternatives that do not requires the use of radioactive materials for this purpose.

III–3. APPROACH TO DISUSED ICSD MANAGEMENT

Dismantling of ICSDs is not practised in Argentina. There is no obligatory disposal of disused ICSDs at present.

III–4. FURTHER CONSIDERATIONS AND LESSONS LEARNED

No special recommendations on this topic.

Annex IV

MEMBER STATE EXPERIENCE (BULGARIA)

IV–1. HISTORICAL BACKGROUND

Bulgaria had one ICSD manufacturer, EKOEL, which shut down in 1999. There are licensed importers, but ICSDs are not exported from Bulgaria.

The number of ICSDs in Bulgaria is estimated at 280 000. These ICSDs have ^{241}Am, Pu and ^{85}Kr sources. To date, ICSDs with ^{226}Ra sources have not been found.

In Bulgaria all sources, including ICSDs, are under the control of the Bulgarian National Regulatory Agency. There are no specific regulations for ICSDs. ICSDs were imported, distributed and installed/removed in public and industrial buildings by authorized organizations and workers.

Use in private houses is highly uncommon (there are no requirements by fire departments to have any type of smoke detector), but their use is not forbidden. The collection of disused ICSDs is centralized at the Specialized Division Permanent Repository for Radioactive Waste — Novi Han, part of the State Enterprise Radioactive Waste (known as SERAW). Transport is performed mainly by that enterprise but there are also a few small authorized companies. The recommended service life of ICSDs is provided by the manufacturer.

IV–2. POLICIES, REGULATIONS AND IMPACT ON STAKEHOLDERS

In the past, regulatory control of radioactive substances was performed according to Bulgarian laws. Since 2004, it is in accordance with EU legislation.

There are no restrictions on the types of radionuclides in ICSDs (e.g. Ra, Pu).

Currently ICSDs are not forbidden, but importers/users prefer smoke detectors without radionuclides since there are no needs for licences for import, installation, removal and no additional costs for collecting. Currently for ICSDs removal there is a charge of €10/source.

There were no incidents that impacted policy, but as a result of the political and economic changes in the 1990s, many sources, including ICSDs, were left without control. Since the reopening of the repository in 1999, the regulatory agency started a campaign for collecting disused ICSDs and other sources. If the owner of a source is known, it pays for the collection and storage. In the case of an orphan source, the government pays.

The Bulgarian approach is Case B: it collects and dismantles disused ICSDs and assures the long term management of both the recovered DSRS within its holder and the secondary radioactive wastes. The procedures for dismantling disused ICSDs, the workplace and the tools and safety measures are approved by the regulatory agency. Operators are trained and tested before starting work. After dismantling, the DSRS are placed in small metal cans (about 1 L) and those cans are placed in 210 L metal drums.

As of the end of 2016, approximately 120 000 ICSDs had been dismantled. Options being considered for their future include borehole disposal of sealed radioactive sources, deep geological disposal or specialized containers for long term storage. Procedures for releasing the non-radioactive material are under development. The possibility for incineration is being considered as well.

IV–3. FURTHER CONSIDERATIONS AND LESSONS LEARNED

Sources need to be handled carefully. Operators need to use gloves, masks and protective suits. Ergonomics need to improve as experience is gained (e.g. to prevent repetitive strain injuries). Shielding is needed for higher numbers of ICSDs handled together.

To avoid storing large volumes of non-radioactive materials, procedures for releasing secondary radioactive wastes from regulatory control need to be created in advance of dismantling.

Experience needs to be shared with other Member States and the IAEA.

Annex V

MEMBER STATE EXPERIENCE (CANADA)

V–1. HISTORICAL BACKGROUND

ICSDs are an important component of fire safety systems in Canada. Both ICSDs and non-radioactive smoke detectors are important components which contribute to the effectiveness of overall fire safety systems.

Canada presently does not have any manufacturers or large-scale exporters of ICSDs. As such, Canada is an importer of any ICSDs which are in use.

The Canadian nuclear regulatory regime provides specific exemptions to regulation for ICSDs which meet certain performance criteria related to the ICSD's radiation safety. These exemptions do not apply to the initial importers/distributors or any manufacturers of ICSDs in Canada.

Distribution of exempted ICSDs within Canada is generally performed through retail sales channels. Installation and removal of these exempted ICSDs can be performed by consumers or their contractors. The distribution, installation and removal of any ICSD which does not meet regulatory requirements for exemption are required to be performed by an entity licensed and authorized by the Canadian Nuclear Safety Commission.

As the disposal of most ICSDs in Canada is exempted from regulation by the nuclear regulator, a current estimate of the number of ICSDs is unknown. However, recent inventory levels at sites licensed to import, distribute or possess non-exempt ICSDs totalled an inventory of approximately 260 000 units. Although the service life of ICSDs are specified by the manufacturer, ICSDs have approximately a 10–15 year recommended period of use.

V–2. CANADA'S POLICIES, REGULATIONS AND IMPACT ON STAKEHOLDERS

Prior to 1978, Canada regulated all activities related to ICSDs, including disposal. This approach was deemed to be impractical in many instances as many ICSD users were unaware of the manufacturer's identity and the return of ICSDs to international manufacturers required the consumer to obtain an export licence. The sales of ICSDs within Canada around this time period were expected to exceed 1 million units annually.

Following discussion and consideration of domestic and international studies, the landfill disposal of ICSDs was permitted on the grounds of the assessed insignificant radiological risk by these studies and the impracticality of regulating such a significant number of low-risk radioactive sealed sources available to the Canadian general public and vital for fire safety.

This decision is revisited from time to time.

Section 6 of 'Nuclear Substances and Radiation Devices Regulations' exempts persons from the need to be licensed for the possession, use, transfer, or abandonment of an ICSD if it meets all the following requirements:

- The ICSD does not contain more than 185 kBq of americium-241 or, where it is in a commercial or industrial facility, not more than 740 kBq of americium-241;
- The radiation dose rate does not exceed 1 µSv per hour at 0.1 m from any of the accessible surfaces of the ICSD;
- The design and construction of the ICSD prevents persons from making direct contact with the nuclear substance that it contains under normal conditions of use;
- All markings and labels on the ICSD are legible;

— The radioactive nuclear substance contained in the ICSD is a sealed source that, when it is mounted in its holder, conforms to ISO 2919, Radiation Protection — Sealed radioactive sources — General requirements and classification (1999);
— The ICSD meets the tests specified in the annex entitled Prototype Tests of the Recommendations for ICSDs in implementation of radiation protection standards (1977) of the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development.

Section 9 of the ‘Nuclear Substances and Radiation Devices Regulations’ requires that the manufacturers or initial importers/distributors of ICSDs which meet exemption requirements are subject to regulation.

Lastly, section 26 of the ‘Nuclear Safety and Control Act’ requires any person to obtain a licence prior to servicing, importing, or exporting an ICSD. This section also requires any person who wishes to possess, use, transfer or abandon an ICSD which does not meet exemption requirements to obtain a licence. There are currently only a few hundred ICSDs in Canada which do not meet exemption criteria. Servicing of an ICSD generally refers to the SRS directly; unlicensed consumers can perform manufacturer-specified maintenance activities, such as dust removal or battery replacement.

All ICSDs in Canada are certified as radiation devices. Although all known ICSDs in Canada contain small amounts of ^{241}Am, there is no specific restriction on the radioisotope used.

These regulations exempting the majority of ICSDs from regulatory control are considered to be valid in consideration of the net public safety benefit of having readily available ICSDs for fire safety systems, with low doses assessed to the public and first responders in the event of an emergency.

V–3. CANADA’S APPROACH TO DISUSED ICSD MANAGEMENT

Canadian regulations permit disposal of an ICSD which meets the requirements of Section 6 of the ‘Nuclear Substances and Radiation Devices Regulations’ without a licence.

The disposal of an ICSD still has to satisfy all other applicable requirements, such as environmental or electronic waste regulations. These regulations are not within the mandate of the Canadian Nuclear Safety Commission.

Licensees who are in the possession of ICSDs which do not meet the requirements of Section 6 of the ‘Nuclear Substances and Radiation Devices Regulations’, as well as initial importers/distributors and manufacturers, need to dispose of any disused ICSDs as long term radioactive waste.

V–4. FURTHER CONSIDERATIONS AND LESSONS LEARNED

It is recommended to publish promotional outreach material to stakeholders, particularly consumers, on their regulatory obligations, as well as to provide information on radiation safety and disposal options.

It is also recommended that an approach to managing disused ICSDs takes into account the net safety benefit of having fire safety equipment readily available to the public, with the socioeconomic impact of regulating a readily available and commonly used consumer good. The overall financial and environmental costs of disposal also need to be considered in a country’s strategy.

Annex VI

MEMBER STATE EXPERIENCE (CHILE)

VI–1. HISTORICAL BACKGROUND

Chile does not have any ICSD manufacturers or exporters. Regulations in Chile consider three categories of radioactive facilities, of which category number 3 includes ICSDs. The importation of such devices require authorization, but the application of this requirement is not assured.

The radioactive waste management section of the Chilean Nuclear Energy Commission (CCHEN) has an inventory of 5643 DSRS coming from ICSDs. The amount of ICSDs currently in operation is not possible to estimate.

Ionization chamber smoke detectors have been installed in buildings of public or private institutions and industries. In special cases they are used in residential buildings.

In the past ten years, the use of ICSDs has been replaced by the use of photoelectric smoke detectors.

The national legislation does not require the installation of fire detection systems in private houses, it is only a requirement for residential and commercial buildings and industries.

The installation of ICSDs is carried out by companies dedicated to implementation of fire detection systems. These companies do not require authorization from the regulatory body to develop their activities (installation and maintenance); but for removal from service, the regulatory body could request some type of authorization. This is not a rule for all companies, since it will depend on consulting the regulatory body.

In case of the maintenance or change of fire detection systems, ICSDs can be removed by the company in charge of the maintenance (sometimes with or without authorization from the regulatory body). Legislation in Chile defines that the generator is in charge of the management of their waste. Therefore, once the ICSDs have been removed, the managers of each company request their management from CCHEN as radioactive waste.

All activities related to radioactive waste management in Chile are centralized at CCHEN, but there is no centralized collection of ICSDs. Each generator is responsible for transporting their ICSDs to CCHEN facilities by themselves or using external services.

VI–2. POLICIES, REGULATIONS AND THEIR IMPACTS ON STAKEHOLDERS

Chile does not have any policies about ICSDs usage. There are no restrictions regarding the type or models of smoke detector that can be imported.

The CCHEN is the only national institution responsible for ICSD management.

All waste from industries or commercial activities needs to be managed as industrial or hazardous waste and the institutions responsible for the management of this types of waste do not receive radioactive waste. In cases where they have received radioactive waste, they usually ask CCHEN to manage these wastes.

VI–3. APPROACH TO DISUSED ICSD MANAGEMENT

Case B: collection and dismantling of ICSDs while assuring the long term management of both the recovered DSRS within their holder and secondary radioactive wastes has been practised in Chile for years.

Users are charged a fee for ICSD management. As there is no centralized collection, generators contact CCHEN to request ICSD management.

All activities for the removal from service, collection and transport to CCHEN are the responsibility of generators. Unlike the importation and installation of ICSDs, generators need to request authorization from the regulatory body for transport and long term management.

After dismantling ICSDs, all DSRS are placed in 250 mL stainless steel capsules for long term storage. Storage in 200 L drums has not been considered.

After dismantling ICSDs, all secondary radioactive waste (plastic, metal, electronics, etc.) are segregated and monitored for recycling or management as industrial or hazardous waste.

Chile does not have waste disposal facilities; long term storage is practised.

Annex VII

MEMBER STATE EXPERIENCE (CHINA)

VII–1. HISTORICAL BACKGROUND

In China, there are ICSD manufacturers, ICSD importers and ICSD exporters. The manufacturing of ICSDs requires approval by the regulatory body. Imported and exported ICSDs are required to be registered with the regulatory body. Therefore, the number of ICSDs in China is well known to the regulatory body.

ICSDs are often installed in public and crowded places such as warehouses, shopping centres, hotels, museums, libraries, movie theatres and so on. ICSDs have also been installed in living areas (households). The service life of ICSDs is generally 5–10 years in China.

In the past, ICSDs represented about 70% of all smoke detectors in China but currently the market for ICSDs is decreasing, especially since 2014. Photoelectric detectors are gradually replacing ICSDs.

In the past the national repository charged the users for the collection of disused ICSD. Since 2017, the government has requested that the national repository receive disused ICSDs cost free.

The most common ICSD radionuclide is ^{241}Am. The use of other radionuclides requires approval by the regulatory body. So far, there have been no incidents or accidents due to the use of ICSDs that have impacted the national policy.

VII–2. POLICIES AND REGULATIONS OF CHINA

For regulation of ICSDs, there is a specific standard in China, ‘Radiation Protection for Ionizing Smoke Fire Detectors.’ The standard has been revised three times, the latest version being GBZ 122 — 2006, published in 2006. This mandatory standard covers all aspects of ICSD life cycle, from manufacture through storage, transport, sale, installation, use, maintenance and cleaning to the management of disused ICSDs.

The general requirements[1] for the ICSDs are:

— The external irradiation at 0.1 m from the ICSDs surface cannot exceed 1 μSv/h to the public;
— The surfaces contamination cannot exceed 0.08 Bq/cm^2 for α and 0.8 Bq/cm^2 for β;
— The total activity of ^{241}Am in an ICSD cannot exceed 10 kBq for household use and 40 kBq for other uses.

The standard mentioned above includes requirements for signage and packaging and instructions for ICSD use, for example the radiation trefoil and the type/activity of radionuclide in the ICSD needs to be indicated on the packaging. In these instructions, consumers are instructed how to use ICSDs, how to maintain them and how to manage them once they are disused. For ICSD manufacturing, importation or the use of radionuclides other than ^{241}Am, a specific radiation protection assessment is necessary and approval of the regulatory body is required.

There are requirements for manufacturing and cleaning of ICSDs in the standard. The organizations responsible for these activities need to be certified by the regulatory body. All manufacturing and cleaning operations need to meet the requirements for an unsealed source workplace under GB18871-2002, Radiation Protection and Safety of Radiation Sources, which is the Basic Safety Standard of China.

[1] See: http://dict.youdao.com/w/general requirements/

The organizations engaged in the storage, transport, sale, installation and maintenance of ICSDs need to be certified by the regulatory body. The transport of ICSDs has to be conducted under GB11806-2004, the Chinese standard for the safe transport of radioactive material which is equivalent to IAEA TS-R-1, ‘Regulations for the Safe Transport of Radioactive Material.’ The storage of ICSDs has be conducted under GB18871-2002.

Unauthorized organizations and individuals are forbidden to remove, dismantle or clean ICSDs. The management of ICSDs requires registration with the regulatory body. Professional workers are assigned to manage ICSDs inventories, to store ICSDs and record the status of ICSDs (in use, standby and disused). An installation map of ICSDs needs to be prepared and periodic inspection is necessary. In the event that an ICSD is stolen or missing, the incident needs to be reported to the regulatory body in a timely manner.

Disused ICSDs are forbidden to be abandoned. They need to be returned to their manufacturer, importer or an authorized recovery organization.

VII–3. APPROACH TO DISUSED ICSD MANAGEMENT

All of the following approaches are conducted in China:

— Case A: collect and store ICSDs as received, awaiting a decision on their further management;
— Case B: collect and dismantle ICSDs and assure the long term management of both the recovered DSRS within its holder and secondary radioactive wastes;
— Case C: recover the radionuclides from the disused DSRS for recycling/reuse and assure the long term management of secondary radioactive wastes.

VII–4. ISSUES RELATED TO ICSD USE

Though there is a specific standard for the management of ICSDs, it cannot be applied efficiently in practice for many reasons. For example, ICSDs are distributed by retail sales (i.e. they are not controlled and consumers can readily buy as many ICSDs as they want). Many ICSDs are installed and/or removed by consumers or by unauthorized organizations. The ICSDs used in government buildings are collected and transported to the national waste repository; however, the ICSDs used by households are not fully collected.

VII–5. FURTHER CONSIDERATIONS

— Disused ICSDs need to be collected centrally for further management;
— The government needs to take the steps needed to ensure that the standard ‘Radiation Protection for Ionizing Smoke Fire Detectors’ can be practically implemented;
— The regulatory body needs to strengthen the supervision of the sale of ICSDs, not only for contractors but also for consumers;
— The only legal owner of radioactive sources needs to be the manufacturer; consumers may only have user’s rights for radioactive sources (i.e. radioactive sources need to be rented to consumers, not owned by consumers);
— Manufactures need to recall disused ICSDs.

Organizations or individuals do not need to be entitled to dispose of disused ICSDs.

Annex VIII

MEMBER STATE EXPERIENCE (CUBA)

VIII–1. HISTORICAL BACKGROUND

In Cuba, there are no ICSD manufacturers or exporters. There are ICSD importers that need to be legally authorized.

Institutions are required to report their ICSD inventories but currently the reporting is incomplete.

Specialized organizations, for example the Servicios de Seguridad Integral, s.a. (SEISA), specify the fire safety requirements in institutions (extinguishers, detectors, etc.) and install the necessary equipment, including ICSDs, which are acquired from importing organizations, for example Empresa Cubana Exportadora e Importadora de Servicios, Artículos y Productos Técnicos Especializados (known as TECNOTEX).

The regulatory authority has authorized SEISA to store, transport, install and remove ICSDs. Only institutions have ICSDs in Cuba; ICSDs are not installed in private homes (although this is not prohibited). The regulatory authority requires SEISA to annually report the list of institutions where they have installed ICSDs, including the number of devices installed and the models, as well as provide a copy of ICSD inventories (devices received and taken out of their inventories).

In the past, SEISA had collection points but this was considered too expensive, therefore collection points were shifted to institutions where ICSDs had been installed. Centralized collection is carried out at the radioactive waste management (RWM) facility — ICSDs are transferred there from the various collection points.

There is no specified service lifetime for ICSDs. Only two models are imported and installed at present, which facilitates their life cycle management.

VIII–2. POLICIES, REGULATIONS AND THEIR IMPACT ON STAKEHOLDERS

There have been no policy changes over time; therefore, there has been no associated impact on stakeholders. There have been no restrictions on the ICSD models that are imported but, as noted, only two models have been imported so far (see Table VIII–1). The Centre for Radiation Protection and Hygiene (the waste management organization in Cuba) is the sole organization responsible for ICSD management; there are no other organizations involved.

There have been no incidents or accidents that would impact on ICSD use.

TABLE VIII–1. MODELS OF ICSD IMPORTED TO CUBA

Model	Radionuclide	Activity
CPX 1451 A	^{241}Am	0.5–1 μCi (12.95–37 KBq)
FSI 851		

VIII–3. APPROACH TO DISUSED ICSD MANAGEMENT

In Cuba, Case B is practised (collection and dismantling ICSDs and assuring the long term management of both the recovered DSRS within its holder and secondary radioactive wastes). The ICSDs at institutional collection points may or may not be stored in 200 L drums as the storage method to be used at institutions is not specified by the regulatory authority.

Prior to their transport to the RWM facility, ICSDs are counted, documented (radionuclides and activity), contamination checked and any issues are resolved (such as a miscount in the number of ICSDs).

The ICSDs collected at institutions are transported to the RWM facility in 200 L drums. These drums are kept in interim storage until there are enough ICSDs to warrant a dismantling campaign. Interim storage involves consolidating the ICSDs received, which may be in additional drums or in the transport drums themselves.

The ICSDs are dismantled according to procedures for each model of ICSD. After dismantling, the DSRS are conditioned into stainless steel capsules. Secondary waste, such as metal, plastic, electronics, etc. is segregated for recycling. Before removal from the RWM facility, these materials are monitored and released in compliance with clearance criteria. First background radiation is measured (the average value and standard deviation is determined). The reference level dictating whether an item is contaminated or not is the average value of the background plus two times the standard deviation. Materials measuring above this value are considered contaminated and managed as radioactive waste. If a more precise measurement is required, a sample is taken and sent to the spectrometry laboratory.

Currently Cuba does not have a radioactive waste disposal facility; therefore, long term storage is currently practised at the RWM facility.

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Annex IX

MEMBER STATE EXPERIENCE (FRANCE)

IX–1. HISTORICAL BACKGROUND

The use of ICSDs began in France at the beginning of the 1940s. The use of ICSDs was then justified by the speedy signal they emitted compared with the other technologies which were on the market at the time.

Their use in dwellings was banned by Decree N°66-450 of 20 June 1966 relating to the general principles of protection against ionizing radiation, forbidding the addition of radioactive substances in products manufactured for household use. However, due to their better technical performance, ICSDs were still used in industrial and service industry buildings and also in buildings open to the general public (hospitals, for example).

This ban was repeated in 2002 by Decree N°2002-460 related to the general protection against the dangers of ionizing radiation, edited in application of European Regulation N°1493/93 and European Directives 96/29/EURATOM and 97/43/EURATOM. All French regulations related to the protection of the workers and the public against the dangers of ionizing radiation were then included in the high-level regulation called the Code of Public Health.

French authorities estimate that around 7 million ICSDs have been installed in France at around 300 000 sites.

IX–2. THE DECREE OF 18 NOVEMBER 2011

An approach initiated for several years by the Nuclear Safety Authority (known as ASN), in concert with fire safety professionals, made it possible to plan for withdrawal of all ICSDs and it led to the publication of the Decree of 18 November 2011, providing for:

— The renewal of the authorization exemption under the Code of Public Health for installations holding fire detection lines on which ICSDs were already installed. These installations remained responsible for the management and recovery of the detectors they hold and had the obligation to establish immediately, with the person or entity in charge of maintaining the detectors, a census form which would be sent to the ASN by 31 December 2014 at the latest.
— The establishment of a 10-year calendar for the withdrawal of detectors, taking into account the size of the installed base and making it possible to guarantee both the industrial sustainability of the recovery channels and the elimination of ICSDs under satisfactory radiation protection conditions.

In addition, the ASN decisions of 21 December 2011:

— Specified, within the framework of a declaration or authorization regime aimed at preventing unauthorized dumping, the regulatory obligations applicable to professionals carrying out activities of installation, removal or maintenance of ICSDs;
— Set the distributor’s obligations with regard to the return of detectors and the information and method for the end holders;
— Organized take-back operations through professionals in charge of removing and maintaining ICSDs;
— Explained the procedures for monitoring the fleet by the Institute for Radiation Protection and Nuclear Safety (IRSN) on the basis of annual reports sent by the professionals in charge of removing and maintaining ICSDs and quarterly statements sent by distributors.

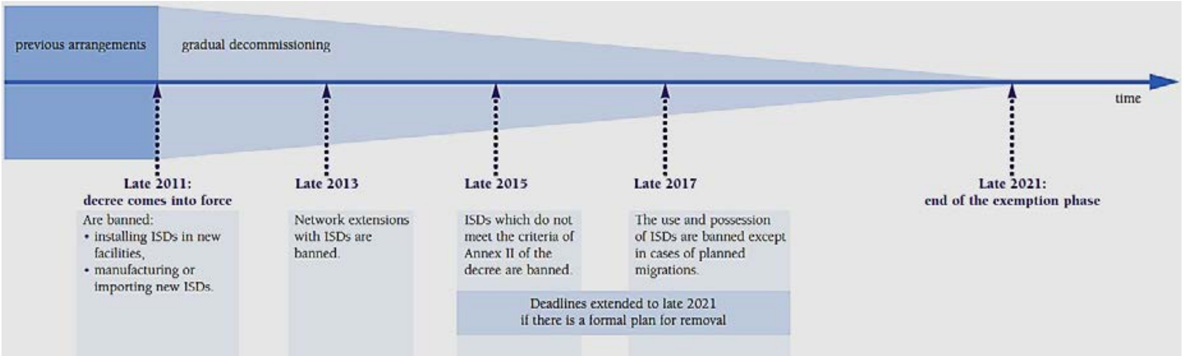

FIG. IX–1. ICSDs withdrawal planning with a total recovery of ICSDs at the end of 2021.

In other words, these regulations stipulated that holders of ICSDs need to identify their fleet and transmit this information to the IRSN and would then have six years until December 2017 to withdraw and replace their ICSDs. If the holders would transmit a migration plan to the IRSN before 1 January 2015 (a census and dismantling and replacement calendar), they would benefit from an additional four years to complete their removal (until December 2021) as summarized in Fig. IX–1.

Thus, disused ICSDs have been and will be collected by licensed operators and dismantled. According to French regulations, radioactive sources (the sealed source itself, source holders or ionization chambers) need to be sent back to the manufacturers. In case of difficulties, operators would contact the IRSN for assistance to find a replacement dealer. If this process could not succeed, the operator would have to ask the ASN to mandate ANDRA, the French national agency for radioactive waste management to take back the sealed source.

For the operations described above regarding the fleet of ICSDs owned by a facility, the 'polluter pays' principle applies.

IX–3. SOME EXPERIENCE FEEDBACK

Six years after the implementation of these new regulations, as of 31 December 2017, ASN had delivered 320 census forms and 7 national authorizations to industrial groups for removal and collection of ICSDs as well as for maintenance of fire detections systems. Moreover, five companies were authorized to dismantle disused ICSDs.

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Annex X

MEMBER STATE EXPERIENCE (ISLAMIC REPUBLIC OF IRAN)

X–1. HISTORICAL BACKGROUND

In the Islamic Republic of Iran, there are no ICSD manufacturers or exporters. Previously there were ICSD importers that did not require authorization from the Iran Nuclear Regulatory Authority (INRA).

Currently, due to a change in approach and users' decisions to use non-ionizing smoke detectors, there are fewer ICSD importers. A permit from the INRA to import ICSDs is now compulsory.

ICSDs were normally installed in institutions, hotels, subway stations, industrial factories, warehouses, stores and in some houses. The installation of ICSDs started at the beginning of the 1970s.

The majority of ICSDs are not listed in the INRA database since ICSD use started many years before the regulatory framework was established. There is little information about ICSDs installed in the country since ICSDs were distributed without any control. Since 2008 the Iran Radioactive Waste Management Co. (IRWA) started collecting ICSDs in a centralized facility. As of early 2021, about 6000 ICSDs have been collected by the IRWA. The great majority of collected ICSDs contain ^{241}Am sources and there are some ICSDs with ^{226}Ra sources.

X–2. APPROACH TO DISUSED ICSD MANAGEMENT

Case B is practised in the Islamic Republic of Iran (collect and dismantle ICSDs to assure the long term management of both the recovered DSRS within its holder and secondary wastes). Disused ICSDs are dismantled in IRWA facilities.

Radioactive material is removed from ICSDs according to procedures for each model of ICSD. For non-radioactive parts, free release measurements are performed. Each part of the secondary waste is separated according to its own regulation and, after ensuring there is no radioactive contamination, it is transferred to the relevant endpoint.

The radioactive parts are placed into in stainless steel capsules, which are then stored in the IRWA's small temporary boreholes that were specifically designed to store and manage DSRS.

The policy and strategy for final disposition of DSRS has not yet been precisely defined although long term storage is currently performed.

When a request to accept ICSDs is received by the IRWA, well trained staff collect and transport the ICSDs to the DSRS warehouse at IRWA. Prior to authorized transportation, ICSDs are counted, documented (radionuclides and activity), contamination checked and any issues are resolved.

Secondary radioactive waste from ICSDs is monitored and released in compliance with clearance criteria. If radioactivity is lower than the exemption level and if smear test results show non-contamination, they are released as municipal waste. Materials measuring above exemption level are considered contaminated and managed as radioactive waste. If a more precise measurement is required, a sample is taken and sent to the spectrometry laboratory.

Waste generators are responsible for management steps of ICSDs and they can remove ICSDs from services without any authorization. After their contract IRWA services, then collection and transportation is done by authorized IRWA technicians.

X–3. FURTHER CONSIDERATIONS AND LESSONS LEARNED

(1) The regulatory body has strengthened the supervision of importing ICSDs. The INRA will ensure the final disposition of disused ICSDs.

(2) Regarding the value of these materials and their disposal risks, recycling is a cost-effective option. Also, if there is a possibility to send them to a third party for recycling, the IRWA is ready to transfer them.

Annex XI

MEMBER STATE EXPERIENCE (MONGOLIA)

XI–1. HISTORICAL BACKGROUND

In Mongolia, currently, there are no ICSD manufacturers or exporters. There are ICSD importers. Currently all radioactive materials need authorization, such as small activity radioactive calibration detectors. Usually ICSDs were imported from the Russian Federation. ICSDs were installed in state and private industry, some in offices. Each user has to declare radioactive materials for each consignment to inform to the regulatory body.

Mongolia has a long term storage facility, which is the centralized Isotope Centre (IC) under the Nuclear Energy Commission (NEC). A detailed inventory exists of all disused radioactive sources stored at the IC. As of 2015, more than 2000 ICSDs had been stored in the IC. Currently the IC is only used for storage for disused radioactive sources.

Mongolia has drafted a national RWM strategy but currently it lacks a full infrastructure to manage its existing inventory of radioactive waste or expected future waste arisings. A system is in place to detect, characterize and manage orphan sources.

Duties of the IC are specified in the Nuclear Energy Law, Article 11.3, which specifies that the State administrative authority needs to have a special, national facility to centrally store, transport and dispose of nuclear material, nuclear waste and non-exploitable radioactive waste. This facility is controlled by the State.

XI–2. ORGANIZATIONAL STRUCTURE AND LEGAL FRAMEWORK

Mongolia has a well-defined organizational structure for RWM working under the prime minister. The RWM policy is under approval. The IC under the NEC is responsible for the safe storage, transportation and management of disused radioactive sources and radioactive wastes within the country.

The NEC of the government of Mongolia was established in 1962 and The Amendment of the Nuclear Energy Law issued on 13 February 2015.

Basic duties of the NEC are:

— Coordinate implementation of state policy on exploitation of radioactive minerals and nuclear energy, use of nuclear technology and development of nuclear research;
— Coordinate activities for ensuring nuclear and radiation protection and safety;
— Develop and adopt safety and security regulations and licensing for nuclear facilities.

The General Agency for Specialized Inspection (GASI) is responsible for regulation, authorization, inspection and enforcement activities related to safety, health, environment, mining, construction, industry, import and export, labour, agriculture, food, trade and service including nuclear and radiation applications and RWM activities.

The National RWM policy and strategy is described in:

— State Policy on the Exploitation of Radioactive Minerals and Nuclear Energy, which has been approved by the Parliament Decision No. 45 (2009);
— Government Decision 222 on Long Term Plan for Implementation of the State Policy (2009).

The strategy will be updated on a regular basis by the NEC in cooperation with GASI.

Radioactive waste will not be exported unless exceptionally authorized by GASI. Radioactive waste that has been exported for processing may be re-imported if authorized by GASI. Before they are considered waste, DSRS need to be exported to the country of origin or another country for reuse or recycling whenever possible and feasible.

XI–3. RADIOACTIVE WASTE SOURCES AND WASTE INVENTORIES

The government delegates responsibility for the development and maintenance of a national inventory of radioactive waste including DSRS to the NEC. In cooperation with GASI, the NEC will work with the waste generators, source owners and operators of waste management facilities to obtain the necessary information.

The GASI uses the inventory application RAIS 3.3 for SRS and the NEC maintains the inventory of DSRS and radioactive waste accepted from generators.

A tracking system will be established by the NEC to keep track of radioactive sources or wastes taken over to the central storage facility.

The GASI manages a national register of sources in use. This information will be shared with the NEC to prevent the creation of orphan sources and to provide a prior indication of future waste arisings (i.e. materials that will probably be added to the national inventory of radioactive waste at a later date).

Operators of facilities that generate radioactive waste need to provide this information through GASI to the NEC, which will consolidate it to produce a national inventory of all radioactive wastes generated and stored in the country, indicating its origin, quantity and characteristics. Using information in the register of sources and information supplied by waste generators, the NEC will estimate inventory of future waste arisings.

XI–4. FURTHER CONSIDERATIONS AND LESSON LEARNED

- Regulations on radioactive waste management have been drafted.
- The IC safely stores DSRS with physical protection.
- A record keeping system was established for DSRS.
- The infrastructure of the radioactive waste storage facility has been improving since 2016.

Annex XII

MEMBER STATE EXPERIENCE (MONTENEGRO)

XII–1. HISTORICAL BACKGROUND

In Montenegro, there are no specific legal provisions concerning ICSD production, import, export, use, removal, transportation, storage, etc. All aspects of an ICSD's life cycle need to follow general legal provisions (including licensing and/or exempting) for radioactive sources.

There are no manufacturers of ICSDs in Montenegro. Import procedures are the same as for any other radioactive source, thus requiring a licence from the regulator. There are no specialized licensed importers of ICSDs.

Export is not specifically regulated; however, it is expected that all radioactive sources imported after the 2009 Radiation Protection Law was enacted will be returned to the manufacturers, which de facto means exported.

There are an estimated 20 000 ^{241}Am ICSDs in Montenegro (including both those in use and disused ICSDs). Some 200 disused ICSDs have been removed so far and are stored at the national radioactive waste facility in Podgorica.

XII–2. APPROACH TO DISUSED ICSD MANAGEMENT

Procurement, installation and maintenance are carried out by licensed institutions. Removal and transportation are carried out by the licensed institution, the Centre for Eco-Toxicological Investigations (known as CETI), which is also the storage operator. Disused ICSDs are not dismantled but are stored as-is after removal from service. There is sufficient storage space for all disused ICSDs in Montenegro.

The country thus follows a 'collect and store as received' policy, Case A, awaiting a decision on further management of disused ICSDs.

Given the limited resources and budgetary restrictions in the country, the optimization of disused ICSDs was discussed; possibilities for (sub-) regional cooperation were particularly addressed. It was acknowledged that political/legal barriers currently prevent some options, such as shared regional storage. However, other aspects of cooperation could be pursued in such fields as training, expertise, maintenance and dismantling services, regulatory harmonization (based on international/IAEA norms/recommendations), etc.

Annex XIII

MEMBER STATE EXPERIENCE (PHILIPPINES)

XIII–1. HISTORICAL BACKGROUND

In the Philippines, ICSDs had been in use before the regulatory body was established. They have been installed in private houses, commercial establishments, public buildings, hotels, airports, hospitals, schools, cinemas and other public places. In the Philippines smoke detectors are a fire safety requirement and need to be installed before a building is occupied. Smoke detectors may be ionizing or photoelectric and even dual mode, but the most common smoke detectors available in the country are ICSDs.

There are no manufacturers of ICSDs in the Philippines and they are not exported. All smoke detectors available in the market are imported by several companies. These were distributed through retail sales or bulk order for use in large buildings; they are installed by individual consumers for residential use only if instructions are provided on how to install them. For buildings requiring several hundreds of ICSDs, these are installed by authorized workers (typically, the contractor is engaged by the owner of the building).

After 10 years of service life, as recommended by the manufacturers, ICSDs are removed from service by the consumer or other authorized workers (demolition contractors, safety officers, etc.). Ionization smoke detectors are available in hardware stores, some of which are located in shopping malls.

XIII–2. POLICIES, REGULATIONS AND IMPACT ON STAKEHOLDERS

Currently, the position of the Philippine Nuclear Research Institute (PNRI) — Regulatory Division on ICSDs is that they are exempted from regulatory control as stipulated in the Code of Philippine Nuclear Research Institute Regulations (known as the CPR), Part 2 ‘Licensing of Radioactive Material’ under Section 11 ‘Specific exemption for items containing radioactive materials.’ In Section 22 of the regulations, manufacturers of ICSDs are required to apply for a licence. Currently suppliers and commercial providers are encouraged to notify the regulatory body of bulk quantities of ICSDs. There is no clear policy on the collection and disposal of disused ICSDs; however, the centralized Radioactive Waste Management Facility (known as RWMF) of the research institute accepts ICSDs for a nominal fee to manage them.

In the absence of specific regulations, the regulatory body adopts IAEA standards and regulations.

XIII–3. APPROACH TO DISUSED ICSD MANAGEMENT

Case B: Collect and dismantle ICSDs and assure the long term management of both the recovered DSRS within their holders and secondary waste.

The RWMF dismantles all ICSDs and conditions the associated DSRS in stainless steel vials in preparation for borehole disposal. The RWMF developed the dismantling and conditioning procedures for the two types of ICSDs received in the facility. A total of 1292 DSRS removed from ICSDs (27% ^{63}Ni, 344 units and 73% ^{241}Am, 948 units). After repatriation, 99 units of ^{241}Am and 344 units of ^{63}Ni remain.

Case C: Recover the radionuclide for recycling/reuse and assure the long term management of secondary radioactive waste.

The research institute requested IAEA assistance on the repatriation of DSRS (^{241}Am, 849 foils) originating in the USA under the US Off-Site Recovery Project (known as OSRP) of the National Nuclear Security Administration which is managed by Los Alamos National Laboratory (known as LANL). The foils were packaged by two laboratory personnel ready for repatriation to the USA together with other ^{241}Am and neutron sources.

XIII–4. FURTHER CONSIDERATIONS AND LESSONS LEARNED

The regulatory body needs to undertake the following:

— Review the regulatory provisions on the exempt quantities of radioactive materials for commercial use, including ICSDs;
— Develop a database of all products and suppliers with radioactive materials for commercial use, including ICSDs, with the help of the IAEA, regulatory bodies from other Member States and other local government agencies (e.g. Bureau of Customs, etc.);
— Coordinate with local government units on the issuance of permits for building demolition and occupancy (new buildings) to include the requirements on the proper management of ICSDs;
— Review the DSRS disposal practices for disused ICSDs;
— Enforce requirements to suppliers or vendors currently involved in the commercial sale and distribution of ICSDs without notification or licence application to the regulatory body.

Annex XIV

MEMBER STATE EXPERIENCE (ROMANIA)

XIV–1. HISTORICAL BACKGROUND

In Romania, currently there are no ICSD manufacturers or exporters, with the last manufacturing unit being shut down in 2011. Prior to 2011, the ICSDs manufactured were either of Romanian design or other foreign models manufactured under licence.

The companies which import ICSDs require authorization. The imported ICSDs primarily contained ^{241}Am but also ^{226}Ra, ^{85}Kr and ^{239}Pu.

The distribution of ICSDs is controlled by the companies authorized by the regulatory body.

The ICSDs have been installed in factories, warehouses, banks, public institutions, power plants, etc. by specialized companies with workers authorized by the regulator.

The ICSDs have a recommended service life specified by the manufacturer in a technical manual and by the regulator in the authorization (usually 10 years).

XIV–2. MANAGING DISUSED ICSDs IN ROMANIA

There are two routes for managing disused ICSDs:

— The ICSDs are dismantled and the radioactive sources are handed over and stored as radioactive waste. The collection of ICSDs from users and their dismantling is conducted by authorized companies. The radioactive sources are transported to one of the two radioactive waste treatment plants, where they are kept in storage. Prior to disposal, plastic and metal components are measured to determine radioactive contamination.

— The ICSDs can be collected from users by authorized companies and transferred outside Romania, if an agreement is in place.

XIV–3. POLICIES, REGULATIONS AND IMPACT ON STAKEHOLDERS

The policies in Romania regarding ICSDs are:

— An authorization is required for the supply, transport, handling (installation, maintenance, decommissioning) of ICSDs and these operations need to be conducted by authorized workers.

— Before the year 2000, an authorization for the use of ICSDs was not required, except for ICSDs containing nuclear materials (e.g. ^{239}Pu).

— The users of ICSDs need to:
  - Keep records of ICSDs (e.g. type, radioactive source contained, manufacturer, number and location of these detectors) and have the obligation to ensure their proper functioning, with the support of service companies authorized by the regulatory authority;
  - Periodically check for radioactive contamination (every 2 years).

The Romanian regulatory body is the National Commission for Nuclear Activities Control. There have not been any incidents or accidents that would impact ICSD usage.

XIV–4. SOME ISSUES RELATED TO THE USE OF ICSDS

- Cases of theft or disappearance of ICSDs due to bad records and supervision, or as a result of the demolition of industrial and buildings where ICSDs were installed;
- The occurrence of fires in installations and buildings equipped with ICSDs that have led to their deterioration or destruction;
- Upgrading and rehabilitation of facilities and buildings with ICSDs that have led to the disappearance of some ICSDs;
- Loss of records of the number and types of ICSDs caused by the bankruptcy of enterprises, the departures of authorized and trained workers from the users, frequent changes in leadership.

XIV–5. CONCLUSIONS

- The import and use of ICSDs is licensed; traceability is regulated by the need of inventory keeping.
- In the 1990s, the majority of disused ICSDs were collected and dismantled and the radioactive sources were managed as radioactive waste. The number of ICSDs in use is decreasing as they are being replaced with thermal or optical detectors.
- Some authorized companies for ICSD decommissioning and transport of radioactive sources (including ICSDs) are discontinuing their activities, thus the number of authorized companies is decreasing and, ultimately, the cost of decommissioning, transport and safe storage of disused ICSDs will increase.

XIV–6. FURTHER CONSIDERATIONS

- Enhancing the capacity of the ICSDs regulator, in particular, with qualified workers to be able to effectively manage situations involving the supply, use, handling, transport, decommissioning and storage of radioactive sources from disused ICSDs;
- Simplification of authorization procedures for companies performing the supply, installation, decommissioning and transport of ICSDs.

Annex XV

MEMBER STATE EXPERIENCE (SERBIA)

XV–1. HISTORICAL BACKGROUND

There are no ICSD manufacturers or exporters in Serbia at present. There are ICSD importers that require authorization by the regulatory body, the Serbian Radiation Protection and Nuclear Safety Agency.

In the past, a research reactor in Serbia produced source material for ICSDs and two types of ICSDs were manufactured in the reactor's laboratory. There were also several manufacturers of ICSDs in Serbia and other countries of the former Socialist Federal Republic of Yugoslavia whose ICSDs are still in use.

More than 100 000 ICSDs are stored in old radioactive waste storage facilities and recorded in a radioactive waste database. The exact number of ICSDs installed in Serbia is not known. For installed ICSDs, control of dosimetry is performed by a licensed organization every two years.

There are ten companies licensed by the regulatory body in Serbia for ICSD maintenance. One condition for obtaining the licence is the holding of a contract with the Public Company Nuclear Facilities of Serbia for RWM. The contract obliges the maintenance company to store disused ICSDs as radioactive waste in the Public Company Nuclear Facilities of Serbia.

Ionization smoke detectors are only installed in public buildings, industrial facilities, buildings for commercial use, etc. There are no ICSDs installed in private houses.

There are examples of damaged ICSDs within scrap metal, building/construction sites damaged by fire, the NATO bombing in 1999 and flooding. In these situations, the detection of ^{241}Am is a challenge. Decommissioning/decontamination of laboratories used for maintenance and production of ICSDs is performed.

No data about in-service ICSD lifetimes are available. In relation to fire protection, they are inspected regularly. Manufacturer's data related to ICSD lifetimes are not available.

XV–2. POLICIES, REGULATIONS AND IMPACT ON STAKEHOLDERS

In accordance with national legislation, smoke detectors with sources of ionizing radiation can be installed if their activity is less than 185 kBq and for which it is established that a single smear test of the source does not release more that 0.5% of the total activity of the source.

ICSDs with gaseous sources or that have decay chain radionuclides that are gases cannot be installed and used. The dose rate measured at 10 cm from any point of the external surface of the ICSD does not need to be higher than 1.0 µSv/h.

Consumers or maintenance companies need to notify the regulator about the number of ICSDs installed.

Cleaning and maintenance of ICSDs is performed according to methods prescribed in technical documentation.

ICSDs that are disused need to be kept by the maintenance companies in locked storage with radiation protection measures in place. For ICSD storage, the person responsible for implementation of radiation protection measures is in charge of the facility.

If ICSDs are lost in the event of fire or other natural disasters, the user of the ICSDs has to notify the regulatory body.

XV–3. APPROACH TO DISUSED ICSD MANAGEMENT

In accordance with national regulation, all disused ICSDs are managed as radioactive waste in Serbia. Serbia practices Case B management of ICSDs (collecting and dismantling of ICSDs).

Removal and collection of ICSDs could be performed by the licensee for ICSDs maintenance or for RWM, before the user decides not to use the device anymore.

Disused ICSDs can only be dismantled in the Waste Processing Facility in the Public Company Nuclear Facilities of Serbia. Depending on the type of ICSDs and radioactive material (^{241}Am, ^{226}Ra, ^{239}Pu, ^{85}Kr) the source or holder with source will be removed from ICSDs, with a 30 times volume reduction and managed as radioactive waste. For all non-radioactive parts, free release measurements are performed.

During dismantling, sources from ICSDs are stored in stainless steel containers or tubes made of transparent plastic. Containers and tubes are stored at the radioactive waste storage facilities in accordance with the facilities' WAC. The goal for RWM in Serbia is disposal, but a decision on the disposal option of disused sources is pending and will be defined in the coming years.

XV–4. FURTHER CONSIDERATIONS AND LESSONS LEARNED

During dismantling, the amount of secondary waste generated is large. Improving methodologies for characterization of secondary waste generated after the dismantling of ICSDs is necessary to reduce the accumulation of secondary waste.

Sharing experiences, photos and manuals for dismantling of ICSDs between Member States is a very important issue. Development of a database for dismantling procedures for the various types and models of ICSDs needs to be considered.

Annex XVI

MEMBER STATE EXPERIENCE (SLOVAKIA)

XVI–1. HISTORICAL BACKGROUND

In Slovakia, there are no ICSD manufacturers or exporters. There are ICSD importers only. Until 1993 the country was part of Czechoslovakia, where a manufacturer is still located in Liberec (the company Lites, formerly Tesla).

Most of the ICSDs installed in Slovakia up to now were produced either by that company or by Siemens. The types of ICSDs installed included MSK 101 (^{226}Ra), MHG 101, MHG 103, MHG 120, MHG 181, MSK 100, MSK 102 (^{241}Am) produced by Tesla, and F7, F-600 and F-15 Cerberus produced by Siemens; newer types with ^{241}Am are MHG 141, 161, 185, 186 produced by Lites.

The use of ICSDs is not regulated in Slovakia. As with other radioactive materials, ICSDs need an import authorization, but only if the country of origin is outside of the EU. The distribution is under regulatory control and requires authorization. ICSDs are installed in institutions, public buildings, banks, offices and industrial companies. Installation in households is rare.

From 1972 to 2001, there was a legal obligation to notify the regulatory body about the number of installed and uninstalled ICSDs according to the Regulation 65/72 Coll. The estimated number of ICSDs installed is about 80 000. From the 1990s onward, the use of ICSDs decreased and, at present, only a small number of the newly installed smoke detectors are ICSDs.

Ionization chamber smoke detector collection is under regulatory control. Disused ICSDs are managed as radioactive waste and an authorization is required for any collecting and handling. Collection of ICSDs is conducted by:

— The manufacturer Lites Liberec from the Czech Republic.
— Three local organizations: two of them dismantle the detectors, the third is authorized for dismantling but collects the whole devices and transports them either to the ICSD producer or to a radionuclide supplier for recycling. One of the dismantling organizations is a part of the national radioactive waste management facility.

About 35 000 disused ICSDs have been collected so far by Slovak organizations; the number collected by the producer (Lites) is not known at the moment.

There is no recommended service lifetime for ICSDs, except in the case that the manufacturer included a lifetime in the instruction for use or in the maintenance documentation. There are no restrictions on the radionuclides in ICSDs.

The dismantled ICSDs can be stored in the newly opened part of the Radioactive Waste Management Facility (operated by JAVYS) intended for institutional (non-nuclear) radioactive waste or exported to the authorized producer or authorized radionuclides supplier. There is no state policy in this field — the authorized organization is free to do this on a contract basis.

XVI–2. POLICIES, REGULATIONS AND IMPACT ON STAKEHOLDERS

For collecting disused sources and institutional radioactive waste, including ICSDs, an authorization is required. The use of ICSDs was never restricted. The Act on Public Health Care No. 355/2007 Coll. Supported by governmental orders requires authorization for ICSD production, for import of radioactive sources from non-EU countries and for collecting of radioactive waste including disused ICSDs.

A new Act on radiation protection has been prepared, which prohibits the import, distribution and installation of new ICSDs in ways similar to those in the Czech Republic.

Annex XVII

MEMBER STATE EXPERIENCE (SLOVENIA)

XVII–1. HISTORICAL BACKGROUND

In Slovenia, there are no ICSD manufacturers, but in the past a research reactor in Slovenia produced source material for ICSDs. The import and export of ICSDs has always been under regulatory control by the Slovenian regulatory body. Some new ICSDs have been imported and some disused ICSDs produced by Apollo (Zarja) were exported for return to their manufacturer.

A notification system is used to control ICSD use and to prevent any undesired situations or loses. Around 60 000 ICSDs are listed in the regulatory body's database. About 30 000 of them are stored in the radioactive waste management facility (RWM storage facility). Regarding past practices, about 30 000 ICSDs may not have been under regulatory control and, therefore, are not included in the regulatory body's database. Unfortunately, there are still a considerable number of ICSDs outside the regulatory body's database and outside regulatory control. One of the reasons is that the use of ICSDs started many years before the regulatory framework and regulatory body database were established.

In addition to import controls, the transfer of ICSDs between European Union Member States is also controlled. At present, the companies that sell ICSDs are also involved in their removal due to the large task of replacing old ICSDs by new technologies (e.g. optical or thermal devices). A combined authorization is issued (for selling/removing). However, this was not a past practice.

The installation of ICSDs started at the beginning of the 1970s. Due to good technical performance, ICSDs were widely used and can be found in industrial, service and even in general public buildings like hospitals or schools. The installation of ICSDs in private dwellings was not practised in Slovenia.

Installation of ICSDs was conducted by companies engaged in servicing and maintenance of ICSDs. Currently, ICSDs are removed only by authorized licensees. However, this was not a practice in the past and old ICSDs were removed during major reconstructions or upgrades of the existing fire alarm systems without notifying the regulatory body.

In the past, ICSDs were collected by the Agency for RWM (ARAO) or by companies engaged in servicing and maintenance of ICSDs that kept them in ad hoc storage facilities. Today, collection is a part of the authorization procedures for companies performing removal and all storage facilities are under regulatory control. In addition, ICSDs can be removed only by authorized licensees. According to Slovenian regulation, centralized collection is carried out at the Central Storage Facility (an RWM storage facility).

No data about in-service ICSD lifetimes are available. However, this lifetime is usually linked with the renovation or major adaptation of buildings and as a technical item in a building, they are expected to be replaced or removed about every 20–30 years, even if working properly. In relation to fire protection, they are inspected regularly.

XVII–2. POLICIES, REGULATIONS AND IMPACT ON STAKEHOLDERS

In the past, ICSDs were at least under partial control of the regulatory body (e.g. import was controlled but dismantling and storage of disused ICSDs were not controlled). However, all ICSDs were inspected by an authorized radiation protection expert every few years and data were regularly sent to the regulatory body.

At present, there is a large decline in the use of ICSDs and, as a rule, they are replaced by new technologies. The regulatory body database includes all known ICSDs in the state, in used as well as disused condition. The import and transfer from or to other European Union Member States is controlled.

Users of ICSDs have to regularly report the regulatory body, every 5 years authorized radiation protection experts report the results of ICSD inspections to the regulatory body.

After removal of ICSDs by companies engaged in servicing and maintenance, ICSDs are put into plastic bags and labelled. The owner of ICSDs asks ARAO for further steps in the process of waste management, which provides collecting, transportation, handling, conditioning and storage services for all disused ICSDs from various users in Slovenia. As a rule, ARAO provides contamination control and collects the ICSDs as soon as practicable. After transferring ICSDs to the RWM storage facility, users have to report change of ownership to the regulatory body within 8 days.

In addition, ARAO reports the change of ownership to the regulatory body. After the change of ownership, ARAO is legally responsible for the safe and secure conditioning and storage of ICSDs. Up to now, ARAO has accepted around 30 000 units of disused ICSDs into an RWM storage facility. This large number of unconditioned ICSDs represents a volume of approximately 30 m^3 which could be problematic from the point of view of fire safety (plastic material), occupancy of storage space, source leaking and degradation of source housings.

Because the storage of disused radioactive sources is usually expensive, especially in the case of a large number of ICSDs, the dismantling was a logical step forward for Slovenia. The radioactive sources were removed from disused ICSDs, packaged in polyethylene bags and loaded in standard steel 210 L drums. The steel drums have been safely stored in the RWM storage facility. The rest of non-radioactive materials (plastic, metal and electronic components) are segregated and prepared for recycling.

After such conditioning, the disused radioactive sources from ICSDs are in more appropriate and safe form for storage and require significantly less space in the RWM storage facility. After the storage in the RWM storage facility, it is likely that the internal bags and drums with ICSDs will be retrieved for further conditioning and repackaging prior to disposal.

There are five stakeholder groups: the regulatory body, ARAO, companies engaged in servicing and maintenance of ICSDs, authorized radiation protection experts and users.

The use of ICSDs is restricted to exclude radionuclides whose daughters are gaseous.

Contamination of workplaces by ^{241}Am has occurred in public places, such as at workplaces in companies engaged in servicing and maintenance of ICSDs. In addition, already controlled ICSDs were lost or ICSDs were identified at landfills, therefore the regulatory body conducted two public campaigns for the safe management of ICSDs, as well as around 70 inspections.

XVII–3. APPROACH TO DISUSED ICSD MANAGEMENT

Slovenia practices Case B management of ICSDs (dismantling of ICSDs). At the RWM storage facility, disused ICSDs are bagged and sorted by model. Dismantling is performed in controlled areas set-up for this work. Non-active components are cleared for release according to documented procedures. Since a disposal facility in Slovenia is not available, conditioned radioactive sources from ICSDs are stored in the RWM storage facility.

XVII–4. FURTHER CONSIDERATIONS AND LESSONS LEARNED

Operational experiences confirmed that conditioning of ICSDs and separation of radioactive from non-radioactive parts is as an effective method for volume reduction of radioactive waste. During conditioning activities, a lot of plastic materials related with the ICSDs were removed from the RWM storage facility. This represents an additional operational safety benefit and reduction of potential fire hazard.

However, dealing with disused ICSDs involves the manipulation of bare sources, which needs special procedures, shielded and ventilated workplaces and tools to protect the operators and prevent the spread of contamination. Dismantling of ICSDs requires different types of precautionary measures to be taken in order to prevent mechanical damage of the radioactive sources and well trained and skilled operators. Dismantling of ICSDs needs to be carried out slowly and carefully to preserve the radioactive source intact and to protect spreading of contamination to non-radioactive parts of the devices.

Annex XVIII

MEMBER STATE EXPERIENCE (SYRIAN ARAB REPUBLIC)

XVIII–1. HISTORICAL BACKGROUND

In the Syrian Arab Republic, there are no ICSD manufacturers or exporters. There are ICSD importers that require authorization. ICSDs are normally installed by consumers or authorized workers in institutions, hotels, hospitals, power stations, etc. In the old days, not all authorized importers had reported ICSD distribution to the regulatory body; therefore, ICSD inventories are currently incomplete. Approximately, 580 ICSDs of five different types and models have been collected and stored at the Central Waste Management Facility for the last 10 years.

XVIII–2. POLICIES AND REGULATIONS

In the past, DSRS and devices were stored at the owner's temporary storage. As the Legislative Decree No. 64 was issued in 2005 and the Prime Minister's Decree No. 134 in 2007, the DSRS need to be repatriated to the country of origin at the end of their life cycle; otherwise, they are collected and stored at the central RWMF.

Since 2016, national instructions for RWM have been developed which would be approved by the Prime Minister upon a recommendation to be made by the Committee of 'Radiation Protection and Safety and Security of Radiation Sources.' In addition, a quality control system for receipt, treatment and conditioning of radioactive waste has been established. Extensive work has been implemented to update the RWM system in compliance with IAEA recommendations. This would be combined with RAIS at the Radiological and Nuclear Regulatory Office (known as RNRO).

XVIII–3. APPROACH TO DISUSED ICSD MANAGEMENT

Recently, the Syrian Arab Republic practised Case B management of ICSDs (collect and dismantle ICSDs and assure the long term management of both the recovered DSRS within its holder and secondary waste). This was achieved by a well trained and specialized team at the central RWM facility which is authorized by the Radiological and Nuclear Regulatory Office.

- The licence has been issued upon a safety assessment study;
- Dismantling procedure of the stored ICSDs, which basically contain ^{241}Am, has been performed into a glove box within a prepared working area taking into account radiation protection aspects (i.e. individual monitoring of occupational exposures and PPE);
- ICSDs have been segregated by models and country makes and dismantled by models;
- The recovered DSRS have been ISO tested (mainly visual and swipe tests), accommodated into 1 L certified stainless steel capsules (homemade) which are intended to be placed into a repository which will be established in the near future;
- Secondary waste (metallic, electronic plates and plastics) has been monitored for contamination and released according to clearance limits prior to recycling/treatment as conventional waste with labels removed;
- Contaminated parts have been considered as radioactive waste and treated accordingly;
- Records, photographs and videos have been maintained throughout the work;

— The workplace has been monitored while the job was accomplished and decontamination has been carried out, if any contamination was detected.

XVIII–4. LESSON LEARNED AND RECOMMENDATION

Operational experience confirmed that management of ICSDs and their DSRS is an effective method for volume minimization of radioactive waste although it needs to be performed with precaution in order to prevent damage to the intact DSRS and spreading of contamination.

The national team could serve as an expert team in the region and will be able to exchange and share experience on an interregional level.

XVIII–5. PHOTOGRAPHS FOR DISUSED ICSD MANAGEMENT

FIG. XVIII–1. Collecting disused ICSDs and dismantling.

(a) (b)

FIG. XVIII–2. (a) Disused ^{241}Am sources recovered from ICSDs and (b) Syrian stainless steel capsule for DSRS conditioning.

(a) (b) (c)

FIG. XVIII–3. Secondary wastes: (a) plastic wastes; (b) metallic wastes; and (c) electronic wastes.

FIG. XVIII–4. Tools for dismantling ICSDs.

Annex XIX

MEMBER STATE EXPERIENCE (THAILAND)

XIX–1. HISTORICAL BACKGROUND

In Thailand, there are no ICSD manufacturers or exporters. There are ICSD importers. Currently, all radioactive materials need authorization. Each importer and user needs to declare the total amount of radioactive material for each consignment to the regulatory body. However, not all authorized importers have reported ICSD distribution to the regulator, therefore records of the distribution of radioactive material are incomplete. ICSDs were normally installed in institutions, hotels, subway station, factories etc.

ICSDs were installed either by consumers or authorized workers. In addition, ICSDs were removed from service either by consumers or companies. There are no designated collection points for disused ICSDs. Consumers or companies collect disused ICSDs and inform the regulatory body Office of Atoms for Peace (OAP). The OAP informs the Radioactive Waste Management Center (RWMC), a part of the Thailand Institute of Nuclear Technology (TINT), a public organization. The RWMC is authorized to manage disused ICSDs and generators pay a service charge. Currently ICSDs are stored.

Since ICSDs are only partially under regulatory control, the number of ICSDs in service may be difficult to determine. There is no recommended in-service lifetime for ICSDs.

XIX–2. POLICIES, REGULATIONS AND IMPACT ON STAKEHOLDERS

The policies on ICSDs are the same as for SRS. There is regulation of SRS distribution or use. Currently, there are three licensees for the import or distribution of ICSDs.

Since 2006, the nuclear institution has split into two organizations:

— OAP as regulatory body;
— TINT as implementation body.

The organizations involved in RWM in Thailand (OAP and TINT) are under the Ministry of Science and Technology and the Bureau of Radiation Safety regulates the RWMC.

Management of radioactive waste in Thailand conforms to international safety standards on RWM in order to achieve and demonstrate a high level of safety. The RWMC mandates the following:

— The licence holder will be responsible for safe management of radioactive waste until the waste is accepted by the waste management organization (TINT);
— Radioactive waste including DSRS will be safely managed by the waste management organization (TINT);
— DSRS (excludes ICSDs) will be repatriated to the country of origin;
— Orphan sources (includes ICSDs) will be recovered by OAP and managed by TINT;
— Discharges of radioactive effluent from licensee’s facilities be regulated by OAP.

XIX–3. APPROACH TO DISUSED ICSD MANAGEMENT

Disused ICSDs that are received at RWMC facilities are stored in drums. Thailand would be Case B: collects and dismantles ICSDs and assures the long term management of both the recovered DSRS within its holder and secondary wastes.

— Currently, about 3500 disused ICSDs have been received at RWMC, TINT;
— In the future, when disused ICSDs will be dismantled, the RWMC, TINT needs to request OAP permission for dismantling disused ICSDs by submitting the procedure (manual procedure and emergency plan).

XIX–4. FURTHER CONSIDERATIONS AND LESSONS LEARNED

— Disused ICSD collection is centralized and the devices are managed as DSRS;
— Authorization is required for using ICSDs;
— RWMC, TINT have to notify the regulator of the number of disused ICSDs stored in storage facilities;
— Develop a database of disused ICSDs and procedure for dismantling disused ICSDs by RWMC, TINT.

ABBREVIATIONS

CCHEN	Chilean Nuclear Energy Commission
CSA	comprehensive safeguards agreements
DSRS	disused sealed radioactive source
GASI	General Agency for Specialized Inspection (Mongolia)
IC	Isotope Centre (Mongolia)
ICSD	ionization chamber smoke detector
INRA	Iran Nuclear Regulatory Authority
IRWA	Iran Radioactive Waste Management Co.
ISO	International Standards Organization
NEC	Nuclear Energy Commission (Mongolia)
OAP	Office of Atoms for Peace (Thailand)
PPE	personal protective equipment
RWM	radioactive waste management
RWMC	Radioactive Waste Management Center (Thailand)
SRS	sealed radioactive source
TINT	Thailand Institute of Nuclear Technology (Thailand)

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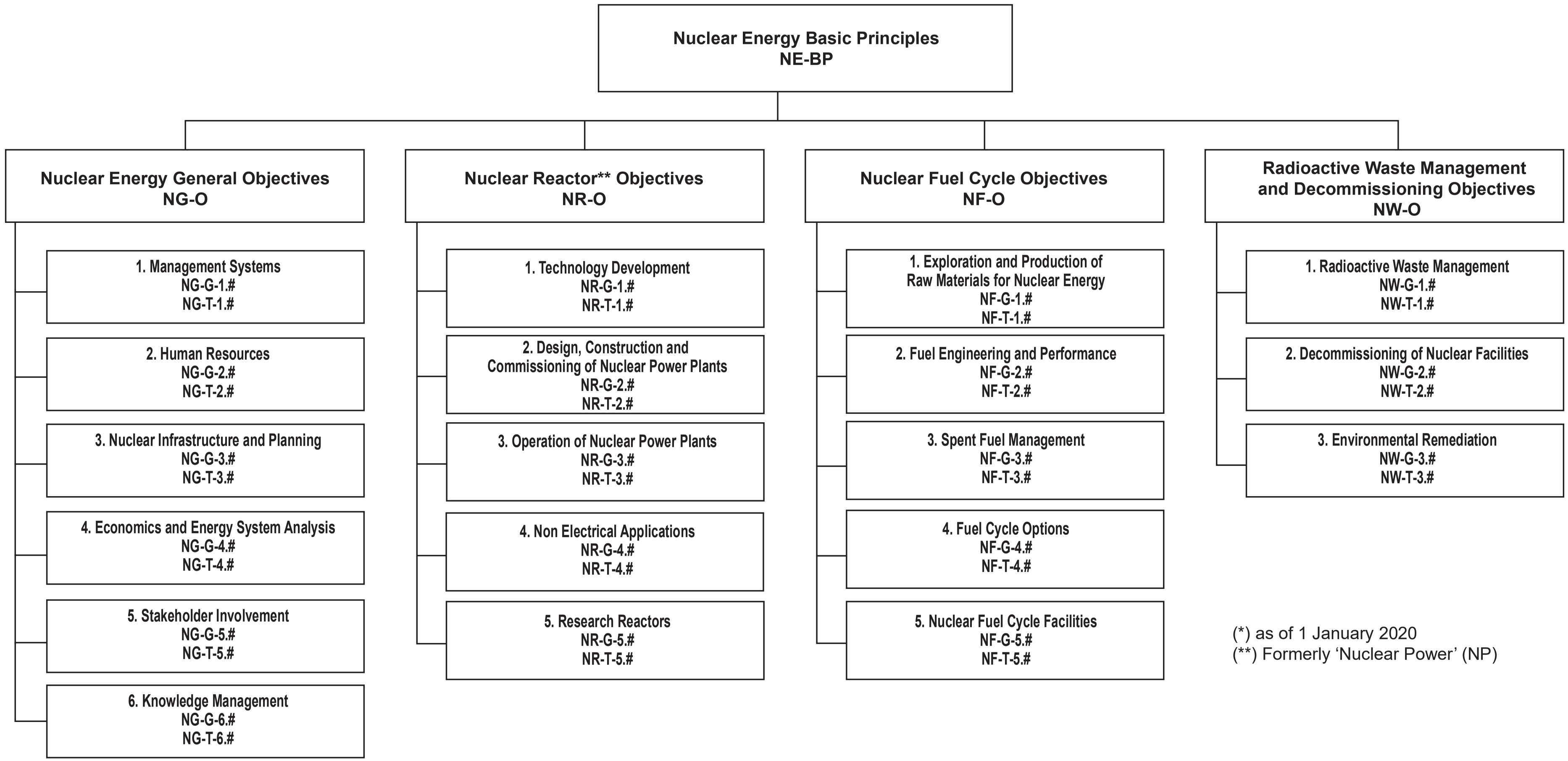

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