IAEA Safety Standards

for protecting people and the environment

Control of Orphan Sources and Other Radioactive Material in the Metal Recycling and Production Industries

Specific Safety Guide

No. SSG-17

IAEA

International Atomic Energy Agency

IAEA SAFETY STANDARDS AND RELATED PUBLICATIONS

IAEA SAFETY STANDARDS

Under the terms of Article III of its Statute, the IAEA is authorized to establish or adopt standards of safety for protection of health and minimization of danger to life and property, and to provide for the application of these standards.

The publications by means of which the IAEA establishes standards are issued in the **IAEA Safety Standards Series**. This series covers nuclear safety, radiation safety, transport safety and waste safety. The publication categories in the series are **Safety Fundamentals**, **Safety Requirements** and **Safety Guides**.

Information on the IAEA's safety standards programme is available at the IAEA Internet site

http://www-ns.iaea.org/standards/

The site provides the texts in English of published and draft safety standards. The texts of safety standards issued in Arabic, Chinese, French, Russian and Spanish, the IAEA Safety Glossary and a status report for safety standards under development are also available. For further information, please contact the IAEA at PO Box 100, 1400 Vienna, Austria.

All users of IAEA safety standards are invited to inform the IAEA of experience in their use (e.g. as a basis for national regulations, for safety reviews and for training courses) for the purpose of ensuring that they continue to meet users' needs. Information may be provided via the IAEA Internet site or by post, as above, or by email to Official.Mail@iaea.org.

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CONTROL OF ORPHAN SOURCES AND OTHER RADIOACTIVE MATERIAL IN THE METAL RECYCLING AND PRODUCTION INDUSTRIES

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The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world''.

IAEA SAFETY STANDARDS SERIES No. SSG-17

CONTROL OF ORPHAN SOURCES AND OTHER RADIOACTIVE MATERIAL IN THE METAL RECYCLING AND PRODUCTION INDUSTRIES

SPECIFIC SAFETY GUIDE

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FOREWORD

by Yukiya Amano
Director General

The IAEA's Statute authorizes the Agency to "establish or adopt… standards of safety for protection of health and minimization of danger to life and property" — standards that the IAEA must use in its own operations, and which States can apply by means of their regulatory provisions for nuclear and radiation safety. The IAEA does this in consultation with the competent organs of the United Nations and with the specialized agencies concerned. A comprehensive set of high quality standards under regular review is a key element of a stable and sustainable global safety regime, as is the IAEA's assistance in their application.

The IAEA commenced its safety standards programme in 1958. The emphasis placed on quality, fitness for purpose and continuous improvement has led to the widespread use of the IAEA standards throughout the world. The Safety Standards Series now includes unified Fundamental Safety Principles, which represent an international consensus on what must constitute a high level of protection and safety. With the strong support of the Commission on Safety Standards, the IAEA is working to promote the global acceptance and use of its standards.

Standards are only effective if they are properly applied in practice. The IAEA's safety services encompass design, siting and engineering safety, operational safety, radiation safety, safe transport of radioactive material and safe management of radioactive waste, as well as governmental organization, regulatory matters and safety culture in organizations. These safety services assist Member States in the application of the standards and enable valuable experience and insights to be shared.

Regulating safety is a national responsibility, and many States have decided to adopt the IAEA's standards for use in their national regulations. For parties to the various international safety conventions, IAEA standards provide a consistent, reliable means of ensuring the effective fulfilment of obligations under the conventions. The standards are also applied by regulatory bodies and operators around the world to enhance safety in nuclear power generation and in nuclear applications in medicine, industry, agriculture and research.

Safety is not an end in itself but a prerequisite for the purpose of the protection of people in all States and of the environment — now and in the future. The risks associated with ionizing radiation must be assessed and controlled without unduly limiting the contribution of nuclear energy to equitable and sustainable development. Governments, regulatory bodies and operators everywhere must ensure that nuclear material and radiation sources are used beneficially, safely and ethically. The IAEA safety standards are designed to facilitate this, and I encourage all Member States to make use of them.

THE IAEA SAFETY STANDARDS

BACKGROUND

Radioactivity is a natural phenomenon and natural sources of radiation are features of the environment. Radiation and radioactive substances have many beneficial applications, ranging from power generation to uses in medicine, industry and agriculture. The radiation risks to workers and the public and to the environment that may arise from these applications have to be assessed and, if necessary, controlled.

Activities such as the medical uses of radiation, the operation of nuclear installations, the production, transport and use of radioactive material, and the management of radioactive waste must therefore be subject to standards of safety.

Regulating safety is a national responsibility. However, radiation risks may transcend national borders, and international cooperation serves to promote and enhance safety globally by exchanging experience and by improving capabilities to control hazards, to prevent accidents, to respond to emergencies and to mitigate any harmful consequences.

States have an obligation of diligence and duty of care, and are expected to fulfil their national and international undertakings and obligations.

International safety standards provide support for States in meeting their obligations under general principles of international law, such as those relating to environmental protection. International safety standards also promote and assure confidence in safety and facilitate international commerce and trade.

A global nuclear safety regime is in place and is being continuously improved. IAEA safety standards, which support the implementation of binding international instruments and national safety infrastructures, are a cornerstone of this global regime. The IAEA safety standards constitute a useful tool for contracting parties to assess their performance under these international conventions.

THE IAEA SAFETY STANDARDS

The status of the IAEA safety standards derives from the IAEA's Statute, which authorizes the IAEA to establish or adopt, in consultation and, where appropriate, in collaboration with the competent organs of the United Nations and with the specialized agencies concerned, standards of safety for protection of health and minimization of danger to life and property, and to provide for their application.

With a view to ensuring the protection of people and the environment from harmful effects of ionizing radiation, the IAEA safety standards establish fundamental safety principles, requirements and measures to control the radiation exposure of people and the release of radioactive material to the environment, to restrict the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation, and to mitigate the consequences of such events if they were to occur. The standards apply to facilities and activities that give rise to radiation risks, including nuclear installations, the use of radiation and radioactive sources, the transport of radioactive material and the management of radioactive waste.

Safety measures and security measures[1] have in common the aim of protecting human life and health and the environment. Safety measures and security measures must be designed and implemented in an integrated manner so that security measures do not compromise safety and safety measures do not compromise security.

The IAEA safety standards reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from harmful effects of ionizing radiation. They are issued in the IAEA Safety Standards Series, which has three categories (see Fig. 1).

Safety Fundamentals

Safety Fundamentals present the fundamental safety objective and principles of protection and safety, and provide the basis for the safety requirements.

Safety Requirements

An integrated and consistent set of Safety Requirements establishes the requirements that must be met to ensure the protection of people and the environment, both now and in the future. The requirements are governed by the objective and principles of the Safety Fundamentals. If the requirements are not met, measures must be taken to reach or restore the required level of safety. The format and style of the requirements facilitate their use for the establishment, in a harmonized manner, of a national regulatory framework. Requirements, including numbered 'overarching' requirements, are expressed as 'shall' statements. Many requirements are not addressed to a specific party, the implication being that the appropriate parties are responsible for fulfilling them.

Safety Guides

Safety Guides provide recommendations and guidance on how to comply with the safety requirements, indicating an international consensus that it is necessary to take the measures recommended (or equivalent alternative measures). The Safety

[1] See also publications issued in the IAEA Nuclear Security Series.

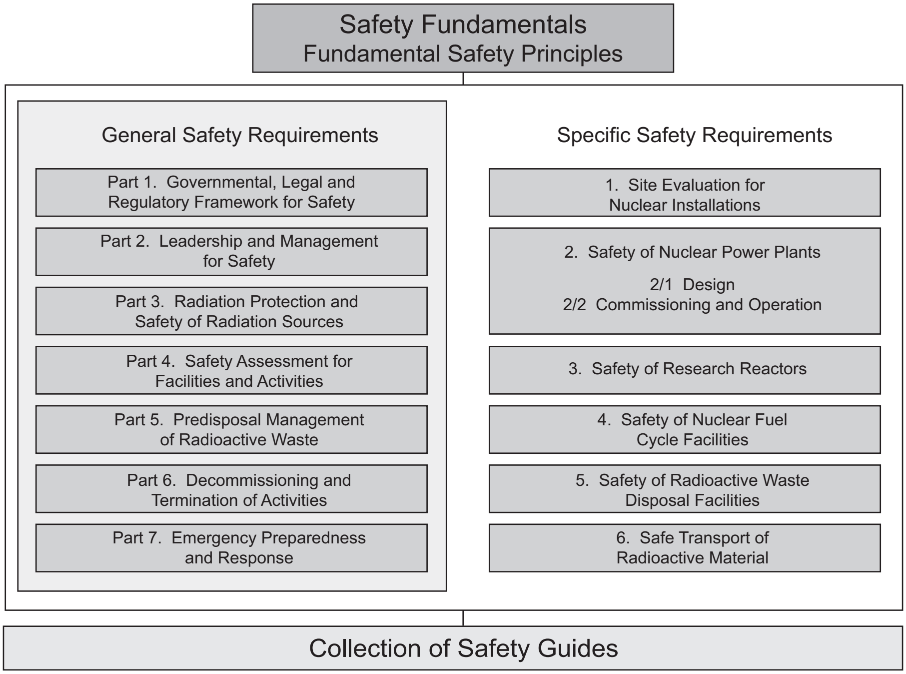

FIG. 1. The long term structure of the IAEA Safety Standards Series.

Guides present international good practices, and increasingly they reflect best practices, to help users striving to achieve high levels of safety. The recommendations provided in Safety Guides are expressed as 'should' statements.

APPLICATION OF THE IAEA SAFETY STANDARDS

The principal users of safety standards in IAEA Member States are regulatory bodies and other relevant national authorities. The IAEA safety standards are also used by co-sponsoring organizations and by many organizations that design, construct and operate nuclear facilities, as well as organizations involved in the use of radiation and radioactive sources.

The IAEA safety standards are applicable, as relevant, throughout the entire lifetime of all facilities and activities — existing and new — utilized for peaceful purposes and to protective actions to reduce existing radiation risks. They can be used by States as a reference for their national regulations in respect of facilities and activities.

The IAEA's Statute makes the safety standards binding on the IAEA in relation to its own operations and also on States in relation to IAEA assisted operations.

The IAEA safety standards also form the basis for the IAEA's safety review services, and they are used by the IAEA in support of competence building, including the development of educational curricula and training courses.

International conventions contain requirements similar to those in the IAEA safety standards and make them binding on contracting parties. The IAEA safety standards, supplemented by international conventions, industry standards and detailed national requirements, establish a consistent basis for protecting people and the environment. There will also be some special aspects of safety that need to be assessed at the national level. For example, many of the IAEA safety standards, in particular those addressing aspects of safety in planning or design, are intended to apply primarily to new facilities and activities. The requirements established in the IAEA safety standards might not be fully met at some existing facilities that were built to earlier standards. The way in which IAEA safety standards are to be applied to such facilities is a decision for individual States.

The scientific considerations underlying the IAEA safety standards provide an objective basis for decisions concerning safety; however, decision makers must also make informed judgements and must determine how best to balance the benefits of an action or an activity against the associated radiation risks and any other detrimental impacts to which it gives rise.

DEVELOPMENT PROCESS FOR THE IAEA SAFETY STANDARDS

The preparation and review of the safety standards involves the IAEA Secretariat and four safety standards committees, for nuclear safety (NUSSC), radiation safety (RASSC), the safety of radioactive waste (WASSC) and the safe transport of radioactive material (TRANSSC), and a Commission on Safety Standards (CSS) which oversees the IAEA safety standards programme (see Fig. 2).

All IAEA Member States may nominate experts for the safety standards committees and may provide comments on draft standards. The membership of the Commission on Safety Standards is appointed by the Director General and includes senior governmental officials having responsibility for establishing national standards.

A management system has been established for the processes of planning, developing, reviewing, revising and establishing the IAEA safety standards. It articulates the mandate of the IAEA, the vision for the future application of the

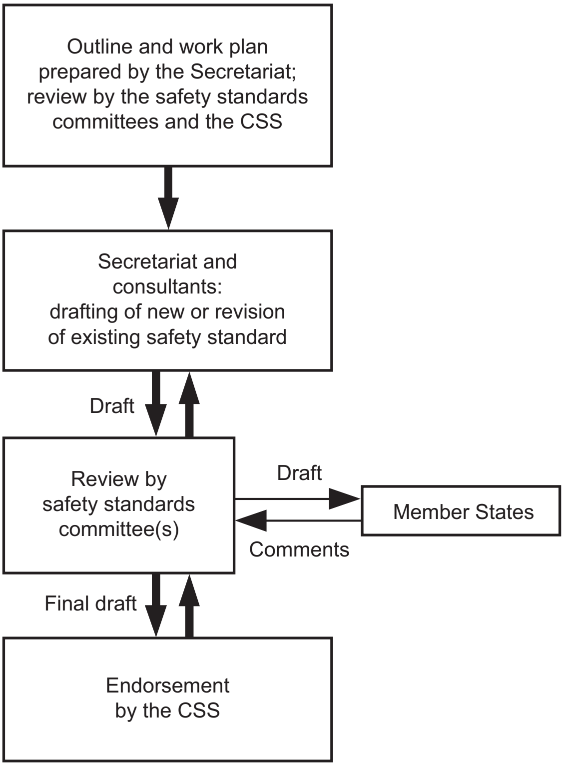

FIG. 2. The process for developing a new safety standard or revising an existing standard.

safety standards, policies and strategies, and corresponding functions and responsibilities.

INTERACTION WITH OTHER INTERNATIONAL ORGANIZATIONS

The findings of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the recommendations of international expert bodies, notably the International Commission on Radiological Protection (ICRP), are taken into account in developing the IAEA safety standards. Some safety standards are developed in cooperation with other bodies in the United Nations system or other specialized agencies, including the Food and Agriculture Organization of the United Nations, the United Nations Environment Programme, the International Labour Organization, the OECD Nuclear Energy Agency, the Pan American Health Organization and the World Health Organization.

INTERPRETATION OF THE TEXT

Safety related terms are to be understood as defined in the IAEA Safety Glossary (see http://www-ns.iaea.org/standards/safety-glossary.htm). Otherwise, words are used with the spellings and meanings assigned to them in the latest edition of The Concise Oxford Dictionary. For Safety Guides, the English version of the text is the authoritative version.

The background and context of each standard in the IAEA Safety Standards Series and its objective, scope and structure are explained in Section 1, Introduction, of each publication.

Material for which there is no appropriate place in the body text (e.g. material that is subsidiary to or separate from the body text, is included in support of statements in the body text, or describes methods of calculation, procedures or limits and conditions) may be presented in appendices or annexes.

An appendix, if included, is considered to form an integral part of the safety standard. Material in an appendix has the same status as the body text, and the IAEA assumes authorship of it. Annexes and footnotes to the main text, if included, are used to provide practical examples or additional information or explanation. Annexes and footnotes are not integral parts of the main text. Annex material published by the IAEA is not necessarily issued under its authorship; material under other authorship may be presented in annexes to the safety standards. Extraneous material presented in annexes is excerpted and adapted as necessary to be generally useful.

CONTENTS

1. INTRODUCTION

BACKGROUND

1.1. The IAEA has issued a number of safety standards establishing requirements for the regulatory control of radioactive material [1–3] and guidance on the security of radioactive sources [4]. Nevertheless, radioactive material may have been in use within a State before a system of control based on these requirements was established. Even now, the regulatory infrastructure within a State may not be sufficiently well developed, or may fail, with the consequence that radioactive sources may be lost from regulatory control and may enter the general environment. Thus, irrespective of the state of development of the regulatory infrastructure within a State, radioactive material may become mixed with scrap metal destined for recycling.

1.2. Scrap metal is an important source material for the metal production industry, contributing a large fraction of the final product (in the case of steel, about 50%). Most cities have several scrapyards, ranging from small operations involving a few individuals through medium sized facilities to, in industrialized States, large scrapyards handling between a hundred thousand and some ten million tonnes of scrap metal each year. The number of metal works and foundries worldwide that buy scrap to melt and refine or cast to shape is in the tens of thousands [5]. Furthermore, there is substantial transboundary movement of scrap metal and other products of the metal recycling and production industries[1] [6]. As a consequence, radioactive material mixed with scrap metal may inadvertently be transported across national borders. In view of this international dimension, a harmonized approach to dealing with radioactive material incorporated into scrap metal is clearly desirable.

1.3. Radioactive sources (including sealed sources, i.e. sources that are permanently sealed in a capsule or closely bonded and in a solid form) are used widely throughout the world in a variety of medical, industrial, research and military applications. A radioactive source that is not under regulatory control,

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[1] The term ‘metal recycling and production industries’ is used in this Safety Guide to indicate all those physical and legal entities involved in the recycling of scrap metal, such as facilities carrying out collection, sorting and processing of scrap metal, foundries that melt scrap metal, and industry associations. The term ‘metal recycling and production facility’ is used to indicate any facility within the metal recycling and production industries.

either because it has never been under regulatory control or because it has been abandoned, lost, misplaced, stolen or otherwise transferred without proper authorization, is referred to as an orphan source [7]. Orphan sources have led to accidents with serious, even fatal, consequences as a result of the exposure of individuals to radiation (see Annex I). The melting of an orphan source with scrap metal or its rupturing when mixed with scrap metal has also resulted in contaminated recycled metal and wastes. If this happens, expensive cleanup operations may be necessary. If the contaminated material is not detected at the metal recycling and production facility, workers may be exposed to radiation and radionuclides may become incorporated into various finished products and wastes, which, in turn, may lead to the exposure of users of these products.

1.4. Concern over accidents involving orphan sources, including those that have occurred in the metal recycling and production industries, led to the establishment of an international undertaking, the Code of Conduct on the Safety and Security of Radioactive Sources (the Code of Conduct) [8] and the associated Guidance on the Import and Export of Radioactive Sources [9]. Nevertheless, the possibility of orphan sources being present in scrap metal remains [10].

1.5. Radioactive material in unsealed form may also be present in scrap metal as a consequence of inadequate control during the decommissioning of a nuclear installation or other facility. It may also arise as a consequence of the presence of radionuclides of natural origin, which occur in industries that process large amounts of raw material; examples are the mining and processing of various ores and the production of oil and gas. The hazard to human health from such low levels of contamination is generally low when compared with that from orphan sources; the main problem is likely to be a financial one.

1.6. The IAEA has assisted the United Nations Economic Commission for Europe (UNECE) in its efforts towards unifying and harmonizing both monitoring strategies for the detection of radioactive material in scrap metal and procedures to be used following the discovery of such radioactive material [11–13]. The major aim of the UNECE is to promote pan-European economic integration, and, in the context of this work, the IAEA provided guidance on radiation safety matters. This Safety Guide takes account of all the work undertaken by the UNECE and the IAEA over the past decade or more to strengthen the safety and security of radioactive sources and the control of other radioactive material, including several relevant international conferences [5, 14–18].

1.7. Application of the requirements of the safety standards and use of the supporting guidance given in this and other Safety Guides will provide confidence to the metal recycling and production industries that scrap metal and recycled metal products and any wastes produced are safe from a radiological perspective.

OBJECTIVE

1.8. The objective of this Safety Guide is primarily to provide recommendations to governments and national authorities, including regulatory bodies, on applying the Fundamental Safety Principles [19] by meeting the Safety Requirements [1–3, 20] in relation to the control of radioactive material in scrap metal and metal products. The recommendations in this Safety Guide take account of the basic principles in the Code of Conduct [8] and the obligations that States Parties may have under international conventions [21, 22]. However, it also provides recommendations that may be used by the metal recycling and production industries in general on the arrangements that should be made to protect workers, members of the public and the environment. Its primary focus is on the control of orphan sources that might be found within the metal recycling and production industries. It also provides recommendations on the control of other radioactive material that might enter the metal recycling and production industries.

SCOPE

1.9. This Safety Guide is concerned with orphan sources and other radioactive material[2] that may enter the metal recycling supply chain. It applies to all operations in the handling of scrap metal for recycling and the subsequent processing of this material. However, in view of the wide range in size of these operations, this Safety Guide provides recommendations on how to apply a graded approach to the control of orphan sources and other radioactive material, on the basis of the size of the individual metal recycling and production facility and on the radioactive material that it might reasonably be expected to encounter.

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[2] In this Safety Guide, when there is no need for a distinction to be made between orphan sources and other radioactive material, the generic term ‘radioactive material’ is used, with the meaning of “material designated in national law or by a regulatory body as being subject to regulatory control because of its radioactivity” [7].

1.10. This Safety Guide does not provide detailed recommendations on the following:

(a) Meeting the requirements for authorized uses of radioactive material that are aimed at preventing a loss of control over radioactive material and which include the monitoring of material for the purposes of clearance[3] from regulatory control.
(b) National, regional or local emergency response plans that may be called into play as a consequence of the discovery of radioactive material in scrap metal, metal products or wastes from metal processing facilities.
(c) The decontamination of premises that might be contaminated as a consequence of the processing or melting of radioactive material in a scrap metal stream.
(d) The subsequent management of any recovered orphan sources or of any radioactive waste following the discovery of radioactive material in scrap metal.
(e) The monitoring of commodities, including scrap metal, as they are transported across national borders, since such monitoring is normally undertaken for the purposes of national security. Nevertheless, it is noted that such border monitoring will contribute to preventing radioactive material from being inadvertently processed within the metal recycling and production industries and should be regarded as an important component part of the overall system of control of radioactive material within a State [5].

References [1–3, 23–28] establish requirements and provide recommendations and guidance on these matters.

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[3] The term 'clearance' is defined in the IAEA Safety Glossary [7] as removal of radioactive material or radioactive objects within authorized practices from any further regulatory control by the regulatory body. This is a specific use of the normal dictionary meaning of the word, which is 'removal of obstructions' or 'permission to proceed'. In radiation safety, it relates to a process of checking material to determine whether it can be considered as non-radioactive within the context of radiation protection regulations and therefore be released from further regulatory control. Clearance levels therefore specify upper limits on any residual contamination by radionuclides, in much the same way as upper limits are given for a whole range of other possible environmental contaminants in different commodities. Thus, any scrap metal that has been cleared in this way need not be subject to regulatory control and may be regarded as safe for recycling.

STRUCTURE

1.11. Section 2 provides a general overview of the principles of radiation protection in relation to the presence of radioactive material in scrap metal. Section 3 provides recommendations on the responsibilities of the various parties involved — national authorities and the metal recycling and production industries — on the basis of the safety standards [1–3, 20] and international agreements, particularly the Code of Conduct [8]. Section 4 provides recommendations on monitoring for radioactive material. Section 5 provides recommendations on the initial response to the discovery of radioactive material. Section 6 provides recommendations on the remediation of contaminated areas, and Section 7 provides recommendations on the management of recovered radioactive material.

1.12. The Safety Guide also contains three annexes. Annex I provides a review of some events involving radioactive material that have occurred in the metal recycling and production industries. Annex II provides a description of the categorization of radioactive sources [29]. Annex III provides some examples of national and international initiatives to deal with radioactive material in scrap metal. The terms used in this Safety Guide are defined in the IAEA Safety Glossary [7], unless otherwise indicated.

2. PROTECTION OF PEOPLE AND THE ENVIRONMENT

GENERAL

2.1. The Fundamental Safety Principles [19] establish the fundamental safety objective and ten fundamental safety principles. This objective, “to protect people and the environment from harmful effects of ionizing radiation”, applies to all facilities and activities[4] that give rise to radiation risks[5], including the presence of radioactive material in scrap metal within the metal recycling and production industries. Principle 7 states that: "People and the environment, present and future, must be protected against radiation risks." Principle 8 states that: "All practical efforts must be made to prevent and mitigate nuclear or radiation accidents."

2.2. Requirements designed to protect people and the environment from harmful effects of ionizing radiation and relevant to establishing control over radioactive material that may be present in scrap metal were established in the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (the BSS) [1] (since revised), the Safety Requirements publication on the Governmental, Legal and Regulatory Framework for Safety [2], and the Safety Requirements publication on Preparedness and Response for a Nuclear or Radiological Emergency [20].

INCIDENTS AND EMERGENCY EXPOSURE SITUATIONS

2.3. Paragraph 3.2 of Ref. [19] states that:

> "Safety is concerned with both radiation risks under normal circumstances and radiation risks as a consequence of incidents ... as well as with other possible direct consequences of a loss of control over a … radioactive source or any other source of radiation. Safety measures include actions to prevent incidents and arrangements put in place to mitigate their consequences if they were to occur."

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[4] The term 'facilities and activities' as used in the Fundamental Safety Principles [19] is a general one encompassing any human activity that may cause people to be exposed to radiation risks arising from naturally occurring or artificial sources. Facilities within the metal recycling and production industries would therefore be included, even though the presence of radioactive material is unwanted.

[5] The term 'radiation risks' is used in a general sense to refer to:

- Detrimental health effects of radiation exposure (including the likelihood of such effects occurring).
- Any other safety related risks (including those to ecosystems in the environment) that might arise as a direct consequence of:
  - Exposure to radiation;
  - The presence of radioactive material (including radioactive waste) or its release to the environment;
  - A loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation [7].

2.4. An emergency is defined as “a non-routine situation that necessitates prompt action, primarily to mitigate a hazard or adverse consequences for human health and safety, quality of life, property or the environment” [7, 20]. It includes situations for which prompt action is warranted to mitigate the effects of a potential hazard. Whether a situation meets the definition of an emergency, therefore, does not depend on the size of the hazard, the severity of the adverse consequences or the nature of the response to mitigate the situation. The discovery of radioactive material in scrap metal or metal products therefore falls within the definition of an emergency. However, the extent of the actions that are taken in response to the discovery of radioactive material in the metal recycling and production industries will vary substantially, from isolation of the suspected radioactive material to shutdown of the facility and restriction of access to certain areas pending further radiological investigation. In some cases, for example, where there has been a release of radioactive material to the atmosphere or a dispatch of contaminated products for general use, action off the site of the facility may be necessary.

2.5. An intervention is an action intended to reduce or avert exposure or the likelihood of exposure to sources of radiation that are not part of a controlled (or authorized) use of radioactive material or that are out of control as a consequence of an accident [7]. Actions taken to control and remove radioactive material from scrap metal following its discovery at a metal recycling and production facility fall within this definition. It is therefore appropriate to apply the radiation protection requirements for intervention established in the BSS to such situations [1].

2.6. Reference [20] defines five threat categories for the purpose of grading the application of the requirements for emergency preparedness and response[6].

[6] The word ‘threat’ is used in Ref. [20] for the purposes of establishing safety requirements relating to emergency preparedness for and response to a nuclear or radiological emergency. It is not to be confused with the use of the word in the context of nuclear security, where it relates to criminal acts involving nuclear and other radioactive material (see also footnote 9).

Paragraph 3.6 of Ref. [20] states that: “Threat category IV applies to activities that can lead to emergencies occurring virtually anywhere; it is also the minimum level of threat, which is assumed to apply for all States and jurisdictions.”[7] Paragraph 3.19 of Ref. [20] furthermore states that: “Locations at which there is a significant probability of encountering a dangerous source that has been lost, abandoned, illicitly removed or illicitly transported shall also be identified in the threat assessment.”[8] Paragraph 3.20 of Ref. [20] states that: “Large scrap metal processing facilities … should be considered in the threat assessment.” The requirements relating to threat category IV established in Ref. [20] therefore apply to the metal recycling and production industries. Recommendations on how to meet the requirements established in Ref. [20] are provided in the supporting Safety Guide [28].

2.7. The radiation protection requirements for intervention are as follows:

(a) “[P]rotective actions or remedial actions shall be undertaken whenever they are justified” (para. 3.3 of Ref. [1]);
(b) “The form, scale, and duration of any such protective action or remedial action shall be optimized so as to produce the maximum net benefit, understood in a broad sense, under the prevailing social and economic circumstances” (para 3.4 of Ref. [1]).

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[7] Reference [20] describes threat category IV as follows:

> “Activities that could give rise to a nuclear or radiological emergency that could warrant urgent protective action in an unforeseeable location. These include non-authorized activities such as activities relating to dangerous sources [see Annex II of this Safety Guide for an explanation of this term] obtained illicitly. They also include transport and authorized activities involving dangerous mobile sources such as industrial radiography sources, nuclear powered satellites or radiothermal generators. Threat category IV represents the minimum level of threat, which is assumed to apply for all States and jurisdictions.”

[8] In the definition of threat assessment given in the IAEA Safety Glossary [7] it is noted that use of the term does not imply that any threat, in the sense of an intention and capability to cause harm, has been made in relation to facilities, activities or sources.

2.8. In order to apply the second of these requirements, the operator[9] of a facility in which radioactive material might be discovered should ensure that appropriate arrangements are put in place to identify such material and to respond in such a way as to keep the radiation doses to workers and members of the public to levels that are as low as reasonably achievable, taking account of economic and social factors. The arrangements should be graded according to the size of the facility and the radioactive material that is likely to be encountered at the facility. In practice, this means that small and medium sized facilities should have some awareness of the problem and be able to visually recognize suspect material (i.e. a package or device that may contain a radioactive source), and awareness of the person or organization to contact in the event that such material is discovered. On the other hand, large facilities should be equipped with radiation detectors and should have sufficient radiation protection expertise available to undertake an initial response to isolate suspect material.

2.9. Detailed information on the protection of workers involved in the response to emergencies and in cleanup operations is provided in Ref. [30].

CONTAMINATION BY RADIONUCLIDES OF ARTIFICIAL ORIGIN

2.10. The concept and the radiological criteria to be used as a basis for determining exemption and clearance levels are defined in Ref. [1]. Reference [31] provides values of activity concentration for bulk amounts of material containing radionuclides of artificial origin based on the criteria of Ref. [1] and on very conservative (i.e. cautious) models of exposure pathways that are more than sufficient to take account of the exposure pathways that might ensue from the recycling of scrap metal [32]. The values of activity concentration

[9] The term ‘operator’ means “Any organization or person … responsible for … *radiation* … *safety* … when undertaking *activities* or in relation to any … *sources* of *ionizing radiation*” [7]. Principle 1 of Ref. [19] places the prime responsibility for safety on the person or organization responsible for facilities and activities that give rise to radiation risks (see footnote 4 for an explanation of the term ‘facilities and activities’). Footnote 5 of Ref. [19] states that: “Not having an authorization would not exonerate the person or organization responsible for the facility or activity from the responsibility for safety.” Paragraphs 4.19 and 4.24 of Ref. [20] also refer to the operator(s) of a facility in threat category IV. The fundamental point is that the term ‘operator’ as used in the IAEA safety standards does not apply only to planned exposure situations that are subject to authorization, but also to industries, such as the metal recycling and production industries, in which radioactive material may be present but which may not be subject to authorization by the regulatory body.

for bulk material containing some commonly encountered radionuclides of artificial origin are given in Table 1.

2.11. Paragraph 5.8 of Ref. [31] states that:

> "there should be no need for any further action (e.g. to reduce exposures) for materials containing radionuclides at activity concentrations below [the values given in Table 1]. In particular, national and international trade in commodities containing radionuclides with activity concentrations below the values of activity concentration provided in [Table 1] should not be subject to regulatory control for the purposes of radiation protection."

As such, the values of activity concentration provided in Table 1 are appropriate for use by the metal recycling and production industries as a basis for determining whether the scrap metal is safe for recycling (see footnote 3). A graded approach consistent with paras 5.11–5.13 of Ref. [31] may be applied to activity concentrations that exceed the values given in Table 1.

CONTAMINATION BY RADIONUCLIDES OF NATURAL ORIGIN

2.12. Reference [31] specifies values of activity concentration below which it is usually unnecessary to regulate material containing radionuclides of natural

TABLE 1. VALUES OF ACTIVITY CONCENTRATION FOR SOME RADIONUCLIDES OF ARTIFICIAL ORIGIN COMMONLY ENCOUNTERED IN BULK MATERIAL [31]

Radionuclide	Activity concentration (Bq/g)
Am-241, Ag-110m, Co-60, Cs-137, Pu-239, Zn-65	0.1
Cm-244, Ir-192, Nb-95, Sr-90, Tc-99, Tl-204, Zr-95	1
Au-198	10
Ni-63	100
Pm-147	1000

origin.[10] These levels, given in Table 2, may also be used to determine whether scrap metal containing radionuclides of natural origin is acceptable for recycling, irrespective of the origin of the material. The values were derived by taking into account the amenability to control of radionuclides of natural origin. Doses to individuals as a consequence of these values of activity concentration were considered to be unlikely to exceed about 1 mSv in a year [31].

2.13. If radionuclides of natural origin are present in an authorized facility, it is the responsibility of the operator of that authorized facility to subject scrap metal to a clearance procedure in accordance with regulatory requirements before it is released for recycling. However, there may be facilities in which radionuclides of natural origin are present that are not subject to regulatory control, and consequently scrap metal from such facilities is unlikely to have been monitored for contamination before its release for recycling. Thus, by default, the main means of controlling this type of material is by monitoring scrap metal entering the metal recycling and production industries.

2.14. Through processing, radionuclides of natural origin may become concentrated in waste products even though the levels of activity concentration in the scrap metal were initially below those given in Table 2. If this is the case, the levels in Table 2 may again be used to determine whether the waste products should be subject to regulatory control.

TABLE 2. VALUES OF ACTIVITY CONCENTRATION FOR RADIONUCLIDES OF NATURAL ORIGIN [31]

Radionuclide	Activity concentration (Bq/g)
K-40	10
All other radionuclides of natural origin	1

[10] There are some situations (such as the use of some building materials containing natural radionuclides) in which exposures from materials due to radionuclides with activity concentrations below those given in Table 2 would necessitate consideration by the regulatory body for some types of regulatory control [31].

3. RESPONSIBILITIES

GOVERNMENTAL, LEGAL AND REGULATORY FRAMEWORK

3.1. Principle 2 of the Fundamental Safety Principles, which refers to the role of government, states that: "An effective legal and governmental framework for safety, including an independent regulatory body must be established and sustained" [19]. This should be achieved "without unduly limiting the operation of facilities or the conduct of activities that give rise to radiation risks" (para. 2.1, Ref. [19]).

3.2. The objective of Ref. [2] is the establishment of requirements in respect of the governmental, legal and regulatory framework for safety for the entire range of facilities and activities involving the use of radiation sources. Reference [2] establishes the requirements for a national framework enabling the government to discharge its responsibilities for radiation protection and safety. Essential parts of a national framework are: legislation and regulations; a regulatory body empowered to authorize and inspect regulated activities and to enforce the legislation and regulations; sufficient resources; and adequate numbers of trained personnel. References [2] and [20] establish requirements, including those relating to the regulatory framework, for an adequate level of preparedness for and response to a nuclear or radiological emergency in any State. Reference [3] establishes requirements for the disposal of radioactive waste, such as might be required following the discovery of radioactive material that has inadvertently been incorporated into scrap metal.

3.3. In addition, there are international agreements and conventions that may be required to be taken into account in establishing an appropriate national framework for radiation protection and safety. These include:

(a) The Code of Conduct on the Safety and Security of Radioactive Sources [8], which is a voluntary undertaking intended to help national authorities to ensure that radioactive sources are used within an appropriate framework of radiation safety and security, and the associated Guidance on the Import and Export of Radioactive Sources [9];
(b) The Convention on Early Notification of a Nuclear Accident [21];
(c) The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency [21];

(d) The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [22].

3.4. Requirement 8 of Ref. [2] relates to emergency preparedness and response and states that: “The government shall make provision for emergency preparedness to enable a timely and effective response in a nuclear or radiological emergency.” Furthermore, it states that: “Emergency response arrangements shall include a clear assignment of responsibility for immediate notification of an emergency to the competent authorities” (para. 2.20, Ref. [2]). It goes on to state that: “The government shall specify and shall assign clear responsibilities for decision making in an emergency” (para. 2.23, Ref. [21]).

3.5. Requirement 9 of Ref. [2] relates to the system for protective actions to reduce existing or unregulated radiation risks and states:

> “The government shall establish an effective system for protective actions to reduce undue radiation risks associated with unregulated sources (of natural and artificial origin) and contamination from past activities or events, consistent with the principles of justification and optimization.”

Furthermore:

> “the government shall designate the organizations to be responsible for making the necessary arrangements for the protection of workers, the public and the environment .... The organization taking the protective action shall have access to the resources necessary to fulfil its function” (para. 2.25, Ref. [2]).

It goes on to state:

> “The regulatory body shall provide any necessary inputs for the protective action, including advising the government or exercising regulatory control over protection actions. It shall establish the regulatory requirements and criteria for protective actions in cooperation with the other authorities involved, and in consultation with interested parties, as appropriate” (para. 2.26, Ref. [2]).

3.6. The salient guidance of the Code of Conduct [8], which applies to all radioactive sources that may pose a significant risk to individuals, society and the environment (i.e. dangerous sources), includes the following:

(1) “Every State should have in place an effective national legislative and regulatory system of control over the management and protection of radioactive sources. Such a system should:

....

“(c) include national strategies for gaining or regaining control over orphan sources;

“(d) provide for rapid response for the purpose of regaining control over orphan sources;

....

“(g) mitigate or minimize the radiological consequences of accidents or malicious acts involving radioactive sources” (para. 8 of Ref. [8]).

(2) “Every State should ensure that appropriate facilities and services for radiation protection, safety and security are available to, and used by, the persons who are authorized to manage radioactive sources. Such facilities and services should include … those needed for:

....

“(b) intervention in the event of an accident or malicious act involving a radioactive source” (para. 9 of Ref. [8]).

(3) “Every State should ensure that adequate arrangements are in place for the appropriate training of the staff of its regulatory body, its law enforcement agencies and its emergency services organizations” (para. 10 of Ref. [8]).

(4) “Every State should ensure that information concerning any loss of control over radioactive sources, or any incidents, with potential transboundary effects involving radioactive sources, is provided promptly to potentially affected States through established IAEA or other mechanisms” (para. 12 of Ref. [8]). This has implications not only relating to the loss of control over a particular source that may find its way into scrap metal, but also relating to such events as the discovery that a radioactive source has been melted with scrap metal and the recycled metal subsequently exported.

(5) “Every State should .... (b) encourage bodies and persons likely to encounter orphan sources during the course of their operations (such as scrap metal recyclers and customs posts) to implement appropriate monitoring programmes to detect such sources” (para. 13 of Ref. [8]).

3.7. Under the Early Notification Convention [21], States Parties commit that, in the event of an accident that may result in a significant transboundary release of radioactive material, they will notify directly or through the IAEA those States that may be affected and the IAEA. Reference [20] further requires

States to notify directly or through the IAEA those States that may be affected and the IAEA in the event of a transnational emergency [7]. The loss of a radioactive source that might become mixed with scrap metal, which may subsequently be transported across national boundaries, or the accidental melting of a radioactive source with the possibility of a release of radioactive material to the atmosphere during recycling of scrap metal, could constitute such a transnational emergency.

3.8. States Parties to the Assistance Convention [21] are required to cooperate among themselves and with the IAEA "to facilitate prompt assistance in the event of a nuclear accident or radiological emergency to minimize its consequences and to protect life, property and the environment from the effects of radioactive releases" (Article 1).

3.9. In Article 28 of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (the Joint Convention) [22] each Contracting Party is required, "in the framework of its national law, [to] take the appropriate steps to ensure that the possession, remanufacturing or disposal of disused sealed sources takes place in a safe manner." Each Contracting Party is also required to "allow for reentry into its territory of disused sealed sources if, in the framework of its national law, it has accepted that they be returned to a manufacturer qualified to receive and possess the disused sealed sources."

THE GOVERNMENT

3.10. The government should consider how the requirements established in Refs [1–3, 20], the basic principles provided in the Code of Conduct [8] and, as appropriate, the obligations of various international conventions [21, 22] should be applied in the context of the metal recycling and production industries within its State.

3.11. The degree to which the metal recycling and production industries will be regulated from the point of view of radiation protection is a matter for each government; it depends very much on the system of regulatory control of the State. However, in the absence of any relevant regulations, the government should first consider implementing a voluntary approach that encourages all entities involved in the radiation protection aspects of the recycling of scrap metal to cooperate in bringing radioactive material under regulatory control.[11] Subsequently, particularly where such voluntary arrangements prove to be insufficient, the government should consider whether additional legislation or regulations need to be established in order to protect people and the environment from hazards associated with the inadvertent processing of radioactive material together with scrap metal and whether the functions of the regulatory body need to be extended.

3.12. In view of the wide range in the size of individual operations, from very small facilities to large facilities handling hundreds of thousands of tonnes or more of scrap metal each year, the government should adopt an approach that is graded according to the size of the facility, the radiation risks and the capabilities of the operator to address the problem of scrap metal containing radioactive material. Although, in principle, this Safety Guide is relevant to all facilities in the metal recycling and production industries, the recommendations relate primarily to large facilities that handle over one hundred thousand tonnes of scrap metal annually and operate shredders and melt scrap metal. Governments and national authorities should determine the degree to which the recommendations should be applied to small and medium sized facilities.

3.13. In establishing national arrangements — whether regulatory or voluntary — the government should consider the following specific issues, taking into account the graded approach, as indicated in para. 3.12:

(a) The degree to which operators of metal recycling and production facilities are encouraged to inform the regulatory body of their operations.
(b) The need for operators of metal recycling and production facilities to establish arrangements for responding to the suspected or actual presence of radioactive material in scrap metal, metal products or wastes. These arrangements should cover the notification of the regulatory body and, as necessary, the competent authority in the area of emergency response, if radioactive material is determined to be present in scrap metal, metal products or wastes.
(c) The need for operators of metal recycling and production facilities to ensure the level of protection of people and the environment as required in the BSS [1].

[11] An example of such a voluntary arrangement is the 'Spanish Protocol', which is described in Annex III.

(d) The need for operators of metal recycling and production facilities to ensure that any radioactive waste arising from radioactive material that has been mixed with scrap metal is managed in an appropriate manner and in accordance with the requirements established in Ref. [3].

3.14. National authorities other than the regulatory body may be responsible for overseeing industrial safety in the metal recycling and production industries and for environmental protection. In addition, there may be other national authorities with responsibilities for nuclear security[12]. Where this is the case, appropriate and effective coordination mechanisms should be established between these various national authorities, including the regulatory body, to ensure that synergies are appropriately exploited and potential conflicts avoided. In particular, consideration should be given to the establishment of ‘memoranda of understanding’ between those concerned, with a national committee representing all the relevant interests to oversee the implementation of the memoranda of understanding, and of regular (e.g. annual) liaison meetings. All interactions between national authorities should be aimed at ensuring protection of workers and the public and protection of the environment.

3.15. The government should also establish a policy and strategy regarding the responsible organizations and the financial arrangements for dealing with the response to and the consequences of any incident involving the discovery of radioactive material in the metal recycling and production industries. The policy and strategy should be such that operators of metal recycling and production facilities are encouraged to report the discovery of radioactive material, so that

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[12] Nuclear security is defined as the prevention and detection of, and response to, theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear material, other radioactive substances or their associated facilities [7]. In this context, it is noted that there is not an exact distinction between the general terms safety and security. In general, security is concerned with malicious acts by humans that could cause or threaten harm to other humans; safety is concerned with the broader issue of harm to humans or the environment from radiation, irrespective of the cause. Both, however, are concerned with negligent actions, and it is this aspect in particular that necessitates effective coordination between the organizations concerned.

appropriate action by the State may be taken to bring the material under regulatory control.[13]

THE REGULATORY BODY

3.16. The regulatory body should maintain oversight of radiation safety within the metal recycling and production industries. In order to do this, it should establish and maintain a list of the metal recycling and production facilities within the State that fall within threat category IV (see para. 2.6).

3.17. Irrespective of the degree of regulation of radiation safety in the metal recycling and production industries, the regulatory body should work towards building a constructive relationship with the industries in order to ensure effective cooperation in the event of an incident or emergency involving radioactive material.

3.18. In keeping with national laws and regulations, the regulatory body should develop policies and strategies for the control of scrap metal, metal products or wastes that might contain radioactive material, in cooperation with other relevant national authorities, including customs and border authorities[14], police and emergency response organizations, organizations with responsibilities for national security, radioactive waste management organizations, the metal

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[13] One of the following approaches could be used for implementing this recommendation:

(a) The government could encourage the establishment of a system whereby the metal recycling and production facilities, possibly through their trade associations or users of radioactive material, cover, by insurance or other means, the costs of recovery of radioactive material or remediation of a contaminated facility.

(b) The government itself, through the regulatory body or otherwise, could cover the cost of regaining control over radioactive material, including any arrangements for its subsequent management.

[14] Customs and border authorities have, inter alia, responsibility for preventing the unauthorized import or export of potentially hazardous material including radioactive material. A major current concern is the threat to national security that may be posed by the illicit trafficking of radioactive material. To counteract this threat, some States have established radiation monitoring programmes at border crossings. Such monitoring programmes also contribute to preventing radioactive material mixed with scrap metal from being transferred across borders. For this reason, there are considerable benefits in the coordination of policies and strategies for safety and security regarding the establishment of radiation monitoring programmes at border crossings.

recycling and production industries, and relevant representatives of workers. These policies and strategies should establish a graded approach, with account taken of the following:

(a) The type, activity and characteristics of the radioactive material that is likely to be encountered (Ref. [8]; see also Annex II);
(b) The volume of scrap metal being processed annually within a State.

3.19. In determining the likelihood that radioactive material is present in scrap metal and its likely nature, account should be taken of the frequency of previous incidents and the origin of the scrap metal being processed, particularly whether a shipment originates from a State with a weak regulatory infrastructure.

3.20. The strategy for the storage, processing, reuse or disposal of any recovered radioactive material should be consistent with the established national policy and strategy on radioactive waste management (see Ref. [3]) and the recommendations provided in para. 5.67 of Ref. [33].

3.21. The regulatory body should participate in any initiative of the metal recycling and production industries to develop guides, agreements or protocols relating to the protection of workers, members of the public and the environment from hazards associated with radioactive material that may be present in scrap metal.

3.22. The role of the regulatory body in an emergency will vary depending on national circumstances and should be determined in advance at the stage of emergency planning. It can range from having responsibility for participating directly in emergency response actions to acting as an adviser to the emergency services and others involved. Irrespective of the national situation, the role and responsibilities of the regulatory body, including its interaction with operators, should be clearly defined and documented, and procedures should be developed to enable it to perform its role and discharge its responsibilities.

3.23. The regulatory body, in cooperation with the competent authority in the area of emergency response, should establish arrangements for its part in the response to incidents and emergencies involving the discovery of radioactive material in the metal recycling and production industries. These arrangements should be in line with the national radiation emergency plan and should be developed in accordance with the requirements established in Ref. [20] and the recommendations provided in Ref. [30]. These arrangements should, as necessary, be developed in conjunction with local and national arrangements for response to radiological emergencies. These arrangements and plans should clearly identify the responsible parties, including those responsible for providing specialized technical advice and assistance in a prompt manner.

3.24. The regulatory body should assist in regaining physical control over any radioactive material discovered in scrap metal. It should also ensure that any radioactive material recovered is appropriately stored pending its removal to a radioactive waste storage or disposal facility authorized to handle the material.

3.25. The regulatory body should ensure that during any cleanup or decontamination activities appropriate precautions are taken to protect workers, members of the public and the environment from radiation hazards, in accordance with the requirements of Ref. [1].

3.26. The regulatory body should liaise with regulatory bodies of other States and with relevant regional and international organizations to promote cooperation, the exchange of relevant information and the harmonization of approaches to the control of radioactive material in scrap metal.

3.27. The regulatory body should undertake its own investigation or should assist in any investigation into any incident involving the detection of radioactive material at a metal recycling and production facility, to determine the possible causes and any lessons to be learned and whether any additional controls may need to be implemented.

3.28. The regulatory body, in cooperation with other relevant national authorities, should ensure that its own staff is adequately trained to fulfil its obligations with respect to incidents and emergencies involving the suspected or actual presence of radioactive material in scrap metal, metal products or wastes. In addition, it should encourage the development of appropriate training programmes for management and workers at metal recycling and production facilities, customs and border authorities, and police and emergency response organizations.

3.29. In the event of a reported loss of radioactive material within the State, or in any other circumstances that might suggest that radioactive material has been brought into the State without appropriate authorization, the regulatory body should alert the metal recycling and production industries, as appropriate, and should notify them if the radioactive material is subsequently recovered.

3.30. The regulatory body should maintain awareness within its own organization and among medical practitioners that the unexpected appearance of radiation injuries (i.e. deterministic effects) to persons is a possible indicator of the presence of an orphan source.[15] Radiation injuries should be regarded as indicative of an emergency exposure situation requiring prompt action to locate and isolate the radioactive source in order to prevent further individuals from being exposed to radiation (see para. 6.35 of Ref. [28]). The IAEA and the World Health Organization have issued a leaflet to inform medical practitioners of how to recognize radiation injuries [34].

3.31. In the event that the regulatory body considers it likely that unauthorized radioactive material has been or could be transported across the State's national boundary into another State, it should alert the customs and border authorities and make arrangements for any potentially affected States to be notified.

3.32. The regulatory body should consider, in cooperation with the metal recycling and production industries, the dissemination of information to facilities regarding the injuries that can be caused by radioactive material in scrap metal, particularly dangerous sources, the actions to be taken in the event of the discovery of radioactive material, and the lessons learned from past events involving the presence of radioactive material in the metal recycling and production industries. In particular, the regulatory body should consider, in cooperation with the metal recycling and production industries, the development of information leaflets and posters to raise awareness of the risk that radioactive material is present in scrap metal. Such leaflets and posters should contain descriptions of radioactive sources that may typically be encountered, their containers and the devices in which they are used, to assist the metal recycling and production industries in the identification of orphan sources. A checklist of initial actions to be taken by operators in the event that radioactive material is discovered and some advice on basic radiation protection should also be provided.[16] Reference [35] provides information on typical sealed radioactive sources and the devices in which they are contained.

3.33. Reference [36] contains action guides, instructions and response cards for specific first responders and teams that will respond to radiological emergencies at facilities, including those whose activities fall within threat category IV.

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[15] The appearance of such injuries among the family and friends of scavengers of scrap metal was the first indication of the accident that occurred in Goiânia in 1987 (see Ref. [I–2] of Annex I).

[16] Such leaflets, posters and basic checklists of initial actions to be taken are particularly important for small and medium sized enterprises with very limited knowledge of radiation safety.

3.34. The operator of a metal recycling and production facility is responsible for the health and safety of its workers and any other persons who may be affected by its activities, including members of the public.[17] In particular, all individuals involved in the metal recycling and production industries should take all reasonable and appropriate measures to ensure that the material that they handle, process or supply is safe for recycling.

3.35. Organizations and associations representing the metal recycling and production industries should support the development of industrial standards for metal recycling and production, particularly where there are no relevant regulations or national guidance in the State. Such standards, which may take the form of guides, agreements or protocols, should be developed in cooperation with the relevant national authorities, including the regulatory body, and the relevant representatives of workers. Examples of protocols and arrangements established between the metal recycling and production industries and national authorities are given in Annex III.

3.36. Operators of metal recycling and production facilities should implement the following:

(a) *Provision of a statement pertaining to international shipments of scrap metal*.[18] Operators of large facilities should request or require suppliers of bulk quantities of scrap metal originating from other States to provide a statement indicating whether the scrap metal has been subjected to radiation monitoring and the results of that monitoring.

(b) *Establishment of a monitoring programme (see Section 4).* Operators of large facilities should conduct appropriate radiation monitoring to determine whether the scrap metal being processed and any resulting products (ingots, metal bars, etc.) and wastes are safe from a radiological perspective (i.e. they do not contain material that is designated in national law or by a regulatory body as being subject to regulatory control because of its radioactivity; see footnote 2). A statement from a supplier giving the

[17] This is a general principle of health and safety, and many States will have legislation that makes this responsibility a requirement, irrespective of the nature of the hazard.

[18] Some States require certification that the shipment has been subjected to radiation monitoring and shown to be safe for recycling. Such certification is a formal statement and implies that the monitoring has been carried out by a body that has been accredited by an appropriately competent organization.

results of radiation monitoring that has been conducted does not provide an absolute guarantee that the scrap metal does not contain radioactive material, in view of the difficulties of using monitoring equipment to detect and measure radioactivity in scrap metal. Therefore, monitoring of scrap metal entering a facility will still be necessary.

(c) *Development of a response plan (see Section 5).* Each operator of a metal recycling and production facility should develop a response plan to deal with the suspected or actual presence of radioactive material in scrap metal, metal products or wastes that is commensurate with the nature of the scrap metal that is processed and the type of facility. The response plan should be developed in cooperation with the competent authorities. The response plan should identify clearly the procedures to follow and the persons responsible for undertaking actions in the event of the suspected or actual presence of radioactive material in scrap metal, metal products or wastes. It should also specify the mechanism for obtaining specialized technical advice and assistance in a prompt manner if this is necessary. In the case of small and medium sized facilities, it may be sufficient to develop a simple plan that indicates the name and telephone number of the person to contact in the event that the presence of radioactive material is suspected.

(d) *Notification of the discovery of radioactive material to the regulatory body.* Each operator of a metal recycling and production facility should inform the regulatory body following the discovery of radioactive material in scrap metal, metal products or wastes. The communication procedure should be agreed with the regulatory body and should be indicated in the response plan.

(e) *Notification to the competent authority in the area of emergency response.* Each operator of a metal recycling and production facility should notify the competent authority in the area of emergency response in the event that the criteria specified in the response plan are exceeded (see para. 5.7). The communication procedure should be agreed with the competent authorities and should be indicated in the response plan.

(f) *Prevention of the dispersion of radioactive material.* Each operator of a metal recycling and production facility should adopt all measures that may be necessary to prevent the further loss of control or dispersion of any radioactive material that is detected.

(g) *Decontamination of contaminated premises.* Each operator of a metal recycling and production facility should participate in arrangements for the decontamination of any contaminated premises in accordance with the requirements and recommendations of Refs [27, 37].

(h) *Transfer of radioactive material.* Each operator of a metal recycling and production facility should arrange for the transfer of any radioactive material that has been discovered to an organization authorized by the regulatory body to receive such material (see para. 7.3).

(i) *Investigation of events.* Each operator of a metal recycling and production facility should undertake an investigation into any incident involving the detection of radioactive material at a metal recycling and production facility, to determine the origin of the material and any lessons to be learned. These lessons may relate to such matters as improvements in monitoring or response to events. The results of such investigations should be made available to the regulatory body upon request.

(j) *Provision of training and information to staff.* Each operator of a metal recycling and production facility should ensure that its staff are trained and informed, as appropriate, on the detection of radioactive material and the procedures to follow in the event that radioactive material is detected.

(k) *Appointment of a person with appropriate competence in radiation safety (hereinafter referred to as the 'on-site radiation safety person').* Operators of large facilities should appoint to this position a person who is suitably qualified and experienced in radiation safety. This person may have other duties (for example, he/she may also be the facility's health and safety officer). Operators of small and medium sized facilities may need only the name and telephone number of a person to contact in the event that the presence of radioactive material is suspected, as indicated in subparagraph (c). Reference [38] provides recommendations on qualifications and training in radiation safety.

(l) *Maintenance of records.* Each operator of a metal recycling and production facility should keep appropriate records covering all the items in this paragraph, as appropriate.

4. MONITORING FOR RADIOACTIVE MATERIAL

GENERAL

4.1. This section provides recommendations on the radiation monitoring that should be undertaken by the metal recycling and production industries. It does not provide recommendations on monitoring of material to be released for recycling at the site of an authorized practice[19], nor on monitoring at borders for the purposes of national security. Technical and functional specifications for border monitoring equipment are provided in Ref. [24].

4.2. In view of the wide range of facilities within the metal recycling and production industries, a graded approach to monitoring should be adopted. It may not be reasonable to expect operators of small and medium sized facilities to undertake comprehensive radiation monitoring. However, as a minimum, national authorities should ensure that operators of such facilities are provided with a basic knowledge and awareness of the following, through leaflets and posters:

(a) The visual appearance of devices and containers that might contain radioactive sources [35];
(b) The radiation symbol (trefoil) [39] and the ionizing radiation supplementary warning symbol [40];
(c) The labels and placards used in the transport of radioactive material [41];
(d) The possibility that heavy metal containers or shielding blocks may be constructed of depleted uranium rather than lead.

These leaflets and posters should provide instructions to the effect that any material, device or container that on visual examination appears suspect should be isolated, and should summarize the guidance provided in Section 5. Further information on how a radioactive source may be recognized is provided in Instruction 1 of Ref. [36].

4.3. While such information should also be made available to operators of large metal recycling and production facilities, as visual observation is still important, the primary means of identifying radioactive material in such facilities should be by means of radiation detectors. Operators of large facilities should recognize that radiation monitoring comprises more than just measurement of radiation levels; it also involves interpretation of measurements, for which an understanding of the significance of any measurement made is necessary.

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[19] In Ref. [1] the term ‘practice’ is used for those situations where radioactive material (or other source of ionizing radiation) is deliberately used for one purpose or another (see Ref. [7]). The term ‘authorized practice’ is used to distinguish those practices that are required to be conducted in accordance with an authorization from the regulatory body from other activities that do not need or are not amenable to control.

4.4. The remainder of this section provides recommendations primarily for large metal recycling and production facilities. Judgement will be necessary as to the degree to which radiation monitoring programmes should be established in smaller facilities.

4.5. Appropriate radiation detection equipment should be used, such as the following [42]:

(a) *Geiger–Müller survey meters.* Pancake Geiger–Müller detectors are designed for beta response and are appropriate for use in contamination surveys. Side window Geiger–Müller detectors are generally applicable for dose rate measurements, but their relative insensitivity to beta radiation makes them unsuitable for contamination surveys.
(b) *Ionization or exposure meters.* As a general rule, survey meters using ionization chambers tend to be less sensitive than side window Geiger–Müller detectors.
(c) *Scintillation detectors.* These are solid state detectors. Detectors that employ sodium iodide and plastic scintillators are appropriate for monitoring low gamma radiation levels.

Monitoring may involve the use of more than one of these detectors. Additionally, some operators of metal recycling and production facilities have used multichannel analysers to identify particular radionuclides.

4.6. Radiation detectors can be hand-held or stationary (i.e. fixed). Hand-held detectors can be placed close to the scrap metal to be monitored and therefore can facilitate determination of the location of a discrete radioactive source or other radioactive material. Another advantage of hand-held detectors is that they can be taken to all parts of the facility. However, they are not suitable for routine monitoring of large consignments of scrap metal. Routine monitoring of such consignments should be undertaken with stationary detectors, which tend to be more sensitive but also more expensive. Stationary radiation detectors are fixed in place and are generally not used for radiation surveys. Instead, these devices should be used as ‘pass–fail’ indicators, i.e. if the radiation level reaches a preset level, the instrument triggers an alarm.

4.7. Operators should be aware of the limitations of the monitoring equipment that they use and should therefore seek the advice of qualified experts[20] in selecting their monitoring equipment. In particular, detectors designed for routine monitoring in metal recycling and production facilities normally detect photon radiation (gamma radiation and bremsstrahlung, which is produced when beta radiation passes through matter) and, in some cases, neutron radiation[21]. The ability of monitors to detect photon (or neutron) radiation will depend on various factors, including the type and amount of non-radioactive material between the detection system and any source of radiation, the activity of the source, and the duration of the measurement as determined by the movement of the detector and/or the source. Furthermore, it is difficult, if not impossible, to detect alpha emitting radionuclides in scrap metal by routine monitoring unless the alpha radiation is accompanied by significant levels of gamma radiation. It is for this reason that the inadvertent melting of such radionuclides as ^{238}Pu and even ^{241}Am[22] occurred in the past, even when good quality and well maintained detection systems were installed at the facility [43].

ROUTINE MONITORING

4.8. The operators of a metal recycling and production facility should review the various steps involved in its processing of scrap metal, from receipt of the scrap metal to the dispatch of any metal products or wastes, to determine the point at which radiation monitoring would be the most effective. Account should be taken of possible shielding by any overlying scrap metal or a container of a source. In particular, the operator should routinely monitor the following:

(a) Consignments of scrap metal on arrival at the facility, preferably close to the point of site entry;
(b) Samples during the steel melting process;
(c) Final products before dispatch.

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[20] Qualified experts may be private individuals or may come from a private or governmental organization (see Ref. [7]).

[21] Neutron detectors are used to detect the presence of fissile material such as ^{239}Pu. These are frequently used in border monitoring equipment where the concern is with the detection of illegal transboundary movement of nuclear material. There are, however, neutron sources that are used in general industry. Americium-241 in combination with beryllium, which is used in moisture gauging equipment, is a common example.

[22] The alpha decay of ^{241}Am is accompanied by the emission of 60 keV photons, which, being of low energy, are readily shielded.

4.9. The operator should also give consideration to the monitoring of gaseous effluents, furnace dusts and slag.

4.10. A source that enters a facility undetected may become more amenable to monitoring as a result of the processing of the scrap metal. Consideration should therefore also be given to the use of stationary monitors to monitor process streams where the amount of material overlying a concealed radioactive source would be at a minimum. Examples of such places are:

(a) On cranes or grapples that handle scrap metal;
(b) On conveyor systems moving scrap metal within the facility;
(c) At the place where the charge bucket that carries scrap metal to the furnace is loaded.

Monitoring of scrap metal moving on conveyor systems within the facility will provide good detection efficiency, because the shielding of any radioactive source by overlying scrap metal will be minimal and the detector can be placed close to the material to be monitored.

4.11. The monitoring equipment should be selected in accordance with the type of facility. Facilities that handle large consignments of scrap metal should use stationary (portal) monitors for monitoring photon (and sometimes also neutron) radiation from consignments on arrival and any products (ingots, metal bars, wastes, etc.) prior to dispatch. Such equipment should be sufficiently sensitive to be able to detect small increments in the level of radiation above natural background levels of radiation. Monitoring of consignments on arrival facilitates the identification of the origin of any radioactive material detected.

4.12. By-product streams and waste streams, in particular gaseous effluents but also furnace dusts and slag, should be monitored routinely.[23] Stationary detectors rather than laboratory analysis of samples should be used wherever possible, as this will allow an immediate response to be made to any radioactive material detected. However, the difficulties of monitoring for alpha emitting radionuclides mentioned in para. 4.7 should be taken into account.

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[23] Because of its volatility, ^{137}Cs will become entrained with furnace dust (see Ref. [41]).

4.13. To be effective, detectors should be placed as close as practicable to the material to be monitored. Equipment should be sufficiently robust for the particular environment conditions in which it is to be used.

LABORATORY ANALYSIS

4.14. As indicated in para. 4.12, stationary detectors should be used wherever possible. However, because some radionuclides do not emit significant amounts of gamma radiation, bremsstrahlung or neutrons, and are therefore difficult to detect using systems that monitor for external radiation, operators of foundries should also consider taking, at regular intervals, samples of their products, slag and furnace dusts for laboratory measurements of alpha and beta activity concentrations.

ACCEPTANCE TESTING, CALIBRATION AND MAINTENANCE

4.15. Portable radiation survey meters should be calibrated before their first use, after repair and at appropriate intervals as specified in regulatory requirements, by the regulatory body or by a qualified expert, as appropriate. The pre-use test should include a test of the instrument's overload performance, i.e. it should be tested to verify that it will operate correctly up to the maximum foreseeable dose rate.

4.16. Following calibration, a sticker should be attached to the instrument to provide information, including the organization performing the calibration, the calibration certificate number, and the date of the calibration or the date when the next calibration is due, as appropriate. Calibration should be carried out by an organization that maintains reference radiation fields traceable to a national standards body.

4.17. Daily checks using radioactive sources should be carried out to verify that the equipment is capable of detecting appropriate increases in radiation levels.

4.18. Fixed radiation monitoring instruments are not calibrated in the same sense as radiation survey meters. Since their operation is 'pass–fail', fixed instruments should be subject to periodic operational testing to ensure that they retain the capability to respond to relevant radiation levels. For example, check sources should be used on a daily basis to verify that the monitors respond appropriately.

In addition, the procedure for daily checking should be performed if a malfunction of the equipment is suspected.

4.19. Records of all calibrations, tests and checks should be kept.

4.20. A maintenance plan for the equipment should, as a minimum, be based on the advice of the manufacturer of the equipment.

4.21. Activities at the metal recycling and production facility should be halted if the radiation detection system becomes inoperable.

USE OF PORTAL MONITORS

4.22. Portal monitors typically consist of an array of detectors in one or more vertical pillars, together with occupancy sensors to allow the instrument to alternate between monitoring of vehicles containing scrap metal and adjustment of the background radiation level and the alarm threshold, as necessary. Because the sensitivity of monitors is strongly dependent on distance, vehicles should pass as close as practicable to the array of detectors. Furthermore, the detectors should be positioned such that they have an unobstructed line of sight of the search area.

4.23. Visual alarm indicators should be selected and installed so that they can be seen clearly by staff at the inspection point. Similarly, audible alarm indicators should be selected and installed so that they can be heard clearly by staff at the inspection point.

4.24. The use of portal monitors to detect radioactive material in vehicles is complicated by the inherent shielding deriving from the structure of the vehicle and its components.[24] The sensitivity of the monitor is also strongly dependent on the duration of the measurement time (see para. 4.33(c)). Both matters should be taken into account in setting the alarm threshold and the investigation level for the instruments [24, 44].

[24] During the monitoring of a vehicle containing scrap metal, the background radiation level is reduced by up to 20% due to the shielding provided by the vehicle and its load [24].

ALARMS AND INVESTIGATION LEVELS

4.25. An investigation level is an activity level at or above which an investigation should be undertaken to determine the cause of the detected radiation [7]. An alarm threshold may be set lower than the investigation level, but should be above the background radiation level where the instrument will be used.[25] Both the alarm threshold and the investigation level should be set such that the probability of failure to detect the presence of radioactive material and the number of false alarms are maintained at acceptable levels. The alarm threshold can be expressed as a multiple of the background radiation level or as a multiple of the standard deviation of the background count rate. Since the relationship between the background radiation level and its standard deviation depends on the detection sensitivity of the instrument and the background radiation level, an investigation level generally applicable to all instruments cannot be derived. Further guidance and information on setting alarm thresholds and investigation levels for portal monitoring equipment are provided in Refs [24, 44].

4.26. There are three main types of alarms[26] of primary interest: false alarms, innocent alarms and non-innocent alarms.

4.27. False alarms are actuated by normal fluctuations in background radiation. In portal monitors, they are caused by the response of the instrument to radiation levels above the alarm level but below the investigation level (see para. 4.25). False alarms might also be caused by interference from nearby radiofrequency radiation, although this will be less likely with modern, well designed instruments.

4.28. Innocent alarms can be verified as being due to radiation other than background radiation at levels above the investigation level, but not due to radioactive material mixed with scrap metal. Innocent alarms might be caused by the presence of a person in the vicinity of the monitor (e.g. the driver of the vehicle) to whom radionuclides have been administered for the purposes of medical diagnosis or treatment.

[25] The investigation level of the instrument cannot be set at the background radiation level, as this would result in an excessive number of false alarms because of the probabilistic nature of radioactive decay.

[26] Alarms may be actuated if the radiation level exceeds the alarm threshold or a suspect package is visually identified in a consignment of scrap metal.

4.29. Non-innocent alarms are those caused by radiation levels above the investigation level other than innocent alarms. Such alarms should be subjected to detailed investigation.

4.30. Any alarm should be subjected to initial investigation to determine whether it is a false alarm, innocent alarm or non-innocent alarm. Procedures should be established for this purpose. Generally, this should involve an initial step of repeating the measurement. If the presence of radioactive material is not confirmed on repetition of the measurement, then no further action is necessary. The occurrence of the alarm should nevertheless be recorded by the operator. However, if the alarm responds in the same manner on repetition of a measurement on a consignment of scrap metal or part of a consignment, and it cannot be shown to be either false or innocent, then it should be treated as non-innocent and the consignment or part of the consignment should be isolated within the facility premises in which it was detected pending further investigation (see Section 5).

4.31. The steps involved in monitoring for radioactive material in scrap metal being received at a metal recycling and production facility are summarized in Fig. 1.

TRAINING AND ENHANCEMENT OF AWARENESS OF PERSONNEL

4.32. Operators should ensure that personnel who use radiation monitoring equipment are adequately trained in its use and understand the significance of the measurements they make and the associated uncertainties. Those who use radiation monitoring equipment should also be trained in how to distinguish between false, innocent and non-innocent alarms, and in the immediate actions to be taken if an alarm is found to be non-innocent. Training should be provided by qualified experts in radiation protection.

4.33. Those who use radiation monitoring equipment should also be made aware of the following technical and practical reasons why it may be difficult to detect the presence of radioactive material:

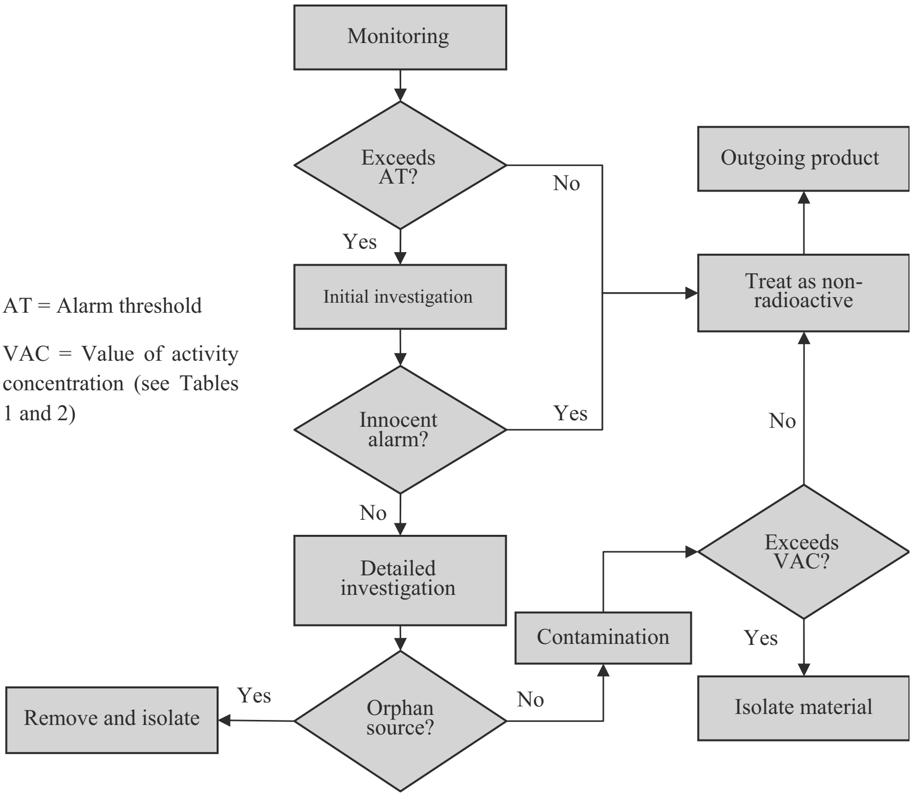

FIG. 1. Steps involved in monitoring for radioactive material in scrap metal being received at a metal recycling and production facility.

(a) The radiation level may be too low to be detected because the radioactive source or material is of low activity[27], is shielded or is too far from the detector.

(b) The radioactive material may emit only alpha radiation or low energy beta or gamma radiation.

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[27] Activity concentrations of radionuclides somewhat above the values given in Tables 1 and 2 may go undetected depending on the shielding provided by the scrap metal and the sensitivity of the radiation monitor to the radiation that is being emitted (see para. 4.7).

(c) The response time characteristics of the monitoring equipment may be too slow for the speed at which the instrument and the radioactive material pass each other (e.g. in the case of a portal monitor, the probability of detection will be reduced if a vehicle passes at high speed between the detectors).
(d) The instrument may need re-calibration to ensure that it has the correct response.
(e) The instrument may not be functional at the time of use.

4.34. The operator should ensure that all staff who physically handle or manage scrap metal are provided with sufficient information such that:

(a) They are aware that they may encounter radioactive material.
(b) They can recognize by sight radioactive sources and their containers, and the various signs, labels and placards that are used to indicate the presence of radioactive material (see Refs [35, 39–41]).
(c) They know and understand what actions should be undertaken in the event that radioactive material is discovered.
(d) They have a basic understanding of the effects of ionizing radiation on human health and the environment.

5. RESPONSE TO THE DISCOVERY OF RADIOACTIVE MATERIAL

GENERAL

5.1. This section provides recommendations on the response to a non-innocent alarm that should be undertaken by the operator of a metal recycling and production facility (i.e. it covers the detailed investigation and subsequent actions shown in Fig. 1). It does not address the response of the competent authorities to an emergency, for which requirements and recommendations are provided in Refs [20, 27, 28].

PLANNING THE RESPONSE

5.2. As indicated in para. 3.36(c), the operator of a metal recycling and production facility should establish a response plan. Indications of the suspected or actual presence of radioactive material, such as the occurrence of a non-innocent alarm, should trigger implementation of the response plan. Any temptation by the operator or other staff in the metal recycling and production facility to ignore a non-innocent alarm should be resisted.[28] The objective of the response plan should be to ensure the protection of workers, members of the public and the environment. The response plan should be consistent with the national radiation emergency plan referred to in para. 3.22 and should be documented, exercised, kept under review and updated as necessary.

5.3. The actions to be taken following an indication of the suspected or actual presence of radioactive material should be included in the response plan. The actions include the following:

(a) All reasonable actions to protect workers, members of the public and the environment should be performed promptly.
(b) Information should be gathered that could be useful in managing any consequences.
(c) In the event that a non-innocent alarm occurs on the arrival of a consignment of scrap metal at a large facility or prior to its processing, the consignment should be isolated pending further investigation (see para. 4.30). The location in which the consignment should be placed in isolation should be specified in the response plan.
(d) In the event that a non-innocent alarm occurs in the processing of scrap metal or in the monitoring of any metal products or wastes, if measures are considered necessary, they should be taken immediately to protect workers and members of the public, and, as appropriate, to stop the further processing and dispatching of any metal products or wastes until the cause of the alarm has been determined and any contamination delineated and the affected areas cordoned off.

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[28] Such a temptation may arise because the operator may want to avoid either increased scrutiny by the regulatory body or being obligated to provide adequate control over an orphan source or other radioactive material that the operator did not seek to possess (see para. 3.15 and footnote 13).

5.4. Paragraph 4.23 of Ref. [20] requires there to be:

> “a person on the site at all times with the authority and responsibilities: ... promptly and without consultation to initiate an appropriate on-site response; to notify the appropriate off-site notification point …; and to provide sufficient information for an effective off-site response. This person shall be provided with a suitable means of alerting on-site response personnel ... and notifying the off-site notification point”.

A footnote to para. 4.23 of Ref. [20] indicates that for facilities in threat category III or IV (see para. 2.6) “this only applies for periods when operations pose a potential risk.” This requirement should be taken as applying to large facilities. The person given these responsibilities should be the on-site radiation safety person appointed by the operator (see para. 3.36(k)) and should be named in the response plan. The on-site radiation safety person should be notified immediately following an indication of the suspected or actual presence of radioactive material.

5.5. The responsibilities and authority of the on-site radiation safety person regarding response to any event should be clearly defined in the response plan. These should include the following:

(a) Ensuring that any suspected radioactive material is appropriately isolated;
(b) Keeping track of people who may have been exposed to radiation;
(c) Informing the management of the metal recycling and production facility of the event;
(d) Seeking the assistance of qualified experts, as appropriate;
(e) On behalf of the operator, informing the regulatory body if the presence of radioactive material is confirmed;
(f) On behalf of the operator, notifying the competent authority in the area of emergency response that the criterion specified in para. 5.7 has been exceeded;
(g) Participating in the regaining of physical control over the radioactive material.

5.6. The response plan should specify the monitoring equipment to be used. In general, follow-up monitoring using hand-held instruments should be sufficient to determine whether the alarm has been actuated by one of the following:

(a) An intact orphan source;
(b) An orphan source that has been ruptured prior to melting;

(c) Radionuclides of natural origin;
(d) Radionuclides of artificial origin;
(e) Contamination of the facility, metal products or wastes due to the processing of radioactive material.

However, where the presence of unsealed radioactive material, particularly material possibly containing alpha emitting radionuclides, is suspected, it may be necessary to take samples for measurement in an appropriate environment with low background levels of radiation or in a radiochemical laboratory.

5.7. In the event that the dose rate exceeds 0.1 mSv/h at 1 m from any surface, object or material, the presence of a dangerous source should be suspected, the competent authority in the area of emergency response should be notified immediately and the possible presence of a dangerous radioactive source should be investigated [28, 36]. The arrangements for dealing with such a situation should be agreed with the competent authority in the area of emergency response and should be included in the response plan.

5.8. The response plan should specify the need for those responding to a non-innocent alarm to be suitably trained and properly equipped with the necessary protective measures.

RESPONSE TO PARTICULAR EVENTS

Rejection of incoming shipments

5.9. If, following a non-innocent alarm, the operator decides to reject the consignment and return it to the supplier, the operator should first notify both the regulatory body and the supplier of the occurrence of the non-innocent alarm and of the intention to return the consignment. The transport of the consignment outside the metal recycling and production facility should only be undertaken in accordance with the national and international requirements for the safe transport of radioactive material [41].

5.10. If the consignment originated from another State, the regulatory body of the State returning the consignment should first satisfy itself that the proposed recipient has been authorized in their State to receive and possess the radioactive material and that the originating State has the appropriate technical and administrative capabilities, resources and regulatory structure to ensure that the material will be managed in a manner consistent with the provisions of Ref. [8].

The remainder of this section provides recommendations on the response to non-innocent alarms other than cases where it is decided that a consignment is to be returned to the supplier.

Response to an intact orphan source

5.11. If a consignment of scrap metal arriving at a large facility appears to contain an orphan source, the consignment containing the source should be moved to a specifically designed place that has been previously specified in the response plan. The area around the consignment should be cordoned off and access should be restricted to suitably qualified and experienced persons. The cordon around the consignment should be set under the guidance of the on-site radiation safety person and on the basis of criteria specified in the response plan (see para. 5.7). The area cordoned off should be such that the ambient dose rate outside the cordoned-off area does not exceed 0.1 mSv/h. This dose rate is based on the operational intervention level given in table 7 of Ref. [28] (see also Refs [36, 44]).

5.12. Further investigation of the consignment should be undertaken with the support of qualified experts and under the guidance of the on-site radiation safety person and/or a qualified expert. The scrap metal surrounding the orphan source should be removed. Due care should be taken, as the surrounding scrap metal may be contaminated owing to leakage of radioactive material from the orphan source, and due attention should be paid to any increase in dose rate as scrap metal that might be shielding a source is removed. The use of hand-held monitoring equipment with gamma spectroscopy capabilities should be considered in order to determine which radionuclides are present.

5.13. In the event that the presence of an orphan source is confirmed, the operator, in cooperation with the on-site radiation safety person and the regulatory body, should make arrangements for the orphan source to be recovered and, if unshielded, to be placed in a suitably shielded container. The recovered orphan source, appropriately shielded, should then be removed to a safe and secure on-site storage location pending a decision on its subsequent management. The storage location should have been identified in advance (i.e. in the response plan). Access to the storage location should be limited to those who have been authorized and are fully aware of the precautions to be taken.

Response to a ruptured orphan source

5.14. In the event that an orphan source has ruptured, the operator, in cooperation with the on-site radiation safety person and the regulatory body, should make arrangements for the orphan source to be recovered and, if unshielded, to be placed in a suitably shielded container. The shielded source and any scrap metal or other material suspected of containing radionuclides with activity concentrations above the values provided in Ref. [31] (see Table 1 of this Safety Guide) should be removed to a safe and secure on-site storage location pending a decision on their subsequent management. Care should be taken to prevent the spread of contamination. The storage location should be identified in advance (i.e. in the response plan) and should be such as to prevent the further spread of the contamination, for example, by exposure to rain. Access to the storage location should be limited to those who have been authorized and are fully aware of the precautions to be taken.

5.15. Areas through which the contaminated scrap metal and ruptured orphan source have passed should be monitored for contamination. Any contaminated area should be cordoned off, and access should be restricted until the area has been decontaminated.

Response to other radioactive material in a consignment of scrap metal

5.16. If radiation measurements on a consignment of scrap metal indicate the presence of radionuclides with activity concentrations above the values provided in Table 1 or Table 2 [31], the consignment should be moved to a safe and secure on-site storage location. The storage location should be identified in advance (i.e. in the response plan). The area should be cordoned off and access to the storage location should be limited to those who have been authorized and are fully aware of the precautions to be taken. The operator, in cooperation with the on-site radiation safety person and the regulatory body, should make arrangements for further investigation. The use of hand-held monitoring equipment with gamma spectroscopy capabilities should be considered in order to determine which radionuclides are present. Laboratory analysis may be necessary in order to determine the radionuclides present and the activity concentration of the material. Only material containing radionuclides with activity concentrations above the values given in Table 1 or Table 2 needs to be treated as being subject to regulatory control and retained in the cordoned-off area.

5.17. Due consideration should be given to the possible spread of contamination arising from the movement of the contaminated scrap metal, for example, by exposure to rain.

Response to the detection of radioactive material in the input streams prior to melting

5.18. In the event of the detection of radioactive material in an input stream of scrap metal prior to melting (e.g. due to contamination on conveyor systems within the facility as a result of the inadvertent shredding of a source mixed with scrap metal), the operator should immediately:

(a) Interrupt the process so that the material in the input stream does not proceed further within the facility;
(b) Cordon off the area and restrict access;
(c) Arrange for an investigation to be undertaken to determine the nature of the radioactive material;
(d) Depending on the nature of the radioactive material, arrange for its removal to a safe and secure on-site storage location in accordance with the recommendations of para. 5.11.

5.19. All work should be undertaken under the guidance of the on-site radiation safety person. Where necessary, the operator should seek technical support from a qualified expert.

Response to contamination due to melting of radioactive material

5.20. In the event of the detection of radioactive material following the melting of scrap metal (e.g. in the off-gases, slag or metal products), the operator should immediately:

(a) Consider whether a dangerous source has inadvertently been melted, and if this is suspected, immediately notify the competent authority in the area of emergency response;
(b) Interrupt all the phases of the process that are thought to have been affected and arrange for monitoring to be undertaken to determine the extent of contamination;
(c) Adopt all measures necessary to prevent further dispersion of radioactive material;
(d) Suspend the dispatch or removal from the facility of any metal products or wastes that might be contaminated;

(e) Notify any organization that may have received any contaminated products;
(f) Undertake (or arrange for the undertaking of) a comprehensive radiological assessment of the situation, to determine the nature and extent of the contamination.

5.21. The comprehensive radiological assessment should be based on a detailed study of the metal recycling process and should include measurements of any slag and dusts that may have been created and monitoring of the immediate surroundings of the area in which the event occurred and, as necessary, of other areas within and outside the facility. Consideration should be given to whether the radioactive material may have been distributed between the metal phase and the slag, dross, gaseous effluents, furnace dusts or other material during the processing of the scrap metal.[29] Laboratory analysis may be necessary in order to determine the activity concentration of the radionuclides in the material. The radiological assessment should be undertaken under the guidance of, or with the support of, the on-site radiation safety person, and, when necessary, the operator should seek technical support from a qualified expert.

5.22. In the event that radioactive material has been released to the environment, the first responders, supported by the local officials, should initiate any off-site response to any event resulting in off-site consequences[30]. Reference [36] provides detailed guidance for first responders.

5.23. Any material, including slag and dust, remaining within the facility and containing radionuclides with activity concentrations above the values given in Table 1 or Table 2 (see Ref. [31]) should be removed to a safe and secure on-site storage location, pending a decision on its subsequent management. The storage location should be identified in advance (i.e. in the response plan) and should be such as to prevent further spread of the contamination, for example, by exposure to rain. Access to the storage location should be limited to those who have been authorized and are fully aware of the precautions to be taken.

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[29] There are significant differences in the behaviour of the radionuclides that might become mixed with scrap metal. For instance, ^{60}Co will largely remain with the metal phase during melting, while ^{137}Cs (usually present in sealed sources in the form of caesium chloride) is more likely to become mixed with dusts or be emitted as an airborne effluent. Americium-241 and radionuclides of natural origin are more likely to become mixed with slag.

[30] Off-site response should be based on national criteria for response to a radiological emergency. However, it is considered unlikely that actions to protect the public will be necessary as a result of environmental contamination following a release of radioactive material to the atmosphere due to the inadvertent melting of an orphan source.

This work should be undertaken under the guidance of the on-site radiation safety person. Where necessary, the operator should seek technical support from a qualified expert.

PROVISION OF INFORMATION TO THE PUBLIC

5.24. Paragraph 4.83 of Ref. [20] states that: “Arrangements shall be made for: providing useful, timely, truthful, consistent and appropriate information to the public in the event of a nuclear or radiological emergency....” Paragraph 4.84 of Ref. [20] states that: “The operator, the response organizations, other States and the IAEA shall make arrangements for co-ordinating the provision of information to the public and to the news and information media in the event of a nuclear or radiological emergency.” Rules for provision of information to the public should be defined in the national radiation emergency plan referred to in para. 3.23 of this Safety Guide.

5.25. Such arrangements are particularly important in the event of a release of radioactive material to the environment or the dispatch of products contaminated as a result of the melting of a dangerous source. The arrangements should be defined in the response plan. Information provided to the public in the event of such an incident at a metal recycling and production facility should include, as appropriate:

(a) The possible health consequences of the incident, including reassurance, as necessary and appropriate, to allay any unjustified fears.
(b) Actions that should be taken by members of the public.
(c) The actions that have already been undertaken in order to protect members of the public. This should include any actions taken to recover contaminated products that may have entered the public arena.

REPORTING OF EVENTS

5.26. Following any event in a metal recycling and production facility in which the presence of radioactive material has been confirmed, the operator should arrange for a report to be prepared describing the event, the types of measurements made, the results, the radiological consequences in terms of exposures of workers and members of the public as far as these are known, and the actions taken to mitigate the consequences. The operator should also attempt to ascertain the origin of the radioactive material, and the results of this investigation should be included in the report. The report should be provided to the regulatory body without delay. Reports of events involving a dangerous source should be shared with all interested parties (e.g. the various national authorities involved in the regular liaison meetings referred to in para. 3.14), in order that all may share in the lessons to be drawn from the event and the response to it.

TRAINING AND INFORMATION

5.27. The operator should ensure that all staff who may need to respond to a non-innocent alarm are aware of the response plan and have a clear understanding of their responsibilities and duties in this respect. In particular, all staff should be trained in how to recognize radioactive material and respond to its suspected or actual presence in scrap metal, metal products or wastes, and in the procedures to follow. Training should be provided by appropriately qualified persons.

5.28. In the context of the response to non-innocent alarms, the on-site radiation safety person (see para. 3.36(k)) should be sufficiently knowledgeable to be able to:

(a) Assess adequately the radiological hazard and provide advice on the radiation safety measures that are necessary;
(b) Determine the precautions that are necessary in order to protect the workers involved in the response to the incident;
(c) Determine when protective actions can be terminated.

INTERNATIONAL COOPERATION

5.29. The Early Notification Convention and the Assistance Convention [21] place obligations on States Parties regarding cooperation with other States and international organizations and provision of assistance in the event of a radiological emergency (see paras 3.7–3.8). As noted in para. 3.7 of this Safety Guide, Ref. [20] requires States to notify directly or through the IAEA those States that may be affected by a transnational emergency. In view of the substantial international trade in scrap metal and products of the metal recycling and production industries, national authorities should establish arrangements for cooperation with the relevant authorities in other States and with relevant intergovernmental organizations regarding any emergency involving a dangerous source in the metal recycling and production industries.

5.30. In particular, such arrangements should cover the notification of any potentially affected State and of the IAEA in the event of any of the following:

(a) A release of radioactive material to the atmosphere at a metal recycling and production facility;
(b) The discovery of the incorporation of radioactive material into metal products or wastes, where the activity concentrations of the radionuclides exceed the values provided in Table 1 or Table 2 (see Ref. [31]) and such products or wastes are transported across a national border;
(c) The loss of a radioactive source that is suspected to have become mixed with scrap metal and transported across a national border.

6. REMEDIATION OF CONTAMINATED AREAS

6.1. Reference [27] establishes requirements for the remediation[31] of areas contaminated by past activities and accidents. Recommendations on meeting these requirements are provided in Ref. [37]. The goal of remediation is the timely and progressive reduction of hazard and eventually, if possible, the removal, without restrictions, of regulatory control from the area. It is noted in Refs [27, 37] that there are situations in which the removal of regulatory control from an area cannot practicably be achieved and it may be necessary to restrict access to or use of the area.

6.2. References [27, 37] should be consulted, since this Safety Guide does not deal with the decontamination of facilities that may have been contaminated as a consequence of the presence of radioactive material in scrap metal. However, a few points are noted here.

6.3. All the parts of a facility that have been contaminated as a consequence of the processing of scrap metal containing radioactive material should be evaluated to determine the need for remediation. However, before this can be done, the nature and extent of the contamination should be appropriately characterized.

[31] Footnote 3 in Ref. [27] states: "'Remediation' does not imply the elimination of all radioactivity or all traces of radioactive material. The optimization process may lead to an extensive remediation but not necessarily to the restoration of pre-existing conditions."

Following this, the operator, under the guidance of the on-site radiation safety person and, as necessary, a qualified expert, and in consultation with representatives of workers, should develop a remediation plan, which should include arrangements for the protection of workers and members of the public. The remediation plan is required to be subject to approval by the regulatory body [27]. As part of the remediation plan, metal processing or production operations may need to be halted until the remediation work has been completed.

6.4. The remediation plan is required to state the goal of the remediation; any reference levels to be used; the nature, scale and duration of the remedial measures; the arrangements for the storage or disposal of any wastes; and the monitoring to be undertaken during and following the remedial operations [27].

6.5. The remediation plan should be carried out with the oversight of the on-site radiation safety person and, as necessary, a qualified expert. Any material contaminated with radionuclides with activity concentrations above the values provided in Table 1 or Table 2 should be removed to a safe and secure on-site storage location, which should have been identified in advance (i.e. in the response plan), and should be subsequently managed as radioactive waste, unless otherwise agreed by the regulatory body (see Section 7).

6.6. The final decision as to whether to release a site from regulatory control should be taken by the regulatory body.

7. MANAGEMENT OF RECOVERED RADIOACTIVE MATERIAL

7.1. This section addresses the management of radioactive material recovered following its discovery at a metal recycling and production facility. Such material should be treated as radioactive waste, and as such it needs appropriate management. The management of such radioactive material should be undertaken in accordance with the safety requirements relating to predisposal management of radioactive waste [3] and with associated recommendations on how to meet these requirements [33]. References [3, 33] should be consulted, since this Safety Guide does not deal with the management of radioactive waste that may have arisen as a consequence of the presence of radioactive material in scrap metal. However, a few points are noted here.

7.2. As indicated in para. 3.15, the government should establish a policy and strategy for the control of radioactive waste in general and of radioactive material recovered in the metal recycling and production industries in particular. The policy and strategy should also cover radioactive waste arising from any contamination that might result from the rupture of an orphan source or the melting of radioactive material with scrap metal. The policy and strategy should be developed in cooperation with the metal recycling and production industries, the regulatory body and organizations for the management of radioactive waste.

7.3. The following should be included as part of the strategies and procedures for managing the radioactive waste created by the presence of radioactive material in scrap metal:

(a) The generation of radioactive waste should be minimized, and where radioactive waste does arise, it should be in a form that facilitates its subsequent handling, processing, transport and storage, and meets the acceptance criteria established for its subsequent management or disposal.
(b) Radioactive waste should be segregated as far as can reasonably be achieved, to minimize the environmental consequences.
(c) Recovered radioactive material should be kept in a safe and secure on-site storage location until it can be removed with the agreement of the regulatory body.
(d) Recovered radioactive material should not be stored at a metal recycling and production facility for protracted periods of time.
(e) Access to recovered radioactive material while in storage at a metal recycling and production facility should be limited to authorized persons who have been appropriately trained in radiation protection.
(f) The appropriate management route for storage or disposal of radioactive material should be determined in cooperation with the regulatory body, account being taken of the nature of the waste and the established national policy on waste management.
(g) Any recovered radioactive material should be transferred to a waste management organization authorized to receive the radioactive waste. The transport of such material is required to be undertaken in accordance with the national and international requirements for the safe transport of radioactive material [41]. If difficulties in meeting the requirements for safe transport are anticipated, these should be discussed in advance with the regulatory body of the relevant State.

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Annex I

REVIEW OF EVENTS INVOLVING RADIOACTIVE MATERIAL IN THE METAL RECYCLING AND PRODUCTION INDUSTRIES

I–1. The metal recycling and production industries have to cope with a variety of potential contaminants. Examples include lubricating oils, flammable fluids, process acids and other hazardous contaminants that may have been left in the scrap at the generating facility. The first formal description of the discovery of orphan sources in the metal recycling and production industries was made in 1986 [I–1]. Since then, there has been a growing appreciation that such incidents can have significant impacts.

ACCIDENTS IN THE SCRAP METAL SUPPLY CHAIN

I–2. A summary of some of the known accidents involving radioactive sources in the scrap metal supply chain is given in Table I–1. The main causes of the accidents were lack of regulatory control, storage of disused sources in unsecured locations and theft of devices containing sources.

INADVERTENT MELTING OF RADIOACTIVE MATERIAL

I–3. Table I–2 gives a summary of some incidents involving the inadvertent melting of a radioactive source with scrap metal.

I–4 A list of 60 events involving unintended melting of radioactive sources between 1983 and 1998 is published in table 1 of Ref. [I–9]. The data, which are summarized in Figs I–1 and I–2, indicate that 69% of these events occurred in the steel industry. Among non-ferrous metals, the industry most affected is the aluminium recycling industry.

I–5. The data also demonstrate (Fig. I–2) that the two radionuclides most commonly implicated in melting incidents are ^{137}Cs (48%) and ^{60}Co (26%). Americium-241, ^{226}Ra and thorium each represent 5–6% of the total number of incidents, but the latter two did not usually originate from sealed radioactive sources. In the case of ^{226}Ra, the origin was probably old luminized items (such as aircraft instrument dials, mainly of military origin) or fake medical devices dating back to the early part of the twentieth century. Thorium originates from materials

TABLE I–1. SUMMARY OF SOME ACCIDENTS INVOLVING RADIOACTIVE SOURCES IN THE SCRAP METAL SUPPLY CHAIN

Location and date	Device	Radioactive source	Cause	Consequences	Ref.
Goiânia, Brazil, 1987	Teletherapy unit	Cs-137 (50 TBq)	Lack of regulatory control Theft from unsecured building for reprocessing as scrap metal	Substantial contamination 21 people with doses above 1 Gy; 4 people died Buildings demolished 3500 m^3 of radioactive waste	[I–2]
Istanbul, Turkey, 1998	Three teletherapy units	Co-60 (3.3 TBq; 23.5 TBq; 21.3 TBq)	Lack of regulatory control Sold as scrap metal	18 people hospitalized; 5 with doses of about 3 Gy; 1 with a dose of about 2 Gy; others with doses below 1 Gy Only two sources recovered intact	[I–3]
Samut Prakarn, Thailand, 2000	One teletherapy unit	Co-60 (15.7 TBq)	Lack of regulatory control Theft from unsecured site for reprocessing as scrap metal	10 people received high doses; 3 (all workers at a scrapyard) died Source recovered intact	[I–4]
Nigeria, 2002	Two well-logging sources	Am-241/Be (721 GBq; 18 GBq)	Theft from a company truck	Sources detected in a scrap metal shipment in Europe	[I–5]

TABLE I–2. SUMMARY OF SOME INCIDENTS INVOLVING THE INADVERTENT MELTING OF RADIOACTIVE SOURCES WITH SCRAP METAL

Location and date	Device	Radioactive source	Cause	Consequences	Ref.
Ciudad Juarez, Mexico, 1983	Teletherapy unit	Co-60 (37 GBq)	Lack of regulatory control Sold as scrap metal	Contamination of reinforced steel bars for buildings; 814 houses demolished 75 people with doses between 0.25 and 7.0 Gy Several foundries required extensive decontamination 16 000 m^3 of soil and 4500 t of metal radioactive waste Cost approximately US $34 million	[I–6]
Algeciras, Spain, 1998	Unknown	Cs-137	Inadvertently melted	Release of Cs-137 to air 6 people slightly contaminated 270 t of contaminated dust US $20 million for lost production; US $3 million for cleanup; US $3 million for waste storage Led to the development of the ‘Spanish Protocol’ (see Annex III)	[I–7]
United Kingdom, 2000	Cardiac pacemaker	Pu-238 (140 GBq)	Inadvertently melted Not detected by portal monitors	Doses were negligible Cleanup and disposal costs believed to be several million US dollars	[I–8]

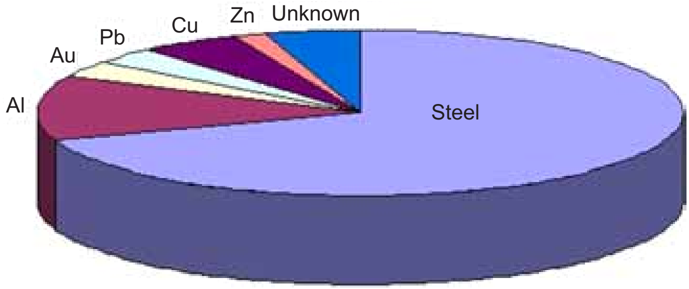

FIG. I–1. Sectors of the metal recycling industry in which events involving inadvertent melting of radioactive sources have occurred.

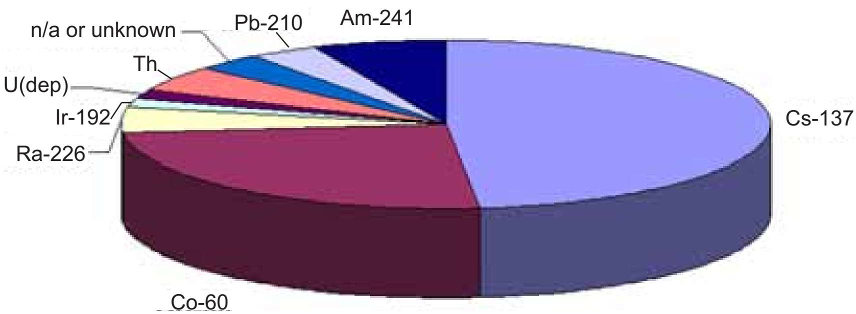

FIG. I–2. Radionuclides involved in melting incidents.

such as magnesium alloys hardened with thorium, which have been widely used to impart appropriate mechanical properties to aeronautical engines.

SUMMARY OF POTENTIAL CONSEQUENCES OF EVENTS INVOLVING RADIOACTIVE SOURCES

I–6. In addition to consequences for human health and the environment, the spectrum of potential consequences of such events is wide and includes:

(a) Anxiety among workers and the general public about health consequences. Some events have resulted in large numbers of people seeking radiation monitoring for reassurance and continuing health surveillance of some people. As a result, the resources of health authorities may be overstretched.

(b) Substantial demands on the resources of the regulatory body and other authorities (such as police, customs, civil defence and emergency planners). The demand may exceed the available resources and so necessitate the assistance of other States and other organizations.
(c) Loss of credibility of the regulatory body, the competent authority in the area of emergency response and the government because of perceived inadequate control over radioactive material and response to the event.
(d) Severe commercial impact due to interruption of operations. The costs of recovery and cleanup of contamination may well exceed the assets of the affected company, causing bankruptcy and loss of jobs.
(e) Loss of confidence in the metal recycling and production industries.
(f) Excessive demand on the national radioactive waste management facilities owing to unplanned waste streams of a quantity that is difficult to manage.
(g) Adverse effects on international relations if the consequences extend beyond national boundaries. These may occur even if the radiological consequences are very low.

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Annex II

CATEGORIZATION OF RADIOACTIVE SOURCES

II–1. High activity radioactive sources, if not managed safely and securely, can cause severe deterministic effects to individuals in a short period of time, which is not the case with low activity sources. The Safety Guide on Categorization of Radioactive Sources [II–1] categorizes radioactive sources in accordance with their potential to cause harm to human health. This categorization is intended to assist regulatory bodies in applying a graded approach to the control of radioactive sources. It also provides a basis for the Code of Conduct on the Safety and Security of Radioactive Sources [II–2]. By extension, it would be appropriate to apply it to the management of radioactive material discovered within the metal recycling and production industries, particularly when establishing the arrangements for emergency preparedness and response (see Refs [II–3, II–4]).

II–2. The categorization is based on the concept of ‘dangerous sources’. Such sources are quantified in terms of their respective ‘D values’ [II–5]. The D value is the radionuclide specific activity of a source that, if not under control, could cause severe deterministic effects for a range of scenarios of accidents that include both external exposure from an unshielded radioactive source and internal and external exposure following dispersal of the radioactive material. There are five categories, with sources in category 1 being the most ‘dangerous’. The activity of a category 1 radioactive source exceeds 1000 times its D value. The activity of a radioactive source in category 5, on the other hand, is less than 1/100th of its D value.

II–3. In the context of scrap metal containing orphan sources, this categorization is used for the purposes of:

(a) Emergency preparedness and response;
(b) Prioritization of actions for regaining control over sources;
(c) Communication with the public as a basis for explaining the relative hazards associated with events involving radioactive sources.

II–4. The five categories of radioactive sources are explained in plain language as follows [II–6]:

Category 1 (extremely dangerous). These sources, if not safely managed or securely protected, are likely to cause permanent injury to any person who was in contact with them for more than a few minutes. Longer periods of exposure would probably be fatal. Typical of this category are radioisotope thermoelectric generators, industrial irradiators and teletherapy sources.

Category 2 (very dangerous). These sources, if not safely managed or securely protected, could cause permanent injury to a person who was in contact with them for a short time (minutes to hours). Exposure of more than a few hours could be fatal. Examples of sources in this category are those used in industrial radiography and high/medium dose rate brachytherapy.

Category 3 (dangerous). These sources, if not safely managed or securely protected, could cause permanent injury to a person who was in contact with them for a period of hours. Exposure could be fatal — although it is unlikely — if contact extended over several days to weeks. Sources in this category are those used in fixed industrial gauges such as level gauges, dredger gauges, conveyor gauges and spinning pipe gauges, and in well logging.

Category 4 (unlikely to be dangerous). It is very unlikely that anyone would be permanently injured by these sources[1]. However, this amount of unshielded radioactive material, if not safely managed or securely protected, could possibly — although it would be unlikely — temporarily injure someone who was in contact with them for many hours, or who was close to them for a period of many weeks.

Category 5 (most unlikely to be dangerous). No one could be permanently injured by these sources.[1]

II–5. The activities corresponding to the thresholds for categories 1, 2 and 3 for some of the more commonly encountered radionuclides are provided in Table II–1. Orphan sources in these three categories will be of greatest interest to the metal recycling and production industries because of the potential health consequences for workers and the severe economic consequences if such sources were to be inadvertently melted. As such, any event in the metal recycling and production industries involving an orphan source in any of these categories has to be treated as a radiological emergency. While orphan sources in the two lowest categories have low consequences for health, if breached they could nevertheless result in significant economic losses.

[1] Possible delayed health effects are not taken into account in this statement.

TABLE II–1. ACTIVITIES CORRESPONDING TO THE THRESHOLDS FOR CATEGORIES OF RADIOACTIVE SOURCES

Radionuclide	Category 1 1000 × D (TBq)	Category 2 10 × D (TBq)	Category 3 D (TBq)
Am-241	6.E+01	6.E–01	6.E–02
Am-241/Be	6.E+01	6.E–01	6.E–02
Cf-252	2.E+01	2.E–01	2.E–02
Cm-244	5.E+01	5.E–01	5.E–02
Co-60	3.E+01	3.E–01	3.E–02
Cs-137	1.E+02	1.E+00	1.E–01
Gd-153	1.E+03	1.E+01	1.E+00
Ir-192	8.E+01	8.E–01	8.E–02
Pm-147	4.E+04	4.E+02	4.E+01
Pu-238	6.E+01	6.E–01	6.E–02
Pu-239[a]/Be	6.E+01	6.E–01	6.E–02
Ra-226	4.E+01	4.E–01	4.E–02
Se-75	2.E+02	2.E+00	2.E–01
Sr-90 (Y-90)	1.E+03	1.E+01	1.E+00
Tm-170	2.E+04	2.E+02	2.E+01
Yb-169	3.E+02	3.E+00	3.E–01
Au-198[b]	2.E+02	2.E+00	2.E–01
Cd-109[b]	2.E+04	2.E+02	2.E+01
Co-57[b]	7.E+02	7.E+00	7.E–01
Fe-55[b]	8.E+05	8.E+03	8.E+02
Ge-68[b]	7.E+02	7.E+00	7.E–01
Ni-63[b]	6.E+04	6.E+02	6.E+01
Pd-103[b]	9.E+04	9.E+02	9.E+01
Po-210[b]	6.E+01	6.E–01	6.E–02
Ru-106 (Rh-106)[b]	3.E+02	3.E+00	3.E–01
Tl-204[b]	2.E+04	2.E+02	2.E+01

[a] Criticality issues and issues relating to accounting and control of nuclear material will need to be considered for sources with large multiples of D.

[b] These radionuclides are very unlikely to be used in individual radioactive sources with activity levels that would place them within categories 1, 2 or 3.

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Annex III

EXAMPLES OF NATIONAL AND INTERNATIONAL INITIATIVES

NATIONAL INITIATIVES

Belgium

III–1. To ensure the protection of the population, workers and the environment against the danger of ionizing radiation, the Federal Agency for Nuclear Control (FANC) has developed and set up a global approach to the radiological surveillance of radioactive material in scrap metal and non-radioactive waste, in close cooperation with the environmental administrations of the three Belgian regions and the Belgian Agency for Radioactive Waste and Enriched Fissile Materials (NIRAS/ONDRAF), in a consultative process with most of the professional federations from the metal working, waste treatment and recycling sectors. The Belgian approach combines several aspects:

(a) Preventing radioactive sources from ending up in other industrial sectors;
(b) Defining the streams in which orphan sources are most likely to occur;
(c) Identifying the facilities in which orphan sources are most likely to be discovered;
(d) Imposing appropriate monitoring in these facilities;
(e) Financing the tracking of management of orphan sources;
(f) Collecting information and providing feedback.

Preventing radioactive sources from ending up in other industrial sectors

III–2. Beyond the control of ionizing radiation that already exists in Belgium, the FANC has strengthened the professional and regulatory monitoring of high activity sealed sources in order to prevent their disappearance or misuse and to avoid high risk orphan sources. Council Directive 2003/122/Euratom of 22 December 2003 on the control of high-activity sealed radioactive sources and orphan sources [III–1] was transposed into Belgian legislation on 23 May 2006. As a result, it is now necessary to provide for the unique identification, marking and recording of each high activity source, as well as for the specific training and informing of all those involved in activities relating to the use of sources. Moreover, targeted inspections and complementary technical controls have been made compulsory. A record sheet is now provided for each orphan source.

Defining the streams in which orphan sources are most likely to occur

III–3. In cooperation with interested parties and the environmental administrations of the three Belgian regions, and on the basis of the national and international experience that it has acquired, the FANC has identified, among material streams treated by the waste recycling and processing industries, which streams run a risk of containing orphan sources. These streams are defined in accordance with the waste classification codes set up by the European Commission and are declared ‘orphan sources sensitive streams’.

Identifying the facilities in which orphan sources are most likely to be discovered

III–4. Industrial sites handling and/or processing one or several of those supply streams with a risk of containing orphan sources will be de facto listed as ‘orphan sources sensitive’. All these facilities will have to apply minimum requirements for personnel training, vigilance measures and response to the discovery of a source. A response procedure in the event that a radioactive source is discovered has been set up and will also be made compulsory.

Imposing appropriate monitoring in industrial facilities

III–5. Among the facilities in which orphan sources are most likely to be discovered, some have a higher probability of being confronted with an orphan source. Consequently, those facilities will have to comply with the obligation of systematic and automatic screening of all streams sensitive to incoming orphan sources — in particular by installing a portal monitor. Scrap metal processing facilities are subject to this obligation.

III–6. Although radiation monitoring outside the nuclear sector has not yet been made compulsory, the FANC considered that the radiation protection aspect and the achievement of uniform practices needs to be dealt with as a priority. So the FANC issued in September 2006 its ‘directives for the use of a radiation portal monitor in the non-nuclear sector’ and a technical annex to these directives. These directives describe the various steps that the operator has to follow when a portal monitor alarm is triggered. They describe the radiation protection measures to be taken by the staff, as well as the information to be provided by the operator to the FANC.

III–7. The operator is allowed to intervene without the assistance of a radiation expert only when the radioactivity does not exceed a specific level. Beyond that level, an expert in radiation protection has to be called to assist in the recovery of the source from the shipment.

III–8. In addition, the FANC is setting up regulatory directives for facilities in which orphan sources are most likely to be discovered and which will not have to undertake systematic and automatic screening through radiation portal monitors. These directives include minimum requirements for staff training, vigilance measures and response to discovery of a radioactive source.

Financing the tracking and management of orphan sources

III–9. In March 2007, the Belgian Council of Ministers adopted a financial solution for the costs associated with the waste management of recovered orphan sources, in the framework of the transposition of Council Directive 2003/122/Euratom of 22 December 2003 on the control of high-activity sealed radioactive sources and orphan sources. When a radioactive source is found, the ‘the polluter pays’ principle is now applied by the FANC, which first tries to identify the polluter and then brings proceedings against it. If the polluter cannot be identified, or if the efforts made to identify the polluter are out of proportion with the costs involved, the source is considered as an orphan source and the financial costs are borne by NIRAS/ONDRAF’s insolvency fund.

III–10. In October 2007 the FANC, NIRAS/ONDRAF and most of the professional federations from the metal working, waste treatment and recycling sectors signed a protocol regarding the tracking and management of radioactive materials and objects outside the nuclear sector.

III–11. Operators who wish to take advantage of the financial arrangements for orphan sources have to contact the FANC and register their facilities. They are obliged to take measures to prevent orphan sources from ending up on their sites and in their installations or in the supply of goods and bulk materials. If such a source is detected, the operator has to follow the guidelines of the FANC and accept its investigation to verify whether its guidelines have been complied with, and to determine possible responsibilities in order to enhance the identification of the party responsible for the presence of the source.

Collecting information and providing feedback

III–12. The FANC is in charge of registering the radiation portal monitors and facilities in which orphan sources are most likely to be discovered. Each radioactive source discovered and each portal monitor alarm triggered has to be reported to the FANC.

III–13. The actions taken by each party (i.e. portal monitor operators, hauliers, FANC inspectors and radiation experts) and the characterization information for each source are recorded in a database in order to provide further feedback and to make it possible to assess and enhance continuously the Belgian authorities' approach.

Bulgaria

III–14. In Bulgaria [III–2], the system of control covers the metal recycling and production industries. The first line of defence is the scrap metal delivery contract (i.e. the declaration provided by the suppliers), which states that according to measurements made by the scrap metal supplier (performed with hand-held devices) the scrap metal is free from radioactive material. The second line of defence consists of measurements performed by the big smelting companies by means of two pillars containing plastic scintillation detectors. If radioactive material is discovered, the scrap metal supplier (national or foreign) is obliged to cover all expenses associated with the recovery and disposal of the material and any cleanup costs.

III–15. Where radioactive scrap metal is detected at the borders, the scrap is returned to the State of origin and the Nuclear Regulatory Agency (NRA) notifies the competent foreign authorities.

III–16. If the owner of the source is unknown, the NRA assigns a responsible organization to deal with it. In this case, the orphan source is declared as radioactive waste and becomes State property, and all expenditures are covered by a specially created State radioactive waste fund. All radioactive material is sent to the State radioactive waste management organization for storage, and the information is recorded by the NRA.

Croatia

III–17. In Croatia [III–2], the appointed Government agency for radiation protection manages situations in which radioactive material is discovered in shipments. Upon discovery of radioactive material in a shipment from abroad, the shipment is sealed and returned to the border. If the detected radioactive material is from within the State, the radiation protection agency provides a safe and secure store for it. The regulatory body then seeks to determine the owner of the radioactive material within the State. If the owner cannot be found, the regulatory body covers the costs of management of the radioactive material.

Netherlands

III–18. Under the Detection of Radioactively Contaminated Scrap Decree of 2003, large firms that trade in scrap metal are obliged to monitor the scrap [III–3, III–4]. Hand-held and portal type equipment is used. The firms have to record the measurements made, arrange financial securities and employ a radiation protection specialist. Furthermore, all alarms have to be reported to the regulatory body. At seaports, a detector mounted on a crane is used to monitor scrap metal that is being off-loaded from the hold of a freighter.

Pakistan

III–19. Pakistan has equipped its entry and exit points with portable radiation detectors that are capable of being used to search for and identify nuclear material or radioactive material. The customs officials at these points have been trained. The import and export of used/old machinery and metal in the form of scrap is allowed only on provision of a ‘radiation free certificate’ to customs. This has enabled Pakistan to monitor the import and export of illicitly trafficked nuclear material and radioactive material and scrap metal containing radioactive material.

III–20. The Pakistan Nuclear Regulatory Authority (PNRA) undertakes surveys of the metal recycling and production industries to search for any indication of the presence of radioactive material. Moreover, a programme to increase the awareness of scrap metal handlers of the possible presence of radioactive material in scrap metal is conducted using brochures and handouts.

Spain

III–21. As a result of the accidental melting of a ^{137}Cs source in a Spanish steel mill in 1998 (see Annex I), the national authorities, relevant private companies and the main trade unions prepared a protocol for the management of any future events of a similar nature. This became known as the ‘Spanish Protocol’. It was signed in 1999 and revised on 1 January 2005 [III–5, III–6].

III–22. The Protocol is a voluntary agreement defining the radiological surveillance of scrap metal and its products, and the duties and rights of the signatories. Its objective is:

> “to establish the conditions required to undertake the radiological surveillance of metallic materials and resulting products … with a view to detecting the possible presence of radioactive materials and avoid the risk of their becoming dispersed and irradiating or contaminating people, property and the environment.”

It is applicable to the recovery, storage or handling of metallic materials for recycling and the processing of metallic materials.

III–23. The companies subscribing to the Protocol obtain advice, assistance and training from expert governmental organizations on the monitoring of scrap metal shipments or processed metal and on appropriate response actions. In the event that radioactive material is discovered, a well defined scheme exists for its management, which involves all governmental agencies concerned.

III–24. The costs are to be borne by the companies unless they can be recovered from the supplier or dispatcher. These costs are much higher for companies that do not subscribe to the Protocol. An exception is where the radioactive source or substance originates from within the territory of Spain, in which case the costs are borne by the national organization responsible for radioactive waste management (ENRESA). The regulatory body can claim back from the company the costs of any work it has performed.

III–25. The Protocol is structured around the following five points of agreement:

> “One — To sign this Protocol for Collaboration on the Radiation Monitoring of metal materials and final products defined in the Technical Annex, which is an integral part hereof, with a view to introducing the monitoring and control measures stated herein.
>
> “Two — To set up at the Ministry of Industry and Energy, for the implementation of this Protocol, a Register in which companies carrying out the activities referred to in the Technical Annex can register, thereby accepting the rights and obligations arising from registration.
>
> “Three — To foster the registration of companies in the Register referred to in the foregoing point, particularly the registration of companies that have facilities for the smelting or the storage and preparation of scrap.

> “Four — To consult every six months to analyse the results of the implementation of this Protocol and study possible amendments to the Technical Annex proposed as a result of this implementation.
>
> “Five — To appoint the Ministry of Industry and Energy as the depository of this Protocol, which will be kept open for accession by other industry associations involved in similar activities.”

III–26. The Protocol is supported by a technical annex, covering in detail the above five points of agreement, and two subsidiary annexes, one dealing with information to be included in the declaration for the inclusion of installations belonging to companies subscribing to the Protocol, and the other providing notification sheets.

III–27. Royal Decree 229/2006 on the control of sealed radioactive sources with high activity and orphan sources came into force in 2006. This is the national adaptation of Council Directive 2003/122/Euratom of 22 December 2003 [III–1] on the control of high-activity sealed radioactive sources and orphan sources (see paras III–37 to III–41). Through this decree, which complements the Protocol, the necessary financial guarantees are established to remove orphan sources and to cover the costs of any incident such sources may cause (although the ‘polluter pays’ principle is invoked wherever possible).

United Kingdom

III–28. In England and Wales, guidance [III–7] provided by the Environment Agency, which is the relevant regulatory body, indicates that when a scrapyard operator inadvertently and unexpectedly acquires a radioactive source and is prepared to dispose of it promptly in the proper way, it is considered not to be reasonable to issue an authorization, which would attract a fee and subsequent continuing annual charges. The reason is that: “To insist on authorisation in these circumstances carries the risk that the Agency would not be informed when such sources are found and that they would be disposed of irresponsibly.” Instead, a pro forma letter is used to acknowledge receipt of a notification from the operator that a radioactive source has been acquired, and that their notification included a date for the planned disposal of the item. Even though there is no charge levied on the operator, it is still the responsibility of the operator to arrange for and fund the disposal of the radioactive source. This is because radioactive waste disposal is a commercial transaction in the United Kingdom (UK) rather than a cost-free national service.

III–29. This approach provides a record of the transaction for the operator as a defence for not being in possession of an authorization, and indicates to the operator that the Environment Agency is likely to conduct an inspection after the planned disposal date to ensure that the commitment to dispose of the radioactive source has been properly discharged. If it has not, the Environment Agency is able to take enforcement action, if that is considered necessary.

III–30. Operators are encouraged to report any such occurrence to the regulatory body. Furthermore, the Environment Agency is committed to being sympathetic to operators who discover radioactive material in consignments. The Environment Agency sees this primarily as an opportunity to:

(a) Secure proper disposal.
(b) If possible, identify the culpable person in order to take the appropriate enforcement action. When enforcement action is successful, there is a higher chance of successful civil action to recover costs.

III–31. The Environment Agency places emphasis on the usefulness of commercial pressures in encouraging the metal recycling and production industries to install monitoring equipment. There is no mandatory requirement to install portal monitors at metal recycling and production facilities, but the major suppliers at the top of the supply chain are contractually bound by their customers to supply scrap metal that is free from radioactive material of any kind. These commercial pressures have created a growth in the numbers of portal monitor detector systems in the metal recycling and production industries in the UK.

III–32. Customs officers operate detection equipment that provides the capability to routinely screen all forms of traffic at UK points of entry for the illicit movement of radioactive material [III–8]. Although installed for security purposes, these arrangements also detect the inadvertent movement of naturally occurring radioactive material, sealed radioactive sources and other radioactive material.

United States of America — Institute of Scrap Recycling Industries

III–33. The Institute of Scrap Recycling Industries (ISRI) has prepared for its members recommended practices and procedures for dealing with radioactive material in the scrap recycling process [III–9, III–10]. To assist operators in the visual recognition of radioactive material, this includes a list of possible waste types and waste descriptions that might be associated with radioactive material, along with photographs of sealed radioactive sources, NORM waste and warning signs. It contains advice on the detection of radioactive material in scrap metal, including equipment settings and positioning, and suitable responses to the discovery of such material. Finally, the ISRS provides some useful names, addresses, web sites and forms. The IRSI has also prepared a ‘scrap specifications circular’. In this, it requires scrap metal to be ‘free of radioactive material’. This is not defined, but it would be reasonable to use the definition provided in this Safety Guide (see the IAEA Safety Glossary [III–11] and footnote 3 of the main text).

INTERNATIONAL INITIATIVES

United Nations Economic Commission for Europe

III–34. Following a June 2006 meeting convened by the United Nations Economic Commission for Europe (UNECE), a group of experts prepared a list of recommendations on monitoring and response procedures on ‘radioactive scrap metal’ which (as defined for the purposes of the UNECE report):

> “may comprise radioactively contaminated scrap metal, activated scrap metal and scrap metal with radioactive source(s) or substances contained within it. It may include both radioactive substances that are subject to regulatory control and radioactive substances that are outside regulatory control” [III–4].

III–35. The document:

> “provides a framework of recommendations and examples of good practice based, to the extent possible, on existing national, regional and international instruments and standards and on national experience. The document is intended to support States in developing their own national systems of monitoring and response while encouraging further cooperation, coordination and harmonization at the international level. It is also intended to facilitate international trade in, and the use of, scrap metal without compromising safety” [III–4].

III–36. The document contains recommendations on:

(a) National responsibilities;
(b) National and international coordination;
(c) Costs and financing;

(d) Prevention of occurrence;
(e) Preparedness;
(f) Detection;
(g) Monitoring (visual, radiation and administrative);
(h) Response to alarms;
(i) Management of detected radioactive material;
(j) National and international reporting;
(k) Training.

European Union

III–37. In recognition of the need to strengthen and harmonize control of sealed radioactive sources throughout the European Union, a Directive [III–1] was promulgated under the Euratom Treaty in 2003. This is concerned with high activity sealed radioactive sources, which broadly correspond to those in IAEA categories 1 and 2 (see Annex II and Refs [III–12, III–13]). The focus of the Directive is on strengthening existing controls relating to authorization of practices, the identification, marking and recording of high activity sources and the training of those who use them, with the overall aim of preventing exposure of workers and the public to radiation arising from inadequate control of high activity sealed radioactive sources and orphan sources.

III–38. Regarding training and information, the Directive includes a requirement for EU Member States to:

> “provide encouragement to ensure that the management and workers in installations where orphan sources are most likely to be found or processed (e.g. large metal scrap yards and major metal scrap recycling plants), and the management and workers in significant nodal transit points (e.g. customs posts), are
>
> “(a) informed of the possibility that they may be confronted with a source;
> “(b) advised and trained in the visual detection of sources and of their containers;
> “(c) informed of basic facts about ionising radiation and its effects;
> “(d) informed of and trained in the action to be taken on site in the event of the detection or suspected detection of a source.” [III–1]

III–39. Specifically regarding orphan sources, the Directive requires EU Member States to:

(1) “ensure that the competent authorities are prepared, or have made provision, including assignment of responsibilities, to recover orphan sources and to deal with radiological emergencies due to orphan sources and have drawn up appropriate response plans and measures.”
(2) “ensure that specialised technical advice and assistance is promptly made available to the persons, not normally involved in operations subject to radiation protection requirements, who suspect the presence of an orphan source. The primary aim of advice and assistance shall be the protection of workers and members of the public from radiation and the safety of the source.”
(3) “encourage the establishment of systems aimed at detecting orphan sources in places such as large metal scrap yards and major metal scrap recycling installations where orphan sources may generally be encountered, or at significant nodal transit points, wherever appropriate, such as customs posts.”
(4) “ensure that campaigns are organised, as appropriate, to recover orphan sources left behind from past activities. The campaigns may include the financial participation of Member States in the costs of recovering, managing and disposing of the sources and may also include surveys of historical records of authorities, such as customs, and of holders, such as research institutes, material testing institutes or hospitals”. [III–1]

III–40. The Directive also deals with the financial security of orphan sources. It requires EU Member States to:

> “ensure that, on the basis of arrangements to be decided by Member States, a system of financial security is established or any other equivalent means to cover intervention costs relating to the recovery of orphan sources and which may result from implementation of the requirements”

that are given in the previous paragraph.

III–41. Other articles deal with international cooperation and information exchange, inspections, designation of a competent authority to carry out the tasks in accordance with the Directive, and reports on the experience gained in implementing it.

IAEA

III–42. A comprehensive programme of work was initiated following a conference on the safety of radiation sources and security of radioactive materials held in Dijon in 1998 [III–14]. The programme is described in a number of action plans [III–15, III–16, III–17].

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BODIES FOR THE ENDORSEMENT OF IAEA SAFETY STANDARDS

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