IAEA Nuclear Security Series No. 6

Technical Guidance
Reference Manual

Combating Illicit Trafficking in Nuclear and other Radioactive Material

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IAEA
International Atomic Energy Agency

COMBATING ILLICIT TRAFFICKING IN NUCLEAR AND OTHER RADIOACTIVE MATERIAL

REFERENCE MANUAL

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 NUCLEAR SECURITY SERIES No. 6

TECHNICAL GUIDANCE

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REFERENCE MANUAL

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INTERNATIONAL ATOMIC ENERGY AGENCY
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FOREWORD

In response to a resolution by the IAEA General Conference in September 2002, the IAEA adopted an integrated approach to protection against nuclear terrorism. This approach coordinates IAEA activities concerned with the physical protection of nuclear material and nuclear installations, nuclear material accountancy, detection of and response to trafficking in nuclear and other radioactive material, the security of radioactive sources, security in the transport of nuclear and other radioactive material, emergency response and emergency preparedness measures in Member States and at the IAEA, and the promotion of adherence by States to relevant international instruments. The IAEA also helps to identify threats and vulnerabilities related to the security of nuclear and other radioactive material. However, it is the responsibility of States to provide for the physical protection of nuclear and other radioactive material and the associated facilities, to ensure the security of such material in transport, and to combat illicit trafficking and the inadvertent movement of radioactive material.

The IAEA has previously issued a number of publications on nuclear security, including three publications on combating illicit trafficking in nuclear and other radioactive material, jointly sponsored by Europol, the IAEA, Interpol and the WCO. Recently, the IAEA has also published — in the IAEA Nuclear Security Series — Technical and Functional Specifications for Border Monitoring Equipment (No. 1), Nuclear Forensics Support (No. 2), Monitoring for Radioactive Material in International Mail Transported by Public Postal Operators (No. 3), Engineering Safety Aspects of the Protection of Nuclear Power Plants against Sabotage (No. 4) and Identification of Radioactive Sources and Devices (No. 5). These publications provide information primarily for customs, police and other law enforcement bodies on the arrangements for effectively preventing, detecting and responding to inadvertent movements and illicit trafficking of nuclear or other radioactive material. However, it is also recognized that there is a need for a broader scope of knowledge, including historical developments and case studies, in such a form that it can easily be used as an information and training resource for law enforcement personnel, legislators, government officials, technical experts, emergency responders, lawyers, diplomats, users of nuclear technology, the media and the public.

The preparation of this publication has involved extensive consultations with Member States, including technical meetings for the review of this manual. The draft was also circulated to Member States to solicit further comments and suggestions before publication. The contributions of the consultants and Member States to this endeavour are greatly acknowledged. The IAEA officers responsible for this publication were R. Abedin-Zadeh and S. Miaw of the Office of Nuclear Security, Department of Nuclear Safety and Security.

EDITORIAL NOTE

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1. INTRODUCTION

1.1. BACKGROUND

Since illicit trafficking and theft of nuclear material can lead to nuclear proliferation and the possible construction of improvised nuclear devices or radiological dispersal and exposure devices, measures to detect and respond to such acts are essential components of a comprehensive nuclear security programme. Continued reports of illicit trafficking in nuclear and other radioactive material underline the need for States to have such a programme in place.

The IAEA's activities in the area of nuclear security have the objective of enhancing the capabilities of States to prevent, detect, and respond to such acts, and to make internationally accepted guidance and technical support available to States, upon request. In particular, these activities include a comprehensive set of guidance publications, of which this reference manual is a part.

1.2. OBJECTIVE

This publication is intended for individuals and organizations that may be called upon to deal with the detection of and response to criminal or unauthorized acts involving nuclear or other radioactive material. However, it should also be useful for legislators, law enforcement agencies, government officials, technical experts, lawyers, diplomats and users of nuclear technology. Although a certain level of technical understanding is essential for dealing with radioactive material, it is neither expected nor necessary for users of this manual to possess a scientific or technical background in order to implement effective measures to detect and respond to criminal or unauthorized acts. However, individuals need to know some basic concepts and techniques that relate to the measures they would need to take if an incident arises from an unauthorized act.

1.3. SCOPE

The press and media often use the term 'nuclear smuggling'. This manual does not use this term because all types of radioactive material need to be considered, not just those that are used in nuclear weapons. The term 'illicit trafficking' has been used in many IAEA documents and publications and

forms part of the name of the IAEA Illicit Trafficking Database. Since the common understanding of the term 'illicit trafficking' deals primarily with trafficking across borders, the term 'criminal or unauthorized acts' is used in this manual. It is taken to include criminal or unauthorized acts both within a State and between States. The term 'act' also can apply to the import, export, possession, sale, delivery, movement, use, storage, disposal or transfer of nuclear and other radioactive material.

This manual emphasizes the international initiatives for improving the security of nuclear and other radioactive material. However, it is recognized that effective measures for controlling the transfer of equipment, non-nuclear material, technology or information that may assist in the development of nuclear explosive devices, improvised nuclear devices (INDs) or other radiological dispersal devices (RDDs) are important elements of an effective nuclear security system. In addition, issues of personal integrity, inspection and investigative procedures are not discussed in this manual, all of which are essential elements for an effective overall security system.

A variety of sources has been used to compile the information in this manual, including Europol (the European Police Office), the IAEA, Interpol (the International Police Organization) and the World Customs Organization (WCO), during jointly sponsored programmes. It aims to assist countries in developing their national infrastructures for the detection of and response to criminal or unauthorized acts involving nuclear and other radioactive material.

The manual considers a variety of elements that are recognized as being essential for dealing with incidents of criminal or unauthorized acts involving nuclear and other radioactive material. Depending on conditions in a specific State, including its legal and governmental infrastructure, some of the measures discussed will need to be adapted to suit that State's circumstances. However, much of the material can be applied directly in the context of other national programmes.

1.4. STRUCTURE

This manual is divided into four main parts. Section 2 discusses the threat posed by criminal or unauthorized acts involving nuclear and other radioactive material, as well as the policy and legal bases underlying the international effort to restrain such activities. Sections 3 and 4 summarize the major international undertakings in the field. Sections 5–8 provide some basic technical information on radiation, radioactive material, the health consequences of radiation exposure and the means of protection against such exposure. Also discussed are the authorized uses of nuclear and other radioactive material and

the regime governing their transport. Sections 9–11 offer guidance on how to manage efforts aimed at preventing, detecting and responding to the threat of criminal or unauthorized acts. Appendix I provides statistics on specific cases of illicit trafficking and highlights aspects of these incidents. Appendix II suggests general search procedures for use by responders when the presence of nuclear or other radioactive material is suspected.

2. THE THREATS

The threat of criminal or unauthorized acts involving nuclear and other radioactive material has grown significantly since the early 1990s. It is well known that terrorist groups have sought to acquire such material. This section describes the material and activities that have the potential of posing the greatest risk to society if they are not properly controlled.

2.1. ASSESSING THE THREAT OF CRIMINAL OR UNAUTHORIZED ACTS

At the outset of the twenty-first century, the world is continuing to experience accelerating technological change. Technologies using nuclear and other radioactive material are no exception to this trend, with such material being used in a growing variety of settings to advance development in States. If not controlled and handled appropriately, such material can pose serious risks to public health, property and the environment.

A detailed assessment of the international nuclear security situation was conducted at an IAEA conference entitled 'Nuclear Security: Global Directions for the Future', held in London from 16 to 18 March 2005 [1]. The following threats were identified in the findings of the conference President:

> "The threats involve criminals or terrorists acquiring and using for malicious purposes:
>
> (a) nuclear explosive devices;
> (b) nuclear material to build an improvised nuclear explosive device;
> (c) radioactive material to construct a radiological dispersal device (RDD); and/or

(d) the dispersal of radioactivity through sabotage of installations in which nuclear and other radioactive material can be found or of such material in transport."

In developing approaches to thwart criminal or unauthorized acts, it is important to recognize that there is a broad spectrum of threats that involve different types of radionuclides, of amounts of material, and of technical complexity. Appropriate strategies must be in place, a priori, to meet these threats. The threats outlined above will be further discussed in this chapter with the exception of sabotage of nuclear facilities or transport. Sabotage against nuclear material and facilities has to be addressed through the establishment of a physical protection system (see Ref. [2]).

In addition to the long recognized threat of the horizontal proliferation of nuclear weapons, the possibility that non-State actors might engage in nuclear or radiological terrorism has become a matter of rising concern for States and international organizations. The attacks on 11 September 2001 in the USA clearly demonstrated that terrorist groups are prepared to use the most violent and indiscriminate means to pursue their aims. Even before these attacks, terrorist incidents such as the March 1995 chemical attack using sarin gas in the Tokyo subway and a number of bombings of civilian facilities had alerted the world community to the escalating threat of large scale terrorism. Since the attacks in New York and Washington, a series of terrorist bombings has continued to heighten such concerns. Although the acts have not so far involved nuclear or other radioactive material, they are important in reaching an accurate assessment of the global threat.

Advances in information technology and the availability of radioactive material have increased the likelihood that a terrorist or other criminal organization could obtain the necessary material, components and expertise to construct a nuclear explosive device or RDD. For this reason, a broad range of controls is focused on monitoring nuclear material to ensure that it is not acquired by unauthorized persons or organizations. Proper controls are a central feature of the long term effort to prevent nuclear and other radioactive material from threatening international peace and security. As will be discussed in Section 4, States have responded to this threat both through national measures and through initiatives involving relevant international organizations, including Europol, the IAEA, Interpol and WCO.

2.2. POTENTIAL NUCLEAR AND RADIOLOGICAL THREATS

The following sections describe the types of radiological threats (e.g. RDDs and nuclear explosive devices). The ordering of these two threat types is given by their probable frequency of occurrence. This ordering also corresponds to the increasing severity of the threat.

2.2.1. Radiological dispersal devices

A major threat recognized at the conference on nuclear security in London in 2005 [1] is that unauthorized persons or groups may acquire radioactive material for use in RDDs, or 'dirty bombs'. These devices combine radioactive material with conventional explosives and, when detonated, could disperse the radioactive material over a wide area, contaminating persons, property and the environment. It should be stressed that non-explosive means could also be used to disperse the radioactive material with damaging effects. Following such an event, the contamination may be further spread through the movement of people and equipment unless appropriate action is taken.

For purposes of countering the threat of RDD incidents, nuclear security measures should focus on the kinds of material that have the potential for causing the greatest and most long lasting damage. A wide range of radioactive material is used in civilian applications. However, the quantities involved in many of them, if dispersed, are not sufficient to cause immediate injury or significant contamination. The focus of concern, therefore, should be on those sources that could cause injury in the short term and, if dispersed, significant levels of contamination of the environment.

The radioactive sources for an RDD that could easily be accessible are those not under regulatory control. This may be because it has never been under regulatory control, or because it has been abandoned, lost, misplaced, stolen or transferred without proper authorization [3]. Numerous incidents and accidents, including the accident in Goiânia [4], have occurred where equipment containing radioactive material has been discarded without due care and with no record or proper transfer of custody.

These incidents — and the radiation exposure that occurred —were accidental in nature. However, radioactive sources that are not under regulatory control could be appropriated by traffickers and transferred to persons or organizations that might wish to use them malevolently.

Uncontrolled sources are occasionally present in scrap metal, and appropriate monitoring systems can be used to detect their presence. Such sources are normally present inadvertently, although the possibility that they might be deliberately incorporated into scrap metal cannot be ruled out. In all

cases, the activities related to legal evaluation, prosecution and investigation have to be considered.

2.2.2. Nuclear explosive devices and material for such devices

The world's only experience with nuclear explosions targeting a human population occurred in Japan in 1945. As a result of the devastation caused, the international community has made enormous efforts during the subsequent decades to prevent the spread of nuclear explosive capabilities; these efforts initially focused on the possibility that additional States would acquire nuclear weapons. The most direct proliferation threat has been seen to involve the transfer of completed nuclear weapons from one State to another. This threat was addressed by the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), which is discussed in Section 3.

However, quite apart from the question of preventing transfers of complete explosive devices, there is a need to prevent transfers of nuclear material. As previously discussed, the primary objective of nuclear security measures should be the detection of the transfer of significant quantities of plutonium or enriched uranium. Verified incidents of illicit trafficking in weapons grade nuclear material have been few in number and have involved minimal quantities. When a suspected incident involving such material comes to the attention of the law enforcement community, it receives very high priority. Nevertheless, experts agree that concern is warranted regarding the number of suspected 'unknown' incidents, which may not have been officially identified or reported. Addressing this would require States and relevant international organizations to share information on a broader scale about the activities of persons or groups that may harbour an interest in acquiring nuclear explosives capabilities.

2.3. PHYSICAL AND OPERATIONAL ASPECTS

Sections 2.4.1–2.4.6 clarify some of the commonly used terms relating to the physical and operational aspects for detection of and response to criminal or unauthorized acts involving nuclear and other radioactive material.

2.3.1. Type of material considered

The scope of this publication covers both nuclear and other radioactive material. The distinction between these two types of material is significant from a risk assessment perspective. The term nuclear material as used in this

publication as any special fissile material or source material that may be used for the development of a nuclear weapon. Special fissionable material means plutonium-239; uranium-233; uranium enriched in the isotopes 235 or 233; and any material containing one or more of the foregoing. Source material means uranium containing the mixture of isotopes occurring in nature; uranium depleted in the isotope 235 and thorium in the form of metal, alloy, chemical compound, or concentrate.. The essential aspect of nuclear material is that, in sufficient quantities, it may be used to construct a nuclear explosive device. The term radioactive material covers a much broader class of substances and includes nuclear material, but also other substances that, although emitting ionizing radiation, are not suitable for producing nuclear explosions. Such material is commonly used in research and applications for science, industry, medicine and agriculture. The catastrophic consequences of a nuclear explosion have led governments to establish particularly stringent controls over nuclear material, typically much stricter than those governing other radioactive material.

2.3.2. Quantity of material considered

Although it is vital to identify the type of radioactive material that may be involved in an incident, it is also important to know the quantity of the material. The quantity is generally given in grams, while the activity of radioactive material is given in becquerels (Bq) or curies (Ci). A nuclear explosion can occur with nuclear material only when the quantity exceeds a certain threshold. However, as will be discussed, exposure to radiation from radioactive material, including nuclear material, is assumed to pose a risk to health at any level, although the actual risk of health effects will be dependent on the magnitude of the dose of radiation received. Thus, incidents involving nuclear material that is not in a quantity sufficient to produce an IND may nevertheless pose health or safety risks.

2.3.3. Cross-border movement

Unauthorized transfers of nuclear and other radioactive material across an international boundary fall within the scope of criminal or unauthorized acts. Although the authorities in a country may be able to effectively handle some incidents resulting from criminal or unauthorized acts, the transboundary movement of material can significantly hamper an effective response. This problem is discussed Section 11.15.

2.3.4. Criminal or unauthorized acts within national borders

It is recognized that an incident resulting from criminal or unauthorized acts involving nuclear and other radioactive material would be of interest to the international community even though it may take place within national borders. A single incident or series of apparently isolated incidents inside a State may provide valuable information to assess security threats beyond that State. Such information helps authorities in other States to identify and apprehend traffickers elsewhere. If nuclear and other radioactive material is offered for illegal sale, information on such transactions can enable both national and international bodies to assess whether such activity poses a significant security threat, and can help identify potential buyers, their capabilities and their motives.

2.3.5. Loss of control

It should be noted that the term *loss of control* does not necessarily include the element of criminal intent. This recognizes that serious risks are posed by uncontrolled nuclear and other radioactive material in circumstances in which legal controls fail because of the lack of a regulatory infrastructure, inadvertence, error or even accident. Pursuing an apparently innocent case of an unauthorized act may enable authorities to identify inadequate physical protection arrangements or even the loss or theft of material from a location where nuclear and other radioactive material is used or stored. This can facilitate an effective response to prevent a significant security breach or damage to property, public health and the environment.

Loss of control of nuclear and other radioactive material makes the involved material more susceptible to theft or misuse. Inadvertent movement, without appropriate controls, can lead to the exposure of persons to radiation or to poisoning by chemical substances associated with the radioactive material. Locating lost material or identifying persons associated with inadvertent movement and re-imposing necessary controls on the material involves measures comparable to those that would be applied in the event of intentional diversion or misuse. Likewise, the intention of persons involved in the illicit movement of nuclear and other radioactive material may be difficult to determine. Accordingly, the question of whether to treat a situation involving a suspected unauthorized act as a criminal case or a civil regulatory issue has to be dealt with by each State on the basis of the specific circumstances and its applicable laws and governmental procedures.

2.3.6. Illicit trafficking under false pretences

The problem of criminal or unauthorized acts involving nuclear and other radioactive material is compounded by the prevalence of incidents dealing with false representations of nuclear or other radioactive material. These must be assessed with the same rigour as episodes involving the actual diversion of nuclear or other radioactive material. Many such cases consist of hoaxes or scams that either falsely claim the presence of radionuclides that do not exist or misrepresent the nature or quantity of trafficked material. When reported, these cases require careful investigation to determine their veracity, which may divert resources away from actual case investigations.

Several hoaxes and scams are particularly noteworthy. These include many reports of 'red mercury', which has been commonly purported to be a constituent of nuclear weapons. Osmium-187 has also been touted as an essential nuclear weapons component. These assertions involving non-fissile material have no technical merit but continue to circulate throughout the world. In most cases, these episodes involve profit-motivated sellers who hope to deceive unsophisticated buyers in the context of economic downturns affecting the Newly Independent States (NIS) and Eastern Europe. More interesting is the rumoured existence of unaccounted compact tactical nuclear weapons ('suitcase bombs') that originated from arsenals in the NIS. Again, while there is little reliable information, this story persists as a potential threat. Because of the relative ease of misrepresenting factual information, scams, hoaxes, and other exaggerated claims are considerably more prevalent than instances in which nuclear or radioactive material is actually intercepted.

3. INTERNATIONAL LEGAL INSTRUMENTS

This section identifies the key international legal instruments and arrangements relevant for the detection of criminal or unauthorized acts involving nuclear and other radioactive material. These instruments have been summarized to provide interested persons with a general understanding of their basic provisions.

With regard to this international legal framework, three aspects should be emphasized. First, it is important that the relevant international instruments receive the broadest and most active support from States. Second, the provisions of these instruments should be reflected in the national laws and

regulations of all States. Third, harmonization of national laws and regulations could contribute to the detection of criminal or unauthorized acts by reducing delay and confusion in the handling of incidents of a cross-boundary character, and by enhancing the coordination of needed response actions.

3.1. INTERNATIONAL LEGAL FRAMEWORK

Criminal or unauthorized acts involving nuclear and other radioactive material and technology have emerged as a major threat to global security. Over the past several decades, a range of international legal instruments have been adopted to deal with issues of radiation protection, nuclear non-proliferation, nuclear and radiation safety and security, physical protection, nuclear transport, and emergency assistance. A number of these instruments contain provisions directly related to efforts to prevent, detect and respond to criminal or unauthorized acts involving nuclear and other radioactive material.

These instruments can have a legal effect on two levels. On one level, they govern the relations among and between States and international organizations. They establish rights and obligations on the part of these entities, either in terms of the sovereign capacity of the parties or of the status accorded by their members. These interactions are governed by principles and procedures of international law. On another level, international instruments confer obligations that have to be implemented by the parties in their national (or domestic) laws. For some States, such provisions are immediately applicable (or self-executing) as national law pursuant to constitutional and legal practice. For other States (the majority) in which international instruments are not self-executing, it is necessary to take additional legal steps, including the enactment of specific national legislation, to make international instruments enforceable. Additionally, some international instruments obligate parties to adopt national legal measures, for example, considering certain actions listed in an instrument as an offence under domestic law.

It is important to bear in mind another distinction regarding international instruments, namely, whether they have a legally binding character or whether they represent voluntary undertakings, guidance or best practices. Instruments such as conventions, treaties or agreements entered into with intent to bind the parties to concrete obligations are commonly referred to as 'hard law'. In contrast, other instruments, commonly referred to as 'soft law', include codes of conduct, statements of principle and international standards or technical documents. These instruments provide recommendations that States may choose to adopt as a matter of policy. This section discusses both hard law and soft law instruments.

Many States have entered into a range of multilateral, regional and bilateral instruments relevant to combating illicit trafficking. These international instruments represent an important part of the legal infrastructure of these States for addressing such trafficking and, accordingly, law enforcement personnel should possess a general appreciation of these instruments and their status under domestic law. Further information on the nature, scope and content of international nuclear law can be found in the Handbook on Nuclear Law published by the IAEA [6].

Given the diverse aspects of the problem of illicit nuclear trafficking, no single international instrument encompasses all provisions relevant to the subject. The following discussion identifies the primary international instruments relevant to the prevention, detection of and response to criminal or unauthorized acts involving nuclear and other radioactive material, briefly summarizing the provisions in those instruments that are directly applicable to the subject. In particular, attention will be focused on multilateral agreements in the nuclear area negotiated under the aegis of the IAEA or relating to IAEA responsibilities. However, other international instruments also provide important support to the international framework. For example, bilateral agreements between neighbouring States often have specific applicability to border and customs control issues, the extradition of offenders and similar matters. These must also be well understood by law enforcement personnel involved in the detection of and response to criminal or unauthorized acts.

3.2. INTERNATIONAL INSTRUMENTS RELEVANT TO CRIMINAL OR UNAUTHORIZED ACTS

In this publication, the following multilateral instruments, which contain provisions that are applicable to nuclear and/or radioactive material trafficking, will be discussed:

- Treaty on the Non-Proliferation of Nuclear Weapons, 1970 [7];
- NPT Exporters Committee — Zangger Committee Guidelines [8];
- Nuclear Suppliers Group Guidelines [9];
- Regional nuclear non-proliferation and arms control treaties [10–13];
- IAEA safeguards agreements [14] and additional protocols [15] thereto;
- Convention on the Physical Protection of Nuclear Material, 1980 (CPPNM), including an amendment adopted in 2005 [5, 16];
- Convention on Early Notification of a Nuclear Accident, 1986 (CENNA) [17];

– Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, 1986 (CACNARE) [18];
– Europol Convention, 1999 [19];
– Convention on Suppression of Acts of Nuclear Terrorism, 2005 [20];
– Code of Conduct on the Safety and Security of Radioactive Sources [3];
– Guidance on the Import and Export of Radioactive Sources [21];
– United Nations Security Council resolution 1540 [22];
– United Nations Security Council resolution 1373 [23].

It is neither practical nor necessary to reproduce the full texts of these instruments in this publication. A summary of the key provisions of each instrument will provide some basic guidance on the potential applicability of a treaty or convention to matters related to the detection of and response to criminal or unauthorized acts involving nuclear and other radioactive material. These summaries provide only a general overview of each treaty or convention. To facilitate accurate interpretation and application of an instrument, the reader is referred to the original text to determine whether or how it may be applied. These texts are available from the IAEA or can be accessed on the IAEA web site at:

http://www.iaea.org/Publications/Documents/Treaties/index.html
http://www.iaea.org/Publications/Documents/Conventions/index.html

3.2.1. Treaty on the Non-Proliferation of Nuclear Weapons

The NPT was opened for signature in 1968 and entered into force on 5 March 1970 [7]. In 1995, the contracting Parties agreed to extend the treaty indefinitely. The NPT is the most widely adopted multilateral arms control instrument. All Member States of the United Nations have become Parties to the treaty with the exception of India, Israel and Pakistan.

The key features of the NPT are:

– Article I: Parties possessing nuclear weapons undertake not to transfer them or other nuclear explosive devices to any recipient, or to assist any non-nuclear-weapon State in acquiring nuclear weapons.
– Article II: Non-nuclear-weapon States undertake not to receive the transfer of nuclear weapons or other nuclear explosive devices and not to manufacture or otherwise acquire nuclear weapons.
– Article III: Each non-nuclear-weapon State agrees to accept IAEA safeguards on specified fissionable material in all its peaceful nuclear activities as one means of verifying its compliance with its treaty obligations (paragraph 1). This article also makes provision for each of

the Parties to the treaty not to provide fissionable material or equipment for processing fissionable material unless there is a safeguards agreement in place (paragraph 2).

The fundamental obligations in Articles I and II of the NPT not to transfer or receive or develop nuclear weapons or explosives devices are quite broad. As per the language of these articles, neither transfer nor receipt may be conducted "directly or indirectly". Assistance to a non-nuclear-weapon State to manufacture or otherwise acquire such devices may not be conducted "in any way". These obligations mandate strict measures by Contracting Parties to prevent any transfers or assistance — including criminal or unauthorized acts — that could contribute to the development of nuclear explosives.

The safeguards provisions in Article III also have a direct bearing on measures to prevent criminal or unauthorized acts. Safeguards measures implemented in the context of an agreement negotiated pursuant to Article III are intended to provide an objective and verifiable means of confirming that States Parties to the NPT are complying with their Article II obligation not to transfer nuclear weapons or explosive devices or to seek or receive assistance in the manufacture of such devices. A threshold issue for NPT Parties upon entry into force of the treaty was to determine precisely which "equipment or material especially designed or prepared for the processing, use or production of special fissionable material" would be subject to both export controls and the application of IAEA safeguards.

The IAEA safeguards system, including model safeguards agreements pursuant to the NPT, has developed over several decades with the input of experts from NPT States Parties and the IAEA Secretariat. The resulting instruments will be summarized in another part of this section. Export control arrangements were developed in a somewhat different manner, since these are applied by contracting Parties under their respective national legal systems.

3.2.2. NPT Exporters Committee: Zangger Committee Guidelines

NPT export controls under Article III.2 have been developed and implemented by a separate body of exporting countries (initially known as the NPT Exporters Committee and now called the Zangger Committee, after its first chairman). The Zangger Committee, which now consists of 35 members, has developed a list of material and equipment that would 'trigger' the application of IAEA safeguards [8].

Accordingly, unauthorized transfers of material, equipment or technology that could assist a non-nuclear-weapon State in developing nuclear explosives would constitute one form of unauthorized act, whether

conducted by private individuals or by entities acting without the authorization of the governments that have jurisdiction over their actions. Similarly, transfers of 'trigger list' items without the application of IAEA safeguards would constitute an unauthorized act. Thus, the NPT provides an important mechanism for prevention and detection of criminal or unauthorized acts involving nuclear material and related goods. Further information on the Zangger Committee can be obtained at the web site: http://www.zanggercommittee.org

3.2.3. Nuclear Suppliers Group Guidelines

Following the development of the Zangger Committee Guidelines, some nuclear supplier countries determined that an additional mechanism for nuclear export control was needed. This led to the creation of the Nuclear Suppliers Group (NSG)[1], the purpose of which was to encompass some supplier countries not party to the NPT and to adopt controls going beyond the scope of material and items covered under Article III of the treaty [9]. The NSG Guidelines cover a wide scope of nuclear related commodities and technology. The Guidelines contain a requirement for formal government assurances from recipients that exported material will not be diverted to an unsafeguarded nuclear fuel cycle or explosive activities. The Guidelines also adopted a requirement for physical protection measures, agreement to exercise particular caution in the transfer of sensitive facilities, technology and weapons usable material, and strengthened retransfer provisions. In doing so, the Guidelines recognize that there is a class of technology and material which is particularly sensitive because it can lead directly to the creation of weapons usable material.

In 1992 the NSG decided to:

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[1] Although not specifically addressing activities involving nuclear and other radioactive material, two other supplier arrangements may be relevant to incidents of criminal or unauthorized acts involving such material. The 'Wassenaar Arrangement' establishes a system of export controls for conventional arms and dual use goods and technologies. The Missile Technology Control Regime (MTCR) establishes guidelines for restricting the proliferation of missiles or other unmanned delivery systems capable of delivering weapons of mass destruction. For nuclear related cases in which conventional arms or missile related commodities or technology may also be involved, reference to these arrangements may be appropriate. Such information may be obtained at: www.wassenaar.org for Wassenaar Arrangements and www.mtcr.info for the MTCR.

– Establish guidelines for transfers of nuclear related, dual use equipment, material and technology (items which have both nuclear and non-nuclear applications), which could make a significant contribution to an unsafeguarded nuclear, fuel cycle or nuclear explosive activity. These Dual-Use Guidelines were published as Part 2 of INFCIRC/254 [9].
– Establish a framework for consultation on the Dual-Use Guidelines for the exchange of information on their implementation and on procurement activities of potential proliferation concern.
– Establish procedures for exchanging notifications issued as a result of national decisions not to authorize transfers of dual use equipment or technology, and to ensure that members do not approve transfers of such items without first consulting with the State that issued the notification.
– Make a comprehensive safeguards agreement with the IAEA a condition for the future supply of trigger list items to any non-nuclear-weapon State. This decision ensured that only NPT Parties and other States with comprehensive safeguards agreements could benefit from nuclear transfers.

The endorsement at the 1995 NPT Review and Extension Conference of the full scope safeguards policy adopted by the NSG in 1992 clearly reflects the conviction of the international community that this nuclear supply policy is a vital element to promote shared nuclear non-proliferation commitments and obligations. Specifically, full scope safeguards and international legally binding commitments not to acquire nuclear weapons or other nuclear explosive devices should be a condition for granting licenses for trigger list items under new supply arrangements with non-nuclear-weapon States. Further information on the NSG can be found at:
http://www.nuclearsuppliersgroup.org .

3.2.4. Regional nuclear non-proliferation and arms control treaties

Beyond the auspices of the NPT, efforts were made in several regions of the world to create special regimes to prevent the emergence of nuclear weapons in those regions. At present, four of these treaty regimes are of potential significance with regard to criminal or unauthorized acts involving nuclear material [10–13]. For those States Parties to these regional arrangements, specific obligations and implementing arrangements may be of significance in shaping nuclear security measures:

– Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean (Tlatelolco Treaty); entry into force: 22 April 1968 [10].

- Article 1 sets forth the obligation of States Parties to prevent the introduction or acquisition of nuclear weapons "by any means whatsoever" or "directly or indirectly".

– South Pacific Nuclear Free Zone Treaty (Rarotonga Treaty); entry into force: 11 December 1986 [11].
  - Article 3 sets forth the obligation not to acquire nuclear weapons.

– Southeast Asia Nuclear-Weapon-Free Zone Treaty (Bangkok Treaty); entry into force: 27 March 1992 [12].
  - Article 3 sets forth the obligation for States Parties not to acquire or possess nuclear weapons.

– African Nuclear-Weapon-Free-Zone Treaty (Pelindaba Treaty); opened for signature: 11 April 1996 [13].
  - Article 3 sets forth basic obligations for States Parties not to acquire nuclear weapons.
  - Article 10 requires States Parties to maintain the highest standard of security and effective physical protection of nuclear material, facilities and equipment to prevent theft or unauthorized use and handling.

3.2.5. IAEA safeguards agreements

The IAEA safeguards system [14] comprises an extensive set of technical measures through which the IAEA Secretariat independently verifies the correctness and the completeness of the declarations made by States about their nuclear material and activities. The detailed oversight of a State's nuclear related activities provided by international safeguards can make an important contribution to preventing criminal or unauthorized acts by confirming that all relevant material is being used only for its intended purpose. The activities conducted by the IAEA, as an expert, independent, multilateral organization, can also help national authorities develop their own practices and procedures to prevent diversion of such material.

In broad outline, safeguards activities comprise three functions: accountancy, containment and surveillance. Accountancy means that States report the types and quantities of relevant material to the IAEA, and the IAEA then verifies the accuracy of these reports. To implement this obligation States need to establish an efficient and effective State system of accounting for and control of nuclear material (SSAC) covering all relevant material. Containment and surveillance involve technical measures, such as seals on containers that hold nuclear material and the use of cameras to record movements in controlled areas of the nuclear facilities of States and other sites. Safeguards measures are implemented pursuant to agreements negotiated between individual States and the IAEA. These very detailed documents set

out relevant principles, procedures and requirements. The following discussion summarizes the most relevant aspects of safeguards that may be useful to persons dealing with the detection of and response to criminal or unauthorized acts involving nuclear and other radioactive material.

3.2.5.1. Safeguards agreements

One set of measures involves verification activities performed at facilities or other locations where States have declared the presence of nuclear material. These measures are conducted pursuant to an agreement negotiated between the IAEA and the State in which safeguards are to be implemented. Safeguards agreements have taken several different forms, depending on whether a particular State is party to the NPT, whether it is classified as a nuclear weapon State or non-nuclear-weapon State under the NPT and other factors. However, because most are non-nuclear-weapon States Parties to the NPT, traditional safeguards have been implemented in all but a few States under IAEA INFCIRC/153, Structure and Content of Agreements between the IAEA and States required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons [14]. This document has been used by the IAEA as the basis for negotiating comprehensive safeguards agreements, which cover all relevant nuclear material in a non-nuclear-weapon State. The essential feature of such an agreement is the State's detailed declaration of its relevant nuclear material and activities to the IAEA. In the past, safeguards under INFCIRC/153 agreements were focused primarily on verifying that declared material and activities were being used for their intended purposes and not being diverted for activities related to the development of nuclear weapons.

A number of provisions in INFCIRC/153 have particular relevance for the detection and response to criminal or unauthorized acts involving nuclear material. Paragraph 8 indicates the information to be provided by a State to the IAEA. Paragraph 34 also indicates information to be provided on the transfer of certain types of material. Paragraphs 91 through 97 of the document — comprising a section titled 'International Transfers' — contain detailed requirements for a safeguards agreement to cover transfers of relevant material both into and out of a State. These requirements include a provision for special reports (Article 97) in the event of unusual incidents that may lead a State to believe there may have been loss of nuclear material. Of course, an incident resulting from the detection of an unauthorized act involving safeguarded nuclear material would be covered by this provision.

3.2.5.2. Additional protocol

After disclosures in the early 1990s that some States covered by INFCIRC/153 agreements were conducting activities relevant to weapons development outside their declared programmes, an initiative was mounted to strengthen the IAEA safeguards system. The initiative to move beyond existing safeguards measures was endorsed by the IAEA Board of Governors, beginning in 1992. Such strengthened measures fall into two categories. The first comprises those measures to be implemented under the legal authority conferred by existing safeguards agreements. The second includes measures to be implemented under the complementary legal authority conferred by additional protocols concluded between States and the IAEA on the basis of the Model Additional Protocol. The protocol is contained in IAEA INFCIRC/540 [15]. In general, safeguards measures provided for in the Model Additional Protocol go beyond previous arrangements by:

- Requiring the State to provide broader information including: detailed information on nuclear fuel cycle activities not involving nuclear material; periodic updates of information; information on intended processing of material; exports and imports; and other matters.
- Introducing complementary access to locations identified by the IAEA.
- Enabling improved inspector access, including such measures as granting multiple entry visas, eliminating visa requirements and simplifying inspector designation.
- Recognizing the IAEA's right to use state of the art communications technologies between IAEA inspectors and Headquarters or IAEA regional offices.

With regard to the detection and response to an unauthorized act, the additional protocol requires reporting of exports and imports of both nuclear material (Article 2.a.(vi)) and equipment and non-nuclear material (Article 2.a.(ix) and Annex II). Reference should be made to the provisions of the additional protocol regarding specified material, equipment and non-nuclear material. In summary, the reporting requirements cover items associated with:

- Reactors and equipment for reactors;
- Non-nuclear material for reactors;
- Processing irradiated fuel elements and equipment especially designed or prepared, for this purpose;
- Fabrication of fuel elements;

– The separation of isotopes of uranium and equipment, other than analytical instruments, especially designed or prepared for this purpose;
– The production of heavy water, deuterium and deuterium compounds and equipment especially designed and prepared for this purpose;
– The conversion of uranium and equipment especially designed or prepared for this purpose.

3.2.6. Convention on the Physical Protection of Nuclear Material

The CPPNM [5] was opened for signature on 3 March 1980 and entered into force on 8 February 1987. It contains several provisions of importance for detection and response to criminal or unauthorized acts. Indeed, the CPPNM's third preambular paragraph notes "the potential dangers posed by the unlawful taking and use of nuclear material". The law enforcement imperative is explicitly noted in preambular paragraph 4, where the Parties affirm "that offences relating to nuclear material are a matter of grave concern and that there is an urgent need to adopt effective measures to ensure the prevention, detection and punishment of such offences". Preambular paragraph 5 emphasizes "the need for international cooperation to establish, in conformity with the national law of each State Party and with this Convention, effective measures for the physical protection of nuclear material".

The relevant features of the CPPNM are as follows:

– Article 1 contains definitions of key terms, including *nuclear material* and *international nuclear transport*.
– Article 2 defines the scope of the Convention. It covers nuclear material used for peaceful purposes while in international nuclear transport and (except for certain inapplicable provisions in Articles 3, 4 and 5) to nuclear material used for peaceful purposes while in domestic use, storage and transport.
– Article 3 provides that Parties agree to ensure that nuclear material is protected during international transport in accordance with the levels described in Annex 1 to the Convention.
– Article 4 provides that Parties agree not to import, to export or to permit the import or export of nuclear material unless the Party has received assurances that the material will be protected during international transport in accordance with levels described in Annex 1 to the CPPNM.
– Article 5 provides that Parties agree to make known to each other their central authority and point of contact for the physical protection of nuclear material and will establish coordinating response mechanisms in the event of unauthorized removal, use or alteration of the nuclear

material. It also details actions to be undertaken in the event of theft, robbery or other unlawful taking of nuclear material and extends those actions to include provision for dealing with credible threats of such events.

- Article 6 provides that Parties agree to protect and maintain the confidentiality of any information they receive in confidence.
- Article 7 details a series of offences in relation to nuclear material that Parties must make criminal by enacting offences under their national laws with appropriate penalties that take into account their grave nature. The offences listed are:

  (a) An act without lawful authority which constitutes the receipt, possession, use, transfer, alteration, disposal or dispersal of nuclear material and which causes or is likely to cause death or serious injury to any person or substantial damage to property.
  (b) A theft or robbery of nuclear material.
  (c) Embezzlement or fraudulent obtaining of nuclear material.
  (d) An act constituting a demand for nuclear material by threat or use of force or by any other form of intimidation.
  (e) A threat:

    (1) to use nuclear material to cause death or serious injury to any person or substantial property damage;
    (2) to commit an offence described in sub-paragraph (b) in order to compel a natural or legal person, international organization or State to do or to refrain from doing any act.

  (f) An attempt to commit any offence described in paragraphs (a), (b) or (c).
  (g) An act, which constitutes participation in any offence described in paragraphs (a)–(f).

- Article 8 describes arrangements to establish jurisdiction over the offences previously listed in Article 7.
- Article 9 calls upon Parties to the Convention to ensure that appropriate measures are taken under national law for the prosecution and/or extradition of any offender.
- Article 10 provides that if a Party to the Convention does not extradite an alleged offender, it must promptly submit the person to its competent authorities for prosecution in accordance with national law.

– Article 11 declares that the offences listed in Article 7 should be considered as extraditable offences and included in any extradition treaty between Parties to the Convention. It also proposes that Parties to the Convention may use it as a legal basis for extradition in a situation where no extradition treaty exists between the Parties to the CPPNM.
– Article 12 states that any person prosecuted for offences under Article 7 should be guaranteed fair treatment at all stages of the proceedings.
– Article 13 makes provision for assistance between Parties to the Convention in relation to any criminal proceedings, and this specifically includes the supply of evidential matter relevant to the case.
– Annex I sets out the levels of physical protection to be applied in the international transport of nuclear material in accordance with three specific categories of material, as set out in Annex II.
– Annex II defines the three categories of nuclear material, Category I, II and III. The categories take the quantity of the specific material as the basis for the categorization. In the case of plutonium, 2 kg or more would be classified at Category I; less than 2 kg but more than 500 g would be classified as Category II; and 500 g or less, but more than 15 g, would be classified as Category III.

3.2.7. Amendment to the CPPNM

In 1999, a process of developing possible amendments to the CPPNM was undertaken under the auspices of the IAEA. A group of experts was convened in several meetings for this purpose. One result of the experts' work was the development of a set of 'objectives and fundamental principles' for physical protection. The 12 fundamental principles were endorsed both by the IAEA Board of Governors and the General Conference in 2001, with a recommendation that States apply them in their national regulatory systems. In July 2005, an Amendment Conference conducted in Vienna adopted an Amendment to the CPPNM [16], which strengthened the CPPNM significantly. The areas covered by it include:

– Extension of its scope to cover nuclear material in domestic use, storage and transport;
– Protection of nuclear material and facilities from sabotage;
– Creation of new offences for smuggling and certain group activities;
– Clarifying national responsibility for physical protection;
– Protection of confidential information;
– Incorporating the objectives and fundamental principles of physical protection;

— Adding relevant definitions;
— Expanding the scope of punishable acts.

Under Article 20.2 of the CPPNM, a proposed amendment enters into force 30 days after the date on which two thirds of the Parties have ratified or accepted the amendment. Given the large number of Parties to the CPPNM, there could be a significant delay in reaching the two thirds figure. However, two legal aspects are relevant to application of the amendments prior to their formal entry into force. First, by signing the amendment, a State may not take action that would defeat the object and purpose of the amendment prior to entry into force. Also, CPPNM Parties — either together or individually — could agree to provisional application of the amendments prior to formal entry into force.

3.2.8. Convention on Early Notification of a Nuclear Accident

The Convention on Early Notification of a Nuclear Accident was adopted on 26 September 1986 and entered into force on 27 October 1986 [17]. Negotiation of the Convention was undertaken in the wake of the Chernobyl accident, with the aim of ensuring that States provide relevant information about nuclear accidents as early as possible in order that transboundary radiological consequences can be minimized.

The Convention has relevance to the detection of and response to criminal or unauthorized acts involving nuclear and other radioactive material because the circumstances of such acts may precipitate serious incidents involving the potential or actual release of radioactive material and which could possibly have an impact across national boundaries. Thus, the Convention constitutes part of the international framework for responding to radiological emergencies that could result from criminal or unauthorized acts.

The key features of the Convention are summarized below:

— Article 1 sets the scope of the Convention to accidents in which a release of radioactive material occurs or is likely to occur and which has resulted or may result in transboundary release with radiological consequences for another State. It also details the facilities and activities to which the Convention applies as being:

(a) any nuclear reactor, wherever it may be located;
(b) any nuclear fuel cycle facility;
(c) any radioactive waste management facility;
(d) the transport and storage of nuclear fuels or radioactive waste;

(e) the manufacture, use, storage, disposal and transport of radionuclides for agricultural, industrial, medical and related scientific and research purposes;
(f) the use of radionuclides for power generation in space objects.

- Article 2 provides for Parties to the Convention to notify other States and the IAEA of any nuclear accident, its nature, time of occurrence and exact location. It also makes it incumbent upon Parties to the Convention to provide information, which will aid in minimizing the radiological consequences of the accident in those States affected.
- Article 3 allows for notification of other nuclear accidents not specified in Article 1, where again the aim is to minimize an accident's radiological consequences.
- Article 4 details the function of the IAEA following its receipt of any notification of a nuclear accident and calls for the IAEA to immediately inform any States which may be physically affected, and also inform relevant international intergovernmental organizations. The IAEA will also provide details of any information it receives in relation to an accident.
- Article 5 specifies the type of information and data to be supplied when a notification is made and provides for the information to be updated at appropriate intervals.
- Article 6 makes it incumbent upon the notifying State to respond promptly to any request for information or consultation by other States affected with a view to minimizing the radiological consequences of the accident.
- Article 7 provides for Parties to make known to other Parties and to the IAEA their competent authorities and points of contact responsible for issuing and receiving notifications and information relating to a nuclear accident. It also provides for the IAEA to maintain an up-to-date list of national authorities and contact points and stipulates that Parties have the responsibility to promptly notify the IAEA of any changes in those points of contact.
- Article 8 provides for the IAEA to render assistance upon request in investigating the feasibility and establishment of a radiation monitoring system. This provision is intended to cater specifically to situations in which a given State Party to the Convention without nuclear activity borders a State that has an active nuclear programme but that is not a Party.

3.2.9. Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency

The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency was adopted on 26 September 1986 and entered into force on 26 February 1987 [18]. It identified the need for an international framework to facilitate the provision of assistance in the event of a nuclear accident or radiological emergency and aims to minimize the radiological consequences of such events. Like the Convention on Early Notification of a Nuclear Accident, the Assistance Convention also has limited applicability to criminal or unauthorized acts involving nuclear or other radioactive material. Nevertheless, if an incident of illicit nuclear trafficking causes or contributes to a radiological emergency, the Convention provides a ready mechanism for seeking and providing necessary assistance. Accordingly, the Convention forms part of the overall international security framework for addressing potential consequences arising from illicit nuclear trafficking activity.

The key features of the Convention are summarized as follows:

- Article 1 details the general provisions of the Convention, making it incumbent upon Parties to cooperate between and among themselves and with the IAEA to facilitate prompt assistance in the event of a nuclear accident or radiological emergency.
- Article 2 describes the mechanism for a Party to the Convention to seek assistance from another Party or from the IAEA and provides for Parties to specify the scope and type of assistance required. It also provides for a State Party to identify and notify the IAEA of experts, equipment and material that could be made available for the provision of assistance to another Party.
- Article 3 specifies the arrangements for direction and control of assistance under the Convention. Under this article, the overall direction, control and coordination within its national boundaries remains the responsibility of the Party requesting assistance, but the assisting Party is required to designate a person to be in charge and retain operational control over personnel and equipment supplied by the assisting Party. Ownership of equipment and material provided by either Party during the period of assistance will be unaffected.
- Article 4 provides for Parties to the Convention to make known — to other Parties and to the IAEA — their competent authorities and points of contact for making and receiving requests for assistance and for accepting offers of assistance. It also provides for the IAEA to maintain the list of national authorities and points of contact and stipulates that

Parties to the Convention have the responsibility to promptly notify the IAEA of any changes to those points of contact.

- Article 5 details the functions of the IAEA, including the collection and dissemination of information relating to experts, equipment, material, methodologies and techniques relevant to response mechanisms for a nuclear accident or radiological emergency. It also provides for the IAEA to assist Parties to the Convention in preparing emergency plans, developing training programmes, transmitting requests for assistance, developing radiation monitoring programmes and conducting investigations where appropriate. Under this article, the IAEA will make resources available to conduct an initial assessment of the accident or emergency and will offer its good offices to any State requesting assistance in the event of a nuclear accident or emergency.
- Article 6 considers the arrangements for maintaining the confidentiality of information and the release of public statements relating to the accident or emergency.
- Article 7 deals with the reimbursement of costs by a requesting State Party and makes it incumbent upon the State Party requesting assistance to reimburse the Party providing the assistance for all services rendered and all expenses incurred. It also provides for a Party offering assistance to waive or postpone reimbursement of costs and expenses.
- Article 8 details arrangements for privileges, immunities and facilities to be extended to personnel of an assisting Party while providing assistance under the terms of the Convention. Such personnel are immune from arrest, detention or legal process with respect to acts or omissions in the performance of their duties and are also exempt from taxation, duties or other charges.
- Article 9 provides for Parties to the Convention to facilitate the transit of personnel, equipment and property through respective territories while the personnel are providing assistance in accordance with the Convention.
- Article 10 deals with claims and compensation regarding death or injury to persons, damage or loss of property or damage to the environment, which might occur in the course of providing assistance. In general terms, the requesting Party is required to indemnify the personnel of assisting Parties and to be responsible financially for any claims or compensation issues.

3.2.10. Europol Convention

The European Police Office (Europol) was established by the Europol Convention, which entered into force in 1999 [19]. This international instrument is a notable example of how regional cooperation to combat terrorism and organized crime can be enacted within the single territory of States having no internal borders. This cooperation involves the exchange and management of sensitive information and the production of intelligence concerning possible terrorist and other criminal activity.

Among the various provisions of the Europol Convention, the following are the most relevant:

- Article 2 provides for cooperation among Europol Member States in preventing and combating serious forms of organized crime and terrorism and other serious forms of international crime, including "trafficking in nuclear and radioactive substances", in cases in which there are factual indications that an organized structure is involved and two or more Member States are affected in such a way as to require a common approach by the Member States owing to the scale, significance and consequences of the offences concerned.
- Article 3 outlines a range of tasks involving cooperative activities of Europol Member States, including facilitation of the exchange and analysis of information and notification of competent authorities concerning possible criminal offences. The Member States agree to work towards improvement of investigative procedures and strategic intelligence, preparing situation reports, engaging in training and improving crime prevention methods and technical and forensic analysis.
- Article 10 deals with Europol work files for the purposes of analysis. The article provides for the management of information concerning criminal offences, in cases where it is necessary to achieve Europol objectives. In addition to data of a non-personal nature, Europol may store, modify, and use data from other files on criminal offences, known as 'analysis work files'. Such files will be opened for the purposes of analysis, defined as the assembly, processing or utilization of data with the aim of helping a criminal investigation. Each analysis project entails the establishment of an analysis group.
- Article 12 details requirements for obtaining a data file of information on individuals to ensure that relevant information can be promptly accessed, while also ensuring necessary protection against misuse.

– Article 14 outlines standards of data protection. These are references to relevant Council of Europe principles concerning how information is to be protected.

3.2.11. International Convention for the Suppression of Acts of Nuclear Terrorism

The most recent international instrument developed to address nuclear security, including the detection of and response to or unauthorized acts involving nuclear and other radioactive material is the International Convention for the Suppression of Acts of Nuclear Terrorism. It was adopted by the United Nations General Assembly in April 2005 and entered into force on 7 July 2007 [20]. Under this Convention, States Parties would have an obligation to criminalize a wide range of activities involving nuclear or other radioactive material. With particular reference to such criminal or unauthorized acts, Article 2.1 establishes as offences the unlawful and intentional possession, use, threat, attempt or participation in acts involving radioactive material[2] with the intent to cause death, serious bodily injury or property damage. In many respects, the offences established under this Convention parallel those established in the CPPNM, which is referenced in the preamble to this Convention.

An important feature of the Convention is its coverage of RDDs. As discussed in Section 2, RDDs could involve the dispersal of radioactive material in a manner leading to contamination of persons and property, but would not produce a nuclear explosion.

With regard to the prevention of nuclear terrorist acts, including criminal or unauthorized acts, Article 8 of the Convention requires Parties to

> "make every effort to adopt appropriate measures to ensure the protection of radioactive material, taking into account relevant recommendations and functions of the International Atomic Energy Agency."

This provision has the interesting legal ramification of drawing so-called soft law instruments developed by the IAEA as voluntary guidance into the framework of hard law. Accordingly, it could be argued that contracting parties to this Convention have the obligation to apply relevant IAEA requirements.

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[2] In this convention, *radioactive material* includes nuclear material.

3.2.12. Code of Conduct on the Safety and Security of Radioactive Sources

As discussed earlier, radioactive sources in the hands of unauthorized persons or groups could be used for malevolent purposes (such as the fabrication of RDDs or 'dirty bombs'), or handled in ways that jeopardize public health, safety and security. An IAEA conference on the Safety of Radiation Sources and Security of Radioactive Material, held in Dijon in September 1998, produced findings in the light of which the IAEA Board of Governors approved an Action Plan for the Safety of Radiation Sources and Security of Radioactive Material in September 1999 [24, 25]. Implementation of the Action Plan led to the development of a Code of Conduct on the Safety and Security of Radioactive Sources to address issues of safety and security concerning radioactive sources. After extensive discussions in a working group of technical and legal experts, the Board of Governors approved the text of the Code of Conduct in 2003 [3]. The 2003 General Conference adopted resolution GC(47)/RES/7 endorsing "the objectives and principles set out in the Code, while recognizing that the Code is not a legally binding instrument." Further, the General Conference recognized "that a high priority should be given to developing and following the guidance in support of the Code of Conduct as specified in the Action Plan for the Safety and Security of Radioactive Sources". The General Conference resolution urged Member States to report to the IAEA's Director General that it "fully supports and endorses the IAEA's efforts to enhance the safety and security of radioactive sources" and that it "is working toward following the guidance contained in the Code".

The Code of Conduct relies on and complements existing international standards for radiation safety and the control of radioactive sources. It provides guidance for States on actions to control radioactive sources. The Code is structured in four parts. A brief preamble recites some of the factors which led to the Code's development and references a number of international instruments taken into account during the drafting. Part I — Definitions — identifies key terms used in the Code, providing clarification of these terms. Part II — Scope and Objectives —describes the coverage of the Code and its intended purposes (paragraphs 2–6). Part III — Basic Principles — contains the bulk of the Code's text, setting forth 24 paragraphs (7–31) of specific guidance on various aspects of controlling radioactive sources. Part III is divided into six subparts, covering specific matters, as follows: General (paragraphs 7–17); Legislation and Regulations (paragraphs 18, 19); Regulatory Body (paragraphs 20–22); Export and Import of Radioactive Sources (paragraphs 23–29); Role of the IAEA (paragraph 30) and Dissemination of the Code (paragraph 31). In addition, an Annex and Table I list the radioactive sources covered by the Code, dividing these into three categories

based on the level of risk to health, safety and security each category presents (with Category 1 being the most dangerous).

For the purposes of this publication, it is not necessary to detail or even summarize the provisions of the Code. The interested reader is directed to the full text for an understanding of the guidance it provides on specific subjects. Nonetheless, it is useful here to identify a few of the Code's provisions of particular relevance for the detection of and response to criminal or unauthorized acts involving radioactive sources:

- Paragraph 8(f) indicates that every State should "provide for measures to reduce the likelihood of malicious acts, including sabotage, consistent with the threat defined by the State".
- Paragraph 16 indicates that every State "should define its domestic threat, and assess its vulnerability with respect to this threat for the variety of sources used within its territory, based on the potential for loss of control and malicious acts involving one or more radioactive sources".
- Paragraph 17 provides guidance on the treatment of confidential information.
- Paragraph 19(g) indicates that national legislation and regulations should provide "requirements for security measures to deter, detect and delay the unauthorized access to, or the theft, loss or unauthorized use or removal of radioactive sources during all stages of management".
- Paragraph 20(j) indicates that a legislatively established regulatory body should "monitor, or request other authorized bodies to monitor, at appropriate checkpoints for the purpose of detecting orphan sources".
- Paragraph 23 indicates that "every State involved in the import or export of radioactive sources should take appropriate steps to ensure that transfers are undertaken in a manner consistent with the provisions of the Code", and that transfers of Category 1 and 2 sources should require prior notification by the exporting State and, as appropriate, consent by the importing State in accordance with their respective laws and regulations.

The paragraphs discussed above are only illustrative of the various provisions in the Code that could assist States in controlling potentially dangerous radioactive material. Both national regulatory and law enforcement agencies could benefit from a comprehensive review of the Code to determine how its guidance could contribute to the detection of criminal or unauthorized acts involving radioactive sources.

3.2.13. Guidance on the import and export of radioactive sources

In conjunction with approval of the Code of Conduct on the Safety and Security of Radioactive Sources, the General Conference resolution requested the development of a guidance document on the import and export of radioactive sources. In September 2004, the IAEA Board of Governors and General Conference endorsed this document, which was published in 2005 as Guidance on the Import and Export of Radioactive Sources [21]. Although not binding, this guidance can also play an important role in the prevention of criminal or unauthorized acts involving radioactive sources. The primary features of the guidance are as follows:

- **Objective (Part II).** Emphasizes the non-binding character of the guidance and the application of the instrument in a manner consistent with national legislation, while not impeding nuclear cooperation and commerce and is consistent with a nation's international commitments.
- **Scope and Definitions (Parts III and IV).** These related provisions link the guidance to the Code in terms of coverage and terminology. Part III contains important definitions for key terms, including the categorization of sources adopted in Table I of the Code, and also 'export', 'import', 'recipient', 'exporting facility', 'exporting State' and 'importing State'.
- **Points of Contact and Application (Parts V and VI).** These two parts are framed to assist States in applying the guidance. Designation of a point of contact (PoC) under Part V can help the State concerned, other States, and the IAEA implement the guidance effectively. Part VI recognizes certain factors that may bear on a State's application of the guidance, including the need to comply with other relevant instruments and in the case where aggregated sources may pose risks equivalent to those that are covered by the code's categorization.
- **Export Authorization (Parts VII and VIII).** These two parts, covering Category 1 and Category 2 sources) set forth administrative and procedural arrangements that States may wish to use in implementing national export controls.
- **Import Authorization (Part IX).** In parallel with the parts on Export Authorization, this part sets forth recommended measures for an importing State to apply to ensure that sources coming into the State will be appropriately regulated and protected.
- **Exceptional Circumstances (Part X).** This part is framed in recognition that under certain conditions adjustments in the application of the guidance may be warranted. Examples of listed exceptional circumstances include:

- cases of considerable health or medical need;
- cases of imminent radiological hazard or security threat;
- cases in which the exporter maintains control of the source throughout the period in which it is used.

— **Transit and Transhipment (Part XI).** This part suggests that, although not covered by the import and export provisions of the guidance, States should consider applying relevant international standards to sources in transit or transhipment.

— **General (Part XII) and Annex I.** These related provisions are meant to help States inform themselves on the status of application of the guidance and other relevant international and domestic measures through completion of a voluntary Self-Assessment Questionnaire that could be provided to the IAEA and other States. The very brief questionnaire in Annex I lists simple questions concerning radiation protection laws and regulations of the State, its regulatory body, national register of radioactive sources, and system of notification and control.

3.2.14. United Nations Security Council resolutions

United Nations Security Council resolution 1540

An important instrument in international law making relevant to the detection of and response to criminal or unauthorized acts involving nuclear material was adopted by the United Nations Security Council on 28 April 2004. Resolution 1540 [22] was enacted pursuant to Chapter VII of the United Nations Charter that authorizes the Security Council to enforce mandatory measures to address threats to international peace and security. Thus, the provisions of resolution 1540 establish legal requirements to be implemented in good faith by all United Nations Member States.

The resolution addresses the "proliferation of nuclear, chemical and biological weapons, as well as their means of delivery". The specific provision relating to the detection of and response to criminal or unauthorized acts involving nuclear material is contained in operative paragraph 2. In that paragraph, the resolution declares that:

> "all States, in accordance with their national procedures, shall adopt and enforce appropriate effective laws which prohibit any non-State actor to manufacture, acquire, possess, develop, transport, transfer or use nuclear, chemical or biological weapons and their means of delivery, in particular for terrorist purposes, as well as attempts to engage in any of the

foregoing activities, participate in them as an accomplice, assist or finance them".

This wide ranging provision is paralleled by additional requirements under paragraph 3, which mandate measures of accountancy for relevant items (paragraph 3(a)); physical protection measures (paragraph 3(b)); border controls, law enforcement measures and international cooperation to prevent criminal or unauthorized acts (paragraph 3(c)); and export and transhipment controls (paragraph 3(d)). Paragraph 3(d) requires that Member States establish and enforce "appropriate criminal or civil penalties" for violations.

Further, paragraph 8 calls upon all States to undertake four activities:

- Promote universal adoption and implementation of multilateral treaties to prevent the proliferation of weapons of mass destruction (WMD);
- Adopt national rules and regulations implementing those treaties;
- Review and fulfil commitment to multilateral cooperation through relevant organizations;
- Develop ways to work with industry and the public regarding the application of national laws.

Paragraph 9 calls upon States to promote dialogue on the threat of proliferation of WMD. Paragraph 10 calls upon States, in accordance with national and international law, to take "cooperative action to prevent criminal or unauthorized acts involving nuclear, chemical or biological weapons, their means of delivery and relevant material".

Paragraph 4 establishes a Committee of the Council to monitor implementation of the resolution [22]. The resolution also calls for national reports on implementation by each Member State within six months of adoption of the resolution.

Resolution 1540 was unusual in that it bypassed the standard process of conventional international law making by means of negotiation and promulgation of instruments in the form of treaties or agreements.

United Nations Security Council resolution 1373

The thrust of United Nations Security Council resolution 1373 [23] is prevention of terrorist financing. It does not require States to take action against criminal or unauthorized acts per se. However, it does declare that:

"...acts methods, and practices of terrorism are contrary to the purposes and principles of the United Nations and that knowingly financing,

planning and inciting terrorist acts are also contrary to the purposes and principles of the United Nations".

Its potential applicability to criminal or unauthorized acts involving nuclear and other radioactive material can be found in its suggestion that States establish:

> "…ways of intensifying and accelerating the exchange of operational information, especially regarding actions or movements of terrorist persons or networks; forged or falsified travel documents; traffic in arms, explosives or sensitive material; use of communications technologies by terrorist groups; and the threat posed by the possession of weapons of mass destruction by terrorist groups".

4. INTERNATIONAL INITIATIVES

Criminal or unauthorized acts involving nuclear and other radioactive material present an ongoing problem of major concern around the world, both to national authorities and international agencies such as the IAEA, WCO, Europol and Interpol. This section describes a range of cooperative measures designed to address criminal or unauthorized acts. It is clear that continued development and enhancement of international cooperation between States and international agencies is one vital element in successfully combating the threat of nuclear terrorism.

In addition to efforts at the national level by many States, a number of initiatives to detect and respond to criminal or unauthorized acts involving nuclear and other radioactive material have been undertaken by international organizations that have responsibilities in the fields of nuclear energy, law enforcement and international trade. The initiatives of the IAEA, WCO, Interpol, Europol and UPU are summarized below.

4.1. INITIATIVES OF THE IAEA

The IAEA is the world's centre of cooperation in the nuclear field. It was established in 1957 within the United Nations family. The IAEA works with its

Member States and multiple partners worldwide to promote the safe, secure and peaceful use of nuclear technologies.

From 1992 to 1994, a series of incidents of illicit trafficking in nuclear material occurred in Bulgaria, the Czech Republic, Estonia, Germany, Hungary, Romania, the Russian Federation, Slovakia, South Africa and Turkey. Among these incidents were several cases in which nuclear material was seized by law enforcement personnel. It was against this background that the IAEA launched a major initiative to address this growing problem.

In September 1994, the IAEA General Conference adopted a resolution [26] calling upon Member States "to take all necessary measures to prevent illicit trafficking in nuclear material". The resolution also invited the Director General "to intensify the activities through which the IAEA is currently supporting Member States in this field" and to submit proposals to the IAEA Board of Governors.

In December 1994, the Board of Governors considered the Director General's report [27] proposing intensified actions by the IAEA Secretariat in support of Member State efforts against illicit trafficking in nuclear and other radioactive material. On the basis of the report, the Board directed the Secretariat to continue its development of the proposed actions through further discussion and consultation with the Member States in support of their efforts. In 1995, the IAEA established a database for recording reported incidents of illicit trafficking. At the 1996 General Conference, a further resolution [28] was adopted that welcomed "the activities in the fields of prevention, response, training and information exchange undertaken by the IAEA Secretariat in support of efforts against illicit trafficking" and requested the Director General to report regularly on the activities being undertaken.

4.1.1. IAEA assessment of illicit trafficking in 1997

The Director General's report of 1997 [29] noted that the primary responsibility for combating illicit trafficking of nuclear material and radioactive sources rested with the Governments of Member States. However, many States had noted that measures were also required at the international level. A number of Member States had agreed to report to the IAEA any incident of illicit trafficking in nuclear material or radioactive sources.

During this early recording period, the majority of the incidents reported to the IAEA involved radioactive sources and natural and low enriched uranium (LEU). Of the 168 cases recorded in the IAEA Illicit Trafficking Database (ITDB) at the end of July 1996, only 9% of the cases involved nuclear material such as high enriched uranium (HEU) or plutonium. However, continuing reports indicated deficiencies in the legal, administrative and

technical arrangements in some Member States for adequately controlling nuclear material and radioactive sources.

The IAEA judged that the potential for smuggling large quantities of weapons grade nuclear material was low. However, it concluded that addressing the detection of criminal or unauthorized acts involving small quantities also remained a priority, particularly in the context of non-proliferation, as larger quantities of nuclear material could be accumulated from small consignments and the detection of small quantities could be indicative of security issues at the facility of origin. The IAEA also recognized that the uncontrolled movement of other radioactive material had resulted in fatal ionizing radiation exposure to individuals and had to be considered as a serious risk to public health.

It was generally agreed that the problem of criminal or unauthorized acts involving nuclear and other radioactive material should be addressed primarily through prevention. A combination of measures for safety, security, physical protection, accountancy and control (including the control of cross border movements) was needed for an overall protective system. Elements of such a system that needed to be enhanced were identified as follows:

- A legal basis for nuclear material control and radiation safety;
- The physical protection of nuclear material;
- SSACs;
- Safety and security of radioactive sources;
- Control of transboundary movements of nuclear and other radioactive material;

By the end of 1997, the IAEA was engaged in a range of activities to combat illicit trafficking:

- **Nuclear and radiation safety legislation.** The IAEA had contributed to the efforts of Member States to establish basic national legislation on radiation safety. These contributions were made primarily through technical cooperation projects, with the necessary legal and technical expertise provided by other parts of the IAEA.
- **Illicit Trafficking Database.** Beginning in 1995, the IAEA had established and maintained the ITDB [30] containing confirmed reports of incidents received from participating States supplemented by information collected from open sources. The ITDB covers both nuclear and other radioactive material (see additional information in Section 4.1.5).
- **Physical protection of nuclear material.** The IAEA had established an expert advisory service for physical protection, known as the Interna-

tional Physical Protection Advisory Service (IPPAS). Through this service, the IAEA arranged, upon request, reviews of Member State physical protection systems.

- **SSACs.** The IAEA had been coordinating activities and tasks conducted by donor States in their support of SSACs in the NIS. For that purpose, coordinated technical support plans were established on the basis of needs that had been identified by the recipient States, by the donor States and during fact-finding missions organized by the IAEA.
- **Radiation safety.** Within the framework of the IAEA's radiation safety activities, an interregional technical cooperation project known as the Model Project on Upgrading Radiation Protection Infrastructures was launched with the objective of strengthening the "radiation safety infrastructure of a number of selected Member States" in order to comply with the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS) [31]. In 2000, the IAEA issued a publication in the IAEA Safety Standards Series, Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety [32], which specifies the requirements related to the legal and governmental infrastructure necessary for, amongst other things, the safety of sources of ionizing radiation, radiation protection, the safe management of radioactive waste and the safe transport of radioactive material.
- **Prevention, detection and response.** With the assistance of Member States and international organizations, in 2002 the IAEA issued three technical publications on the prevention of [33], detection of [34], and response to [35] illicit trafficking or inadvertent movement of radioactive material.
- **Training.** The IAEA organized training courses on physical protection, transport and illicit trafficking and a train-the-trainers course on the prevention of illicit trafficking. The Secretariat also organized several training courses on physical protection and SSAC.
- **Information exchange.** The IAEA arranged for a group of representatives of several international organizations concerned with illicit trafficking and its consequences to meet during 1995 and 1996 to discuss ways in which relevant intergovernmental organizations could benefit from each other's experience and assist States in their efforts to combat illicit trafficking in nuclear material and radioactive sources.
- **Analytical services.** The IAEA was asked to provide assistance in the classification of two separate incidents of illicit trafficking of nuclear material. On-site measurements were made and, in one case, additional analysis of seized nuclear material was performed at the Agency's Laboratories, Seibersdorf.

During the period 1998–2000, the incidence of reported and confirmed illicit trafficking incidents in the ITDB showed an increase. To some extent, this increase is attributable to improved State reporting due to enhanced detection capabilities, a greater awareness of the problem and a growing readiness on the part of States to share information. IAEA training has greatly contributed to these improvements (see Appendix I).

4.1.2. IAEA response to the events of 11 September 2001

Following the terrorist attacks of 11 September 2001 in the USA, the IAEA convened a Special Session on Combating Nuclear Terrorism. This meeting was held in Vienna on 2 November 2001 and was attended by more than 200 experts and officials from Member States.

At its regular session, immediately following the Special Session, the IAEA General Conference requested the Director General to review the IAEA's programmes with a view to strengthening protection against nuclear terrorism. The Secretariat responded by proposing a number of new initiatives. The proposals were considered by the Board of Governors at its first session in 2002.

4.1.3. IAEA 2002–2005 Plan of Activities to Protect against Nuclear Terrorism

In March 2002, the IAEA Board of Governors approved a three year Plan of Activities to Protect against Nuclear Terrorism, which came to be known as the IAEA Nuclear Security Plan of Activities (NSPA). This Plan was built on a number of existing IAEA activities, such as the ITDB, which were enhanced and expanded. In addition, several new elements were added.

4.1.4. IAEA Nuclear Security Plan (NSP) for 2006–2009

As the three year period of the Nuclear Security Plan of Activities approached its end, the IAEA Secretariat and policy making organs considered how to renew this important activity. On the basis of extensive consultations, including an open-ended meeting on 21 June 2005 and informal consultations in August 2005, a revised plan was developed. It was decided to adopt a four year period for the plan, encompassing two of the IAEA's two year budget cycles. The new Nuclear Security Plan (NSP) continues and enhances many of the activities developed under the 2002–2005 programme. The Plan features a three part framework:

– Activity Area I – Needs Assessment, Analysis and Coordination;
– Activity Area II – Prevention;
– Activity Area III – Detection and Response.

With specific relevance to criminal or unauthorized acts, the following objectives are worth noting:

– **Under Activity Area I:** "To understand illicit global trafficking trends and patterns, including theft and other malicious acts involving radioactive material".
– **Under Activity Area II:** "To achieve effective protection, control, accountancy and registry of all nuclear and other radioactive material and associated facilities, as requested, within a State".
– **Under Activity Area III:** "To enhance capabilities of States to detect, interdict and respond to illegal acts involving nuclear and other radioactive material and associated facilities".

4.1.5. ITDB

An important continuing element in the IAEA programme for nuclear security is the ITDB. This database was created in August 1995 following a meeting in March of the IAEA Board of Governors at which the Director General was requested to develop a reliable database of information on incidents of illicit trafficking to assist Member States and to better inform the public. The database was created to:

– Provide States with authoritative information on illicit trafficking incidents;
– Assist States in determining what actions may be needed in relation to illicit trafficking;
– Help States to formulate internal policy on illicit trafficking;
– Assist the IAEA in maintaining details of illicit trafficking incidents;
– Aid the IAEA in the identification of common threats and trends relating to incidents of illicit trafficking;
– Assist the IAEA with the prioritization of nuclear security activities;
– Provide a reliable source of basic information to the public on matters concerning illicit trafficking incidents.

The scope of the database includes incidents which involve unauthorized acquisition, provision, possession, use, transfer or disposal of nuclear and other radioactive material, whether intentional or unintentional, and with or without

crossing international borders. The ITDB also includes information on unsuccessful or thwarted incidents, and on those involving inadvertent loss of control of nuclear and other radioactive material.

The ITDB is compiled from State confirmed and 'open source' reports. The IAEA records an illicit trafficking incident after the first information is received from a State, the media, or other source. If an incident is made known to the IAEA through non-official means, the respective State will be contacted and requested to provide verification of the incident.

The design of the ITDB incorporates flexibility in the type and amount of information that can be recorded about an illicit trafficking incident. The basic information contains the date, location, type and quantity of material. The IAEA considers this information to be 'unrestricted', but will disseminate it to parties outside the IAEA for official use only.

More detailed information in the ITDB is not released without specific authorization from the reporting State. When a State supplies information for inclusion in the ITDB, it must specify the level or degree of restriction that can be applied and how that information can be distributed.

The ITDB is implemented on the basis of information supplied on a voluntary basis by IAEA Member States. An important contribution of the ITDB is to provide a real time mechanism for international interaction, allowing all Member States of the IAEA to have access to relevant information on incidents of illicit trafficking and thereby enabling them to learn from the experience of other countries.

Several hundred additional incidents have been reported in open sources but have not been confirmed. Many confirmed incidents recorded in the ITDB involved deliberate intent to illegally acquire, smuggle or sell nuclear or other radioactive material. The ITDB also includes incidents in which actions were inadvertent, such as unauthorized disposal of radioactive material. An analysis of the accumulated data and selected cases is presented in Appendix I.

4.2. INITIATIVES OF THE WCO

Established in 1952 as the Customs Cooperation Council, the WCO is an independent intergovernmental body whose mission is to enhance the effectiveness and efficiency of customs administrations. With 171 Member Governments, it is the only intergovernmental worldwide organization competent in customs matters.

The WCO has been cooperating with the IAEA for a number of years on combating the smuggling of nuclear and other radioactive material. It has been recognized that the primary line of defence in combating illicit trafficking of

this kind would be the various customs administrations of its constituent Member States.

Customs administrations worldwide have two basic functions, namely:

- Collection and protection of revenue;
- Protection of society and the environment.

Customs is the primary agency at international frontiers to interdict the illicit movements of goods, including nuclear and other radioactive material.

As a response to international concern and in the interest of Member State customs administrations, the WCO made increased efforts to assist the administrations in enhancing their enforcement capabilities for preventing, detecting and responding to the illicit trafficking of nuclear and other radioactive material. It was intended to raise awareness for the need to securely monitor and control nuclear and other radioactive material and to establish processes and procedures to detect and respond to illicit trafficking.

The WCO efforts included the following elements:

- Raising the awareness levels of Member State customs administrations and staff;
- Producing and disseminating training material;
- Providing training assistance to Member States;
- Promoting the adoption of a recommendation on Action against Illicit Cross-Border Movement of Nuclear and Hazardous Material in 1997;
- Increasing the necessary exchange of information and intelligence;
- Developing and maintaining a centralized, internet based database and communication tool to facilitate the exchange of information between WCO Member States, including information on radioactive and nuclear material;
- Creating a framework for international cooperation between Member State customs administrations and international bodies such as the IAEA and Interpol, actively involved in similar programmes to combat illicit activities of this kind.

The WCO participated in a series of international conferences and technical cooperation meetings with the common aim of devising tactics and strategies to combat illicit trafficking in radioactive material. This resulted in the establishment of a working relationship between the WCO and IAEA that was eventually formalized in May 1998 under a joint Memorandum of Understanding (MoU). The MoU established a framework for promoting

cooperation at a national level between national customs administrations and regulatory bodies responsible for the control of radioactive material.

The MoU reflects the role of the WCO in assisting Member State customs administrations worldwide to define control policies and law enforcement programmes which contribute to the fight against illicit trafficking in nuclear and other radioactive material, focusing on prevention, inspection, investigation and prosecution and recognizing the need for appropriate raising of awareness and training.

The key features of the MoU can be summarized as follows:

- Article 1 provides that the two agencies consult regularly on policy issues regarding training, technical assistance and other matters of common interest. This article also states that the two agencies will keep each other informed of developments on any projects of mutual interest and, where appropriate, will arrange consultation meetings.
  Article 2 provides that each agency will designate an official to act as the focal point for the maintenance of close contact. It also contains an undertaking for each agency to coordinate efforts and thereby achieve the best use of information relevant to illicit trafficking in nuclear and other radioactive material. It makes provision for the prompt exchange of information, subject to restrictions where there is a need to maintain the confidentiality of certain information. Each agency agrees to invite representatives of the other agency to meetings where matters of mutual interest are to be discussed.
- Article 3 details arrangements for technical and financial cooperation and provides a framework whereby both agencies may cooperate in the development and implementation of technical assistance programmes and may combine their human and financial resources to undertake such programmes.
- Article 4 details arrangements for joint technical meetings and missions, and in this regard both agencies may, in appropriate cases, agree to jointly sponsor consultations, technical meetings and training courses.
- Article 5 details the administrative arrangements for implementing the MoU.

Since that time, the WCO has jointly sponsored, in conjunction with the IAEA and Interpol, the production of reports [33–35] on the topics of preventing, detecting and responding to illicit trafficking in radioactive material. These reports provide detailed information on various aspects of dealing with the problem of illicit trafficking in radioactive material, and also

its inadvertent movement. They highlight the strategic, tactical and operational concepts adopted jointly by these international agencies.

In addition to the production of these reports, WCO, again in cooperation with the IAEA and Interpol, has jointly sponsored a series of international training courses aimed at raising the awareness of the problems associated with illicit trafficking in radioactive material and providing participants with basic information on radiation safety, detection and response methods. These training courses are continue at the international and national levels.

In 2000, WCO developed an enforcement, communication and cooperation instrument known as the Customs Enforcement Network (CEN). This is a global enforcement system to support and enhance the ability of customs organizations to fight against transnational organized crime. It allows Member States to process and exchange information electronically and in encrypted form. It also includes a database with a template for nuclear material. The system allows Member States to conduct analyses and produce strategic and tactical intelligence to identify regional and international trends and methods of operation.

As part of a comprehensive package of security and facilitation measures, an electronic Databank on Advanced Technology was developed by a WCO Task Force on Security and Facilitation of the International Trade Supply Chain. The Databank provides detailed and updated information on technical equipment, available in the market place, which can assist Member State customs administrations in making the international supply chain and cross-border movements of persons and goods secure from terrorism and international criminal activity.

In June 2003, the WCO Council approved the new international Convention on Assistance in Customs Matters, known as the 'Johannesburg Convention'. This instrument covers all customs offences, including the illicit trafficking of radioactive and nuclear material. It provides a legal basis for the exchange of information and mutual administrative assistance between customs administrations.

Through the task force and subsequent related work, WCO produced a number of measures, instruments and guidelines to secure and facilitate global trade, the most important of which are:

- SAFE Framework of Standards, which provides customs administrations with a number of implementation options and guidelines for securing and facilitating the supply chain;
- A revised version of the WCO Data Model, which includes 27 key data elements which can be used for the identification of high risk consignments;

– Guidelines for cooperation between customs and business;
– Revision of guidelines to the revised Kyoto Convention to take account of security considerations;
– Guidelines for the development of national laws for the collection and submission of customs information taking into account data protection and data security;
– Intelligence and risk management guide;
– *Unique Consignment Reference*, aimed at providing an origin to destination reference key for all international consignments;
– Guidelines on advance passenger information.

All of the above initiatives aim to increase security and facilitate legal trade. Increased security will help to ensure the integrity of the international supply chain and prevent its use by terrorists to deliver weapons of mass destruction or to otherwise promote criminal activity. Additional information on WCO and its programmes can be found on its web site: http://www.wcoomd.org

In February 2006, a cooperation agreement was signed between the IAEA and WCO with a view to augmenting international efforts to enhance nuclear security, including the prevention of nuclear terrorism, and to combat illicit trafficking in nuclear and other radioactive material. The agreement includes mutual consultation regarding training and technical assistance, exchange of information, technical and financial cooperation in the interest of the respective activities and coordination of technical meetings and missions.

4.3. INITIATIVES OF INTERPOL

Interpol is the world's largest international police organization, with 186 member countries. Created in 1923, it facilitates cross-border police cooperation, and supports and assists all organizations, authorities and services whose mission is to prevent or combat international crime.

Interpol initiated efforts on illicit trafficking in nuclear and other radioactive material during the late 1980s. However, the organization recorded a marked increase in the number of cases during the early 1990s. By 1993, a series of cases had attracted media attention worldwide and Interpol became actively engaged in promoting international police cooperation. Interpol was aware of the IAEA–WCO initiatives and recognized that the problem was not confined merely to cross-border movement (the domain of customs administrations), but was of concern to all law enforcement agencies.

In 1994, Interpol conducted an analytical study of cases of illicit trafficking in radioactive material covering Eastern and Western Europe. The study used information from the Interpol Database, but also made reference to open sources of information, including press reports and other media information. The analysts were hampered in their work by difficulties in verifying information and obtaining access to detailed information of a sensitive nature involving military installations or personnel. Notwithstanding the inability to develop comprehensive data, the analysis provides a useful snapshot of the general situation prevailing at the end of 1994. The results of the analytical study are summarized below:

- There was a dramatic increase in reported cases from 1992 to 1994.
- The origins of the substances, although not always possible to determine, were mainly from countries of the former Soviet Union.
- The substances seemed to come from nuclear power plants, military units, factories or mines.
- The principal transit routes originated from Central and Eastern Europe, three clear routes being identified. The northern route involved the passage of material through the Baltic and Nordic countries. The central route entailed passage of material through countries such as Bulgaria, the Czech Republic, Hungary, Poland and Slovakia. The southern route involved the passage of material through Armenia, Azerbaijan or Turkey.
- In general, the illicit material was destined for the western European countries of Austria, Germany or Switzerland, with Germany considered the country with the most potential buyers. However, a buyer's market could not be established during the study period.
- The most frequent material appeared to be uranium, natural or low enriched, but the cases of most concern involved plutonium and HEU. Other material seized was plutonium-239, caesium-133, caesium-134, caesium-137, cobalt-57, cobalt-60, iridium-192, radium-226, strontium-90, californium-249, californium-252, rubidium-85 and lithium-6.
- In most cases, the packaging of the illicit radioactive material was not adequate and represented a danger to the public and the environment. Most of the offenders were not aware of the dangers and were unfamiliar with the means to shield radioactive sources and thereby protect themselves.
- The offender profile of providers or sellers of the material was mainly persons of Russian nationality, while the buyers or intermediaries were, by and large, not from Eastern European countries. Generally, the suppliers were either middlemen or acting on their own volition. There

did not appear to be any involvement of organized crime or terrorist organizations.

In the years following that assessment, Interpol jointly sponsored — in conjunction with the IAEA and WCO — a series of technical publications [33–35] and training courses on combating illicit trafficking in radioactive material and on understanding the associated problems (as described in the previous section on the WCO).

Interpol continues to collate and analyse data on any report of illicit trafficking and to integrate its information with data being collated by the IAEA and WCO. Its information database and analytical assessments provide a ready reference to all police entities worldwide. Interpol also participates in multi-agency technical cooperation meetings relating to the illicit trafficking in radioactive and nuclear material and facilitates interaction between police agencies at the international level.

4.4. INITIATIVES OF EUROPOL

Europol aims at improving the operation of the competent authorities in its member countries in preventing and combating drug trafficking and other serious forms of international organized crime. Since its origin, Europol has devoted special attention to the threat posed by the illicit trafficking of nuclear and radiological substances. Article 2.2 of the Europol Convention states:

> "In order to achieve progressively the objective mentioned in paragraph 1, Europol shall initially act to prevent and combat unlawful drug trafficking, trafficking in nuclear and radioactive substances, illegal immigrant smuggling, trade in human beings and motor vehicle crime."

This type of crime was thus integrated into the original set of mandated areas covered by Europol, at the same level, for instance, as that of trafficking with drugs and illegal immigration.

Europol has jointly sponsored, in conjunction with the IAEA, Interpol and WCO, the production of technical publications on the topics of preventing, detecting and responding to illicit trafficking in nuclear and other radioactive material.

In the aftermath of the terrorist attacks against the USA in September 2001, Europol organized two international conferences to consider the new threat posed by international terrorism and the possible use by terrorists of chemical, biological, radiological and nuclear (CBRN) substances.

During the first Europol CBRN experts meeting in January 2002, national experts identified a number of emerging issues that defined the future areas of activity of the organization in relation to the potential use of CBRN substances by terrorists:

- Creation of a network of national contact points;
- Development of the Europol CBRN Rapid Alert System (RAS) (early notification and dissemination);
- Establishment of a Europol Knowledge Management Centre (as a repository of good practices);
- Promote sharing of knowledge of national structures and laws;
- Development of a media strategy and public information;
- Continuation of evidence gathering and laboratory procedures;
- Gathering of intelligence on CBRN issues;
- Liaison with relevant international organizations, namely the IAEA and the Organisation for the Prohibition of Chemical Weapons (OPCW).

At the second CBRN meeting, Europol brought together European Union (EU) law enforcement and international organizations.

The new threat posed by international terrorism demanded a coordinated approach in a number of criminal areas. In this context, during 2003, the Europol Counter Proliferation Programme (CPP) was launched. The CPP includes activities to prevent:

- Illicit trafficking of nuclear and radiological substances;
- Illicit trafficking of firearms, ammunition and explosives;
- Criminal use of CBRN weapons.

The CPP includes a number of projects and activities dealing directly with CBRN concerns in general and the illicit trafficking of nuclear and radiological substances, in particular:

- A directory of national contact points;
- A directory of legislation (national, EU regional, international);
- A directory of national contact points for media management;
- A CBRN Information Centre;
- A knowledge management centre;
- Specialized reports;
- A yearly situation and trend report on illicit trafficking of nuclear and radiological substances;
- A monthly CBRN open source bulletin;

– Ad hoc papers;
– Development of the Europol CBRN (RAS) that will be connected to other RASs of the European Commission (EC) covering critical sectors for security, e.g. the Ecurie network (for nuclear and radiological emergencies);
– Operational support to EU member countries.

Europol maintains two analytical work files (AWFs) on counterterrorism. The 'opening order' of both AWFs — supporting national agencies' investigations in this field — covers the use of CBRN weapons and the illicit trafficking of such material by terrorist organizations.

In addition, the Europol CPP has developed high levels of cooperation with relevant international organizations, such as the IAEA, WCO, Interpol, OPCW, different bodies of the United Nations, and relevant General Directorates and Departments of the EC (e.g. the Joint Research Centre, Health and Consumer Protection, Energy and Transport). This has led to cooperation agreements with some of these organizations, namely the EC, WCO and Interpol, which allows the mutual exchange of information. Further cooperation agreements are in progress.

4.5. INITIATIVES OF THE UNIVERSAL POSTAL UNION

Established in 1874, the Universal Postal Union (UPU) — with its headquarters in the Swiss capital Bern — is the second oldest international intergovernmental organization after the International Telecommunications Union. With 191 member countries, the UPU is the primary forum for cooperation between postal services. The organization also fulfils an advisory, mediating and liaison role, and renders technical assistance where needed. It sets the rules for international mail exchanges and makes recommendations to stimulate growth in mail volumes and to improve the quality of service for customers.

The UPU and IAEA have recognized that the international postal system could become a vehicle for the unauthorized movement of radioactive material. In October 2002, the UPU and IAEA signed an MoU to ensure the safe and secure transport of acceptable radioactive material through the mail and the detection of illicit radioactive material, including nuclear material, in the international mail stream. The agreement calls for the development of safe and cost effective packaging requirements and simple and effective labelling and marking requirements for radioactive material in the mail stream.

A concrete effort under the IAEA–UPU agreement has been to develop a guidance document concerning control procedures and equipment that can be used for the detection of gamma and neutron radiation in public mail and private mail carriers. Working with the Austrian Research Centre Seibersdorf, and in cooperation with WCO, a publication has been published in the IAEA Nuclear Security Series [36]. The objective of the guide is to provide an overview of existing information and countermeasures to protect postal employees and customers and the general public from the possible health hazards of illegally transported radioactive material. The main elements in this guide are:

– A discussion of threat scenarios;
– Distribution paths in mail processing and possible monitoring locations;
– A description of typical radiation monitoring equipment;
– A possible response plan;
– An implementation plan for mail monitoring;
  An overview of recommended training;
– Two annexes describing the process of detection of radioactive material in the public mail, and four specific scenarios that illustrate situations in which radioactive material could enter the public mail stream, with recommendations to be taken in each scenario.

5. UNDERSTANDING RADIATION AND ITS EFFECTS

This section provides some basic information on atomic structure and radiation as background to the material in subsequent chapters, which deal with radiation safety. More information on atomic structure and radiation safety can be found in the IAEA publication Radiation, People and the Environment [37].

5.1. STRUCTURE OF MATTER

All matter in the world consists of atoms. These are the basic building blocks of the elements. Each atom contains a tiny, central, positively charged nucleus and a number of electrons. The electrons carry negative electric charge and move around the nucleus. They occupy *shells* of various energy levels. The

nucleus, which contains most of the mass of an atom, is, in fact, only a very small part of the overall volume.

Figure 1 shows a diagrammatic representation of an atom of lithium (strictly, one of the isotopes of lithium, see below). The nucleus of the atom contains protons, which carry a positive charge, and neutrons, which carry no charge at all. In an electrically neutral atom, the number of electrons exactly balances out the number of protons. Thus, in the atom shown below, there are four neutrons and three protons balanced by three electrons.

The number of electrons in the atom — and hence the number of protons in an electrically neutral atom — gives an element its unique characteristics, in particular, its chemical properties. Since most of the mass of an atom is concentrated in the nucleus and the mass of a proton and neutron is the same, the total mass of protons plus neutrons is called the mass number. Thus, the mass number of the lithium atom represented in the figure is 7 and this particular isotope of lithium is designated lithium-7 or, using the symbol for lithium, ^{7}Li.

The number of neutrons in the nucleus of an atom of a particular element can vary. Thus, if there were only three neutrons in the nucleus of a lithium atom, the total mass of protons plus neutrons would be 6 and the particular isotope of lithium would be designated lithium-6 or ^{6}Li. Isotopes, then, are different forms of the same element, the difference being in the number of neutrons and hence the mass number. Since isotopes of the element also have the same number of electrons in the shell, they have similar chemical properties.

Figure 2 shows the isotopes of hydrogen: hydrogen-1 (common hydrogen with a nucleus of only one proton); hydrogen-2 (called deuterium with a nucleus of one proton and one neutron); and hydrogen-3 (called tritium with one proton and two neutrons).

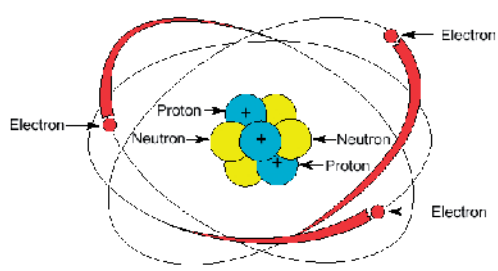

FIG. 1. The basic structure of an atom.

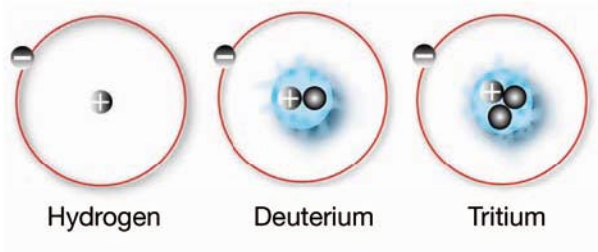

FIG. 2. Isotopes of hydrogen (+: proton; ○ neutron; –: electron).

5.2. RADIOACTIVITY AND RADIATION

Although the nucleus of many isotopes of elements are stable, most are not. Stability is determined mainly by the balance between the number of neutrons and protons that the nucleus contains. Nuclei with too many neutrons tend to transform themselves to a more stable structure by converting a neutron into a proton. This process, known as beta decay, results in the emission of a negatively charged electron called a beta particle. Nuclei with too many protons convert the excess protons to neutrons with the emission of a positron, which is a positively charged electron.

These transformations often leave the nucleus with excess energy that it loses as gamma rays, which are energetic photons, or discrete parcels of energy without mass or charge.

The phenomenon whereby atoms undergo spontaneous random disintegration is called *radioactivity*, and the particles (beta particles or positrons) and gamma rays are referred to collectively as *radiation*. The act of transformation is termed *decay* and the nucleus that changes and emits radiation is called a *radionuclide*.

The nuclides of some heavy isotopes of elements decay by producing an alpha particle, consisting of two protons and two neutrons. The alpha particle is much heavier than the beta particle and carries two units of positive charge.

Thus, it is the nucleus of an atom that determines its nuclear properties: whether it is stable or not, and if it is unstable, the type of radioactive decay that will take place.

The rate at which a radionuclide decays in a given amount of a radioactive material is known as its *activity* and is expressed in a unit called the becquerel (Bq), where 1 Bq equals one transformation per second. Multiples of the becquerel are frequently used, such as the megabecquerel, MBq, which is 1 million Bq.

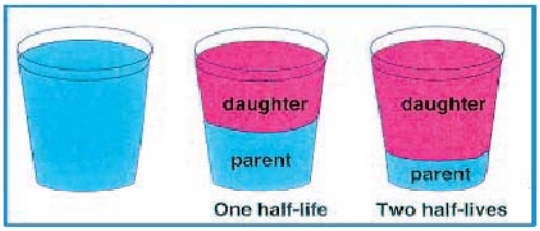

FIG. 3. Schematic illustration of the radioactive decay of a radionuclide into a nuclide of another element, or daughter.

The time taken for the activity of a radionuclide to fall to half its original value is called the *half-life*. In other words, this is the time it takes for one-half of the initial number of atoms to undergo radioactive decay. When a radionuclide decays, it transforms into a nuclide of another element, sometimes referred to as the *daughter* product. So, after one half life, half of the starting material remains, and after another half-life, half of this half is gone, i.e. one-quarter of the starting material remains. After ten half-lives, only about one thousandth of the original amount is left. The schematic illustration of radioactive decay is presented in Fig. 3.

The half-lives of radionuclides can range from small fractions of a second to many millennia. That of uranium-238, which exists naturally, is 4470 million years.

5.3. TYPES OF RADIATION

Most types of radiation come from radioactive material. These are alpha (α) particles, beta (β) particles and gamma (γ) rays. Positrons will not be considered further here. However, some types of radiation are produced in other ways, the most important of which are X rays. These are normally produced by firing a beam of electrons at a metal target (usually tungsten). The electrons in the metal atoms absorb energy from the electron beam and then release the energy in the form of X rays as they 'relax'. Once the beam is switched off, the X rays disappear. X ray machines are therefore not radioactive and are of no concern from the point of view of illicit trafficking or other unauthorized transfer of radioactive material.

Neutrons (n) are emitted by unstable nucleus, in particular during atomic fission and nuclear fusion. The properties of alpha and beta particles, gamma and X rays as well as neutron radiation are summarized in the following paragraphs.

5.3.1. Alpha particles

Alpha particles are nuclei of the helium atom. They consist of two protons and two neutrons and are therefore positively charged and are relatively heavy. They only have a short range in air (1–2 cm) and can be blocked completely by paper or skin. Outside to the body, alpha radiation is not hazardous; however, it is hazardous if emitted by radioactive material within the body because of the large exposures that can result to nearby tissue.

5.3.2. Beta particles

Beta particles are fast-moving electrons ejected from unstable nuclei of atoms. They are much smaller than alpha particles and therefore can penetrate further into matter — several metres of air and centimetres of solid material, depending upon their energy. They can be blocked by plastic a few centimetres thick or a few millimetres of glass. Large exposures to high energy beta particles can cause skin 'burns'. Beta emitters can also be hazardous if taken into the body.

5.3.3. Gamma rays

Gamma radiation is a type of electromagnetic or photon radiation, similar to light or radio waves only with much higher energy. It has no mass and no charge. It is often emitted from an unstable nucleus that is emitting a beta particle. Gamma radiation causes ionization in atoms when it passes through matter, primarily due to interactions with electrons. It can be very penetrating and only a substantial thickness of dense material such as concrete, steel or lead can provide good shielding. Gamma radiation can therefore deliver significant doses to internal organs without the material emitting it being taken into the body.

Figure 4 summarizes the penetrating power of alpha and beta particles and gamma rays.

5.3.4. X rays

X rays have the same physical nature as gamma rays, i.e. they are electromagnetic radiation. However, while gamma rays are emitted from the nucleus of the atom, X rays are generated in the electron shell, and are produced by the rapid slowing down of an electron beam. Like gamma rays, X rays are penetrating and, in the absence of shielding by dense material, can deliver significant doses to internal organs.

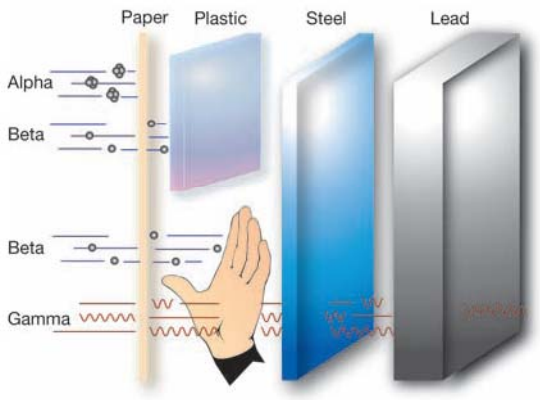

FIG. 4. The penetrating power of alpha and beta particles and gamma rays.

5.3.5. Neutrons

Neutrons are uncharged particles and are emitted by unstable nuclei, in particular, during nuclear fission and nuclear fusion (see below). Apart from a component of cosmic rays, neutrons are usually produced artificially. Neutrons are, however, emitted in detectable quantities by plutonium, a material used in nuclear weapons. Neutron sources are also found in commerce, particularly in moisture and density gauges.

Because they are electrically neutral, neutrons can be very penetrating. Neutron radiation therefore requires heavy shielding to reduce exposures. For example, it takes several metres of concrete or metal to stop neutrons, depending on the neutron energy.

5.4. RADIATION AND MATTER

When radiation passes through matter, it deposits energy in that material. Alpha and beta particles, being electrically charged, deposit energy through electrical interactions with electrons in the material. Gamma rays lose energy in a variety of ways, but each involves liberating electrons from atoms. Neutrons also lose energy in various ways, the most important being through collisions with nuclei that contain protons. The protons are then set in motion and, being charged, they again deposit energy through electrical interactions. So, in all cases, the radiation ultimately produces electrical interactions in the material.

If an electron in an atom receives enough energy from these interactions, it may escape, leaving a positively charged atom (ion), as shown in Fig. 5. The

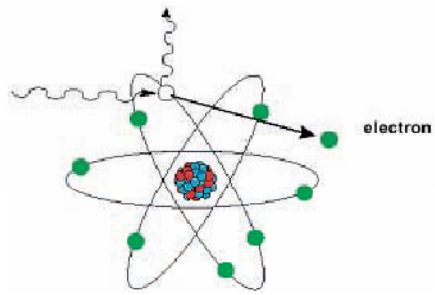

FIG. 5. In ionization the removal of an electron leaves a positively charged atom.

process by which a neutral atom (or molecule) becomes charged is called *ionization*. Any radiation that causes ionization is known as *ionizing radiation*.

Ionizing radiation is only one form of radiation. Radiation that does not cause ionization is known as non-ionizing radiation, examples of which are radio frequency waves, microwaves, infrared radiation, visible light and ultraviolet radiation. Only ionizing radiation is of interest here.

5.5. NUCLEAR FISSION AND NUCLEAR FUSION

Some atoms that contain a large number of protons and neutrons can be split into two smaller fragments by bombardments with neutrons. This process is called *nuclear fission*. The process of nuclear fission releases huge amounts of energy and is the basis of nuclear energy.

Uranium-235 is the nuclear fuel mostly commonly used. The smaller fragments of uranium-235 produced by nuclear fission are generally highly unstable and therefore radioactive. Examples of these *fission products* are iodine-131, caesium-137 and strontium-90. The process of nuclear fission is illustrated in Fig. 6.

A different process may occur with some light atoms. For example, atoms of the isotopes of hydrogen — deuterium and tritium — may be fused together to form heavier atoms. This process is called *nuclear fusion* and also releases huge amounts of energy. To occur, the process requires very high temperatures indeed — some millions of degrees.

While nuclear fission is the basis of 'atom bombs'; nuclear fusion is the basis of thermonuclear weapons or 'hydrogen bombs'. So far, however, nuclear fusion has not been used for producing electricity because of the substantial engineering difficulties in containing deuterium and tritium at such high temperatures.

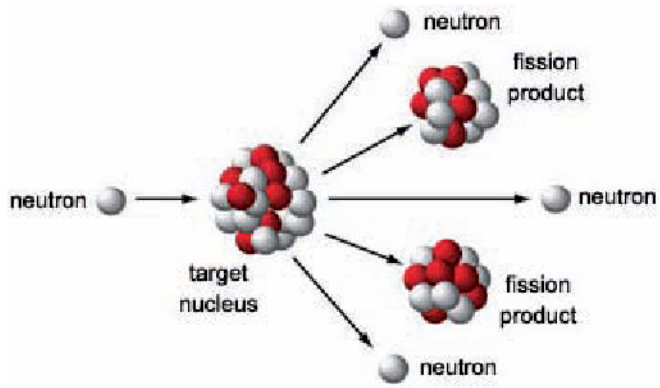

FIG. 6. Fission reactions are the heart of nuclear reactors and nuclear weapons.

5.6. BIOLOGICAL CONSEQUENCES OF EXPOSURE TO IONIZING RADIATION

The basic unit of biological tissue is the cell. An important molecule in the cell is deoxyribonucleic acid (DNA), which is found mainly in the nucleus of the cell (note that the nucleus of the cell is not to be confused with the nucleus of an atom). It is the interaction of ionizing radiation, either directly or indirectly, with the DNA that is responsible for the biological consequences of radiation exposure. Damage to the DNA caused by radiation exposure may be repaired. However, if that damage is not repaired correctly, the cell may die or mutate.

5.6.1. Dose quantities

The amount of energy that ionizing radiation deposits in a unit mass of matter, such as human tissue, is called the *absorbed dose* and is expressed in a unit called the gray (Gy). However, types of ionizing radiation differ in the way in which they interact with biological material, so that equal absorbed doses (or equal amounts of energy deposited) do not necessarily have the same biological effects. For instance, 1 Gy to tissue from alpha radiation is much more harmful than 1 Gy from beta radiation since an alpha particle loses its energy much more densely along its path. So the quantity, *equivalent dose*, has been defined in order to put all the different types of ionizing radiation on an equal basis. This is expressed in the unit called sievert (Sv), and is obtained from the absorbed dose multiplied by a radiation weighting factor; thus, for example, the weighting factor for alpha radiation is set at 20 times that for beta radiation.

A further complication is that the risks caused by exposure to ionizing radiation differ according to the tissue or organ that has been exposed and, again in order to be able to put everything on the same basis, a further weighting factor is set to reflect this. Thus, the quantity *effective dose*, also expressed in sieverts, is obtained by multiplying the equivalent dose by a tissue or organ weighting factor that reflects the relative risk to that tissue or organ and then summing all of these weighted equivalent doses over all of the tissues or organs exposed. In this way, the effective dose provides a measure of the radiation risk to people, irrespective of whether they have been exposed externally or by radioactive material deposited in the body.

5.6.2. Health effects

High doses are necessary to cause a sufficient number of cells to die for there to be observable effects. Thus, a very high dose to the whole body of a person can cause death within days or weeks. For example, a dose of 5 Gy or more received instantaneously would probably be lethal, at least, without treatment. Such a dose to a limited area of the body might not prove fatal, but other early effects could occur. For example, an instantaneous absorbed dose of 5 Gy to the skin would probably cause erythema ('skin burns', although the damage may well be more severe than that caused by a conventional burn because it may well go deeper due to the penetration of the radiation).

Mutation of a cell is assumed to be possible at any level of exposure, although the risk (probability) of the mutation eventually leading to health consequences will depend on the magnitude of the dose received. Thus, if the dose is lower than that which will lead to early health effects or is delivered over a longer period of time, there is the possibility of cancer induction later in life. There is also the possibility of health consequences for the descendants of the irradiated person, although such health consequences have never actually been observed in human populations. The principal concern then with low doses of radiation is with the induction of cancer.

Information on the effects of exposure to ionizing radiation is collected and assessed periodically by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) [38].

5.7. LEVELS OF EXPOSURE

Ionizing radiation is a fact of life. Radioactive material occurs naturally throughout the environment. It is a continuous source of radiation exposure since it is present in all soils, rocks and building material. It is also present in the

diet, and therefore every human being contains trace amounts. Examples are carbon-14, potassium-40 and uranium, thorium and the radioactive daughter products of these such as radium-226 and polonium-210 (both of these are daughters of uranium-238). Humans are also exposed to cosmic rays, which reach the Earth from outer space. The highest dose of exposure from such natural sources, however, comes from radon-222, a radioactive daughter product of uranium-238, which being a gas escapes into the air and leads to a dose primarily to the lung.

Since the discovery of X rays and radioactivity more than 100 years ago, humans have found ways of producing radiation and radioactive material artificially. The first use of X rays was in medical diagnosis, but since then many other uses of radiation and radioactive material have been introduced. In addition, radioactive material of artificial origin has been introduced into the environment as a consequence of the fallout from the atmospheric testing of nuclear weapons and discharges of radioactive waste, primarily from the nuclear industry.

UNSCEAR, in addition to assessing the biological effects of radiation exposure, also routinely collects and collates information on the doses that persons received from radiation from both natural and artificial sources. The results of the latest review, published in 2000, are reflected in the pie chart shown in Fig. 7 [38]. The annual effective dose, averaged over the population of the world, is about 2.8 mSv (a mSv, or millisievert, is a thousandth of a sievert). Over 85% of this total is from natural sources, with about half coming from radon-222 (strictly, it comes mostly from the immediate radioactive daughter products of radon-222 which, being solid, are deposited in the lung). Medical exposure of patients accounts for 14% of the total.

These averages conceal the substantial variations in individual exposure. The greatest variations in dose arise from radon in the home, which can give annual doses of 10 mSv or more. Annual doses to those exposed to radiation at work are limited by law in most countries to 50 mSv or less, although only a

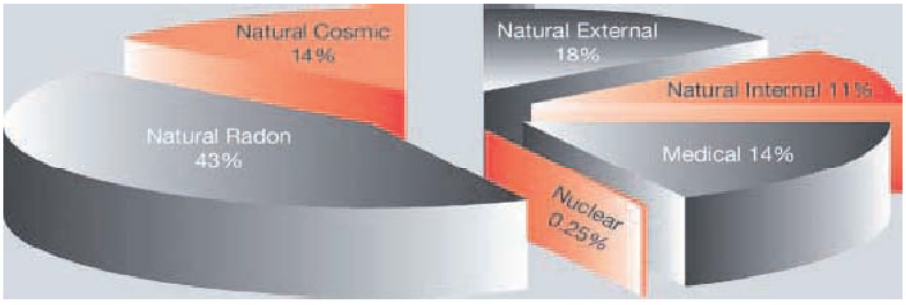

FIG. 7. Average radiation exposure from all sources.

small fraction of the workforce exceeds 20 mSv. Members of the public are unlikely to receive more than a fraction of 1 mSv in a year from exposure to artificial sources. Doses to patients in some diagnostic procedures may be around 10 mSv.

6. RADIATION SAFETY

This section presents the principles of radiation safety and how they are applied in the protection of the health and safety of human beings.

6.1. INTERNATIONAL ARRANGEMENTS

Approaches to protection against ionizing radiation are remarkably consistent throughout the world. This is due largely to the existence of a well established and internationally recognized framework.

The International Commission on Radiological Protection (ICRP) is a non-governmental scientific organization founded in 1928, which has regularly published recommendations for protection against ionizing radiation. Its authority derives from the scientific standing of its members and the merit of its recommendations. It bases its estimates of the probability of fatal cancer mainly on studies of populations that have been exposed to relatively high levels of radiation, particularly the survivors of the atomic bombs that were dropped on Japan in 1945, and on the work of UNSCEAR.

The IAEA has a statutory function to establish safety standards where appropriate in collaboration with other relevant international organizations. In doing this, it relies heavily on the work of UNSCEAR and the ICRP. It also has a responsibility for providing for the application of those standards at the request of a State and it does this through various mechanisms, including the provision of services and training.

The most relevant safety standards are:

- International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS)[31], sponsored by the IAEA and five other international organizations;
- Preparedness and Response for a Nuclear or Radiological Emergency [39], sponsored by the IAEA and six other international organizations;

– Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety [32].

The first two specify technical, scientific and administrative requirements for the safe use of radiation. The third specifies the basic infrastructure requirements in order to implement the requirements given in the other two.

6.2. GENERAL PRINCIPLES

For all human actions or practices that add to the radiation exposure that individuals receive from natural sources, the ICRP recommends a system of protection based on three central requirements:

(1) **Justification of a practice.** No practice involving exposure to radiation should be adopted unless it produces at least sufficient benefit to the exposed individuals or to society to offset the radiation detriment that it causes.
(2) **Optimization of protection.** In relation to any particular source of radiation within a practice, the dose to any individual from that source should be below an appropriate dose constraint, and all reasonable steps should be taken to adjust the protection so that exposures are 'as reasonably achievable', economic and social factors being taken into account.
(3) **Application of individual dose limits.** A limit should be applied to the dose received by any individual as the result of all the practices (other than medical diagnosis or treatment) to which the individual is exposed.

In some cases, such as after an event that causes a release of radioactive material to the environment, it may be necessary to intervene to reduce the exposure of people. Under such circumstances, the ICRP recommends a system of radiological protection for intervention based on two principles — justification for the intervention taking account of the reduction in dose and costs of achieving that reduction, and optimization of the level of protection. They differ from the set for practices in that they omit limits for individuals, because limits might require measures to be taken that would be out of all proportion to the likely benefit of the reduction in dose.

6.3. LIMITATION OF DOSES

The third requirement for practices — application of individual dose limits — is an obligation not to expose individuals and their descendants to an unacceptable degree of risk. The ICRP [40] has proposed dose limits for those who are occupationally exposed to radiation and for the general population and these are given in the BSS:

- For workers, 20 mSv in a year (averaged over five years), with no more than 50 mSv in any one year;
- For members of the public, 1 mSv in a year.

There are also separate limits for exposure of the skin, extremities and the lens of the eye.

There are two common misconceptions about dose limits. The first is that they mark a line between absolute safety and what is unsafe. This is not in fact the case. All radiation exposure is prudently assumed to have the potential to cause harm so these limits reflect a judgement regarding the level of risk that is considered acceptable. The second is that all that is necessary in protection is to keep doses below the limits. Again, this is not so. The overriding requirement is optimization of protection.

6.4. PROTECTION AGAINST EXTERNAL EXPOSURE

The first way in which external exposure to radiation can be reduced is to *increase the distance from the source* of the radiation. The dose rate for gamma and X ray radiation generally varies with the inverse square of the distance from a 'point' source. For example, doubling the distance from a radiation source will reduce the dose rate by a quarter. Remote handling devices, such as forceps or tongs, should therefore be used to minimize direct contact with radioactive sources and their containers.

The second method to reduce the dose is to *minimize the time* of exposure.

The third method is to *shield the radiation* source. The most suitable shielding material varies according to the type of radiation, as follows:

- **Beta radiation:** Plastic material of a few centimetres in thickness. Handlers of beta emitting radionuclides should always wear protective goggles to shield their eyes.

– **Gamma and X radiation:** Lead of between 1 and 10 cm thickness, or 30–60 cm of concrete, depending on the gamma energy.
– **Neutron radiation:** Hydrogen based material of between 10 and 50 cm thickness, such as water, paraffin or plastic, depending on the neutron energy.

6.5. PROTECTION AGAINST INTERNAL EXPOSURE

There are three ways radioactive material can be incorporated into the body and cause internal exposure: inhalation, ingestion and absorption through a break in the skin. If there is the risk of inhaling radioactive particles, it is necessary to use respiratory protection such as a filter mask. Also, persons close to radioactive material should not smoke. To avoid the ingestion of radioactive particles, it is a fundamental safety procedure not to introduce any food or drink into a location where there are radioactive substances. Persons working with radioactive material should ensure that they do not have any undressed wound, cuts or abrasions and should guard against puncture wounds from such packaging items as nails, wire or splinters. They should be particularly careful to avoid lacerations from glass breakage or other sharp material that might be present in a damaged container.

7. AUTHORIZED USES AND NUCLEAR COMMERCE

This section provides a survey of the types of authorized activities involving nuclear and other radioactive material. It also provides information on the regulatory arrangements that apply. Knowledge of these issues is a prerequisite to effectively combat criminal or unauthorized acts involving nuclear and other radioactive material.

7.1. GENERAL CONSIDERATIONS

Any programme to combat criminal or unauthorized acts with nuclear and other radioactive material has to be conducted in a way that recognizes the widespread authorized uses of nuclear and other radioactive material,

including lawful international commerce in such material and related services, equipment and technology.

The ability to recognize criminal or unauthorized acts involving nuclear and other radioactive material depends on an understanding of two aspects. First, there should be a basic appreciation of the range of authorized activities involving nuclear and other radioactive material. Second, there should be knowledge of the process adopted by the State for authorizing activities involving nuclear and other radioactive material, including the nature of licences, registration certificates or other permissions issued by relevant governmental regulatory bodies.

This section provides only an outline of the accepted uses of nuclear and other radioactive material and the systems for granting authorizations. It should not, therefore, be considered as providing a comprehensive review.

7.2. GENERAL APPLICATIONS

In the main, nuclear and other radioactive material is used in four specific areas:

- The nuclear fuel cycle;
- Industry;
- Medicine and biology;
- Other scientific research and applications.

7.2.1. Nuclear fuel cycle

There are several stages in the nuclear fuel cycle. The first stage involves the mining and extraction of uranium, which is processed into a product known as 'yellow cake'. The next stage usually involves enrichment of the uranium in uranium-235, the fissile isotope of uranium and the subsequent production of the nuclear fuel, often in the form of uranium oxide pellets. These are then combined into fuel rods and bundles. The fuel in the nuclear reactor is assembled in an array known as the core, which also contains the moderator — a material, generally water or graphite, that slows down the neutrons to a level at which they interact effectively with the uranium-235 to cause it to fission. A coolant, usually water or gas, conducts heat away from the fuel and then passes through heat exchangers to make steam, which drives the turbines to generate electricity.

Fresh fuel is only mildly radioactive and can be handled without shielding. Once in the reactor however, there is an enormous increase in activity due mainly to the fission products that have been generated in the fuel. After removal from

the reactor, the spent fuel remains hot and must be cooled to prevent melting, as well as shielded to reduce radiation exposure. The spent fuel is then either stored pending final disposal, or reprocessed in order to separate out the highly radioactive fission products and recover the nuclear material for further use.

The nuclear fuel cycle is shown in diagrammatic form in Fig. 8.

7.2.2. Industrial uses

Radioactive material is widely used in industry, for instance in sterilization plants, in industrial radiography, or as an integral part of specialized equipment such as gauges, which measure level, thickness, density, moisture, volume or composition of material. They are also used in smoke detectors and in various luminous devices.

In many of these uses, the quantity of radioactive material is very small. In others, the radionuclide is very short-lived, with the radioactive content dissipating or *decaying* in a matter of weeks, days or hours. Such items are of minor concern from a nuclear security perspective. However, some industrial gauges or instruments used for oil well logging and radiography for non-destructive testing contain large activities of radioactive material emitting high

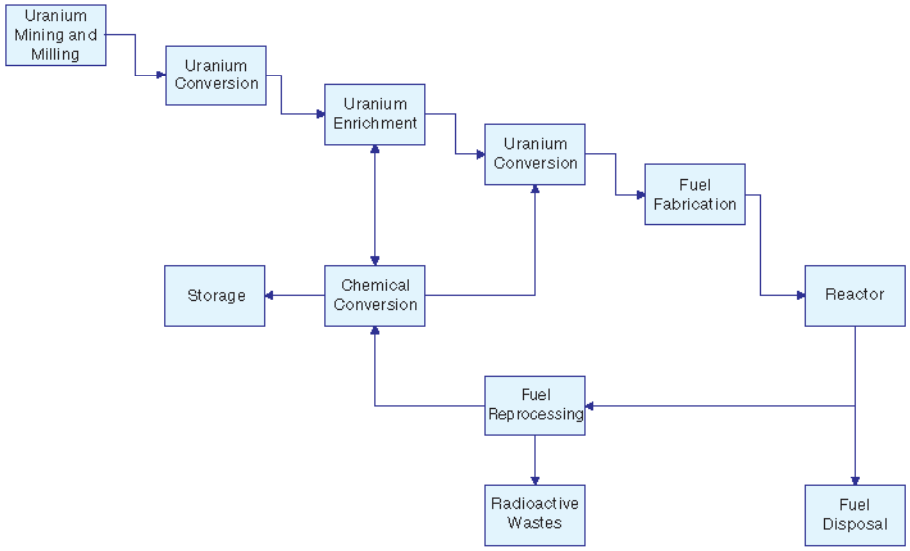

FIG. 8. Flow of the nuclear fuel cycle.

FIG. 9. Portable gauges containing radioactive material.

levels of radiation. These are of principal interest in the context of criminal or unauthorized acts. Examples are presented in Fig. 9.

7.2.3. Medical and biological uses

The main medical and biological uses of radioactive material are in:

– **Nuclear medicine.** Applications in this area involve the use of radionuclides in the diagnosis or treatment of disease. A range of radionuclides are used. The diagnostic procedure involves the patient being given the radionuclides in a carrying substance, which is preferentially taken up by the tissue of organ under study. Administration may be by injection, ingestion or inhalation. The radionuclide used emits gamma rays, which are penetrating and can therefore be detected outside the body, and an image obtained for the purpose of diagnosis. The most common radionuclide used is technetium-99m, which has a half-life of only 6 hours.

  In the treatment of disease, much greater activities are given to the patient resulting in much higher doses to the target tissues or organs. The

treatment of an overactive thyroid gland — hyperthyroidism — is probably the most common therapeutic procedure, the radionuclide used being iodine-131, which has a half-life of about 8 days.

— **Radiotherapy.** Radiotherapy is used in the treatment of certain illnesses and conditions — mainly cancer — by irradiation of tumours, blood and tissue. Radiotherapy takes advantage of the fact that some cells are severely affected by ionizing radiation. Cells multiply at different rates, and the quickly multiplying cells are affected more strongly than are standard cells. Since many forms of cancer are characterized by rapidly dividing cells, they can sometimes be treated with radiation therapy. Typically, cancer tumours are irradiated by intensive radiation beams (teletherapy) or small radioactive sources are inserted into the body close to the tumour (brachytherapy). The radionuclides used are generally cobalt-60 or caesium-137 and the activities involved are very high. Examples of devices containing these sources are presented in Fig. 10.

7.2.4. Scientific uses

Radioactive material is used in many ways in scientific research, but one of the principal uses is to set standards for the measurement of alpha, beta and gamma emitting radionuclides.

FIG. 10. Teletherapy units with cobalt-60 or caesium-137 sources.

7.3. SPECIFIC RADIONUCLIDES

Some of the more common radionuclides are listed in this section, and examples are given of their various applications in industrial, medical or scientific use. All these radionuclides can trigger an alarm. Detection instruments are discussed in Section 10 and the procedures for response are presented in Section 11. The radionuclides are:

- **Americium-241.** Used in many smoke detectors for homes and businesses, to measure levels of toxic lead in dried paint samples, to ensure uniform thickness in rolling processes like steel and paper production, to help determine where oil wells should be drilled, and in moisture gauges.
- **Barium-133**. Used in portable gauges to detect void spaces.
- **Cadmium-109.** Used to analyse metal alloys for checking stock and sorting scrap.
- **Calcium-47.** Important aid for biomedical researchers studying the cell function and bone formation of mammals.
- **Californium-252.** A frequently used neutron source for well logging in oil field exploration, to gauge the moisture content of soil in road construction and building industries, and to measure the moisture of material stored in silos.
- **Carbon-14.** Helps in research to ensure that potential new drugs are metabolized without forming harmful by-products.
- **Caesium-137.** Used for gamma radiography, gauging, to treat cancer, to measure and control the liquid flow in oil pipelines, to tell investigators whether oil wells are blocked with sand, and to ensure the right fill level for packages of food, drugs and other products.
- **Chromium-51.** Used for research purposes in red blood cell survival studies.
- **Cobalt-57.** Used in nuclear medicine to help physicians interpret diagnostic scans of patient organs, and to diagnose pernicious anaemia.
- **Cobalt-60.** Used for teletherapy, gamma radiography, gauging, to sterilize surgical instruments and to preserve poultry, fruits and spices.
- **Copper-67.** When injected with monoclonal antibodies into a cancer patient, helps the antibodies bind to and destroy the tumour.
- **Curium-244.** Used in mining to analyse material excavated from drilling operations and gauging.
- **Gallium-67**. Used for localization of inflammations and tumours.
- **Iodine-125.** Widely used to diagnose thyroid disorders.

– **Iodine-129.** Used to check some radioactivity counters in in vitro diagnostic testing laboratories.
– **Iodine-131.** Used to diagnose and treat thyroid disorders.
– **Iridium-192.** Used for gamma radiography to test the integrity of pipeline welds, boilers and aircraft parts and in brachytherapy.
– **Iron-55.** Used to analyse electroplating solutions and gauging.
– **Krypton-85.** Used to gauge the thickness of thin plastics and sheet metal, rubber, textiles and paper; and to measure dust and pollutant levels.
– **Nickel-63.** Used to detect explosives, and as voltage regulators and current surge protectors in electronic devices.
– **Phosphorus-32.** Used in molecular biology and genetics research.
– **Plutonium-238.** Used for pacemakers, space applications, radioisotopic thermoelectric generators (RTGs) and portable gauges.
– **Polonium-210.** Reduces the static charge in the production of photographic film and phonograph records.
Promethium-147. Used to gauge the thickness of thin plastics, thin sheet metal, rubber, textiles, and paper.
– **Radium-226.** Used in the past in many different applications such as luminous paint, brachytherapy and radiography.
– **Selenium-75.** Used in protein studies in life science research and in radiography.
– **Sodium-24.** Used to locate leaks in industrial pipelines and in oil well studies.
– **Strontium-90.** Used in RTGs, thickness gauges, calibration, medical treatment (brachytherapy).
– **Strontium-85.** Used to study bone formation and metabolism.
– **Technetium-99m.** The most widely used radionuclide for diagnostic studies in nuclear medicine. Different chemical forms are used for brain, bone, liver, spleen and kidney imaging and also for blood flow studies.
– **Thallium-201.** Used for heart scintigraphy.
– **Thallium-204.** Measures the dust and pollutant levels on filter paper, and gauges the thickness of plastics, sheet metal, rubber, textiles and paper.
– **Thorium-229.** Helps fluorescent lights to last longer.
– **Thorium-230.** Provides colouring and fluorescence in coloured glazes and glassware.
– **Thorium-232** in thoriated tungsten. Used in electric arc-welding rods in the construction, aircraft, petrochemical and food processing equipment industries. Ensures easier starting, greater arc stability and less metal contamination.
– **Tritium (^{3}H).** Used for life science and drug metabolism studies to ensure the safety of potential new drugs; for self-luminous aircraft and

commercial exit signs; for luminous dials, gauges and wristwatches; and for producing luminous paint.

– **Uranium-235.** Fuel for nuclear power plants and naval nuclear propulsion systems, also used to produce fluorescent glassware, a variety of coloured glazes and wall tiles.
– **Xenon-133.** Used in nuclear medicine for lung ventilation and blood flow studies.

In addition to the above list, other radionuclides can be found in Ref. [41].

7.4. CATEGORIZATION OF RADIOACTIVE SOURCES

The radionuclides and the amounts of radioactive material used vary considerably. High activity sources, if not managed safely and securely, can cause severe health effects to individuals in a short period of time, whereas low activity sources are unlikely to cause exposures with harmful consequences. This is an important point that should be taken into account in the consideration of management of any unauthorized radioactive material that has been discovered. It calls for an approach that is graded according to the harm that might be caused.

An IAEA Safety Standard titled Categorization of Radioactive Sources [42] has been developed to provide a risk based ranking to radioactive sources so that risk informed decisions can be made, in a graded approach to the control of radioactive sources for the purposes of safety and security. The categorization is based on the potential of radioactive sources to cause harm to human health and is intended to assist in ensuring an appropriate level of control for each source. It provides support for the international harmonization of measures for the safety and security of radioactive sources and provides a basis for the Code of Conduct on the Safety and Security of Radioactive Sources [3].

The categorization is based on the concept of 'dangerous sources', which are quantified in terms of '*D* values'. The *D* value is the activity of a specified radionuclide which, if not under control, could cause severe health effects in the short term, including death, for a range of scenarios that include both external exposure from an unshielded source and internal exposure following dispersal of the source material. The categorization system has five levels, with sources in Category 1 being the most 'dangerous', because they can pose a very high risk to human health if not managed safely and securely. The activity of a Category 1 source exceeds 1000 times the *D* value. At the lower end, sources in

Category 5 are the least dangerous. The activity of a Category 5 source is less than one-one hundredth of the *D* value.

A comprehensive listing of *D* values is given in Ref. [42]. This categorization should be used for making risk informed decisions so that the response to any incident can be appropriately graded. Only those items containing radioactive material in the higher categories, in particular, Category 1 and Category 2, are of primary concern from the perspective of nuclear security. Examples include irradiators, teletherapy devices, industrial radiography sources, brachytherapy sources giving a high or medium dose rate, and large calibration sources.

7.5. RADIOACTIVE SOURCE CONTAINERS

Shielded containers that are specifically designed to hold radioactive sources during storage and use are also used for their transport. These may include portable radioactive source holders, well logging sources, soil moisture gauges, and density and level gauges. These objects may emit considerable radiation and are typically shipped with industrial equipment. Of particular concern are soil moisture detectors that are compact units containing both a neutron and gamma emitter and are designed to measure moisture content. These detectors may incorporate an americium-241–beryllium neutron source and a caesium-137 source. For this reason, these signatures might be incorrectly interpreted as neutrons and gamma rays associated with nuclear material. There are thousands of these containers in authorized use and it is not uncommon for these containers to be stolen, lost, or abandoned with their radioactive sources still inside. If such a container is used for transport, it must meet all of the provisions of the IAEA Regulations for the Safe Transport of Radioactive Material [43]. Response personnel should remain alert to the variety of radioactive sources in transit.

7.6. AUTHORIZATION PROCESS

Personnel involved in the prevention, detection of and response to criminal or unauthorized acts need to have a basic understanding of the national authorization process that confirms the lawfulness of use of nuclear and other radioactive material. Because the task of identifying criminal or unauthorized acts involving nuclear and other radioactive material can involve complex technical judgments beyond the routine capabilities of law enforcement agencies, front line personnel should know which governmental

agencies have expertise in dealing with nuclear and other radioactive material. They should also be familiar with the form and content of authorizations issued by such authorities and the means for verifying whether or not suspect persons or activities are covered by valid authorizations.

Under its national legal infrastructure, each State should have developed its own legislation, regulations, standards, procedures and documentation for authorizing uses of nuclear and other radioactive material, including domestic and international commerce in such material. The following summary indicates the key elements of a national system of authorizations that can guide law enforcement personnel in a review of their own State systems. A fuller description of these elements can be found in the IAEA Handbook on Nuclear Law [6] and IAEA Safety Standards Series No. GS-R-1 [32] and No. GS-G-1.5 [44].

The first element of a national system of nuclear and radiation control is a legal framework provided by legislation (general laws adopted by the national parliament). Some of the provisions relevant to criminal acts may be contained in a State's general criminal legislation; others may be set forth in specific laws dealing with nuclear and other radioactive material. Still other provisions may be contained in commercial laws, including those dealing with international trade. Training of personnel involved in combating illicit trafficking should identify the relevant laws applicable to activities of concern, and the relevant agencies or authorities with responsibility for applying or enforcing these measures.

Essential elements of a national infrastructure are: legislation and regulatory body empowered to authorize and inspect regulated activities involving nuclear and other radioactive material and to enforce the legislation and regulations; sufficient resources; and adequate numbers of trained personnel. The regulatory body should be established by the government to regulate the introduction and conduct of any activities involving nuclear and other radioactive material. It should be independent of those who are authorized to conduct activities involving nuclear and other radioactive material.

The general functions of the regulatory body include the assessment of applications for permission to conduct activities that entail or could entail exposure to radiation; the authorization of such activities, subject to certain specified conditions; the conduct of periodic inspections to verify compliance with the conditions; and the enforcement of any necessary actions to ensure compliance with the regulations and standards.

Because of the technology involved, responsibility for issuing authorizations is typically assigned to a special regulatory body possessing the expertise to determine whether the proposed use is consistent with regulations, standards

of health, safety, security and environmental protection. Responsibilities are sometimes allocated to several agencies (for example, medical uses may be authorized by a Ministry of Health, while industrial uses may be authorized by a separate Nuclear or Radiation Protection Commission or Board and export/import licences issued by a Ministry of Foreign Trade). Law enforcement personnel combating unlawful acts involving nuclear and other radioactive material should be familiar with the overall institutional structure for control of nuclear and other radioactive material and activities so that necessary liaison with relevant bodies in the case of incidents can be accomplished efficiently and promptly.

The authorization process typically involves a number of steps:

- Submission of an application to the regulatory body for possession or use of material;
- Review of the application by the regulatory body;
- Granting of a licence, or registration certification (types of authorizations) with conditions to the person requesting authorization.

A regulatory body may, in issuing an authorization to acquire nuclear or other radioactive material, require an agreement that involves the prompt return of disused sources to the supplying State. Where the return of nuclear and other radioactive material to the State of origin is not possible, the responsible authority needs to arrange for safe and secure storage. The secure storage and safe disposal of radioactive material no longer in use, and for which no further use is foreseen, is a key aspect of ensuring that security and control are not lost. This is particularly important because responsible individuals move or are replaced and corporate memory is lost. The regulatory body is expected to perform inspections to ensure that users have properly stored or disposed of radioactive material deemed to be waste.

The regulatory body must be notified of the loss of control over nuclear and other radioactive material due to loss or theft, and also of seizures. The notification would typically include a description of the nuclear and other radioactive material and any associated equipment, its last known location and the circumstances associated with the loss or theft.

With regard to the security of radioactive material during transport, the regulatory body's transport regulations normally require carriers to promptly report missing packages and transport accidents involving radioactive material. When a consignment is undeliverable, it is required to be placed in a safe and secure location and the competent authority must be informed. Similar arrangements apply to leaking or damaged packages.

The training of law enforcement officers engaged in combating criminal or unauthorized acts involving nuclear and other radioactive material should include information on the kind of documentation applicable to authorized persons, organizations or activities. The basic form and content of licences or registration certificates should be either readily familiar to front line personnel or readily available for checking against documentation presented by persons suspected of criminal or unauthorized acts involving nuclear and other radioactive material. Given the possibility of forged or expired documents, law enforcement personnel should also be trained to recognize the most obvious signs of false documentation and to implement the procedures for verifying the validity of authorizations.

7.7. IMPORT AND EXPORT CONTROLS

Another authorized activity concerning nuclear and other radioactive material involves transfers crossing a State's national frontiers. Each country should have promulgated its own legal and institutional framework for the controlling items being exported from or imported to the country, including the transit of such material destined for other States that may pass through a State's territorial jurisdiction.

With nuclear material, such arrangements are necessary to implement national commitments under various international instruments, particularly the NPT [7] in which Parties have pledged not to assist other States in the acquisition of nuclear weapons. (See NPT, Articles I and II). Further, NPT Article III.2 contains an obligation not to provide certain material or technology unless it is subject to IAEA safeguards. Two current IAEA safeguards documents — INFCIRC/153 [14], for comprehensive safeguards agreements, and INFCIRC/540, the Model Additional Protocol [15] for strengthened safeguards — contain detailed provisions applicable to relevant transfers of nuclear material, equipment and technology. Regional non-proliferation treaties contain parallel commitments. In addition, many countries have bilateral agreements with other countries concerning the export/import of nuclear and other radioactive material, equipment and technology. These agreements vary according to the specific arrangements between the countries.

A more complete discussion of export/import controls over nuclear and other radioactive material is set forth in the IAEA Handbook on Nuclear Law [6]. As emphasized in that publication, a State's legislative and regulatory framework for controlling nuclear transfers should have an adequate scope. This is because almost any State can become a transit jurisdiction for illicit trafficking. Persons seeking to evade export controls in States with more

sophisticated controls will seek to channel unauthorized commodities or technology through States where controls may be weak. Therefore, in defining its export/import control system, a State should cover commodities and information identified in the guidelines of established nuclear supplier groups.

In addition, the Code of Conduct on the Safety and Security of Radioactive Sources [3] and the Guidance on the Import and Export of Radioactive Sources [21] also give recommendations on export and import of radioactive material. In particular, the Code recommends that every State involved in the import or export of radioactive sources should take appropriate steps to ensure that transfers are undertaken in a manner consistent with the provisions of the Code. It goes on to require that transfers of radioactive sources in IAEA Categories 1 and 2 take place only with the prior notification by the exporting State and, as appropriate, the consent by the importing State in accordance with the respective laws and regulations of both States. Furthermore, it recommends that every State should allow for re-entry into its territory of disused radioactive sources if, in the framework of its national law, it has accepted that they be returned to a manufacturer authorized to manage the disused sources. These recommendations are further developed in the supporting Guidance on Export and Import of Radioactive Material.

8. TRANSPORT OF NUCLEAR AND OTHER RADIOACTIVE MATERIAL

This section gives an overview of requirements that have been widely adopted for both national and international transport of nuclear and other radioactive material. The IAEA Transport Regulations are quite detailed and complex and are revised periodically; some States may vary these requirements to fit their particular circumstances. For this reason, personnel involved in combating criminal or unauthorized acts involving nuclear and other radioactive material need to be fully familiar with their respective national regulations and legislation governing transport in addition to their familiarity with the IAEA Transport Regulations.

8.1. GENERAL CONSIDERATIONS

The brief overview of the authorized uses of nuclear and other radioactive material in section 7 provides a general indication of how widely such material is used in industry, medicine and science. All of this material must be transferred from a processing or fabrication facility to the location where it is to be used. Thus, the diversity in the legitimate uses of this material signals the breadth and variety of transport required to meet the needs of authorized users.

Transport obviously represents a key stage in any programme to restrain illicit trafficking. Not only is the transfer of nuclear and other radioactive material to an unauthorized person 'illicit', but also the physical transfer of commodities provides an occasion for personnel to detect and seize relevant material or items. In fact, this stage may provide the best opportunity for front line personnel to identify and prevent unauthorized transfers. Such seizures can take place during routine monitoring and inspection of different modes of transport, in a public setting, with the aid of unobtrusive detection equipment. This can avoid the need to conduct search and seizure activities on private property, which is typically constrained by the need to obtain search warrants or other judicial or administrative approvals.

For many years the nuclear industry has implemented a well defined set of requirements applicable to the transport of nuclear and other radioactive material. Although a primary purpose of these requirements has been to protect public health and safety, some of the requirements also have a major bearing on the physical protection of the transported items. As a result, these arrangements can contribute to the effort to control criminal or unauthorized acts involving nuclear and other radioactive material. It is important that personnel have a general appreciation of existing transport requirements for nuclear and other radioactive material as a necessary context for evaluating whether specific shipments may raise suspicions of criminal or unauthorized acts involving such material that may require prompt action.

In addition, legitimate shipments of commercial material can be used to 'mask' the presence of unauthorized nuclear and other radioactive material. Law enforcement personnel should be aware of this possibility that may be discovered through intelligence information or measurements.

8.2. IAEA TRANSPORT REGULATIONS

In 1959, the United Nations Economic and Social Council recognized the need for regulatory guidance on the safe transport of radioactive material.

Based on this request, the IAEA prepared Regulations for the Safe Transport of Radioactive Material [43]. This publication sets forth detailed and definitive standards of safety, which provide an acceptable level of control of the radiation, criticality and thermal hazards to persons, property and the environment that are associated with the transport of nuclear and other radioactive material. The regulations are intended to apply to the national and international transfer of such material by all modes of transport. Many countries have adopted these regulations and incorporated them into their national legislation. The Transport Regulations stipulate that:

- The consignor must ensure that the packaging is adequate for the hazard of the material.
- The carrier must take all precautions to ensure that any radiological hazards are minimized.

Protection is provided by specifying design criteria for each type of package and then limiting the nature and activity of radioactive material that can be transported. This is augmented by applying some simple rules for handling and storage, with some additional information on how packages should be secured during transport.

The Transport Regulations guard against the dispersion of radioactive material by ensuring that the containment features of the packaging are adequate and the design and strength of the packaging are appropriate to the nature and activity of the material being transported. The Transport Regulations also guard against radiation hazards by incorporating shielding in the packaging, warning of radiation levels by use of suitable labels and markings, limiting external dose rate and detailing certain stowage criteria.

8.3. TRANSPORT INDEX

The Transport Index (TI) is a number assigned to a package to provide control over specific groups of packages. The aim is to reduce exposure risks to people associated with, and exposed during, the transport operation. The TI is set at 100 times the maximum dose rate in mSv/h at a distance of 1 m from the package.

8.4. PACKAGES

The main focus of safety issues is geared towards package control, rather than operational control, and because of this package requirements permeate the IAEA Transport Regulations. There are different types and classifications of packages:

– Excepted packages;
– Industrial packages;
– Type A packages;
– Types B (U) and B(M) packages;
– Type C packages;
– Packages containing fissile material.

Package means the packaging with its radioactive contents. There are general requirements that are applicable to the design of all types of packages that contain radioactive material. For example, the mass, volume and shape of the package should be such that it can be easily and safely transported, and the package must be designed in such a manner that it can be properly secured.

In addition to these general requirements, the different package design features are required to withstand certain tests — described in the Transport Regulations — such as the water spray test, the free drop test, the stacking test and the penetration test. This is to ensure that the package design is adequate to withstand normal handling, routine and accident conditions during transport without loss of contents or significant increase in external radiation. The test requirements become more stringent when the material to be transported poses a potentially high level of hazard.

8.5. EXCEPTED PACKAGES

Excepted packages have a low potential hazard and have a minimum packaging and labelling requirement. In most cases they do not require labelling other than a UN number[3] and certain packages may be shipped by mail. Although most design and use requirements do not apply to excepted packages, the package must meet the following requirements:

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[3] Dangerous goods are given UN numbers and proper shipping names according to their hazard classification and their composition. Radioactive material is assigned to hazard Class 7.

– The contents must be able to be identified when the package is opened;
– A UN number must be displayed on the outside of the package unless the package is being shipped by mail;
– The package must meet general design requirements regarding resistance to shock, vibration, water retention and degradation.

8.6. INDUSTRIAL PACKAGES

There are three types of industrial packages, which are given the designation IP-1, IP-2 and IP-3. Industrial packages are used to transport material of relatively low intrinsic hazard. Such material is commonly referred to as LSA (low specific activity) or SCO (surface contaminated object). There is no specified mass limit to the shipment and typically such consignments involve material such as ores, concentrates and wastes. Commercially available steel drums are commonly used, but there are certain additional requirements when compared to 'excepted' packages.

8.7. TYPE A PACKAGES

Type A packages are designed to withstand normal routine conditions of transport without loss of contents or significant increases in external radiation levels. They must also conform to prescribed limits with regard to package size, activity, quantities and the potential hazards. The packaging design is subjected to a series of tests that simulate normal transport conditions and also entail a water spray test, a free drop test, a compression test and a penetration test.

8.8. TYPES B(U) AND B(M) PACKAGES

Types B(U) and B(M) packages (approved 'unilateral' or 'multilateral') are used to transport quantities in excess of the Type A limits. They must conform to a design that is approved by a competent authority and typically carry irradiated nuclear fuel, high level radioactive waste and other highly radioactive material. The package design must be such that it limits the release of the contents or the increase in radiation dose, even in a severe accident. In addition to all the tests and design features associated with Type A, the package design has to conform to additional tests relating to impact, penetration, fire immersion and water immersion. According to the test criteria, the type B packages have to withstand all accidents with 95% confidence.

8.9. PACKAGES CONTAINING FISSILE MATERIAL

Packages containing fissile material are subject to special controls, which reflect the fissile nature of the radioactive material.

8.10. SHIPPING DOCUMENTS

All consignments of radioactive material must be accompanied by shipping documents which must provide the following information, as detailed in Ref. [43]:

- The proper shipping name;
- The United Nations Class number '7';
- The United Nations number assigned to the material;
  The name or symbol of each radionuclide;
- A description of the physical and chemical form of the material, or a notation that the material is special form radioactive material or low dispersible radioactive material;
- The maximum activity of the radioactive contents during transport;
- The category of the package, i.e. I-WHITE, II-YELLOW, III-YELLOW (see section 8.11);
- The transport index (categories II-YELLOW and III-YELLOW only) (see section 8.11);
- For consignments, including fissile material, the criticality safety index;
- The identification mark for each competent authority approval certificate applicable to the consignment;
- For consignments of more than one package, the information contained above should be given for each package.

For the transport of material in special arrangement[4] or in type B packages or packages containing fissile material, additional authorization or certificates must be included in the shipping documents. It is essential that the personnel involved in combating criminal or unauthorized acts involving nuclear and other radioactive material are aware of these shipping documents that are specific to each country and type of shipment.

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[4] Special arrangement means those provisions, approved by the competent authority, under which consignments, which do not satisfy all the applicable requirements of the Transport Regulations, may be transported [42].

8.11. LABELLING

In addition to shipping documents, all consignments must have appropriate labelling on the packaging. The labelling will identify those packages, which contain radioactive material; provide a guide as to storage, handling and radiation exposure hazards; and identify the contents in the event of an accident or damage to the package. The labels are graded numerically and are also colour coded, but the category of each label is linked to the radiation level at any point on the external surface of the package. The categories are shown in Table 1.

TABLE 1. LABELLING CATEGORIES FOR PACKAGES THAT CONTAIN RADIOACTIVE MATERIAL

Maximum radiation levels on external surface	Category	Transport index
Not more than 0.005 mSv/h	I-WHITE	TI = 0
More than 0.005 mSv/h, but not more than 0.5 mSv/h	II-YELLOW	TI ≤1
More that 0.5 mSv/h, but not more than 2 mSv/h	III-YELLOW	TI ≤10
More than 2 mSv/h but not more than 10 mSv/h	III-YELLOW[b]	

Note: The material should be transported in accordance with exclusive use conditions as detailed in the IAEA Transport Regulations [42].

In addition, the presence of a label with criticality safety index indicates the presence of nuclear material. The labels must conform to the standard design; the four types of label are shown in Figs 11–14.

8.12. MARKINGS

In addition to the labels, other markings are required on the packages [43]:

– Each package should be legibly and durably marked on the outside of the packaging with an identification of either the consignor or consignee, or both.

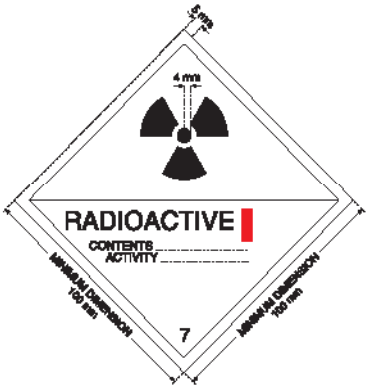


FIG. 11. Labelling for packages that contain radioactive material: Category I – WHITE label; surface ≤0.005 mSv/h; TI = 0.

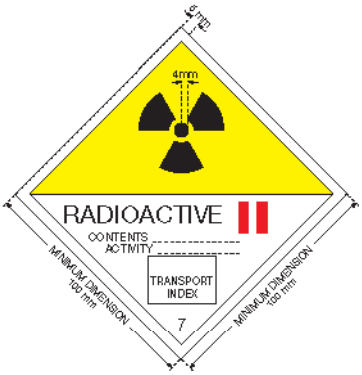


FIG. 12. Labelling for packages that contain radioactive material: Category II – YELLOW label; surface ≤0.5 mSv/h; TI ≤1.

– For each package, other than excepted packages, the United Nations number preceded by the letters 'UN', and the proper shipping name should be legibly and durably marked on the outside of the packaging. In the case of excepted packages, other than those accepted for international movement by post, only the United Nations number, preceded by the letters 'UN', should be required.
– Each package of gross mass exceeding 50 kg should have its permissible gross mass legibly and durably marked on the outside of the packaging.
– Each package which conforms to:

FIG. 13. Labelling for packages that contain radioactive material: Category III – YELLOW label; surface ≤2 mSv/h, TI ≤10.

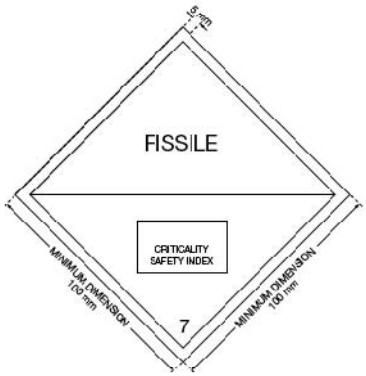


FIG. 14. Labelling for criticality safety index.

"(a) An *IP-1*, an *IP-2* or an *IP-3 design* shall be legibly and durably marked on the outside of the *packaging* with "TYPE IP-1", "TYPE IP-2" or "TYPE IP-3" as appropriate;

(b) A *Type A package design* shall be legibly and durably marked on the outside of the *packaging* with "TYPE A";

(c) An *IP-2*, an *IP-3* or a *Type A package design* shall be legibly and durably marked on the outside of the *packaging* with the international *vehicle* registration code (VRI Code) of the country of origin of *design* and either the name of the manufacturer or other identification of the *packaging* specified by the *competent authority* of the country of origin of *design*."

– Each package which conforms to an approved design should be legibly and durably marked on the outside of the packaging with:

(a) The identification mark allocated to that design by the shipping documents;
(b) A serial number to uniquely identify each packaging which conforms to that design;
(c) In the case of a Type B(U) or Type B(M) package design, with 'TYPE B(U)' or 'TYPE B(M)'.

– Each package which conforms to a Type B(U), Type B(M) package design should have the outside of the outermost receptacle, which is resistant to the effects of fire and water, plainly marked with the trefoil symbol by embossing, stamping or other means resistant to the effects of fire and water.
– Where LSA-I or SCO-I material is contained in receptacles or wrapping material and is transported under exclusive use, the outer surface of these receptacles or wrapping material may bear the marking 'RADIOACTIVE LSA I' or 'RADIOACTIVE SCO I', as appropriate.

8.13. PLACARDS

8.14. All freight containers which contain or have a consignment of radioactive material, other than exempted packages and tanks, are required to display placards on the outside of the container or tank. Four placards must be displayed on the end walls and sides of the container or tank. A sample design of a placard is shown in Fig. 15. In some circumstances it is permissible to display an enlarged form of the relevant label in place of a placard.

FIG. 15. Placard design. The number 7 is the UN hazard class number, which indicates the presence of radioactive material.

9. PREVENTING CRIMINAL OR UNAUTHORIZED ACTS

This section outlines the supporting infrastructure concerned with the control of nuclear and other radioactive material, in order to prevent their being available for criminal or unauthorized acts. In particular, it explains the contribution that may be made by customs, police and other law enforcement bodies.

The information in this section neither aims nor intends to interfere with the regulation or practice of customs or other law enforcement agencies. It is intended to support their countermeasures to combat criminal or unauthorized acts involving nuclear and other radioactive material. Its purpose is to provide an overview of the issues involved and of the roles and responsibilities of the national bodies participating in efforts to prevent criminal or unauthorized acts involving nuclear and other radioactive material.

Effective prevention strategies, policies and procedures can be developed on the basis of these foundations. An important element in prevention is the development of a range of economic, regulatory and criminal penalties to deter criminal or unauthorized acts involving nuclear and other radioactive material. These penalties have to be proportionate to the seriousness of the incidents committed and should be clearly set forth in national law. Prevention activities have to be accomplished through partnership among the operators of facilities using or storing nuclear and other radioactive material, regulatory bodies with technical expertise in such material and law enforcement, and response agencies who can advise on crime prevention tactics. This section describes the main aspects of preventive measures taken pursuant to legislative provisions, administrative requirements, cooperative measures; basic notions of crime prevention are also presented.

9.1. GENERAL CONSIDERATIONS

The term *prevention* used in this section is intended to include measures that will be undertaken by regulatory bodies competent in radiation protection, safety and security agencies, as well as those measures that are undertaken by police, customs and other law enforcement bodies.

International instruments establish obligations relating to criminal or unauthorized acts involving nuclear and other radioactive material. In the case of nuclear material, primary among these instruments is the CPPNM [5, 16] and in the case of radioactive material, it is the non-binding Code of Conduct [3]. The IAEA General Conference, in September 2003, urged each State to

write to the IAEA Director General indicating that it fully supports and endorses the IAEA's efforts to enhance the safety and security of radioactive sources, is working towards following the guidance contained in the Code of conduct, and encourages other countries to do the same. In this regard, as of September 2007, a total of 90 countries had written to the Director General.

In addition to these international instruments, international guidance, such as that contained in the BSS [31] and in Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety (GS-R-1) [32], forms the basis for the safety legislation covering radioactive material implemented in most States.

The legislation, enacted within States to cover nuclear and other radioactive material, operates on the fundamental principle that any act or activity involving nuclear and other radioactive material requires an authorization by the relevant regulatory body, unless that act or activity has been specifically exempted. In line with this approach, it is logical to conclude that if an authorization (or exemption from authorization) does not exist for any act or activity involving nuclear or radioactive material, then the detection of any such unauthorized act must form the basis for commencing an investigation into a possible breach of the legislation existing in that State.

Such criminal or unauthorized acts would range from simple administrative oversight (such as failure to renew the authorization by the due date), through to the theft of nuclear and other radioactive material for malicious purposes (such as diverting nuclear material to construct an IND, or stealing radioactive material for use in an RDD and the potential dispersal or release of radioactive material in the air or water.

Criminal or unauthorized acts involving nuclear and other radioactive material then do not automatically indicate that there is an intention to use the nuclear or radioactive material in a malicious way, but the detection of any unauthorized act should be regarded by regulators, customs officials, national or border police as the starting point for an investigation.

Such an investigation may result in a range of penalties, from a simple caution or small fine for a breach of administrative law, up to a custodial sentence for breach of a civil or criminal law. The determination of the appropriate penalty for a breach of administrative or criminal laws is rightly the responsibility of the justice system and lies outside the scope of this publication. However, it is important to remember that the detection of any unauthorized act involving nuclear or radioactive material should be treated seriously and a full and proper investigation undertaken.

9.2. MONITORING COMPLIANCE

In relation to preventing criminal or unauthorized acts involving nuclear and other radioactive material, the regulatory body should implement a compliance monitoring programme. The key elements of compliance monitoring are requirements for:

- On-site inspection, particularly the examination of records to ensure that material is maintained as authorized;
- Verification that losses, potential loss of control, and theft are reported;
- Periodic feedback from users on the status of the material.

9.2.1. Control measures

The controls placed on material that is being used, stored or transported are normally commensurate with the activity and properties of the material. Examples of such controls are:

- A clearly designated and exclusive place for handling and storage;
- Notices, signals or other warnings to indicate the presence of nuclear and other radioactive material;
- Indication of reference levels of radiation dose rates and contamination at appropriate locations;
- Physical barriers, including:
    - controlled access to the place of use or storage;
    - guards or electronic surveillance, locks, sealing procedures or other means to ensure that the area is physically secure.
- Intrusion detectors, if applicable.

Regular audits and assessments of the physical controls are conducted by those responsible for nuclear and other radioactive material to verify that the notices and barriers continue to provide an acceptable level of security and safety. The regulatory body is expected to ensure that the operator responsible for any such facility has established written procedures that individuals with responsibility for handling radioactive material must follow. Mobile radioactive sources, such as those used in industrial radiography or portable gauges, are particularly vulnerable to loss of control or theft. For such sources, secure temporary storage at remote locations is essential when they are not in use.

9.2.2. Detection equipment

Intrusion detection equipment may be required under some authorizations issued by a regulatory body, particularly for nuclear material as required under the CPPNM. In addition, States may wish to evaluate their needs for intrusion detection equipment at locations where the use of Category 1, 2 and 3 radioactive sources is authorized [42].

9.2.3. Training

The national regulatory body, customs, police and other law enforcement bodies are advised to cooperate in the development of training material and the holding of training courses. Training needs to have clear and concise objectives. States may consider using training material that has been produced by the IAEA, WCO, Europol and Interpol. It is recommended that any training material or course on the prevention of criminal or unauthorized acts involving nuclear and other radioactive material also cover the relevant detection and response issues and address both theoretical and practical aspects.

9.2.4. Raising public awareness

Raising public awareness is an important part of efforts at the national level to prevent criminal or unauthorized acts involving nuclear and other radioactive material. The national authority, customs, police and other law enforcement bodies are encouraged to participate in the development and establishment of an effective programme to raise public awareness.

The form of a public awareness programme should be consistent with the national regulations and, accordingly, will vary between States. It may include information on changes in legislation, advertising campaigns directed towards target groups such as metal recycling industries or news items on successful instances of prevention.

9.2.5. Cooperative measures

Regulatory and other appropriate law enforcement bodies are advised to cooperate and regularly exchange information as part of strengthening their capabilities for increasing security of nuclear and other radioactive material. It is recommended that this be done both domestically and internationally, and that advantage be taken of the current cooperative initiatives by the IAEA, WCO, Interpol, Europol and European Commission. These initiatives are

aimed at: strengthening the infrastructures of States and international agencies; increasing competence and vigilance; and avoiding duplication among the various bodies.

The following recommendations are aimed at developing cooperation and communication within and between States.

National level cooperation: The national programme on the prevention of criminal or unauthorized acts involving nuclear and other radioactive material should include all competent national agencies with related responsibilities. Such a programme is most effective when it covers the nuclear safety and radiation protection authorities, relevant law enforcement agencies, responders and customs and intelligence services.

For efficient cooperation and communication, the national regulatory body(ies), customs, police and other law enforcement officers are advised to:

- Establish a network of contact points as part of an overall coordination and control mechanism;
- Encourage cooperative intelligence and similar efforts by customs and law enforcement officers to prevent the uncontrolled movement and trade in smuggled nuclear and other radioactive material;
- Encourage the exchange of information between agencies, authorities and services concerning criminal or unauthorized acts involving nuclear and other radioactive material;
- Establish and maintain a reliable, extensive and continuously updated database on cases of criminal or unauthorized acts involving nuclear and other radioactive material , using a common reporting protocol;
- Adopt a common notification and reporting format.

Bilateral and regional cooperation: National regulatory and other authorities are advised to consider formally cooperating and exchanging information with appropriate national authorities in neighbouring countries and with countries that have been identified as possible sources of seized nuclear or radioactive material. This will foster bilateral, regional and international cooperation and communication concerning criminal or unauthorized acts involving nuclear and other radioactive material and also create opportunities to review existing control mechanisms. It is recommended that regular meetings be arranged among the national authorities of neighbouring states to promote bilateral and regional cooperation.

International cooperation: National authorities are encouraged to take advantage of the assistance available from international organizations for sharing information and expertise, organizing and participating in technical

meetings, and supporting national programmes, including improving the relevant databases.

National authorities are requested to inform the appropriate international organizations of cases of criminal or unauthorized acts involving nuclear and other radioactive material or seizures of nuclear or radioactive material in accordance with their national legislation and channels of communication. In particular, it is helpful if events can be reported to the IAEA, WCO, Europol and Interpol for inclusion in their databases on nuclear and other radioactive material.

9.3. BASIC ELEMENTS OF CRIME PREVENTION

The law enforcement community has long recognized the following basic elements of crime prevention:

– Remove or deny the opportunity for a crime;
– Remove the motive or incentive for a crime;
– Increase the likelihood that perpetrators will be caught;
– Apply punitive penalties to offenders.

In addition, resolution 2002/13 and its Annex of the United Nations Economic and Social Council provides general guidance on crime prevention including strategies and measures to reduce the risk of crimes and their harmful effects on individuals and society [45].

These general principles are also applicable to the prevention of criminal or unauthorized acts involving nuclear and other radioactive material, given that the cases of interest typically involve a series of criminal acts, from the initial theft or unlawful appropriation to the unlawful disposition of such material. Where illicit trafficking has been made a specific offence under national legislation, application of the preventive elements is relatively straightforward. However, even if no specific offence has been codified, "other possible criminal offences" may arise from the criminal or unauthorized acts involving nuclear and other radioactive material. Some of these include:

– Conspiracy to commit criminal acts;
– Bribery and corruption offences;
– Burglary of storage facilities;
– Theft of nuclear or other radioactive material;
– Criminal negligence on the part of those responsible for the safe storage and security of the nuclear and other radioactive material;

– Assault occasioning bodily harm or reckless endangerment of human life in situations where innocent individuals have been exposed to excessive radiation levels;
– Criminal damage arising from the contamination of property;
– Violation of export or import controls.

In addition to criminal offences such as those mentioned above, criminal or unauthorized acts involving nuclear and other radioactive material could, in some instances, result in civil liability actions. Physical protection and inventory control are important elements in any prevention programme. In addition, using criteria primarily applicable to safety issues may not be effective as a basis for addressing the threat of criminal or terrorist activity, the major concern posed by criminal or unauthorized acts involving nuclear and other radioactive material. Those with malicious intent may not be particularly concerned with safety issues, including the safety of their own operatives. Persons prepared to commit criminal or terrorist offences may not be deterred by the threat of civil regulatory penalties.

9.4. REMOVING OR DENYING OPPORTUNITY

A primary goal in preventing criminal or unauthorized acts involving nuclear and other radioactive material is to prevent the diversion of material from a user facility, typically by theft or other unlawful means. One component of prevention therefore entails the implementation of physical protection measures to ensure that there is no unauthorized access to a location where nuclear and/or other radioactive material is stored. To achieve a high level of physical protection it is necessary to:

– Conduct an objective and thorough risk or threat assessment of potential criminal activity in the region and at the installation or storage facility.
– Conduct a security survey of the installation to determine the appropriate physical protection measures necessary to counter the potential threat.
– Install the necessary physical protection measures.

This does not mean that implementing of such measures ensures absolute security, given that even the most elaborate and sophisticated physical protection measures can be breached. Information or assistance from an insider who works at a facility or who has routine lawful access to the facility is a common approach to overcoming physical protection measures. Thus, physical protection features have to be contrived to deny unlawful or

unauthorized access through several means: first, by deterring access; second, by delaying or hampering a would-be thief; and, third, by ensuring a rapid reaction capability through which security staff can respond immediately to an intruder alarm.

The second element in denying opportunity is to impose strict inventory control of nuclear and other radioactive material, including both regular and random checks. Such control can help reduce the risk of theft by an insider. Insiders are deterred by the knowledge that a discrepancy in the inventory would spark an immediate investigation and response that would focus on them, among other suspects. Such inventory control has to specify:

- The type and quantities of the nuclear and other radioactive material;
- Any equipment in which the material is used;
- The nature and location of the storage facilities;
- The individuals responsible for the safe handling and security of the material;
- The persons who are authorized to receive, possess, transfer, store or dispose of the radioactive material.

Moreover, inventory control has applicability to safety issues and is a fundamental feature of regulations to account for and control the use of nuclear and radioactive substances.

An element relates to what is known in the law enforcement community as an 'intelligence footprint'. This is when an intelligence analyst unifies a series of apparently unrelated pieces of information to form the conclusion that certain facilities or installations are to be targeted by those with malicious intent. Intelligence analysis can also help assess the risk that a terrorist organization may be seeking to acquire nuclear or radioactive material, equipment or technology necessary for constructing a nuclear explosive device or RDD. This 'intelligence footprint' should be regarded as a trigger for a proactive response, which may include action to interdict the criminal activity. Recent disclosures of a widespread black market in centrifuge technology for uranium enrichment and nuclear explosive designs involving private companies and government entities are one example of how intelligence information can be used to prevent unauthorized transfers of nuclear related commodities and information. Such activity also signals the need for heightened security measures at all facilities which use or store nuclear and/or radioactive material.

9.5. INCENTIVES AND MOTIVES

There can be many incentives for the criminal and motives for unauthorized acts involving nuclear and other radioactive material. Some persons engaging in this activity (typically the sellers) are motivated simply by financial gain. In contrast, potential buyers may harbour a range of motives. Some buyers may be acting as brokers or middlemen. Such persons may provide a 'cover' to enable both buyers and sellers to evade regulatory controls or conceal their identities from authorities, thereby facilitating criminal or unauthorized acts. However, buyers may have more sinister motives arising from criminal, political, ideological or social objectives. Unlike the simple profit motive, the task of influencing these more erratic motivations — some of which may be the product of extremist or fanatical views — may be extraordinarily difficult, if not impossible. For example, if the buyer is a terrorist organization whose motive is to acquire a nuclear weapon for political or ideological ends, the economic aspects of the transaction will be almost irrelevant to the acquisition of the material. Other than stringent and uniformly applied sanctions at a government level, economic factors would be unlikely to affect the buyer's behaviour. Addressing such 'philosophical' or 'revolutionary' motivations can be accomplished only by convincing those seeking radioactive material for malicious purposes that threats, extortion or terrorism will not assist them in achieving their goals. Such matters are obviously well beyond the scope of a law enforcement handbook. However, a law enforcement prevention strategy can usefully focus on financial motivations.

For those seeking financial gain from an unauthorized transfer of nuclear and other radioactive material, there are means for rendering such transactions commercially unattractive and also very risky for those engaged in such trade. The first requirement is to conduct a realistic assessment of the 'marketplace' for unauthorized nuclear and other radioactive material on the basis of relevant intelligence and databases and to devise means for influencing that 'market place'. From the seller or broker perspective, if there is a high probability that severe financial penalties will be imposed on anyone found dealing in nuclear and other radioactive material, the activity becomes less attractive. In this regard, there may be parallels to illicit trafficking in dangerous drugs, where the international community has taken steps to seize or sequester all the known assets of convicted drug dealers. The rationale is that seizure of all financial assets against the potential financial rewards from the sale of the dangerous drugs represents a strong deterrent against the activity. If similar provision were imposed upon anyone engaged in criminal or unauthorized acts involving nuclear and other radioactive material, such crimes would be less attractive from an economic standpoint.

Justification for the seizure of assets could be found in offsetting the costs of disposal of the illegal nuclear or radioactive material, compensation to anyone adversely affected by the criminal or unauthorized acts involving such material, and to defray legal, administrative and operational expenses incurred in the activity to intercept the culprits and interdict the unauthorized material.

Extending the concept of economic penalties to the organizations responsible for the control and safe storage of the material would also have an effect. If an organization that lost control of nuclear or radioactive material due to lax inventory control or security systems were to suffer severe financial penalties, this would have both a deterrent and stimulating effect. The installation or facility would be deterred from tolerating lax security systems and stimulated to protect such material and invest in appropriate security measures.

9.6. INCREASING THE LIKELIHOOD OF APPREHENDING PERPETRATORS

Reducing opportunities for crime will also increase the risk that culprits will be caught because a smaller window of opportunity for theft or diversion will make it easier for authorities to detect the commissioning of a crime. Additional measures can also be imposed to increase the likelihood that a culprit will be caught.

The three principal methods to increase the chances of catching a culprit are to:

- Have in place a rapid notification system to cater to any instance of loss of control;
- Have an effective monitoring programme;
- Use nuclear forensics and attribution to identify the source of detected material.

9.6.1. Sharing information

A first measure involves information sharing. An effective notification process, under which all law enforcement bodies and regulatory authorities are informed immediately of the loss of control of nuclear or radioactive material, allows these agencies to move into a heightened alert status to actively pursue recovery of missing material and the arrest of perpetrators. To be effective, the notification process must match the speed and ease of modern travel and communication systems. It must also be tailored to both the national situation and the possibility that criminal or unauthorized acts involving nuclear and

other radioactive material will extend across national borders. In this regard, existing notification procedures of Interpol, Europol and WCO can provide rapid dissemination of information to law enforcement agencies worldwide.

9.6.2. Increasing detection capability

A second method is to increase the chance of detection using radiation monitoring equipment. Most facilities handling nuclear and other radioactive material, such as nuclear plants or laboratories, have in place radiation detection systems mainly as a control measure for safety reasons. Having radiation monitors at the exit points of a facility or installation increases the chances of early detection, registering when a culprit tries to leave the facility illicitly carrying such material.

Many States have instigated radiation monitoring programmes at border crossing points, airports and maritime ports of entry. This entails the use of both portable equipment and the installation of fixed radiation monitors which basically serve to screen all personnel and vehicles for radiation when passing through a monitoring point. If nuclear or radioactive material is transported through a radiation monitoring station, this activates an alarm and results in the deployment of an immediate response by border control or other law enforcement personnel.

Certainly from the perspective of public transport, whether by sea, land or air, it is vital to prevent unauthorized nuclear and other radioactive material from being carried onto aircraft, trains, buses or ferries, where passengers are normally seated in close proximity to each other for a prolonged period of time. The health risks associated with an unauthorized act involving nuclear and other radioactive material will increase substantially if the material is brought onto public transport. This can result from many people spending extended periods of time in close proximity to radioactive material being transported in an unsafe manner.

9.6.3. Nuclear and classical forensics

Nuclear forensics and attribution are used to assign responsibility for the intended or actual use of nuclear or radioactive material and devices in criminal acts or acts that threaten national and international security. Nuclear forensics include the collection of isotopic, chemical and physical evidence for determining the source of material used in criminal or unauthorized acts involving nuclear and other radioactive material, including those individuals involved in the unauthorized diversion of such material. Nuclear forensics combine elements of both classical — or traditional — forensics that normally

have been a part of criminal investigation and radiation measures and radiochemical analysis. Traditional elements may include fingerprint, hair, fibre, and DNA analysis. Radiological forensics includes determining the major and minor isotopic content of material, major and trace element concentration, and physical data including textural and morphological features. The two elements complement each other. It is essential to characterize seized samples while preserving all forensic evidence. Attribution will guide response to the detection of criminal or unauthorized acts involving nuclear and other radioactive material, including any potential prosecution. Nuclear attribution combines many aspects of investigation, including results from nuclear forensic sample analysis, understanding of radiochemical signatures and environmental signatures, knowledge of the production of nuclear and radiochemical materials and their usefulness for nuclear or radiological devices, and information from law enforcement and intelligence sources.

Nuclear forensics and attribution are relatively new concepts. Owing to the complex requirements that call for capabilities from both classical and nuclear forensics, only a small number of States have the resources and capabilities to conduct this combined examination. For this reason it is important to promote international cooperation in nuclear forensics in order to handle it in a systematic manner and to share expertise. To this end, the IAEA has developed in cooperation with the International Technical Working Group on Nuclear Smuggling (ITWG) a common framework to pursue nuclear forensic investigations and best scientific approaches to the collection and interpretation of nuclear forensic evidence.

It is important to recognize that any nuclear forensic capability has to be well planned and organized in order to ensure that any evidence that is collected is admissible in a subsequent prosecution. Forensics can be quickly compromised if evidence is not collected early and stringent procedures are not used. Any national response programme should address this problem. It is recommended that a forensic evidence management team (FEMT) be established that consists of qualified individuals and that will aid in the recovery of evidence from the scene. It is advisable that these professional include law enforcement officials, radiological assessors and environmental experts. The FEMT will also have the responsibility for trace evidence. All equipment and resources used in the evidence have to be subject to a programme of quality control to eliminate the possibility of cross-contamination. First response personnel and their leaders are responsible for ensuring that no cross contamination takes place due to bad operational practice (e.g. such as not changing gloves). In cases where forensic facilities that include laboratories are to be used in an investigation, a documented quality control programme must be in place in accordance with all rules of evidence.

9.7. PENALTIES

Criminal sanctions have a greater deterrent effect than economic sanctions. Although minor incidents may be adequately penalized through regulatory enforcement measures such as punitive fines, licence suspension or revocation or the like, more stringent penalties under criminal law should be imposed for more serious incidents. Determining the seriousness of an incident involves such factors as the type and quantity of material involved, the perpetrator's criminal intent or lack thereof, whether the incident created actual or potential injury to persons or property and whether the offence was repeated.

The value of establishing stringent penalties for criminal or unauthorized acts involving nuclear material has been recognized in the CPPNM [5], its amendment [16] and the United Nations Security Council resolution 1540 [22]. Article 7 of the CPPNM lists a number of malicious actions involving nuclear material. These range from unauthorized possession, use or transfer of such material to theft or robbery, embezzlement, extortion, threats, attempts to commit proscribed acts and participation in these activities. The article further requires that these acts "shall be made a punishable offence by each Party State under its national law" and that such offences are "punishable by appropriate penalties which take into account their grave nature". This provision could provide a basic framework or starting point for drafting a provision to be incorporated into a State's national law.

It should be noted that the legal instruments referred to above do not apply to non-nuclear material. Similarly, the approach for all radioactive material must be to tailor penalties to reflect the gravity of the offence. The deterrent effect of penalties can differ, depending on the character and motives of perpetrators. Traffickers who commit thefts or other acts involving nuclear and other radioactive material for purposes of financial gain may be deterred by the possibility of severe penalties. However, terrorists or extremists who commit acts for political reasons may not be deterred by any potential penalties, even the most severe.

10. TECHNICAL DETECTION METHODS

Law enforcement agencies seeking to detect and respond to criminal or unauthorized acts involving nuclear and other radioactive material need to use radiation detection equipment. They have to be familiar with the different

types of equipment and their operating capabilities. This section provides an overview of the main types of equipment, highlighting their general uses, and discusses some of the limitations associated with such equipment.

Research work is ongoing to modify or redesign equipment, to overcome many of the shortcomings identified in different studies and to produce reliable and effective systems which are easy to use and which will aid law enforcement personnel. Therefore, the involved personnel must be up-to-date on the kinds of systems used for the detection of nuclear and other radioactive material.

10.1. RADIATION DETECTION EQUIPMENT

When using the techniques and equipment discussed below, it is important to recognize that detecting nuclear and other radioactive material addresses two objectives. First, there is the obvious objective of identifying material that may pose risks so as to enable its seizure or appropriate handling in order to prevent injury or other damage to public safety and security. Second, the results of detection may be used in the enforcement process in legal proceedings against the offenders, who may be subject to civil or criminal penalties. As discussed in section 11, to meet this second objective, care must be taken to ensure that detection equipment is properly calibrated, that measurements are properly taken and that the chain of custody of relevant material has been maintained.

The key identifying feature of nuclear and other radioactive material is that it emits ionizing radiation. Although ionizing radiation cannot be seen, felt or touched, its presence can be detected with the use of specialized equipment. The four basic types[5] of radiation detection equipment are:

(1) **Fixed radiation portal monitors (RPMs)** are pass-through type monitors typically consisting of two pillars containing gamma radiation detectors and usually neutron detectors, and monitored from a display panel. They can provide alarm capability to indicate the presence of nuclear or radioactive material above a preset threshold. Portal monitors are used for personnel, vehicles, packages and other cargo in a variety of venues. Typically, all these applications use instruments that are either personnel or vehicle portal monitors.

[5] There is also specialized equipment used in laboratories, but it is unlikely that law enforcement personnel will encounter or use such equipment.

(2) **Personal radiation detectors (PRDs)** are radiation detectors approximately the size of a telecommunications pager, which can be worn by front line officers. PRDs can provide a flashing light, tone, vibration or numerical display that corresponds to the level of radiation present.

(3) **Hand-held gamma and neutron search detectors (GSDs and NSDs)** are radiation detectors used to identify the location of radioactive material. GSDs and NSDs provide greater sensitivity than do PRDs.

(4) **Hand-held radionuclide identification devices (RIDs)** are radiation detectors that can analyse the energy spectrum given off by a radionuclide to identify it. They can be used also as survey instruments to locate nuclear and other radioactive material.

In addition to using the above detectors, it may be necessary to check for contamination by measuring alpha and beta radiation, either using an external probe connected to the multipurpose instrument or a separate contamination monitor.

All these types of equipment have the same basic function. Radiation emitted from the nuclear and other radioactive material interacts with the detector and the resulting energy is converted into an electrical signal, which is processed by the device. The process entails counting and averaging the radiation levels against a specific threshold and then producing a result in the form of a digital or analogue reading, and a visual, acoustic or vibration alarm.

The signal from the radioactive material must be isolated from the natural background radiation, which will vary according to locations. It is, therefore, necessary to ascertain the prevailing background radiation levels at the location where the radiation detection equipment is to be used and to set up the equipment relative to the average normal reading for background radiation. Once this is done, the alarm threshold for the equipment can be set high enough to allow for fluctuations in the background radiation levels. Even if the equipment is set to trigger an alarm at four sigma[6] above the normal background level, at least one false alarm per day can be anticipated due to fluctuations in the background radiation level.

[6] Sigma is the standard deviation of the measurement.

10.2. DESCRIPTION AND SPECIFICATION OF RADIATION DETECTION EQUIPMENT

As part of the programme to detect and respond to criminal or unauthorized acts involving nuclear or other radioactive material, the IAEA — in a joint project with WCO, Europol and Interpol — provided guidelines for the standard description and specification of various types of radiation detection equipment. These descriptions are detailed in IAEA-TECDOC-1312 [34] and in IAEA Nuclear Security Series No. 1, Technical and Functional Specifications for Border Radiation Monitoring Equipment [46]. The second publication provides a set of technical specifications that can be used in design testing, qualifying and purchasing border radiation monitoring equipment. Due to continuing advances in radiation monitoring equipment, the guidance represents a consensus on the minimum specifications that are currently achievable.

10.3. FIXED RADIATION PORTAL MONITORS

10.3.1. General description

Fixed installed pedestrian and vehicle radiation monitors are designed to be used at checkpoints such as those at road and rail border crossings, airports or maritime ports, to detect the presence of gamma and neutron radiation in order to alert the officer of the presence of nuclear or radioactive material. RPMs are the preferred option where the traffic of goods, vehicles or people can be funnelled into narrow confines, known as nodal or choke points, because of their inherently greater sensitivity over hand-held detectors or PRDs. RPMs provide high sensitivity monitoring of a continuous flow of persons, vehicles, luggage, packages, mail and cargo, while minimizing interference with the flow of traffic. Technical specifications are different for pedestrian and vehicle monitors. Any installation of automated portal monitors should be supported by additional radiation detectors and multipurpose hand-held instruments for the verification of alarms, the localization of the source and the identification of the radionuclide. The resulting information is used by initial responders to determine the adequate level of response, which depends on the type of radiation (gamma/neutron), dose rate, surface contamination and type of radionuclide. The use of suitable occupancy sensors that trigger the data collection process is essential for achieving the required low false alarm rate. It is also essential that gamma and neutron radiation levels are measured and indicated separately.

Fixed installed instruments scan pedestrians or vehicles as they pass through the area that is being screened by the instrument. Such radiation monitoring systems continuously measure the background radiation level and adjust the alarm threshold to maintain a constant statistical false alarm rate.

The monitoring distance is important in the operation of fixed installed instruments. For pedestrian monitoring, passage should be restricted in such a way that the person being screened remains at a distance of 1 m or less from the instrument. For vehicle monitoring, two pillar monitors are required and the distance between pillars should be not more than six metres. Figures 16 and 17 present the typical vehicle and pedestrian radiation monitors.

Vehicle portal monitors always have an occupancy sensor. Pedestrian monitors may or may not have an occupancy sensor. If an occupancy sensor is used, it has to be positioned in such a way that it is triggered only when the area being screened by the instrument is occupied and not triggered by individuals walking in the vicinity of the monitor.

10.3.2. Installation and operation, calibration and testing

A fixed installed radiation instrument is only as effective as the 'choke point' where it is installed. The instrument should be installed in such a manner that all pedestrians, vehicles, or cargo traffic are forced to pass through the area being monitored. When installing a fixed radiation monitoring system, the detector should be positioned so that it reaches the widest range of the defined

FIG. 16. Vehicle monitors installed at a border crossing.

FIG. 17. Typical pedestrian monitor installed at an airport.

search area. The instrument should have an unobstructed view of the whole search region. Large obstacles such as gates or walls, which could shadow the monitor, should be avoided.

The effectiveness of a fixed installed instrument is strongly dependent on its ability to measure the radiation intensity over the entire search area. A prompt response to alarms is also required as these alarms may be monitored from a remote location. Alarm indications should be in clear view of the persons staffing the inspection point. Distinct indicators of gamma and neutron alarms should be registered. Observation by closed circuit TV systems is highly recommended, particularly with a view to documenting evidence.

Fixed installed instruments must be calibrated and should be checked periodically using small radioactive sources to verify that they can detect increases in radiation intensity. A simple daily test verifies that the system is operating properly and that no repair is urgently required. Records must be kept to ensure that it can be properly used in any legal proceeding.

10.3.2.1. Pedestrian monitors

These monitors may be installed as single or dual pillar monitors. Barriers must be installed to restrict the traffic so that pedestrian passage is within 1 m of the monitor. Where pedestrian traffic corridors are wider than 1.5 m, dual pillars should be installed, but even dual pillars lose effectiveness when the distance between the pillars is larger than 4 m. The monitor should be placed away from heavy doors, which can cause too many false alarms, since effective

shielding by the doors may lead to increased fluctuations in the radiation background due to scattering.

Because of the possibility of gamma shielding in luggage and packages, these monitors are most effective when complementary information is obtained from an X ray machine to identify easily the presence of shielding material. It should be noted that X ray machines could interfere with radiation detectors such as RPMs and specialized installation measures must be taken.

10.3.2.2. Vehicle monitors

Using fixed installed instruments to scan vehicles for radioactive sources is complicated by inherent shielding in the vehicle structure and its components. While simple truck-bed monitors are effective in detecting abnormal radiation levels in shipments of metals for recycling, they are much less effective in detecting radioactive material that is being trafficked illicitly and purposely concealed. This is due to the detector geometry, which is different in the detector pillars depending on whether they are horizontal or vertical. Monitors designed to detect illicit radioactive material, which include detectors to view all areas above and below vehicles, are more effective than truck-bed monitors for this purpose.

It is important that barriers that do not obstruct the view of the monitor are installed to protect the monitor from being accidentally damaged by vehicles. It is recommended that the detectors monitor one lane only. Since the sensitivity of the monitor is also strongly dependent on the length of monitoring time, the instrument is normally placed where the speed of the vehicle is controlled and reduced. The speed of the vehicle is expected to be about 8 km/h and the vehicle should not be permitted to stop while passing through the monitor. In addition, occupancy sensors are positioned so as to be triggered only when the area being screened by the monitoring system is occupied and not by other motion in the vicinity.

10.3.3. Verification of alarms from RPMs

The first step, when a radiation alarm is triggered by an RPM, is to determine whether the alarm was real or false by repeating the measurement under the same conditions or by using another instrument. The following paragraphs explain how to proceed for the different types of instruments.

10.3.3.1. Pedestrian monitors

When the passage of an individual through a pedestrian monitor results in an alarm, the person should be passed through the same monitor a second time to see if the alarm recurs. If the alarm recurs, he/she has to be separated from the items that he or she is carrying and investigated further. At this point, a radiation survey using a PRD, RID or hand-held search instrument of the person and his/her belongings should be performed to determine the dose rate. If the radiation level is greater than 0.1 mSv/h at 1 m distance, then the source of this radiation must be promptly removed from the person and isolated. No one should be allowed in an area where the dose rate is above 0.1 mSv/h at 1 m and expert professional assistance should be requested. The value of 0.1 mSv/h at 1 m has been selected in accordance with the IAEA Transport Regulations [43].

If the radiation level is below 0.1 mSv/h, a surface scan of the individual and the items should be performed using a hand-held radiation monitor (see Appendix II). If the source of the radiation is determined to be in one of the carried items, care should be taken to ensure that the individual is not carrying an explosive device or concealing it in his/her belongings. When the source of the radiation has been located, it should be identified using a portable radionuclide identifier. If at any point in the investigation a neutron alarm is confirmed by any of the radiation instruments, which can be based on presence of nuclear material, expert assistance should be requested.

The most frequently encountered alarms at pedestrian monitors are those caused by medical outpatients who have received nuclear medicine treatment. The radionuclides may either be localized in or distributed throughout the body. Using an RID, iodine-131, thallium-201 and technetium-99m are the most frequently observed radionuclides. If, however, other radioactive material than medical is identified, expert professional assistance should be obtained immediately.

10.3.3.2. Vehicle monitors

When the passage of a vehicle through a radiation portal results in an alarm, the vehicle should be removed from the flow of traffic for further investigation. If possible, the vehicle should be passed through the same RPM again to see if the alarm repeats. If this happens or if a second passage is not possible, the driver and passengers should be removed from the vehicle and be scanned separately. At this point, a radiation survey of the individuals and the vehicle should be performed. If the radiation level is greater than 0.1 mSv/h at 1 m, expert professional assistance should be requested. If the radiation level is below 0.1 mSv/h, a surface scan of the vehicle, the driver and passengers or

other individuals should be performed using a hand-held radiation monitor in accordance with standard search techniques (see Appendix II). If a neutron alarm is confirmed, expert professional assistance should be requested. When the source of the radiation has been located, it should be identified using an RID.

For truck traffic and cargo containers, the most frequent alarms will frequently be caused by large quantities of naturally occurring radioactive material (NORM). For example, large shipments of fertilizer, agricultural produce, tobacco products, some mining ores, porcelain and timber have been known to cause innocent alarms. However, these radiation signatures are mostly uniformly distributed through the load and, therefore, may be different from the signature of a smuggled amount of radioactive material, which would be more isolated.

10.4. PERSONAL RADIATION DETECTORS

10.4.1. General description

Personal radiation detectors are small, lightweight, highly sensitive radiation monitors, which are similar in size to a message pager or mobile phone and can be worn on a belt or in a pocket for automated, hands-free operation for alerting the user. They can also be hand-held for searching close to a suspected item. Personal dosimeters are much less sensitive and are not suitable for this purpose. PRDs may also be used as an improvised, automated radiation monitor, engaging their capability to alarm and retain these readings for later review and retrieval. These instruments are particularly useful for the personal radiation safety of the officer and in patrolling large areas with few or no choke points, such as airports or maritime ports. PRDs should be issued to and worn by every law enforcement officer on duty and are ideally suited for use by first responders to a radiation alarm. In addition, they do not require extensive training to operate. Another advantage is the inherent mobility of PRDs, which allows a closer approach to a suspected radioactive source, when it is safe to do so. Figure 18 presents a few typical PRDs.

A PRD is based on a scintillation detector (caesium–iodide (CsI), sodium–iodide (NaI), or equivalent) to ensure high gamma sensitivity. It is maintenance free, of rugged construction, weather resistant and battery operated with a battery life of at least 400 hours. The alarm threshold is automatically adjusted before use to account for the natural background radiation at a particular location. A PRD normally is able to produce three

FIG. 18. Typical PRDs.

types of alarms: visual (light), audible (tone), and vibrating (silent) alarm, when the radiation intensity exceeds the alarm threshold.

For covert operation, disabling the audible alarm is possible. The audible tone changes to provide an indication of different dose rates, i.e. if the dose rate increases, then the frequency of the audible tone is also increased. A display provides a simple, luminescent indication, which again is proportional to the dose rate. These indications serve two purposes:

– Radiation safety, i.e. to warn the user of increased radiation levels;
– As a search tool for locating radioactive sources.

10.4.2. Operation

A PRD is normally worn on the body, pocket, belt or similar location. A self-testing feature can verify proper operation of the instrument before usage. False alarms will occur occasionally due to fluctuations in background radiation levels. When the alarm threshold is set properly, false alarms should not occur more than once per hour. Radiation triggering innocent alarms may

occasionally be detected by a PRD. This is due to the fact that many objects contain small quantities of radioactive material such as natural thorium, uranium, potassium-40 or radium-226. In addition, the devices provide the dose rate indication within the common dose rates with ±50% uncertainty.

10.4.3. Verification of alarms from PRDs

Following an alarm, specific actions should be taken to determine the cause of the alarm. One can confirm the alarm by moving the PRD over the person, packages, vehicle or cargo. The surface of the suspected item can be scanned by PRD at a distance of 5–10 cm. When directing the PRD to a radioactive source, the alarm becomes more intense and the biggest signal (visual, audible or vibrating) is issued from the PRD.

10.4.4. Testing and calibration

A PRD is normally tested on a daily basis for its ability to detect radiation. This can be done by placing the instrument near a radiation check source and observing a repeatable radiation level. It is recommended that the instrument be calibrated once a year by a qualified person or maintenance facility.

10.5. HAND-HELD GAMMA/NEUTRON SEARCH DETECTORS

10.5.1. General description

Hand-held gamma/neutron search instruments are battery powered and designed for high gamma and neutron detection sensitivity combined with limited size and weight to allow for hand-held operation for a sufficiently long time. Their purpose is to detect and locate gamma and neutron emitting radioactive material, either as the primary search (detection) device to search pedestrians, packages, cargo and vehicles, or as a complementary device to be used when searching for and localizing gamma neutron sources detected by an RPM. The probability of detection is increased if the user moves the instrument closer to any radioactive material that is present. In addition, it is more likely to detect radiation when the instrument is moved reasonably slowly over the area to be scanned. However, moving too slowly means that a survey takes longer, and so there is a compromise between speed and sensitivity. Searching a motor vehicle is much more difficult and time consuming, compared with searching people or packages.

Hand-held radiation monitors continuously make short measurements of the radiation level and compare the results with the alarm threshold. The most significant difference between the hand-held and fixed installed monitors is the human factor, which strongly influences the ability of a hand-held instrument to detect radioactive material in the field. Training is therefore of vital importance.

10.5.2. Operation

Hand-held instruments can be used either as the primary or secondary search device for validating a reading from a fixed installed monitor. The instrument should be equipped with an audible alarm to enable the user to perform the search without watching the device. For search applications, the instrument should have a handle that makes it easy to hold and it should be as light as possible. A gamma instrument would typically use NaI or plastic scintillator material or equivalent.

While plastic scintillators provide inherent neutron sensitivity, additional neutron detectors such as helium-3 tubes are essential for adequate neutron sensitivity and for the capability to distinguish between gamma and neutron alarms, which are possible only if two different detectors for gamma and neutrons are used.

Hand-held instruments can make measurements on short time scales of approximately 0.5 s so that they can be used to quickly scan the surfaces of packages, pedestrians, vehicles and cargo. To provide a search capability, the alarm indication either automatically resets itself every 0.2–0.5 s, or the frequency of the alarm tone is increased with the count rate. The hand-held instruments are normally tested — on a daily basis if possible — for a continued ability to detect radiation. This may be done by placing the instrument near a radiation check source and observing a repeatable radiation level. Like most radiation detectors, it is recommended that hand-held instruments be calibrated once a year by a qualified person or maintenance facility.

10.6. HAND-HELD RADIONUCLIDE IDENTIFICATION DEVICES

Modern multipurpose RIDs are available for detecting gamma and neutron radiation. These instruments can be used for searching and localizing radioactive sources and simultaneously for making gamma dose rate measurements for radiation safety purposes and indicating the neutron count/dose rate. Furthermore, these instruments can be operated as gamma spectrometers to

identify certain user defined radionuclides. For this purpose, the gamma radiation spectra are compared with gamma lines or reference spectra of frequently observed radionuclides and identified if statistically significant agreement is observed. However, these instruments are not intended for use as legal dosimeters, which may also be required. Some instruments additionally have an external, detachable alpha/beta surface contamination probe.

To qualify as an RID, its gamma spectrometer must have the following minimum features:

- Measurement of a gamma spectrum over a large energy range (not only in a few regions of interest);
- Internal processing of the spectrum to determine energy, area of gamma lines and/or the spectrum shape;
- Decision logic which evaluates either the whole spectrum or the list of gamma energies/intensities found against a library of radionuclides (either gamma spectra or a look up table consisting of energies and intensities);
- Use of decision making filters to properly assign gamma lines with similar energies, but emitted by different radionuclides, taking into account the measured peak areas and to properly identify mixtures of radionuclides and shielded samples, which produce gamma spectra with a high level of scattered gamma rays and an alteration of the observed intensities.

Hand-held instruments can be used either as the primary search (detection) device to search pedestrians, packages, cargo, and motor vehicles with a great deal of flexibility to locate the radioactive source or as a secondary search device for verifying alarms obtained with fixed installed detectors or PRDs. The neutron detection sensitivity of hand-held instruments, however, is often not sufficient to localize a weak neutron source. In this case, if a special high sensitivity hand-held neutron search/monitor device is not available, the long period timer/counter mode should be available to detect, at least, the presence of a weak neutron field. Modern instruments are required to have a computer link, which can be used to transfer the spectra to a notebook, e.g. for remote transmission to an expert team. It is essential that the instrument be equipped with a selectable audible signal indicator or optional 'silent' alarm function (e.g. with vibrating function) to enable the user to perform the search without watching the display. The audio and visual indications need to be clearly distinct for gamma and neutron radiation. Many of the characteristics in the search mode are similar to those of PRDs. Figure 19 presents a few typical RIDs.

For effective searching, the RID is self-contained (no external detectors or cabling, except surface contamination monitor), rugged and weighs less than

FIG. 19. Typical hand-held RIDs.

3 kg. It has a comfortable, ergonomically designed carrying handle to allow for single-handed operation for extended periods while wearing gloves.

10.7. RADIONUCLIDE IDENTIFICATION

Most of the radionuclides likely to be encountered at borders can be identified by instruments capable of identifying spectra consisting of gamma ray energy peaks between 30 keV and at least 3 MeV. The radionuclides of greatest interest and those most likely to be encountered are listed below in increasing isotopic number. Radionuclides should be identified by the individual radionuclide and the relevant category, i.e. nuclear, medical, industrial and NORM. For uranium, plutonium and radioactive iodine, it is sufficient to display the element and category only. Multipurpose RIDs are capable of identifying all relevant radionuclides including:

– **Nuclear material:** ^{233}U, ^{235}U, ^{238}U; also recycled (covering HEU, LEU, natural uranium (NU), depleted uranium (DU)), ^{237}Np and ^{239}Pu (ranging from reactor to weapons grade).
– **Medical radionuclides:** ^{18}F, ^{67}Ga, ^{99m}Tc, ^{111}In, ^{123}I, ^{125}I, ^{131}I, ^{133}Xe, ^{201}Tl, ^{51}Cr and ^{103}Pd.
– **Industrial radionuclides:** ^{57}Co, ^{75}Se, ^{60}Co, ^{133}Ba, ^{137}Cs, ^{192}Ir, ^{241}Am and ^{152}Eu.
– **NORM:** ^{40}K (fertilizer, kitty litter, tiles, ceramics), ^{226}Ra (in equilibrium with daughters), ^{232}Th and decay products, and ^{238}U in NU and its decay products (e.g. in Fiesta ware or coloured glass).

10.8. DETECTION STRATEGY FOR DEPLOYMENT OF BORDER MONITORING EQUIPMENT

In general, governments adopt a radiation detection strategy based upon the assessed threat of criminal or unauthorized acts or inadvertent movement of radioactive material. In some cases, where the level of assessed threat is very low, the strategy on the use and deployment of radiation detection equipment is that it will only be used in response to a specific report or other information. In other countries, where a high level of assessed threat is present, the policy is to adopt a wide-ranging monitoring programme in which all border crossing points, maritime ports and airports are screened by the deployment of fixed installed RPM systems. Mobile equipment could be used as well for random search or target vehicles.

The deployment and use of border radiation detection equipment should be based upon the national design basis threat. The factors that may be considered when deciding upon a strategy with regard to the use of radiation detection equipment are the:

– Type and quantity of material to be detected;
– Capability of law enforcement personnel to operate radiation detection equipment and to respond to alarm activations;
– Number of border crossing locations, maritime ports or airports to be screened;
– Volume of traffic entering or leaving the country;
– Volume of domestic traffic between installations that store or use radioactive material;
– Number of illicit trafficking cases disclosed within the country and its immediate neighbouring countries;
– Financial implications of the various policy options.

The topography of particular sites will also determine the types of radiation detection equipment that should be used. In general, if vehicles or passengers can be channelled through a choke point, i.e. they can come through a control area in single file, then fixed installed RPM systems are probably most useful. In places where operations are conducted on a widely dispersed area, it is more suitable to use PRDs or hand-held search instruments.

Detection equipment can be affected by environmental factors, factors such as radiofrequencies and severe weather can cause equipment malfunction. Extreme weather, in particular, can pose problems for equipment. Such malfunctions may make these instruments temporarily or permanently unusable.

11. RESPONSE MEASURES

This section describes the response arrangements required for threats or actual cases of potential criminal or material. However, it does not cover all response arrangements that should be included in a comprehensive response programme. For example, this publication does not describe emergency response measures or detailed forensic methods since an emergency response is typically needed *after* an event of criminal or unauthorized acts has evolved into radiation exposure of the public and/or the environment.

National response arrangements should be developed consistent with IAEA standards and guidelines. This can be accomplished by establishing an infrastructure incorporating response plans, emergency preparedness and radiation protection into fully integrated national and local response plans. Detailed guidance on developing a capability to respond to radiological emergencies can be found in a variety of IAEA publications [39, 47, 48].

11.1. RESPONSE PROCESS AND SCREENING

Within the context of this publication, the term 'response' means the collection of actions recognized as necessary to respond to alarms, threats and detection of criminal or unauthorized acts involving nuclear and other radioactive material, including the process for notification, radiation protection, collection of evidence and prosecution. In order to implement proper measures for response to criminal or unauthorized acts, the process

involves detection, confirmation, identification, assessment of the situation, and the taking of appropriate steps to protect the health of the population and secure the material.

When an alarm is activated, as a result of detection by radiation monitoring instruments, the front line officer should report the circumstances to the on-duty supervisor, providing as much information as is immediately available. From initial observations at the scene, the front line officer should be able to provide the following information:

– Radiation measurements;
– Presence of packages bearing radiation warning symbols;
– Type of packaging of the nuclear or other radioactive material;
– Condition of the packaging and whether it appears damaged or breached;
– Any labelling or other information to indicate the nature of the suspected nuclear or other radioactive material;
The fact that there is no readily discernible reason for the alarm.

For this purpose, equipment and standard operating procedures are put in place for the screening of individuals, vehicles, cargo, mail, luggage, and other commerce. The standard operating procedures describe how individuals and commerce are screened for radioactive material. Appendix II presents a generic procedure for search techniques for pedestrians, packages and vehicles.

Radiation alarms are observed on a routine basis during screening. The vast majority of these alarms are handled in a routine manner. This routine handling usually involves secondary processing out of the flow of commerce to verify the presence of radiation. When the presence of radiation is verified, the response is to determine if it is due to naturally occurring radioactive material, medical radionuclides in individuals, or legitimate commercial sources. In such cases, barring any other administrative discrepancies, the individual or commerce can be allowed to proceed.

If an abnormal situation arises that cannot be handled routinely, the initial response is to further investigate the situation, including potentially 'reaching back' to a support organization where greater expertise exists than is available locally. This reach-back process may involve multiple layers of experts, ultimately resulting in the potential for an emergency response if warranted.

11.2. RESPONSE REQUIREMENTS

Response measures are either reactive or proactive, depending upon the circumstances of each incident. In general terms, discovery or disclosure of an unauthorized act requires an immediate reactive response, while intelligence based reports of a similar nature require a proactive response.

A proactive response will be required in the following circumstances:

- Discovery of discrepancies in the inventory of nuclear or other radioactive material;
- Receipt of information suggesting illicit trafficking activity in nuclear or other radioactive material;
- Indications that radiation sickness is occurring;
- Other indications of radiation of an unknown origin.

A reactive response will be required in the following circumstances:

- Detection of unauthorized or uncontrolled radioactive material by means of a radiation monitoring programme;
- Notification of radioactive material having been found in an unauthorized location;
- Notification of an object suspected of containing radioactive material;
- Notification of an incident involving, or suspected of involving, radioactive material;
- Discovery of a discrepancy between a customs declaration form and the corresponding shipment of nuclear or other radioactive material.

11.3. SCALE OF RESPONSE

An assessment of previous incidents has shown that diverse situations, ranging from illicit possession of small quantities of radioactive material, which is relatively harmless, to the possession of and trafficking in weapons grade nuclear material, may pose a serious security threat. Events involving serious health hazards or effects have also occurred. Regardless of the severity of the incident, the overriding considerations should be to:

- Minimize any potential health hazards;
- Bring the nuclear and other radioactive material under appropriate control;
- Investigate, gather evidence and prosecute offenders;

— Address public concerns.

The scale of the response should be consistent with the severity of the situation. Where there is no significant health hazard, security implication or proliferation threat, the operational response of front line officers should suffice, assuming that there is no health hazard and the routine response mechanisms of their respective local authority can deal with the incident simply and effectively.

A serious incident requires a more elaborate and extensive response mechanism. It is therefore appropriate to consider a flexible approach.

11.4. ALARM VERIFICATION

Instruments that can cause alarms are radiation pagers/search detectors, border portal monitors, or other equivalent detectors. Figure 20 presents a flow chart for the general alarm response scheme. An alarm triggered by an instrument can be of three main types:

— False alarms;
— Innocent alarms;
— Confirmed non-innocent alarms.

11.4.1. False alarms

When an alarm is activated by the radiation detection instrument itself, perhaps owing to an electrical fault or other internal breakdown, the alarm is called a *false alarm*. An example of a false alarm is an alarm without the presence of radioactive material within the detection parameters of the instrument. False alarms could be caused by nearby radio frequency interference or by misuse or malfunction of the instruments.

11.4.2. Innocent alarms

Innocent alarms refer to an actual increase in radiation level in the search area. This type of alarm can involve radionuclides detected in persons that have had medical treatment/examination or in cargoes with NORM, or in legal shipments of radioactive material. In fact, solar flares can cause a temporarily increased background level of radiation that can activate an alarm.

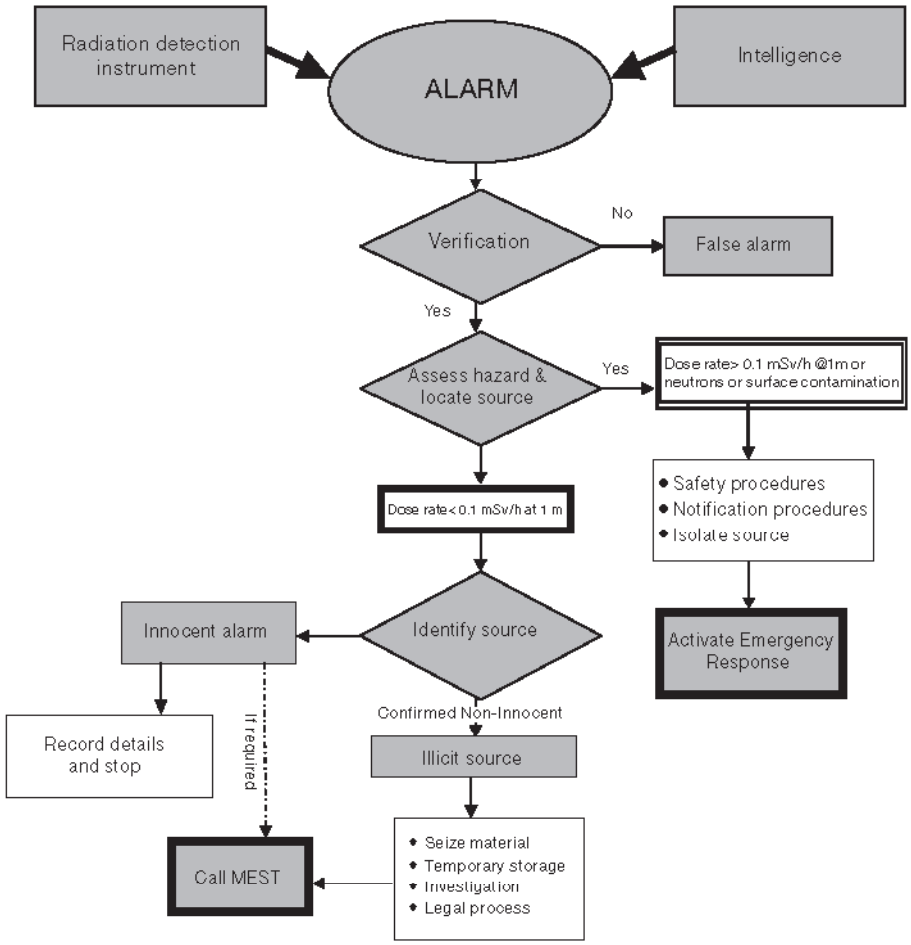


FIG. 20. General alarm response.

Examples of innocent alarms which may need decision support from experts include:

– Green glass containing uranium;
– Optical lenses with thorium;
– Video screens with thorium;
– Gas lantern mantles with thorium;
– Watches and other measuring instruments containing radium;
– Fertilizer and kitty litter, etc., containing potassium-40;
– Ceramics containing uranium and thorium;

– Welding rods containing thorium;
– Tailings from the oil industry or desalination plants containing radium-226 and thorium;
– Scrap metal shipments that are otherwise harmless in terms of not being transported with malicious intent;
– Solar flares.

In some cases, those involved in criminal or terrorist activities can orchestrate innocent alarms in order to test the capability of equipment and procedures.

For truck traffic and cargo, the most frequent radiation alarms will be caused by large quantities of NORM. Note that most NORM contains several radionuclides, not all of which might be identified by the use of a spectroscopic device such as an RID (see section 10). The radiation signature of NORM is mostly uniformly distributed through the load and, therefore, is different from the signature of a smuggled amount of radioactive material, which would be more isolated.

11.4.3. Confirmed non-innocent alarms

Confirmed non-innocent alarms refer to the actual increase of radioactivity in the search area. Once a designated expert has confirmed that an alarm is non-innocent, the situation constitutes an incident. The expert will, accordingly, serve as the first responder at the scene. In such cases, the incident should be considered as a crime scene and as such the rules of evidence should be followed before any agency or team is allowed onto the scene.

11.5. SAFETY CONSIDERATIONS

If the dose rate is above 0.1 mSv/h at 1 m, or neutron or surface contamination is present, it is essential that the suspected radioactive material be isolated and the scene cordoned off until a member of the expert support team or the radiological assessor arrives. The IAEA Manual for First Responders to a Radiological Emergency [48] provides guidelines for assessment of the situation and for establishment of the cordoned area.

Regardless of the scale of the incident, response personnel must always be aware that there may be hazards associated with an incident involving nuclear or other radioactive material. In such cases, the safety of response personnel and of the general public is of paramount importance and the procedures to mitigate health hazards to themselves and the public should be

followed. Ref. [48] provides personnel protection guidelines that should always be followed when a radiological hazard is suspected.

Only a qualified radiological assessor can adequately assess the hazard presented by the radioactive material. As soon as possible, response activities should be subject to international standards to monitor and control the dose rate of the material as established by the radiological assessor.

11.6. EXPERT ADVICE

The use of radiation detection equipment requires specialized training and technical knowledge. In the event that front line officers are unable to verify the alarm and conduct an initial radiological assessment, or deem that they require assistance, they should inform their on-duty supervisor. In many circumstances, a designated expert is available at national borders, but if not, the on duty supervisor may call specialists on a 24 hour/day basis for assistance by following established procedures. These specialists are qualified to verify the alarm and assess the radiological hazard of the situation. In addition, there must be provisions to obtain immediate advice (over the phone or otherwise) from other national authorities for managing serious incidents and routine incidents when there is any doubt or ambiguity in making the initial hazard assessment. Any such deployed specialists should have training in crime scene management and forensic rules of evidence.

11.7. MOBILE EXPERT SUPPORT TEAM

It is recommended that a country establish one or more mobile support teams that can provide support to responders. In this publication, this will be referred to as a mobile expert support team (MEST). A MEST should include a person equipped and trained to use basic radiation monitoring instruments and perform simple assessment tasks. The MEST should also include a forensic evidence management team (FEMT) or at least have team members who are trained in crime scene management and classical forensic science. Examples of incidents requiring the support of the MEST include:

- A medical radionuclide in a person with a dose rate exceeding the national permitted limits;
- A medical radionuclide not in a person, or incorrect shipping documents;
- NORM in a shipment with a dose rate/activity exceeding national permitted limits;

– Neutrons detected and confirmed;
– Low levels of surface contamination;
– Transport of nuclear and other radioactive material without shipping documents or incorrect radionuclide/TI or labelling;
– A dose rate >0.1 mSv/h at a distance of 1 m (national regulations may deviate from this).

If there are indications that the situation represents a significant radiological hazard [48], a qualified radiological assessor/team should be called and the emergency response should be undertaken within the incident command structure.

The main responsibility of the MEST for detection/response is to provide timely expert support services. If responders are not supported by timely MEST services, they may feel insecure and reduce the sensitivity of the detection equipment to avoid weak alarms, or may fail to follow detection response procedures properly. Furthermore, front line officers can proceed with the categorization of a source based on inaccurate results. Without timely support from MEST, the categorization may be inconclusive (e.g. verified radiation alarm, but undetermined radionuclide/category) or wrong conclusions may be drawn. As a result, the illicit trafficking of radioactive material may occur and go undetected.

Additional MEST functions could include:

– National training in equipment used for the detection of criminal or unauthorized acts involving nuclear and other radioactive material;
– Project support (e.g. installation and operation of border monitoring equipment in the country);
– In accordance with national regulations, a link to international (e.g. IAEA) or regional nuclear forensic experts and laboratories for the in-depth characterization and determination of the origin of the material seized;
– Equipment support (from purchase to maintenance);
– Measurement technology support (liaison with vendors, recalibration);
– Expertise in the legal process (if proceedings arise, e.g. after a seizure of radioactive material);
– Measurement support for special cases (e.g. pre-event radiological surveys and background mapping, characterization of suspected RDD, support of security services, search and detection of uncontrolled sources).

11.8. INTERNATIONAL ASSISTANCE

If required response measures go beyond national capabilities, international assistance may be requested through the IAEA. In this context, it is important that the arrangements for response to nuclear security related events are integrated with national incident and emergency response arrangements, as outlined in Ref. [48].

In order to meet its legal responsibilities under the Assistance Convention, the IAEA Secretariat is prepared to respond appropriately and efficiently to any incident or emergency situation that may have actual or potential radiological consequences to health, property or the environment and which would require urgent IAEA involvement. In addition, it is in the position to respond to requests for emergency assistance. To address these issues, a 24 hour warning and operational focal point has been established — the IAEA Incident and Emergency Response Centre (IEC) — which: (a) maintains a 24 h/7 d alert and coordination structure for emergency requests for assistance; and (b) using arrangements established within the Secretariat and with competent authorities, facilitates the management of a rapid coordinated response by the IAEA to situations that may give rise to radiological consequences, irrespective of their cause.

11.9. ROUTINE RESPONSE

If radiation detection equipment alarms, and or intelligence is received to suggest that a case of illicit trafficking is to take place or law enforcement authorities have conducted a stop and search procedure leading them to suspect the presence of radiation, the following should be considered:

— Confirm that the alarm is genuine by following a pre-planned verification procedure. This might involve the use of a second set of monitoring equipment or by passing the suspected material through the detection equipment two or more times. If these procedures confirm that the alarm is false, the incident can be closed by recording the details for future reference. Appendix II suggests a detailed procedure for searching pedestrians, packages and vehicles. In some circumstances it may be necessary to bring in additional specialists to make the necessary diagnosis to establish a false or confirmed non-innocent alarm. Details of such experts and resources should be available to the first responder as a result of prior arrangements with the identified experts.

– Ascertain that any intelligence is credible and the information received as part of that intelligence is genuine. If it is confirmed, contact and inform the designated national authorities and set up a line of communication. If it is unconfirmed, the case can be closed by recording the details.
– If the source is discovered and there is no significant health hazard, then the competent person designated as being in charge should first ascertain whether it is an innocent alarm, such as an authorized shipment or an innocent person that has been receiving radiological medical treatment.
– In cases in which it has been confirmed that the incident is an innocent alarm, it is prudent to estimate whether the event was orchestrated in order to 'test' the detection capabilities of a particular border or other guarded pathway. Experience has shown that organized criminal groups involved in the trafficking of contraband will test security at border crossings to identify weak spots before attempting to breach the security system.

  Until such time as a complete radiological assessment is made, first response personnel must take precautions to avoid contact with the radioactive material and to follow the general personnel protection guidelines given in Ref. [39].
– Should the presence of radioactive material be confirmed, and the level of radiation is below 0.1 mSv/h, then assess:
  - all possible hazards including fires, exposed high voltage wires, sharp or falling objects, or hazardous chemicals;
  - transport placard(s)/labels/markings indicating radioactive or other hazardous material and UN numbers;
  - the presence of people at risk.

Always consider the possible malicious nature of the incident and be aware of the possibility of so-called 'booby 0traps' and secondary devices.

Place cordons around the scene. The incident should be treated as carefully as a crime scene and as such, collection of evidence needs to carefully documented. The FEMT must be consulted and a strategy for entry into the scene and for any examination of the scene needs to be developed to prevent the unnecessary loss of evidence.

– If the situation allows, the first responder should establish the location of the radioactive material. At this stage, it is sufficient to determine the general location of the radioactive source without knowing its exact location. That is, it would be acceptable to determine that the radioactive source was confined to a piece of luggage, to a vehicle or to something such as a large commercial container in which the material could be

isolated if the situation proved to be hazardous. The location of the radioactive material should be determined, if possible, without opening the container or object holding the material.

- If it has been established that there are no significant radiological health hazards associated with the incident, the expert should attempt to identify the radioactive material. This can be accomplished through examination of shipping papers, package markings or with the use of a suitable hand-held gamma spectrometry device. At this stage, it is possible that the suspected radioactive source may be found to be lawfully possessed or non-radioactive, in which case the details of the situation should be recorded and the response terminated.
- If there is evidence of a criminal or unauthorized act, then the agency responsible should seize the persons, material and evidence with the aim of prosecuting those responsible. All items connected with the incident are to be considered as evidence, including packaging, vehicles, suspect clothing, and as such the rules of evidence shall apply.
- Any radiation measurements taken from a suspect or innocent victims including response workers must be recorded following the rules of evidence as these measurements may become vital prosecution evidence at a later date. An assessment of previous incidents has shown that the majority are of an inconsequential nature with little or no radiological hazard. Such incidents can be dealt without the necessity to activate an emergency response plan.

11.10.EMERGENCY RESPONSE

The duty supervisor or the designated mobile expert support should consider the scale of situation. If it comes within the scope of a potential or actual dangerous radiological incident, the duty supervisor or the designated MEST should activate the emergency response plan if she/he has authority to do so or, if necessary, seek authorization from a designated senior officer. When a dangerous radiological situation develops, according to the severity of the potential or actual event and in particular when a health hazard is identified or an RDD is suspected, then an immediate response should be initiated as outlined in Ref. [48]. This should include some or all of the following steps:

- Consider the possible malicious nature of the event and be alert to the risk of so-called 'booby traps' and explosive devices.
- If the presence of an RDD is suspected or the contamination of an area or dispersion of radioactive material has occurred, assume that a radio-

logical hazard is present until the radiological assessor performs a conclusive negative assessment.

- Isolate, evacuate and rescue the injured from the potentially hazardous area and implement other appropriate actions using public protection guidelines. It should be noted that even in extremely high radiation fields, limited stays (minutes) for life saving activities should not result in serious injuries.
- Provide first aid to the seriously injured and arrange transport to medical facilities.
- Notify local and national authorities.
- Attempt to gather potentially exposed or contaminated, but uninjured, people (such as drivers or passengers) in a safe and secure location (public processing/registration area) to be properly identified and registered and to await medical and radiological evaluation.
- In safe and secure locations, gather people who may have information useful to a criminal or safety investigation, who will be interviewed by personnel of the appropriate services.
- Treat the area as a crime scene and prevent the destruction of evidence.
- Determine if people/facilities may have been exposed or contaminated during movement of the radioactive material prior to discovery.
- Inform emergency services of any items or personnel that have left the facility without being monitored to determine if they are contaminated.
- Notify the public information officer that is responsible for handling this kind of emergency.
- Do not disturb the scene, except to perform life saving actions and to prevent catastrophic conditions, until the radiological assessor has fully assessed all the hazards and the law enforcement/security team and forensics have released the scene.

As outlined in Ref. [48], the entire response should be fully integrated using an incident command system under an incident commander at the site.

11.11.CLASSICAL AND NUCLEAR FORENSICS

While classical and nuclear forensics share the same name of *forensics*, their respective aims can conflict with one another. If one were allowed to override the other, there could be a total loss of a significant part of the forensic evidence available to the investigators. For example, when a radioactive item is sampled to identify the origin, swabbing the whole of the item for the sake of convenience will destroy any other evidence, such as fingerprints and DNA.

Classical forensics is a form of science used in the field of criminal investigation. It is an accepted practice of scene examination that has been adopted in countries throughout the world. Nuclear forensics is the process of determining the origin, method and time of the production of radioactive material and includes the ability to cross-match with other seized radioactive material.

When an item has been recovered from a situation involving an unauthorized act, it is essential for the item to be subjected to forensic examination, both classical and nuclear. If this is going to be undertaken at the scene, then an FEMT needs to be established. This will be a group made up of qualified individuals taken from those agencies involved in the recovery of evidence from the scene, such as law enforcement/customs, radiological assessors and environmental experts. For small incidents this would be organized at a local level, but for any substantial recovery or incident, the formation of this team would be essential.

The purpose of the FEMT is to examine the scene, recover any evidence and register all operations, both on paper and with photographic and film documentation. An additional task is to address and deal with all conflicts that will arise during the evidence recovery phase. Past incidents have shown that without this, group conflicts quickly arise and result in time delays and the loss of vital evidence.

In addition, data held in the international catalogue of sealed radioactive sources [49] — a database for radioactive sources, devices and manufacturers to identify abandoned or disused radioactive sources — can be used to find clues as to the identity of an unknown source such as what the radioactive source looks like. It also gives information on devices, their manufacturers and suppliers. The catalogue delivers the identity of the most likely source or device, and is available to the points of contact to IAEA Member States.

11.12.TRANSPORT AND STORAGE OF RADIOACTIVE MATERIAL

This response operation must also include the transport of contaminated items. The risk of contamination must be eliminated before the material can be removed. Afterwards, the items must be transported in conformity with the provisions of national safety standards and with IAEA safety standards in the Transport Regulations [43]. There may be an occasion when the transport of the item does not satisfy all of the applicable requirements of the Regulations. In that case, the regulatory body responsible for transport safety may authorize transport under special arrangements.

Appropriate locations should be foreseen for the temporary storage of seized material. When transporting and temporarily or permanently storing

radioactive or nuclear material, including contaminated items, the rules of evidence must be followed as far as safety will allow. This material will undoubtedly form part of the evidence in any criminal proceedings, so it is important that the continuity and integrity of the evidence is maintained. For example, the items will need to be escorted from the scene to the storage area to provide continuity. While in storage the items will need to be secured and any access to them by authorized personnel will need to be recorded to maintain their integrity.

During the process of transport and storage, it is the responsibility of all involved to prevent the unnecessary loss of evidence. Security and safety must be the first priority, but all precautions to minimize the loss of vital forensic evidence must be taken (e.g. the wearing of gloves while handling items and, if possible, the wearing of paper suits to prevent cross-contamination of fibres and DNA with recovered evidence). Response workers involved in this phase of operations should have some form of forensic awareness training.

In order to ensure the security of seized material, proper measures must be applied to the storage location.

11.13.CONTROL OF POTENTIALLY CONTAMINATED SUSPECTS

The control of suspects poses additional difficulties to those typically encountered in a criminal situation. A suspect may have been in close proximity to the radioactive source and have become contaminated. The arresting officers may themselves become contaminated through their contact with the suspect. There may be health hazards to both the suspect and the arresting officers arising from this contamination.

Possibly contaminated suspects and any official personnel who have been in contact with them need to follow the general protection guidelines given in Ref. [48]. In general, all readings and findings related to a suspect are considered as vital evidence and, as such, the rules of evidence should be followed. If contamination of suspects is confirmed, then the suspects and those who have been in contact with them need to be decontaminated.

11.14.INITIAL LEGAL EVALUATION

If it is determined that the incident may involve a criminal act, the first responder should take measures to gather and preserve evidence that may be used in a future prosecution. These measures should include the traditional considerations of record keeping, preservation of evidentiary integrity and

chain of custody. As promptly as possible, authorities responsible for further legal action should be notified.

11.15.PROSECUTION OF OFFENDERS

As previously discussed (for example, in Sections 3 and 9), it is important that States take prompt and effective measures that are consistent with their own national laws and procedures to prosecute persons who engage in criminal acts. Trafficking incidents very often involve the international movement of material thus potentially involving the laws of more than one State. In such cases, there will be a need to cooperate between national authorities.

Further information on cross-border cooperation and the assistance available to deal with international incidents of criminal or unauthorized acts involving nuclear and other radioactive material may be obtained from the WCO, Europol, Interpol and IAEA.

11.16.TRACING SEIZED MATERIAL

Most nuclear and other radioactive material involved in criminal or unauthorized acts has been diverted from its legal possessors and control as the result of theft, loss, illegal transfer or carelessness. Accordingly, there is an investigative need to trace seized material through the chain of possession. Identification of the source of the material is crucial to future prevention efforts to improve physical protection at the originating facility.

Extracting as much information as possible from material seized in a criminal context, together with information about the perpetrators of criminal or unauthorized acts, may also help contribute to an analysis of the flow of radioactive material into and through illegal markets. Collecting high quality information on material and its origins can allow for patterns in such activity to become more visible. Nuclear forensics and nuclear interpretation have become increasingly important tools in determining the source of contraband radioactive material.

The tracing and analysis of seized material may:

- Reveal useful investigative facts in specific criminal investigations;
- Connect crimes, seized material and persons to criminal investigations within countries and across international borders;
- Create useful analytical information to better understand the flow of the illicit market and to capture such substances before they are misused.

11.17.MEDIA LIAISON

An incident involving unauthorized act in nuclear and other radioactive material will almost certainly attract the attention of the news media. This is particularly the case if there are radiological hazards associated with the incident. Representatives of the media are likely to be present at the scene of the event and may broadcast their coverage even before the full mobilization of the response personnel occurs.

It is important that personnel at the scene are aware of the potential for rapid media response and should make arrangements for the reception, assembly and control of media personnel as soon as possible. The incident commander should establish a single focal point for briefing the media and informing the public, a public information centre needs to be established and a public information officer appointed to ensure that information is consistent, and hence to avoid confusion and maintain credibility. The public information officer could be part of the incident command system, as described in Ref. [18].

The press must not be allowed unrestricted access to the scene. Instead, the issue of regular bulletins to mediapersonnel will keep them updated on the facts as the response progresses. This allows them to do their work without having to make repeated inquiries. It should also ensure that media personnel do not hinder the work of the incident commander.

Appendix I

STATISTICS ON ILLICIT TRAFFICKING INCIDENTS AND SELECTED CASES

The IAEA has been maintaining the ITDB since 1995. The ITDB is the only collection of State confirmed information on incidents of illicit trafficking and other unauthorized activities involving nuclear and other radioactive material. By December 2006, 95 Member States were participating in the ITDB programme and reporting incidents.

The scope of information in the ITDB covers incidents involving unauthorized acquisition, provision, possession, use, transfer or disposal of nuclear and other radioactive material, whether intentional or unintentional, and with or without crossing international borders. It also covers unsuccessful or thwarted acts of the above type, the loss of material and the discovery of uncontrolled material.

I.1. AGGREGATE NUMBERS

As of 31 December 2006, States had reported a total of 1080 incidents of illicit trafficking and other unauthorized activities involving nuclear and other radioactive material to the ITDB. Of these, about 25% involved nuclear material and about 70% other radioactive material, mainly sealed radioactive sources. The remainder involved radioactively contaminated and other material. Figure 21 shows the distribution of incidents reported to the ITDB between 1993 and 2006 by type of material. In addition, there are numerous incidents reported in open sources which have not yet been confirmed or otherwise commented on to the ITDB by the States concerned.

I.2. INCIDENTS INVOLVING CRIMINAL ACTIVITY

Of the incidents reported by States, about 54% show evidence of criminal activity, such as theft, illegal possession and attempts to sell or smuggle nuclear or radioactive material across national borders. The number of such incidents reported declined sharply between 1994 and 1996, but since then it has been gradually increasing.

Thefts have involved primarily sealed industrial radioactive sources, e.g. sources used in gauges or radiography devices. Reports of theft have been

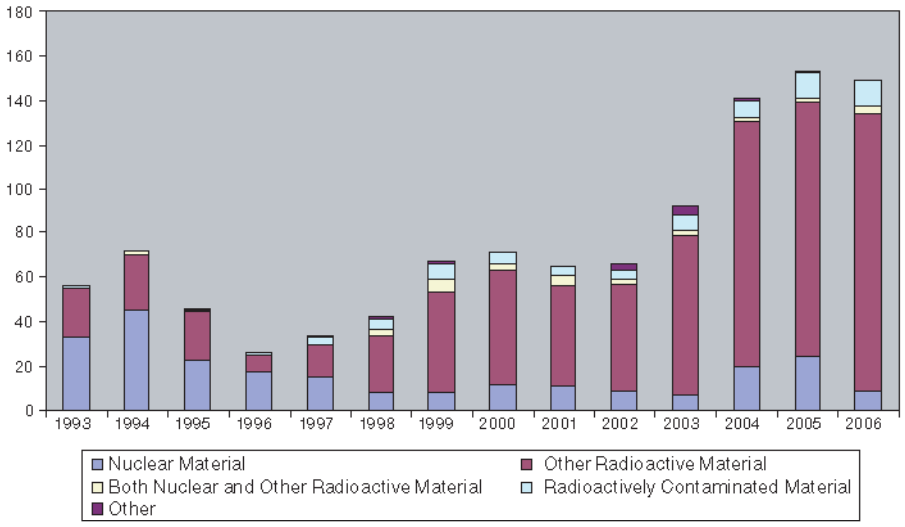


FIG. 21. Incidents confirmed to the ITDB (1993–2006).

gradually increasing since 1998. The intentions and motives behind the thefts are very difficult to determine. Sealed sources and the devices in which they are used are attractive to thieves both because of their intrinsic value and because of the value of the shielding and encapsulating metals used to protect the user against radiation. It is noteworthy that in about 60% of the cases the stolen material was not subsequently reported as recovered.

Information on incidents involving illegal possession shows predominantly opportunistic and amateurish activities. As a result of unprofessional methods usually used to smuggle and offer the material for sale, such activities are more susceptible to detection. Well-organized trafficking networks using established channels for smuggling in other illegal goods will be more difficult to detect and interdict.

Nuclear trafficking activities reported to the ITDB appear to have been mainly supply driven. In other words, the trafficking process was initiated by sellers with no pre-identified buyer. Cases show that traffickers become very vulnerable to interdiction when soliciting buyers, hence law enforcement and intelligence authorities were able to detect and foil trafficking operations in many cases. Trafficking with a pre-identified buyer would be less susceptible to detection.

There is clearly a demand for nuclear and other radioactive material. In most of the trafficking incidents for which information was available, the

perpetrators believed that the material they sought to sell had high value and thus could be sold on the illegal market for a substantial amount of money. In the overwhelming majority of such cases, however, this perception proved to be unfounded.

Only a few cases have been reported where buyers existed. The small number of such cases limits the potential for drawing broader conclusions. It is noteworthy, however, that malicious use and attempts to acquire nuclear and radioactive material for such purposes have been recorded.

There have also been cases when perpetrators intentionally distorted information on the material offered for sale, hoping to profit from the naivety and technical incompetence of a potential buyer. Such hoaxes or confidence tricks have, over the years, involved a broad variety of material, from LEU fuel pellets to non-radioactive material, which were offered for sale as weapons grade HEU or plutonium (Fig. 22).

I.3. INCIDENTS INVOLVING HEU AND PLUTONIUM

Illicit trafficking in HEU and plutonium is a matter of grave concern. In the hands of terrorists or other criminals, such weapons usable material may contribute to the construction of an IND.

As of 31 December 2006, Member States had reported a total of 13 incidents involving HEU to the ITDB. In addition, in January 2007, Georgia reported the seizure of 79.5 g of 89% HEU in Tbilisi in February 2006. Table 2 summarizes the reported incidents involving HEU.

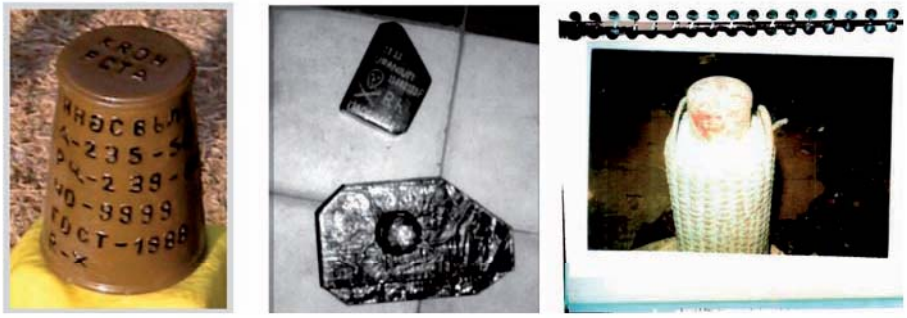


FIG. 22. Objects such as those pictured above have been offered for sale in various parts of the world purporting to be HEU, plutonium, bomb grade nuclear material, or nuclear warheads.

TABLE 2. INCIDENTS INVOLVING HEU AND Pu CONFIRMED TO THE ITDB, 1993–2006

Incidents involving HEU			
Date	Location	Material involved/ quantity	Incident description
1993-05-24	Vilnius, Lithuania	HEU/150 g	4.4 t of beryllium, including 140 kg contaminated with HEU, were discovered in the storage area of a bank.
1994-03	St. Petersburg, Russian Federation	HEU/2.972 kg	An individual was arrested in possession of HEU, which he had previously stolen from a nuclear facility. The material was intended for illegal sale.
1994-06-13	Landshut, Germany	HEU/0.795 g	A group of individuals was arrested for illegal possession of HEU.
1994-12-14	Prague, Czech Republic	HEU/2.73 kg	HEU was seized by police in Prague. The material was intended for illegal sale.
1995-06	Moscow, Russian Federation	HEU/1.7 kg	An individual was arrested in possession of HEU, which he had previously stolen from a nuclear facility. The material was intended for illegal sale.
1995-06-06	Prague, Czech Republic	HEU/0.415 g	An HEU sample was seized by police in Prague.
Incidents involving HEU and Pu			
Date	Location	Material involved/ quantity	Incident description
1995-06-08	Ceske Budejovice, Czech Republic	HEU/16.9 g	An HEU sample was seized by police in Ceske Budejovice.
1999-05-29	Rousse, Bulgaria	HEU/10 g	Customs officials arrested a man trying to smuggle HEU at the Rousse customs border checkpoint.

TABLE 2. INCIDENTS INVOLVING HEU AND Pu CONFIRMED TO THE ITDB, 1993–2006 (cont.)

Incidents involving HEU			
Date	Location	Material involved/ quantity	Incident description
2001-07-16	Paris, France	HEU/0.5 g	Three individuals trafficking in HEU were arrested in Paris. The perpetrators were seeking buyers for the material.
2003-06-26	Sadahlo, Georgia	HEU/~170 g	An individual was arrested in possession of HEU while attempting to illegally transport the material across the border.
2005-03 to 2005-04	New Jersey, USA	HEU/3.3 g	A package containing 3.3 g of HEU was inadvertently disposed of.
2005-06-24	Fukui, Japan	HEU/0.0017 g	A neutron flux detector was reported lost at a nuclear power plant.
2006-02-01	Tbilisi, Georgia	HEU/79.5 g	A group of individuals was arrested trying to illegally sell HEU.
2006-03-30	Hennigsdorf, Germany	HEU/47.5 g	Authorities discovered trace amounts of HEU on a piece of tube found amidst scrap metal entering a steel mill.

The majority of these incidents involved illegal possession of HEU often accompanied by smuggling activities and attempts or intent to sell the material. Although the number of the reported incidents involving HEU has been relatively small and the quantities seized have been below one SQ[7], there is a possibility that in some cases the seized HEU could represent samples of larger quantities available for purchase or at risk of theft. These larger quantities may still remain in circulation and available for illegal deals or be in the possession of groups with malicious intent.

[7] Significant quantity: the amount of nuclear material sufficient to make a nuclear explosive device.

In most cases, the seized HEU had not been previously reported as stolen. If a failure to detect the theft was the reason, this may indicate that more HEU has been stolen than recovered. The additional HEU may remain in illegal circulation.

In the majority of incidents, Pu was in the form of fabricated sources, such as smoke detectors or Pu/Be neutron sources which contain trace amounts of ^{239}Pu. While Pu used in such sources is not directly suitable for use in an IND, trafficking in this material still warrants attention. In several cases, Pu sources were offered for sale. This may point to a real black-market demand for Pu, or nuclear material in general, which the perpetrators attempted to service with material of lesser consequence.

I.3.1. Examples of trafficking cases

The summaries of the cases below combine information reported to the ITDB by Member States and information which was obtained from open sources. An effort has been made to verify the accuracy of the open source reports. A full assessment of each case is, however, difficult without State confirmed information on all salient aspects.

Case 1

Location: Prague
Date: 14 December 1994
Material: 2.73 kg HEU (87.7% ^{235}U)

According to press reports, a group of individuals, including a trader, a former nuclear physicist, and an owner of a small transportation company, brought HEU into the Czech Republic for sale in 1994. The perpetrators, who were allegedly under pressure from a criminal group, were not able to find buyers for months. Finally, on 14 December 1994, they went to a restaurant in Prague to give a sample of HEU to a potential buyer. After the potential buyer left, they were arrested and nearly 3 kg of HEU was found in the back seat of their car. The police allegedly acted on a tip from an anonymous caller. The material was in plastic bags placed inside several lead containers. In the course of the investigation, it was ascertained that the material had been brought by train from abroad.

Later in June 1995, samples of the same material were seized in the Czech Republic on two occasions. HEU seized in Landshut, Germany, in June 1994, was also shown to be connected with the Prague seizure. The seized material appears to have the same origin and the sequence of these events indicates that they may have been part of a larger quantity of HEU available for illegal sale.

Information also shows that these trafficking events were not isolated incidents. While it is not known whether or not the groups of people apprehended in Germany and the Czech Republic had direct knowledge of each other's activities or existence, it is apparent that the material at that time was supplied to them by one group of sellers who may have had access to its origin and therefore may have stolen more. However, this group of sellers' reliance on inexperienced middlemen to sell the material is indicative of limited previous involvement in nuclear trafficking.

Case 2

Location: Rousse (Ruse), Bulgaria
Date: 29 May 1999
Material: 10 g HEU, (72.7% ^{235}U)

On 29 May 1999, Bulgarian customs officers stopped a private car for a routine customs inspection at the Rousse border checkpoint on the border with Romania. The driver's nervous behaviour provoked the suspicion of the customs officials and triggered a more thorough examination. Eventually, a lead container with, as it was later determined, a 10 g sample of HEU was found in the car's boot and the driver was arrested (Fig. 23).

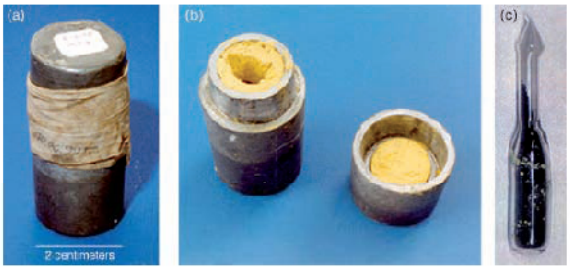


FIG. 23. Packaging of HEU seized in Bulgaria, May 1999. Source: Lawrence Livermore National Laboratory, http://www.llnl.gov/str/March05/Hutcheon.html.

The HEU powder was inside a glass ampoule embedded in yellow wax placed inside a lead container.

The press reported that the detainee was returning from an unsuccessful meeting with a potential buyer in another country. The culprit was prosecuted and sentenced to two years probation. Later he disappeared and subsequently died in a road accident.

Case 3

Location: Paris, France
Date: 16 July 2001
Material: 0.5 g HEU, (72.7% ^{235}U)

In July 2001, acting on a tip-off, Paris police established surveillance on several people suspected of trafficking in uranium. On 16 July 2001, the vehicles of two of these people were examined in the absence of their occupants and an abnormally high level of radioactivity was discovered. The suspects were subsequently arrested and a lead container with an ampoule holding HEU was discovered in one of the vehicles. During a search in the home of one of the detainees, investigators found plane tickets to foreign destinations, and certified copies of money transfers.

The investigation determined that the material had been brought to France from Eastern Europe. The group arrested in France was looking for a buyer for up to 2 kg of the same material, as claimed by one of the detainees. The arrested persons were subsequently charged with unauthorized importation and possession of nuclear material and sentenced to various terms of imprisonment.

Commentary on Cases 2 and 3

It was established that samples of HEU seized in both cases had the same origin, and are likely to have come from the same larger batch of HEU available for illegal purchase. Furthermore, the packaging of the HEU samples in both cases was very similar, i.e. the material was inside a glass ampoule surrounded by yellow wax placed inside a lead cylindrical container. This indicates that in both cases the samples may have been provided by the same groups of sellers. Further samples of this material have not been seen in trafficking incidents since.

Case 4

Location: Bangkok, Thailand
Date: 13 June 2003
Material: ^{137}Cs, 2.78 GBq
Source: Bangkok Post, 14 June 2003

On 13 June 2003, acting on a tip-off, Thai police apprehended an individual in the parking lot of a Bangkok hotel attempting to sell what was purported to be uranium. In fact, it turned out to be a ^{137}Cs source.

According to the press, the perpetrator had brought the material illegally from abroad. The perpetrator is said to have claimed that he had been acting as intermediary, representing another individual, who had more such material for sale.

Commentary

There is no information available on the origin of the material or confirming that more material was available.

Some press reports claimed that up to 30 kg of ^{137}Cs had been seized in this incident. If this had been the case, its activity level would have been in the order of about 1000 PBq, which would have required several tonnes of lead shielding. Press reports often confuse the net weight of the material with its gross weight, which includes containers and packaging.

Case 5

Location: Quininde, Ecuador
Date: 10 December 2002
Material: ^{192}Ir, 9.5 TBq (combined activity of five sources)

On 10 December 2002, five gamma projectors containing ^{192}Ir sources used by a construction firm for non-destructive analysis and quality control of welded components were stolen from the firm's radiation storage bunker. One of the thieves was suspected to be a former employee of the company. Later, the thieves demanded ransom for the return of the stolen devices. One month later, the company bought three devices back from the thieves for $3000. The remaining two have not been recovered.

Commentary

In the past few years an increasing number of cases have involved rewards being offered for the stolen radioactive material. This practice has the potential for encouraging theft of radioactive material for the reward or for blackmail. There is no hard evidence, however, on how many thefts of material have been provoked by such practice.

Appendix II

EXAMPLES OF RADIOLOGICAL SEARCH TECHNIQUES

This appendix discusses general search procedures for use by responders when radioactive substances are suspected. It does not address the cases where contamination is suspected. These examples are meant to be used for establishing specific guidelines and procedures [50].

II.1. GENERAL SEARCH TECHNIQUES

The following techniques apply to *any* search being performed using hand-held instruments:

At all times, be mindful of safety and security precautions. Do not ignore 'situational awareness' practices while performing searches: suspicious persons must be safely controlled, and suspicious packages should be examined by non-intrusive means whenever possible. Do not attempt to open suspicious packages that have radiation signatures.

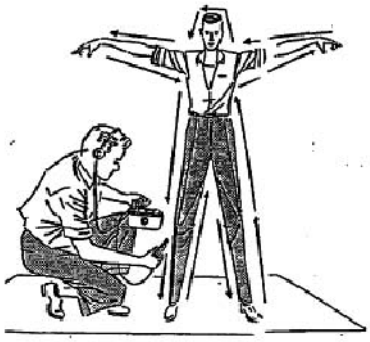
- Move the hand-held search device over the surface of every person, package, and vehicle you wish to assess.
- It is important to get the search instrument close to the object you wish to search! A distance of no more than 15 cm is suggested, especially if searching for possible neutron sources.
- Small sources are often easy to localize. If the search device reacts everywhere as you scan an object, the radioactive material is probably distributed uniformly. This may be an indication of NORM, of contamination, or (in the case of people) an indication of a recently administered medical radionuclide treatment.

II.2. PEDESTRIAN SEARCH TECHNIQUES

Follow these procedures to perform a thorough search for gamma sources (note that the legitimate presence of neutron sources is highly unlikely). Allow 15 seconds to conduct a search; this should permit a scan of both a person's front and back.

- Make sure that the search device is on, working properly, and has acquired a recent background measurement.

– Begin your scan near one foot. Sweep up one side of the body towards the head, and then sweep down the other side (see figure below). This should take approximately 5 s.
– Ask the person to turn around, and then repeat the scan, moving from one foot towards the head and back down towards the other foot.



II.3. SEARCHING PACKAGES

Briefcases, purses, and packages are common items that people carry. The following search procedure is recommended:

– Make sure that the search device is on, working properly, and has acquired a recent background measurement;
– Pass the search device over the surface of *each* item;
– Look for items that may be used as radiation shields;
– If a package is sealed and cannot be opened for a visual search, use more care in scanning to make sure it does not contain semi-shielded sources;
– Search slowly over the surface of the package, taking plenty of time to scan all sides.

II.4. VEHICLE SEARCH TECHNIQUES

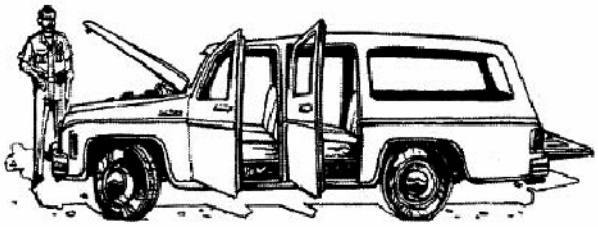
Motor vehicles (cars or trucks with or without cargo) are more challenging to search than people or packages, and so the search procedure takes much longer. Remember: do a visual search at the same time that you are doing a radiological search! Check any large, heavy containers very carefully with your search device.

II.4.1. Preparing for a vehicle search

- Make sure that the search device is on, working properly, and has acquired a recent background measurement.
- Prepare the vehicle for search by asking the driver to turn off the engine and open the hood, trunk, and all doors.
- Request that the driver and any passengers get out of the vehicle, verify their identity and ensure that they stand away from the vehicle during the inspection.
- Search each occupant using the procedure described above. Even if a legitimate source is located, continue searching the other occupants and the vehicle to make sure that additional sources are not being "masked" by the legitimate source!

II.4.2. Performing a vehicle search

- Search under the vehicle's hood, including the hood itself.
- Search the vehicles trunk, including the trunk cover.
- Search the vehicle's interior
- Enter each door and search around every object and surface within reach. Include in your search unlikely places, such as the dashboard, sun visor, headliner area, floor, under the seats, and the space behind the rear seat.
- If you cannot reach an area, search it from outside the vehicle (preferably though glass rather than through metal); this should be done more slowly than normal.



– Search the cargo area in trucks.
– Search the exterior of the vehicle. This includes under the frame rails and bumpers, and the wheel wells in front and behind the tires. Search the tires.
– For large trucks or cargo containers, search wherever possible and practical. A stepladder may be needed.

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This publication is intended for individuals and organizations that may be called upon to deal with the detection of and response to criminal or unauthorized acts involving nuclear or other radioactive material. It will also be useful for legislators, law enforcement agencies, government officials, technical experts, lawyers, diplomats and users of nuclear technology. In addition, the manual emphasizes the international initiatives for improving the security of nuclear and other radioactive material, and considers a variety of elements that are recognized as being essential for dealing with incidents of criminal or unauthorized acts involving such material.

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