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Technical Guidance
Reference Manual

Monitoring for Radioactive Material in International Mail Transported by Public Postal Operators

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MONITORING FOR RADIOACTIVE MATERIAL IN INTERNATIONAL MAIL TRANSPORTED BY PUBLIC POSTAL OPERATORS

REFERENCE MANUAL

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TECHNICAL GUIDANCE

MONITORING FOR RADIOACTIVE MATERIAL IN INTERNATIONAL MAIL TRANSPORTED BY PUBLIC POSTAL OPERATORS

REFERENCE MANUAL

JOINTLY SPONSORED BY THE
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FOREWORD

Illicit trafficking of nuclear and other radioactive material has been an issue of concern since the first seizures in the early 1990s. By the end of 2004 Member States had confirmed 540 cases, while about another 500 remain unconfirmed. Most of the confirmed cases have a criminal dimension, even if they were not for known terrorist purposes. The attacks of September 2001 in the USA dramatically emphasized the requirement for the enhanced control and security of nuclear and other radioactive material. In response to a resolution by the IAEA General Conference in September 2002 the IAEA has adopted an integrated approach to protection against nuclear terrorism. This brings together IAEA activities concerned with the physical protection of nuclear material and nuclear installations, nuclear material accountancy, detection and response to illicit nuclear trafficking, the security and safety of radioactive sources, emergency response measures — including pre-emergency measures in Member States and at the IAEA — and the promotion of State adherence to relevant international instruments.

States have the responsibility for combating illicit trafficking and the inadvertent movements of radioactive material. The IAEA cooperates with Member States and other international organizations in joint efforts to prevent incidents of illicit trafficking and inadvertent movements and to harmonize policies and measures by providing relevant advice through a range of technical assistance and documents. In this context, the IAEA issued a group of three technical documents, co-sponsored by the World Customs Organization, Europol and Interpol, on the inadvertent movement and illicit trafficking of radioactive material. The first is Prevention of the Inadvertent Movement and Illicit Trafficking of Radioactive Material (IAEA-TECDOC-1311), the second is called Detection of Radioactive Material at Borders (IAEA-TECDOC-1312) and the third is Response to Events Involving the Inadvertent Movement or Illicit Trafficking of Radioactive Material (IAEA-TECDOC-1313).

The Universal Postal Union (UPU) recognizes that the international postal network could be used as a vehicle for the illicit trafficking of nuclear material and other radioactive material and has, therefore, a great interest in detecting such transports, primarily to protect postal employees and customers but also to protect other postal items, equipment and buildings. It is mandated to assist member countries on means to ensure a safe and secure postal system. The UPU requested that a cooperative effort be undertaken to prepare this report, which considers how radioactive material in international mail might affect UPU members; it includes recent efforts for border security monitoring. This publication can be used by public postal operators and common carriers when choosing the most effective detection systems for screening nuclear or other radioactive material in mail processing operations.

This publication is based on a report entitled Guidelines for Monitoring of Radioactive Material in Public Mail, prepared by P. Beck of the Austrian Research Centre Seibersdorf under an IAEA contract. The report is unique in that it brings together a concise but comprehensive description of the various techniques and equipment used to detect and control radioactive material during mail processing. It also incorporates the experience accumulated by various public postal operators throughout the world and that gained in dealing with cases of illicit events involving nuclear or other radioactive material. The work undertaken by the Austrian Research Centre Seibersdorf in this endeavour, and in particular by P. Beck, is gratefully acknowledged.

The preparation of this publication in the IAEA Nuclear Security Series has involved extensive consultations with Member States, including an open-ended technical meeting in Vienna in July 2004 and a Research Coordination Meeting in Sochi, Russian Federation, in October 2004. As a final step, the draft was circulated to all Member States to solicit further comments and suggestions before publication. The IAEA officer responsible for this publication was R. Abedin-Zadeh of the Office of Nuclear Security, Department of Nuclear Safety and Security.

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1. INTRODUCTION

1.1. BACKGROUND

The Universal Postal Union (UPU) [1] and the IAEA have engaged in a joint effort to develop guidelines for the detection of unauthorized movements of radioactive material[1] through the international postal system. In 2002, the two organizations signed a memorandum of understanding that aimed at ensuring 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 UPU–IAEA agreement of October 2002 calls for the development of safe and cost-effective packaging requirements, with simple and effective labelling and marking, when radioactive material is accepted for mailing. It further aims to share information of mutual interest between the two organizations and to develop joint training programmes and awareness campaigns.

Postal services worldwide apply strict measures to regulate the mailing of radioactive material and other dangerous goods, guided by the UPU/Postal Security Action Group (PSAG) Interagency Dangerous Goods Project Team. Among the steps being taken, the UPU will, through the PSAG and other bodies, encourage the postal services of its 190 member countries to apply measures to ensure the detection of illicit trafficking involving radioactive material. The IAEA will ensure that issues related to safe and secure postal transport are adequately addressed in its standards and guides. At the global level, the IAEA's Regulations for the Safe Transport of Radioactive Material serve as the basis for model regulations of the United Nations Economic and Social Council's Committee of Experts on the Transport of Dangerous Goods. These, in turn, serve as the basis for the international modal regulatory documents issued by the International Civil Aviation Organization (ICAO) for air transport, the International Maritime Organization (IMO) for sea transport, the United Nations Economic Commission for Europe (UNECE) for road, rail and inland waterway transport in Europe, and the UPU for transport by post.

Some public postal operators allow the mailing of very limited quantities of radioactive material such as those present in certain radiopharmaceuticals.

[1] It should be noted that in this publication — since nuclear material is also radioactive — the term 'radioactive material' includes nuclear material.

In addition, mail will contain 'innocent' and generally harmless radioactive material such as some ceramics, camera lenses, watches or instruments with radium dials, rock samples and other naturally occurring radioactive material (NORM). Generally, NORM shows up infrequently in the mail stream, unlike the bulk cargo stream found at land borders and seaports. Occasionally, items such as blood from a person who has received a medical radiopharmaceutical treatment may be found in the mail through innocent action. To detect the illicit trafficking of radioactive material, some countries have installed monitoring procedures for the mail stream to detect such material. The major items of interest are radioactive material that could be used for malevolent acts. Current international radiation monitoring measures range from routine radiation monitoring to preliminary feasibility studies at several mail handling centres. This guide is based on observations made in 2003 by some international or national postal offices and private mail distribution centres.

The illegal transport of conventional explosives has already been observed in public mail [2]. Some of these events led to serious health hazards and even death. The combination of radioactive material and conventional explosives in a letter or parcel has been identified as a serious threat scenario [3].

With the exception of the transport of radiopharmaceuticals in some countries, the occurrence of significant radioactive material in public mail is very unlikely. Any discovery of such material can be classified either as legal, illegal or as a transport of NORM. However, private shipping companies routinely transport radioactive material in accordance with the international transport regulations for dangerous goods [4–6].

No official studies on mail monitoring and, therefore, no confirmed information about the frequency of radioactive material in public mail exist. However, due to the ease of use of public mail, the illicit trafficking of radioactive material in public mail represents a potential risk to the public and postal workers that could have dire consequences.

1.2. SCOPE

This publication provides guidance on control procedures and equipment that can be used for the detection of gamma and neutron radiation as a result of the illicit trafficking of radioactive material in public mail and private mail carriers. It does not describe specific detection procedures for alpha or beta emitting radiation sources. It gives a qualitative characterization of the radiation hazards caused by radioactive material in public mail. It also describes countermeasures and defines a response procedure in the case of the detection of radioactive material.

The focus of this report is on international mail monitoring by public postal operators. However, the techniques and equipment described could be used for domestic purposes. The techniques and procedures could also be used by private courier services. Procedures concerning labelling and packaging requirements for radioactive sources are outside the scope of this report. The handling of illicit radioactive material in international mail is generally within the purview of the national customs administration, which works cooperatively with postal authorities. This publication is intended as an informative guide on the methods used for monitoring international mail for radioactive material rather than defining roles and responsibilities which will differ between countries.

1.3. OBJECTIVE

The main objective of this publication is to give an overview of existing information and of countermeasures to protect postal employees and customers and the general public from the possible health hazards from illegally transported radioactive material. Furthermore, it provides:

— 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.

2. SCENARIOS FOR THE ILLEGAL TRANSPORT OF RADIOACTIVE MATERIAL

2.1. INTRODUCTION

Since only a few public postal operators permit the shipment of small amounts of radionuclides for medical use or limited consumer products according to international transport regulations, the legal occurrence of significant radioactive sources in public mail should, in general, be very rare. Today, radioactive material for medical use typically has half-life periods of hours or days and can be distinguished from other radioactive material by gamma spectrometry, even from outside a package. Another possible issue of concern is the illicit trafficking of nuclear material (e.g. uranium and plutonium isotopes) [7] or other radioactive material using the public mail system. The malevolent act of using a radioactive source in the public mail system to threaten the public is an additional potential scenario. Terrorists could use mailed radioactive material to threaten the public at large and to gain national or international attention.

Scenarios for the illegal transport of radioactive material in public mail can be summarized as involving:

— Incorrect or no labelling;
— Incorrect transport documents;
— Illicit trafficking of radioactive material;
— Malevolent acts using radioactive material in the public mail.

In this report, only illicit trafficking of radioactive material in the public mail will be considered.

The potential radiation exposure caused by some radioactive sources, for example by ingestion or inhalation of radioactively contaminated dust, can lead to serious health hazards or even to death. The health risk depends on the exposure to the radiation source and is expressed in the radiation quantity *effective dose*. For radiation measurements, the quantity *ambient dose equivalent* is used. For both radiation quantities, the sievert (Sv) is the unit of measurement [8, 9]. Typical natural background radiation is about 50–100 nSv per hour ($nSv \cdot h^{-1}$). The worldwide average annual dose, almost entirely from natural sources, is 2.4 mSv [10].

The parameters influencing radiation exposure are the type of radiation emitted by the item and the activity of the radioactive material. A certain mass of a radioactive material corresponds generally to a certain amount of radiation activity. Both quantities are exchangable and can be calculated from each other. The mass of a radioactive source is usually given in grams (g), and the activity of the source is given in becquerels (Bq). The radiation dose rate depends on the distance from the radioactive source, the shielding in front of the source, the composition or matrix of the radioactive material, and the type of radiation emitted by the source. Typical shielding material includes lead, tungsten, depleted uranium or any other material with a high density. For further information, see Ref. [8] and the web site of the US National Institute for Standards and Technology (NIST) [11].

Obvious procedures with regard to radiation protection are therefore to:

— Keep a large distance from any unknown radioactive source;
— Minimize the exposure time;
— Use shielding material for the radioactive substance.

Furthermore, any contact should be avoided since the surface of the consignment containing the radioactive material could be contaminated. A detailed description of radiation protection fundamentals is contained in Ref. [12].

With regard to the estimation of a radioactive source in public mail in a possible threat scenario, the maximum weight and size of a letter or a parcel have to be taken into account. Generally the weight limit for letter post items is 2 kg, but in certain cases it can be up to 5 kg depending on bilateral agreements. The exchange of parcels whose individual weight exceeds 20 kg is optional, with a maximum individual weight of 50 kg. The maximum size of a letter item is length, width and depth combined: 900 mm. However, the greatest dimension cannot exceed 600 mm with a tolerance of 2 mm. Generally, the maximum size of a parcel cannot exceed 2 m for any dimension, or 3 m for the sum of the length and the greatest circumference measured in a direction other than that of the length. In addition, for international consignments, a mail bag is specified as containing several letters and parcels to one addressee with a maximum weight of 30 kg.

The maximum size of a single consignment is not taken into account as a reducing parameter with regard to the amount of radioactive material. To estimate the amount of radioactive material that could be transported by public mail, two different weight categories can be identified:

— Up to 2000 g (standard letter);
— Up to 50 kg (express mail service (EMS), parcel, mail bag), the most used maximum weight being 20 kg.

2.2. SCENARIOS FOR THE ILLICIT TRAFFICKING OF RADIOACTIVE MATERIAL IN PUBLIC MAIL

Depending on the type of illicit radioactive material and the surrounding shielding, several scenarios can be identified. In this report, four scenarios are discussed:

— Radioactive material in public mail with internal shielding;
— Radioactive material in public mail with no shielding;
— Radioactive material in public mail;

— Combination of a radioactive source with conventional explosives.

Any radiation outside such a consignment above a certain dose rate level (see Section 4) can be assessed by a personal radiation detector (PRD), a hand-held radionuclide identifier (RID) or a radiation portal monitor (RPM).

The most likely scenario is the illegal shipment of a radioactive source within a shielded container transported by EMS or parcel mail. Using appropriate shielding (lead or depleted uranium), industrial sources such as ^{137}Cs (caesium) or ^{60}Co (cobalt) could be hidden in EMS or parcel mail with a total weight of 20 kg. For both, radioactive sources scenarios are possible, where the source may not be detected from outside the parcel. However, if the parcel is opened and the shielding is dismantled, the radiation exposure from these sources could lead to serious health hazards (see Annex II, Scenario 1). The use of X ray scanners provides an indication of heavy shielding material inside the consignment. Such information should lead to further investigation of a suspicious shipment.

If unshielded radioactive material is transported by public mail, it is possible that postal workers and the public could be exposed to potential health hazards even without opening the package. If a radioactive liquid substance or radioactive dust is involved, the package could become contaminated. In such cases, transport of the item could lead to the contamination of postal workers and the public and also of buildings and equipment. If no shielding is used, the most likely scenario is the illicit trafficking of radioactive material by letter mail with a maximum weight of 20 g (standard letter) or up to 2000 g (reduced rate letter). For industrial sources such as ^{137}Cs and ^{60}Co with a mass of 15 g, a lethal radiation dose could potentially be absorbed within a short time and lead to instant health effects on the skin and other human tissue, and death after some days. The temperature produced by both sources in such a case cannot be neglected. The radiation exposure can be measured by any gamma radiation detector, as described in this report, at a distance of about 100 m (see Annex II, Scenario 2).

Another scenario using public mail is the illicit trafficking of nuclear material (e.g. uranium and plutonium isotopes), which could be used to build a nuclear weapon. Since uranium and plutonium also emit alpha radiation, the ingestion or inhalation of contaminated dust is a potential health hazard. Both isotopes can be detected by hand-held instruments (e.g. RIDs) or RPMs (see Section 5). The illicit trafficking of a 20 kg EMS or parcel mail with unshielded uranium can be detected instantly by any radiation monitor equipment described in Section 4. With appropriate shielding, a considerable amount of uranium could be hidden in such a parcel. Even small amounts of unshielded plutonium can be detected by radiation monitoring equipment and, with significant shielding, plutonium can still be detected in a 20 kg EMS or parcel mail located in front of a suitable radiation detector. The addition of neutron detection capability to a gamma ray detection system adds significantly to the ability to detect shielded plutonium. X ray scanners can provide an indication of heavy shielding material inside a consignment.

Conventional explosives have been observed in public mail [2]. Such incidents can lead to serious injuries or death. Several security experts have described the use of a radioactive dispersal device (RDD) as a very likely scenario for a malevolent act [3]. The hazard consists of the consequences of conventional explosives and the radioactive contamination of the population, buildings and the environment. Depending on the amount and half-life of the radioactive material dispersed, the contamination could cover a wide area for an extended period. Although the effect is not comparable to that of a nuclear weapon, the consequences of an explosion of an RDD could include health effects and public panic. The dispersal of radioactive material depends on the explosive power and type of radioactive material. Scenarios with and without shielding material are conceivable. Although any radioactive material could be used in combination with conventional explosives, the most likely scenarios include the use of industrial sources such as ^{137}Cs or ^{60}Co. X ray screening is recommended for the detection of high density shielding material and explosives.

3. DISTRIBUTION PATHS OF PUBLIC MAIL AND POSSIBLE MONITORING LOCATIONS

3.1. INTERNATIONAL MAIL STREAM

Worldwide, more than 18 million international letters cross borders each day. In 2002, this represented an annual traffic of 6.7 billion international letters. Some 4.6 billion international parcels are sent by post annually and this represents some 13 million parcels per day.

There are large differences between the amounts of mail sent internationally. The USA (819 million) and the United Kingdom (582 million) export the largest volume of letter post items. Among developing countries, Saudi Arabia (197 million) sends the largest number of letter post items abroad. Major users of the postal network include inhabitants of the USA, who send an average of 660 items per person per year, Norway (548) and

Liechtenstein (473). At the opposite end of the scale, Bhutan and Zambia are among those countries with an average of one item per inhabitant. In some 50 developing countries the average number of items sent per person is less than one.

The volume of international ordinary parcels increased globally by 10.5% from 2001. Industrialized countries[2] experienced the most growth (12.7%), but volume increases were also noted in Africa (8%), Latin America and the Caribbean (18.5%), and the Middle East (0.9%). Developing countries experienced an overall decrease of 2% in international ordinary parcels. Decreases were particularly noted in Asia and the Pacific (5.7%), and Europe and the Commonwealth of Independent States (3.6%).

The typical mail stream path starts from picking up mail at street letter boxes and post offices, bringing it into a domestic sorting centre, and then carrying it to an office of exchange for international sorting and transportation abroad. Public international mail is mostly transported by airplane or truck, but also by ship and train, to the office of exchange in the country of destination. Further, the mail is delivered to a sorting and distribution centre, a regional distribution office and finally delivered to the addressee. For ease of loading or unloading aircraft or trucks, mail is transported in consignments of bags or containers. The number of domestic sorting and distribution centres depends on the individual logistical structure of the country. Figure 1 shows a general scheme of the international mail stream.

3.2. MAIL MONITORING STRATEGY

3.2.1. Introduction

The most efficient monitoring of mail consignments is done in an office of exchange. These facilities exist in the country of origin and in the country of destination. Monitoring can take place at both locations or only at one, for the import of public mail, or for both import and export of public mail. However, it should be recognized that health hazards to postal workers and the public

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[2] The UPU list of industrialized countries (as of January 2004) is as follows: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Liechtenstein, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Portugal, San Marino, Spain, Sweden, Switzerland, United Kingdom, Vatican, and the USA.

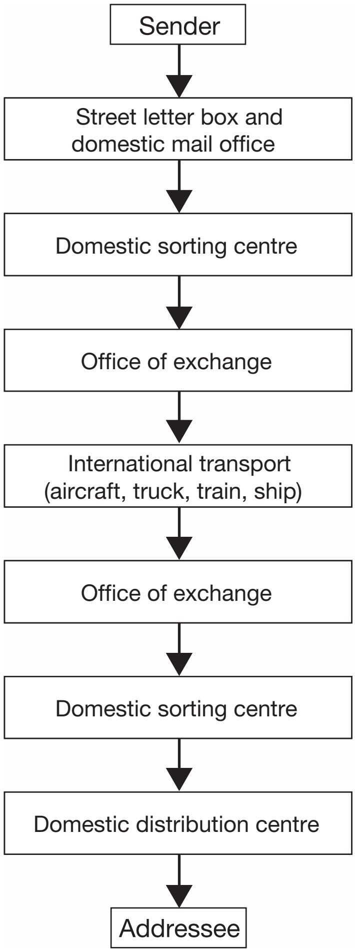

FIG. 1. The international public mail stream.

could start at street letter boxes or domestic mail offices in the country of origin.

Offices of exchange are individually organized. While at some locations highly sophisticated distribution logistics supported by information technology exist, at others the mail distribution is still primarily done manually. Mail screening is already established as part of quality management and logistics at some offices of exchange.

The most efficient method is for radiation monitoring to start at the entrance of the office of exchange, where all incoming consignments in bags, trolleys or containers are scanned. Thus, mail containing radioactive material could be detected before it enters the facility and precautions against possible health hazards from radiation exposure could be taken. For this application, typical vehicle RPMs should be used. The minimum activity or mass of radioactive material that can be detected depends on the distance of the monitor to the consignment, the radionuclide and any shielding material involved (see Refs [13–18]).

Scanning single letter mail and parcels is done best on conveyor belts, which usually are available for automatic sorting in an office. Monitoring letter mail and parcels provides the most sensitive detection of radioactive material. The distance from the monitor to the consignment should be between 10 and 50 cm. The minimum quantity of radioactive material that can be detected depends on the distance of the monitor from the consignment, on the radionuclide, and on any shielding material involved (see Section 2 and Ref. [12]). It is recommended that radiation conveyor belt scanning be combined with X ray scanning.

Alternatively, postal workers at mail entry points or in the manual sorting of mail could use PRDs or hand-held instruments for radiation inspection. However, the sensitivity to radiation is less when compared to with RPMs or radiation conveyor belt monitors (RCMs).

3.2.2. Comparing monitoring methods

In summary, the following mail monitoring methods can be distinguished:

(a) Monitoring a vehicle or container: truck, trolley, or container.
(b) Monitoring single mail items: letter, parcel, or mail bag.
(c) Combination of vehicle and single mail monitoring.
(d) Monitoring by individual postal workers wearing PRDs or hand-held devices.

A combination of the above methods can also be considered. However, ultimately the decision to use a particular method or a combination of monitoring methods should be a balance between the sensitivity to detect radioactive material, the costs of the monitoring equipment and the operational procedures required for response to an alarm. Generally, monitoring equipment is more expensive for systems employing larger detectors with higher sensitivities.

3.2.3. Monitoring of a vehicle or container

Monitoring logistics are very simple for a whole container, for example, after unloading an airplane and before the mail enters an office of exchange. The solution is relatively inexpensive because it usually requires only one or two RPM systems. The monitoring process typically requires several seconds. The monitoring time depends mainly on the size of the item that is to be scanned. Because of the distance from the RPM to the container or vehicle (typically 1 or 2 m), this method is less sensitive than a conveyor belt monitor due to the self-shielding effect of the load. In the case of an alarm, the container has to be stopped, unloaded and the radioactive substance located manually with the use of a hand-held radiation search device. This process of searching the interrupted container can take a long time.

3.2.4. Automatic monitoring of single mail items with RCMs

The radiation monitoring of a single mail item is highly sensitive. Since letter mail and parcels are transported on a conveyor belt, the monitoring device can be very close. In the case of an alarm from the monitoring equipment, the suspicious piece of mail can be localized instantly. The monitoring time for a large number of single mail items is longer than the radiation survey of a whole container. To improve the throughput of the monitoring process, several RCMs can be installed in parallel. The monitoring equipment for single mail items is usually designed for indoor operation and uses smaller detectors, which are less expensive compared with vehicle portal monitors. Depending on the number of monitoring paths, single mail monitoring can require more investment for equipment than whole container monitoring. If an X ray monitor screens every piece of mail, a radiation monitor can operate together with it, as the radiation monitor will not slow down the screening process. No additional personnel are needed for the survey, since the radiation monitor works in parallel with the X ray system and sounds an alarm automatically.

3.2.5. Combination of vehicle and single mail monitoring

If high sensitivity and high speed monitoring are required, a combination of both methods is recommended. The radiation protection of workers is significantly increased because a monitoring device checks every container before it enters the distribution facility. High sensitivity monitoring and quick localization of the radioactive substance is guaranteed. The alarm level of the entrance monitors may be different to ensure radiation protection for the workers and the mail facility.

3.2.6. Monitoring with PRDs

Alternatively, mail can be monitored for radiation quite inexpensively by using PRDs, which can also be used during hand sorting. Postal workers are typically in close proximity to mail during loading, unloading and mail processing operations. However, PRDs are much less sensitive when compared with hand-held radiation instruments and RPMs. Although the gamma sensitivity is reasonably good, PRDs have a very low sensitivity to neutron radiation, or need a very long measurement time for an indication of neutron presence. Currently, it is not recommended to use neutron sensitive PRDs exclusively as an alternative to neutron hand-held instruments or neutron sensitive RPMs.

4. RADIATION MONITORING EQUIPMENT

4.1. INTRODUCTION

Currently, limited practical experience and historical information of mail screening is available to derive detailed specifications for mail monitoring equipment. At a number of locations, border radiation monitoring systems are in use and have been modified for mail monitoring. A flow chart describing the process leading to detection of radioactive material in public mail is summarized in Annex I. It describes the instruments that can be used for mail monitoring. Details on the procedures and equipment used in detecting illicit radioactive material at borders are described in IAEA-TECDOC-1312 [19]. The minimum requirements covering technical specifications of the equipment are given in Ref. [13]. Monitoring devices used to detect and characterize radioactive material at checkpoints can be divided into the following categories:

— RPMs;
— RCMs;
— PRDs;

— Neutron search detectors (NSDs);
— Multipurpose hand-held RIDs.

Other instruments that are not covered here are the devices used by expert responders who move to the scene in the case of a serious incident or the danger of a radiological malevolent act. These responders are equipped with more sophisticated instruments, such as alpha and beta contamination probes, portable gamma spectrometers with medium and high resolution detectors, coincidence neutron detection systems, health physics instrumentation, portable X ray imagers and air samplers.

Additional PRDs and multipurpose hand-held instruments for the personal radiation safety of the postal workers, verification of alarms, and localization of the source and identification of the radionuclide should support any installation of automated RPMs or RCMs. First responders use the derived information to determine the adequate level of response (operational, tactical or strategic). The level of response depends on the type of radiation (gamma/neutron), dose rate, surface contamination and type of radionuclide.

4.2. RADIATION PORTAL MONITORS

4.2.1. General

RPMs are designed to be used at road, rail, airport or seaport checkpoints to detect gamma and neutron radiation, which could indicate the presence of radioactive and nuclear material. RPM are the preferred option where the traffic of goods and public mail can be funnelled into narrow confines, known as nodal or choke points, because of their inherent greater sensitivity over hand-held detectors or PRDs. They can provide high sensitivity monitoring of a continuous flow of vehicles, trolleys with mail and packages, cargo and mail containers, while minimizing interference with the flow of traffic. Technical specifications distinguish between monitors for smaller or larger vehicles. RPMs are available for permanent installation in concrete or as movable detectors on wheels. The sensitivity is almost comparable. The minimum technical requirements for RPMs are given in Ref. [13].

4.2.2. Operation

The RPM should be double sided with two symmetric pillars. The detection sensitivity depends upon the proximity of the detector and source, and the speed of the vehicle. The maximum recommended distance between pillars is 6 m and is dependent on the width of the vehicle to be scanned. It is important that barriers that do not obstruct the view of the monitor be installed to protect the monitor from being accidentally damaged by vehicles. Detectors should monitor one lane only. RPMs can be of a car or truck type, differing in the height of the search region. Figure 2 depicts the monitoring of a whole container.

Since the sensitivity of the monitor is also strongly dependent on the monitoring time, the instrument needs to be placed where the speed of the vehicle is controlled and reduced. Instruments vary in their capabilities, but it is recommended that the speed of the vehicle not exceed 8 km·h^{-1}, although in some situations a higher speed of up to 30 km·h^{-1} can be required to maintain the flow of traffic. For higher vehicle speed requirements, the sensitivity of the detectors needs to be increased accordingly. It is essential that the occupancy sensor be of a type suitable for the particular application and positioned to be triggered only when the monitoring portal is occupied and not by other traffic in the vicinity.

FIG. 2. An RPM being used to monitor an aircraft mail container.

4.2.3. Calibration and routine checking

The RPM should be calibrated and tested periodically. It should be checked daily using small radioactive sources to verify that it can detect radiation intensity and that corresponding alarms are triggered. Self-diagnostic tests should be included to cover as many functions as practicable, and when these tests indicate the possibility of malfunction, an alarm should be triggered. It is recommended that the equipment be calibrated once a year by a qualified person or maintenance facility.

4.3. RADIATION CONVEYOR BELT MONITORS

4.3.1. General

RCMs are designed to be used at checkpoints, where public mail is put on a conveyor belt for detailed radiation surveillance to detect the presence of gamma and neutron radiation, which could indicate the presence of radioactive or nuclear material. RCMs are located at an appropriate position on a conveyor belt where mail containers enter and before they are unloaded for further inspection. They provide very high monitoring sensitivity of a continuous flow of single mail items and parcels. Usually, RCMs are combined with X ray screening of public mail. Technical specifications distinguish between monitors for smaller or larger sizes and different arrangements of the conveyor belt. The minimum technical requirements for RCMs are given in Ref. [13].

4.3.2. Operation

RCMs should be mounted so as to provide close monitoring of the consignment. The following methods can be used:

— One detector on one side, or at the beginning of the conveyor belt;
— Two detectors, symmetrically left and right of the conveyor belt;
— Above the conveyor belt;
— Below the conveyor belt;
— A combination of the above.

The sensitivity of detection depends on the proximity of the detector to the radiation source and on the speed of the conveyor belt. The maximum recommended distance between the detector and the conveyor belt is 1.5 m.

The use of the conveyor belt drive should not interfere with detector operation and monitor sensitivity. The maximum speed should not exceed 0.5 $m \cdot s^{-1}$. If an alarm sounds, the conveyor belt should stop automatically. RCMs do not usually use an occupancy sensor. If an such a sensor is used, it should be of a type suitable for the particular application and be positioned so that it is triggered only when the conveyor belt monitor is occupied and not by other movements in the vicinity. Figure 3 shows an RCM.

4.3.3. Calibration and routine checking

RCMs should be calibrated and tested periodically [13]. Specifically, they should be checked daily with small radioactive sources to verify that they can detect increases in radiation intensity and that corresponding alarms are triggered. Self-diagnostic tests should be included to cover as many functions as practicable, and when these tests indicate the possibility of malfunction, an external alarm should be given. It is recommended that the equipment be inspected and functionally tested once a year by a qualified person or maintenance facility.

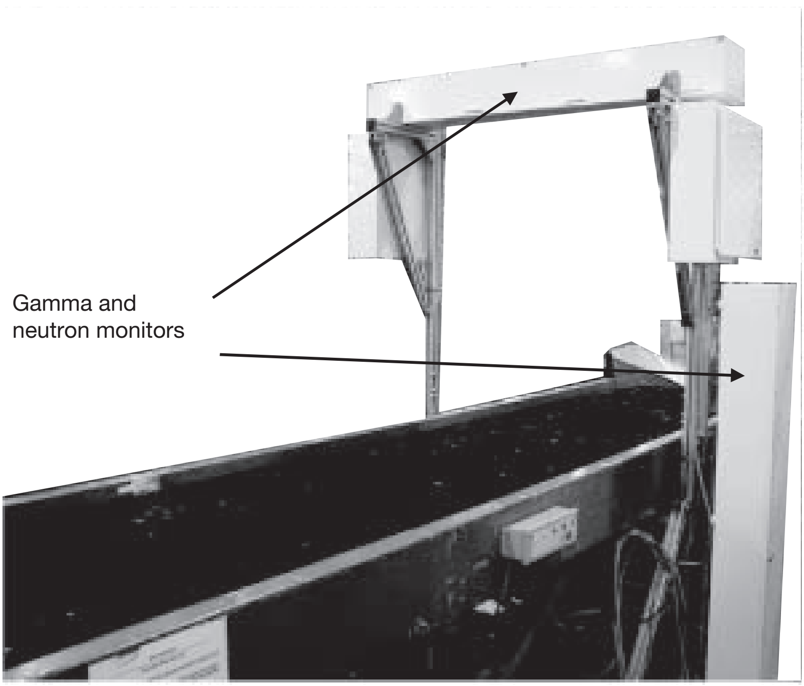

FIG. 3. Principal features of an RCM.

4.4. PERSONAL RADIATION DETECTORS

4.4.1. General

PRDs are small, lightweight radiation monitors worn on the body to alert the user about the possible presence of radioactive or nuclear material by detecting gamma and neutron radiation. They can be used for searching or locating radioactive material and will warn the user of significant radiation levels. These instruments are particularly useful as personal radiation protection detectors or when patrolling large areas. PRDs can be worn by every postal worker, and are ideally suited for use by first responders to a radiation alarm because of their small size. In addition, they do not require extensive training to operate. Another advantage is their inherent mobility, which allows a closer approach to a suspected radiation source when it is safe to do so. The minimum technical requirements for PRDs are given in Ref. [13].

4.4.2. Operation

The current level of technology permits the use of both gamma and neutron/gamma PRDs. Although combined neutron/gamma PRDs are normally preferable, there are applications that do not require neutron detection. Therefore, these technical specifications can be applied to both types of PRDs.

To reach the highest neutron detection efficiency, the PRD must be worn near the body to utilize the additional body moderation. PRDs can be used in 'silent mode' to warn the user of the presence of radioactive material without alerting other persons in proximity. PRDs are ideally suited for use by individual workers and first responders to a radiation alarm. Because they are small and light, they can be brought close to a radiation source, partially compensating for their low detector volume and sensitivity. However, it should be noted that well shielded sources, as would be expected in illicit trafficking, are not likely to be detected by portable radiation detection instruments and can only be detected by very large and highly sensitive, fixed, installed RPMs. If mounted on a pole, PRDs can reach the upper part of a truck. At extremely low temperatures, they can be thermally insulated and warmed up from time to time, e.g. by putting them in the user's pocket to keep them operational. Finally, they do not require extensive training to operate.

Since these instruments are relatively inexpensive and small enough to be worn on the belt or in a pocket, it is recommended that each worker be routinely equipped with a PRD while on duty. They have low power consumption so that they can be used continuously. The use of pocket type radiation detectors worn by many personnel in the course of their regular duties can represent a ‘moving curtain’ that can be very flexible compared to fixed, installed instruments when choke points are not feasible, and thus cover a wide variety of possible areas. An additional application is their use in a timer/counter mode. If a suspicious item with a weak radiation field needs to be checked, it can be measured for a longer period, resulting in a greater increase in detection sensitivity.

PRDs should have a memory that can integrate the accumulated gamma and neutron dose. This function permits the detection of weak neutron sources. Some PRDs also record a time distribution of the dose rate (or count rate) that is a useful feature to document in the results of a radiation search operation.

4.4.3. Calibration and routine checking

PRDs should also be calibrated and tested periodically [13]. They should be checked daily with small radioactive sources to verify that they can detect increases in radiation intensity and that corresponding alarms are triggered. Self-diagnostic tests should be included to cover as many functions as practicable, and when these tests indicate the possibility of malfunction, an external alarm should be given. It is recommended that the equipment be inspected and its functions tested once a year by a qualified person or maintenance facility.

4.5. NEUTRON SEARCH DETECTORS

4.5.1. General

NSDs are designed for high neutron detection sensitivity combined with limited size and weight to allow for hand-held operation for a sufficiently long period of time. Their purpose is to detect and locate radioactive material, in particular plutonium or commercial neutron sources like californium (^{252}Cf). The probability of detection is increased if the user moves the instrument closer to any radioactive material that is present. In addition, radiation is more likely to be detected when the instrument is moved reasonably slowly over the area to be scanned. However, moving so slowly means that a survey will take longer, and so a compromise is required between speed and sensitivity. Experience has shown that a thorough radiation search of a package or a person can be performed in approximately 15 seconds. Searching a motor vehicle is much more difficult and time consuming. The minimum technical requirements for NSDs are given in Ref. [13].

4.5.2. Operation

The most important feature of the NSD is the highest achievable neutron detection efficiency. This must be accomplished at an acceptable size, weight and level of ruggedness. The NSD must have the ability for extended single handed operation in outdoor environmental conditions. Other important features include a selectable dwell time with clear audible alarms and a visible indication of the neutron signal as a function of time (e.g. in a strip chart), thus making the neutron source localization process easier to perform. The NSD should have a high contrast display containing all necessary information, including time stamp, local memory, computer link and acoustic alarm/alert indicators. Background subtraction and alarm generation principles should be similar to those used in PRDs and RIDs.

To determine the location of the radiation source, the alarm indication should be either automatically or manually reset. The repetition rate of the audio alarm should increase with increasing count rate. To ensure radiological safety during the search operation, simultaneous indication of the count rate and the automatic sounding of a high dose rate alarm are essential.

4.5.3. Calibration and routine checking

NSDs should be calibrated and tested periodically [13]. Self-diagnostic tests should be included to cover as many functions as practicable, and when these tests indicate the possibility of malfunction, an external alarm should be given. It is recommended that the equipment be inspected and its functions tested once a year by a qualified person or maintenance facility.

4.6. MULTIPURPOSE HAND-HELD RIDs

4.6.1. General

RIDs are used to detect, locate and identify radioactive material and simultaneously provide sufficiently accurate gamma dose rate measurements to ensure radiation safety during the localization and identification of radioactive material. These instruments provide greater sensitivity of detection compared with PRDs, but they are heavier and more expensive. Some of these instruments, apart from spectrometric gamma detectors, are equipped with a neutron sensor, and some of them use a detachable alpha/beta detector to check for surface contamination. Hand-held RIDs are mostly used for detection in targeted search situations and for identification of the radionuclide causing an alarm. For example, they are used to:

— Verify an alarm triggered by RPMs, RCMs and PRDs;
— Localize the radioactive source;
— Indicate the gamma and neutron dose rate and count rates (counts/s);
— Identify the radionuclide.

The minimum technical requirements for RIDs are given in Ref. [13].

4.6.2. Operation

Hand-held instruments can be used as either the primary detection device to effectively search mail, parcels, containers and vehicles with a great deal of flexibility to locate the radiation source or as a secondary search device to verify alarms obtained from fixed, installed RPMs or PRDs. Their neutron detection sensitivity, however, is often not sufficient to localize a weak neutron source. In this case, if a hand-held neutron search device is not available, a long period timer/counter mode should be available to detect the presence of a weak neutron source.

Some modern instruments are capable of transmitting data to a computer for analysis or, via remote transmission, to an expert team. It is essential that the instrument be equipped with a selectable audible signal indicator to enable the user to perform the search without watching the display. This needs to be clearly distinct for gamma and neutron radiation. Many of the characteristics in the search mode should be similar to that of PRDs.

For applications with the instrument in search mode, a hand-held instrument should produce a selectable acoustic signal that indicates the detection of gamma rays and/or neutrons and allows the user to pay full attention to the search without having to look at the display. It should have a comfortable, ergonomically designed carrying handle to allow for extended, single-handed operation for long periods with protective gloves.

4.6.3. Calibration and routine checking

The RID should be calibrated and tested periodically. It should be checked daily with small radioactive sources to verify that it can detect increases in radiation intensity and that corresponding alarms are triggered. Self-diagnostic tests should be included to cover as many functions as practicable, and when these tests indicate the possibility of malfunction, an external alarm should be given. It is recommended that the equipment be inspected and its functions tested once a year by a qualified person or maintenance facility.

5. RESPONSE PLAN

This section describes the structure of a response plan starting with the detection of radioactive material in public mail and the response that follows. It is similar to other response plans dealing with radiological accidents. However, it should be stressed that no single model will be appropriate in all circumstances. Other formats and structures are entirely adequate, provided they are comprehensive and national, regional and local conditions have been taken into account. If one model has been found and defined, it should be used for the whole organization. Further guidance on the subject will also be found in Ref. [20]. Responsibility for executing this response plan may vary between countries, but may typically be the customs organization.

A generic response scheme concerning the occurrence of radioactive material in public mail can be summarized as involving:

— Detection and verification;
— Assessment and localization;
— Identification.

5.1. DETECTION AND VERIFICATION

An instrument gives an alarm if a certain radiation level is exceeded. The radiation level is related to dose rate but is normally indicated as a count rate. Once an alarm has been activated, it is necessary to verify whether or not it is genuine. This is achieved by repeating the measurement of the possible radiation source with the same instrument or by using a different instrument, such as a PRD or hand-held instrument. The first responder at the facility supervises detection and verification.

5.2. ASSESSMENT AND LOCALIZATION

A verified alarm necessitates searching for and localizing the origin of the radiation. Then, it is important to make a radiological assessment for radiation safety purposes as well as to determine the appropriate level of response. A specially trained support team carries out the assessment and localization.

5.3. IDENTIFICATION

The measurement of the gamma spectrum will often permit the radionuclide to be identified. This information is essential to categorize the nature of the event and determine further response, particularly to distinguish between innocent/nuisance alarms and genuine alarms caused by illicit radioactive material, or to trigger a high level alert if nuclear material is detected. The specially trained support team or an emergency response team carries out the identification.

An example of a generic response scheme is given in Fig. 4.

An individual response plan should be worked out, supported by the management of the organization, the security response team and any other organization that has to react in the case of a response. A model for the response plan is given in the sections that follow.

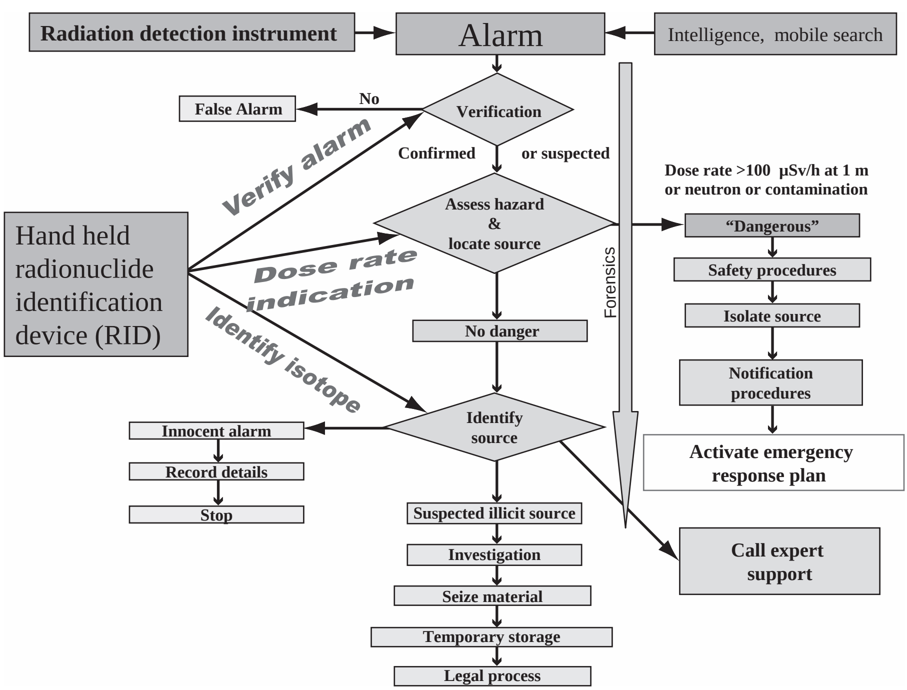

FIG. 4. Generic response scheme.

5.4. MODEL FOR A RESPONSE PLAN

Title page

The title of the plan, the approval date, concurrence/signatures and signatures of the heads of all agencies with a role in the response mechanisms should be given.

The document should contain the following sections:

1. Introduction

The purpose, participating agencies (customs, law enforcement officers, etc.), the scope of the plan, the national authorities and the relationship to other plans should be mentioned.

1.1. Purpose

1.2. Participating agencies (such as customs, law enforcement officers)

1.3. Scope

1.4. Definitions

1.5. Authorities:
- — National legislation relating to unauthorized acts involving radioactive material;
- — Definition of which agencies are responsible for planning, decisions, and actions.

1.6. Relationship to other plans:
- — Description of how a response to unauthorized acts is integrated into the general planning for other emergencies.

2. Planning basis

A brief description of the situations that require a response is given. The geographical areas, showing relevant jurisdiction over an incident occurring within those areas, should be given.

3. Organization and responsibilities

3.1. General responsibilities

The responsibilities of responding agencies, and local and national government, should be given here.

3.2. National organization

A detailed structure of the organization at the national level should be given here, if appropriate.

3.3. Interfaces

The major interfaces between responding agencies and their relationship to local and national government should be described.

4. Concept of operations

The following concepts should be considered and a description of each included. An expansion of each concept will be necessary and other concepts can also be included as appropriate.

4.1. Overview of tactics and strategy

4.2. Command structure

4.3. Command facilities

4.4. Overall management

4.5. On-scene management

4.6. General outline of procedures to mitigate health hazards

4.7. Casualty management

4.8. Seizure and disposal of radioactive material

4.9. Incident investigation

4.10. Media awareness

5. Emergency preparedness

5.1. Responsibility

A description should be given of who is responsible for producing the response plan and for maintenance of the plan.

5.2. Revisions

Here the requirements and mechanisms for revision of the plan should be explained.

5.3. Training

The general training policy and requirements, including who is responsible for training, should be defined.

5.4. Exercises

Information should be given on how often exercises take place, who is responsible for planning, preparation and implementation and how lessons learned can be incorporated into the plan. This can also include drills and tabletop exercises.

5.5. Public education

Responsibilities for educating the public on response plans should be defined.

6. Requirements for response time

6.1. On-site intervention by responsible staff

The response by first responders should be defined, for example less than 10 minutes, or in the context of the response plan using the locally trained staff or other resources;

6.2. Assistance by experts available

Assistance by experts should be defined;
During working hours: 10 min–2 h;
Night hours: 10 min to next day;
24 hour phone assistance.

6.3. A worst case of a standstill of public mail traffic caused by a suspicious situation with a radioactive substance:

Define the worst case during a standstill

6.4. Final investigation

Scientific services or nuclear forensic response team:

Define the response and the response time of the scientific response team, — for example over 1–2 d, — the suspicious material will be transported to a suitable laboratory for identification by the scientific response team or nuclear forensic team.

6. IMPLEMENTATION OF PUBLIC MAIL RADIATION MONITORING

The implementation of a public mail radiation monitoring system requires a good understanding and preparation of the legal, practical and economic factors. Major items to be considered include:

— Establishing the legal basis for the public mail monitoring;
— Defining the responsible authority;
— Contracting a project management team;
— Defining and implementing the mail monitoring project.

6.1. ESTABLISHING THE LEGAL BASIS

Establishment of the national radiation monitoring of public mail starts with identifying the national legal basis. The legal basis could be defined by national:

— Customs codes;
— Regulations concerning radiation protection of the public;
— Regulations concerning safety and security of the public;
— Transport regulations concerning transport of radioactive material or dangerous goods.

6.2. DEFINING THE RESPONSIBLE AUTHORITY

It is essential to identify the responsible national authority for public mail radiation monitoring. The responsible organization could include:

— Customs;
— Law enforcement;
— Border police;
— National postal administration;
— Civil aviation authority;
— Appropriate governmental authority.

6.3. CONTRACTING A PROJECT MANAGEMENT TEAM

A competent body experienced in radiation protection, radiation measurements, instrument testing and training should manage the project. Once the contractor has been identified, an outline for a detailed mail radiation monitoring project should be provided.

6.4. DEFINING AND IMPLEMENTING A MAIL RADIATION MONITORING PROJECT

A mail radiation monitoring project can be defined by the following tasks:

— Determination of roles and responsibilities for the handling of radiation detection and response;
— Design of the mail monitoring strategy;
— Definition of the national mail monitoring locations;
— Identification of the appropriate monitoring equipment;
— Planning a test phase of monitoring equipment;
— Installation and functional testing of the monitoring equipment on-site;

— Development of the response plan;
— Training of the local operator on-site;
— Establishing support for the local operator.

6.4.1. Design of a mail radiation monitoring strategy

A monitoring strategy has to be decided, e.g. what kind of mail monitoring equipment should be installed. The following items are possible mail monitoring strategies and possible combinations:

— 100% screening of every public mail item;
— Monitoring of mail containers;
— Single item letter mail and parcel monitoring;
— Monitoring of all international incoming mail and outgoing mail dispatches;
— Monitoring at the entrance of all main offices of exchange;
— Combination of the above.

6.4.2. Definition of national monitoring locations

The major monitoring locations have to be decided in cooperation with the local public postal operator and the responsible authority as defined in Section 7.2. Possible locations for mail monitoring operations could be:

— Office of exchange;
— Domestic sorting facility;
— Domestic distribution facility;
— Others, as specified in Fig. 1.

6.4.3. Identification of appropriate equipment

The appropriate monitoring equipment needs to be identified. Appropriate monitoring systems are:

— RPMs;
— RCMs;
— PRDs;
— NSDs;
— RIDs.

Currently, various types and models of standard radiation monitoring equipment are available on the market [13]. If a specific, non-standard radiation monitoring instrument is required, the development or adoption of existing equipment should be undertaken.

6.4.4. Test phase of equipment

Radiation monitoring equipment to be installed requires tests for set-up, commissioning and adaptation to the on-site environment. Some equipment can even have problems after delivery by the manufacturer. A test phase saves time during regular monitoring. A time consuming installation phase can be expected if unforeseen problems occur with untested equipment.

6.4.5. Installation of monitoring equipment

The installation should take place with tested equipment at the mail monitoring location.

6.4.6. Development of the response plan

The response plan should be developed, together with the local public postal operator, the national responsible authorities and all parties responsible in an emergency case. Guidance on the response plan is given in this section and in Ref. [20].

6.4.7. Training the local public postal operator

On-site training of managers, postal supervisors and postal workers should be conducted after the equipment is installed. Guidance on the training is given in Section 8. The training should cover:

— Basics in radiation protection as appropriate;
— Monitoring equipment;
— Routine monitoring procedures;
— Training in response to an alarm.

6.4.8. Support for the local public postal operator

After the installation of equipment and completion of the training programme, the local public postal operator usually needs some support to implement the monitoring system and procedures.

7. TRAINING

Field studies have demonstrated that effective radiation monitoring cannot be guaranteed without proper training of the responsible supervisors and staff, even with the installation of high quality equipment [21]. The emergency response team, the responsible managers, postal supervisors, and workers should receive training on radiation protection basics for their own safety and that of the public. The training should provide appropriate theoretical lectures and practical exercises. The training plan and its periodic revision should be described in the response plan. It is advisable to include this training in other existing emergency training structures.

The following target groups or personnel should be identified for training:

— Managers and decision makers;
— Supervisors in postal and customs organizations as applicable;
— Postal workers and customs employees as applicable;
— Emergency response teams.

Appropriate training and course content for these groups could include the following elements:

(a) Awareness training for managers and decision makers
  — Introduction to the problem of radioactive material in public mail to heighten the awareness of responsible managers;
  — Short theoretical background on the health hazards of radiation;
  — Informative and practical exercises.

(b) Introductory training course for postal workers and customs employees
  — Information on radiation protection;
  — Training on monitoring equipment;
  — Practical exercises in responding to alarms.

(c) Advanced training course for postal and customs supervisors
  — Theoretical background information on radiation protection;
  — Training on monitoring equipment;
  — Searching for and localizing radioactive sources;
  — Development of a response plan;
  — Practical exercises in responding to alarms.

(d) Training course for the emergency response team
  — Theoretical and practical training in radiation protection;
  — Training on monitoring equipment;

— Searching for and localizing radioactive sources;
— Development of a response plan;
— Practical exercises in responding to alarms;
— Identification of radioactive sources.

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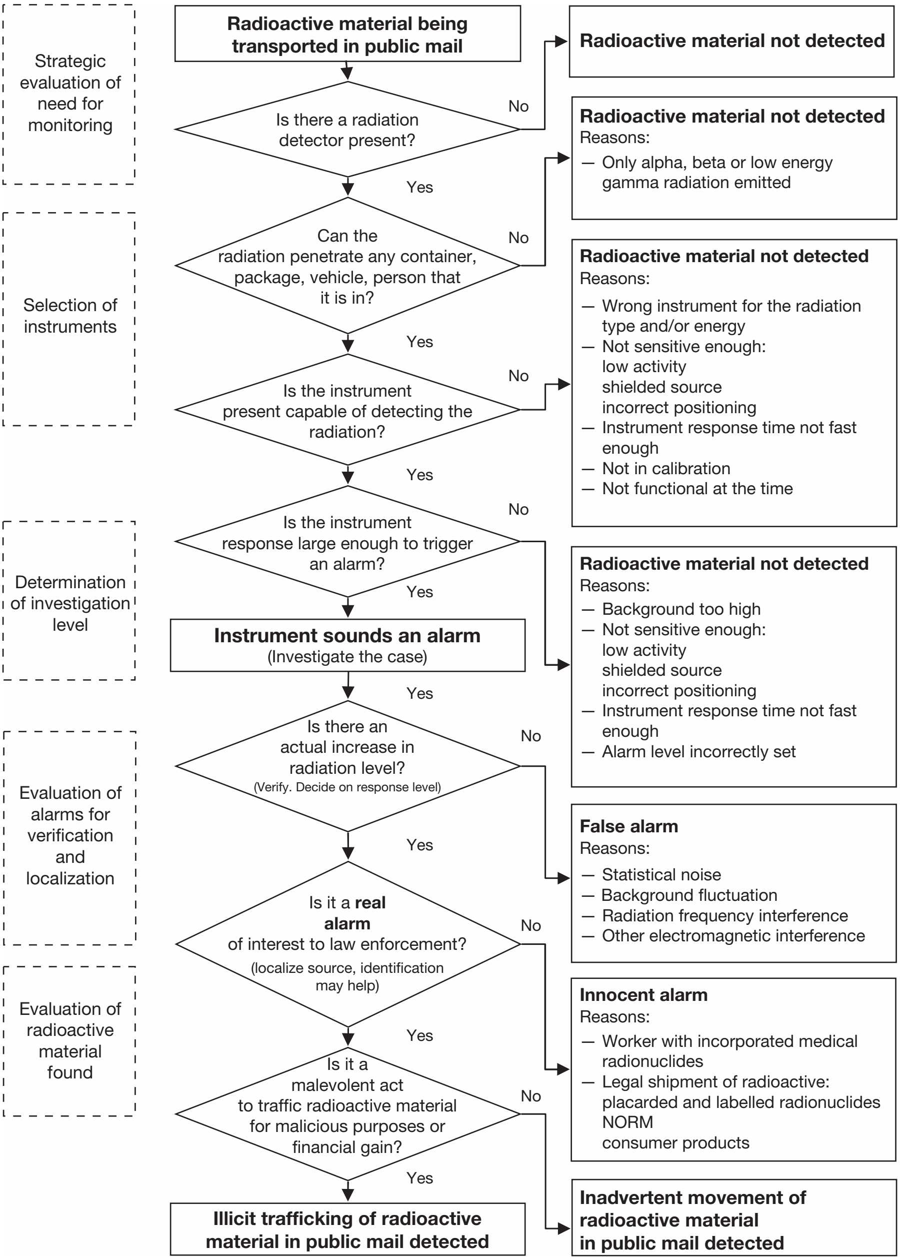
Annex I

PROCESS LEADING TO DETECTION OF RADIOACTIVE MATERIAL IN PUBLIC MAIL



Annex II

RADIOACTIVE MATERIAL IN PUBLIC MAIL: FOUR DIFFERENT SCENARIOS

II–1. SCENARIO 1: RADIOACTIVE MATERIAL WITH INTERNAL SHIELDING IN PUBLIC MAIL

The most likely scenario is the illegal shipment of a radioactive source within a shielding container transported by EMS or parcel mail. Any radiation outside such a consignment which is above a certain dose rate level (see Section 4) can be assessed by a PRD, RID or RPM.

The individual country regulates the maximum weight for a single parcel consignment; in general, it is between 10 and 50 kg. Most of the countries accept a 20 kg consignment by EMS or parcel mail.

For an estimation of the health hazard due to a radioactive source in a consignment, the type of radiation and shielding material and also the radiation detector efficiency have to be taken into account. As examples, two different sources in different shielded consignments, all of a total weight of 20 kg, are considered. In all cases, a typical radiation environment of 0.05 $\mu Sv \cdot h^{-1}$, a measurement distance of 10 cm and a conveyor transport speed of 0.5 $m \cdot s^{-1}$ have been considered in the analysis.

Even a significant mass and activity of a radioactive ^{137}Cs or ^{60}Co source, adequately shielded, can be transported in a mail consignment without any health hazard to postal workers and the public. The maximum possible activity transported under these conditions is different for a ^{137}Cs and ^{60}Co source. However, if the package is opened and the shielding is dismantled, the radiation exposure from either source could lead to serious health hazards or even to death.

The worst case scenario of illicit trafficking of radioactive material using shielding is a ^{137}Cs source or other sources with lower photon emitting energy covered with lead or shielding by depleted uranium. With regard to the radiation protection of postal workers, the radiation exposure should be measured with a PRD, RID or RPM. X ray screening is recommended for the detection of high density shielding material. Any such information should lead to further investigations concerning a suspicious shipment.

II–2. SCENARIO 2: RADIOACTIVE MATERIAL IN PUBLIC MAIL WITH NO SHIELDING

If radioactive material is contained in public mail without heavy shielding, postal workers and the public can be exposed to potential health hazards even without opening the package. If a radioactive liquid or radioactive dust is involved in a malevolent activity, the whole package could become contaminated. The transportation of the item could lead to the contamination of postal workers and the public. Radioactive gamma and neutron contamination above a certain dose rate level on the outside of a consignment can be assessed by using a PRD, RID or RPM (see Section 5).

If no shielding is used, the most likely scenario is an illegal transport of a radioactive substance by letter mail with a maximum weight of 20 g (standard letter) or up to 2000 g (reduced rate letter).

For an estimation of the mass of a radioactive source that could be transported in a standard letter of 20 g, case A uses a ^{137}Cs source, whereas case B uses a ^{60}Co source. Radiation sources usually are housed in a small iron cylinder of 10–30 mm length and 5 mm diameter. The maximum depth of a standard letter is 5 mm. Such a cylinder has a typical weight of 1–5 g; the remaining weight is therefore 15–19 g.

In case A, a standard letter contains 15 g of ^{137}Cs. The corresponding activity is about 50 TBq (1.3 kCi). The ambient dose equivalent rate at 1 m distance is 4 Sv·h^{-1}, and at 10 cm distance about 400 Sv·h^{-1}. In case B, a standard letter contains 15 g of ^{60}Co. The corresponding activity is about 630 TBq (17 kCi). The ambient dose equivalent rate at 1 m distance is 648 Sv·h^{-1}, and at 10 cm distance 65 kSv·h^{-1}.

In both cases A and B, a lethal radiation dose could potentially be absorbed within a short time and lead to instant health effects on the skin and other human tissue and death after some days. In this regard, the temperature produced in both cases A and B cannot be neglected. For the radiation protection of postal workers, exposure can be measured with a PRD, RID or RPM at a distance of some 100 m.

II–3. SCENARIO 3: NUCLEAR MATERIAL IN PUBLIC MAIL

Another scenario using public mail is illicit trafficking of nuclear material (e.g. uranium or plutonium isotopes), which could be used to build a nuclear weapon. Uranium and plutonium are radiotoxic substances due to their alpha radiation emission, particularly if contaminated dust is ingested or inhaled.

Both isotopes emit neutrons and gamma radiation that can be detected by RIDs or RPMs (see Section 5).

Uranium in its natural form consists of the isotopes ^{238}U (99.3%) and ^{235}U (0.7%). A high enrichment of ^{235}U is needed to build a nuclear weapon. A typical composition of weapons grade uranium is more than 90% of ^{235}U.

Plutonium is another fissile material used to build nuclear weapons; it does not exist in natural form. It is produced in nuclear facilities using natural uranium. A typical composition of weapons grade plutonium is more than 93% of ^{239}Pu.

The illicit trafficking of 20 kg of unshielded natural uranium can be detected instantly by any radiation monitoring equipment described in Section 4. The ambient dose equivalent rate at 1 m distance will not lead to a significant radiation health hazard due to the amount of natural uranium or weapons grade uranium, which however may not be measured at this distance if adequate shielding geometry and material are used.

The illicit trafficking of weapons grade plutonium can be detected instantly by the radiation monitoring equipment described in Section 4. The ambient dose equivalent rate at 1 m distance will not lead to a significant radiation health hazard. Even if a significant shielding material is used, neutron radiation could be detected by the neutron sensitive radiation monitoring equipment described in Section 4.

X ray screening is recommended for the detection of high density shielding material. Any such information should lead to further investigations concerning a suspicious shipment.

II–4. SCENARIO 4: COMBINATION OF A RADIOACTIVE SOURCE WITH CONVENTIONAL EXPLOSIVES

Conventional explosives have been observed several times in public mail. Such incidents can lead to a serious health hazard or death. Several security experts have described the use of an RDD as a very likely scenario for a malevolent act. The hazard consists of the consequences of conventional explosives and the radioactive contamination of the population, buildings and the environment. Depending on the activity and half-life of the radioactive material dispersed, the contamination could cover a wide area for an extended time period. Although the effect is not comparable with a nuclear weapon, the consequences of an explosion of an RDD could lead to health effects and public panic.

The maximum amount of dispersed radioactive material depends on the amount of explosives and the radioactive material used; scenarios with and without shielding material are conceivable. Although any radioactive material could be used in combination with conventional explosives, the most likely scenarios include the use of industrial sources such as ^{137}Cs or ^{60}Co. The radiation detectors described in Section 5 can detect mail consignments containing shielded and unshielded ^{137}Cs or ^{60}Co radioactive material. Taking into account the weight of explosives, a corresponding lower amount of radioactive material has to be considered.

X ray screening is recommended for the detection of high density shielding material and explosives.

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