IAEA Safety Standards

for protecting people and the environment

Arrangements for Preparedness for a Nuclear or Radiological Emergency

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Safety Guide

No. GS-G-2.1

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ARRANGEMENTS FOR PREPAREDNESS FOR A NUCLEAR OR RADIOLOGICAL EMERGENCY

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

IAEA SAFETY STANDARDS SERIES No. GS-G-2.1

ARRANGEMENTS FOR PREPAREDNESS FOR A NUCLEAR OR RADIOLOGICAL EMERGENCY

SAFETY GUIDE

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FOREWORD

by Mohamed ElBaradei
Director General

The IAEA's Statute authorizes the Agency to establish safety standards to protect health and minimize danger to life and property — standards which the IAEA must use in its own operations, and which a State can apply by means of its regulatory provisions for nuclear and radiation safety. A comprehensive body of safety standards under regular review, together with the IAEA's assistance in their application, has become a key element in a global safety regime.

In the mid-1990s, a major overhaul of the IAEA's safety standards programme was initiated, with a revised oversight committee structure and a systematic approach to updating the entire corpus of standards. The new standards that have resulted are of a high calibre and reflect best practices in Member States. With the assistance of the Commission on Safety Standards, the IAEA is working to promote the global acceptance and use of its safety standards.

Safety standards are only effective, however, if they are properly applied in practice. The IAEA's safety services — which range in scope from engineering safety, operational safety, and radiation, transport and waste safety to regulatory matters and safety culture in organizations — assist Member States in applying the standards and appraise their effectiveness. These safety services enable valuable insights to be shared and I continue to urge all Member States to make use of them.

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

The IAEA takes seriously the enduring challenge for users and regulators everywhere: that of ensuring a high level of safety in the use of nuclear materials and radiation sources around the world. Their continuing utilization for the benefit of humankind must be managed in a safe manner, and the IAEA safety standards are designed to facilitate the achievement of that goal.

PREFACE

In March 2002, the IAEA's Board of Governors approved a Safety Requirements publication, Preparedness and Response for a Nuclear or Radiological Emergency, jointly sponsored by seven international organizations, which established the requirements for an adequate level of preparedness for and for response to a nuclear or radiological emergency in any State. The IAEA General Conference, in resolution GC(46)/RES/9, encouraged Member States "to implement, if necessary, instruments for improving their own preparedness and response capabilities for nuclear and radiological incidents and accidents, including their arrangements for responding to acts involving the malicious use of nuclear or radioactive material and to threats of such acts", and has further encouraged them to "implement the Safety Requirements for Preparedness and Response to a Nuclear or Radiological Emergency".

The Convention on Early Notification of a Nuclear Accident ('Early Notification Convention') and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency ('Assistance Convention') adopted in 1986 place specific obligations on the Parties and on the IAEA. Under Article 5a (ii) of the Assistance Convention, one function of the IAEA is to collect and disseminate to States Parties and Member States information concerning methodologies, techniques and available results of research relating to response to such emergencies.

This Safety Guide is intended to assist Member States in the application of the Safety Requirements publication on Preparedness and Response for a Nuclear or Radiological Emergency, Safety Standards Series No. GS-R-2, and to help in fulfilling the IAEA's obligations under the Assistance Convention. In fulfilling its functions under the Assistance Convention and Early Notification Convention, the IAEA works together with other international organizations within an Inter-Agency Committee for Response to Nuclear Accidents (IACRNA). IACRNA has cooperated in the establishment of common requirements for preparedness and response for a nuclear or radiological emergency. Six members of IACRNA co-sponsored the development of Safety Standards Series No. GS-R-2. The Food and Agriculture Organization of the United Nations (FAO), the International Labour Office (ILO), the Pan American Health Organization (PAHO), the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) and the World Health Organization (WHO) are joint sponsors of this Safety Guide.

CONTENTS

1. INTRODUCTION

BACKGROUND

1.1. Under Article 5(a)(ii) of the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (the ‘Assistance Convention’) [1], one function of the IAEA is to collect and disseminate to States Parties and Member States information concerning methodologies, techniques and available results of research relating to response to such emergencies.

1.2. In March 2002, the IAEA’s Board of Governors approved a Safety Requirements publication, Preparedness and Response for a Nuclear or Radiological Emergency, issued as Safety Standards Series No. GS-R-2 [2], jointly sponsored by seven international organizations, which established the requirements for an adequate level of preparedness for and for response to a nuclear or radiological emergency in any State. The IAEA General Conference in resolution GC(46)/RES/9 encouraged Member States “to implement, if necessary, instruments for improving their own preparedness and response capabilities for nuclear and radiological incidents and accidents, including their arrangements for responding to acts involving the malicious use of nuclear or radioactive material and to threats of such acts” and has further encouraged them to “implement the Safety Requirements for Preparedness and Response to a Nuclear or Radiological Emergency”.

This Safety Guide is not a standalone text. It should be used in conjunction with Ref. [2], referred to in this text as ‘the Requirements’.

OBJECTIVE

1.3. The primary objectives of this Safety Guide are:

- To provide guidance on those selected elements of the Requirements [2] for which guidance has been requested by Member States and for which there is an international consensus on the means to meet these requirements;
- To describe appropriate responses to a range of emergencies;
- To provide background information, where appropriate, on the past experience that provided a basis for the Requirements, thus helping the

user to better implement arrangements that address the underlying issues.

SCOPE

1.4. The guidance presented in this Safety Guide concerns emergency preparedness for a nuclear or radiological emergency. The range of possible nuclear or radiological emergencies of concern is enormous, extending from a general emergency at a nuclear power plant to emergencies involving lost, stolen or found radioactive material. The guidance presented in this Safety Guide is applicable to the entire range of emergencies, concentrated on the general aspects of emergency preparedness.

1.5. Clearly, this Safety Guide cannot take all State specific, site specific or emergency specific factors into account. Planners should remain flexible in their use of the guidance and should adapt it to take account of local sociopolitical, economic and other factors.

1.6. This Safety Guide does not provide detailed guidance on all the arrangements or operational criteria necessary to respond effectively to a nuclear or radiological emergency. The IAEA has published more detailed information on developing and maintaining an effective emergency response capability. Reference [3] provides an overview of this information. Guidance on preparing for emergency response to transport accidents involving radioactive material is provided in Ref. [4].

1.7. This Safety Guide does not provide guidance on the tactical or investigative response to terrorist or other criminal acts. It does address the coordination of such a response with the response to deal with actual or to anticipate potential radiological consequences.

STRUCTURE

1.8. This Safety Guide is divided into six sections. Section 2 provides guidance on basic concepts that must be understood to apply the guidance. Sections 3, 4 and 5 provide guidance on how to meet the requirements in the corresponding sections of the Requirements [2]. Section 6 discusses the concept of operations, describing in general terms how the response should proceed for different types of emergency. The Safety Guide also contains eight appendices and an annex which provide further elaboration and clarification. Recommendations expressed as ‘should’ statements carry the implication that it is necessary to take the measures recommended or equivalent alternative measures to comply with the Requirements. Requirements quoted directly from Ref. [2] are expressed as ‘shall’ statements.

2. BASIC CONCEPTS

TYPES OF EMERGENCY

2.1. The approaches for developing the capability to respond to a nuclear or radiological emergency differ depending on the characteristics of the emergency. Consequently, it is convenient to divide the guidance for emergency preparedness and response into two classes:

(a) Nuclear emergencies. These are categorized in threat category I, II or III[1], depending on their on-site and off-site threats. Nuclear emergencies may occur at:

— Large irradiation facilities (e.g. industrial irradiators);
— Nuclear reactors (research reactors, ship reactors and power reactors);
— Storage facilities for large quantities of spent fuel or liquid or gaseous radioactive material;
— Fuel cycle facilities (e.g. fuel processing plants);
— Industrial facilities (e.g. facilities for manufacturing radiopharmaceuticals);
— Research or medical facilities with large fixed sources (e.g. teletherapy facilities).

(b) Radiological emergencies. These are categorized in threat category IV. They can occur anywhere and so this guidance is applicable to all States. Radiological emergencies include:

[1] The threat categories are discussed in paras 2.19 and 2.20.

— Uncontrolled (abandoned, lost, stolen or found) dangerous sources;[2]
— Misuse of industrial and medical dangerous sources (e.g. of those used in radiography);
— Public exposures and contamination from unknown origins;
— Re-entry of a satellite containing radioactive material;
— Serious overexposures;[3]
— Malicious threats and/or acts;
— Transport emergencies.

RADIATION INDUCED HEALTH EFFECTS

2.2. The Requirements [2] (para. 2.3) present the following practical goals of emergency response in relation to radiation induced health effects:

"— To prevent the occurrence of [severe] deterministic health effects[4] in workers and the public;
— To render first aid and to manage the treatment of radiation injuries;
— To prevent, to the extent practicable, the occurrence of stochastic health effects in the population."

2.3. This section reviews the important aspects of radiation induced health effects that may result from a nuclear or radiological emergency. Reference [5] provides a further discussion of these health effects.

Deterministic effects

2.4. One of the primary objectives of the response to an emergency is to prevent the occurrence of deterministic effects. A deterministic effect of radiation is one for which generally a threshold level of dose exists, below which there is no effect and above which the severity of the effect increases

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[2] A dangerous source is a source that could, if not under control, give rise to exposure sufficient to cause severe deterministic health effects. This categorization is used for determining the need for emergency response arrangements and is not to be confused with categorizations of sources for other purposes. Dangerous sources are discussed further in Appendix III.

[3] A serious overexposure is one that can result in severe deterministic health effects.

[4] 'Severe deterministic effect' is defined in the Glossary under 'deterministic effect'.

with the dose received. The threshold differs for different organs and for different effects. A deterministic effect is described as 'severe' if it is fatal or life threatening or results in a permanent injury that reduces quality of life. The thresholds for severe deterministic effects are — except for doses to the foetus — one or more grays (Gy) from radiation at high dose rates (thousands to millions of times the normal radiation doses due to background levels of radiation) delivered over a short period of time. Keeping the doses below these thresholds will prevent deterministic effects.

2.5. Radiological emergencies in the past have resulted in severe deterministic effects, including fatalities and very serious injuries, among the public [6–12]. Severe deterministic effects have also occurred in patients owing to accidental medical overexposure [13, 14].

2.6. Severe deterministic effects have occurred among workers and responders in emergencies at facilities in threat categories I, II and III [15–18]. Severe deterministic effects could also result off a site owing to a release of large amounts of radioactive material from facilities in threat category I. This threat is most probably limited to large reactors[5] and facilities where there are large quantities of volatile radioactive material, such as facilities for reprocessing fuel waste.

Stochastic effects

2.7. For a stochastic health effect of radiation, the probability of its occurrence increases with increasing dose, and the severity of the effect (if it occurs) is independent of dose. Stochastic effects are assumed to occur without a threshold level of dose and they include cancers (e.g. thyroid cancer and leukaemia) and hereditary effects.

2.8. Only the exposure of many tens of thousands of people to whole body doses in the range of 100–200 mSv [15] or of many tens of thousands of children to thyroid doses of the order of 50 mSv [19] (i.e. at dose rates thousands of times higher than those due to background levels of radiation) could result in a detectable increase in the incidence of cancer among those population groups

[5] In the Chernobyl accident, dose rates off the site were higher than 1 Gy/h from the deposition of radioactive material, which is sufficient to cause severe deterministic health effects within a few hours [15]. Fortunately, these dose rates occurred only in uninhabited areas.

exposed. Even emergencies that have led to the exposure of very large groups of people (e.g. the Chernobyl accident) who received doses well above those due to background levels of radiation have not resulted in a detectable increase in the incidence of solid cancers among those exposed.[6]

2.9. Typically, following a nuclear or radiological emergency a number of people (not all of whom may be experts) will make estimates of a radiation induced increase to be expected in the incidence of cancers and other effects (e.g. birth defects) that may appear among those population groups who were exposed to radiation as a result of the emergency. Such stochastic health effects would not be individually attributable to radiation exposure (as they could not be distinguished from health effects with other causes). Estimates of consequences for a population may be made on the basis of the collective radiation dose (i.e. the sum total of all individual doses in an exposed population, expressed in man-sieverts) and levels of radiation health risks derived from observations made on exposed population groups who received high radiation doses (e.g. survivors of the atomic bombing in Japan). However, health consequences to be expected are generally estimated for people who have received only low radiation doses. In estimating such health consequences certain assumptions have to be made because of scientific uncertainties concerning the biological effects of radiation exposure at low doses and low dose rates. For the purposes of the system of radiation protection the assumption is made that there is no threshold level of radiation dose below which there is no associated radiation risk. This is only an assumption, however; data on radiation health risks that are yielded by studying the effects of exposure at high doses are not directly applicable for low dose exposure. Moreover, the very small projected increases in the incidence of cancers among those people exposed with such low levels of dose would in any case be undetectable epidemiologically against the fluctuations in the spontaneous incidence. Incautious estimates of the health effects of low dose exposures have

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[6] As of 2000 no excess solid cancers had been observed among the approximately 200 000 people who performed recovery operations within the 30 km zone in 1986–1987 where the highest doses were received following the Chernobyl accident [15]. However, a major increase was detected in the incidence of thyroid cancer among those persons who had received radiation doses as a foetus or child following the Chernobyl accident. This detectable increase in incidence in this population group was due to a very large release of radioiodine, resulting in high thyroid doses in hundreds of thousands of children (primarily due to the consumption of contaminated milk and leafy vegetables). This radiation induced rise in cancer incidence was easily detected epidemiologically because of the very low spontaneous rate of thyroid cancers among the children.

led to what many consider is an exaggerated view on the part of the public of the risks associated with radiation, and consequently in inappropriate and, in some cases, counterproductive and harmful ‘protective’ actions being taken by the public and by officials. Risks of stochastic effects occurring as a result of low radiation doses (e.g. lower than 100 mSv) that are quantified for the purposes of radiation protection should therefore be interpreted for and communicated to the public with great caution, if at all. Any such quantification should be accompanied by a plain language explanation that makes it clear that, for such low doses, any radiation induced increase in the incidence of health effects in a population would be inherently very difficult, if not impossible, to detect. This plain language explanation should also discuss the risks and consequences of any actions taken to reduce the risks associated with exposure. If others (e.g. official or unofficial parties within or outside the State) make such estimates, consideration should be given to providing a clear explanation that puts these estimates in perspective.

2.10. One of the important goals of emergency preparedness is to prevent, to the extent practicable, the occurrence of stochastic effects. Since it is assumed that any dose, no matter how small, can increase the risk of occurrence of a stochastic effect, it would be impracticable and probably harmful to attempt to reduce the dose, and thus its associated risk, resulting from an emergency to near zero. In fact, some actions taken to reduce the risk of stochastic effects (e.g. relocation from an area with insignificant levels of contamination) may do more harm than good. The difficulty lies in determining what is practicable and reasonable. To address this issue, international standards provide generic intervention and action levels at which various protective measures would be justified on radiation protection grounds [2]. Taking protective action at levels significantly below these levels could do more harm than good.

Special concern

2.11. One special concern is radiation exposure of the embryo or foetus (exposure in utero). The health effects of radiation exposure in utero may include both deterministic effects (e.g. a reduction in average intelligence quotient among an exposed group) and stochastic effects expressed in the child after birth (e.g. radiation induced cancers). As with the general population, only the exposure of a large number of pregnant women to doses many times those due to normal background levels of radiation could possibly give rise to a detectable increase in stochastic effects among children exposed in utero.[6] During the period of 8–25 weeks after conception, foetal doses in excess of about 100 mGy may result in a verifiable decrease of intelligence quotient [20].

This would correspond to dose rates a thousand or more times those due to normal background levels. However, doses sufficient to result in deterministic effects in a child born following in utero exposure, as a consequence of a nuclear or radiological emergency, have not been reported.[7]

EXPOSURE PATHWAYS

2.12. The ways in which people can be exposed to radiation are referred to as exposure pathways and include:

— External exposure from contact with or being in proximity to a source of radiation (e.g. a source, a plume containing radioactive material or ground contamination);
— Ingestion (e.g. of contaminated food, milk or water, inadvertent ingestion of contamination on hands);
— Inhalation from a plume or due to the resuspension of deposited radioactive material;
— Contamination of skin and clothing.

2.13. For radiological emergencies that have involved uncontrolled dangerous sources in the public domain, historically the most important pathways of exposure have been external exposure and inadvertent ingestion. Severe deterministic effects have resulted from unshielded dangerous sources being carried (e.g. by hand or in pockets) or taken home [9–12, 21].[8] In one instance, individuals who were not aware of the hazard removed a dangerous amount of radioactive material from its container and scattered this material. This led to the contamination of large and complex areas in a city, and at least one victim inadvertently ingested an amount of this material with fatal consequences [6]. In these emergencies, the most important means of movement of the radioactive material was human activity.

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[7] Studies on adverse consequences relating to the Chernobyl accident have been performed in those areas close to the plant where the doses were highest. “So far, no increase in birth defects, congenital malformations, stillbirths, or premature births could be linked to radiation exposure caused by the [Chernobyl] accident” [15].

[8] In one emergency, a family member picked up a tiny, shiny cylinder (a lost radiography source) and took it home. This resulted in the deaths of eight family members and relatives in the following three months [21].

2.14. Workers in irradiation facilities (threat category III) have received lethal exposures from being near extremely dangerous unshielded sources[9] [16, 17], in one case for less than a minute [22]. Workers have also received fatal doses almost instantaneously from being near an accidental criticality event in a fuel cycle facility [18].

2.15. For radiological emergencies an airborne release of radioactive material is of concern primarily if a dangerous source containing dispersible material is in a fire or explosion. The distance at which such a release is hazardous is typically limited to less than a few hundred metres, but this depends on many factors such as the size of the source, the amount of material dispersed into the air, its dilution, the movement of the plume and the size and nature of the particles.[10] It may be that none of these factors is known with any certainty during an emergency.

2.16. For airborne releases from facilities the significant pathways of exposure for the public are mainly:

— External gamma radiation from the plume, called cloud shine;
— External gamma radiation from radioactive material deposited on the ground, called ground shine;
— Inhalation of radioactive material contained in the plume;[11]
— Ingestion of contaminated food, milk or water;
— To a lesser extent, deposition of radioactive material on the skin.

2.17. The pattern of the radioactive material deposited following an airborne radioactive release is very complex, as was seen following the Chernobyl [15, 23] and Tomsk [24] accidents. For facilities in threat category I, airborne releases have been postulated (e.g. for large reactors [25]) or have actually occurred (i.e. in the Chernobyl accident [15]) that would result or have resulted in doses sufficient to cause severe or even fatal deterministic effects within a few hours to persons off the site. For some facilities in threat categories I and II, airborne releases have been postulated or have actually occurred [25, 26] that would result or have resulted in doses over several days sufficient to warrant

[9] See Table 9 for the D values of different radionuclides.

[10] Appendix III provides a plain language explanation of the possible impacts of emergencies involving dangerous sources.

[11] Resuspension could be an important pathway of exposure if the deposited material contains significant amounts of alpha emitters (e.g. Pu).

the implementation of urgent protective measures to prevent severe deterministic effects or reasonably to reduce the risk of stochastic effects.

2.18. There may also be emergencies at some threat category II facilities that involve unshielded criticalities and that would result in off-site doses (without a significant airborne release[12]) sufficient to warrant the implementation of urgent protective actions within a distance of several hundred metres.

THREAT CATEGORIES

2.19. The Requirements [2] and the guidance in this publication are often specified for the threat categories summarized in Table 1. Threat categories I, II and III represent decreasing levels of threat at major facilities and therefore correspond to decreasing stringency of requirements for emergency preparedness and response. Facilities in threat categories I and II warrant extensive on-site and off-site arrangements for emergency preparedness. For facilities in threat category III the radiation related threat is limited to the site or to areas on the site (e.g. treatment rooms or laboratories), but arrangements to inform and reassure the public in the event of an emergency are still warranted.

2.20. Threat category IV includes radiological emergencies that could occur anywhere unexpectedly and applies always in all jurisdictions, possibly together with other threat categories. Threat category IV includes emergencies involving the types of event listed in Table 2.

2.21. These threat categories apply both to facilities or practices and to governmental jurisdictions for which various levels of preparedness are warranted. Section 3 provides guidance on determining threat categories and Appendix I gives examples of threat categories for different practices.

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[12] Criticality accidents cannot produce sufficient amounts of fission products to result in a significant airborne radioactive release; however, the energy produced could result in an airborne release of other hazardous material that may be present at the time of the criticality.

TABLE 1. FIVE CATEGORIES OF NUCLEAR AND RADIATION RELATED THREATS FOR THE PURPOSES OF THE REQUIREMENTS (taken directly from Ref. [2])

Threat category	Description
I	Facilities, such as nuclear power plants, for which on-site events[a] (including very low probability events) are postulated that could give rise to severe deterministic health effects[b] off the site, or for which such events have occurred in similar facilities.
II	Facilities, such as some types of research reactors, for which on-site events[a] are postulated that could give rise to doses to people off the site that warrant urgent protective action in accordance with international standards[c], or for which such events have occurred in similar facilities. Threat category II (as opposed to threat category I) does not include facilities for which on-site events (including very low probability events) are postulated that could give rise to severe deterministic health effects off the site, or for which such events have occurred in similar facilities.
III	Facilities, such as industrial irradiation facilities, for which on-site events are postulated that could give rise to doses that warrant or contamination that warrants urgent protective action on the site, or for which such events have occurred in similar facilities. Threat category III (as opposed to threat category II) does not include facilities for which events are postulated that could warrant urgent protective action off the site, or for which such events have occurred in similar facilities.
IV	Activities that could give rise to a nuclear or radiological emergency that could warrant urgent protective action in an unforeseeable location. These include non-authorized activities such as activities relating to dangerous sources obtained illicitly. They also include transport and authorized activities involving mobile dangerous sources such as industrial radiography[d] sources, nuclear powered satellites or radiothermal generators. Threat category IV represents the minimum level of threat, which is assumed to apply for all States and jurisdictions.

TABLE 1. FIVE CATEGORIES OF NUCLEAR AND RADIATION RELATED THREATS FOR THE PURPOSES OF THE REQUIREMENTS (taken directly from Ref. [2]) (cont.)

Threat category	Description
V	Activities not normally involving sources of ionizing radiation, but which yield products with a significant likelihood[e] of becoming contaminated, as a result of events at facilities in threat category I or II, including such facilities in other States, to levels necessitating prompt restrictions on products in accordance with international standards.

[a] Such on-site events would be events involving an atmospheric or aquatic release of radioactive material or external exposure (e.g. due to a loss of shielding or a criticality event) that originates from a location on the site.

[b] Doses in excess of those for which intervention is expected to be undertaken under any circumstances (Refs [2, 5]). See the Glossary under 'deterministic effect'.

[c] See Annex III of Ref. [2].

[d] For the purposes of this Safety Guide a mobile source is a source, such as a radiography camera, that is authorized to be used under the control of the operator at any location.

[e] Contingent on the occurrence of a significant release of radioactive material from a facility in threat category I or II.

AREAS AND ZONES

2.22. The Requirements [2] establish numerous requirements relating to generic areas: on the site (on-site) and off the site (off-site). In addition, the Requirements [2] establish requirements (para. 4.48) for two off-site emergency zones: the precautionary action zone (PAZ) and the urgent protective action planning zone (UPZ). Finally, the Requirements [2] establish requirements (para. 4.89) for areas in threat category V.

On-site area

2.23. The on-site area is the area under the control of the operator or first responders.

2.24. For facilities in threat category I, II or III, the on-site area is the area surrounding the facility within the security perimeter, fence or other designated property marker that is under the immediate control of the facility operator.

TABLE 2. TYPES OF EVENT ASSOCIATED WITH RADIOLOGICAL EMERGENCIES

— Detection of medical symptoms of radiation exposure due to unknown sources
— Lost dangerous source
— Theft of a dangerous source
— Found dangerous source
— Recovery of an uncontrolled dangerous source
— Radiography: disconnected or damaged source
— Radiography: source in a fire
— Damage to a fixed dangerous sealed source (e.g. as used in gauges)
— Public contamination and/or exposure (including that caused intentionally)
— Re-entry of a satellite containing radioactive material
— Accident with a nuclear weapon
— Transport emergency
— Emergency in radiology or nuclear medicine
— Emergency in radiotherapy
— A serious overexposure
— Credible or confirmed terrorist threats
— Non-credible terrorist threats
— An explosive radiological dispersal device
— Intentional contamination of water supply
— Intentional contamination of food and/or other products
— Detection of elevated radiation levels (in air, water, food or other products)
— Notification of a transnational emergency by the IAEA or any State

2.25. For licensed practices using radiography sources or other dangerous sources in threat category IV this is the area under the control of the operator.

2.26. For radiological emergencies involving transport, uncontrolled sources or localized contamination the first responders should establish a security perimeter containing the inner and outer cordoned areas to define the on-site area [27]. This is shown in Fig. 1. Appendix II provides suggested sizes for the inner cordoned area for various radiological emergencies.

Off-site area

2.27. The off-site area is the area beyond that area under the control of the facility, operator or first responders.

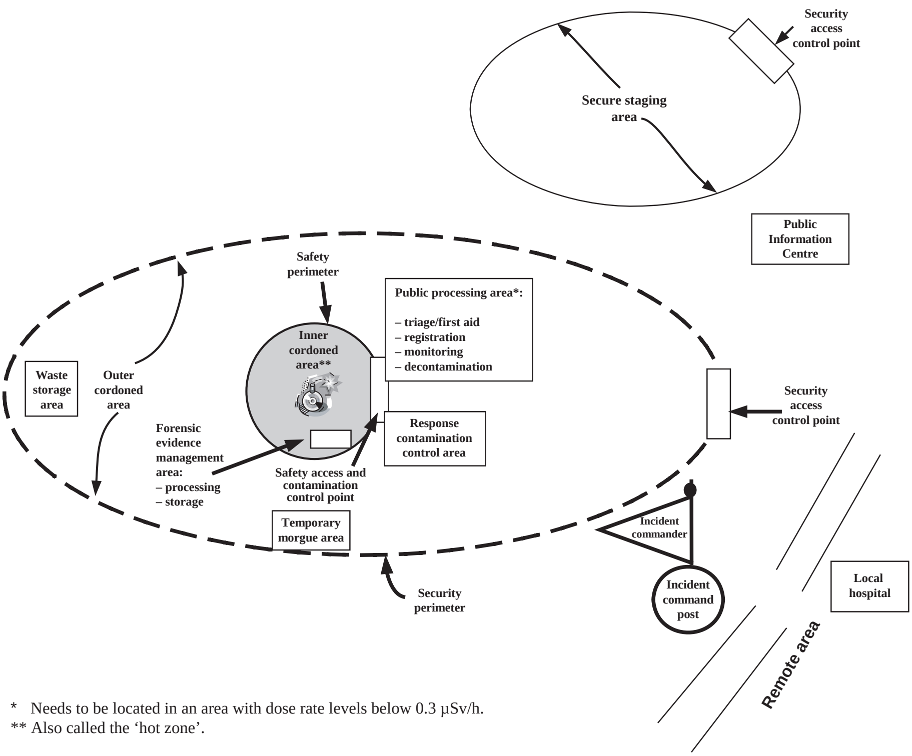

FIG. 1. Areas established by first responders (Appendix VIII provides a description of some of the facilities and locations shown).

2.28. The Requirements [2] (para. 4.48) require that, for facilities in threat category I or II, arrangements be made for effectively making and implementing decisions on urgent protective actions to be taken off the site within:

"(i) A precautionary action zone, for facilities in threat category I, for which arrangements shall be made with the goal of taking precautionary urgent protective action, before a release of radioactive material occurs or shortly after a release of radioactive material begins, on the basis of conditions at the facility (such as the emergency classification) in order to reduce substantially the risk of severe deterministic health effects.

"(ii) An urgent protective action planning zone, for facilities in threat category I or II, for which arrangements shall be made for urgent

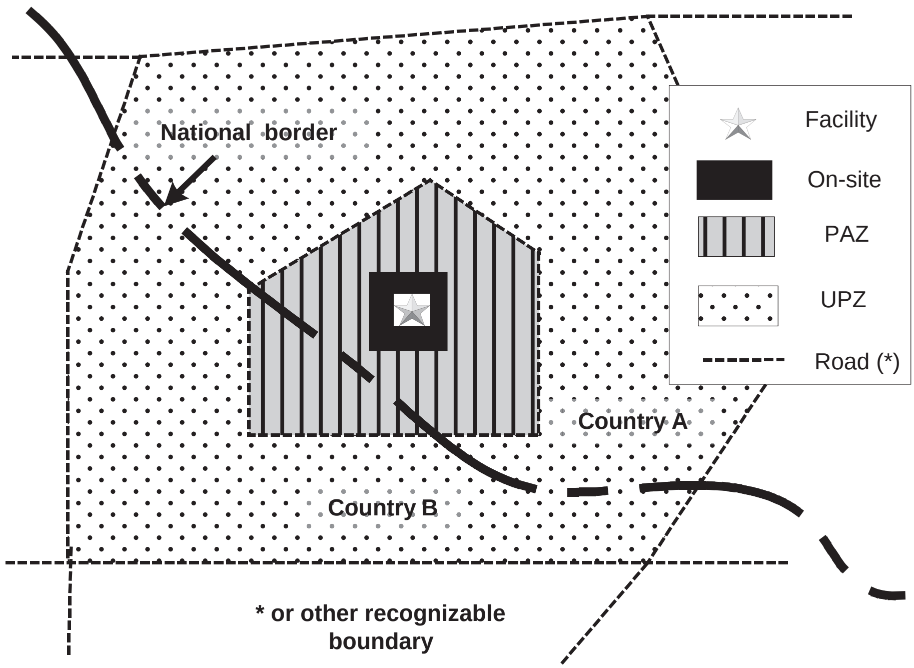

FIG. 2. Emergency zones.

protective action to be taken promptly, in order to avert dose off the site in accordance with international standards."

2.29. The PAZ and UPZ should be roughly circular areas around the facility, and their boundaries should be defined, where appropriate, by local landmarks (e.g. roads or rivers) to allow easy identification during a response, as illustrated in Fig. 2. It should be noted that the zones should not stop at national borders. The size of the PAZ and the UPZ should be in accordance with the guidance provided in Appendix II.

2.30. The Requirements [2] (para. 4.89) establish requirements for areas with activities in threat category V. Threat category V includes activities that might yield products with a significant likelihood of becoming contaminated, as a result of events at facilities in threat category I or II, to levels necessitating prompt restrictions on products in accordance with international standards.

3. GENERAL REQUIREMENTS

BASIC RESPONSIBILITIES

3.1. The Requirements [2] require (para. 3.3) that legislation be adopted to clearly allocate responsibilities for preparedness and response for a nuclear or radiological emergency and for meeting the Requirements.

3.2. Responsibilities for emergency preparedness and response are typically assigned at three levels: operator, off-site and international. Table 3 summarizes the emergency preparedness arrangements that should be the responsibility of the operator and off-site officials.

Operator level

3.3. The operator may be:

— The staff and operating organization of a facility in threat category I, II or III;
— A designated and qualified individual who is authorized to operate equipment containing dangerous sources (threat category IV); such devices are found in:
  - Radiotherapy [28];
  - Industrial radiography;
  - Well logging;
— Those responsible for the on-scene operation of a facility where uncontrolled dangerous sources may be encountered; such facilities include:
  - Border crossings, airports and seaports;
  - Scrap metal dealers and processors.

3.4. The assignment of responsibilities for response to emergencies in transport is discussed in Ref. [4].

3.5. The operator should be responsible, as appropriate, for:

— Identifying and/or detecting an emergency or hazard (e.g. dangerous sources);
— Taking immediate action to mitigate the consequences of the emergency;

TABLE 3. EMERGENCY PREPAREDNESS ARRANGEMENTS BY THREAT CATEGORY

Threat categories I and II	
Operator	Off-site officials responsible for response within the emergency zones
Arrangements to promptly: classify an emergency; protect those on the site and on-site emergency workers; mitigate the consequences of the emergency; notify and recommend protective actions for the public to off-site officials; obtain off-site assistance; conduct environmental monitoring near the facility; and assist off-site officials in keeping the public informed.	Arrangements to promptly: implement urgent protective action within the emergency zones; conduct environmental monitoring; control consumption of contaminated food; provide emergency services to the facility; provide medical treatment for individuals who have been contaminated or overexposed and register them for long term medical follow-up on the basis of predetermined criteria; tell the public and media in plain language of the risks and of the actions they should take; respond to inappropriate public reactions; report transnational emergencies to the IAEA; respond to IAEA notifications; and request IAEA assistance when needed.
Threat category III	
Operator	Off-site officials (near the facility)
Arrangements to promptly: classify an emergency; protect those on the site and on-site emergency workers; inform off-site officials; obtain off-site assistance; ensure that there are no off-site risks; and assist off-site officials in keeping the public informed.	Arrangements to promptly: provide emergency services; protect emergency workers; provide medical treatment to those contaminated or overexposed and register them for long term medical follow-up on the basis of predetermined criteria; confirm there are no off-site impacts; inform the public and media in plain language of the risks and of the actions they should take; respond to inappropriate public reactions; report transnational emergencies to the IAEA; respond to IAEA notifications; and request IAEA assistance when needed.

TABLE 3. EMERGENCY PREPAREDNESS ARRANGEMENTS BY THREAT CATEGORY (cont.)

Threat category IV	
Operator (dangerous source)	Off-site officials (national level)
Arrangements to promptly: recognize an emergency; take action to protect people nearby; mitigate the consequences of the emergency; inform off-site officials of the risks; and provide technical assistance to off-site officials if needed.	Arrangements to: inform as part of an ongoing programme medical practitioners, scrap metal dealers and border crossing officials of the recognition and response to a radiological emergency; promptly make decisions on protective actions in accordance with international standards; provide local officials with assistance in assessing and responding to radiological conditions; provide medical treatment to those contaminated or overexposed and register them for long term medical follow-up on the basis of predetermined criteria; inform the public and media in plain language of the risks and of the actions they should take; respond to inappropriate public reactions; report transnational emergencies to the IAEA; respond to IAEA notifications; and request IAEA assistance when needed.
Threat category V	
Farmers and food production processors	Off-site officials
Arrangements to respond promptly to official instructions to protect food and water supplies and to control potentially contaminated food and water.	Arrangements to issue instructions to protect food and water supplies and to control potentially contaminated food and water and products, in accordance with international standards.

— Protecting individuals on the site and within the area controlled by the operator;
— Declaring the class of the emergency (if appropriate);
— Notifying off-site officials and possibly providing them with recommendations on protective actions and technical assistance;
— Establishing ongoing communication with off-site officials;

- Assisting the off-site officials in keeping the public informed and countering incorrect information and inappropriate public reactions;
- Providing, if possible, initial radiological monitoring and technical advice.

Off-site level

3.6. The off-site level consists of organizations that will perform the response actions carried out off the site, and should include:

- Local officials.

  - For facilities in threat category I, II or III, local officials are the government and support agencies responsible for providing immediate support to the operator and prompt protection of the public in the emergency zones;
  - For a radiological emergency in the public domain, local officials are the emergency services responding at the scene. These include the police, firefighting and civil emergency services or medical personnel, and they may be the first to learn of an emergency.

- Medical practitioners. They should be able to recognize radiation induced injuries and notify the appropriate officials.
- National and regional officials. These are the governmental agencies responsible for planning and response at the national (or regional) level and also non-governmental organizations (NGOs). These agencies should be responsible for providing technical assistance to local responders and for implementing protective actions and other actions that do not need to be implemented urgently to be effective. At the national level, preparations should be made to respond to radiological emergencies that can occur anywhere unexpectedly. These preparations should be designed to support local officials in dealing with these emergencies.
- Officials in all States should be responsible for the implementation of protective actions within the emergency zones of a facility in threat category I or II.

International level

3.7. The international level consists of organizations responsible for providing international assistance as described in the Joint Radiation Emergency Management Plan of the International Organizations [29]. It includes:

— IAEA implementation of the Convention on Early Notification of a Nuclear Accident (‘Notification Convention’) and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (‘Assistance Convention’) [1], and para. 4.15 of the Requirements [2]. The Parties to the Notification Convention commit themselves to informing forthwith those States that may be affected by a significant transboundary release and the IAEA and to meeting the international requirements [2]. States adopting the Conventions must notify States and the IAEA of a transnational emergency. These notifications can be made directly or through the IAEA. However, areas in States with territory within the emergency zones should be notified promptly and directly and not through the IAEA. Under the Assistance Convention, States commit themselves to facilitating prompt assistance in the event of an accident. The IAEA, with the help of Member States and other international organizations, has provided assistance in emergencies under the Assistance Convention, including conducting environmental monitoring, making aerial surveys, providing medical consultation and treatment, assisting with source recovery and assisting with media relations.
— Organizations, such as the United Nations Office for the Coordination of Humanitarian Affairs (OCHA), the World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO), that can provide technical, humanitarian or medical assistance in the event of an emergency.

National coordinating authority

3.8. The Requirements [2] require (para. 3.4) that an existing governmental body or organization be established or identified to act as a national coordinating authority whose function, among others, is to coordinate the threat assessment[13] for threats within the State and to ensure that the functions and responsibilities of operators and response organizations are clearly assigned and are understood by all response organizations.

3.9. The national coordinating authority should be an existing ministry or a standing committee with representatives of all national organizations that play a major part in the response to a nuclear or radiological emergency. This

[13] The term ‘threat assessment’ does not imply that any threat, in the sense of an intention and capability to cause harm, has been made in relation to such facilities, activities or sources.

authority should have the ability to coordinate the response preparations for all the national organizations with roles in preparation for, or response to, nuclear or radiological emergencies, conventional emergencies or criminal activities (e.g. terrorist attacks or threats).

3.10. The national coordinating authority should ensure that a threat assessment (see paras 3.24–3.31) is conducted periodically to identify any new practice or event that could necessitate an emergency response. This should include the exchange of information with nearby States.

3.11. The national coordinating authority should determine which tasks each organization plans to perform during an emergency, whether it is actually responsible for them and whether it has adequate resources and capabilities to perform them. The findings should then be assessed at the national and local levels to identify gaps, overlaps and conflicts. The national coordinating authority should resolve any conflicts and incompatible arrangements between the various participating organizations.

3.12. The national coordinating authority should ensure that organizations that perform tasks (conventional, radiological or law enforcement) that are critical to a successful response have agreed to their assigned responsibilities as defined in the concept of operations (see Section 6). Reference [3] provides a list of tasks that are critical for a successful response.

3.13. The national coordinating authority should coordinate the development of the national all-hazards response plan or the national radiation emergency plan and should foster the implementation by other States of measures designed to fulfil the relevant international obligations[14] in accordance with the Requirements [2] (para. 3.5). (In this context, a 'radiation emergency' means the same as a 'nuclear or radiological emergency'.)

3.14. The individual groups to which roles and responsibilities are assigned should make a commitment to develop the necessary response capability.

3.15. Within the national coordinating body, a single overall national radiation emergency planning coordinator should be designated to guide the preparedness process.

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[14] For example, to notify promptly those States with territory within the emergency zones in the event of a general emergency.

3.16. The coordinator should have in-depth technical and operational knowledge of emergency preparedness and response issues and should have sufficient decision making authority to ensure an effective coordination process. The coordinator should be provided with sufficient staff and resources for the long term to develop and maintain the response capability once it has been established. This should include a multi-year budget.

Integrated planning (all hazards approach)

3.17. A nuclear or radiological emergency may be caused by or may involve different types of hazards, including natural (e.g. storms), technological (e.g. nuclear power generation) or criminal and malicious activity (e.g. theft, sabotage, terrorist attacks). The response to each of these hazards would probably involve different response organizations with their own response terminology, cultures and plans.

3.18. Consequently, the Requirements [2] (para. 3.11) require that the national coordinating authority and the response organizations ensure that the arrangements for response to a nuclear or radiological emergency are coordinated with the arrangements for response to conventional emergencies.

3.19. The planning and preparations for response to a nuclear or radiological emergency should be integrated with the planning for response to hazards of all types and should fully involve the national or local organizations responsible for response to conventional emergencies such as those due to fires, floods, earthquakes, tsunamis or storms. Since an emergency may involve criminal activity such as terrorism or theft, preparations should also involve law enforcement agencies.

3.20. Consequently, the Requirements [2] (para. 3.12) require that “All organizations that may be involved in the response to a nuclear or radiological emergency shall ensure that appropriate management arrangements are adopted to meet the timescales for response throughout the emergency. Where appropriate, the management system shall be consistent with that used by other response organizations in order to ensure a timely, effective and coordinated response.”

3.21. The preparation (planning) for response to all hazards should be structured into a coherent and interlocking system (Fig. 3). At the top level

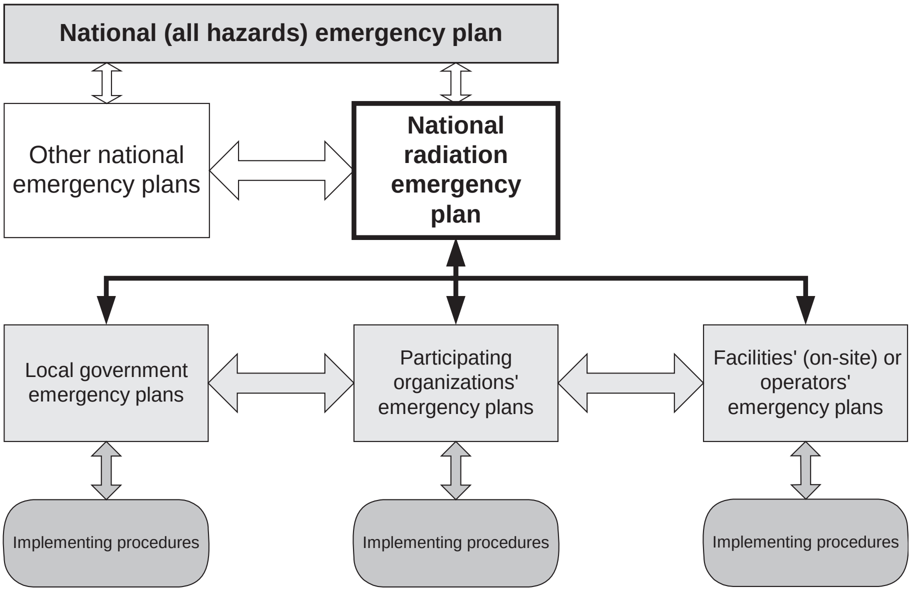

FIG. 3. Integrated planning concept.

should be a national emergency plan for an integrated response to any combination of hazards. The national radiation emergency plan may be a part of this all hazards plan. If there is no national all hazards plan, the national radiation emergency plan should provide for integration with the responses of other organizations during emergencies involving a combination of actual and perceived radiation hazards. The national radiation emergency plan should describe the concepts of operations, and roles and responsibilities of all the responding organizations, and their relationships with each other, summarizing more detailed plans and ensuring that all the other planning is integrated and compatible. In particular, the national radiation emergency plan should provide sufficient detail to ensure that the plans for the functional areas that are performed by personnel drawn from different ministries or organizations can function effectively. This could be accomplished by attaching to the national radiation emergency plan detailed functional plans for operations such as incident command, radiological monitoring and assessment, medical response and public affairs.

3.22. The next level should contain the plans developed by individual agencies, governmental jurisdictions and facilities or operators. The final level should represent the procedures (e.g. implementing instructions and operating procedures) and resources that will be used during an emergency to carry out the plans. Reference [3] outlines the various levels of plans and procedures.

3.23. To optimize the use of resources and the effectiveness of the response, response plans should be highly coordinated and consolidated. Planning should not be done by one organization or agency without consultation with the others. Responsibilities should be assigned jointly with the participation of all concerned parties.

THREAT ASSESSMENTS

3.24. The Requirements [2] (paras 3.13–3.20) require that operators, the national coordinating authority and other appropriate organizations periodically conduct a threat assessment for the threats posed by facilities, sources, practices, on-site areas, off-site areas and locations to determine which threat categories apply. Moreover, these bodies are required to identify facilities, sources, practices, on-site areas, off-site areas or locations for which nuclear or radiological emergencies[15] could warrant (Ref. [2], para. 3.17):

— “Precautionary urgent protective action to prevent severe deterministic health effects by keeping doses below those for which intervention would be expected to be undertaken under any circumstances;[16]
— “Urgent protective action to prevent stochastic effects to the extent practicable by averting doses, in accordance with international standards;[17]
— “Agricultural countermeasures, countermeasures to ingestion and longer term protective measures, in compliance with international standards[17]; or
— “Protection for the workers responding (undertaking an intervention), in accordance with international standards.[18]”

3.25. The threat assessment should include the exchange of information with any nearby States whose territory may fall within the PAZ or UPZ (see paras 2.28–2.30 and Appendix II) of a facility located within the territory of the State performing the threat assessment.

3.26. The threat assessment should also identify:

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[15] Including events with a very low estimated probability of occurrence.
[16] Annex II of Ref. [2].
[17] Annex III of Ref. [2].
[18] Annex I of Ref. [2].

— Significant non-radiation-related threats (e.g. UF_6 or other hazardous chemical releases) to individuals on and off the site who are associated with the facility;
— The operators of dangerous sources (threat category IV in Tables 1 and 4);
— The threat category of the jurisdictions within the State, on the basis of Table 5.

3.27. Operators of facilities in threat categories I, II and III and operators using dangerous sources should perform threat assessments to identify emergencies that could warrant the implementation of protective actions on or off the site. This threat assessment should be reviewed and revised periodically to take into account emergencies in similar facilities, in particular if there have been changes to on-site operations or off-site conditions that could have an impact on the preparations for emergency response.

3.28. A minimum level of threat (threat category IV in Table 1) should be assumed to exist for all jurisdictions. States should therefore assess their vulnerability to emergencies that can occur anywhere. This threat assessment should include:

— Types of shipments of radioactive material that have passed through the State and their main routes and focal points (e.g. distribution centres);
— Uses of dangerous sources (e.g. medical or industrial);
— Locations where spent and/or recovered dangerous sources are stored;
— Locations at which there is a significant probability of encountering an uncontrolled dangerous source that has been stored, lost, abandoned, stolen or illicitly transported. These should include scrap metal processing facilities, national border crossing points, seaports and airports.

3.29. Appendix I provides the typical threat categories for practices and Appendix III provides a method for determining whether a quantity of radioactive material should be considered a dangerous source.

3.30. The threat category of off-site jurisdictions should be consistent with their responsibilities in the response to an emergency, as shown in Table 5 and as illustrated in Fig. 4. Different threat categories may be applicable for a governmental jurisdiction (local or national): while typically only one threat

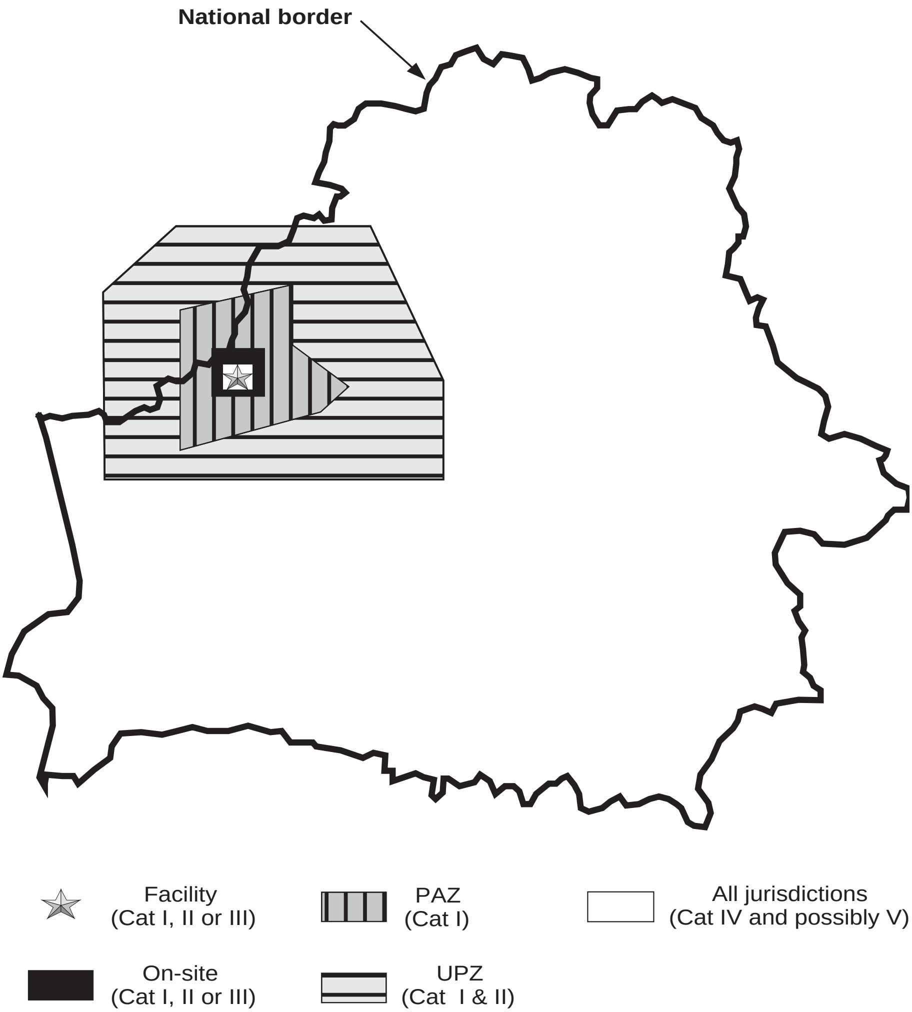

FIG. 4. Emergency zones and areas, and application of threat categories (this figure is not to scale).

category can apply to a facility and on-site area, all jurisdictions, as a minimum, fall within threat category IV.

3.31. The results of this analysis should be documented and included in the national all hazards plan or national radiation emergency plan (see paras 3.21–3.23) with a list and a map that show the threat categories of the facilities and their local jurisdictions. The results of the threat analysis should be used to implement a graded approach to emergency preparedness arrangements commensurate with the potential magnitude and the nature of the hazard.

TABLE 4. SUGGESTED CRITERIA FOR DETERMINING EMERGENCY THREAT CATEGORIES FOR FACILITIES AND PRACTICES

Threat category	Criteria[a]
I	Facilities for which emergencies have been postulated that could result in severe deterministic health effects off the site, including: • Reactors with power levels greater than 100 MW(th) (power, nuclear ship and research reactors);[b] • Facilities and/or locations containing recently discharged irradiated reactor fuel with a total of more than about 0.1 EBq of ^{137}Cs (equivalent to the inventory in a 3000 MW(th) reactor core); • Facilities with inventories of dispersible radioactive material sufficient to result in severe deterministic effects off the site.[c]
II	Facilities for which emergencies have been postulated that could result in doses warranting urgent protective action being taken off the site, including: • Reactors with power levels greater than 2 MW(th) and less than or equal to 100 MW(th) (power reactors, nuclear ship and research reactors); • Facilities and/or locations containing recently discharged irradiated reactor fuel requiring active cooling; • Facilities with potential for an uncontrolled criticality within 0.5 km of the off-site boundary; • Facilities with inventories of dispersible radioactive material sufficient to result in doses warranting urgent protective action being taken off the site.[d]
III	Facilities for which emergencies have been postulated that could result in doses warranting urgent protective action being taken on the site, including: • Facilities with the potential, if shielding is lost, for causing direct external dose rates of more than 100 mGy/h at 1 m; • Facilities with potential for an uncontrolled criticality more than 0.5 km from the off-site boundary; • Reactors with power levels of less than or equal to 2 MW(th); • Facilities with inventories of radioactive material sufficient to result in doses warranting urgent protective action being taken on the site.[e]

TABLE 4. SUGGESTED CRITERIA FOR DETERMINING EMERGENCY THREAT CATEGORIES FOR FACILITIES AND PRACTICES (cont.)

Threat category	Criteria[a]
IV	Practices involving mobile dangerous sources, including: • A mobile source with: (i) potential, if shielding is lost, for causing direct external (shine) dose rates of more than 1 mGy/h at 1 m, or (ii) dangerous sources according to Appendix III; • Satellites containing dangerous sources according to Appendix III; • Transport of quantities of radioactive material that would be dangerous sources according to Appendix III if not controlled. Facilities/locations at which there is a significant probability of encountering an uncontrolled dangerous source, such as: • Large scrap metal processing facilities; • National border crossing points, seaports and airports.

[a] Site specific analysis can be performed to determine the appropriate threat category.
[b] This is on the assumption that the reactor has been operating at this power level sufficiently long to build up the ^{131}I inventory close to 10 PBq/MW(th). For research reactors, owing to the great variety in their design and operation, a facility specific analysis should be performed to determine whether there could be sufficient inventory and energy to result in a significant airborne release off the site.
[c] Inventories 10 000 times the A/D_2 value calculated in Appendix III may place a facility in threat category I if it is assumed that 10% of the inventory could be released to the atmosphere in a single event.
[d] Inventories 100 times the A/D_2 value calculated in Appendix III may place a facility in threat category II if it is assumed that 10% of the inventory could be released to the atmosphere in a single event.
[e] Inventories 0.01 times the A/D_2 value calculated in Appendix III may place a facility in threat category III if it is assumed that 10% of the inventory could be released in a single event into a room from which people can be evacuated within a few minutes.

TABLE 5. EMERGENCY THREAT CATEGORIES FOR GOVERNMENT JURISDICTIONS

Threat category	Local preparedness is warranted for jurisdictions	National preparedness is warranted for States
I	With responsibility for urgent protective actions within the PAZ and UPZ of a threat category I facility	With territory within the PAZ or UPZ of a threat category I facility
II	With responsibility for urgent protective actions within the UPZ of a threat category II facility	With territory within the UPZ of a threat category II facility
III	With responsibility for providing emergency services to a threat category III facility, including firefighting, police and medical services	Containing a threat category III facility
IV	Applies to all jurisdictions	Applies to all jurisdictions
V	With farming or food production processing facilities and/or responsibility for taking local action for agricultural and ingestion control	With territory that may warrant control of potentially contaminated food and/or water and products in the event of an emergency at a threat category I or II facility, including those located in other States

4. FUNCTIONAL REQUIREMENTS

IDENTIFYING, NOTIFYING AND ACTIVATING

4.1. The severity of nuclear emergencies has not always been initially recognized or comprehended by facility operators even when there were indisputable indications of the severity of the event [18, 30]. In some nuclear emergencies it has taken considerable time (hours to days) to select and implement various response actions, including urgent protective action for the public. In addition, in several emergencies it took considerable time to coordinate the response and this, in many cases, severely degraded the effectiveness of the on-site and off-site response. These failures have been attributed to the following: (1) emergency arrangements that did not address the full range of postulated emergencies; (2) procedures that lacked predetermined criteria as a basis for determining the severity of the event and making decisions about the response; (3) an absence of emergency arrangements (e.g. provision for prompt decision making) that could enable a coordinated response on and off the site within minutes to hours.

4.2. Consequently, the Requirements [2] (para. 4.19) require the operator of a facility or practice in threat category I, II, III or IV to make arrangements for the prompt identification of an actual or potential nuclear or radiological emergency and determination of the appropriate level of response. Furthermore, the Requirements [2] (para. 4.20) require that the criteria for classification be "predefined emergency action levels (EALs) that relate to abnormal conditions for the facility or practice concerned, security related concerns, releases of radioactive material, environmental measurements and other observable indications." The Requirements [2] (para. 4.25) also require that declaration of a particular class of emergency "shall promptly initiate the appropriate level of co-ordinated and preplanned emergency response on and off the site. The responsibilities and initial response actions of all response organizations shall be defined for each class of emergency."

4.3. The classification system and the immediate actions that should be taken by on-site and off-site response organizations immediately upon declaration of the level of emergency should be in accordance with the guidance in Appendix IV.

4.4. The emergency action levels should be based on the consideration of the full range of postulated emergencies, including those of very low estimated probability of occurrence (see para. 3.15 of Ref. [2]).

4.5. The emergency action levels should include, to the extent possible, symptomatic thresholds that will allow the operator, on the basis of information readily available during the emergency, promptly to declare, with a minimum of effort, the appropriate levels of emergency. The emergency action levels for reactor emergencies should be in accordance with Ref. [31].

4.6. Standardized national guidance on the response at the local (first responders) and national level that encompasses the types of radiological emergency listed in Table 2 should be developed and made available, with training, to the appropriate response organizations. This guidance should be consistent with the concepts of operation discussed in Section 6. The action guides in Ref. [3] (Appendix 7) could provide a basis for the response actions for most of the types of emergency listed in Table 2; Ref. [4] should be used for emergencies involving transport.

International Nuclear Event Scale (INES)

4.7. The Requirements [2] (footnote 27) point out that the emergency response classification system should not be confused with the International Nuclear Event Scale (INES). The INES is used for communicating to the public the severity or estimated severity of an event and cannot be used as the basis for emergency response actions.

4.8. The Requirements [2] require (para. 4.20) that "It shall be ensured that the process of rating the event on the joint IAEA and OECD/NEA International Nuclear Event Scale (INES) does not delay classification or other response actions."

4.9. Experience has shown that in the early phase of an emergency its nature and its potential consequences may not be fully understood. Any INES rating made during this phase may be subject to change as more information becomes available. While an emergency is developing, no final rating should be assigned. Early announcement of the rating may help the public to understand the significance of the event only if the situation is clear and a provisional INES rating can genuinely be established.

4.10. If an INES rating is requested and sufficient information is available, the best estimate for a provisional rating should be given. If there is insufficient information to define a rating plus or minus one level, it should be stated in a broader communication on the emergency that there is not yet enough information available to provide an INES rating.

TAKING URGENT PROTECTIVE ACTIONS AND ASSESSING THE INITIAL PHASE

4.11. The Requirements [2] require (para. 4.42) that "Urgent protective action, in accordance with international standards[19], shall be taken to prevent to the extent practicable the occurrence of severe deterministic health effects and to avert doses."

[19] See Annexes II and III of Ref. [2].

4.12. The Requirements [2] define an urgent protective action as “A protective action in the event of an emergency which must be taken promptly (normally within hours) in order to be effective, and the effectiveness of which will be markedly reduced if it is delayed.”

4.13. The urgent protective actions and countermeasures should include the following, which are further described in Appendix V:

— For radiological emergencies, isolation of a contaminated area or radioactive source;
— Prevention of inadvertent ingestion;
— Evacuation;
— Sheltering;
— Respiratory protection and protection of skin and eyes;
— Decontamination of individuals;
— Prophylaxis with stable iodine;
— Protection of the food supply and prevention of the consumption of significantly contaminated foodstuffs and water;
— Management of the medical response;
— Protection of international trade.

4.14. International standards[20] have been established for determining whether and when evacuation, shelter, relocation and food restrictions are justified. However, these standards cannot be used directly during an emergency since they are not specified in terms of quantities that are directly measurable in a facility or in the environment.

4.15. Consequently, the Requirements [2] (para. 4.71) require that “arrangements shall be made for promptly assessing the results of environmental monitoring and monitoring for contamination on people in order to decide on or to adapt urgent protective actions to protect workers and the public, including the application of operational intervention levels (OILs) with arrangements to revise the OILs as appropriate to take into account the conditions prevailing during the emergency.”

[20] For facilities it may be possible for the criteria for decisions on protective actions to be established at the time of the emergency, provided that there is a high degree of assurance that they can be established and implemented immediately upon the receipt of field monitoring results.

4.16. All States should develop default OILs (see footnote 20) in advance, as part of the preparedness process, for determining whether and when exposure rates or contamination levels warrant taking protective action and other countermeasures in the event of a nuclear or radiological emergency. OILs should be developed for:

— The isolation of a contaminated area or dangerous source;
— Evacuation or substantial shelter;
— Stable iodine prophylaxis;
— Decontamination of people;
— Decontamination or control of vital equipment, vehicles and personal property;
— Immediate medical treatment;
— Long term medical monitoring;
— Countermeasures against excessive doses from ingestion;
— Control of international trade, goods and products.

4.17. OILs should be developed for radioactive releases and/or direct exposures resulting from emergencies involving facilities in threat categories I, II and III and for radiological emergencies, by using realistic assumptions and including arrangements to revise the OILs as appropriate to take into account the conditions prevailing during the emergency.

4.18. The default OILs for the dose rates from deposition resulting from a nuclear reactor emergency, which are used to make decisions concerning evacuation and substantial shelter, and the arrangements for their revision, should be consistent with Ref. [31].

4.19. The OILs for the isolation of a contaminated area or dangerous source should be consistent with Appendix II, Table 7.

4.20. For most radiological emergencies, first responders should initiate the initial urgent protective action. Often, the first responders will not have radiological monitoring equipment and they may have misconceptions about the risks, which may compromise the initial response.[21]

[21] For example, in some emergencies first responders have been reluctant to perform life saving actions or to treat victims because of indications that radioactive material was present.

4.21. Consequently, the Requirements [2] (para. 4.47) require that "First responders shall be informed that, in the event of an immediate threat to life (such as a fire), they should not delay any action to save human life or prevent serious injury for the reason that signs or placards indicate the possible presence of radioactive material."

4.22. For the emergencies listed in Table 2, the initial actions to be taken by first responders should be predetermined and communicated to the first responders. In general, the actions should be initiated on the basis of information and conditions that are observable by the first responder at the scene.

4.23. Emergencies have been postulated or have occurred at facilities in threat category I for which urgent protective measures should be taken off the site within the PAZ before or shortly after a radioactive release if they are to be effective. The effectiveness of protective actions in these cases can best be ensured by taking the actions upon the detection of dangerous conditions in the facility and not awaiting a release or environmental monitoring results. Emergencies have also been postulated or have occurred at facilities in threat categories I and II for which urgent protective measures should be promptly taken within the UPZ on the basis of the results of radiological monitoring off the site.

4.24. During general emergencies at facilities in threat categories I and II it has taken many hours or days to decide on and to implement urgent protective actions for the public.[22] Subsequent analysis showed that, even with the delays, inappropriate protective action had been taken. This occurred because no arrangements for making decisions promptly were in place[23] for these low probability emergencies.

4.25. Consequently, the Requirements [2] (para. 4.48) require that "For facilities in threat category I or II arrangements shall be made for effectively

[22] After the Chernobyl accident, imposition of restrictions on the consumption of contaminated milk was delayed for several days. This delay probably resulted in several thousand avoidable cases of thyroid cancer among children.

[23] In most cases, a meeting was held to decide what to do and who should do it. In addition, the decision makers were untrained (often they were too busy to attend training courses or exercises). In one case, a regulatory body interfered in the process for making decisions on protective actions even though it had no designated role in this area.

making and implementing decisions on urgent protective actions to be taken off the site. This capability shall make use of existing public infrastructure[24] to limit the occurrence of severe deterministic health effects and to avert doses, in accordance with international standards (Ref. [2], Annexes II and III), for the full range of possible emergencies[25] at those facilities."

4.26. For facilities in threat categories I and II these arrangements should include provisions for promptly taking urgent protective actions off the site upon the declaration of an emergency, in accordance with Appendix VII and based on OILs for environmental measurements. The arrangements should be based on site specific analysis to best ensure that severe deterministic effects will be prevented and that other justified actions taken will be in accordance with international standards. These arrangements should be established with the goal of meeting the time objectives in Appendix VI.

4.27. The decision support systems, including those using computer models, may not be able to predict the size and timing of a radioactive release (the source term), the movements of plumes, deposition levels or resulting doses sufficiently quickly or accurately during an emergency that they could provide the sole basis for deciding on initial urgent protective actions. This is particularly true for emergencies for which protective actions must be initiated before or shortly after a release to be effective or for which a release is by an unmonitored pathway. Consequently, for such emergencies, immediate protective actions should be implemented out to a predetermined distance from the facility in all directions when severe conditions are detected in the facility. The protective actions and the distance should be determined in advance and should be consistent with Appendix II, or should be determined on the basis of site specific analysis.

4.28. Emergencies have occurred in facilities in threat categories I, II and III that have resulted in hazardous conditions on the site.

4.29. Consequently, the Requirements [2] (para. 4.51) require that, for these facilities, specific arrangements be in place to effectively implement urgent protective action for the people on the site. These arrangements should apply to all people in areas controlled by the operator, such as visitors or others (e.g. construction workers, fishermen).

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[24] Such infrastructure includes, for example, buildings and transport networks.

[25] The full range of possible emergencies includes those of very low probability.

4.30. In an emergency, public officials will make recommendations with regard to what protective actions the public should take. It may be that neither these officials nor the public understand the principles or terminology of radiation protection. The arrangements for taking protective action should therefore include a plain language explanation of how the protective actions would ensure the safety of the public.

4.31. Inconsistencies between measures taken by different States may be difficult to explain and may possibly result in a loss of trust in officials on the part of the public. Consequently, the arrangements should include a means to ensure that the recommended countermeasures or actions are coherent among States or that any differences can readily be explained to the public to allow the public and decision makers to make informed decisions.

KEEPING THE PUBLIC INFORMED

4.32. It has often been stated that the public panicked during a nuclear or radiological emergency when they expressed concern or did not follow official recommendations. However, subsequent investigations have found that in some emergencies the public received, apparently from official sources, the news media and other people, confusing and inconsistent information concerning the risks of exposure and the appropriate actions to be taken to reduce the risks. In many cases the confusion was partly the result of attempts by local officials, national officials and the operator, without prior coordination, to address the news media from different locations (e.g. the national capital, the regional capital, the location of the emergency) [32]. Under these circumstances, the public did what they felt was appropriate to protect themselves, their families and their interests. This often resulted in the public taking actions that did not appear to follow official recommendations or that were later found to be inappropriate and, in some cases, harmful (see para. 4.52), and which resulted in severe adverse economic and psychological consequences.

4.33. The severity of the non-radiological effects may depend in part on how well the following questions from the public are answered:

— Is the situation safe?
— How do I keep my family and myself safe and how do I protect my interests?

4.34. It may be impossible to answer these questions simply and effectively without preparation. Officials are not experienced in responding to these questions since a nuclear or radiological emergency is a very rare occurrence and even professionals (e.g. medical practitioners or radiation professionals) may have misconceptions (often assumed to be well established truths) concerning the risks associated with radiation and how to reduce them.

4.35. Consequently, the Requirements [2] (para. 4.83) require that "Arrangements shall be made for: providing useful, timely, truthful, consistent and appropriate information to the public in the event of a nuclear or radiological emergency….".

4.36. These arrangements should include provision:

— To designate an individual within each organization with the role, during the response, of coordinating the provision of information to the news media.
— To arrange to coordinate the provision of information to the public by national officials, local officials and the operator. This could include the establishment, as soon as possible, of a public information centre, as described in Appendix VIII, to serve as the single source of information.[26] For facilities in threat category I, the public information centre should be at a pre-established location.
— To give plain language answers to typical questions, descriptions of the risks involved and appropriate actions that the public can take to reduce the risks.
— To identify and correct misleading and harmful information.

MANAGING THE MEDICAL RESPONSE

4.37. Many emergencies resulting from lost or uncontrolled radioactive sources are first discovered through reports by physicians who have observed medical symptoms that they suspect to be radiation induced injuries [6, 12]. Local physicians are inexperienced in the diagnosis of radiation induced injuries. There have been several emergencies in which people suffering from radiation

[26] During the Three Mile Island emergency in the USA in 1979, the President of the USA directed that all official information should come from one place in order to prevent the confusion that resulted from providing information from several places [32].

induced injuries made several visits to medical professionals before radiation exposure was suspected. In each of these cases, other information (e.g. that the patient remembered seeing the radiation trefoil) prompted doctors to consider radiation exposure as a possible cause of the symptoms.

4.38. Consequently, the Requirements [2] (para. 4.77) require that "Arrangements shall be made for medical personnel, both general practitioners and emergency staff, to be made aware of the medical symptoms of radiation exposure and of the appropriate notification procedures and other immediate actions warranted if a nuclear or radiological emergency is suspected."

4.39. Experience also shows [6–14, 33] that emergencies that result in a wide range of radiation induced injuries and personal contamination requiring specialized treatment are possible in any State and that local medical practitioners and hospitals may not have a good understanding of how to treat overexposed or contaminated patients. Medical personnel without training in radiological response have in some cases been reluctant to treat potentially contaminated victims for fear of contaminating themselves. There are only a few medical centres around the world with significant experience in the diagnosis and specialized treatment of radiation induced injuries. However, radiation induced injures have been effectively treated in national hospitals in cases in which doctors benefited from international consultations with specialists.[27]

4.40. In emergencies involving actual or possible personal contamination (e.g. the terrorist attack with sarin nerve gas in the Tokyo subway in 1995), local hospitals may be confronted with individuals seeking treatment, many of whom may have travelled individually to nearby medical facilities. Such individuals would most probably not have been monitored for contamination and the medical staff would not know the kind of contamination (if any) to which they had been exposed. The hospitals would therefore need to implement procedures that are appropriate for all possible types of contamination (by radiological, chemical or biological agents).

[27] The IAEA and WHO have, under the terms of the Assistance Convention [1], arranged for consultations with or treatment at international specialized centres in numerous emergencies.

4.41. Consequently, the Requirements [2] (para. 4.80) require that "Arrangements shall be made at the national level to treat people who have been exposed or contaminated." These arrangements should include:

— A limited national capability to provide initial treatment of contaminated and/or severely overexposed patients;
— Arrangements to provide advice and expertise to local hospitals;
— Guidelines for local medical facilities on the response to possible emergencies, involving all possible types of contamination (by radiological, chemical or biological agents);
— National and international arrangements to provide highly specialized treatment for exposed people, which include arrangements to consult specialists with significant experience in the diagnosis and specialized treatment of radiation induced injuries (this could include the use of specialized drugs such as 'Prussian blue' (iron(III)-hexacyanoferrate(II)) and chelating agents). Such a consultation could be obtained under the Assistance Convention through the IAEA or WHO [1].

4.42. It is possible that during a nuclear or radiological emergency individuals might receive radiation doses that lead to high individual risks of incurring radiation induced cancers. It is also possible — although unlikely (see footnote 6) — that there may be a detectable increase in the incidence of cancers among the exposed population group owing to the extra radiation induced cases. However, in past emergencies there were no pre-established criteria for determining who should receive long term medical follow-up with the purpose of detecting the disease early, and hence treating it more effectively. Furthermore, criteria established after emergencies were often set at a low level of received dose or were not based on radiation dose criteria at all. This led to the designation of groups for follow-up in which it was impossible to detect any increase due to extra radiation induced cases in the incidence of cancers because of the inherent limitations on epidemiological studies given the relatively small effects. This resulted in an exaggerated perception of radiation risks on the part of the public and consequently in an unjustified and inefficient use of resources.

4.43. Consequently, the Requirements [2] (para. 4.81) require that "Arrangements shall be made for the identification, [tracking,] long term health monitoring and treatment of people in those groups that are at risk of sustaining detectable increases in the incidence of cancers [and other health effects] as a result of radiation exposure due to a nuclear or radiological emergency." Inclusion of people in a long term monitoring programme should be on the basis of criteria that provide an opportunity to detect an increase in the incidence of cancers among the exposed population group due to radiation induced cases and to treat cancers more effectively at an early stage.

4.44. Emergencies resulting in severe deterministic effects among on-site personnel and on-site responders have been postulated or have occurred in facilities in threat categories I, II and III. Facilities in threat category I could also potentially give rise to emergencies that result in severe deterministic effects among the public.

4.45. Consequently, the Requirements [2] (para. 4.78) require that "Facilities in threat category I, II or III shall make arrangements to treat a limited number of contaminated or overexposed workers, including arrangements for first aid, the estimation of doses, medical transport and the initial medical treatment of contaminated or highly exposed individuals in local medical facilities." These arrangements should include capabilities:

— To admit a limited number of personnel from these facilities;
— To treat and decontaminate exposed or contaminated patients;
— To identify persons needing specialized treatment following radiation exposures;
— To control the spread of contamination and to prepare patients for transport to a referral hospital (see Appendix VIII) that can treat persons having received severe overexposures in accordance with Refs [34–36].

4.46. In addition, there should be a referral hospital designated outside the UPZ that can provide highly specialized treatment for a limited number of exposed and/or contaminated persons, as well as for persons with combined injuries as a result of the emergency.

TAKING AGRICULTURAL COUNTERMEASURES, COUNTERMEASURES AGAINST INGESTION AND LONGER TERM PROTECTIVE ACTIONS

4.47. The Requirements [2] (para. 4.85) require that "Agricultural countermeasures and longer term protective actions in accordance with international standards[28] shall be taken to avert doses."

[28] See the guidelines reproduced in Annex III of Ref. [2].

4.48. Agricultural countermeasures and longer term protective actions are countermeasures and protective actions that do not need to be implemented promptly to be effective, and include:

— Relocation;
— Longer term agricultural[29] countermeasures and remedial actions;
— Longer term countermeasures relating to international trade;
— Medical follow-up;
— Decontamination of areas and their return to normal use.

4.49. These actions are intended to avert doses delivered over long periods (months to years) or to anticipate and detect medical conditions that may only appear years later. A limited delay in their implementation, while measurements are taken and the situation is assessed, would therefore appear to be justified. However, the emergencies at Chernobyl in 1986 and in Goiânia in 1987 showed that at the time of the emergency the development of criteria for taking longer term protective actions was driven by public mistrust and political pressure, resulting in criteria that were not in accordance with generally accepted radiation protection principles.

4.50. Consequently, the Requirements [2] (para. 4.89) require that "For areas with activities in threat category V arrangements shall be made for taking effective agricultural countermeasures, including restriction of the consumption, distribution and sale of locally produced foods and agricultural produce following a release of radioactive material." These arrangements should include default OILs and they should be in place for all activities in threat category V.

4.51. The Requirements [2] (para. 4.90) require that "In the urgent protective action planning zone and beyond, where relocation may be necessary as a result of a major release of radioactive material from a facility in threat category I or II, arrangements shall be made for effective temporary relocation. These arrangements shall include: OILs for dose rates due to deposition and deposition densities; the means to revise the OILs; timely monitoring for ground contamination; the means for accomplishing relocation; and arrangements for assisting those persons who have been relocated."

[29] This includes measures relating to livestock, food production, gardens, forest products, fishing and water supplies.

MITIGATING THE NON-RADIOLOGICAL CONSEQUENCES OF THE EMERGENCY AND RESPONSE

4.52. Virtually all nuclear and radiological emergencies have resulted in members of the public taking inappropriate actions[30], which can result in significant adverse psychological and economic effects. Even emergencies with few or no radiological consequences off the site [18, 30] have resulted in significant non-radiological consequences among the off-site population. This has included possibly thousands of abortions that were undergone in Europe after the Chernobyl accident owing to misplaced fears of radiation induced health effects in babies [37]. This effect occurred even though doses due to the Chernobyl accident were well below levels at which deterministic health effects could be induced in the embryo or foetus [37]. Other examples include spontaneous evacuation, interference with the funerals of people who had previously been contaminated, boycotting of products from areas where emergencies had occurred, refusal to sell airline tickets to people from areas where emergencies had occurred, and refusal to provide medical treatment to contaminated victims.

4.53. Consequently, the Requirements [2] (para. 4.96) require that "Arrangements shall be made for responding to public concern in an actual or potential nuclear or radiological emergency" and for "monitoring for and responding to any related health effects and preventing inappropriate actions on the part of workers and the public."

OTHER ACTIONS

4.54. All States should make arrangements to protect their interests in the event of an emergency. These arrangements should take account of:

— Citizens in the affected State(s);
— Embassies in the affected State(s);
— Travellers to the affected State(s);
— Travellers from the affected State(s);
— Transport and trade with the affected State(s);

[30] Inappropriate actions include, for example, discrimination against possibly exposed persons, spontaneous evacuation, the hoarding of food and unwarranted terminations of pregnancy.

— Any installation or activity in the State similar to that involved in the emergency.

5. REQUIREMENTS FOR INFRASTRUCTURE

5.1. The Requirements [2] (Section 5) establish the requirements for infrastructural elements that are essential for providing an adequate response capability. These infrastructural elements are:

— Authority;
— Organization;
— Coordination of emergency response;
— Plans and procedures;
— Logistical support and facilities;
— Training, drills and exercises;
— A quality assurance programme.

5.2. Inadequate responses to emergencies can often be traced back to an inadequacy in one or more of these infrastructural elements. The following gives some examples:

— Authority: There have been cases where the operator delayed notifying off-site authorities while conferring with management or attempting to solve a problem. This occurred because there was not a person on the site at all times with the authority and responsibility for promptly classifying the emergency and notifying off-site authorities.
— Coordination: There have been radiological emergencies in which different responding organizations were unaware of or did not recognize the responsibilities of the other response organizations; this resulted in delay and confusion, especially when dealing with local officials. Also there have been cases of agencies or ministries that believed incorrectly that they had a role in the response to an emergency because the public or senior officials thought so; this too had hindered the emergency response since they actually had no defined role and had not, therefore, been included in the planning process. There have also been cases of further emergencies arising during the initial emergency, where the simultaneous

implementation of uncoordinated plans (e.g. the security plan and the emergency plan) interfered with the emergency response.[31]

— Procedures and training: As discussed earlier, during the Three Mile Island and Chernobyl emergencies the on-site and off-site response staff did not initially recognize or comprehend the severity of the event or initiate the appropriate response. It was said that the staff at the Chernobyl nuclear power plant when the accident happened in April 1986 were very brave but they did not know what to do early in the emergency [38]. Such failures have been attributed to training that did not address severe accidents and to procedures that lacked predetermined criteria on the basis of which to classify events and to make decisions in response. Major emergencies were not addressed if their occurrence was considered to be not credible, i.e. so improbable they did not need to be given serious consideration. Another common problem is that those who occupy senior positions (e.g. leaders of the national or local government) in the response organization in many cases do not attend training or exercises and thus are not sure what to do when called on under stressful response conditions.

— Facilities and logistics: Equipment and facilities used under normal conditions are not adequate during emergencies. As an example, overloading and sometimes breakdown of public telephone networks (land line and mobile networks) in the vicinity of an emergency often occur shortly after the public becomes aware of events that they perceive as significant — not necessarily always emergencies.[32] This occurs when people telephone to offer assistance and to enquire about the safety of family and friends. Other common problems are that items of communications equipment used by response personnel are not compatible and therefore response organizations cannot communicate with each other, and that available equipment (e.g. monitoring instruments) is unsuitable for emergency use (e.g. their ranges are not sufficient or they are not suitable for the working conditions).

— Quality assurance programme: Failure to have a system in place to ensure that the emergency arrangements made are maintained at an adequate

[31] In one case, the response to an intruder included essentially locking all the doors in a nuclear power plant, which interfered with activation of the emergency centres, off-site communications and notifications.

[32] This occurred in the USA following the attacks on 11 September 2001, earthquakes and the Three Mile Island emergency in 1979 and, in at least one case, by people telephoning for tickets for a rock music concert.

state of readiness has resulted in many problems. In some emergencies, equipment, supplies and facilities required for the response were not available or were inadequate because they: (a) had not been procured in advance; (b) were not located near to where they were needed; (c) had been taken and not returned to the emergency stores or replaced; (d) were not operational when needed; (e) were not properly maintained or calibrated; (f) had exceeded their recommended life; (g) did not have the necessary fuel, lubricant, power supply, food and water supplies or other expendable supplies for long term operation; or (h) were not suitable for use under the conditions prevailing during the emergency (e.g. rain, high temperatures, high dose rates). Experience also shows that outdated call lists, procedures and other documentation have hindered emergency response. This is primarily because emergencies are rare events so equipment, facilities and resources designated solely for emergency response are not normally used and frequently there is no adequate programme to ensure that these resources are maintained.

5.3. Consequently, Section 5 of the Requirements [2] establishes requirements for infrastructural elements that are essential to providing the capability of fulfilling the functional requirements.

5.4. In developing the infrastructure needed in an emergency, the following characteristics of emergencies should be considered:

— Emergencies are rare and in many cases result from events that were considered improbable;
— Responders will have little or no experience in dealing with emergencies;
— The functions that must be performed and the conditions under which they would have to be be performed can be considerably different from those associated with the normal jobs of the responders;
— The response may be carried out under highly stressful and possibly dangerous conditions;
— Actions may need to be performed immediately.

5.5. Emergency facilities should be provided that are in accordance with Appendix VIII.

5.6. Examples of emergency response organizations and plans and procedures are provided in Ref. [3]. The reader should review Ref. [3] for a comprehensive discussion of the factors that should be considered when preparing to make the necessary arrangements to develop and maintain these infrastructural elements.

6. CONCEPT OF OPERATIONS

GENERAL

6.1. The Requirements [2] (paras 5.13–5.14) require each response organization to prepare an emergency plan for coordinating and performing their assigned response functions. As defined in the IAEA Safety Glossary, an emergency plan should contain a concept of operations.

6.2. The concept of operations should be a brief description of the ideal response to an emergency. It should be developed at the beginning of the preparedness process to ensure that all those involved in the development of a response capability share a common vision. This section provides a summary of the threats posed by a nuclear or radiological emergency and an example of a concept of operations for dealing with any such emergency.

6.3. There are two operational concepts that apply in responding to any emergency. First, the response should operate under a system similar to the integrated incident command system as described in Ref. [3]. The most important characteristic of an incident command system is that there should be a single incident commander responsible for directing the response of all the organizations responding to the emergency (response to radiological hazards, response to conventional hazards, and law enforcement). This responsibility should be assigned to an individual in the organization that has the primary role in each phase of the response. As the emergency progresses, the primary role will typically pass from the operator or the first responders to a local official and finally to a national official, or to a command group (composed of representatives of the facility and other principal response organizations) for events involving several jurisdictions or ministries. The incident commander should direct the response from an incident command post (see Appendix VIII) located near the scene of the emergency if appropriate.[33]

6.4. The second general operational concept is that arrangements should be made to promptly provide useful and coordinated information to the public via the news media. This should include arrangements to ensure that the public statements of the operator, local officials and national officials all provide a

[33] There may be emergencies, such as transnational emergencies, for which it is not reasonable for the command post to be located near the scene of the emergency.

consistent message to the public. While this could be accomplished by other means, in this concept of operations it is accomplished by establishing, as soon as possible, a single location as the public information centre (see Appendix VIII). In addition, in all cases the public should be provided with a plain language explanation of the risks to them, the actions they can take to reduce the risks and the actions being taken to ensure that people are safe and their interests are being protected. It should be recognized that this applies to any event perceived as an emergency by the public or the media.

6.5. The arrangements for facilities in threat categories I, II and III should be established with the goal of meeting the time objectives given in Appendix VI.

6.6. Programmes to deal with the longer term impact of an emergency should be carefully developed according to internationally accepted criteria, and social, psychological and economic factors should be considered. Methods for compensation (if any) should be carefully considered and targeted at compensating for the tangible consequences of the emergency. Recovery operations should be conducted subject to the full system of detailed requirements in respect of occupational exposure.

THREAT CATEGORIES I AND II

Threat description

6.7. For reactors and facilities with large amounts of spent fuel or dispersible radioactive material, the primary risk arises from airborne releases of radioactive material. For the biggest releases (general emergencies, see Appendix IV) postulated at facilities in threat category I, the risk of severe deterministic effects off the site can only be substantially reduced by taking urgent protective action in the PAZ (see Appendix II) before or shortly after a release. This can best be ensured by the implementation of this action upon the detection and classification of dangerous conditions in the facility, and not by awaiting a release or the results of environmental monitoring. For facilities in threat categories I and II, airborne releases have also occurred or been postulated that result or that would result in doses from exposure to ground shine over several days that warrant taking urgent protective measures to prevent severe deterministic effects or reasonably to reduce the risk of stochastic effects. There could also be emergencies at facilities in threat category II involving unshielded criticalities that result in off-site doses (without a significant airborne radioactive release[34]) sufficient to warrant the implementation of urgent protective action within several hundred metres. Prompt monitoring to locate and evacuate hot spots or areas with high dose rates due to shine from the facility can prevent the majority of these doses and their associated effects. Deposition from major releases that warrant relocation and the imposition of restrictions on food consumption may occur at a considerable distance.

6.8. Off-site releases or doses arising from criticalities at facilities in threat categories I and II are not predictable with any accuracy and a release could result in a very complex pattern of deposition and doses off the site. However, in most cases emergency action levels can be identified in advance and these will indicate serious conditions in time to classify the emergency and to initiate a response before a significant release or significant exposure occurs.

6.9. On-site dose rates during an emergency at facilities in threat categories I, II and III may be very high (e.g. >10 Gy/h), and there is a risk of contamination by beta emitters and other hazardous conditions (e.g. emission of steam) in areas where staff action may be needed to mitigate the consequences of the emergency. People responding on the site should therefore be provided with appropriate protective equipment and training.

6.10. The actions taken to respond to the long term consequences of these emergencies may result in serious detrimental social, psychological and economic impacts on the public if they are not based on internationally accepted criteria and if their long term social, psychological and economic impacts are not considered.

Concept of operations

6.11. Before or shortly after a radioactive release or a criticality, the operator (facility staff) should declare a general emergency on the basis of predetermined emergency action levels. Upon the declaration of an emergency, the facility staff should notify the jurisdictions within the PAZ, the UPZ and

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[34] Criticalities cannot produce sufficient amounts of fission products to result in an airborne radioactive release that would warrant the implementation of urgent protective actions off the site. Nonetheless, it is likely that the energy produced by a criticality would result in the release of other hazardous materials that may be present.

the area where agricultural countermeasures may be warranted (including jurisdictions within other States).

6.12. Within about 15 minutes of the declaration of an emergency the facility staff should recommend to off-site officials that they perform the protective actions specified in Appendix VII. The facility staff should take all possible actions to prevent or mitigate the release or the exposure and should perform all other immediate actions specified in Appendix IV. Local officials should provide police and firefighting services and medical assistance to the site, if requested, and should decide on the protective actions to recommend to the public. They should warn the populations in the PAZ and the UPZ (e.g. with sirens) and should inform them (e.g. via radio or television messages) within 30 minutes of being notified of the general emergency. The public, having been instructed in advance, should promptly take the actions recommended. National officials should notify the IAEA and all States that may be affected (e.g. where food restrictions are warranted). The facility staff should promptly monitor the PAZ and UPZ to determine whether additional protective actions are needed and should continue until relieved by off-site officials. Following a radioactive release or a criticality default OILs should be used by officials to immediately assess environmental data and determine whether additional protective actions are warranted. A radiological monitoring and assessment centre should be established at which all environmental monitoring, sampling and assessment is coordinated. The facility operator should ensure that the people on the site or those responding from off the site are protected from all possible hazards. People coming from the site who have been contaminated or exposed above predetermined criteria should be taken to local hospitals and treated in accordance with procedures. Physicians treating exposed individuals should consult doctors with experience in dealing with overexposures. Local officials, supported by national officials, should assist in obtaining specialized treatment for exposed individuals, through the IAEA if necessary. Triage centres should be established within 24 hours outside the evacuated area to screen casualties and to determine the level of treatment for any overexposed members of the public and on-site personnel. People who have been contaminated or exposed above predetermined criteria should be assigned to predetermined and prepared hospitals located outside the affected area. National officials should support local officials, should conduct monitoring away from the site and should coordinate longer term protective actions. Soon after the public is warned (e.g. by means of sirens), the news media should be briefed by a single government spokesperson. Joint press briefings should be given periodically (at a joint public information centre) with participation by the operator and local and national officials.

6.13. The personal data of people who have incurred exposures due to an emergency at a level high enough to give rise to a high individual risk of developing radiation induced cancer, or to lead to a detectable increase due to radiation exposure in the incidence of health effects among the population exposed, should be recorded in a registry. Those individuals listed in the registry should be provided with information on their individual risks and should be considered for long term medical follow-up to be able to detect early and treat effectively any radiation induced cancers or other radiation induced injuries.

THREAT CATEGORY III

Threat description

6.14. Emergencies at facilities in threat category III may occur with little warning and could result in significant exposure in areas on the site (e.g. a radiotherapy treatment room). However, for most emergencies, emergency action levels for classifying emergencies (see Appendix IV) that ensure a prompt, effective on-site response can be developed for the facility.

6.15. In most cases, emergencies involve industrial or radiotherapy sources in an exposed position, or the dispersal of radioactive material and contamination of people, places or things (e.g. products) at industrial, research or educational facilities as a result of a source being melted, ruptured or spilled. In most cases only a limited area (e.g. a treatment room) of the facility is involved. Such emergencies should be detected promptly by the operator and should be limited to an area under administrative control. The source of the contamination and the potentially exposed or contaminated persons and items should be promptly identified, and the cause and scope of the emergency should be promptly determined.

6.16. Depending on the facility concerned there may be high dose rates, contamination by beta emitters or other hazardous conditions in areas where action by the staff is required to mitigate the consequences of the emergency. People responding on the site should therefore be provided with appropriate protective equipment and training.

6.17. Threat category III has no credible emergencies postulated for which urgent off-site protective action is warranted. Emergencies at facilities in threat category III may, however, cause considerable concern and lead to unnecessary actions being taken among the population and by off-site officials. Emergencies at such facilities can result in significant adverse psychological and economic consequences if the public or off-site officials are not aware that the emergencies do not in themselves pose any risk off the site. However, there may be a risk that contaminated persons, products, packages or equipment leave the site.

Concept of operations

6.18. The facility staff should declare a facility emergency (see Appendix IV) on the basis of predetermined emergency action levels, should take any necessary life saving action, and should evacuate and secure potentially hazardous areas and notify local off-site officials. These officials should provide police and firefighting services and medical assistance to the site if requested. The operator should ensure that all people on the site (including those responding from off the site) are provided with appropriate protection. Access to the potentially hazardous area should be restricted until authorized by the radiation protection officer (or radiological assessor) but should be allowed for the purpose of saving lives. If there is a potential for contamination or contaminated individuals or products to be leaving the facility or area, off-site officials should be promptly notified and advised on the action to be taken. Monitoring and technical assistance should be provided to off-site officials if needed. If there are serious overexposures, the facility staff should gather information concerning the circumstances and any other information that would be helpful for reconstructing doses. Highly contaminated or severely overexposed persons should be identified on the basis of predetermined criteria and should be taken to local hospitals (if appropriate) and treated there in accordance with advanced training and procedures. Physicians treating exposed individuals should consult doctors with experience in dealing with overexposures. Local officials, supported by national officials, should assist in obtaining specialized treatment for exposed persons, through the IAEA if necessary. The facility staff should promptly conduct monitoring to confirm, on the basis of default OILs, that no protective actions are necessary elsewhere on the site. Local officials, with the assistance of the facility staff, should promptly conduct monitoring to confirm, on the basis of default OILs, that no protective actions are needed off the site and that no persons and objects leaving the facility are contaminated. Local and national officials should promptly inform the public and the news media of the emergency. Soon after the public is notified, the news media should be briefed by a single government spokesperson. Joint press briefings should be given periodically (at a joint public information centre) with participation by the operator and local and national officials. Recovery operations should be conducted subject to the full system of detailed requirements for occupational exposure.

6.19. The personal data of people who have incurred exposures due to an emergency at a level high enough to give rise to a high individual risk of developing radiation induced cancer, or to lead to a detectable increase due to radiation exposure in the incidence of health effects among the population exposed, should be recorded in a registry. Those individuals listed in the registry should be provided with information on their individual risks and should be considered for long term medical follow-up to be able to detect early and treat effectively any radiation induced cancers or other radiation induced injuries.

THREAT CATEGORY IV (RADIOLOGICAL EMERGENCIES)

Threat description

6.20. Planning for emergencies in threat category IV applies everywhere and represents the minimum level of preparedness appropriate for all States. In general, this applies to emergencies involving:

— Dangerous sources;
— Transport of radioactive or fissile material;
— Severe overexposure.

6.21. Appendix III provides plain language statements of the risks arising from uncontrolled dangerous sources. Reference [3] provides 'action guides' that summarize the threat and the necessary response to a range of radiological emergencies.

Dangerous source related emergency

6.22. In this Safety Guide, the term 'source emergency' applies to emergencies involving:

— Medical symptoms of radiation exposure;
— Lost or stolen dangerous sources;
— Mobile dangerous sources;
— Public exposure and/or contamination;
— Nuclear weapons;
— Re-entry of satellites containing radioactive material.

6.23. Many, if not most emergencies with uncontrolled sources are first discovered by physicians treating people reporting medical symptoms of radiation exposure.

6.24. There are typically several fatalities among the public around the world each year resulting from someone who is unaware of the hazard of handling a lost or stolen dangerous source. There have been several cases in which prompt announcements alerting the public of a hazard, following the loss or theft of a source, have resulted in prompt recovery of the source and thus the prevention of serious consequences.

6.25. Among the most common types of mobile dangerous sources are radiography cameras. The operator generally handles these sources with limited or no assistance. However, there have been emergencies that have resulted in serious exposure of the operator and other workers owing to an inadequate response by the operator or a loss of control over the source by the operator.

6.26. Emergencies with contamination and/or exposure of the public may involve the spread of contamination for a long period before its detection. There have been cases where contamination was not detected for several years. Such emergencies can result from the rupture or dispersal of uncontrolled (lost or stolen) radioactive material in the public domain. In several cases, a member of the public has unknowingly ruptured a sealed source, and other members of the public have unknowingly spread the radioactive material. These emergencies can have very serious consequences. For example, the Goiânia emergency [6] resulted in four deaths and a volume of 5000 m^3 of radioactive waste. Emergencies involving contamination of members of the public may also result from the undetected dispersal of controlled material. The undetected melting of gauges into metal products is an example. The most important feature of such emergencies is that the source and the scope of the emergency are unknown at the time of detection. These emergencies are often detected through the diagnosis of radiation induced injuries by physicians or during routine checks, such as monitoring at borders or entrances to facilities that detects contamination of people, vehicles, packages or products. In some cases, contamination has been detected in imports, leading to transnational emergencies. By the time contamination is detected the area contaminated and the number of people exposed can be very large. Emergencies such as these, understandably, often receive intense public and media attention.

6.27. Accidents with nuclear weapons are very rare and such an accident would probably involve a vehicle or aircraft crash. The primary risk may arise from the inhalation of toxic materials such as plutonium, enriched uranium or beryllium. The most important feature of an emergency involving a nuclear weapon is that commonly available monitoring instruments and radiological assessment teams may not be able to identify the cause (e.g. Pu) of dangerous levels of airborne contamination and deposition. To respond adequately to such an emergency, specially trained and equipped radiological assessment teams are required. The owner of the nuclear weapon involved should be responsible for providing these radiological assessment teams. Consequently, first responders should be made aware of the potential hazards and of the precautions to take until specialized assistance arrives.

6.28. On several occasions satellites carrying dangerous amounts of radioactive material have re-entered the atmosphere. In most cases, the State responsible for the satellite provides, often through the IAEA or another UN system organization, an estimated time and location for the re-entry. However, these estimates have often been inaccurate. Typically, the radioactive components — less than one cubic metre in volume — shatter upon re-entry and the debris impacts over an area of 100 000 km^2 or more. Thus, in most cases it would be virtually impossible to identify the area of impact with sufficient accuracy to allow effective precautionary protective actions to be taken. For emergencies involving satellites, the risk is very low and consists principally in someone finding and handling radioactive debris. None of the satellite re-entries to date have resulted in a known case of significant exposure or the contamination of water or food. Nevertheless, these emergencies often receive intense attention from the international news media.

Transport emergency

6.29. A transport emergency could result in a release of radioactive material, a loss of shielding or a loss of criticality control. In the event of an emergency, firefighters are generally well equipped with standard protective clothing and equipment for respiratory protection. This equipment should provide good protection against radioactive contamination and inhalation of airborne radioactive material, but it does not provide protection against penetrating radiation. By following basic principles to limit inhalation, inadvertent ingestion and external exposure (e.g. limiting the time spent near the possible source of exposure), emergency services should be able to respond safely and effectively until radiation specialists arrive. Historically, there have been no reported transport emergencies involving radioactive material that have had serious radiological consequences [4].

Emergency involving severe overexposure

6.30. Severe overexposures can result from controlled sources such as radiotherapy devices or from uncontrolled sources. In some cases, equipment, software or human factors (e.g. confusion over the procedures provided by the manufacturer) were contributing causes. Other users (nationally and internationally) of similar devices should therefore be promptly alerted to the circumstances of any such emergency. However, there have been cases in which the investigation of the cause of such an overexposure was delayed, resulting in the loss of important information and in substantial delays (months) in warning other users of the devices. In other cases, a failure to alert other users of similar devices and techniques of the occurrence of emergencies may have allowed further overexposures to occur.

6.31. Once diagnosed, severe overexposures have in some cases been inadequately treated owing to the inexperience of the local medical staff, resulting in considerable unnecessary suffering. There are several medical centres around the world with the necessary experience to develop treatment strategies for radiation injuries. Advice from these centres and other assistance may be obtained through the IAEA or the WHO under the Assistance Convention [1].

Concept of operations

6.32. Emergencies may result from natural phenomena, accidents or deliberate acts (e.g. criminal activities); however, the necessary emergency response will be essentially the same regardless of the cause of the emergency. For major emergencies, preparations at the local level should be aimed at being able to recognize a possible radiological emergency (e.g. recognizing labels for radioactive material and recognizing the clinical symptoms of radiation exposure), being familiar with basic precautions and knowing who should be called on to provide further assistance. Local officials will most probably need assistance from officials at the national level in dealing with the radiological aspects of the emergency. If there is public or media interest, the news media should be promptly briefed by a single official spokesperson. Preparedness at the national level should include adopting operational criteria and having the capability to promptly advise (e.g. over the telephone) and support local officials if necessary in controlling a limited radiological emergency, with provision to ask for international assistance if this capability is overwhelmed.

6.33. The response organization for a nuclear or radiological emergency may be composed of elements drawn from the national or local organizations responsible for the first response to an emergency involving hazardous material (e.g. radioactive material), conventional hazards (e.g. fire) or criminal activities (e.g. theft or terrorism). All of these elements should form a single coordinated response organization that is structured to take into account the concerns of the various elements in the response, such as the need for the collection of evidence, while also ensuring the safety of the responders.

6.34. If additional radiological assistance is needed, national officials should request it through the IAEA under the Assistance Convention [1]. The IAEA would arrange for additional radiological support and consultation with physicians experienced in treating severe overexposure.

Dangerous source related emergencies

6.35. First responders or physicians should be able to promptly recognize the medical symptoms of a radiological emergency. Even if radiation or contamination is suspected, the first responders or physicians should promptly implement life saving actions (e.g. rescuing persons from a fire) and should provide first aid for serious injuries without delay and without waiting for the results of radiological monitoring. They should also isolate the possible source of exposure and then notify local officials. If an emergency involves a source that should be under the control of the operator, the operator should implement immediate actions, including measures to protect people nearby, and should report any uncontrolled sources. The operator should also notify and provide technical assistance to off-site officials. When local officials are notified of a potential hazard they should take immediate precautions to confine radioactive material and to protect people in the vicinity. National officials should provide advice to local officials and should dispatch personnel and radiological assessment teams to assist with monitoring, decontamination, media relations and medical treatment. National support radiological assessment teams and personnel should be mobilized using pre-identified experienced personnel from throughout the State. Off-site officials should brief the local news media collectively shortly after monitoring activities or protective actions have been initiated.

6.36. In the case of a lost or stolen dangerous source the operator should report the loss to the appropriate officials and provide a description of the device and of the threat to the public. The operator should also conduct a search for the source and provide technical support to off-site officials. Off-site officials should make a timely public announcement describing the source (providing an illustration if possible) and emphasizing the hazard. If theft is suspected, the operator should protect the scene and any records that may be important to an investigation and should coordinate any additional action with law enforcement officials. If a lost or stolen dangerous source may have originated from another State or may have been taken across a border, the potentially affected States and the IAEA should be notified. Officials should conduct an investigation to determine the reason why the source was not properly controlled and whether further sources may have been lost or stolen.

6.37. In an emergency involving a radiography camera (a mobile dangerous source) under the control of an operator, the operator: should carry out a radiation survey; should cordon off the area in accordance with Appendix II; should set up barricades as required; should verify the location of the source; should seek advice from the radiation protection officer (radiological assessor); and should notify the local authorities. A recovery plan should be developed to minimize the exposure of workers. The recovery operation should be carried out with the use of suitable tools and without exceeding occupational dose limits. During the recovery operation, the location of the source and the doses to the workers should be continuously monitored and controlled. The recovered source should be stored in a properly shielded and secure container.

6.38. In an emergency involving public exposure and/or contamination, local officials should notify national officials and should isolate, on the basis of preliminary information, potentially contaminated people and areas. A consolidated incident command post should be established in the vicinity. Monitoring and interviews should be conducted to identify the source and to isolate significant contamination in accordance with Appendix II. A radiological monitoring and assessment centre should be established at which all environmental monitoring, sampling and assessment is coordinated. Default OILs should be used to determine whether protective actions are warranted. The local media should be briefed before or shortly after monitoring is commenced or protective actions are initiated in public areas. Medical facilities at which exposed or contaminated patients can be treated should be identified and their staff should be briefed on the treatments being used and the possible risks to the staff. An experienced radiological assessor should be assigned to the hospital. The public should be evacuated from significantly contaminated areas and should be kept informed of the status of the situation and actions they should take, any health risks and any consequences for their families and property. Field monitoring centres should be established in the vicinity for triage, management and decontamination of potentially contaminated individuals and for isolated temporary storage of contaminated items. The affected population should be monitored in accordance with predetermined criteria, decontaminated and admitted to hospital if appropriate. Preparations should be made to monitor those who are concerned about possible contamination (the 'worried well'). If necessary, additional expertise and equipment should be promptly requested through the IAEA under the Assistance Convention [1]. A system should be established to ensure that products and people leaving the area are not contaminated above predetermined criteria. Before recovery efforts begin, a long term plan should be developed with objectives and criteria that are in accordance with international standards. Decontamination and other methods of remediation should be tested before their long term application. Methods of compensation should be carefully considered and should be targeted at the consequences of the emergency. The personal data of people who have incurred exposures due to an emergency at a level high enough to give rise to a high individual risk of developing radiation induced cancer, or to lead to a detectable increase due to radiation exposure in the incidence of health effects among the population exposed, should be recorded in a registry. Those individuals listed in the registry should be provided with information on their individual risks and should be considered for long term medical follow-up to be able to detect early and treat effectively any radiation induced cancers or other radiation induced injuries. Joint press briefings should be given (at a joint public information centre) periodically with participation by the operator and local and national officials.

6.39. For emergencies involving contaminated products, monitoring and interviews should be conducted to identify and isolate the source of contamination. If the contaminated products may have originated from another State or may have been taken across a border, the potentially affected States and the IAEA should be notified in accordance with the Requirements [2]. An analysis should be performed to determine the risks and the criteria — on the basis of international standards — for clearance. The national news media should be briefed before or shortly after the initiation of monitoring or protective actions in public areas. A system should be established to ensure that products leaving and entering the areas are not contaminated in excess of predetermined criteria.

6.40. In response to an accident involving a nuclear weapon, the first responders should take initial life saving action, should isolate the area in accordance with Appendix II and should notify national officials. Specially trained and equipped personnel should be provided by the State responsible for the nuclear weapon to assist in monitoring, recovery and other follow-up actions.

6.41. In response to the re-entry of a satellite containing dangerous amounts of radioactive material, the State responsible for the satellite should notify the IAEA of the estimated time and location of re-entry and should provide an analysis of the risks. The IAEA should inform the potentially affected States. These States should inform the public of the limited nature of the hazard. If, following re-entry, the area of concern can be bounded (e.g. through sightings), the public should be instructed to report and to avoid possible debris from a crash. Monitoring should be conducted to locate radioactive debris if the search area can be reasonably limited. Ground based monitoring should be used to investigate reported possible debris or areas first identified by airborne monitoring. Airborne monitoring should be initiated, possibly through the IAEA, if a limited area of concern has been identified.

Transport emergency

6.42. The carrier should immediately take initial life saving and first aid actions without concern for the risk associated with radioactive material, and should isolate the source and notify local emergency response services. First responders should take the initial actions appropriate for the UN number or labels affixed to the item being shipped [3, 4]. Typically, this involves isolating the accident scene, taking the names of people who may have been in the area (for possible follow-up) and requesting radiological assistance from regional or national officials. National officials should send a radiological assessment team to conduct monitoring and cleanup if necessary. Reference [4] provides a detailed discussion of the response to transport emergencies.

Emergency involving serious overexposure

6.43. In a case of serious overexposure[35], interviews should be conducted, photographs should be taken and the information necessary to estimate doses should be gathered at the scene. Medical examinations and blood tests should

[35] A serious overexposure is one that could result in severe deterministic health effects.

be promptly performed to assist in estimating doses. The IAEA may be contacted to arrange for consultation with physicians with expertise in treating overexposures. A course of treatment, based on the estimated doses received, should be established in consultation with experts. Decisions on treatment should take into consideration both the physical and the psychological suffering of patients.

6.44. The operator should conduct an investigation to determine the cause of the overexposure, and should take actions to prevent further overexposures and to preserve information that may be important in the investigation of the cause. National officials should promptly identify the causes of the overexposures that could give rise to similar overexposures in other States and should report them to the IAEA. The IAEA should inform other States of relevant information that warrants their attention.

THREAT CATEGORY V

Threat description

6.45. Preparedness for events in threat category V is intended for providing prompt restrictions on food, water or products in accordance with international standards. The Chernobyl accident in 1986 resulted in contamination exceeding the international standards for food restrictions more than 1000 km from the plant site.

6.46. The staff of an affected facility in threat categories I or II should declare a general emergency (see Appendix IV) and notify the IAEA or the affected States before a radioactive plume arrives. However, the first indication of an emergency may be the detection of airborne contamination. For some States, the entire territory could be contaminated at levels warranting restrictions on foodstuffs and agricultural products. The patterns and levels of contamination will be complex, varying both temporally and spatially. OILs for gross gamma dose rates due to ground deposition can be used to identify areas where food contamination can be expected to be well above the international criteria warranting restrictions. However, laboratory analysis of food samples should be used to confirm that the concentrations warrant such restrictions.

Concept of operations

6.47. The State where an emergency occurs is required to notify potentially affected States and the IAEA of a possible significant transboundary release (general emergency). The IAEA, in accordance with the Notification Convention [1], also transmits the notification to potentially affected States. Upon receiving notification of an emergency potentially affecting their State, national officials should provide instructions to the public, farmers, and processors and distributors of foodstuffs on measures to take to protect the food supply. They should also conduct monitoring and sampling to determine what actions are required for the control of foodstuffs. OILs should be used as input in making decisions on imposing restrictions on foodstuffs. These OILs should be determined in advance, with local conditions (e.g. a limited supply of food) taken into consideration. In no case should the consumption of food be allowed that would result in doses approaching levels at which they could result in severe deterministic effects. The criteria used should be in accordance with international standards and should be coordinated with neighbouring States. OILs for gross gamma dose rates due to ground deposition should be used to identify areas to which access should be restricted until laboratory analysis of food samples can be conducted. Programmes for dealing with the long term impact of a nuclear or radiological emergency in threat category V should be carefully developed according to internationally accepted criteria, and the long term sociological, psychological and economic impacts should be considered.

6.48. If a State detects contamination at significant levels that is suspected to have originated in another State, national officials should promptly alert the IAEA of the possible occurrence of a transnational emergency.

Appendix I

TYPICAL THREAT CATEGORIES

I.1. Table 6 provides a summary of the typical threats and associated threat categories of selected practices and events.

TABLE 6. TYPICAL THREAT CATEGORIES OF PRACTICES

Practice	Threat summary	Typical threat category[a]
	Facilities manufacturing or using radioisotopes for industry, medical purposes or scientific research	
Radiopharmaceutical manufacturing	Off-site: No potential for deterministic effects. A small potential for a release in excess of urgent generic intervention levels (GILs) near the facility. Major fires at facilities and loading dock fires appear to represent the greatest potential for a release in excess of urgent GILs. The threat will be a function of inventory and volatility. Explosions, tornadoes, spills and leaks represent small risks. On-site: Severe deterministic effects very unlikely on the site, but doses in excess of occupational limits are possible.	Limited[b] or III
Radiopharmacies	Off-site: No potential for a release in excess of urgent GILs. On-site: No potential for exceeding urgent GILs on the site. Very small potential for exposures above occupational dose limits.	Limited[b]
Hospitals	Off-site: No potential for a release in excess of urgent GILs. On-site: Severe deterministic effects possible for staff if sealed sources (e.g. brachytherapy sources or radiation beams) are misused or are not controlled and secured. In addition, radioactive medication and diagnostic drugs can represent a hazard if not properly controlled and administered.	III or IV

TABLE 6. TYPICAL THREAT CATEGORIES OF PRACTICES (cont.)

Practice	Threat summary	Typical threat category[a]
Sealed source manufacturing	Off-site: No potential for deterministic effects. A small potential for a release in excess of urgent GILs near the facility. A major facility fire appears to represent the greatest potential for a release in excess of urgent GILs. The release will be a function of inventory and volatility. Explosions, tornadoes, spills and leaks represent small risks. On-site: Severe deterministic effects possible for staff during the manufacturing process due to loss of shielding, ingestion or inhalation.	III
Research laboratories	Off-site: Unless large quantities of radioactive or fissile material are stored or used in a single location, there is no potential for exposures in excess of urgent GILs. On-site: Potential for severe deterministic effects. This will be site specific.	Limited[b] or III
Warehousing and burial of low level waste	Off-site: No potential for exceeding urgent GILs for burial operations for low level waste. On-site: No potential for exceeding urgent GILs on the site. Small potential that, if the waste contains radioiodine, a major fire involving waste in a warehouse may result in a release leading to occupational dose limits being exceeded.	Limited[b]
Depleted uranium products	Off-site: No potential for exceeding urgent GILs. Potential for deaths following a UF_6 release due to chemical toxicity of HF (product of a UF_6 release). The potential is a function of the UF_6 inventory. Greatest risk appears to be ruptures of heated tanks containing many tonnes. On-site: No potential for exceeding urgent GILs.	Limited[b]

TABLE 6. TYPICAL THREAT CATEGORIES OF PRACTICES (cont.)

Practice	Threat summary	Typical threat category[a]
	Source	
— Sterilization irradiators — Industrial radiography — Teletherapy — High and medium dose rate brachytherapy — Category 1 and 2 sources in Ref. [39]	Off-site: If controlled, no potential for exceeding urgent GILs; if uncontrolled (lost or stolen), potential for fatal exposure in minutes if unshielded and for severe tissue damage if held. On-site: Localized exposure sufficient for fatal doses in minutes if source unshielded.	III or IV[c]
— Gauges — Well logging — Category 3 sources in Ref. [39]	Off-site: If uncontrolled (lost or stolen), potential for fatal exposure if unshielded and for severe tissue damage if held. On-site: Potential for fatal exposure if unshielded.	IV[c]
— Moisture density gauge — Static eliminator — Tritium exit signs — Pu pacemaker — Consumer products — Category 4 and 5 sources in Ref. [39]	Off-site: Little or no potential for exceeding urgent GILs. On-site: Little or no potential for exceeding urgent GILs.	Limited[b]
	Fuel cycle	
Uranium milling and mining	Off-site: No potential for a release in excess of urgent GILs. Contamination warranting intervention (e.g. water contamination) could result from failures of tailing ponds. On-site: No potential for exceeding urgent GILs.	Limited[b]
Yellow cake processing	Same as uranium mining and processing.	Limited[b]

TABLE 6. TYPICAL THREAT CATEGORIES OF PRACTICES (cont.)

Practice	Threat summary	Typical threat category[a]
UF_6 conversion plants	Off-site: Potential for deaths following a UF_6 release due to chemical toxicity of HF (product of a UF_6 release). The potential is a function of the UF_6 inventory. Greatest risk appears to be ruptures of heated tanks containing many tonnes.	Limited[b, d]
	On-site: Same as off-site.	
Enrichment plants	Off-site: Same as UF_6 conversion plants.	Limited[b]
	On-site: Same as UF_6 conversion plants.	
Fuel fabrication using uranium	Off-site: Risk for UF_6 same as for UF_6 conversion plants. Potential for doses in excess of urgent GILs from criticality accidents if the fissile material is processed in an unshielded location within 200–500 m of the site boundary.	II or III
	On-site: Risk for UF_6 same as for UF_6 conversion plants. Potential for deterministic effects and doses in excess of urgent GILs on the site from criticality accidents.	
Fuel fabrication using plutonium	Off-site: Potential for doses in excess of urgent GILs from criticality accidents if the fissile material is processed in an unshielded location within 200–500 m of the site boundary. Large fires or explosions could result in doses off the site in excess of urgent GILs near the facility. This will be a function of the inventory.	II or III
	On-site: Potential for deterministic effects and doses in excess of urgent GILs from criticality accidents. Fires and explosions could result in doses in excess of urgent GILs from inhalation.	
Fresh fuel (not irradiated)	Off-site: No potential for doses in excess of urgent GILs.	Limited[b]
	On-site: No potential for doses in excess of urgent GILs.	

TABLE 6. TYPICAL THREAT CATEGORIES OF PRACTICES (cont.)

Practice	Threat summary	Typical threat category[a]
Spent fuel, pool storage	Off-site: For damage to fuel in a pool (underwater), no potential for doses in excess of urgent GILs. If the fuel in the pool is totally uncovered, doses in excess of urgent GILs may be possible. Distance of concern depends on inventory. If a pool containing fuel discharged from a reactor core within the past few months is drained, severe deterministic effects are possible. The potential and the distances of concern depend on quantities and pool design. On-site: For damage to fuel in a pool (underwater), doses from ^{85}Kr could exceed urgent GILs in the pool area. For a drained pool, the dose from the direct shine from the pool could be several sieverts per hour near the pool. If fuel is uncovered, the dose near the pool could result in severe deterministic effects.	I, II or III
Spent fuel, dry cask storage	Off-site: No potential for doses in excess of urgent GILs. On-site: No potential for doses in excess of urgent GILs from inhalation. If shielding is lost, direct shine dose could exceed urgent GILs.	III

TABLE 6. TYPICAL THREAT CATEGORIES OF PRACTICES (cont.)

Practice	Threat summary	Typical threat category[a]
Reprocessing of spent fuel	Off-site: Small potential for doses in excess of urgent GILs from criticality accidents (depending on location of criticality). Large fires or explosions could result in doses in excess of urgent GILs several kilometres from the facility, depending on the inventory and the volatility of the radionuclides. Ruptures of large liquid storage tanks could result in contamination that would warrant extensive intervention. This will be a function of inventory and volatility.	I or II or III
	On-site: Potential for severe deterministic effects and doses in excess of urgent GILs from criticality accidents. Fires and explosions could result in inhalation doses in excess of urgent GILs and could result in severe deterministic effects. If shielding is lost, direct shine dose could exceed urgent GILs or could result in severe deterministic effects.	
	Reactors (power, ship, research)	
Reactors >100 MW(th)	Off-site: Emergencies involving severe core damage have the potential to cause severe and even fatal deterministic effects. Doses in excess of urgent GILs are possible more than 5 km from the facility. Deposition resulting in doses in excess of relocation GILs and ingestion generic action levels is possible at great distances from the facility. An emergency not involving core damage has only a small potential for exceeding urgent GILs.	I or II
	On-site: For emergencies involving core damage, doses sufficient to result in severe and even fatal deterministic effects are possible.	

TABLE 6. TYPICAL THREAT CATEGORIES OF PRACTICES (cont.)

Practice	Threat summary	Typical threat category[a]
Reactors 2–100 MW(th)	Off-site: Doses due to inhalation of short lived iodine in excess of urgent GILs are possible if cooling of the core is lost (core melt).[e] On-site: Potential for doses in excess of urgent GILs if fuel cooling is lost. If shielding is lost, direct shine dose could exceed urgent GILs or could result in severe deterministic effects.	II or III
Reactors <2 MW(th)	Off-site: No potential for doses in excess of urgent GILs. On-site: Potential for doses in excess of urgent GILs from inhalation (depending on design) if fuel cooling is lost. If shielding is lost, direct shine dose could exceed urgent GILs or could result in severe deterministic effects.	III
	Transport	
Excepted packages UN 2910 UN 2911 UN 2909 UN 2908	These shipments contain only minor amounts of radioactive material. There is no risk of any radiological consequences requiring special protective actions. Ground contamination resulting from the emergency may require decontamination.	None
Industrial packages UN 2912 UN 3321 UN 3322 UN 2913	These packages contain only qualified ‘low specific activity’ materials or qualified ‘surface contaminated objects’. Urgent GILs may be exceeded, however, in the vicinity of a damaged package, since industrial packages are not designed to survive accidents and the only external radiation limit on the unshielded but qualified contents is 10 mSv/h at a distance of 3 m. Ground contamination resulting from the emergency may require decontamination.	None

TABLE 6. TYPICAL THREAT CATEGORIES OF PRACTICES (cont.)

Practice	Threat summary	Typical threat category[a]
Type A packages UN 2915 UN 3332	The activity allowed for Type A packages limits the radiological hazard. Doses in excess of urgent GILs are possible beyond the immediate vicinity of the package. Ground contamination resulting from the emergency would require decontamination.	IV[f]
Type B packages [B(U) and B(M)] UN 2916 UN 2917	Type B packages normally contain large amounts of radioactive material. Type B packages have been designed to withstand all credible land and sea transport accidents. The radioactive content of a Type B package shipped by air is restricted. For 'low dispersible radioactive material', the limit is as authorized by the competent authority for the package design. For other material: if it is special form, the restriction is 3000 A_1 or 100 000 A_2, whichever is lower; if it is other than special form, 3000 A_2 [40]. For all other radioactive material, the restriction is 3000 A_2. Doses in excess of urgent GILs are considered possible in an air accident but not credible in land or surface mode transport. However, in the event of an emergency, this should be confirmed by monitoring.	IV[f]
Type C packages UN 3323	Type C packages normally contain large amounts of radioactive material. Type C packages have been designed to withstand all credible land and sea accidents and most credible air transport accidents. Doses in excess of the urgent GILs are not considered credible. However, in the event of an emergency, this should be confirmed by monitoring.	IV[f]

TABLE 6. TYPICAL THREAT CATEGORIES OF PRACTICES (cont.)

Practice	Threat summary	Typical threat category[a]
Special arrangements UN 2919	Shipments of non-fissile or fissile excepted radioactive material transported under special arrangements require seven days prior notification to the competent authorities of each State involved. In an emergency, urgent GILs may be exceeded. Ground contamination resulting from the emergency may require decontamination.	Limited or IV[f]
Packages containing fissile material UN 2977 UN 3324 UN 3325 UN 3326 UN 3327 UN 3328 UN 3329 UN 3330 UN 3331	Industrial, Type A, Type B and Type C packages may all contain fissile material. Such packages containing fissile material are designed with the contents limited, so as to maintain subcriticality during both normal and accident conditions of transport. The risk summary is therefore the same as that for the relevant Industrial, Type A, Type B or Type C package. Type IF, Type AF, Type B(U)F or Type B(M)F packages that are involved in an air accident and contain only fissile UF_6 may release UF_6 with its associated chemical hazard. However, packages containing only UF_6 have no risk of any radiological consequences requiring special protective actions. Ground contamination resulting from the emergency may require decontamination.	Limited or IV[f]
Packages containing UF_6 UN 2978	Packages containing non-fissile or fissile excepted quantities of UF_6 that are involved in an air accident may release UF_6 with its associated chemical hazard. There is no risk of any radiological consequences requiring special protective actions. Ground contamination resulting from the emergency may require decontamination.	Limited[d]

TABLE 6. TYPICAL THREAT CATEGORIES OF PRACTICES (cont.)

Practice	Threat summary	Typical threat category[a]
	Other	
Nuclear weapon accident (Pu dispersal)	If there is a fire or explosion resulting in dispersal of Pu from a nuclear weapon, deterministic effects are possible from inhalation of the plume or resuspension of deposited material within about 1 km. The area of significant contamination could be of the order of a square kilometre. It may not be possible to detect dangerous levels of airborne contamination with common radiation survey instruments.	IV
Lost/stolen dangerous source	Lethal doses are possible for persons handling an unshielded dangerous source (see Glossary and Appendix III). Lethal doses and considerable contamination resulting in doses above urgent GILs are possible from a ruptured source. A considerable area may be contaminated owing to dispersal by human activities.	IV
Contamination from a significant transboundary release	Deposition leading to doses in excess of the relocation GILs and ingestion generic action levels is possible at great distances from a facility in threat category I or II.	V
Re-entry of a nuclear powered satellite	The risk is very small and it would be virtually impossible to limit the area of concern so that protective action could reasonably be taken. The handling of debris could result in deterministic effects.	IV

TABLE 6. TYPICAL THREAT CATEGORIES OF PRACTICES (cont.)

Practice	Threat summary	Typical threat category[a]
Import of contaminated food or material	Off-site: Uncontrolled (unknowing) use of contaminated steel and other products could result in doses in excess of the occupational dose limits (very small risk) but it is very unlikely that urgent protection action GILs can be exceeded. Food contamination could exceed the generic action level for food protection. On-site: The risk would arise from unknowingly bringing radioactive material or sources onto the site of a practice. The facility of the practice may be the first to identify the hazard.	V

[a] The method described in Section 3 should be used for determining the threat category.

[b] No special emergency preparations are required for the radiological hazard other than those needed for any normal radiation protection programme. However, emergency preparations may be warranted to address perceived concerns and normal industrial and workplace safety for hazards associated with chemical toxicity and other non-radiological hazards associated with the practice.

[c] Threat category IV: mobile dangerous source.

[d] The chemical toxicity due to a UF_6 release is far more important than the radiation dose, even for highly enriched uranium. A lethal concentration of HF (due to chemical toxicity) may be possible off the site.

[e] For research reactors, because of the great variations in the design and operation of the installations, a site specific analysis should be performed to determine whether there is sufficient inventory and energy to result in a significant airborne release off the site.

[f] Transport packages that comply with international regulations [40] are not considered dangerous sources owing to their design and content limits, provided that they are properly controlled and only removed from their packaging under properly supervised conditions. However, if they are lost, stolen or inadvertently removed from their packaging (in an uncontrolled way), they may be considered a dangerous source (see Appendix III).

Appendix II

AREA AND ZONE SIZES

RADIOLOGICAL EMERGENCIES

II.1. Table 7 provides suggestions for the approximate radius of the inner cordoned area (see safe distances in Fig. 1) in a radiological emergency. Appendix VII discusses the protective actions that are justified within these areas.

FACILITIES IN THREAT CATEGORIES I AND II

II.2. Table 8 provides suggestions for the approximate radii of the emergency zones for facilities in threat categories I and II. The distances in Table 8 are suggested with due recognition of the great uncertainties involved and they should be revised by a factor of up to two during their application if necessary to meet local conditions. The choice of the suggested radii represents a judgement of the distance from the site of the emergency for which it is reasonable to make advanced arrangements to ensure an effective response. In a particular emergency, protective actions may be warranted only in a small part of the zones. For the most serious emergencies, protective actions might need to be taken beyond the radii suggested.

II.3. The radii shown in Table 8 are suggestions on the basis of a general analysis. Each State may carry out an independent analysis to determine its own zone sizes that are appropriate in view of the specifics of the State, provided that the analysis: (a) addresses the full range of possible emergencies, including those of low probability, as required by the Requirements (Ref. [2], para. 4.48); and (b) is carried out with the goal of meeting the requirements for establishing these zones as established in the Requirements (Ref. [2], para. 4.48).

II.4. The sizes of the zones are shown in terms of the radius of a circle centred at the source of a potential release or criticality. However, the actual boundary of the zones should not be a circle but should be established to conform to physical and geographical features such as roads or rivers or to political boundaries, as illustrated in Figs 2 and 3. A discussion of the philosophy for establishing the zone size follows Table 8.

TABLE 7. SUGGESTED RADIUS OF THE INNER CORDONED AREA (SAFETY PERIMETER) IN A RADIOLOGICAL EMERGENCY

Situation	Initial inner cordoned area (safety perimeter)
Initial — outside	
Unshielded or damaged potentially dangerous source[a]	Spill area (if a spill occurs) plus 30 m around
Major spill from a potentially dangerous source	Spill area plus 100 m around
Fire, explosion or fumes involving a potentially dangerous source	300 m radius
Suspected bomb (potential radiological dispersal device), exploded or unexploded	400 m radius or more to protect against an explosion
Initial — inside a building	
Damage, loss of shielding or spill involving a potentially dangerous source	The room affected and adjacent areas (including floors above and below)
Fire, suspected radiological dispersal device or other event involving a potentially dangerous source that can spread materials in the building (e.g. internal dispersion through the ventilation system)	Entire building and appropriate outside distance as indicated above
Based on OILs — following the initial determination	
— Ambient dose rate of 100 μSv/h[b] — 1000 Bq/cm^2 beta and/or gamma deposition[c,d] — 100 Bq/cm^2 alpha deposition[d]	Wherever these levels are measured

[a] See Appendix III.

[b] The ambient dose rate is measured at 1 m above ground level for strong gamma emitters.

[c] These levels are not directly measured in the field and therefore OILs must be developed for the instruments to be used to determine if these levels of deposition are present.

[d] Deposition levels can only be assessed by a qualified radiological assessor.

Precautionary action zone (PAZ)

II.5. The PAZ, which only applies to facilities in threat category I, is the area within which arrangements should be made to implement precautionary urgent protective actions before or shortly after a major release with the aim of preventing or reducing the occurrence of severe deterministic effects.

TABLE 8. SUGGESTED EMERGENCY ZONES AND AREA SIZES[a]

Facilities	Precautionary action zone (PAZ) radius[b,c]	Urgent protective action planning zone (UPZ) radius[d]
Threat category I facilities		
Reactors >1000 MW(th)	3–5 km	5–30 km[e]
Reactors 100–1000 MW(th)	0.5–3 km	5–30 km[e]
A/D_2 from Appendix III is $\geq 10^5$ [f]	3–5 km	5–30 km[e]
A/D_2 from Appendix III is $\geq 10^4$–10^5 [f]	0.5–3 km	5–30 km[e]
Threat category II facilities		
Reactors 10–100 MW(th)	None	0.5–5 km
Reactors 2–10 MW(th)	None	0.5 km
A/D_2 from Appendix III is $\geq 10^3$–10^4 [f]	None	0.5–5 km
A/D_2 from Appendix III is $\geq 10^2$–10^3 [f]	None	0.5 km
Fissionable mass is possible within 500 m of site boundary[g]	None	0.5–1 km

[a] The radius is the approximate default distance from the facility at which the boundary of the zone should be established. Variation by a factor of two or more during application is reasonable. A different distance should be used when this is substantiated by a detailed safety analysis.

[b] The suggested radii are the approximate distances for which the acute (2 day) dose to the bone marrow or lung could (with a very low probability) approach levels that are life threatening (i.e. exceed the values in Annex II of Ref. [2]). A maximum radius of 5 km is recommended, as discussed elsewhere in this appendix. The source term (release) used for reactor emergencies is typical of that postulated for the range of low probability accidents that could potentially lead to severe deterministic effects off the site.

[c] The radii were selected on the basis of calculations performed with the RASCAL 3.0 computer model [41]. For the purpose of the calculation, average meteorological conditions, no rain, a ground level release and an exposure for 48 hours to ground shine are assumed, and the centreline dose to a person outside for 48 hours is calculated.

[d] The suggested radii are the approximate distances for which the total effective dose for inhalation, cloud shine and ground shine for 48 hours will not exceed 1–10 times the GIL for evacuation, with a maximum radius of 5–30 km, as recommended for the reasons discussed elsewhere in this appendix.

[e] A distance of between 5 and 30 km may be considered reasonable if supported by a site specific analysis.

[f] Assuming that 10% of the inventory is released to the atmosphere.

[g] The radial distance (500 m) is the distance at which the GIL for evacuation is exceeded, on the assumption that the building containing the criticality (fissile material) does not provide significant shielding and that the criticality results in 10^{19} fissions [42]. This includes the dose due to external irradiation (gamma and neutron) and was calculated using the RASCAL 3.0 model [41].

II.6. The suggested sizes for the PAZ are based on expert judgement made in consideration of the following:

- Urgent protective actions taken before or shortly after a release within this radius will avert doses exceeding the thresholds for early death for the vast majority of major emergencies postulated for these facilities.
- Urgent protective actions taken before or shortly after a release within this radius will prevent doses exceeding the urgent protective action GILs for the majority of emergencies postulated for the facility.
- Dose rates that could be fatal within a few hours were observed at these distances during the Chernobyl accident.
- The maximum reasonable radius for the PAZ is assumed to be 5 km because: (a) except for the emergencies with the most severe consequences, it is the distance limit out to which doses that would lead to early deaths are postulated [25, 26]; (b) it provides a reduction in dose by a factor of about ten in comparison with the dose on the site; (c) it is very unlikely that urgent protective actions will be warranted at a significant distance beyond this radial distance; (d) it is considered the practical limit of the distance to which substantial sheltering or evacuation can be promptly implemented before or shortly after a radioactive release; and (e) implementing precautionary urgent protective actions to a larger radius might reduce the effectiveness of the actions for the people nearer the site who are at the greatest risk.

Urgent protective action planning zone (UPZ)

II.7. The UPZ, which applies to facilities in threat categories I and II, is the area where preparations are made to promptly shelter in place, to perform environmental monitoring and to implement urgent protective actions on the basis of the results of monitoring within a few hours following a release.

II.8. The suggested sizes of the UPZ are based on expert judgement made in consideration of the following:

Threat category I facilities

- These are the radial distances, studies [26] suggest, out to which monitoring to locate and evacuate hot spots (due to deposition) within hours may be warranted to significantly reduce the risk of doses that would lead to early deaths in the emergencies with the most severe consequences postulated for power reactors.

— At these radial distances there is a reduction by a factor of approximately ten in concentration (and thus risk) due to a release in comparison with the concentration at the PAZ boundary.
— This distance provides a substantial base for the expansion of response efforts.
— A distance of 5–30 km is assumed to be the practical limit for the radial distance within which to conduct monitoring and to implement appropriate urgent protective actions within a few hours.
— For average meteorological (dilution) conditions, beyond this radius, for most postulated emergencies with severe consequences the total effective dose to an individual would not exceed the urgent protective action GILs for evacuation.

Threat category II facilities

Atmospheric release

— For average meteorological (dilution) conditions, beyond the UPZ radius, only the postulated emergencies with the most severe consequences would result in a total effective dose to an individual in excess of the urgent protective action GILs for evacuation.
— Preparations within this radius provide a substantial base for the implementation of effective urgent protective actions beyond it, if needed.
— A distance of 0.5 km was selected as the smallest radius, in consideration of possible wake effects caused by buildings.

Fissionable mass (criticality)

— The radiological risk due to a criticality is dominated by the external dose due to gamma and neutron radiation.
— Beyond this radius, most accidental criticalities would not result in a total effective dose to an individual in excess of the urgent protective action GILs for evacuation.
— The off-site doses due to past criticality accidents have not warranted urgent protective actions beyond a distance of 0.5–1 km.

Appendix III

DANGEROUS SOURCES

III.1. The Requirements [2] use the term ‘dangerous source’ in the definition of threat category IV (see Table 1) and establish requirements for operators using dangerous sources or emergencies involving dangerous sources (paras 3.19, 4.17–4.19, 4.37, 4.38 and 5.13).

III.2. This appendix provides guidance on:

— Determining the quantity of radioactive material that should be considered dangerous;
— Providing plain language statements of the risks to the public and emergency responders and typical public warnings and instructions for radiological emergencies.

DETERMINING DANGEROUS QUANTITIES (*D* VALUES)

III.3. A source or uncontrolled radioactive material should be categorized as a dangerous source in accordance with the process described below, with the following exceptions:

— This guidance does not apply for irradiated fuel (e.g. reactor spent fuel). In these cases, Table 4 should be used to determine the threat category.
— Radioactive material being transported in accordance with international requirements [40] should not be considered a dangerous source provided that it is properly controlled and only removed from the packaging under supervised conditions. However, if it is lost, stolen or inadvertently removed from its packaging, this guidance should be applied to determine whether it should be considered a dangerous source.

III.4. For all materials, calculate the following:

$$A / D_1 = \Sigma_i \frac{A_i}{D_{1,i}}$$

where

A_{i} is the activity (TBq) of each radionuclide i over which control could be lost in an emergency or an event;

$D_{1,i}$ for each radionuclide i is taken from Table 9.

III.5. For dispersible material[36] calculate the following:

$$A / D_2 = \Sigma_i \frac{A_i}{D_{2,i}}$$

where

A_i is the activity (TBq) of each radionuclide i that is in a dispersible form and over which control could be lost in an emergency or an event;

$D_{2,i}$ for each radionuclide i is taken from Table 9.

III.6. A source or uncontrolled material should be categorized as a dangerous source if either of the *A/D* values calculated above is greater than 1.[37] Reference [50] provides an explanation of the basis for the D values and the actual D values for over 400 radionuclides.

PLAIN LANGUAGE STATEMENTS OF THE RISKS AND TYPICAL PUBLIC WARNINGS FOR RADIOLOGICAL EMERGENCIES

III.7. This section provides plain language statements of the risks to the public and to emergency responders in the event of a radiological emergency, and typical warnings that should be given to the public.

III.8. The risks are assessed on the assumption that the source or material concerned is not being managed safely or kept securely, and that someone

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[36] Powders, gases and liquids, and especially volatile, combustible, water soluble and pyrophoric material, should be considered to be at risk of dispersal.

[37] It is possible, but unlikely, that a smaller amount than this could cause injury. However, sources this large are considered sufficiently dangerous to warrant taking extraordinary measures (searches, public announcements) to secure them if control over them is lost (e.g. by their being stolen or lost) and if they could be in the public domain.

TABLE 9. D VALUES (TBq) [3]

Source and material[a]		
Radionuclide	D_1[b]	D_2[c]
H-3	UL[d]	2.E+03[e]
C-14	2.E+05	5.E+01
P-32	1.E+01	2.E+01
S-35	4.E+04	6.E+01
Cl-36	3.E+02	2.E+01[f]
Cr-51	2.E+00	5.E+03
Fe-55	UL[d]	8.E+02
Co-57	7.E–01	4.E+02
Co-60	3.E–02	3.E+01
Ni-63	UL[d]	6.E+01
Zn-65	1.E–01	3.E+02
Ge-68	7.E–02	2.E+01
Se-75	2.E–01	2.E+02
Kr-85	3.E+01	2.E+03
Sr-89	2.E+01	2.E+01
Sr-90 (Y-90)[g]	4.E+00	1.E+00
Y-90	5.E+00	1.E+01[h]
Y-91	8.E+00	2.E+01
Zr-95 (Nb-95m/Nb-95)[g]	4.E–02	1.E+01
Nb-95	9.E–02	6.E+01
Mo-99 (Tc-99m)[g]	3.E–01	2.E+01
Tc-99m[h]	7.E–01	7.E+02
Ru-103 (Rh-103m)[g]	1.E–01	3.E+01
Ru-106 (Rh-106)[g]	3.E–01	1.E+01
Pd-103 (Rh-103m)[g]	9.E+01	1.E+02
Cd-109	2.E+01	3.E+01
Te-132 (I-132)[g]	3.E–02	8.E–01[h]
I-125	1.E+01	2.E–01
I-129	UL[d]	UL[d,f]
I-131	2.E–01	2.E–01[h]
Cs-134	4.E–02	3.E+01

TABLE 9. D VALUES (TBq) [3] (cont.)

Source and material[a]		
Radionuclide	D_1[b]	D_2[c]
Cs-137 (Ba-137m)[g]	1.E–01	2.E+01
Ba-133	2.E–01	7.E+01
Ce-141	1.E+00	2.E+01
Ce-144 (Pr-144m, Pr-144)[g]	9.E–01	9.E+00
Pm-147	8.E+03	4.E+01
Eu-152	6.E–02	3.E+01
Eu-154	6.E–02	2.E+01
Gd-153	1.E+00	8.E+01
Tm-170	2.E+01	2.E+01
Yb-169	3.E–01	3.E+01
Re-188	1.E+00	3.E+01
Ir-192	8.E–02	2.E+01
Au-198	2.E–01	3.E+01
Hg-203	3.E–01	2.E+00
Tl-204	7.E+01	2.E+01
Po-210	8.E+03	6.E–02
Ra-226 (progeny)[g]	4.E–02	7.E–02
Th-230	9.E+02	7.E–02[f]
Th-232	UL[d]	UL[d,f]
U-232	7.E–02	6.E–02[f]
U-235 (Th-231)[g]	8.E–05	8E–05[i]
U-238	UL[d]	UL[d,f]
U natural	UL[d]	UL[d,f]
U depleted	UL[d]	UL[d,f]
U enriched > 20%	8E–05[i]	8E–05[i]
U enriched > 10%	8E–04[i]	8E–04[i]
Np-237 (Pa-233)[g]	3.E–01[j]	7.E–02
Pu-238	3.E+02[i]	6.E–02
Pu-239	1.E+00[i]	6.E–02
Pu-239/Be[k]	1.E+00[i]	6.E–02
Pu-240	4.E+00[i]	6.E–02

TABLE 9. D VALUES (TBq) [3] (cont.)

Source and material[a]		
Radionuclide	D_1[b]	D_2[c]
Pu-241 (Am-241)[g]	2.E+03[i]	3.E+00
Pu-242	7.E–02[i]	7.E–02[f]
Am-241	8.E+00	6.E–02
Am-241/Be[k]	1.E+00	6.E–02
Cm-242	2.E+03	4.E–02
Cm-244	1.E+04	5.E–02
Cf-252	2.E–02	1.E–01

[a] The amount of material in the public domain, if not under control (i.e. because of allowing removal of shielding or allowing dispersal accidentally or by a malicious act), that could give rise to doses resulting in permanent injury that decreases the quality of life.

[b] D_1 is for external exposure and applies to both dispersible and non-dispersible materials.

[c] D_2 is for dispersible material. Airborne dispersal by fire or explosion, inadvertent ingestion and intentional contamination of water was considered.

[d] UL: unlimited quantity. Emergency planning for dealing with radiological consequences is not recommended.

[e] Assumes that skin absorption doubles the absorbed dose from inhalation.

[f] Emergencies involving these amounts of these radionuclides may result in airborne concentrations in excess of the concentrations posing immediate danger to life or health (IDLH) for chemical toxicity, and arrangements for dealing with these risks are warranted.

[g] The *D* values were calculated in consideration of both the parent and important decay products (radionuclides shown in parentheses) that are present after up to ten years. Decay products with a half-life of less than one year can be assumed to be in equilibrium with their parents.

[h] Does not pose a long term concern as it is short lived and within one month or less the radiological hazard will be greatly diminished.

[i] There is no immediate radiation hazard but the *D* value was established on the basis of the criticality hazard.

[j] The *D* value represents a radiological and criticality hazard.

[k] Neutron generator.

could — knowingly or unknowingly — remove the radioactive material from the container or packaging in which it was to be used or safely shipped. Handling of the material, contamination of public water supplies and fires and/or explosions were considered.

Risks to public

III.9. An amount of radioactive material is considered 'dangerous' if it could cause permanent injury or be immediately life threatening if not managed safely and contained securely. Permanent injuries include burns requiring surgery and debilitating injuries to the hands. Temporary injuries include skin reddening and irritation and temporary changes in the composition of the blood. Exposures are considered to be immediately life threatening[38] if they could result in injuries to tissues or organs that are fatal within at most a few years. Exposures that are immediately life threatening:

— Typically arise from very high radiation doses received over a period of hours to months owing to the presence nearby of dangerous amounts of unshielded material, for example from a dangerous source placed in a drawer next to the bed.
— Arise in rare cases from inadvertently eating or drinking (or for someone very close by, inhaling) small amounts of dispersible material, for example if someone opens the container of a dangerous amount of radioactive material that is in a dispersible form. Powders, gases and liquids, and volatile, combustible, water soluble and pyrophoric materials are all dispersible.
— Could arise from 'inhalation' for radioactive material in a plume from a fire or explosion (e.g. from a radiological dispersal device).

III.10. It should be noted that there is the potential for amounts that are a very small fraction (e.g. 1/100) of the D values given in Table 9 to be dangerous. This would be the case in the event of intentional ingestion of radioactive material or intentionally exposing oneself to a radioactive source.

Risks to responders

III.11. There will be little or no health risks to response personnel provided that in taking response actions near any hazardous material they take normal precautions, such as the use of respiratory protection against material released in a fire or explosion. Limited stays (such as for rescues) near a radioactive source or material would probably not be dangerous. There would be little or no health hazard to medical staff who are treating or moving exposed or

[38] This does not refer to the possibility of causing cancer, which is very small, as discussed in the following.

contaminated persons provided that they protect themselves against the inadvertent ingestion of radioactive material by normal barrier methods such as the use of surgical gloves.

Other concerns

III.12. Radiological emergencies involving radioactive material in these amounts are very unlikely to result in any detectable increase in the incidence of cancer due to radiation induced cases among the population groups exposed.

III.13. Public concern about any incident involving radioactive material must always be duly considered, regardless of the threat indicator. Significant adverse (and unwarranted, in terms of the radiological risks involved) public reactions have occurred in the past, even though the levels of contamination and exposure were not dangerous. Such reactions have included pregnant women having unnecessary abortions, discrimination against possibly exposed persons and boycotts of local businesses and products.

Public warnings and/or instructions

This section provides typical warnings/instructions for the public for various radiological emergencies.

For a radiological emergency involving possible public exposure, the public should be provided (as appropriate) with the following advice:

— Those who left the scene without being assessed or instructed as to further actions should be instructed: not to smoke, eat, drink or place their hands near their mouths until they have washed their hands; to shower and change clothes if possible and place their clothes in a plastic bag and keep them; and to go to the specified place to be assessed and be given instructions;
— Anyone who transported victim(s) must go to the specified place for individual monitoring and monitoring of vehicles.

If an airborne radioactive release is suspected, people within about 1 km of the site of the emergency should be advised:

— To remain indoors during the release;
— Not to consume any food or water that may have been contaminated (e.g. vegetables grown outside or rainwater) until monitoring of food has been performed;
— That an announcement of the results will follow;
— To make sure that children do not play on the ground;
— To wash hands before eating;
— To avoid dusty areas or activities that will create dust;
— Not to be concerned about those evacuated (it is not dangerous to be near them);
— Not to go to the scene to volunteer to help — if assistance is needed, announcements will be made.

If a dangerous source is lost or stolen, the public should be provided (as appropriate) with the following information:

(1) Time and location of loss of control over the source;
(2) The governmental organization leading the response;
(3) The details of the request for help in finding this dangerous item;
(4) A description and if possible illustration or drawing of the item;
(5) Advice that:
— The item is very dangerous and if found should not be touched, and everyone should be kept at least 10 metres away from it;
— Any persons who think they may have seen the item should immediately report this to [specify];
— Any persons who have touched or been near the item should contact [specify].

Medical practitioners should be alerted to the possibility that patients may present themselves with symptoms of radiation exposure (e.g. burns with no apparent cause, i.e. the person does not remember being burned).

Scrap metal dealers are also asked to be alert.

Appendix IV

EMERGENCY CLASSES FOR EMERGENCIES AT FACILITIES[39]

IV.1. Table 10 describes the abnormal facility conditions that correspond to each type of facility emergency listed in the Requirements (para. 4.19 [2]), together with the immediate actions that should be initiated on and off the site upon declaration of one of these types of emergency. Emergency action levels should be developed for the abnormal conditions that correspond to each type of emergency (see para. 4.5).

[39] Facilities in threat categories I, II and III.

TABLE 10. CLASS DESCRIPTION FOR EMERGENCIES AT FACILITIES

Emergency class description	Immediate response actions, threat category I and II facilities
General emergency	
Events resulting in an actual or substantial risk of an atmospheric release or radiation exposure due to a criticality or loss of shielding requiring implementation of urgent protective actions off the site. This could be: — Actual or projected[a] damage to the reactor core or large amounts of recently discharged fuel (see Table 4); — Actual damage to barriers or critical safety systems that would result in a release (e.g. of reprocessing waste) or criticality that would warrant taking precautionary protective action off the site;	Operator and on-site: — Take life saving actions and give first aid on the site; — Notify off-site officials; — Recommend protective actions in accordance with Appendix VII; — Summon the emergency services if needed; — Evacuate non-essential personnel and visitors or provide them with special on-site sheltering, and account for all persons on the site; — Provide protection from hazardous conditions for on-site emergency response personnel and for those arriving from off the site; — Take action to mitigate the consequences of the emergency, including requesting off-site assistance; — Provide technical assistance to the facility control room; — Conduct off-site monitoring near the facility and provide results to the radiological monitoring and assessment centre (see Appendix VIII); — Activate the full response coordinated under a unified emergency response management system similar to the incident command system;[b] — Establish continuous communication with off-site officials; — Establish, with off-site officials, a unified emergency response management system similar to the incident command system (see Appendix VIII); — Conduct, with off-site officials, joint media briefings at the public information centre (see Appendix VIII).

TABLE 10. CLASS DESCRIPTION FOR EMERGENCIES AT FACILITIES (cont.)

Emergency class description	Immediate response actions, threat category I and II facilities
General emergency	
— Potential or actual criticality near the facility boundary; — Detection of radiation levels off the site warranting the implementation of urgent protective measures; — Terrorist or criminal act resulting in an inability to monitor or control critical safety systems needed to prevent a release or exposure that could result in doses off the site that warrant urgent protective actions.	Off-site: Within the PAZ and the UPZ: — Implement immediate protective actions as recommended at the facility and in accordance with Appendix VII; — Establish the radiological monitoring and assessment centre (see Appendix VIII), conduct monitoring in and around the UPZ and revise protective actions based on OILs; — Activate the full response coordinated under a unified emergency response management system similar to the incident command system;[b] — Provide radiation protection for emergency workers; — Ensure that all governmental agencies are informed; — Notify the IAEA; — Establish provision to monitor and decontaminate evacuees and manage the medical response and initial treatment, and consult experts on the treatment of persons with severe overexposures; — Initiate joint media briefings at the public information centre with on-site officials (see Appendix VIII). The area in which food and water contamination may warrant restrictions: — Issue instructions to protect water supplies[c] and for farmers to protect crops and put animals on stored feed as appropriate; — Restrict movement of contaminated food until it has been monitored; — Conduct monitoring to determine where ingestion OILs could be exceeded and to provide appropriate recommendations for protection.

TABLE 10. CLASS DESCRIPTION FOR EMERGENCIES AT FACILITIES. (cont.)

Emergency class description	Immediate response actions, threat category I and II facilities
Site area emergency	
Events resulting in a major decrease in the level of protection for those on the site and near the facility. This could be: — A major decrease in the level of defence in depth provided for the core of a reactor or actively cooled fuel (see Table 4); — A major decrease in protection against an accidental unshielded criticality; — Conditions such that any additional failures could result in a general emergency; — Doses off the site approaching the urgent protective action intervention levels; — Terrorist or criminal act with the potential to disrupt the performance of critical safety functions or to result in a major release or severe exposure.	Operator and on-site: — Take life saving actions and give first aid on the site; — Notify off-site officials; — Recommend that preparations be made to implement protective actions in accordance with Appendix VII; — Summon the emergency services if needed; — Evacuate non-essential personnel and visitors or provide them with special on-site sheltering, and account for all persons on the site; — Provide protection from hazardous conditions for on-site emergency response personnel and for those arriving from off the site; — Activate the full response coordinated under a unified emergency response management system similar to the incident command system;[b] — Take action to mitigate the consequences of the emergency, including requesting off-site assistance; — Provide technical assistance to the facility control room; — Conduct off-site monitoring near the facility and provide results to the radiological monitoring and assessment centre (see Appendix VIII); — Establish continuous communication with off-site officials; — Conduct, with off-site officials, joint media briefings at the public information centre (see Appendix VIII); — Reassess the classification and revise if warranted.

TABLE 10. CLASS DESCRIPTION FOR EMERGENCIES AT FACILITIES. (cont.)

Emergency class description	Immediate response actions, threat category I and II facilities
Site area emergency	
	Off-site: — Prepare to implement urgent protective actions off the site and take measures in accordance with Appendix VII to protect the food supply; — Alert the population in the PAZ or UPZ, advising them to remain attentive for further instructions; — Activate the full response coordinated under a unified emergency response management system similar to the incident command system;[b] — Provide radiation protection for emergency workers; — Provide firefighting, police or medical services in support of the facility if requested; — Establish the radiological monitoring and assessment centre (see Appendix VIII) and conduct monitoring in and around the UPZ, and revise the classification as appropriate; — Ensure that all governmental agencies are informed; — Notify the IAEA; — Establish provision to manage the medical response and initial treatment, and consult experts on the treatment of persons with severe overexposures; — Initiate, with on-site officials, joint media briefings at the public information centre (see Appendix VIII).
	Within the area where food and water contamination may warrant restrictions: — Issue instructions to protect water supplies[c] and for farmers to protect crops and put animals on stored feed as appropriate.

TABLE 10. CLASS DESCRIPTION FOR EMERGENCIES AT FACILITIES. (cont.)

Emergency class description	Immediate response actions, threat category I and II facilities
Facility emergency	
Event resulting in a major decrease in the level of protection for on-site personnel; however, these events cannot evolve into a general or site area emergency warranting the implementation of protective actions off the site. For threat category I and II facilities, this could be: — A fuel handling emergency; — An in-facility fire or other emergency not affecting safety systems; — Terrorist or criminal activity resulting in hazardous on-site conditions but with no potential to result in a criticality or release off the site that would warrant urgent protective actions.	Operator and on-site: (see Ref. [43] for further guidance for radiotherapy facilities): — Take life saving actions and give first aid on the site; — Notify off-site officials and summon emergency services if needed; — Evacuate non-essential personnel and visitors from the potentially hazardous area and account for all persons on the site; — Monitor on-site personnel for contamination and ensure that contaminated individuals or items do not leave the site undetected; — Provide first aid, decontaminate, estimate exposures and take injured and exposed individuals for treatment; — Confirm that off-site protective actions are not needed; — Provide protection from hazardous conditions for on-site and off-site emergency response personnel; — Activate partial response; — Take actions to mitigate the emergency and to provide technical assistance to control room or operating staff; — Establish continuous communication with off-site officials; — Activate a partial response coordinated under a unified emergency response management system similar to the incident command system;[b] — Conduct, with off-site officials, joint media briefings at the public information centre (see Appendix VIII); — Reassess the classification and revise if warranted.

TABLE 10. CLASS DESCRIPTION FOR EMERGENCIES AT FACILITIES. (cont.)

Emergency class description	Immediate response actions, threat category I and II facilities
Facility emergency	
For threat category III, this could be: — A major decrease in the level of defence in depth provided for the core of a small reactor (see Table 4); — Loss of shielding or control of a large gamma emitter or spent fuel; — Rupture of a dangerous source; — A criticality away from the site boundary; — High doses on the site approaching urgent protective action intervention levels; — Emergencies resulting in significant exposure or contamination of the public or staff on the site; — Terrorist or criminal activity potentially resulting in hazardous on-site conditions.	Off-site: — Conduct monitoring around the facility to confirm that off-site actions are not needed; — Activate the full response coordinated under a unified emergency response management system similar to the incident command system;[b] — Ensure that governmental agencies are informed; — Provide fire, police or medical services in support of the facility if requested; — Provide initial treatment for the injured and consult experts to determine a treatment strategy for those with overexposures; — Initiate, with on-site officials, joint media briefings at the public information centre (see Appendix VIII).

TABLE 10. CLASS DESCRIPTION FOR EMERGENCIES AT FACILITIES. (cont.)

Emergency class description	Immediate response actions, threat category I and II facilities
Alert	
Events involving an unknown or significant decrease in the level of protection of the public or on-site personnel.[d]	Operator and on-site: — Take life saving actions and give first aid on the site; — Notify off-site officials; — Activate, by using the incident command system under an incident commander, the appropriate part of the response needed to analyse and resolve the condition resulting in the alert or to reduce the potential threat; — Conduct off-site monitoring near the facility (if appropriate); — Implement actions to mitigate the consequences of the event and to provide technical assistance to control room or operations staff (if required); — Initiate, with off-site officials, joint media briefings at a public information centre if the alert receives media or public attention. Off-site: — Increase readiness; — Implement the minimum components of a unified management system for emergency response similar to the incident command system; — Ensure that all governmental agencies are informed; — Provide fire, police or medical services in support of the facility if requested; — Initiate, with on-site officials, joint media briefings at the public information centre if the alert receives media or public attention.

[a] Indicated by a loss of critical safety functions needed to protect the core or large amounts of recently discharged fuel.
[b] Incident command systems as described in Ref. [3].
[c] Typically only small open water supplies or water supplies that use rainwater are at risk.
[d] Such events may involve release barriers, critical safety systems, instrumentation, staff, natural occurrences, and fires or terrorist or criminal acts.

Appendix V

OVERVIEW OF URGENT PROTECTIVE ACTIONS AND OTHER ACTIONS

ISOLATION AND PREVENTION OF INADVERTENT INGESTION

V.1. In most radiological emergencies involving uncontrolled dangerous sources, individuals can be protected from the radiological hazards by isolating the source and preventing inadvertent ingestion. They can avoid significant exposure due to contact and shine by moving away from a dangerous source, and workers can greatly reduce their dose by the use of remote handling tools. Keeping hands and possibly contaminated objects out of the mouth can prevent inadvertent and possibly fatal ingestion. These are all actions that individuals can take immediately, once they are aware of the hazard. Consequently, the Requirements [2] (para. 4.48) require that arrangements be made to issue a warning to the public in the event of a dangerous source being lost or illicitly removed and possibly being in the public domain. This warning should include instructions to the public on how to isolate a possibly dangerous source and how to prevent the inadvertent ingestion of radioactive material.

SHELTERING

V.2. Sheltering is relatively easy to implement, but it may not be possible to extend it for long periods of time. Sheltering will provide some protection against exposure via all the major exposure pathways during the early phase of a nuclear or radiological emergency. Sheltering 'in place' can also be used whenever individuals in a potential area of risk are instructed to 'go inside and shut the windows and doors and listen to the radio or television for further instructions' while further assessments of preparations for evacuation are being made. Sheltering can also be used whenever conditions make evacuation dangerous (e.g. in severe weather conditions).

V.3. The effectiveness of sheltering varies greatly, depending on the characteristics of the radioactive release or the sources of the exposure (e.g. a criticality), the construction of the shelter and the exposure pathway. External exposure can be reduced by a factor of ten by sheltering in a large structure, while a lightweight building provides little protection from external gamma radiation. Estimating the protection provided against inhalation of radioactive material in the plume by sheltering is very complex. For a short release, most buildings will reduce inhalation doses by a factor of two or three. However, the reductions in the inhalation doses resulting from long releases typically decrease rapidly after a few hours as the concentrations of radioactive material in the structure increase. After passage of the plume, the inhalation doses in most structures could even be greater than those outside if some of the contamination from the plume is trapped in the shelter. Consequently it should be recommended that normal shelters be ventilated (aired out) after a major release has terminated.[40]

V.4. Because of the great variability of building structures, shelters can be considered as belonging to one of three categories, as shown in Table 11.

V.5. Predetermined shelter locations should be provided with a means of determining whether radiation levels are acceptable (e.g. measuring instruments and criteria for judging the results) and arrangements for meeting human needs.

EVACUATION

V.6. A room, facility or geographic area can be evacuated. Timely evacuation can prevent exposures via all possible exposure pathways and removes individuals from the proximity of the emergency so that they are no longer an immediate concern for response officials.

V.7. Numerous evacuations have been carried out in response to emergencies involving natural, chemical and radiological hazards and terrorist activities. Studies of these evacuations show [44, 45] that the risks of the evacuation itself for the normal population were smaller than those due to normal travel under similar weather conditions. However, evacuation may be more dangerous for special groups in the population, such as hospital patients, if it is not prepared for adequately. The following should be taken into account in preparing for evacuation:

— Criteria and decision making;
— Established evacuation routes and traffic control;

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[40] This is made difficult by the uncertainties associated with projections of the timing (duration) and size of major releases and plume movements, as was seen following the Chernobyl accident in 1986.

TABLE 11. SHELTER TYPES AND USES

Type	Description	Uses and recommendations
Normal	Typical European and North American homes and their basements.	May not provide adequate protection (e.g. from a major airborne plume close to a facility[a] in threat category I). Should be used in the event of a major release if evacuation is impossible (e.g. in a severe storm) or when preparing to evacuate.
Substantial	Inside halls of large multistorey buildings or large masonry structures away from walls or windows. Estimated protection factor of 10 from external and inhalation dose.	May provide adequate protection for short periods. Can be used as urgent protection for up to a day. However, the effectiveness should be assessed by means of monitoring and users should be provided with instructions on application.
Special	Designed to provide a reduction by a factor of more than 100 in external and inhalation doses.	Provides adequate protection. Should be used as the primary urgent protective measure for the design period of the shelter.

[a] The distances within which shelter is ineffective in reducing the risk of severe deterministic effects should be based on site specific analysis; however, for the most severe emergencies postulated for nuclear power plants, shelter in a typical frame house of the type found in the USA is projected to provide inadequate protection within about the first 3 km from the site of the emergency.

— Access control and protection of property;
— Arrangements for special population groups and facilities;
— Consideration of farm animals and pets;
— Provisions for meeting the human needs of evacuees.

RESPIRATORY PROTECTION AND PROTECTIVE CLOTHING

V.8. The respiratory protection equipment typically used by firefighters provides good protection against the inhalation hazard for most emergencies involving an airborne release of radioactive material. Skin contamination is not a major threat, provided that simple steps are taken to protect the skin and to prevent inadvertent ingestion. However, conditions on the site of a facility in threat category I, II or III may be very severe and may require specialized protective equipment.[41] For example, the standard protective clothing worn by firefighters during the Chernobyl accident in 1986 did not provide adequate protection for the skin. Personnel responding to radiological emergencies should use respiratory protection equipment whenever an inhalation hazard is suspected. In addition, the Requirements [2] (para. 4.62) require that arrangements be made for taking all practicable measures to provide protection for emergency workers at facilities in threat categories I, II and III for the range of anticipated hazardous conditions in which they may have to perform response functions on or off the site.

V.9. Improvised respiratory protection (e.g. a wet cloth over the mouth and nose) has been shown to be effective but it has not been demonstrated that the public will apply it effectively during an emergency. Improvised respiratory protection should not be assumed to provide adequate protection from an inhalation hazard and therefore its implementation should not be allowed to interfere with evacuation or sheltering.

DECONTAMINATION OF INDIVIDUALS

V.10. People have been contaminated by airborne radioactive releases and by handling radioactive material. Significant levels of skin contamination are very rare, and for most emergencies contamination has not presented a health risk. However, skin contamination can have severe adverse psychological and economic effects. In some cases contaminated people have been shunned and medical professionals have refused to treat them. In addition, skin contamination did contribute to the deaths of several on-site responders (firefighters) during the Chernobyl accident in 1986, and the inadvertent ingestion of contaminated particles that were on the skin of persons who were contaminated in the accident in Goiânia, Brazil in 1987 may have been fatal. These accidents illustrate the two scenarios for which prompt decontamination may be important in preventing severe deterministic effects:

[41] In the Chernobyl accident, water contaminated with radioiodine soaked through the protective clothing of the fire-fighters, resulting in beta radiation burns that contributed to several fatalities. In many responses, on-site efforts have been hampered by a lack of protective equipment (e.g. field radiation detection instruments with a high range (e.g 10 Gy/h) or air tanks for self-contained breathing apparatus).

— Those who may have been heavily contaminated by a major airborne radioactive release should be promptly decontaminated to prevent burns to large areas of the skin. This would probably only be an issue for those on the site during a major release from a facility in threat category I and possibly threat category II or III.
— Those who may have skin contamination that could be hazardous and which could possibly give rise to inadvertent ingestion (e.g. by placing a hand on or in the mouth) should be promptly decontaminated. This hazard would most probably be of concern to someone who handled a dangerous source containing dispersible material or something directly contaminated by such a source.

V.11. In the radiological accident in Goiânia, over 100 000 people were monitored in order to reassure them that they were not significantly contaminated. Similar reactions by the public should be expected in the event of an emergency that may possibly involve contamination of the public.

V.12. Contamination by a wide range of radioactive materials is easy to detect; however, criteria are needed to differentiate between significant and insignificant levels in terms of possible health consequences. Lack of criteria has resulted in unnecessary decontamination, diversion of resources, unwarranted anxiety among the public and loss of equipment or facilities.[42] Consequently, operational criteria should be established to assess levels of contamination on people and equipment.

V.13. Simply changing clothing, showering or washing exposed skin will reduce dangerous levels of contamination and prevent the spread of contamination at significant levels. These simple, cost effective decontamination measures should be used even for contamination at lower levels, provided that they are carried out in such a way as to minimize unwarranted anxiety and do not result in the waste or unjustified diversion of resources. In emergencies, especially when large numbers of people are involved, decontamination measures should be limited to these basic measures and only limited (i.e. easy and simple) efforts should be made to control the wastes arising from the decontamination.

[42] Some emergency plans state that vehicles or facilities that are contaminated cannot be used, but do not define what levels of contamination constitute being contaminated.

PROPHYLAXIS WITH STABLE IODINE

V.14. The uptake by the thyroid gland of radioiodine from inhalation can be reduced by the administration of certain amounts of stable (non-radioactive) iodine which saturates the thyroid. This is called stable iodine prophylaxis, thyroid blocking or iodine blockade.

V.15. To achieve maximum effectiveness, stable iodine must be administered before or soon after the intake of radioiodine. The effectiveness of the measure decreases rapidly with delay, and can be reduced to 50% or less if administered 6 hours after a single intake of radioactive iodine. The reduction in the dose to the thyroid gland is only about 20% if stable iodine is given 10 hours after intake, while it falls almost to zero if stable iodine is given 24 hours after the intake of radioiodine [46].

V.16. There has been considerable concern about adverse side effects on health from the intake of stable iodine. The WHO, partly on the basis of experience gained from the response to the Chernobyl accident, found the risk of severe adverse side effects to be negligible and stable iodine prophylaxis to be both safe and effective [47] if the iodine is provided in the correct dosages and those with known severe allergic reaction are excluded. WHO has provided guidance on the appropriate dosages in Ref. [47]. These dosages are different for adults and children.

V.17. Emergencies involving core damage at large reactors (threat category I) can release significant amounts of airborne radioactive iodine (radioiodine) over several days, as was seen in the Chernobyl accident. The thyroid gland absorbs and concentrates iodine once it has been inhaled or ingested; thus, the potential exists for large thyroid doses following the occurrence of severe core damage at a large reactor. A large dose to the thyroid can result in deterministic effects in the thyroid gland and radiation induced thyroid cancer. In the event of actual or possible core damage, stable iodine prophylaxis should therefore be used:

— To prevent deterministic effects in the thyroid gland (e.g. hypothyroidism);
— To reasonably reduce the risk of stochastic effects (e.g. radiation induced thyroid cancer) from the inhalation of radioiodine within or near the facility.

V.18. The risks of deterministic effects to the thyroid are principally of concern for individuals on the site and for the population close to the site (e.g. within the UPZ).

V.19. To be most effective, stable iodine prophylaxis should be provided before or shortly after an intake of radioiodine (i.e. before or shortly after a radioactive release). Consequently, for emergencies involving severe core damage at reactors of facilities in threat categories I and II, arrangements should be made to provide stable iodine prophylaxis promptly (i.e. before or within hours of a release) to individuals who are on the site and to the population within the UPZ, including emergency workers. In developing these arrangements, the following should be considered:

— Criteria and decision making;
— The logistics of storage, restocking and distribution;
— The need for instructions to users to ensure that the correct dosages are taken and that individuals with known severe allergies are excluded from the iodine prophylaxis;
— Medical follow-up of those with actual or perceived side effects.

V.20. Appropriate arrangements should be made for the continuation of stable iodine prophylaxis for more than one day if there is:

— Potential for significant releases of radioiodine for several days following the onset of an emergency;
— Potential for inadvertent ingestion after passage of the radioactive plume;
— In-growth of ^{132}I from the decay of ^{132}Te in the environmental contamination following a release.

V.21. Doses to the thyroid, in the vast majority of cases, will not give rise to life threatening effects if individuals are properly treated. However, death could result from doses to the bone marrow, lungs and other organs, which are not protected by stable iodine prophylaxis. Only substantial sheltering or evacuation can protect these organs. The sheltering or evacuation of people at risk of life threatening doses should therefore not be delayed for the provision of stable iodine prophylaxis.

PROTECTION OF THE FOOD AND WATER SUPPLY AND RESTRICTION OF SIGNIFICANTLY CONTAMINATED FOOD AND WATER SUPPLIES

V.22. Following a major release from a facility in threat category I or II, one of the primary sources of exposures may be the ingestion of contaminated food or milk.[43] Ingestion of radioactive material may also be of concern if an explosion or human activity spreads dispersible material from a dangerous source.

V.23. The Chernobyl accident showed that the contamination of drinking water sources due to an airborne radioactive release might not be a major concern, except if rainwater is being used directly for drinking or cooking.

V.24. Consequently, for facilities in threat categories I and II (with the potential for an emergency that may result in a major release) arrangements should be made:

— To instruct the public not to eat locally produced food within the UPZ that may have been directly contaminated and not to consume milk from animals that may graze on possibly contaminated ground;
— To instruct the public to protect sources of water (e.g. to disconnect rainwater collection pipes) and to protect important sources of food that may become contaminated;
— Promptly to conduct monitoring and to implement the appropriate restrictions on food and on drinking water from rainwater within the area where food or water may be contaminated to levels warranting restrictions.

V.25. These arrangements should be developed in consideration of:

— Arrangements for the distribution and processing of food;
— Instructions for the public and for farmers;

[43] The consumption of milk contaminated with radioiodine was the primary cause of an increase in the incidence of thyroid cancers among children following the Chernobyl accident. Radiation induced thyroid cancers due to the Chernobyl accident occurred among people living at different distances from the plant and the vast majority were observed at more than 50 km from the plant. The most effective protective action to prevent or reduce these thyroid cancers would have been to restrict the consumption of potentially contaminated food and milk.

— Availability of replacement foods;
— Operational criteria.

V.26. If restrictions could result in severe health effects (e.g. malnutrition), they should not be applied unless ingestion of the food could result in severe deterministic effects.

PROTECTION OF INTERNATIONAL TRADE AND COMMERCIAL INTERESTS

V.27. Nuclear and radiological emergencies that have occurred in the past have had major adverse economic consequences. This was in part because steps were not taken immediately to reassure people, including national and international customers. It should be noted that threats as reported in the media or as perceived internationally can be as influential as real threats. Consequently, in the event of a nuclear or radiological emergency (or in the event of reports of such an emergency) that may have or that may be perceived to have an impact on trade, there should be provision for taking measures immediately to ensure that all goods in trade meet international standards. The exemption levels and clearance levels in Ref. [48] may be considered as a basis for protecting international trade after an emergency.

MEDICAL MANAGEMENT

V.28. Nuclear and radiological emergencies have occurred that warrant taking immediate action to treat and to identify those who should receive long term medical follow-up. These actions are discussed in the section on managing the medical response, paras 4.37–4.46.

Appendix VI

RESPONSE TIME OBJECTIVES

VI.1. Response time objectives are suggested time objectives for selected critical response functions or tasks for facilities in threat categories I, II and III. They should, once established, be part of the performance objectives for a response capability and should be used as part of the evaluation criteria for exercises (Ref. [2], para. 5.36). These time objectives were developed on the assumption that: (a) emergencies resulting in severe conditions can be classified and off-site officials can be notified within minutes [49];[44] (b) severe conditions warranting protective action on the site can occur within minutes; (c) releases can occur from a facility in threat category I that require the implementation of urgent protective action to prevent deterministic effects within the PAZ within one or two hours; (d) monitoring within the UPZ may be warranted within 4–6 hours following a release to identify locations where additional protective actions may be needed; and (e) the news media will become aware of events and will become a major source of information for the public within hours.

TABLE 12. RESPONSE TIME OBJECTIVES

Element/task	Threat category I facility			Threat category II facility			Threat category III facility	
	Facility level	Local level	National level	Facility level	Local level	National level	Facility level	Local level
Establishing emergency management operation (the objective is timed from the time at which the emergency is classified by the facility operator)								
Announce who is the director of on-site emergency response to those on the site	<15 min							

[44] This should be accomplished as soon as possible. Over the past 20 years, the USA has demonstrated that this goal can be achieved within 15 minutes of detection of the event. This goal has been further formalized as part of the US emergency preparedness requirements in accordance with Ref. [49].

TABLE 12. RESPONSE TIME OBJECTIVES (cont.)

Element/task	Threat category I facility			Threat category II facility			Threat category III facility	
	Facility level	Local level	National level	Facility level	Local level	National level	Facility level	Local level
Activate emergency operations facility and/or incident command post (see Appendix VIII)	<1 h	<1 h		<1 h	<1 h			<2 h
Emergency operations facility/ incident command post is fully functional (all organizations represented)	<2 h	<2 h		<2 h	<2 h			<3 h
Identifying, notifying and activating (the objective is timed from the time at which conditions indicating that emergency conditions exist are detected)								
Classify the emergency (declaration of emergency)	<15 min			<15 min			<15 min	
Notify local authorities (PAZ and UPZ) after classification[a]	<15 min			<15 min			<1 h	
Fully activate emergency organization	<2 h	<6 h	<12 h	<2 h	<6 h		<2 h	
Notify all States within the UPZ	<1 h		<1 h			<1 h		
Notify the IAEA			<2 h			<2 h		
Performing mitigatory actions (the objective is timed from the time at which the emergency is classified)								
Initiate mitigatory actions	<15 min			<15 min			<15 min	

TABLE 12. RESPONSE TIME OBJECTIVES (cont.)

Element/task	Threat category I facility			Threat category II facility			Threat category III facility	
	Facility level	Local level	National level	Facility level	Local level	National level	Facility level	Local level
Have operational support centre functional (see Appendix VIII)	<30 min							
Provide technical assistance to the on-site responders (activate technical support centre) (see Appendix VIII)	<1 h							
Provide on-site damage control teams	<30 min			<1 h			<1 h	
Obtain support of off-site emergency services	<30 min			<30 min			<30 min	
Taking urgent protective action								
Recommend urgent protective actions for the public on the basis of the emergency classification	<30 min			<30 min				
Make decisions on urgent protective actions	<30 min	<30 min		<30 min	<30 min			
Complete implementation of facility protective actions	<1 h			<1 h			<1 h	

TABLE 12. RESPONSE TIME OBJECTIVES (cont.)

Element/task	Threat category I facility			Threat category II facility			Threat category III facility	
	Facility level	Local level	National level	Facility level	Local level	National level	Facility level	Local level
Providing information and issuing instructions and warnings to the public (the objective is timed from the time at which the initial notification by the facility of a general emergency is received)								
Initially warn and inform the public within the PAZ and UPZ of urgent protective actions required		<1 h			<2 h			
Activate the public information centre and commence coordinated (between the facility and off-site officials) briefings for the news media		<4 h			<4 h			<6 h
Assessing the initial phase								
Conduct environmental monitoring near the facility	<1 h			<1 h			<2 h	
Conduct environmental monitoring within the PAZ, near the facility		<4 h						
Conduct environmental monitoring within the UPZ		<12 h	<12 h		<12 h	<12 h		

TABLE 12. RESPONSE TIME OBJECTIVES (cont.)

Element/task	Threat category I facility			Threat category II facility			Threat category III facility	
	Facility level	Local level	National level	Facility level	Local level	National level	Facility level	Local level
Radiological monitoring and assessment centre fully functional (see Appendix VIII)		<24 h			<24 h			

[a] This should be accomplished as soon as possible. Over the past 20 years, the USA has demonstrated that this goal can be achieved within 15 minutes of detection of the event. This goal has been further formalized as part of the US emergency preparedness requirements in accordance with Ref. [49].

Appendix VII

URGENT PROTECTIVE ACTION OFF THE SITE

RADIOLOGICAL EMERGENCIES

VII.1. For instances of transport emergencies, found sources, radiological dispersal devices, contamination or accidents involving a nuclear weapon (all emergencies in threat category IV), the following urgent actions should be promptly taken before an assessment of monitoring results becomes available.

First responders

VII.2. Within the inner cordoned area (inside the safety perimeter; see Appendix II): warn that women who are or who may be pregnant should not work within the cordoned area; perform life saving actions (do not delay life saving actions on account of possibly elevated levels of radiation); limit stays in the area to the performance of critical tasks; use available respiratory protection (if airborne contamination is suspected); take action to prevent inadvertent ingestion; change clothing and wash, especially hands, face and hair, as soon as possible; get monitored if needed. As soon as possible the doses received by emergency workers should be monitored and controlled in accordance with international standards by the radiological assessor at the scene.

Public

VII.3. Within the inner cordoned area (inside the safety perimeter; see Appendix II): evacuate (or use substantial sheltering) as directed by the authorities; avoid possibly contaminated smoke or dust; do not eat potentially contaminated food until it has been monitored; do not eat or smoke or place hands on or in the mouth to avoid inadvertent ingestion, and change clothing and wash, especially hands, face and hair, as soon as possible; get monitored as directed by the authorities.

VII.4. If a major airborne release is suspected, people within about 1 km of the site of the emergency should be advised:

— To remain indoors during the release;
— Not to consume any food or water that may have been contaminated (e.g. vegetables grown locally or rainwater) until informed of its safety;

— To ensure that children do not play on the ground;
— To wash hands before eating, drinking or smoking until food has been monitored (after which the results will be announced);
— To avoid dusty areas or activities that will raise dust.

VII.5. The public should also be advised of what to do if they are concerned that they may have been contaminated and of where to get additional information (it should be ensured that any advice will not interfere with the immediate response).

VII.6. For other response actions that should be taken during a radiological emergency, see Appendix 7 of Ref. [3].

FACILITIES IN THREAT CATEGORIES I AND II

VII.7. Urgent protective actions for facilities in threat categories I and II are shown in Table 13.

TABLE 13. URGENT PROTECTIVE ACTIONS FOR THREAT CATEGORY I AND II FACILITIES

Threat category	Suggested protective action
I	General emergency: — Promptly evacuate or provide special sheltering[a] for the public and non-essential workers on the site; — Promptly evacuate or provide substantial sheltering[b] for the public in the PAZ (in all directions); — For an emergency involving a nuclear reactor, provide stable iodine for thyroid blocking within the PAZ and UPZ; — Recommend to the public within the UPZ that they remain indoors and listen to the radio or television for further instructions (in-place sheltering); — Promptly conduct monitoring within the UPZ (including the shelters in the PAZ) to determine where OILs could be exceeded and to evacuate if appropriate; — Restrict consumption of possibly contaminated food or water and provide instructions to protect food and water supplies and agricultural products; — Restrict access to the evacuated area and areas where sheltering is recommended; — Monitor the people evacuated and determine whether decontamination or medical treatment is needed.
II	General emergency: — Recommend to the public within the UPZ that they remain indoors and listen to the radio or television for further instructions; — Promptly conduct monitoring of the UPZ to determine where OILs could be exceeded and to evacuate if appropriate; — Restrict consumption of possibly contaminated food or water and provide instructions to protect food and water supplies and agriculture products; — Restrict access to the evacuated area and areas where sheltering is recommended; — Monitor the people evacuated and determine whether decontamination or medical treatment is needed.
I & II	Site area emergency: — Provide instructions to protect water supplies and agricultural products.

[a] Special shelters are designed to provide protection against dose due to inhalation and radiation shine (shielding and filtering); see Table 11.

[b] Substantial sheltering is provided by large multistorey structures without any special features; see Table 11.

Appendix VIII

EMERGENCY FACILITIES AND LOCATIONS

VIII.1. There are two different types of emergency related facilities or locations: those established in advance and those established at the time of the emergency. In both cases the functions of and operational conditions and requirements for the facilities or locations should be carefully considered, and necessary advance preparations should be made. Facilities or locations established in advance (e.g. the technical support centre for a nuclear power plant) are designed, built and equipped to support their functional and operational requirements. If the facility or location is to be established at the time of an emergency, advance preparations should be made to find a suitable location and to establish the centre rapidly under field conditions. These preparations would include: developing site selection criteria; assigning the responsibility for acquiring a site during an emergency; and also, having procured and prepared in advance equipment (e.g. generators), supplies and other items needed to establish the centre in the field, establishing a team for setting up the centre. Establishing such a centre under field conditions should be exercised.

VIII.2. Each emergency facility or location should be:

— Designed to support the functions that take place within it;
— Usable under emergency conditions;
— Integrated into the incident command system.

VIII.3. The steps in developing an adequate facility or a capability to establish a centre are as follows:

(1) Determine the functions of the facility;
(2) Determine the relationship of the facility to other facilities, areas or functions in the response system;
(3) Determine the operational conditions under which the facility must function (e.g. environmental and radiological conditions);
(4) Establish a design team;
(5) Analyse the organization of the facility or area;
(6) Assess the flows (e.g. of people, information, samples) associated with each position within the organization;
(7) Determine the workstation requirements for each position;

(8) Determine the needs for space, light and power and other environmental needs for each position, including food and water supplies and sanitary and sleeping arrangements;
(9) Determine the possible radiological and environmental conditions during operation;
(10) Develop a conceptual design;
(11) Develop and test a prototype.

VIII.4. The facilities and locations recommended for each threat category are listed in Table 14 and described in Table 15.

TABLE 14. RECOMMENDED EMERGENCY FACILITIES AND LOCATIONS

Facility or location	Threat category				
	I	II	III	IV	V
Assembly point	✓	✓	✓		
Assistance centres[a,b]	✓	✓	✓	✓	✓
Control room[c]	✓	✓	✓		
Designated hospital[d]	✓	✓	✓	✓	
Emergency operations facility[c]	✓	✓			
Facility medical service	✓	✓			
Incident command post[e]	✓	✓[a]	✓[a]	✓[a]	✓[f]
Laboratory	✓	✓			
Notification point	✓	✓	✓	✓	
Operational support centre	✓				
Public information centre	✓	✓[a]	✓[a]	✓[a,b]	✓[b,f]
Radiological monitoring and assessment centre	✓	✓	✓[b]	✓[b]	✓[f]
Referral hospital[g]	✓	✓	✓	✓	✓
Reception centres	✓	✓	✓	✓	✓
Response organization emergency operations centres	✓	✓	✓	✓	✓
Staging area	✓	✓	✓	✓	
Technical support centre	✓				
Triage area[a]	✓	✓	✓	✓	
Warning point				✓	

[a] The location will be determined at the time of the event.
[b] If needed.
[c] A backup emergency operations facility should be provided at a different location for use if the primary facility is unusable. The backup emergency operations facility can be located in an existing facility and may be provided with only minimum capabilities.
[d] This will be a designated hospital near each facility in category I, II or III. A single hospital would be sufficient in a State without any facilities in category I, II or III.
[e] The incident command post may be located in an existing facility (e.g. in the emergency operations centre).
[f] A single national facility would probably be established for an emergency involving major contamination.
[g] A referral hospital could be a single highly specialized hospital in or outside the State.

TABLE 15. DESCRIPTIONS OF RECOMMENDED EMERGENCY FACILITIES AND LOCATIONS

Facility/ location	Functions	Characteristics
Assembly points	Locations where non-essential personnel at the facility are assembled, accounted for and sheltered or evacuated.	Areas (one or more) within the facility security boundary with sufficient room for on-site non-essential (non-response) staff (including construction workers or other non-permanent personnel). Easily accessible, provides some protection against a release or exposure, and is continuously monitored. Activation time: within 15 minutes of the declaration of an emergency.
Assistance centres (e.g. reception or relocation centres)	For providing members of the public with financial and other assistance during and after an emergency.	Locations determined at the time of an emergency; easily accessible to the affected public.
Control room	For operational control of the facility, detection and classification of the emergency, and activation of the response organization. Non-operational functions should be transferred to other facilities as soon as possible.	Access to data needed to detect and classify an emergency and to implement mitigatory actions; provided with sufficient protection to remain habitable[a] during major emergencies; provided with continuous monitoring of radiation levels; and provided with security to prevent unauthorized access.
Designated hospital	For providing treatment to individuals exposed and/or contaminated as a result of a nuclear or radiological emergency at the facility.	Provision — made in advance — for treating contaminated/exposed personnel from the threat category I, II or III facility, including provisions for contamination control and access to qualified personnel.

TABLE 15. DESCRIPTIONS OF RECOMMENDED EMERGENCY FACILITIES AND LOCATIONS (cont.)

Facility/ location	Functions	Characteristics
Emergency operations facility	Coordination of the on-site and off-site response to an emergency warranting off-site protective actions. Typically staffed by the director of the on-site response, the director of the off-site response and the incident commander. When the incident commander is present, this becomes the incident command post.	Access to the information required to coordinate on-site and off-site response decisions; reliable communications with on-site and off-site response centres and organizations; continuous monitoring of radiation levels; security to prevent unauthorized access. If located within the UPZ, it should be provided with sufficient protection to remain habitable[a] during an emergency or provided with a backup. Activation time: within 1 hour of declaration of a site area or general emergency.
Facility medical service	For providing contaminated workers and members of the public (if applicable) with first aid at the facility and preparing them to be taken to the designated hospital.	Available 24 hours a day. Only first aid and minimal provisions to prepare contaminated persons for transport (e.g. blankets).
Incident command post	Location of the incident commander and other members of the unified command and support staff.	Could be located in another emergency facility (e.g. emergency operations facility or emergency operations centre). For facilities in threat category I or II it will most probably be located within the emergency operations facility. For other emergencies it will most probably be located in an area that is secure, safe and convenient for directing operations. Activation time: within 1 hour of declaration of an emergency.

TABLE 15. DESCRIPTIONS OF RECOMMENDED EMERGENCY FACILITIES AND LOCATIONS (cont.)

Facility/ location	Functions	Characteristics
Laboratory (backup)	Analysis of radioactive samples from the facility, environmental samples and bioassay samples or reading of thermoluminescence dosimetry (TLD) badges.	Should be in a secure location and not within the PAZ or UPZ.
Notification point	The facility where notification of an actual or potential nuclear or radiological emergency is received and from which the appropriate off-site response is initiated.	Should be continuously operational (24 hours a day, 7 days a week) and in a secure location, and should have a redundant power supply and secure communications. This should be the facility used to receive notification of and initiate the off-site response to conventional emergencies (e.g. fires). If located within the emergency zones, it should be habitable during an emergency at the associated threat category I or II facility.
Operational support centre	Operational control of personnel performing tasks within the facility (e.g. environmental monitoring, health physics, damage control and firefighting) and providing health physics support for personnel responding from off the site.	Within the facility security boundary; secure and reliable communications with the control room, with teams in the facility and with off-site responders (e.g. fire services); with sufficient room to assemble, equip and prepare teams; continuous monitoring of radiation levels; in a location that will probably remain habitable under emergency conditions; ready access to equipment, instruments and protective clothing needed by response teams. Activation time: within 30 minutes of declaration of an emergency.

TABLE 15. DESCRIPTIONS OF RECOMMENDED EMERGENCY FACILITIES AND LOCATIONS (cont.)

Facility/ location	Functions	Characteristics
Public information centre	Coordination of all information released to the news media concerning the emergency by the facility, local governments and national governments. Staffed by representatives of all these organizations.	Located in the vicinity of the site of the emergency with space and infrastructure to support use by the news media and for conducting media briefings. For facilities in threat category I, it is a predesignated facility outside the UPZ. Activation time: within 4 hours of the declaration of an emergency requiring use of the facility.
Radiological monitoring and assessment centre	Coordination of the radiological monitoring, sampling and assessment provided by all response organizations (facility, local governments, national governments).	Location to be determined at the time of the emergency on the basis of radiological and operational considerations. Activation time: within 24 hours of the declaration of an emergency requiring use of the facility.
Referral hospital	Provides highly specialized treatment to exposed and/or contaminated individuals as well as for persons with combined injuries as a result of the nuclear or radiological emergency.	Hospital that specializes in the treatment (haematology, surgery) of radiation induced injuries. If there is no such hospital in the State, national arrangements should be put in place to request treatment at such a facility through the IAEA or the WHO under the Assistance Convention.
Reception centres	Locations for the initial reception, monitoring, decontamination and registration of evacuated members of the public. Provides or arranges for humanitarian support (e.g. food, housing).	Located in an existing facility (e.g. a school). For facilities in threat category I and II, it should be beyond the UPZ boundary.

TABLE 15. DESCRIPTIONS OF RECOMMENDED EMERGENCY FACILITIES AND LOCATIONS (cont.)

Facility/ location	Functions	Characteristics
Response organization emergency operations centres	Facilities established by various response organizations from which the organization's support for the response will be directed. An emergency operations centre should be established by the regulatory body, ministries with responsibility for radiological or conventional response, local governments, corporate headquarters for the facility, national laboratories with expertise and the response organization for radiological assessment.	Provision for effective coordination with the response of the incident command system.
Staging areas	Locations used to collect and organize additional resources as they arrive in the vicinity of the emergency.	Locations identified at the time of an emergency. Should be in a location that will remain habitable, will not interfere with other ongoing response actions and can be secured.
Technical support centre	Technical support for the control room operators in mitigating the consequences of the emergency.	Secure and reliable communications with the control room and outside sources of technical support; access to plant data, information and tools needed to develop strategies for dealing with major emergencies. If located at the facility, it should be protected to allow operation under major emergency conditions. Activation time: within one hour of the declaration of an emergency.
Triage area	Field location where medical and radiological triage is performed, first aid is provided and affected persons are prepared for being taken to hospital.	Location identified at the time of an emergency. Should be a safe and secure location near the scene with access for medical transport.

TABLE 15. DESCRIPTIONS OF RECOMMENDED EMERGENCY FACILITIES AND LOCATIONS (cont.)

Facility/ location	Functions	Characteristics
Warning point	The facility that is set up to receive alerts at all times and to promptly respond to incoming notifications, warning messages, requests for assistance or requests for verification of a message from the IAEA. The facility through which the competent authority is contacted by the IAEA.	Continuously operational (24 hours a day, 7 days a week), in a secure location, with redundant power, secure communications and prompt access to speakers of English. The fax machines and other means used to receive notifications from the IAEA should be continuously operational and frequently monitored.

[a] This should include provisions to monitor and control radiological exposures and contamination, to control other hazards (e.g. heat, air quality) and to meet human needs (e.g. with food, water and sanitary and sleeping arrangements) if the facility may be isolated for an extended period during an emergency.

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Annex

SUPPORTING INFORMATION FOR ZONE SIZES IN APPENDIX II

REACTOR

A–1. For research reactors, owing to the wide variations in their design and operation, a facility specific analysis should be performed to determine whether sufficient inventory and energy could be contained in the reactor to result in a significant airborne release off the site in an accident. The methods described in Ref. [A–1] could be used.

A–2. For facilities in threat category I, calculations [A–2, A–3] were performed on the assumption of core melt and early containment failure.

A–3. For reactors with power levels less than 100 MW(th), calculations on the assumption of average meteorological conditions do not project doses that would lead to any early deaths off the site (>250 m), and thus these reactors fall into threat category II. The calculations were performed by using Refs [A–2, A–3].

A–4. For threat category II, it was assumed the reactor has been operating at this power level sufficiently long to build up the ^{131}I inventory close to 10 PBq/MW(th) [A–2, A–3].

A–5. Severe core damage and therefore a major off-site release is not considered credible for reactors with power levels below 2 MW(th), and thus these reactors fall into threat category III.

SPENT FUEL

A–6. Calculations [A–2, A–3] indicate that people off the site could suffer severe deterministic effects owing to a release resulting from a Zircaloy® fire (an exothermic Zr + H_2O reaction) in a large amount of spent reactor fuel. Such a reaction might be possible in densely stored fuel that has been discharged from a reactor core in the past year. Zircaloy® fires are unlikely unless the fuel in the pool is substantially uncovered [A–4].

A–7. Calculations [A–2 to A–4] indicate that doses warranting urgent intervention off the site might be possible if a large amount of spent reactor fuel reaches temperatures in excess of 1000°C, resulting in failure of the fuel cladding. Such temperatures are possible only if fuel that is being actively cooled in a pool becomes totally uncovered [A–4].

CRITICALITY

A–8. Calculations [A–2, A–5] show that a criticality farther than about 500 m from the site boundary will not cause shine doses (i.e. doses due to gamma plus neutron radiation) off the site that exceed the recommended GILs for urgent protective actions (i.e. 10 mSv [A–6]). These calculations assume that there is no shielding and a criticality resulting in 1×10^{18} fissions initially, resulting in an effective dose rate from shine (i.e. due to gamma plus neutron radiation) of 1 mGy/h at 0.3 km. It is also assumed that the criticality will continue until there are about 1×10^{19} fissions, resulting in a total off-site dose of 10 mSv. A criticality cannot produce sufficient fission products to result in a significant airborne release. However, the thermal energy (heat) from a criticality may be sufficient to result in a release of radioactive or other hazardous material already present in the vicinity of the criticality (e.g. in the process stream).

REFERENCES TO THE ANNEX

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GLOSSARY

accident. Any unintended event, including operating errors, equipment failures or other mishaps, the consequences or potential consequences of which are not negligible from the point of view of protection or safety.

arrangements (for emergency response). The integrated set of infrastructural elements necessary to provide the capability for performing a specified function or task required in response to a nuclear or radiological emergency. These elements may include authorities and responsibilities, organization, coordination, personnel, plans, procedures, facilities, equipment or training.

avertable dose. The dose that could be averted if a countermeasure or set of countermeasures were to be applied.

collective dose. The total radiation dose incurred by a population.

dangerous source. A source that could, if not under control, give rise to exposure sufficient to cause severe deterministic effects. This categorization is used for determining the need for emergency response arrangements and is not to be confused with categorizations of sources for other purposes.

deterministic effect. A health effect of radiation for which generally a threshold level of dose exists above which the severity of the effect is greater for a higher dose. Such an effect is described as a 'severe deterministic effect' if it is fatal or life threatening or results in a permanent injury that reduces quality of life.

emergency. A non-routine situation or event that necessitates prompt action, primarily to mitigate a hazard or adverse consequences for human health and safety, quality of life, property or the environment. This includes nuclear and radiological emergencies and conventional emergencies such as fires, release of hazardous chemicals, storms or earthquakes. It includes situations for which prompt action is warranted to mitigate the effects of a perceived hazard.

emergency action level (EAL). A specific, predetermined, observable criterion used to detect, recognize and determine the emergency class.

emergency class. A set of conditions that warrant a similar immediate emergency response. This is the term used for communicating to the response organizations and the public the level of response needed. The events that belong to a given emergency class are defined by criteria specific to the installation, source or practice, which if exceeded indicate classification at the prescribed level. For each emergency class, the initial actions of the response organizations are predefined.

emergency classification. The process whereby an authorized official classifies an emergency in order to declare the applicable emergency class. Upon declaration of the emergency class the response organizations initiate the predefined response actions for that emergency class.

emergency phase. The period of time from the detection of conditions warranting an emergency response until the completion of all the actions taken in anticipation of or in response to the radiological conditions expected in the first few months of the emergency. This phase typically ends when the situation is under control, the off-site radiological conditions have been characterized sufficiently well to identify where food restrictions and temporary relocation are required, and all required food restrictions and temporary relocations have been implemented.

emergency plan. A description of the objectives, policy and concept of operations for the response to an emergency and of the structure, authorities and responsibilities for a systematic, coordinated and effective response. The emergency plan serves as the basis for the development of other plans, procedures and checklists.

emergency preparedness. The capability to take actions that will effectively mitigate the consequences of an emergency for human health and safety, quality of life, property and the environment.

emergency procedures. A set of instructions describing in detail the actions to be taken by response personnel in an emergency.

emergency response. The performance of actions to mitigate the consequences of an emergency for human health and safety, quality of life, property and the environment. It may also provide a basis for the resumption of normal social and economic activity.

emergency services. The local off-site response organizations that are generally available and that perform emergency response functions. These may include police, firefighters and rescue brigades, ambulance services and control teams for hazardous materials.

emergency worker. A worker who may be exposed in excess of occupational dose limits while performing actions to mitigate the consequences of an emergency for human health and safety, quality of life, property and the environment.

emergency zones. The precautionary action zone and/or the urgent protective action planning zone.

exposure. The act or condition of being subject to irradiation. Exposure can be either external exposure (due to a source outside the body) or internal exposure (due to a source within the body).

first responders. The first members of an emergency service to respond at the scene of an emergency.

incident. Any unintended event, including operation errors, equipment failures, initiating events, accident precursors, near misses or other mishaps, or unauthorized act, malicious or non-malicious, the consequences or potential consequences of which are not negligible from the point of view of protection or safety.

initial phase. The period of time from the detection of conditions that warrant the performance of response actions that must be taken promptly in order to be effective until those actions have been completed. These actions include mitigatory actions by the operator and urgent protective actions on and off the site.

intervention. Any action intended to reduce or avert exposure or the likelihood of exposure to sources that are not part of a controlled practice or that are out of control as a consequence of an accident.

intervention level. The level of avertable dose at which a specific protective action is taken in an emergency or a situation of chronic exposure.

longer term protective action. A protective action that is not an urgent protective action. Such protective actions are likely to be prolonged over weeks, months or years. These include measures such as relocation, agricultural countermeasures and remedial actions.

mitigatory action. Immediate action by the operator or other party:

(1) To reduce the potential for conditions to develop that would result in exposure or a release of radioactive material requiring emergency actions on or off the site; or
(2) To mitigate source conditions that may result in exposure or a release of radioactive material requiring emergency actions on or off the site.

notification.

(1) A document submitted to the regulatory body by a legal person to notify an intention to carry out a practice or other use of a source;
(2) A report submitted promptly to a national or international authority providing details of an emergency or a possible emergency, for example as required by the Convention on Early Notification of a Nuclear Accident;
(3) A set of actions taken upon detection of emergency conditions with the purpose of alerting all organizations with responsibility for emergency response in the event of such conditions.

notification point. A designated organization with which arrangements have been made to receive notification (meaning (3)) and to initiate promptly the predetermined actions to activate a part of the emergency response.

notifying State. The State that is responsible for notifying (meaning (1)) potentially affected States and the IAEA of an event or situation of actual, potential or perceived radiological significance for other States. This includes:

— The State Party that has jurisdiction or control over the facility or activity (including space objects) in accordance with Article 1 of the Convention on Early Notification of a Nuclear Accident; or
— The State that initially detects, or discovers evidence of, a transnational emergency, for example by detecting significant increases in atmospheric radiation levels of unknown origin; detecting contamination in transboundary shipments; discovering a dangerous source that may have originated in another State; or diagnosing medical symptoms that may have resulted from exposure outside the State.

nuclear or radiological emergency. An emergency in which there is, or is perceived to be, a hazard due to:

(a) the energy resulting from a nuclear chain reaction or from the decay of the products of a chain reaction; or
(b) radiation exposure.

off-site. Outside the site area.

on-site. Within the site area.

operational intervention level (OIL). A calculated level, measured by instruments or determined by laboratory analysis, that corresponds to an intervention level or action level. OILs are typically expressed in terms of dose rates or of activity of radioactive material released, time integrated air concentrations, ground or surface concentrations, or activity concentrations of radionuclides in environmental, food or water samples. An OIL is a type of action level that is used immediately and directly (without further assessment) to determine the appropriate protective actions on the basis of an environmental measurement.

operator (or operating organization). Any organization or person applying for authorization or authorized and/or responsible for nuclear, radiation, radioactive waste or transport safety when undertaking activities or in relation to any nuclear facilities or sources of ionizing radiation. This includes private individuals, governmental bodies, consignors or carriers, licensees, hospitals, self-employed persons, etc. Operator includes either those who are directly in control of a facility or an activity during use of a source (such as radiographers or carriers) or, in the case of a source not under control (such as a lost or illicitly removed source or a re-entering satellite), those who were responsible for the source before control over it was lost.

practice. Any human activity that introduces additional sources of exposure or exposure pathways or extends exposure to additional people or modifies the network of exposure pathways from existing sources, so as to increase the exposure or the likelihood of exposure of people or the number of people exposed.

precautionary action zone. An area around a facility for which arrangements have been made to take urgent protective actions in the event of a nuclear or radiological emergency to reduce the risk of severe deterministic effects off the site. Protective actions within this area are to be taken before or shortly after a release of radioactive material or an exposure on the basis of the prevailing conditions at the facility.

protective action. An intervention intended to avoid or reduce doses to members of the public in emergencies or situations of chronic exposure.

radiation protection officer. A person technically competent in radiation protection matters relevant for a given type of practice who is designated by the registrant or licensee to oversee the application of relevant requirements established in international safety standards.

radiation specialist. A person trained in radiation protection and other areas of specialization necessary in order to be able to assess radiological conditions, to mitigate radiological consequences or to control doses to responders.

radiological assessor. A person who in the event of a nuclear or radiological emergency assists the operator of a dangerous source by performing radiation surveys, performing dose assessments, controlling contamination, ensuring the radiation protection of emergency workers and formulating recommendations on protective actions. The radiological assessor would generally be the radiation protection officer.

regulatory body. An authority or a system of authorities designated by the government of a State as having legal authority for conducting the regulatory process, including issuing authorizations, and thereby regulating nuclear, radiation, radioactive waste and transport safety.

response organization. An organization designated or otherwise recognized by a State as being responsible for managing or implementing any aspect of an emergency response.

significant transboundary release. A release of radioactive material to the environment that may result in doses or levels of contamination beyond national borders from the release which exceed international intervention levels or action levels for protective actions, including food restrictions and restrictions on commerce.

site area. A geographical area that contains an authorized facility, activity or source, and within which the management of the authorized facility or activity may directly initiate emergency actions. This is typically the area within the security perimeter fence or other designated property marker. It may also be the controlled area around a radiography source or a cordoned off area established by first responders around a suspected hazard.

source. Anything that may cause radiation exposure — such as by emitting ionizing radiation or by releasing radioactive substances or materials — and can be treated as a single entity for protection and safety purposes. For example, materials emitting radon are sources in the environment; a sterilization gamma irradiation unit is a source for the practice of radiation preservation of food; an X ray unit may be a source for the practice of radiodiagnosis; a nuclear power plant is part of the practice of generating electricity by nuclear fission, and may be regarded as a source (e.g. with respect to discharges to the environment) or as a collection of sources (e.g. for occupational radiation protection purposes). A complex or multiple installation situated at one location or site may, as appropriate, be considered a single source for the purposes of application of international safety standards.

special facility. A facility for which predetermined facility specific actions need to be taken if urgent protective actions are ordered in its locality in the event of a nuclear or radiological emergency. Examples include chemical plants that cannot be evacuated until certain actions have been taken to prevent fire or explosions and telecommunications centres that must be staffed in order to maintain telephone services.

special population groups. Members of the public for whom special arrangements are necessary in order for effective protective actions to be taken in the event of a nuclear or radiological emergency. Examples include disabled persons, hospital patients and prisoners.

stochastic effect (of radiation). A radiation induced health effect, the probability of occurrence of which is greater for a higher radiation dose and the severity of which (if it occurs) is independent of dose. Stochastic effects may be somatic effects or hereditary effects, and generally occur without a threshold level of dose. Examples include various forms of cancer and leukaemia.

threat assessment. The process of analysing systematically the hazards associated with facilities, activities or sources within or beyond the borders of a State in order to identify:

(a) Those events and the associated areas for which protective actions may be required within the State;
(b) The actions that would be effective in mitigating the consequences of such events.

transnational emergency. A nuclear or radiological emergency of actual, potential or perceived radiological significance for more than one State. This includes:

(1) A significant transboundary release of radioactive material (however, a transnational emergency does not necessarily imply a significant transboundary release of radioactive material);
(2) A general emergency at a facility or other event that could result in a significant transboundary release (atmospheric or aquatic) of radioactive material;
(3) Discovery of the loss or illicit removal of a dangerous source that has been transported across or is suspected of having been transported across a national border;
(4) An emergency resulting in significant disruption to international trade or travel;
(5) An emergency warranting the taking of protective actions for foreign nationals or embassies in the State in which it occurs;
(6) An emergency resulting in or potentially resulting in severe deterministic effects and involving a fault and/or problem (such as in equipment or software) that could have implications for safety internationally;
(7) An emergency resulting in or potentially resulting in great concern among the population of more than one State owing to the actual or perceived radiological hazard.

urgent protective action. A protective action in the event of an emergency which must be taken promptly (normally within hours) in order to be effective, and the effectiveness of which will be markedly reduced if it is delayed. The most commonly considered urgent protective actions in a nuclear or radiological emergency are evacuation, decontamination of individuals, sheltering, respiratory protection, iodine prophylaxis and restriction of the consumption of potentially contaminated foodstuffs.

urgent protective action planning zone. An area around a facility for which arrangements have been made to take urgent protective actions in the event of a nuclear or radiological emergency to avert doses off the site in accordance with international safety standards. Protective actions within this area are to be taken on the basis of environmental monitoring or, as appropriate, prevailing conditions at the facility.

warning point. A contact point that is staffed or able to be alerted at all times for promptly responding to, or initiating a response to, an incoming notification (meaning (2)), warning message, request for assistance or request for verification of a message, as appropriate, from the IAEA.

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