EPR-RESEARCH REACTOR

2011

EMERGENCY PREPAREDNESS AND RESPONSE

Generic Procedures for Response to a Nuclear or Radiological Emergency at Research Reactors

PUBLICATION DATE: SEPTEMBER 2011

IAEA
International Atomic Energy Agency

IAEA SAFETY STANDARDS AND RELATED PUBLICATIONS

IAEA SAFETY STANDARDS

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

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

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

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

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

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

RELATED PUBLICATIONS

The IAEA provides for the application of the standards and, under the terms of Articles III and VIII.C of its Statute, makes available and fosters the exchange of information relating to peaceful nuclear activities and serves as an intermediary among its Member States for this purpose.

Reports on safety and protection in nuclear activities are issued as **Safety Reports**, which provide practical examples and detailed methods that can be used in support of the safety standards.

Other safety related IAEA publications are issued as **Radiological Assessment Reports**, the International Nuclear Safety Group's **INSAG Reports**, **Technical Reports** and **TECDOCs**. The IAEA also issues reports on radiological accidents, training manuals and practical manuals, and other special safety related publications.

Security related publications are issued in the **IAEA Nuclear Security Series**.

The **IAEA Nuclear Energy Series** consists of reports designed to encourage and assist research on, and development and practical application of, nuclear energy for peaceful uses. The information is presented in guides, reports on the status of technology and advances, and best practices for peaceful uses of nuclear energy. The series complements the IAEA's safety standards, and provides detailed guidance, experience, good practices and examples in the areas of nuclear power, the nuclear fuel cycle, radioactive waste management and decommissioning.

Generic Procedures for Response to a Nuclear or Radiological Emergency at Research Reactors

The following States are Members of the International Atomic Energy Agency:

AFGHANISTAN
ALBANIA
ALGERIA
ANGOLA
ARGENTINA
ARMENIA
AUSTRALIA
AUSTRIA
AZERBAIJAN
BAHRAIN
BANGLADESH
BELARUS
BELGIUM
BELIZE
BENIN
BOLIVIA
BOSNIA AND HERZEGOVINA
BOTSWANA
BRAZIL
BULGARIA
BURKINA FASO
BURUNDI
CAMBODIA
CAMEROON
CANADA
CENTRAL AFRICAN REPUBLIC
CHAD
CHILE
CHINA
COLOMBIA
CONGO
COSTA RICA
CÔTE D'IVOIRE
CROATIA
CUBA
CYPRUS
CZECH REPUBLIC
DEMOCRATIC REPUBLIC OF THE CONGO
DENMARK
DOMINICAN REPUBLIC
ECUADOR
EGYPT
EL SALVADOR
ERITREA
ESTONIA
ETHIOPIA
FINLAND
FRANCE
GABON
GEORGIA
GERMANY
GHANA
GREECE
GUATEMALA
HAITI
HOLY SEE
HONDURAS
HUNGARY
ICELAND
INDIA
INDONESIA
IRAN, ISLAMIC REPUBLIC OF
IRAQ
IRELAND
ISRAEL
ITALY
JAMAICA
JAPAN
JORDAN
KAZAKHSTAN
KENYA
KOREA, REPUBLIC OF
KUWAIT
KYRGYZSTAN
LATVIA
LEBANON
LESOTHO
LIBERIA
LIBYAN ARAB JAMAHIRIYA
LIECHTENSTEIN
LITHUANIA
LUXEMBOURG
MADAGASCAR
MALAWI
MALAYSIA
MALI
MALTA
MARSHALL ISLANDS
MAURITANIA
MAURITIUS
MEXICO
MONACO
MONGOLIA
MONTENEGRO
MOROCCO
MOZAMBIQUE
MYANMAR
NAMIBIA
NEPAL
NETHERLANDS
NEW ZEALAND
NICARAGUA
NIGER
NIGERIA
NORWAY
OMAN
PAKISTAN
PALAU
PANAMA
PARAGUAY
PERU
PHILIPPINES
POLAND
PORTUGAL
QATAR
REPUBLIC OF MOLDOVA
ROMANIA
RUSSIAN FEDERATION
SAUDI ARABIA
SENEGAL
SERBIA
SEYCHELLES
SIERRA LEONE
SINGAPORE
SLOVAKIA
SLOVENIA
SOUTH AFRICA
SPAIN
SRI LANKA
SUDAN
SWEDEN
SWITZERLAND
SYRIAN ARAB REPUBLIC
TAJIKISTAN
THAILAND
THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA
TUNISIA
TURKEY
UGANDA
UKRAINE
UNITED ARAB EMIRATES
UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND
UNITED REPUBLIC OF TANZANIA
UNITED STATES OF AMERICA
URUGUAY
UZBEKISTAN
VENEZUELA
VIETNAM
YEMEN
ZAMBIA
ZIMBABWE

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''.

EPR-
RESEARCH
REACTOR
2011

Emergency Preparedness
and Response

Generic Procedures for Response to a Nuclear or Radiological Emergency at Research Reactors

IAEA
International Atomic Energy Agency

For further information on this publication, please contact:

Incident and Emergency Centre
Department of Nuclear Safety and Security
International Atomic Energy Agency
Vienna International Centre
PO Box 100
1400 Vienna, Austria
email: official.mail@iaea.org

GENERIC PROCEDURES FOR RESPONSE TO A
NUCLEAR OR RADIOLOGICAL EMERGENCY
AT RESEARCH REACTORS
IAEA, VIENNA, 2011
IAEA-EPR

Printed by the IAEA in Austria
September 2011

FOREWORD

Under Article 5.a(ii) of the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (Assistance Convention), one function of the IAEA is to collect and disseminate to States Parties and Member States information concerning methodologies, techniques and results of research relating to response to nuclear or radiological emergencies. The IAEA publishes the Emergency Preparedness and Response Series to fulfil that function. This publication is part of that series.

IAEA Safety Standards Series No. GS-R-2 Preparedness and Response for a Nuclear or Radiological Emergency, contains the following requirement: "To ensure that arrangements are in place for a timely, managed, controlled, coordinated and effective response at the scene…".

The IAEA General Conference, in resolution GC(53)/RES/10, continues to encourage Member States "…to enhance, where necessary, their own preparedness and response capabilities for nuclear and radiological incidents and emergencies, by improving capabilities to prevent accidents, to respond to emergencies and to mitigate any harmful consequences…".

This publication is intended to assist Member States meet the requirements of GS-R-2 and enhance their preparedness by providing guidance on the response by facility personnel to emergencies at research reactor facilities.

The IAEA officer responsible for this publication was G. Winters of the Department of Nuclear Safety and Security.

EDITORIAL NOTE

The use of particular designations of countries or territories does not imply any judgement by the publisher, the IAEA, as to the legal status of such countries or territories, of their authorities and institutions or of the delimitation of their boundaries.

The mention of names of specific companies or products (whether or not indicated as registered) does not imply any intention to infringe proprietary rights, nor should it be construed as an endorsement or recommendation on the part of the IAEA.

CONTENTS

1. **INTRODUCTION**

1.1. BACKGROUND

Under Article 5(a)(ii) of the Convention on Assistance in the Case of a Nuclear Emergency or Radiological Emergency, one function of the IAEA is to collect and disseminate information concerning nuclear and radiological emergency response methodologies, techniques and available results of research to States Parties and Member States relating to response to such emergencies. Several publications have been published with generic guidelines for response to radiation emergencies [1, 2, 3, 4].

The IAEA published guidance to provide Member States a set of emergency response procedures for nuclear power plants [1]. This publication provides guidance for development of emergency response procedures and implementation of an Emergency Plan at research reactors in Threat Categories[1] II and III. A research reactor in Threat Category III is not expected to create a situation where members of the public beyond the site boundary are threatened by any reactor emergency. Research reactors with power levels up to about 2 MW are usually in this category. Research reactors with higher power levels are in Threat Category II and may threaten the public beyond the site boundary during severe emergencies.[5] The difference in affected populations creates a difference in the response organization as well as a difference in the scope of the response actions that may be required.

Each research reactor operating organization should evaluate the consequences of reactor emergencies, including events with low probability [6] and determine the appropriate Threat Category for that reactor. The analyses performed for the reactor Safety Analysis Report [7] may already include the necessary work to determine if there is a risk to the off-site population and the extent of that risk in terms of potential radiation doses to members of the public and the distance from the reactor that could warrant implementation of urgent protective actions by members of the public. The guidance in this publication is expected to be suitable for research reactors with power levels from zero-power critical facilities to several tens of MW.

1.2. OBJECTIVE

The objectives of this publication are:

- To describe appropriate responses to a range of emergencies at Threat Category II and III research reactor sites;
- To describe the on-site organization needed to respond to these emergencies;
- To provide tools to organize the emergency response actions at these reactor sites;
- To provide procedures on how to determine the need for on-site and off-site protective actions.

---

[1] The term “threat category” is used here as described in Ref. [5] and only for the purposes of emergency preparedness and response; this usage does not imply that any threat, in the sense of an intention and capability to cause harm, has been made in relation to facilities, activities or sources.

1.3. SCOPE

The guidance in this publication concerns emergencies at research reactors in Threat Category II and III. Procedures are provided for the on-site response and, for Threat Category II only, the additional appropriate off-site response. This guidance is presented in two separate parts that follow this Introduction. Each part contains all the material for the response to emergencies at a research reactor in the applicable Threat Category.

This publication covers the determination of the appropriate emergency class and protective actions for a nuclear or radiological emergency at research reactors. It does not cover nuclear security at research reactors. The term “threat category” is used in this publication as described in Ref. [5] and for the purposes of emergency preparedness and response only; this usage does not imply that any threat, in the sense of an intention and capability to cause harm, has been made in relation to facilities, activities or sources. The threat category is determined by an analysis of potential nuclear and radiological emergencies and the associated radiation hazard that could arise as a consequence of those emergencies.

1.4. STRUCTURE

The publication consists of four parts. This section is an Introduction to the background, objective, scope and structure of the publication. Section 2, Overview, explains how the emergency response procedures are organized, the response team structure on which the guidelines are based, responsibilities of each response team member and information to assist developing site-specific procedures from the generic procedures provided here.

The remaining two parts are labelled Part 1 and Part 2. Each Part contains a complete set of generic emergency response procedures for Threat Category II research reactors and Threat Category III research reactors, respectively. Research reactors up to several tens of MW are covered by these generic emergency response procedures. Appendices with each Part provide supplementary information.

The emergency response procedures in each Part consist of Action Guides that are the generic emergency response procedures for the site emergency response team positions and Worksheets that may be used to assist information organization and recording during the response.

Emergency response information adapted to the TRIGA design and details of TRIGA fuel and potential releases from the fuel in reactor emergencies are provided in Ref. [8] for use with the emergency response procedures in Part 1 or Part 2.

The terms used in this publication are defined in Refs [9] and [10] and a List of Abbreviations is included before the References. Further, the terms “site” and “facility” are used interchangeably throughout the publication.

2. **OVERVIEW**

2.1. EMERGENCY RESPONSE PROCESS

An emergency at a research reactor initiates two different sets of actions. The reactor operating personnel react to the emergency by implementing the appropriate emergency operating procedures. These procedures are intended to return the reactor and the associated support systems to a safe and stable condition. Guidance for the emergency operating

procedures is provided in other publications, including some publications published by the IAEA such as Refs [7] and [11].

The emergency response actions are intended to prevent or mitigate radiological threats to individuals, both at the reactor site and beyond the site boundary. An Emergency Response Team at the reactor site has the responsibility to implement this emergency response process. The size of the Emergency Response Team needed to adequately manage the actions necessary to protect people from the radiological threat that occurs due to the emergency will depend on the size of the site, the reactor threat category and the number and location of people at risk from the emergency.

Research reactor sites may have more than one nuclear or radiological installation. In this publication, no distinction is made between the research reactor facility and the site on which the research reactor is located. Further, in this publication the words facility and site are used interchangeably. The procedures provided here may serve either a single research reactor or an entire site. The reactor operating organization may adapt these procedures to either situation. The individuals who are needed to fill the roles on the Emergency Response Team may come from the reactor staff or the overall site organization. Some sites may wish to implement these procedures at both organization levels, and coordinate the response actions.

Research reactor power level and operating schedule determines the reactor fission product inventory that could be released during an emergency. Most of the emergencies at research reactors create a risk to individuals due to the potential for fuel damage that could release the fuel fission products. Low power research reactors are less of a risk because the decay heat from fission products is unlikely to cause a gross failure of the fuel, and less severe fuel damage limits the amount of fission products released from the fuel. In cases where a threat assessment shows that no event, even those with low probability, creates a risk to people beyond the site boundary, then the research reactor is a Threat Category III facility. The Emergency Response Team for Threat Category III may be smaller due to the absence of need to protect people beyond the site boundary. Figure 1 shows an Emergency Response Team suitable for Threat Category III facilities. The procedures in Part 2 of this publication are based on this organization.

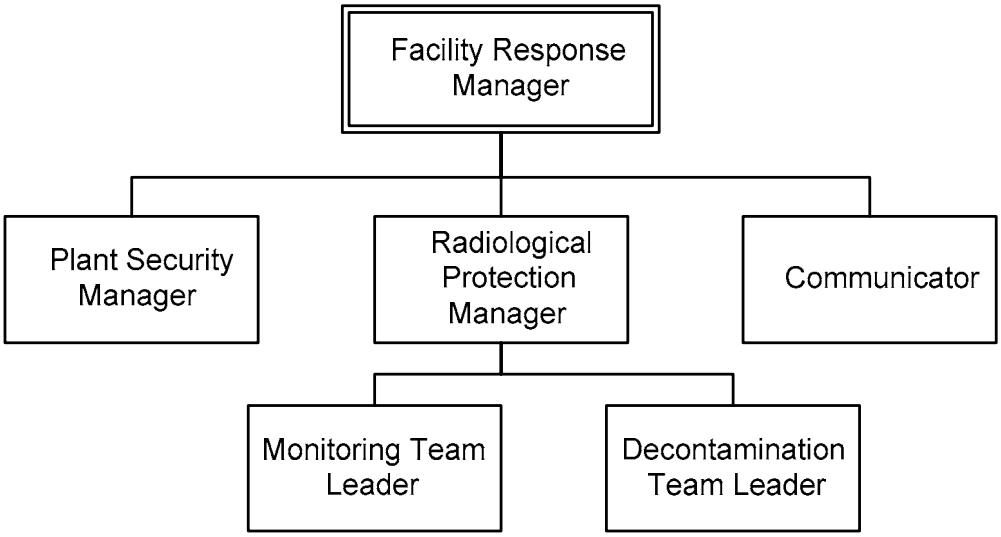


FIG. 1. Threat Category III Emergency Response Team.

Research reactors that can create a risk to off-site personnel are Threat Category II facilities and require additional positions on the Emergency Response Team to respond to the off-site

consequences. The organization in Figure 2 is intended to provide the necessary positions. Threat Category II research reactors often are located at sites with more resources and the larger Emergency Response Team can be accommodated.

There are multiple ways to organize an Emergency Response Team and the ones presented here may not fit the needs of every research reactor. Additional positions may be needed to accomplish tasks not directly associated with mitigating the radiological threat. Each site should determine a suitable organization and then modify the Action Guides depending upon the actions assigned to each individual role on the Emergency Response Team.

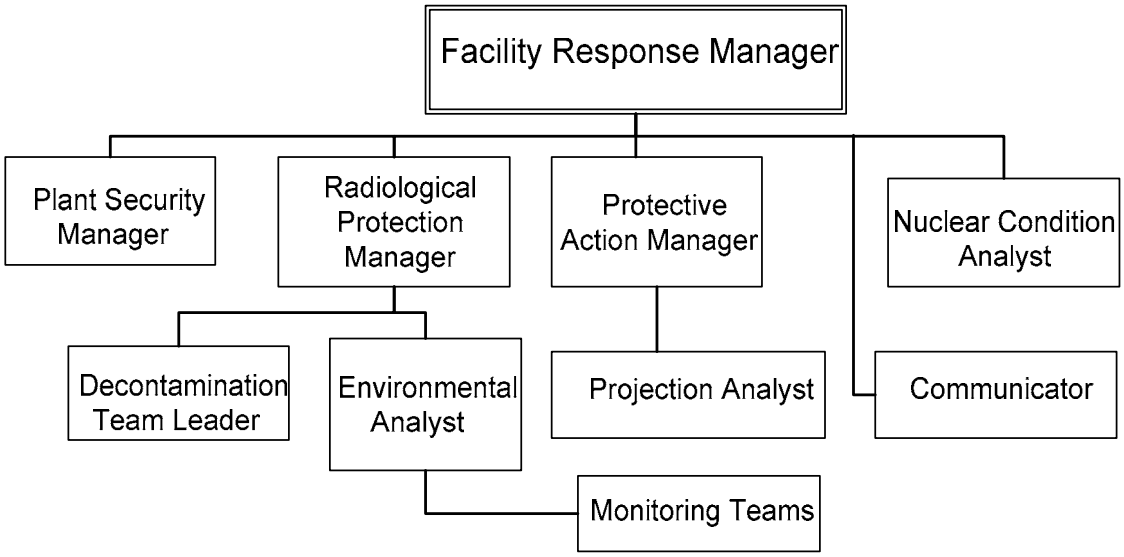


FIG. 2. Threat Category II Emergency Response Team.

The emergency response process may be viewed as consisting of three phases:

- Early Phase
  - To stabilize the reactor condition;
  - To rapidly assess the emergency and initiate actions to mitigate the consequences of the emergency;
  - To minimize radiation exposure to on-site personnel and arriving off-site responders;
- Middle Phase
  - To request the appropriate level of off-site assistance;
  - To determine the need for off-site protective action;
  - To keep the public informed; and
- Late Phase
  - To return the facility to a normal operating state.

The first step in the early phase is the responsibility of the reactor operating personnel with direction provided by reactor emergency operating procedures. The remaining steps are the responsibility of the Emergency Response Team with direction from emergency response procedures, such as those in this publication. A part of the late phase consists of recovery actions rather than emergency response actions. The transition from emergency response to recovery is an important step and one that must be planned. The Emergency Response Team and any organizations external to the site that were involved in the emergency response must

develop a set of conditions that need to be achieved to allow this transition to occur. Once the recovery response begins, it is assumed that some other organization, perhaps even the normal facility organization, is responsible for recovery actions, and the Emergency Response Team has completed its responsibilities.

2.2. EMERGENCY CLASS

An internationally recognized emergency classification system is used to classify an emergency depending on the severity level of the emergency and the response actions are initiated accordingly. Ref. [6] describes four classes for nuclear and radiological emergencies. The classes, in order of highest severity to lowest, are General Emergency, Site Area Emergency, Facility Emergency and Alert. Threat Category II research reactors can experience emergencies at any of these levels of severity. The classes of General Emergency and Site Area Emergency involve threats to people beyond the site boundary so Threat Category III facilities do not require those two classes.

A General Emergency should be declared if an actual release or substantial risk of a release is present and radiation exposure to members of the public could occur unless urgent protective action is implemented off-site. An event that includes significant fuel damage is one situation that may meet these conditions. Note that a release does not have to occur to declare a General Emergency. The presence of significant fuel damage may present enough of a substantial risk that a General Emergency should be declared.

When the event causes a major decrease in the level of protection for those on the site and the off-site population near the facility then the appropriate emergency class is Site Area Emergency. An example of the conditions for this emergency class is a risk that could, if the condition worsened, result in fuel damage or a condition where some minor fuel damage has already occurred.

Facility Emergency is an emergency class that does not pose a risk to the off-site population, but represents a major decrease in the level of protection for on-site personnel only and is not expected to evolve into a situation posing a threat off-site. On-site personnel are expected to have to implement urgent protective action to reduce the risk.

The least severe emergency class is an Alert. This class involves unknown or significant decrease in the level of protection for on-site personnel or the public.

The expectation for every emergency class is that an Emergency Response Team of positions described in Section 2.4 will be activated at a level appropriate to the emergency situation. The purpose of activating the Team is to relieve the operating staff of the dual duties of operating the reactor and fulfilling the roles on the Team as they must do initially. The replacement Team members allow the operating staff to give their undivided attention to mitigation of the consequences of the event in the reactor facility without distractions from off-site inquiries and other communications.

There are also emergencies that do not require an emergency response at even the level of an Alert because there is no or only an insignificant threat of radiological consequences from the event. The facility may initiate some protective measures and may require off-site assistance, but unless a radiological threat is present, the emergency response would not be expected to follow these response procedures.

The classification process involves judgement. These procedures are not a substitute for good judgement, but are intended to provide descriptive scenarios to allow much of that judgement to be provided in the form of written guidance, including:

- Symptoms defined by specific values of parameters observable by the operators,
- Operating status of reactor safety systems, or
- Conditions external to the facility.

This concept should be recognized during the preparation process of adapting these response procedures to the needs of the facility and the facility personnel.

2.3. PROTECTIVE ACTION PLANNING

There is potential risk of radiation exposure to on-site or off-site personnel in all radiation emergencies. Planning is needed to determine how to implement the appropriate protective actions for the emergency situation. Protective actions may be urgent or long term. Urgent protective actions are those which must be implemented promptly, usually within a few hours, to be effective. Examples are evacuation, sheltering, decontamination or restriction of consumption of certain foods. Relocation is an example of a long term protective action.

Ref. [5] describes two protective action zones: urgent protective action planning zone (UPZ); and precautionary action zone (PAZ). Both are roughly circular areas cantered on the reactor facility and the PAZ is the area closest to the reactor facility. For Threat Category III research reactors both of these zones are expected to be within the site boundary. This is a direct consequence of the absence of risk to the off-site population. Threat Category II research reactors are expected to have the PAZ within the site boundary, but the UPZ may extend a few kilometres outward from the site boundary. The boundary of the UPZ must be determined by the facility based on an analysis of the radiological consequences of the emergencies that pose a risk to the off-site population. Then the UPZ boundaries need to be communicated to the off-site organization that has the authority to implement protective actions in the UPZ. Determination of the sizes of the zones is described in Appendix IV of Part 1.

In some cases, the research reactor threat assessment may show exceptions to the expectations that the PAZ does not extend off-site. Sites with small controlled areas or residential areas close to site boundaries could determine that the PAZ includes areas beyond the site boundary. These situations require close cooperation with the off-site authorities. The specific scenario for the emergencies potentially affecting the off-site population needs to be included in the emergency planning so that on the occurrence of such an emergency prompt urgent protective action based solely on plant conditions can be recommended to the off-site authorities.

One difference between the PAZ and the UPZ with regard to protective action implementation is the process to determine when protective actions are necessary. For the UPZ, urgent protective actions are usually implemented only if radiological monitoring shows that radiation levels exceed operational intervention levels (OIL) that have been established based upon national regulations or international standards. In contrast, within the PAZ, urgent protective actions are implemented immediately on the basis of conditions at the facility [6] with the aim of preventing or reducing the occurrence of severe deterministic effects [2]. Since the UPZ for Threat Category II is off-site, the facility can only recommend urgent protective actions to the off-site authorities, and may not even be performing the environmental monitoring that is evaluated to determine if urgent protective actions are

necessary. Nevertheless, Ref. [5] requires that there be arrangements with the off-site authorities to make decisions on protective action promptly upon notification of a nuclear or radiological emergency at the facility.

Protective actions based on environmental measurements are determined by comparing the measured radiation levels to OILs. Default, also called baseline, OIL values are provided in this publication based on Ref. [12]. Most commonly available radiation monitors are suitable for comparing measured values to the baseline OILs. Ref. [12] also contains a method to verify instrument suitability to compare instrument reading to the baseline OILs.

2.4. EMERGENCY RESPONSE TEAM

The positions on the Emergency Response Team are temporary roles, needed for the emergency response only, and then ended when the recovery phase begins. The site Emergency Plan must identify the individuals who are designated to fill those roles when an emergency occurs. Normally several individuals will be designated for each role to ensure adequate emergency response for extended periods of time and adequate response during times of individual unavailability such as business travel, illness or vacations. Certain roles are so important that individuals must always be available at the research reactor to fill the role. One of these important roles is the Facility Response Manager. This position has immediate duties to perform when an emergency occurs and Ref. [5] requires that there always be an individual on the site to perform those duties.

The positions on the Emergency Response Team are described in the following paragraphs. Where the responsibility differs between Threat Category II and Threat Category III those differences are discussed. The usual difference is that with fewer positions, the Threat Category III response team combines responsibilities. However, as part of the process of adapting these procedures to a particular facility, it could be decided to use a larger organization and not combine responsibilities as is described below. The only constraint should be what the facility can support with personnel and working space.

2.4.1. Facility Response Manager

The senior individual responding to the emergency is designated the Facility Response Manager in these procedures and takes charge at the site. The Emergency Plan should identify who is assigned this responsibility based on position at the facility, and with a single chain of preferences. For example, the chain of individuals who are designated the Facility Response Manager may show the Reactor Manager, or the site equivalent, as the first choice, the Chief Operator as the second choice and the on-duty Reactor Operator as the third choice. The purpose of this chain of individuals is to always have someone at the reactor or the site prepared and authorized to perform the functions assigned to the position of Facility Response Manager. This position is needed for both Threat Category II and Threat Category III research reactors.

The Facility Response Manager is responsible for assessment of the emergency conditions in order to determine the emergency classification and then initiate the appropriate response, including notifications that cause a response team to assemble and warn the off-site authorities of the emergency condition. The position is the leader of a team of more detailed specialists who are expected to respond to the emergency. Responsibilities of the Facility Response Manager include:

- Determine that an emergency has occurred and establish the appropriate response team;
- Concur with the emergency class determined by the Nuclear Condition Analyst;
- Direct the actions of the Emergency Response Team;
- Announce the emergency on-site and order on-site protective actions;
- Notify off-site authorities and recommend off-site protective actions or preparation for off-site protective actions;
- Verify accountability of all the personnel who were on the site when the emergency began;
- Declare an end to the emergency phase of the response, thus commencing the recovery phase.

2.4.2. Radiological Protection Manager

The facility positions that serve in the role of Radiological Protection Manager should also be designated by the Emergency Plan, and are usually from the organization responsible for radiation protection at the reactor. This individual may be a Radiation Protection Technician at first if no other individuals from the Radiation Protection organization are present. The Radiological Protection Manager is responsible to:

- Develop a plan to monitor the radiation environment on the site first, then off the site (or simultaneous if enough Monitoring Teams are available) and supervise the collection of the data;
- Evaluate the need for medical assistance and/or decontamination and recommend an assistance request for the needed support from off-site through the Facility Response Manager;
- Assess environmental monitoring data as it is reported and alert the Protective Action Manager when monitoring shows that OILs are being exceeded;
- Specifically authorize unnecessary personnel to leave the site;
- Authorize Emergency Workers to exceed occupational exposure limits;
- Obtain informed consent from Emergency Workers prior to their assignment to intervention tasks.

This position is needed for both Threat Category II and Threat Category III research reactors.

The Radiological Protection Manager is assisted with an Environmental Analyst and a Decontamination Team Lead.

2.4.3. Environmental Analyst

The environmental monitoring is done by Monitoring Teams using a monitoring plan approved by the Radiological Protection Manager. The Environmental Analyst is responsible to supervise these Monitoring Teams, including, but not limited to:

- Conducting briefings for assigned tasks to the Monitoring Teams;
- Verifying suitability of monitoring equipment for the assigned tasks;

- Promptly reporting results to the Radiological Protection Manager and, if directed, to the Protective Action Manager;
- Ensuring personal safety of the Monitoring Teams.

Threat Category III facilities may have the Monitoring Teams directly supervised by the Radiological Protection Manager, and this is the arrangement shown on Figure 1.

2.4.4. Decontamination Team Leader

This may be a large or small team depending on the particular event. However, several key responsibilities are assigned. Specifically:

- Evaluating medical and radiological condition of injured individuals;
- Recommending the need for prompt off-site medical first-aid when appropriate;
- Determining if on-site personnel are contaminated, decontaminating them when necessary, and then recommending their release to the Radiological Protection Manager.

The Threat Category III research reactor may also chose to have the Radiological Protection Manager directly supervise the Decontamination Team.

2.4.5. Protective Action Manager

The Protective Action Manager may be immediately required to initiate certain protective actions. The Emergency Plan should identify who is assigned to this position so a clear responsibility to perform the required duties assigned to a particular position. The responsibilities are:

- Recommend appropriate protective actions to the Facility Response Manager for on-site personnel;
- Recommend off-site protective actions, based on emergency class or environmental data;
- Evaluate collected environmental data and project where OILs may be exceeded in order to assist planning for environmental monitoring;
- Revise default OILs if detailed analysis permits such revision and inform the Facility Response Manager of the option to implement the revised OILs.

The Protective Action Manager is assisted by a Projection Analyst.

The scope of the protective actions is reduced for Threat Category III research reactors since there is no need for off-site protective actions. Figure 1 omits this position and the on-site protective action responsibility is transferred to the Radiological Protection Manager.

2.4.6. Projection Analyst

The Projection Analyst reports to the Protective Action Manager and performs the projections that can alter the environmental monitoring plan. This position is also responsible to consider revising OILs when more detailed analysis of the radioactive material is performed. The position may also perform hand or computer calculations of radiological consequences of a release from the facility as part of the projection analysis. There is no need for this position at Threat Category III facilities.

2.4.7. Nuclear Condition Analyst

The Nuclear Condition Analyst is a technical expert assigned to provide detailed technical advice to the Facility Response Manager. The specific responsibilities are:

- Evaluate the initial emergency conditions and determine an emergency class;
- Maintain a close awareness of reactor and containment conditions to determine if a change to the emergency class is necessary, and if operating personnel are successfully mitigating the emergency;
- Advise the Radiological Protection Manager of actual or imminent fuel damage and potential releases to the external atmosphere.

Note that for some research reactors this position may be a team of individuals due to complexity of the reactor or the emergency. Even though there may be several technical specialists assigned to this team, the team must have a leader who shall have the responsibilities of Nuclear Condition Analyst. At Threat Category III research reactors the responsibilities of this position may be performed by the Facility Response Manager. Figure 1 does not show this position; however, the position may be added to reduce the work load of the Facility Response Manager.

2.4.8. Communicator

The Communicator assists with communications between the Facility Response Manager and the off-site authorities and media. Multiple off-site contact points could require more than one individual performing communication functions. However, only one of those should be the Communicator to preserve control of the communications to off-site authorities. The specific responsibilities are:

- Initiate all off-site notifications appropriate to the emergency when directed to do so by the Facility Response Manager;
- Draft a media statement for approval by the Facility Response Manager and the appropriate off-site authorities;
- Inform the Facility Response Manager of information or queries received from off-site that necessitate a response from the site;
- When directed, initiate calls to off-duty facility personnel and request they report to the facility to assist with the emergency response.

This position is needed for both Threat Category II and Threat Category III research reactors.

2.4.9. Plant Security Manager

The Plant Security Manager takes charge of site security, usually with specific actions determined by the site security plan. This position on the Emergency Response Team is to coordinate the actions in the site security plan with the emergency response procedures. Specific functions of the Plant Security Manager are:

- Establish control over the site entry and exit points such that only necessary emergency response support can enter the site and only individuals that the Radiological Protection Manager determines to be unnecessary to the response may leave;
- Coordinate with local police officials if their response is necessary;
- Respond to security threats to the facility as determined by the site security plan.

This position is needed for both Threat Category II and Threat Category III research reactors.

The on-duty operating personnel may be the initial emergency responders. This is most likely to occur when emergencies occur outside the normal business hours. In the emergency response roles they must assume, it may be necessary for a single individual to perform the actions of multiple emergency response roles. For example, the senior operations person, perhaps the Shift Supervisor, at a Threat Category II research reactor that experiences an emergency may have to perform some steps from the Facility Response Manager Action Guide, since declaring an emergency condition and activating the response team are immediate actions for this response position, and steps from the Nuclear Condition Analyst Action Guide since determining the emergency class is an immediate task of that response position. The facility staffing levels will determine how the immediate response actions can be divided among available personnel. The facility Emergency Plan must make clear how those response roles are assigned to the on-duty operations staff as well as identifying those individuals authorized to replace operations personnel in the response roles.

The position descriptions above are not the only arrangement of responsibilities that can be developed and each research reactor site should use an arrangement that best fits the circumstances. The only constraint is to have some one person responsible for the overall response, the Facility Response Manager, with subordinate positions solely responsible for a well-defined set of duties. The emergency response procedures in this publication are, however, developed with the team structure described above and shown on Figure 1 or Figure 2. Each of the positions has an Action Guide that provides sequential instructions for performance of the assigned tasks.

2.5. INFORMATION TABLES

Tables accompany some of the Action Guides to provide information that is used in the decision making process for a particular Emergency Response Team position. The use of the tables is described below. Some tables are omitted from Part 2 for Threat Category III research reactors because of the response differences regarding off-site threats.

2.5.1. Emergency Classification Table — Table A.1

The classification table is the basis for establishing the emergency class of an event. It is an aid to the Emergency Response Team by providing symptoms of an emergency and then descriptions of conditions that determine levels of severity of that emergency. The severity descriptions are intended to use instrument values and reactor or reactor system conditions related to the event so the operators may quickly establish an emergency class without the need for detailed calculations or consultations with individuals who are not on the site when the emergency is first recognized. Each site may add detail and more specific information to increase the usefulness of the table.

When adding site-specific details to the Emergency Classification Table, the operating organization should consider the level of severity of an event that requires activation of an on-site emergency response team. A description of an event that does not need an emergency response team would not be expected to be listed on the table. The intent of the emergency classification table is to describe events and severity that do require the assistance of an emergency response team in addition to the normal reactor operations personnel.

Emergency classification tables that have been modified to better describe events at TRIGA research reactors are included in Ref. [8]. Both Threat Category II and Threat Category III TRIGA Emergency Response Tables are provided.

Observable symptoms of an emergency are shown in the left side column labelled “For the following entry conditions”. These are the abnormal conditions that alert the operating personnel of a potential emergency. The remaining columns are descriptions of severity, with the most severe conditions that will determine the emergency class on the left. Conditions with severe fuel damage are considered to be a General Emergency due to the potentially large release of fission products which may escape from the facility. The severity conditions are described in terms of specific values on readily observed instrumentation or operating status of reactor equipment, components, such as control rods, or systems.

The Table in this publication is an example of a generic table, one not adapted to the terminology and details of a specific research reactor. The research reactor operating staff needs to modify this example Table using reactor specific information that customizes the Table to the facility. Additional entry conditions may be necessary to include a full range of the abnormal conditions that can indicate an emergency. Some entry conditions may be deleted if the situation does not cause an emergency situation at the specific research reactor.

The site-specific table, like that shown for Threat Category II, may not present severity descriptions for all four emergency classes for every initiating event. Some severity descriptions may not be applicable for a particular emergency event. For example, the site may conclude that a particular event has no severity that corresponds to Facility Emergency because if the severity is more than an Alert, there is a potential threat to the off-site population and the correct emergency class is Site Area Emergency. There may also be events that can never threaten the off-site population and so do not have the class of Site Area Emergency or General Emergency.

The Nuclear Condition Analyst, with information from observations of reactor parameters or with reports from the reactor operating personnel uses the Emergency Classification Table to determine the emergency class that best matches the current conditions. When the current conditions fit more than one emergency class under different entry conditions, the emergency class representing the most severe emergency is the correct choice. As always, selecting an emergency class requires judgement. The Classification Table is one tool that can reduce the amount of judgement needed in the stress of recognizing an emergency by preparing written and carefully described guidance in the Table to assist the emergency responders.

The Classification Table for Threat Category III facilities is considerably simpler than for Threat Category II due to needing only two emergency classes. Nevertheless, adapting the Table to the specific Threat Category III research reactor is just as important.

The determination of the emergency class is a significant decision because subsequent actions depend on that decision, and the urgency of subsequent actions is also influenced by the emergency class. The initial decision on emergency class is made by the Nuclear Condition Analyst. The decision is expected within 15 minutes [6] of recognizing an emergency condition. Information collection must be brief and quickly concluded to make the decision. The expectation, and development of the Emergency Classification Table, is such that information readily available from facility instrumentation can provide the necessary input to the decision. Calls to managers or supervisors who are not at the facility or assembling a group of individuals who are on the site to hold a meeting are improper responses to the need for a prompt decision.

2.5.2. Emergency Response Priorities — Table A.2

The purpose of this Table is to establish priorities of response actions and response time objectives based on the emergency class. The response time objectives are different for Threat

Category II and Threat Category III. Specific values are taken directly from Appendix VI of Ref. [6]. The priorities are important in the first few hours, or less, of the emergency response when there are often more tasks to initiate than the facility is able to respond to.

Notification of off-site authorities is another prompt action and delays will cause subsequent actions to also be delayed. For example, failure to promptly notify off-site authorities affects their ability to meet the time objectives to activate the local level response organization or the time objective for the national level organization to react. The actions that initiate response from off-site authorities are expected to occur sooner than in situations where the off-site authorities are not expected to react with their own response actions. Thus, the emergency class and threat category of the facility alter the response time objectives.

The actions and response time objectives in Table A.2 are only those that are the responsibility of the facility. There are also response time objectives for the local (off-site) response organizations and the national organization. These are not included in this publication, but may be found in Refs [2] and [6].

2.5.3. Guidance Values for Limiting Exposure of Emergency Workers — Table B.1

When an emergency has been declared, certain radiological standards are changed. Table B.1 is only applicable during a declared emergency and permits increased radiation exposure criteria in some defined situations associated with the emergency. These exceed the occupational exposure limits that apply during other situations, including the recovery phase.

The individuals who are Emergency Workers are determined by the individual site and may include both on-site personnel, such as reactor operating personnel or radiation monitoring personnel, and off-site personnel such as the first responders to a request for assistance, normally fire fighters, emergency medical support and individuals with similar emergency response skills. Emergency workers who undertake actions in which the dose received might exceed the single year dose limit for occupational exposure should do so voluntarily, should have been clearly and comprehensively informed in advance of the associated health risk, and should be trained, to the extent feasible, in the actions that may be required [12]. These procedures establish the Radiological Protection Manager as the Emergency Response Team position responsible to ensure the appropriate briefing occurs to provide informed voluntary consent. Appendix 2 provides a sample briefing.

2.5.4. Environmental Monitoring Priorities — Table B.2 in Part 1

Threat Category II facilities have more area to monitor for the radiological consequences of an emergency than a Threat Category III facility. Table B.2 in Part 1 is only for the Threat Category II site and is an aid to the Radiological Protection Manager who is responsible to quickly establish an environmental monitoring plan. Part 2 of this publication does not have an environmental monitoring priority table since all environmental monitoring will be performed on the site.

The priorities in this table are to monitor for radiological threats on-site first, then extend that monitoring to off-site areas. The basis for that priority is that on-site personnel are the first to be affected by the emergency condition and any release would be more easily identified by on-site monitoring where the release would be less diluted and dispersed. The monitoring results are then evaluated to determine if the appropriate protective actions have been implemented. Further, monitoring for conditions warranting urgent protective actions takes priority over monitoring for long term protective actions.

It may not be the responsibility of the research reactor personnel to perform the off-site monitoring. In that case, the Emergency Response Team would provide direction to the off-site authorities as to what radiological threats could exist based on the specific conditions at the site.

2.5.4.1. Protective Actions Based on Emergency Classification — Table C.1, Part 1 and Table B.2, Part 2

These Tables are intended to provide guidance on urgent protective actions that should be implemented before environmental monitoring results are available. The basis is that some emergency conditions present severe radiological threats and delaying implementation of urgent protective action endangers individuals unnecessarily. Threat Category III research reactors are not expected to require off-site urgent protective actions so Table B.2 in Part 2 does not include guidance for off-site protective actions. Research reactors that are Threat Category II facilities have an Urgent Protective Planning Zone (UPZ) that includes off-site areas. However, urgent protective actions in the UPZ will be based on environmental monitoring results and not on emergency class.

Preparation for the on-site urgent protective actions is necessary. The site Emergency Plan should specify evacuation routes, assembly locations and sheltering site and then ensure that every individual assigned to the site is aware of that information.

2.5.5. Protective Actions Based on Environmental Measurements — Table C.2, Part 1, and Table B.3, Part 2

Environmental measurements are expected within an hour for areas on the site [6]. The information may show that the previously implemented urgent protective actions may be altered. This Table provides the OIL values for urgent protective actions, both on-site and off-site.

The OIL values in this table, and the table discussed in paragraph 2.5.6 below, were developed for protection of a representative person[2] as defined in Ref. [13] and the fetus (pregnant woman). The values are based on generic criteria for taking effective urgent and early protective actions to reasonably reduce the risk of stochastic health effects and medical actions to detect and effectively treat health effects resulting from radiation exposure. Medical management criteria is provided in Ref. [12]. OILs for ground and skin contamination are based on evaluating a large set of radionuclides, including a mixture of fission products, for the degree of hazard if involved in an emergency. Further discussion of the bases for the OILs may be found in Ref. [12].

Activity values for contamination by α and β particle emitting radionuclides are provided in counts per second (cps). Most commonly available field radiation survey instruments that display cps are suitable for determining if radiation levels exceed the OIL. Criteria to determine suitability of a specific instrument is found in Ref. [12]. If practical, instrument-specific OIL values should be determined for the emergency monitoring instruments as a preparedness action. The use of instrument-specific OIL values requires extra diligence by those who supervise the monitoring teams to ensure that the instrument-specific OIL values are with the intended monitoring instrument.

---

[2] The representative persons considered for these OIL values are an adult for external exposure in the environment and inhalation and a 1 year old child for dose from ingestion of radioactive material.

For the early phase environmental monitoring following a release of fission products, γ radiation surveys are adequate to determine if protective actions are appropriate. For releases of other radionuclides, for example, isotopes prepared for medical use, radiation surveys for α and β particle emitting radionuclides may be appropriate. This is also recommended if the radioactive material is unknown.

2.5.6. Default Screening OILs for Food, Milk, and Water Concentrations, Default Radionuclide-specific OILs for Food, Milk, and Water Activity Concentrations and Equilibrium Radioactive Chains — Tables C.3, C.4 and C.5, Part 1 only

Deposited radioactive materials may create a radiological threat from eating foodstuffs that have been contaminated by the material. Analysis of food, milk and water samples is performed to evaluate the contamination level of these foodstuffs. The OIL5 value based on gross activity of α or ß particle emitting radionuclides is conservative. Additional analysis to identify the specific nuclides present in the foodstuffs may result in accepting the material as satisfactory where the gross activity criteria for α or ß particle emitting radionuclides would reject the material.

The OIL6 calculation data provided in Table C.4 for assessing compliance with OIL6 assume a time period of five years after creation of the parent nuclide and its involvement in the emergency. Therefore, daughters with half-lives less than 1 year and less than that of the parent were assumed to be in equilibrium with their longer lived parents. In such cases the OIL6 contribution for the parent includes the activity of the daughter. The contribution of the daughters listed in Table C.5 should not be considered separately.

The contributions of daughters with a half-life either greater than 1 year or greater than that of the parent are not combined with contributions of the parent. Therefore the contribution of these daughters must be considered separately.

2.5.7. Containment Release Rate Guide — Table D.1, Part 1

Research reactors that have a containment structure will need to consider the effectiveness of that structure during an emergency by estimating a release rate from the structure. All containment structures have a design leak rate that should be known to the research reactor staff. In addition, recognized containment deficiencies may exist and cause higher leak rates. Evaluation of the containment condition is a responsibility of the Nuclear Condition Analyst. The Projection Analyst may require the results of that evaluation if attempts are made to determine the consequences of a fission product release into the containment. The source term necessary to calculate the quantity of fission products reaching the off-site areas depends upon a containment leak rate.

With no known containment deficiencies and little or no containment pressure above the external pressure, the design leak rate should be an acceptable value to use to estimate the release source term outside containment. Other situations may require assuming higher release rates and this table may assist the Nuclear Condition Analyst. Worksheet D.2 provides a place to record the results of the evaluation by the Nuclear Condition Analyst.

2.6. WORKSHEETS

Several worksheets are provided as tools to organize and record information that is important to the emergency response. Additionally, each responder may wish to keep a log of actions important to that position. The collection of worksheets and logs would allow replacement responders, in a response that lasted many hours, to become knowledgeable of the response

status. Additionally, these same records are valuable information to evaluate the acceptability of the response and to use in preparing reports that may be required of the facility.

Each worksheet includes a set of instructions and a statement of purpose. The individual site should view these worksheets as examples and incorporate those that are determined to be useful to the site response into the site-specific emergency response procedures. Some specific needs of the site could result in the development of additional worksheets. Conversely, some of those in this publication may serve no purpose in the site response, and could be deleted from the site emergency response procedures.

2.7. SITE EMERGENCY PLAN AND TRAINING

The material in this publication is not an Emergency Plan, but only the emergency response procedures that are one part of an Emergency Plan. These emergency response procedures will not be effective without an Emergency Plan to provide additional support, coordination with off-site authorities to obtain emergency response resources that the facility may need and does not have at the site, and additional agreements with off-site organizations for emergency reporting. For example, Ref. [6] expects certain response times and actions from local and national authorities and the site Emergency Plan must identify who those organizations are and how they are contacted. Worksheet E.1, Part 1, and Worksheet C.1, Part 2, are designed for this purpose. Additionally, organizations should be requested to agree with the Emergency Plan where an activity initiated from the facility requires action or a response from the off-site organization.

Assistance to develop an emergency plan is available from the IAEA in Ref. [2], including an outline of a Facility Emergency Plan. The facility Emergency Plan must recognize and work with emergency plans that are implemented at local and national levels. In cases where those plans do not exist, or are inadequate to address emergency response to nuclear or radiological emergencies that occur at the facility, then facility personnel should address the issues with the local and national emergency planners to upgrade those external plans. Example local and national emergency plans are also found in Ref. [2].

An Emergency Plan and the included emergency response procedures must be tested and the responding individuals must be trained to understand and use the procedures. A specific individual at the facility should be designated to provide the necessary training. This individual could also be responsible for updating and revising the Emergency Plan when necessary. The training must include any off-site organization that could be asked to support an emergency response at the facility. Ref. [2] describes the elements of a training program including identification of the skills necessary to perform the response functions and both initial and continuous training recommendations. The preparation, conduct and evaluation of emergency preparedness exercises is described in Ref. [14]

PART 1:
RESPONSE TO A NUCLEAR OR RADIOLOGICAL EMERGENCY AT THREAT CATEGORY II RESEARCH REACTORS

ACTION GUIDES

AG.A.1 FACILITY RESPONSE MANAGER

When to apply the Action Guide:

In case of any radiation emergency at a research reactor.

ACTIONS

Assess the situation and classify the emergency

- Receive a briefing from the individual(s) who identified the emergency or the Facility Response Manager if relieving that individual.
- Question thoroughly to understand the scope of the emergency.

NOTE

Activating the Facility Response Manager position is the transition from normal reactor operations to site emergency response.

- Verify the appropriate reactor emergency operating procedure is in progress or is complete.
- Consider immediately requesting assistance appropriate to the event, for example the fire brigade or police.
- Using Table A.1 review a recommended classification from the Nuclear Condition Analyst and determine the appropriate class of the emergency. Emergency classification is expected within 15 minutes of identification that an emergency exists.
- Assemble the necessary emergency response team and initiate the response using Table A.2 to determine priorities.

NOTE

Worksheet A.2 is an action item checklist that may be of assistance.

Establish Communications

- Inform on-site personnel and off-site authorities of the emergency.
- Initiate on-site protective actions with recommendations from the Protective Action Manager.

CAUTION

Based on prior knowledge of the threat from a release, off-site protective actions may be appropriate before environmental monitoring is performed. Sheltering should be considered if a release is likely to cause an evacuation recommendation once the environmental monitoring results are available.

- Determine if off-site individuals should take protective actions prior to determination of the radiation environment beyond the site boundary. Inform off-site authorities using Worksheet C.5 if only preparations for urgent protective action are advised or Worksheet C.6 if urgent protective actions are recommended.

- Review status of on-site protective actions and Priority 2 and 3 actions with the Radiological Protection Manager, the Communicator and the Nuclear Condition Analyst.
- Maintain communications with off-site authorities to keep them informed and provide emergency responder protective actions and exposure guidelines.

NOTE

Additional support comes from off-site when the on-site resources are inadequate for the situation. Keeping those resource providers updated helps them anticipate and assemble that support.

- Review Worksheet E.2 for a record of notifications completed by the Communicator.

Direct the activities of the other responders

- Transmit protective action recommendations to off-site authorities when environmental surveys demonstrate the need for them. Explain to the off-site authorities the reasons for the recommended actions.
- Request off-site authorities confirm when the recommended protective actions have been completed.
- Hold periodic briefings with the response team. Update those reviews as additional responders arrive and are assigned duties.
- Periodically review the classification with input from the Nuclear Condition Analyst and the Radiological Protection Manager.

NOTE

New information can change the classification; these reviews ensure that the classification remains appropriate given the new information.

- Maintain a record of information and the decisions resulting from that information. Use this record as briefing material for the next Facility Response Manager.

Transition to recovery actions

- Assemble a team appropriate to the recovery actions when the situation has been fully assessed and the emergency response actions have stabilized the situation.

TABLE A.1. SYMPTOM BASED EMERGENCY CLASSIFICATION FOR THREAT CATEGORY II RESEARCH REACTOR
(Revise as necessary to the site-specific details and parameters)

For the following entry conditions:	Declare a General Emergency if:	Declare a Site Area Emergency if:	Declare a Facility Emergency if:	Declare an Alert if:
CRITICAL SAFETY FUNCTION IMPAIRMENT				
Failure to stop nuclear reaction[3]	Failure to scram when above 5% *[or insert site specific power level]*[4] power **and** any of the following: •Pool/tank water level below top of active fuel **or** •Abnormal increase (100–1000x) in multiple radiation monitors **or** •Other indication of actual or imminent core damage	Failure to scram when above 5% *[or insert site specific power level]* power, abnormal conditions indicate automatic or manual scram is necessary and unable to maintain normal tank/pool water level	Failure to scram when above 5% *[or insert site specific power level]* power and abnormal conditions indicate automatic or manual scram is necessary	Failure to fully shut down as part of normal shutdown with sufficient heat removal available
Inadequate core cooling — pool/tank level[5], such as pool or tank leakage greater than capacity of make-up water system, inadvertent drainage of pool/tank	Pool/tank water level is, or is projected to be, below top of active fuel for greater than *[insert site specific time period to cause release of fission products from fuel elements]* minutes	Pool/tank water level is or is projected to be below top of active fuel		Pool/tank water level decreasing over a longer time period than expected while systems are responding as designed

[3] Stop nuclear reaction is more general term that includes reactor scram, which is used only for insertion of control rods to the reactor.

[4] Failure to scram reactor is usually evaluated if reactor power is greater than 5 % and conditions indicate that scram is necessary (safety systems are usually capable to remove heat rate less than 5 % of nominal power). For some plants different, plant specific value should be used.

[5] Inadequate core cooling is characterized by two kinds of entry conditions — pool/tank water level and decay heat removal capability.

TABLE A.1. SYMPTOM BASED EMERGENCY CLASSIFICATION FOR THREAT CATEGORY II RESEARCH REACTOR
(Revise as necessary to the site-specific details and parameters)

For the following entry conditions:	**Declare a General Emergency if:**	**Declare a Site Area Emergency if:**	**Declare a Facility Emergency if:**	**Declare an Alert if:**
Inadequate core cooling — loss of decay heat removal capability, such as failure of primary or secondary circulating pumps, failure of heat exchangers or valves required for decay heat removal, fuel channel blockage, loss of emergency core cooling system	Absence of ability to transfer decay heat to the environment for [*site-specific time for fuel temperature to exceed design values with only ambient losses available for decay heat removal]* **and** Abnormal increases (100–1000x) in multiple radiation monitors **or** Other indications of imminent or actual core damage *Note: Consideration of imminent containment boundary failure might be considered as further additional criteria* [6]	Actual or projected long term failure of the ability to remove decay heat to the environment potentially affecting the ability to protect the core	Unavailability of normal system for decay heat removal. **and** Unavailability of Emergency Core Cooling System	Unavailability of normal system for decay heat removal
Loss of AC or DC power sources			Failure of all power sources for reactor safety systems and reactor monitoring instrumentation	AC or DC power needed for safety systems and their supporting systems operation is lost or reduced to a single source

[6] In case of core damage, the status of the containment barriers will strictly affect the magnitude of fission products release.

TABLE A.1. SYMPTOM BASED EMERGENCY CLASSIFICATION FOR THREAT CATEGORY II RESEARCH REACTOR
(Revise as necessary to the site-specific details and parameters)

For the following entry conditions:	**Declare a General Emergency if:**	**Declare a Site Area Emergency if:**	**Declare a Facility Emergency if:**	**Declare an Alert if:**
Loss of or degraded control of safety systems including post-accident instrumentation[7]	Unavailability of safety system instruments or controls in the control room and remote control locations **and** any of the following: •Pool/tank water level below the top of active fuel **or** •Abnormal increases (100–1000x) in multiple radiation monitors **or** •Other indications of imminent or actual core damage	Unavailability of safety system instruments or controls in the control room potentially affecting the ability to protect the core	Unavailability of safety system instruments or controls in the control room	Unreliable functioning of several safety system instruments or controls in the control room
LOSS OF FISSION PRODUCT BARRIERS				
Major increased risk of damage to the core or irradiated fuel	Loss of all the systems required to protect the core or spent fuel for more than 45 minutes *[or insert site specific time required to uncover core for more time than required to initiate fission product release from any irradiated fuel]*	Failure of an additional safety system component will result in uncovering the core or irradiated fuel		Actual or predicted failures leaving just one safety system to prevent core damage, irradiated fuel damage or a major release

[7] Safety systems control capability can be either degraded or completely lost; both cases are reflected. Unreliable functioning of several safety system instruments or alarms and unavailability of safety system instruments or controls is considered. Post-accident instrumentation provides the essential information to support safety system operation and control and is included.

TABLE A.1. SYMPTOM BASED EMERGENCY CLASSIFICATION FOR THREAT CATEGORY II RESEARCH REACTOR
(Revise as necessary to the site-specific details and parameters)

For the following entry conditions:	**Declare a General Emergency if:**	**Declare a Site Area Emergency if:**	**Declare a Facility Emergency if:**	**Declare an Alert if:**
High I-131 concentration in pool/tank water or High airborne activity in containment[6] *Note:* *Water samples should not be taken if they will result in high individual doses.* *- Use only concentrations from sample taken after the start of the event* *- Water concentrations may not be representative*			*[Determine a site specific airborne activity from fission products in the containment[8] such that the design basis release rate from containment causes on-site radiation levels that require urgent protective action at any on-site area]*	I-131 concentration greater than *[insert site specific value 100 times technical specifications or other operational limits]*
Containment barrier damaged	Containment is unable to perform the design function and a large release of fission products from the fuel is in progress or is imminent	Containment is unable to perform the design function and a release of fission products from the fuel is possible		Containment is unable to perform the design function and the reactor is shutdown[9]

[8] The term containment is used to refer to either containment structure or confinement structure.

[9] This is not intended to require declaration of an Alert if containment is open during maintenance provided the reactor conditions permit opening containment.

TABLE A.1. SYMPTOM BASED EMERGENCY CLASSIFICATION FOR THREAT CATEGORY II RESEARCH REACTOR
(Revise as necessary to the site-specific details and parameters)

For the following entry conditions:	**Declare a General Emergency if:**	**Declare a Site Area Emergency if:**	**Declare a Facility Emergency if:**	**Declare an Alert if:**
RADIATION LEVELS				
Effluent (airborne or other) release rates above release limits	Effluent monitor readings for more than 15 minutes greater than *[insert site specific list of effluent monitors and readings indicating that in 1 hour the off-site doses will be greater than the intervention levels for urgent protective actions assuming average meteorological conditions] or effluent readings exceeding regulatory limits such that protective actions are required off-site*	Effluent monitor readings for more than 15 minutes greater than *[insert site specific list of effluent monitors and readings indicating that in 4 hours the off-site doses will be greater than 0.10 of the intervention levels for urgent protective actions assuming average meteorological conditions*]	Effluent monitor readings for more than 15 minutes greater than *[insert site specific list of effluent monitors and readings indicating that in 4 hours the on-site doses will be greater than 0.10 of the intervention levels for urgent protective actions assuming average meteorological conditions*]	Effluent monitor readings *[insert site specific list of effluent monitors and release limits]* less than release limits but unexpected

TABLE A.1. SYMPTOM BASED EMERGENCY CLASSIFICATION FOR THREAT CATEGORY II RESEARCH REACTOR
(Revise as necessary to the site-specific details and parameters)

For the following entry conditions:	**Declare a General Emergency if:**	**Declare a Site Area Emergency if:**	**Declare a Facility Emergency if:**	**Declare an Alert if:**
High radiation levels in control room or other areas requiring continuous access for safety system operation and maintenance *Note: Inconsistent monitor readings could result from incomplete mixing, a failed monitor or by seeing radiation from a contaminated system nearby. Monitors may show high, low or centre range if they fail. Readings can be confirmed using hand-held monitors outside the area.*		Radiation levels greater than 10 mSv/h *[or insert site specific dose rate based on personnel exposure limits]* for more than 1h. or Projected dose to operating personnel could exceed 50 mSv during necessary occupancy period[10]	Radiation levels greater than 1 mSv/h *[or insert site specific dose rate based on personnel exposure limits]* potentially lasting several hours.	Unexpected radiation levels greater than 0.10 mSv/h *[or insert site specific dose rate based on personnel exposure limits]* or 100x background potentially lasting several hours.
High radiation levels in areas requiring occasional occupancy to maintain or control safety systems		Radiation levels greater than 100 mSv/h *[or insert site specific dose rate based on personnel exposure limits]* potentially lasting several hours.	Radiation levels greater than 10 mSv/h *[or insert site specific dose rate based on personnel exposure limits]* potentially lasting several hours.	Radiation levels greater than 1 mSv/h *[or insert site specific dose rate based on personnel exposure limits]* potentially lasting several hours.

[10] The value was chosen because 50 mSv is the maximum annual occupational exposure limit.

TABLE A.1. SYMPTOM BASED EMERGENCY CLASSIFICATION FOR THREAT CATEGORY II RESEARCH REACTOR
(Revise as necessary to the site-specific details and parameters)

For the following entry conditions:	**Declare a General Emergency if:**	**Declare a Site Area Emergency if:**	**Declare a Facility Emergency if:**	**Declare an Alert if:**
High radiation levels in non-critical occupied areas, for example, experimental facilities			Abnormal radiation level increase (>100X) detected on multiple instruments, or Abnormal radiation levels greater than 1 mSv/h	Abnormal radiation level increase (>10X) detected on multiple instruments, or Abnormal radiation levels greater than 0.1 mSv/h
Elevated containment radiation levels *Note: Inconsistent monitor readings could result from incomplete mixing or a failed monitor or by seeing radiation from a contaminated system nearby[11]. Monitors may show high, low or centre range if they fail. Readings can be confirmed using hand-held monitors outside the containment.*	Greater than 5 Gy/h or *[Determine site specific reading from fission products such that the design basis containment leakage causes off-site radiation levels requiring urgent protective action in the UPZ]*	Greater than 1 Gy/h or *[Determine site specific reading from fission products in the containment such that containment failure causes off-site radiation levels requiring urgent protective action in the UPZ]*	*[Determine a site specific reading from fission products in the containment such that the design basis leakage from containment requires urgent protective action on the reactor site]*	Containment radiation levels increase more than 0.10 mGy/h
Unplanned increase in reactor radiation levels	Multiple reactor radiation monitors show an unplanned or unpredicted increase by a factor of 100 or more and any other indication of actual core damage or damage to fuel specimens installed in the reactor	Multiple reactor radiation monitors show an unplanned or unpredicted increase by a factor of 100 or more potentially caused by damage to the core or fuel specimens installed in the reactor	Multiple reactor radiation monitors show an unplanned or unpredicted increase by a factor of 10 or more potentially warning of damage to fuel specimens installed in the reactor	Multiple reactor radiation monitors show an unplanned or unpredicted increase by a factor of 10 or more

[11] Radiation from a contaminated system nearby could also affect the radiation monitors inside the containment.

TABLE A.1. SYMPTOM BASED EMERGENCY CLASSIFICATION FOR THREAT CATEGORY II RESEARCH REACTOR
(Revise as necessary to the site-specific details and parameters)

For the following entry conditions:	**Declare a General Emergency if:**	**Declare a Site Area Emergency if:**	**Declare a Facility Emergency if:**	**Declare an Alert if:**
High ambient dose rates at or beyond the site boundary	Ambient dose rates at or beyond the site boundary greater than 1 mSv/h *[or insert the site specific operational intervention level for evacuation]*	Ambient dose rates at or beyond the site boundary greater than 0.1 mSv/h *[or insert 1/10 of the site specific operational intervention level for evacuation]*		Ambient dose rates at or beyond the site boundary greater than 10μSv/h *[or insert site specific reading indicating 100 times background]*
SECURITY, FIRE, NATURAL AND OTHER EVENTS				
Security event (intruder or terrorist attack) *Note that the site Security Plan may require actions in addition to the emergency response procedures.*	Security event causes containment damage and Security event causes core damage	Security event causes containment damage or Security event causes core damage	Security event, actual or threatened, that could result in damage to any safety system operation or the reactor	Credible security threat to the reactor or reactor safety systems
Fire or explosion on the site	Fire or explosion that causes fuel damage and a release of fission products affecting off-site locations	Fire or explosion that has the potential to cause personnel contamination or fuel damage affecting off-site locations	Fire or explosion that has the potential to cause personnel contamination or fuel damage affecting on-site locations	Fire or explosions potentially affecting areas containing safety systems
Unexpected media or public inquiry				Inquiry requesting information on a perceived or real emergency
Toxic or flammable gases		Toxic or flammable gases that prevent control of reactor safety systems		Toxic or flammable gases in the research reactor

TABLE A.1. SYMPTOM BASED EMERGENCY CLASSIFICATION FOR THREAT CATEGORY II RESEARCH REACTOR
(Revise as necessary to the site-specific details and parameters)

For the following entry conditions:	**Declare a General Emergency if:**	**Declare a Site Area Emergency if:**	**Declare a Facility Emergency if:**	**Declare an Alert if:**
Major natural or external disaster such as: •earthquake •tornado •floods •high winds •fire or explosion threatening the site •vehicle or airplane[12] crash •hurricane •tsunami •storm surge •lightning strikes [13]	Major natural or external event resulting in fuel damage and the release of fission products to the environment	Major natural or external events resulting in damage or impaired access to safety and/or decay heat removal systems or affecting their long term operation	Natural or external events resulting in damage to reactor systems or building or causes fuel damage that affects the on-site population	Natural major or external events that threaten the reactor such as: •Events beyond the design basis of the reactor or the reactor building/containment •Events resulting in actual or potential loss of access to the site for an extensive period of time
Flooding of reactor building				Flooding that can affect the safety systems
Loss of communications				Events resulting in actual or potential loss of communications to the site for an extensive period of time
Radioactive material control			Loss of control of a dangerous source on the site[14]	Loss of control of or access to fuel not installed in the reactor or Loss of control of any radioactive material

[12] Airplane crash can also cause severe damage to plant and decrease the plant safety.

[13] Lightning strikes can also cause severe damage to plant and decrease the plant safety.

[14] Appendix 8 of Ref. [2] and Ref. [15] provide the information to determine the amount considered dangerous for many nuclides.

TABLE A.1. SYMPTOM BASED EMERGENCY CLASSIFICATION FOR THREAT CATEGORY II RESEARCH REACTOR
(Revise as necessary to the site-specific details and parameters)

For the following entry conditions:	**Declare a General Emergency if:**	**Declare a Site Area Emergency if:**	**Declare a Facility Emergency if:**	**Declare an Alert if:**
Reactor Senior Operator opinion	Conditions that warrant taking urgent protective actions off-site	Conditions that warrant preparing the public to implement urgent protective actions	Conditions that warrant taking protective actions on-site	Abnormal conditions warranting obtaining immediate additional assistance for the on-site operations staff **or** Abnormal conditions warranting increased preparedness of off-site officials
Human Error[15]				Error results in violation of reactor operating limits and conditions or damages an experimental apparatus
Injured Person				Individual(s) injured and/or contaminated with off-site treatment and/or decontamination required

[15] Human error resulting in an emergency more severe than an Alert would be expected to create conditions included in another set of Entry Conditions.

TABLE A.1. SYMPTOM BASED EMERGENCY CLASSIFICATION FOR THREAT CATEGORY II RESEARCH REACTOR
(Revise as necessary to the site-specific details and parameters)

For the following entry conditions:	Declare a General Emergency if:	Declare a Site Area Emergency if:	Declare a Facility Emergency if:	Declare an Alert if:
FUEL HANDLING AND SPENT FUEL POOL EVENTS				
Abnormal refuelling or irradiated fuel conditions, such as fuel handling error		Water level below top of irradiated fuel **or** radiation level in pool area > 30 mSv/h	Loss of ability to maintain water level above irradiated fuel	Damage to irradiated fuel but fuel remains covered
Fuel handling abnormality, such as mechanical damage to fuel or control rod			Abnormal radiation level increase on multiple monitors during fuel transfers or movements	Damage to fuel element or control rod
EXPERIMENTAL EQUIPMENT AND SYSTEMS EVENTS				
Experimental equipment abnormality			Damage to an experimental assembly that can result in overexposure to facility personnel	Damage to in-core experimental assembly **or** Unplanned reactor scram or shutdown, manual or automatic, for an unknown reason
Unplanned reactor scram				Reactor scram, unknown cause

TABLE A.2. EMERGENCY RESPONSE PRIORITIES

Priority	Action	Response Time Objective for Emergency Class				Responsibility
		General Emergency	Site Area Emergency	Facility Emergency	Alert	
1	Classify event based on reactor and radiological conditions	Initial classification — within 15 minutes of recognizing an emergency condition Subsequent classification — Review periodically and when conditions change or new information is available				Nuclear Condition Analyst
	Notify on-site personnel and facility management	Complete within 15 minutes of classification				Facility Response Manager
	Notify off-site authorities	Within 15 minutes of classification		Within 1 hour of classification		Facility Response Manager
	Recommend on-site protective actions	Immediately after classification and after major changes in radiological conditions; complete implementation within 1 hour				Protective Action Manager
	Activate on-site Emergency Response Team	Determine needed support and request immediately after classification; complete within 2 hours				Facility Response Manager
	Obtain support of off-site emergency services	Request support as soon as the need is recognized				Facility Response Manager
2	Develop environmental monitoring plan	Within 30 minutes after classification				Radiological Protection Manager
	Deploy on-site environmental monitoring teams	Within 30 minutes after classification; complete within 1 hour				Environmental Analyst
	Recommend off-site urgent protective actions	Within 30 minutes after classification		No off-site protective actions are expected to be required		Protective Action Manager
3	Initiate environmental monitoring off-site and near the facility	Within 1 hour after classification		No off-site environmental monitoring is expected to be required		Environmental Analyst
	Assess environmental monitoring results and revise environmental monitoring plan	On-site — complete within 1 hour after classification Off-site — Continuously, as environmental monitoring results are available				Radiological Protection Manager
	Review urgent protective actions	Continuously, as environmental monitoring results are available				Protective Action Manager
4	Project off-site radiological consequences	Commence within 1 hour using on-site environmental monitoring results		No off-site radiological consequences are expected		Projection Analyst

AG.B.1. RADIOLOGICAL PROTECTION MANAGER

ACTIONS

- Obtain a briefing on reactor conditions and radiological conditions from the previous Radiological Protection Manager.
- Verify expected activity for the next shift with the Facility Response Manager.
- Initiate/Continue actions from Table A.2, Emergency Response Priorities. Verify accountability of all personnel on the reactor site.
- Develop a plan for environmental monitoring priorities, or continue an existing plan, based on the specific event, Table B.2, Environmental Monitoring Priorities, and the emergency class.
- Communicate the monitoring plan to the Environmental Analyst and confirm initiation of the monitoring.
- Verify that the Environmental Analyst understands when monitoring data is to be immediately brought to the attention of the rest of the Emergency Response Team.

NOTE

Off-site protective actions are not normally initiated until the environmental monitoring shows conditions are exceeding OILs. Monitoring data needs to be rapidly disseminated to the rest of the Emergency Response Team so that the appropriate protective actions are recommended without delays.

- Brief on-site Emergency Workers on the Guidance Values for Limiting Exposure of Emergency Workers from Table B.1.
- Authorize Emergency Workers to exceed occupational exposure limits with necessary planned response tasks. Repeat the briefing of Table B.1 exposure guidance for Emergency Workers coming from off-site.

NOTE

For Monitoring Teams, this briefing may be included with the briefing by the Environmental Analyst for the survey they have been assigned. It is not required that the Radiological Protection Manager personally give the briefing, but the Radiological Protection Manager needs to ensure it has been delivered

- Ensure that no individuals leave the site until they are no longer needed and have been registered on Worksheet B.4, Registry Form For Persons Involved In Emergency.
- Review environmental survey information as it is received and keep the Facility Response Manager and the Protective Action Manager informed of environmental monitoring results.
- Maintain a record of information and the decisions resulting from that information. Use this record as briefing material for the next Radiological Protection Manager.

TABLE B.1. GUIDANCE VALUES FOR RESTRICTING EXPOSURE OF EMERGENCY WORKERS [12]

Tasks	Guidance value[a]
Life-saving actions	$H_P(10)$[b] < 500 mSv This value may be exceeded under the circumstances in which the expected benefits to others clearly outweigh the emergency worker's own health risks, and the emergency worker volunteers to take the action and understands and accepts this health risk
Actions to prevent severe deterministic effects and actions to prevent the development of catastrophic conditions that could significantly affect people and the environment	$H_P(10)$ < 500 mSv
Actions to avert a large collective dose	$H_P(10)$ < 100 mSv

[a] These values apply only for the dose from exposure to external penetrating radiation. Doses from exposure to non-penetrating external radiation and from intake or skin contamination need to be prevented by all possible means. If this is not feasible, the effective dose and the equivalent dose to an organ that are received have to be limited to minimize the health risk to the individual in line with the risk associated with the guidance values given here.

[b] $H_p(10)$ is the personal dose equivalent $H_p(d)$ where d = 10 mm.

TABLE B.2. ENVIRONMENTAL MONITORING PRIORITIES

Priority	When	Where	Survey Type	Objective	Results
1	After classification. Repeat every hour until readings are stable or decreasing, then every 4 hours.	On-site, up to the site boundary. Emphasize occupied areas. Use permanently installed instrumentation, where available, to reduce personal exposures.	All[a]	Measure dose rates on-site to establish safe areas and identify a release of radioactive material.	Immediately notify the Environmental Analyst if dose rates exceed OIL1. Record on Worksheet B.1 and provide copies to the Emergency Response Team.
2	After classification	Conduct surveys off-site starting at the site boundary and downwind of the reactor. If terrain or buildings could prevent release from reaching the ground this close to the site, start further out.	All[a]	Determine if a release from the reactor is occurring and identify where OIL1 is being exceeded. Measurements should be used to project where OIL1 may be exceeded.	Record on Worksheet B.2. Immediately notify the Environmental Analyst if readings exceed OIL1. If no release has been detected, continue surveys out to about 500 m from the site boundary
3	During a release from the site	Conduct surveys off-site starting where OIL1 is no longer exceeded.	All[a]	Identify where OIL2 is being exceeded. Measurements should be used to project where OIL2 may be exceeded.	Record on Worksheet B.2 and move survey outward to the areas that are projected to exceed OIL2.
4	During a release from the site	Conduct surveys off-site starting where OIL2 is no longer exceeded.	All[a]	Identify where OIL3 is being exceeded. Measurements should be used to project where OIL3 may be exceeded.	Record on Worksheet B.2 and move survey outward to the areas that are projected to exceed OIL3.
5	After release has ended or after plume passage	Areas where OIL3 was exceeded.	Gamma Spectroscopy Analysis	Measure plume deposition determine if OIL6 is exceeded	Record on Worksheet B.2.
6	After release has ended or after plume passage	At least twice the distance from the boundary where OIL3 was exceeded	Gamma Spectroscopy Analysis	Verify OIL6 is not being exceeded..	Record on Worksheet B.2.

[a] All types means measure α, β, and γ radiation.

AG.B.2. ENVIRONMENTAL ANALYST

ACTIONS

- Review the environmental monitoring data collected on prior shifts.
- Receive a briefing from the Radiological Protection Manager and the departing Environmental Analyst to include the emergency class, the status of the emergency response and the planned environmental surveys for the next few hours. Survey priorities are provided in Table B.2.

NOTE

The survey priorities are intended to define, in order of urgency, boundaries of territories where measurements exceed OIL1, then OIL2 and then OIL3. These OILs are provided in Table C.2.

- Determine what personal protective equipment the Monitoring Teams may require based on the expected radiation levels and the current required protective actions.

NOTE

Some of the environmental survey data may require updating to remain valid. This needs to be included in the planned surveys on this shift.

- Evaluate the need to repeat a prior survey based on current conditions compared to the conditions present for the first set of environmental measurements.

CAUTION

A change for the worse, such as an increase in an on-going release, may require an immediate resurvey of areas to determine if urgent protective actions are now required in areas that did not previously require them.

- Repeat surveys if a known change in conditions puts people thought to be safe at risk from the change. The most immediate need would be an expansion of the evacuation areas due to exceeding OIL1 criteria.
- Brief the Monitoring Teams using the guidance in Appendix II and assign specific monitoring tasks to each.
- Verify that the necessary monitoring equipment is operable and calibrated and that the appropriate personal protective equipment is available.

NOTE

General briefing guidance is provided in Appendix II. A written briefing sheet should be used and retained for each briefing.

- Demand immediate reports if any OIL criteria are exceeded and promptly provide that information to the Radiological Protection Manager and the Protective Action Manager.
- Maintain the worksheets that show the monitoring results.
- Bring results above background to the immediate attention of the Radiological Protection Manager and the Protective Action Manager.

NOTE

Urgent protective action determination is based on the environmental surveys. The survey results can also alter the monitoring plan so providing results to the Managers allows decisions to be made promptly.

- Review the monitoring plan with the Projection Analyst to determine if there are additional off-site areas to survey before having a monitoring team return to the site.

NOTE

Once a monitoring team is in the field, it may be more efficient to assign to them monitoring tasks for additional areas rather than lose time in travel back and forth between the site and the areas being surveyed.

- Maintain a record of information and the decisions resulting from that information. Use this record as briefing material for the next Environmental Analyst.

AG.B.3. DECONTAMINATION TEAM LEADER

ACTIONS

- Review logs and current worksheets to become familiar with the status of the emergency response and the current radiological environment.
- Receive a briefing from the Radiological Protection Manager and the departing Decontamination Team Lead.
- Obtain work direction and personnel assignments from the Radiological Protection Manager.
- Verify the approval to release specific individuals from the site.
- Brief the assigned team personnel as to their duties and responsibilities using the guidance in Appendix II.
- Verify suitability of equipment for the assigned tasks including knowledge of use of the proper instruments, calibration status of the instruments and additional materials needed.
- Perform the assigned tasks.
- Record information on all individuals on-site, including those who arrive after the emergency is declared, using Worksheet B.4, Registry Form For Persons Involved In Emergency.

NOTE

This worksheet is completed to be able to contact the individuals involved in the emergency if that becomes necessary at a later time.

- Complete Worksheet B.5, Victim Contamination Control Record (On-Scene Assessment), for any contaminated individuals.

CAUTION

A copy of Worksheet B.5 must be provided to the off-site medical treatment facility if an injured and contaminated individual is transported.

- Obtain concurrence from the Radiological Protection Manager for transport to an off-site medical treatment centre.
- Provide a knowledgeable escort with suitable radiation monitoring equipment for any contaminated individuals sent off-site for medical treatment unless the off-site medical treatment facility agrees no such assistance is necessary.
- Maintain a record of information and the decisions resulting from that information. Use this record as briefing material for the next Decontamination Team Lead.

AG.C.1.PROTECTIVE ACTION MANAGER

ACTIONS

- For an ongoing emergency, review current radiological status and receive a briefing from the departing Protective Action Manager and Projection Analyst.

- Verify expected activity for the next shift with the Facility Response Manager.

- Recommend on-site protective actions from Table C.1 after the emergency classification has been made by the Facility Response Manager. Record the recommendations and completion of implementation of the recommended actions on Worksheet C.4, On-site Protective Actions.

- Evaluate the need for urgent protective actions for off-site populations based on emergency classification. Recommended urgent protective actions for off-site populations are provided to the appropriate off-site authorities with a copy of Worksheet C.6, Recommended Off-Site Protective Actions.

NOTE

Sheltering is the easiest and least disruptive urgent protective action to recommend if fuel damage and a release are suspected until environmental survey information confirms that no protective action is necessary, or that additional actions should be recommended. Sheltering also collects people in their homes so that an evacuation is more orderly.

- If urgent protective actions are not considered appropriate prior to obtaining environmental survey data, recommend to the Facility Response Manager any preparations for urgent protective actions that should be proposed to off-site authorities. Preparations for off-site urgent protective actions for off-site populations are provided to the appropriate off-site authorities with a copy of Worksheet C.5, Preparation For Off-Site Protective Actions.

- Continuously review developing radiological information and evaluate the need for revisions to the on-site protective actions, and initiation of urgent protective actions off-site. Table C.2 lists the appropriate on-site and off-site protective actions based on environmental measurements.

CAUTION

When an OIL is exceeded at one location in a sector, it is assumed that other locations in the same sector are also exceeding the OIL and the protective actions should be applied to the entire sector. Because of uncertainties in the path that the release can take, adjacent sectors may also be exceeding the OIL.

- Recommend urgent protective action to the Facility Response Manager in any sector where environmental measurements exceed an OIL. Consider applying the same protective actions to adjacent sectors as well. All the protective actions associated with an OIL that has been exceeded should be recommended at the same time. Recommended urgent protective actions for off-site populations are provided to the appropriate off-site authorities with a copy of Worksheet C.6, Recommended Off-Site Protective Actions.

- Recommend to the Radiological Protection Manager where additional radiological surveys are needed based on projection of potential or actual releases.

NOTE

Application of urgent protective actions is based on environmental measurements, not on a projection.

- Maintain a record of any recommended protective actions, the area in which they were to be established and the time at which they were confirmed to have been completed. Use Worksheets C.4 and C.6 for these records.

- Alert The Radiological Protection Manager if OIL4 criteria have been exceeded and on-site decontamination is needed.

- Evaluate the isotopes present in off-site and on-site deposition samples to determine if the default OILs may be recalculated for the existing conditions.

- Evaluate the isotopes present in off-site food, milk and water samples to determine if the default OIL6 may be recalculated for the conditions.

CAUTION

The basis for the default OILs may cause them to be more restrictive than the actual conditions require. A change to an OIL must be readily explained in plain language to the off-site authorities, and receive their concurrence.

- Propose to the Facility Response Manager revised OILs based on the isotopes present in samples.

- Maintain a record of information and the decisions resulting from that information. Use this record as briefing material for the next Protective Action Manager.

TABLE C.1. PROTECTIVE ACTIONS BASED ON CLASSIFICATION

Protective actions	Classification[a]		
	Facility Emergency	Site Area Emergency	General Emergency
Evacuate or shelter non-essential personnel at the reactor site	✓	✓	✓
Provide on-site personnel and emergency workers with thyroid blocking agent, self-reading dosimeter and respiratory protection as required and brief them on exposure guidance	✓	✓	✓
Prepare for evacuation or sheltering of the public within urgent protective action planning zone		✓	
Recommend sheltering and preparations for evacuation within the urgent protective action planning zone and await further instructions			✓
Recommend public within 50 km to avoid eating potentially contaminated food or milk			✓
Recommend to off-site officials to implement restriction of consumption of potentially contaminated food up to 50 km from the reactor			✓
Initiate the system for tracking potentially highly exposed individuals for later medical follow-up	✓	✓	✓

a No urgent protective actions are suggested for Alert. If desired, the site can establish the on-site protective actions considered appropriate for this emergency class.

TABLE C.2. DEFAULT OILs FOR FIELD SURVEY MEASUREMENTS [12]

OIL	OIL value	Response action (as appropriate) if the OIL is exceeded
Environmental measurements		
OIL1	Gamma (γ) 1000 μSv/h at 1 m from surface or a source 2000 cps direct beta (β) surface contamination measurement[e] 50 cps direct alpha (α) surface contamination measurement[f]	• Immediately evacuate or provide substantial shelter[a] • Provide for decontamination of evacuees[b] • Reduce inadvertent ingestion[c] • Stop consumption of local produce[d], rainwater and milk from animals grazing in the area • Register and provide for a medical examination of evacuees • If a person has handled a source with a dose rate equal to or exceeding the 1000 μSv/h at 1 m[e] provide an immediate medical examination
OIL2	Gamma (γ) 100 μSv/h at 1 m from surface or a source 200 cps direct beta particle (β) surface contamination measurement[f] 10 cps direct alpha particle (α) surface contamination measurement[f]	• Stop consumption of local produce[d], rainwater and milk from animals grazing in the area until it has been screened and contamination levels have been assessed using OIL5 and OIL6 • Temporarily relocate those living in the area; before relocation reduce inadvertent ingestion[c]. Register and estimate the dose to those in the area before relocation to determine if medical screening is warranted. Relocation of the areas with the highest potential exposure should begin within days • If a person has handled a source with a dose rate equal to or exceeding the 100 μSv/h at 1 m[e], provide medical examination evaluation; any pregnant women who have handled such a source should receive an immediate medical evaluation and dose assessment
OIL3	Gamma (γ) 1 μSv/h at 1 m from surface 20 cps direct beta (β) surface contamination measurement[f, i] 2 cps direct alpha (α) surface contamination measurement[f, i]	• Stop consumption of non-essential[g] local produce[d], rainwater and milk from animals[h] grazing in the area until it has been screened and contamination levels have been assessed using OIL5 and OIL6 • Screen local produce, rainwater and milk from animals[h] grazing in the area at least 10 times the distance to which OIL3 is exceeded and assess samples using OIL5 and OIL6 • Consider providing iodine thyroid blocking[j] for fresh fission products[k] and for iodine contamination if replacement for essential[g] local produce or milk is not immediately available • Estimate the dose of those who may have consumed food milk or rainwater from the area where restrictions were implemented to determine if medical screening is warranted
Skin contamination		
OIL4	Gamma (γ) 1 μSv/h at 10 cm from the skin 1000 cps direct beta (β) skin contamination measurement[f] 50 cps direct alpha (α) skin contamination measurement[f]	• Provide for skin decontamination[b] and reduce inadvertent ingestion[c] • Register and provide for a medical examination

Note: The OILs should be revised as soon as it is known which radionuclides are actually involved. The OILs should also be revised, if necessary, as part of the preparedness process, to be more consistent with the instruments to be used during the response. However, the default OILs in this table can be used without revision to make a conservative assessment immediately.

a Inside closed halls of large multi-storey buildings or large masonry structures and away from walls or windows.

b If immediate decontamination is not practicable, advise evacuees to change their clothing and shower as soon as possible. Guidance for performing decontamination may be found in Refs [16] and [17].

c Advise evacuees not to drink, eat or smoke and keep hands away from the mouth until hands are washed.

d Local produce is food that is grown in open spaces that may be directly contaminated by the release and that is consumed within weeks (e.g. vegetables).

e This external dose rate criterion applies only to sealed dangerous sources and does not need to be revised in an emergency.

f Performed using good contamination monitoring practice.

g Restricting essential foods could result in severe health effects (e.g. severe malnutrition), and therefore essential foods should be restricted only if replacement food is available.

h Use 10% of OIL 3 for milk from small animals (e.g. goats) grazing in the area.

i Deposition by rain of short lived naturally occurring radon progeny can result in count rates of four or more times the background count rate. These rates should not be confused with the deposition rates due to the emergency. Count rates due to radon progeny will decrease rapidly after the rain stops and should be back to typical background levels within a few hours.

j Only for several days and only if replacement food is not available.

k Fission products that were produced within the last month, thus containing large amounts of iodine.

Criteria to determine suitability of instruments for Table C.2 may be found in Ref. [12].

TABLE C.3. DEFAULT SCREENING OILs FOR FOOD, MILK AND WATER ACTIVITY CONCENTRATIONS FROM LABORATORY ANALYSIS [12]

OIL	OIL value	Response action if the OIL is exceeded
OIL5	Gross beta (β): 100 Bq/kg or Gross alpha (α): 5 Bq/kg	Above OIL5: Assess using OIL6 (Table C.4) Below OIL5: Safe for consumption during emergency phase

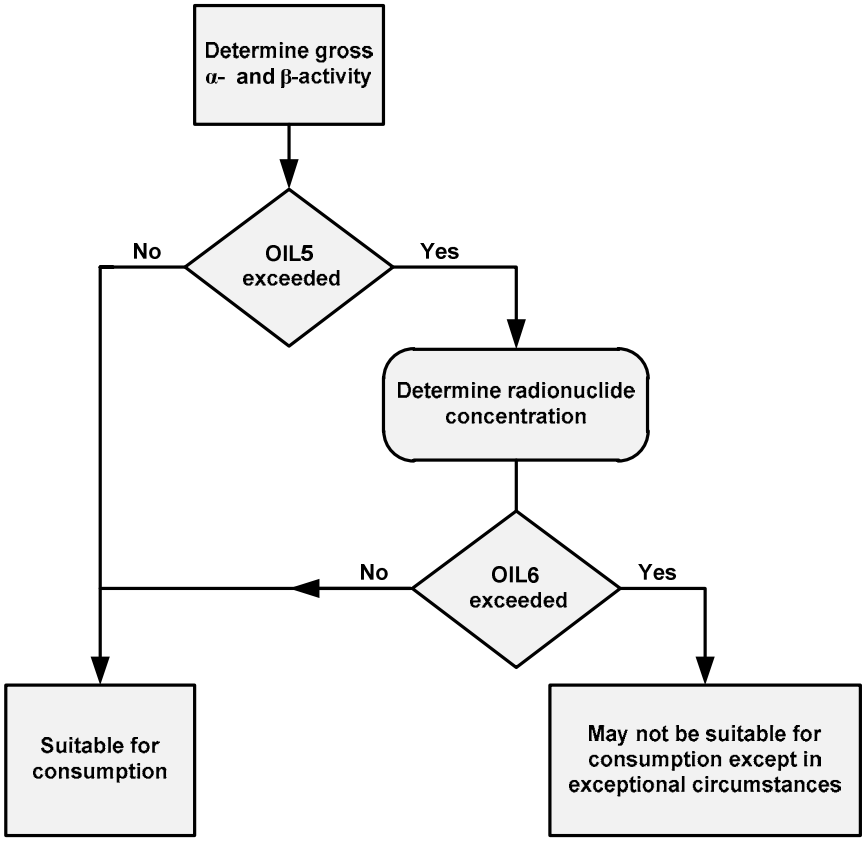


FIG. C.1. Determine Suitability of Foodstuffs.

TABLE C.4. DEFAULT RADIONUCLIDE SPECIFIC OILs FOR FOOD, MILK AND WATER ACTIVITY CONCENTRATIONS FROM LABORATORY ANALYSIS [12]

Radionuclide		OIL6, Bq/kg
H-3		2×10^5
Be-7		7×10^5
Be-10		3×10^3
C-11		2×10^9
C-14		1×10^4
F-18		2×10^8
Na-22		2×10^3
Na-24		4×10^6
Mg-28	+[a]	4×10^5
Al-26		1×10^3
Si-31		5×10^7
Si-32	+	9×10^2
P-32		2×10^4
P-33		1×10^5
S-35		1×10^4
Cl-36		3×10^3
Cl-38		3×10^8
K-40		NA[b, c]
K-42		3×10^6
K-43		4×10^6
Ca-41		4×10^4
Ca-45		8×10^3
Ca-47	+	5×10^4
Sc-44		1×10^7
Sc-46		8×10^3
Sc-47		4×10^5
Sc-48		3×10^5
Ti-44	+	6×10^2
V-48		3×10^4
V-49		2×10^5
Cr-51		8×10^5
Mn-52		1×10^5
Mn-53		9×10^4
Mn-54		9×10^3
Mn-56		3×10^7
Fe-52	+	2×10^6
Fe-55		1×10^4
Fe-59		9×10^3
Fe-60		7×10^1
Co-55		1×10^6
Co-56		4×10^3
Co-57		2×10^4
Co-58		2×10^4
Co-58m		9×10^7
Co-60		8×10^2
Ni-59		6×10^4
Ni-63		2×10^4
Ni-65		4×10^7
Cu-64		1×10^7
Cu-67		8×10^5
Zn-65		2×10^3
Zn-69		6×10^8
Zn-69m	+	3×10^6
Ga-67		1×10^6
Ga-68		2×10^8

TABLE C.4. DEFAULT RADIONUCLIDE SPECIFIC OILs FOR FOOD, MILK AND WATER ACTIVITY CONCENTRATIONS FROM LABORATORY ANALYSIS [12]

Radionuclide		OIL6, Bq/kg
Ga-72		1×10^6
Ge-68	+	3×10^3
Ge-71		5×10^6
Ge-77		6×10^6
As-72		4×10^5
As-73		3×10^4
As-74		3×10^4
As-76		4×10^5
As-77		1×10^6
Se-75		4×10^3
Se-79		7×10^2
Br-76		3×10^6
Br-77		5×10^6
Br-82		1×10^6
Rb-81		8×10^7
Rb-83		7×10^3
Rb-84		1×10^4
Rb-86		1×10^4
Rb-87		2×10^3
Sr-82	+	5×10^3
Sr-85		3×10^4
Sr-85m		3×10^9
Sr-87m		3×10^8
Sr-89		6×10^3
Sr-90	+	2×10^2
Sr-91		3×10^6
Sr-92		2×10^7
Y-87	+	4×10^5
Y-88		9×10^3
Y-90		9×10^4
Y-91		5×10^3
Y-91m		2×10^9
Y-92		1×10^7
Y-93		1×10^6
Zr-88		3×10^4
Zr-93		2×10^4
Zr-95	+	6×10^3
Zr-97	+	5×10^5
Nb-93m		2×10^4
Nb-94		2×10^3
Nb-95		5×10^4
Nb-97		2×10^8
Mo-93		3×10^3
Mo-99	+	5×10^5
Tc-95m	+	3×10^4
Tc-96		2×10^5
Tc-96m		2×10^9
Tc-97		4×10^4
Tc-97m		2×10^4
Tc-98		2×10^3
Tc-99		4×10^3
Tc-99m		2×10^8
Ru-97		2×10^6
Ru-103	+	3×10^4
Ru-105		2×10^7

TABLE C.4. DEFAULT RADIONUCLIDE SPECIFIC OILs FOR FOOD, MILK AND WATER ACTIVITY CONCENTRATIONS FROM LABORATORY ANALYSIS [12]

Radionuclide		OIL6, Bq/kg
Ru-106	+	6×10^{2}
Rh-99		1×10^{5}
Rh-101		8×10^{3}
Rh-102		2×10^{3}
Rh-102m		5×10^{3}
Rh-103m		5×10^{9}
Rh-105		1×10^{6}
Pd-103	+	2×10^{5}
Pd-107		7×10^{4}
Pd-109	+	2×10^{6}
Ag-105		5×10^{4}
Ag-108m	+	2×10^{3}
Ag-110m	+	2×10^{3}
Ag-111		7×10^{4}
Cd-109	+	3×10^{3}
Cd-113m		4×10^{2}
Cd-115	+	2×10^{5}
Cd-115m		6×10^{3}
In-111		1×10^{6}
In-113m		4×10^{8}
In-114m	+	3×10^{3}
In-115m		5×10^{7}
Sn-113	+	1×10^{4}
Sn-117m		7×10^{4}
Sn-119m		1×10^{4}
Sn-121m	+	5×10^{3}
Sn-123		3×10^{3}
Sn-125		2×10^{4}
Sn-126	+	5×10^{2}
Sb-122		2×10^{5}
Sb-124		5×10^{3}
Sb-125	+	3×10^{3}
Sb-126		3×10^{4}
Te-121		1×10^{5}
Te-121m	+	3×10^{3}
Te-123m		5×10^{3}
Te-125m		1×10^{4}
Te-127		1×10^{7}
Te-127m	+	3×10^{3}
Te-129		2×10^{8}
Te-129m	+	6×10^{3}
Te-131		4×10^{8}
Te-131m		3×10^{5}
Te-132	+	5×10^{4}
I-123		5×10^{6}
I-124		1×10^{4}
I-125		1×10^{3}
I-126		2×10^{3}
I-129		NA[d]
I-131		3×10^{3}
I-132		2×10^{7}
I-133		1×10^{5}
I-134		2×10^{8}
I-135		2×10^{6}
Cs-129		1×10^{7}

For footnotes see end of table.

TABLE C.4. DEFAULT RADIONUCLIDE SPECIFIC OILs FOR FOOD, MILK AND WATER ACTIVITY CONCENTRATIONS FROM LABORATORY ANALYSIS [12]

Radionuclide		OIL6, Bq/kg
Cs-131		2×10^{6}
Cs-132		4×10^{5}
Cs-134		1×10^{3}
Cs-134m		3×10^{8}
Cs-135		9×10^{3}
Cs-136		4×10^{4}
Cs-137	+	2×10^{3}
Ba-131	+	1×10^{5}
Ba-133		3×10^{3}
Ba-133m		9×10^{5}
Ba-140	+	1×10^{4}
La-137		4×10^{4}
La-140		2×10^{5}
Ce-139		3×10^{4}
Ce-141		3×10^{4}
Ce-143		5×10^{5}
Ce-144	+	8×10^{2}
Pr-142		6×10^{5}
Pr-143		4×10^{4}
Nd-147		6×10^{4}
Nd-149		8×10^{7}
Pm-143		3×10^{4}
Pm-144		6×10^{3}
Pm-145		3×10^{4}
Pm-147		1×10^{4}
Pm-148m	+	1×10^{4}
Pm-149		3×10^{5}
Pm-151		8×10^{5}
Sm-145		2×10^{4}
Sm-147		1×10^{2}
Sm-151		3×10^{4}
Sm-153		5×10^{5}
Eu-147		8×10^{4}
Eu-148		2×10^{4}
Eu-149		9×10^{4}
Eu-150b		3×10^{6}
Eu-150a		4×10^{3}
Eu-152		3×10^{3}
Eu-152m		4×10^{6}
Eu-154		2×10^{3}
Eu-155		1×10^{4}
Eu-156		2×10^{4}
Gd-146	+	8×10^{3}
Gd-148		1×10^{2}
Gd-153		2×10^{4}
Gd-159		2×10^{6}
Tb-157		9×10^{4}
Tb-158		3×10^{3}
Tb-160		7×10^{3}
Dy-159		7×10^{4}
Dy-165		7×10^{7}
Dy-166	+	6×10^{4}
Ho-166		5×10^{5}
Ho-166m		2×10^{3}
Er-169		2×10^{5}

TABLE C.4. DEFAULT RADIONUCLIDE SPECIFIC OILs FOR FOOD, MILK AND WATER ACTIVITY CONCENTRATIONS FROM LABORATORY ANALYSIS [12]

Radionuclide		OIL6, Bq/kg
Er-171		6×10^{6}
Tm-167		1×10^{5}
Tm-170		5×10^{3}
Tm-171		3×10^{4}
Yb-169		3×10^{4}
Yb-175		4×10^{5}
Lu-172		1×10^{5}
Lu-173		2×10^{4}
Lu-174		1×10^{4}
Lu-174m		1×10^{4}
Lu-177		2×10^{5}
Hf-172	+	2×10^{3}
Hf-175		3×10^{4}
Hf-181		2×10^{4}
Hf-182	+	1×10^{3}
Ta-178a		1×10^{8}
Ta-179		6×10^{4}
Ta-182		5×10^{3}
W-178	+	2×10^{5}
W-181		1×10^{5}
W-185		2×10^{4}
W-187		1×10^{6}
W-188	+	3×10^{3}
Re-184		2×10^{4}
Re-184m	+	3×10^{3}
Re-186		1×10^{5}
Re-187		5×10^{5}
Re-188		7×10^{5}
Re-189		8×10^{5}
Os-185		2×10^{4}
Os-191		8×10^{4}
Os-191m		1×10^{7}
Os-193		7×10^{5}
Os-194	+	8×10^{2}
Ir-189		2×10^{5}
Ir-190		6×10^{4}
Ir-192		8×10^{3}
Ir-194		6×10^{5}
Pt-188	+	6×10^{4}
Pt-191		9×10^{5}
Pt-193		8×10^{4}
Pt-193m		3×10^{5}
Pt-195m		3×10^{5}
Pt-197		2×10^{6}
Pt-197m		1×10^{8}
Au-193		8×10^{6}
Au-194		1×10^{6}
Au-195		2×10^{4}
Au-198		3×10^{5}
Au-199		5×10^{5}
Hg-194	+	2×10^{2}
Hg-195		2×10^{7}
Hg-195m		8×10^{5}
Hg-197		1×10^{6}
Hg-197m		2×10^{6}

For footnotes see end of table.

TABLE C.4. DEFAULT RADIONUCLIDE SPECIFIC OILs FOR FOOD, MILK AND WATER ACTIVITY CONCENTRATIONS FROM LABORATORY ANALYSIS [12]

Radionuclide		OIL6, Bq/kg
Hg-203		1×10^4
Tl-200		5×10^6
Tl-201		3×10^6
Tl-202		2×10^5
Tl-204		3×10^3
Pb-201		2×10^7
Pb-202	+	1×10^3
Pb-203		2×10^6
Pb-205		2×10^4
Pb-210	+	2.0
Pb-212	+	2×10^5
Bi-205		7×10^4
Bi-206		8×10^4
Bi-207		3×10^3
Bi-210		1×10^5
Bi-210m		2×10^2
Bi-212	+	7×10^7
Po-210		5.0
At-211	+	2×10^5
Ra-223	+	4×10^2
Ra-224	+	2×10^3
Ra-225	+	2×10^2
Ra-226	+	2×10^1
Ra-228		3.0
Ac-225		3×10^3
Ac-227	+	5.0
Ac-228		7×10^6
Th-227	+	9×10^1
Th-228	+	2×10^1
Th-229	+	8.0
Th-230		5×10^1
Th-231		2×10^6
Th-232		4.0
Th-234	+	8×10^3
Pa-230		5×10^4
Pa-231		2×10^1
Pa-233		3×10^4
U-230	+	8×10^2
U-232		2×10^1
U-233		1×10^2
U-234		2×10^2
U-235	+	2×10^2
U-236		2×10^2
U-238	+	1×10^2
Np-235		7×10^4
Np-236l	+	8×10^2
Np-236s		4×10^6
Np-237	+	9×10^1
Np-239		4×10^5
Pu-236		1×10^2
Pu-237		2×10^5
Pu-238		5×10^1
Pu-239		5×10^1
Pu-240		5×10^1
Pu-241		4×10^3

TABLE C.4. DEFAULT RADIONUCLIDE SPECIFIC OILs FOR FOOD, MILK AND WATER ACTIVITY CONCENTRATIONS FROM LABORATORY ANALYSIS [12]

Radionuclide		OIL6, Bq/kg
Pu-242		5×10^1
Pu-244	+	5×10^1
Am-241		5×10^1
Am-242m	+	5×10^1
Am-243	+	5×10^1
Am-244		4×10^6
Cm-240		4×10^3
Cm-241		3×10^4
Cm-242		5×10^2
Cm-243		6×10^1
Cm-244		7×10^1
Cm-245		5×10^1
Cm-246		5×10^1
Cm-247		6×10^1
Cm-248		1×10^1
Bk-247		2×10^1
Bk-249		1×10^4
Cf-248		2×10^2
Cf-249		2×10^1
Cf-250		4×10^1
Cf-251		2×10^1
Cf-252		4×10^1
Cf-253		3×10^4
Cf-254		3×10^1
Es-253		5×10^3
Pu-239/Be-9		5×10^1
Am-241/Be-9		5×10^1

a '+' indicates radionuclides with progeny listed in Table C.5 that are assumed to be in equilibrium with the parent radionuclide and therefore do not need to be considered independently when assessing compliance with OILs.

b NA: not applicable.

c The dose from ingestion of K-40 is considered not to be relevant because K-40 does not accumulate in the body and it is maintained at a constant level independent of intake [18].

d Not a significant source of radiation because of the low specific activity.

TABLE C.5. EQUILIBRIUM RADIOACTIVE CHAINS [12]

Parent radionuclide	Progeny radionuclides considered in OIL6 assessment as being in equilibrium with the parent
Mg-28	Al-28
Si-32	P-32
Ca-47	Sc-47 (3.8)[a]
Ti-44	Sc-44
Fe-52	Mn-52m
Zn-69m	Zn-69 (1.1)
Ge-68	Ga-68
Sr-90	Y-90
Y-87	Sr-87m
Zr-95	Nb-95 (2.2)
Zr-97	Nb-97m (0.95), Nb-97
Tc-95m	Tc-95 (0.041)
Mo-99	Tc-99m (0.96)
Ru-103	Rh-103m
Ru-106	Rh-106
Pd-103	Rh-103m
Pd-109	Ag-109m
Ag-108m	Ag-108 (0.09)
Ag-110m	Ag-110 (0.013)
Cd-109	Ag-109m
Cd-115	In-115m (1.1)
In-114m	In-114 (0.96)
Sn-113	In-113m
Sn-121m	Sn-121 (0.78)
Sn-126	Sb-126m, Sb-126 (0.14)
Sb-125	Te-125m (0.24)
Te-121m	Te-121
Te-127m	Te-127
Te-129m	Te-129 (0.65)
Te-132	I-132
Cs-137	Ba-137m
Ba-131	Cs-131 (5.6)
Ba-140	La-140 (1.2)
Ce-144	Pr-144m (0.018), Pr-144
Pm-148m	Pm-146 (0.053)
Gd-146	Eu-146
Dy-166	Ho-166 (1.5)
Hf-172	Lu-172
Hf-182	Ta-182
W-178	Ta-178a
W-188	Re-188
Re-184m	Re-184 (0.97)
Os-194	Ir-194
Pt-188	Ir-188 (1.2)
Hg-194	Au-194
Pb-202	Tl-202
Pb-210	Bi-210, Po-210

TABLE C.5. EQUILIBRIUM RADIOACTIVE CHAINS [12]

Parent radionuclide	Progeny radionuclides considered in OIL6 assessment as being in equilibrium with the parent
Pb-212	Bi-212 , Tl-208 (0.4), Po-212 (0.71)
Bi-210m	Ti-206
Bi-212	Tl-208 (0.36), Po-212 (0.65)
At-211	Po-211 (0.58)
Rn-222	Po-218, Pb-214, Bi-214, Po-214
Ra-223	Rn-219, Po-215, Pb-211, Bi-211, Tl-207
Ra-224	Rn-220, Po-216, Pb-212 , Bi-212, Tl-208 (0.36), Po-212 (0.65)
Ra-225	Ac-225 (3.0), Fr-221 (3.0), At-217 (3.0), Bi-213 (3), Po-213 (2.9), Pb-209 (2.9), Tl-209 (0.067), Pb-209 (0.067)
Ra-226	Rn-222, Po-218, Pb-214, Bi-214, Po-214
Ac-225	Fr-221, At-217, Bi-213, Po-213 (0.98), Pb-209, Tl-209 (0.022)
Ac-227	Th-227 (0.99), Ra-223 (0.99), Rn-219 (0.99), Po-215 (0.99), Pb-211 (0.99), Bi-211 (0.99), Tl-207 (0.99), Fr-223 (0.014), Ra-223 (0.014), Rn-219 (0.014), Po-215 (0.014), Pb-211 (0.014), Bi-211 (0.014), Tl-207 (0.014)
Th-227	Ra-223 (2.6), Rn-219 (2.6), Po-215 (2.6), Pb-211 (2.6), Bi-211 (2.6), Tl-207 (2.6)
Th-228	Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.036), Po-212 (0.64)
Th-229	Ra-225, Ac-225, Fr-221, At-217, Bi-213, Po-213 (0.98), Pb-209 (0.98), Tl-209 (0.02), Pb-209 (0.02)
Th-234	Pa-234m
U-232	Th-226, Ra-222, Rn-218, Po-214
U-235	Th-231
U-238	Th-234, Pa-234m
Np-237	Pa-233
Pu-244	U-240, Np-240m
Am-242m	Am-242, Cm-242 (0.83)
Am-243	Np-239

a The value inside the parentheses is the activity of the daughter radionuclide, per unit of the parent, assumed to be present.

OIL6 is exceeded if the following is satisfied:

$$\sum_i \frac{C_{f,i}}{OIL6_i} > 1$$

where:

$C_{f,i}$ is the activity concentration of radionuclide *i* in the food, milk or drinking water (Bq/kg);

$OIL6_i$ is the activity concentration of radionuclide *i* from Table C.4 (Bq/kg).

If OIL 6 is exceeded the following actions should be taken:

- Stop consumption of non-essential[16] food, milk or drinking water and conduct an assessment on the basis of realistic consumption rates. Replace essential food, milk and water promptly or relocate people if replacement of essential food, milk and water is not possible.

- For fission product (e.g. containing iodine) and iodine contamination, consider providing iodine thyroid blocking if replacement of essential food, milk or water is not immediately possible.

- Estimate the dose of those who may have consumed milk, food or rain water from the area where restrictions were implemented to determine if medical screening is warranted. Medical management criteria are provided in Ref. [12].

[16] Restriction of consumption of essential food could result in severe health effects (e.g. severe malnutrition).

AG.C.2. PROJECTION ANALYST

ACTIONS

- Review the current status of environmental measurements and any projection calculations already completed.
- Obtain a briefing from the Protection Action Manager and the departing Protection Analyst.
- Contact the Environmental Analyst to determine the environmental sampling plans for this shift and what projections may be needed.

CAUTION

Projected protective action distances are only estimates and are used to decide where additional sampling should be done. These projections may be as much as a factor of 10 in error due to uncertainties and weather. Emergency class or data from environmental surveys will determine recommended protective actions.

- Use current environmental survey measurements and project distances for various protective actions on Worksheet C.3, Protective Action Projections. Review results with the Protective Action Manager.
- Present projection calculations to the Environmental Analyst to help decide where additional sampling should be done.

NOTE

Use the projections to make the sampling plan efficient in time and manpower.

CAUTION

The use of computer software to predict the dispersion of radioactive material is not always accurate and should not replace environmental surveys. Worksheet C.3 calculations may be just as accurate, and can be performed more quickly.

- If radiological consequence assessment software, such as InterRAS [1], is available, setup and run cases to be able to evaluate the potential spread of radioactivity with appropriate weather conditions. Repeat this step if weather conditions change.
- Review results from the step above with the Environmental Analyst and the Protective Action Manager to determine if the current or planned sampling plan should be modified.
- Maintain a record of information and the decisions resulting from that information. Use this record as briefing material for the next Projection Analyst.

AG.D.1. NUCLEAR CONDITION ANALYST

(Some steps below may be revised to contain more specific values, such as radiation levels for certain actions, or containment conditions that indicate leakage rates.)

ACTION

- Review information previously collected regarding the status of the emergency, such as Worksheet D.1 if already completed.

- Receive a briefing from the Facility Response Manager and the departing Nuclear Condition Analyst.

- Review Table A.1 and recommend an emergency classification or a change to the existing classification, as appropriate, to the Facility Response Manager. This decision by the Facility Response Manager is expected with 15 minutes of declaring an emergency exists.

- Record the emergency conditions and reactor condition on Worksheet D.1, Emergency Condition Assessment.

- Evaluate the operational information regarding reactor status and containment condition. Based on known radiation levels, determine if fuel damage has already occurred and assess the potential for future fuel damage. Figure D.1 is a guide. Record information on Worksheets D.1, Emergency Condition Assessment, and D.2, Fuel Damage and Containment Assessment.

NOTE

The presence or absence of fuel damage is an important determination to make because it can initiate specific monitoring for a release and assist an early decision regarding protective actions for on-site and off-site.

- If fuel damage is known or suspected, inform the Facility Response Manager, Radiological Protection Manager and Protective Action Manager and review the emergency classification.

NOTE

Fuel damage may not have been considered in the initial emergency classification decision. Known or suspected fuel damage could cause a change in emergency classification or protective actions on-site and off-site.

- Assess the potential for release from containment using Table D.1. Record the assessment details on Worksheet D.2, Fuel Damage and Containment Assessment.

- If a release is likely, inform the Radiological Protection Manager of the sectors on-site and off-site to be sampled to verify the presence or absence of a release and its magnitude.

NOTE

A known containment or reactor building confinement deficiency can help guide the monitoring to rapid detection of a release.

- Periodically review reactor conditions for changes that could cause a change in the determination of fuel damage or release potential if fuel damage has occurred. Prepare a new Worksheet D.1, Emergency Condition Assessment, or D.2, Fuel Damage and Containment/Confinement Assessment, as necessary if changes have occurred that invalidate a prior copy.

- Maintain a record of information and the decisions resulting from that information. Use this record as briefing material for the next Nuclear Condition Analyst.

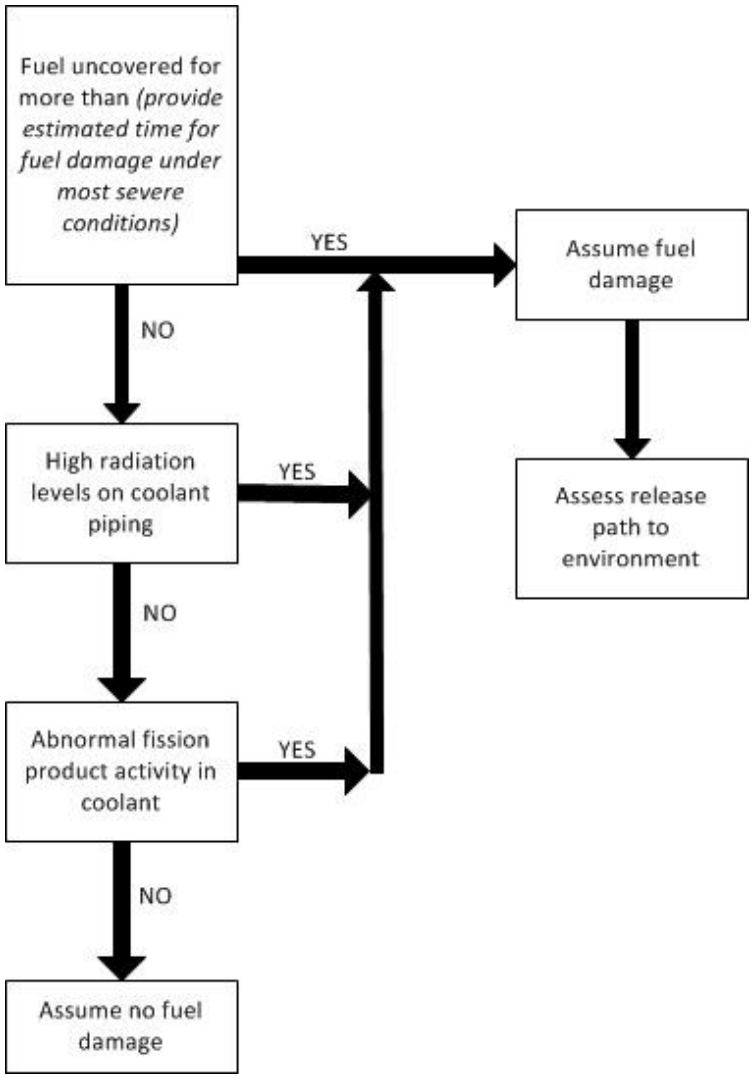


FIG. D1 Fuel Damage Assessment

Instructions for customization of Figure D.1:

Figure D.1 requires a value for time to damage of uncovered fuel to help the Nuclear Condition Analyst assess if fuel damage has occurred or is likely to occur before the fuel can be covered with coolant. If known, both a time interval for gap release and one for fuel melt

should be provided based on the maximum power history. Alternatively, a chart or graph that plots time to fuel damage versus recent power history could be provided with the procedure.

Radiation levels on coolant piping can be an indicator of fuel damage. Radiation levels at specific locations should be recorded at various power levels under normal operating conditions. Subsequent measurements during an emergency can be compared to these normal values to assess the release of fission products from the fuel. Permanently installed radiation detectors on selected piping can permit these comparisons to be made even if radiation levels prevent access. Absence of coolant flow will reduce the usefulness of these measurements.

TABLE D.1. CONTAINMENT RELEASE RATE GUIDE

The release rate will be very difficult to determine and is the most important information to determine the off-site threats. Use the rate that best fits observations and a worst case estimate. Reality will probably be somewhere in between those two cases. Reactors with only confinement need to determine release based on ventilation turnover, any operable filtering or other process to remove airborne particulate and gaseous fission products. If none are available, assume a release rate based on building ventilation turnover, or 100% per hour.

Release Rate	Containment Release Condition
100% per hour	• Intentional venting of containment • No containment
100% per day	• Containment has design leak rate > 1% per day and is isolated • Containment not fully isolated
< 0.1 % per day	• Containment has a design leak rate < 1% per day and is isolated

AG.E.1. COMMUNICATOR

ACTIONS

- Review logs and current worksheets to become familiar with the emergency response status.
- Receive a briefing from the Facility Response Manager and departing Communicator.
- When all shift changes have been completed, verify that Worksheet A.1 has been updated, or update the worksheet.
- Perform notifications as directed by the Facility Response Manager using Worksheet E.1, Call List for Off-Site Contact Points, for contact information. Maintain Worksheet E.2, Emergency Notification Record, to make sure a necessary notification is not overlooked.
- Establish/Maintain contact with the Public Information Coordinator who is on the off-site response team.
- With guidance from the Facility Response Manager, prepare initial and subsequent public information releases for review and approval of the Facility Response Manager or a designated alternate.

CAUTION

Reviews with off-site authorities are to allow them to propose revisions to the information. Off-site authorities should be reminded to not release any information unless the Facility Response Manager has authorized the release.

- Review pending information releases with off-site authorities.
- Release information to the public through the off-site authorities when authorized by the Facility Response Manager.

NOTE

Prompt and correct information is important to prevent inappropriate public response to the emergency.

- Initiate updates to off-site contacts as directed by the Facility Response Manager when significant information becomes available or changes.
- Bring new information from off-site to the attention of the Facility Response Manager.
- Keep the Facility Response Manager apprised of off-site responses and requests for information.
- Maintain a record of information and the decisions resulting from that information. Use this record as briefing material for the next Communicator.

AG.F.1. PLANT SECURITY MANAGER

ACTIONS

- Review logs and current worksheets to become familiar with the emergency response status.
- Obtain a briefing on site security, reactor conditions and radiological conditions from the previous Plant Security Manager.
- Verify expected activity for the next shift with the Facility Response Manager.
- Initiate/Continue actions from the site Security Plan in such a way that they are coordinated with other response actions (response procedures).
- Verify the appropriate radiological protection for site Security personnel based on reactor conditions.
- When emergency assistance is requested from off-site, inform the entry gate personnel of the expected arrival time and which emergency service is expected, such as fire truck, ambulance, or others. Direct the entry gate personnel to maintain a record of these arrivals for later registration on Worksheet B.4.

NOTE

Off-site assistance is expected to be requested quickly once the need is recognized. Verify with the Facility Response Manager such requests need to be provided to the site Security personnel.

- Ensure that individuals leave the site only when the Radiological Protection Manager has confirmed the individuals are not required for the emergency response and are not contaminated or injured.
- Report to the Facility Response Manager when the requested off-site emergency responders have arrived.
- Prepare and deliver periodic briefings on the site security situation as requested by the Facility Response Manager
- Maintain a record of information and the decisions resulting from that information. Use this record as briefing material for the next Plant Security Manager.

WORKSHEETS

Performed by: *Facility Response Manager*	**WORKSHEET A.1. RESPONSE ORGANIZATION ASSIGNMENTS**	No. _____

(Revise the distribution list below based on the site Emergency Plan)
(May also add on-site phone contact information to the distribution list if desired)

Date: _____

Prepared by: _____
(full name)

Time: _____

Provide copies to:

Facility Response Manager
Nuclear Condition Analyst
Off-Site Officials
Projection Analyst
Plant Security Manager
Radiological Protection Manager
Protective Action Manager
Communicator
Environmental Analyst

(Add other Positions based on the site plan for use of this worksheet)

Position	Person Assigned	Signature
Facility Response Manager		
Radiological Protection Manager		
Protective Action Manager		
Nuclear Condition Analyst		
Communicator		
Projection Analyst		
Environmental Analyst		
Incident Commander for Off-Site Responders		
Decontamination Team		
Monitoring Team A		
Monitoring Team B		
Off-Site Public Information Coordinator		
Plant Security Manager		

Instruction for the use of Worksheet A.1. Response Organization Assignments

This worksheet provides the members of the Emergency Response Team and the Off-Site Officials with a list of who, by name, is assigned to the response team positions. For emergencies that are quickly resolved, there may be only one such worksheet needed for the response. Emergency conditions that are extended to more than a single shift will prepare a new worksheet each shift to keep the information correct for the individuals on the shift.

Customization may consist of adding the names of the additional positions on the response team if the particular site assigns additional positions. The Distribution list for copies may need to be altered if there are additional positions. Similarly, site terminology for the names of the positions may be used.

Performed by: *Facility Response Manager*	**WORKSHEET A.2. FACILITY RESPONSE MANAGER'S CHECKLIST**	No. _____

Action Item	Complete
Mitigate the initiating event and verify correct response by reactor operations	
Classify event using Table A.1	
Notify on-site officials	
Determine the required emergency response positions and mobilize the personnel	
Account for all on-site personnel	
Implement urgent protective actions on-site	
Identify injured and/or contaminated individuals	
Notify off-site authorities, request necessary support	
Determine the potential for urgent protective actions off-site and inform authorities	
Measure on-site dose rates	
Re-evaluate on-site protective actions	
Verify no off-site radiation or extend surveys to off-site areas	
Map on-site contamination	
Arrange for first aid of injured personnel	
Initiate decontamination of on-site personnel	
Alert hospital if medical transport is necessary, identify radiological escort	
Recommend off-site protective actions, if required by monitoring results	
Develop initial public statement and establish contact with media	
Additional Actions (list below):	

Instructions for use of Worksheet A.2. Facility Response Manager's Checklist

This checklist is intended to be a one page list of actions that the Facility Response Manager would follow as the response to an emergency is conducted. The checklist is not a substitute for the Facility Response Manager Action Guide, but a resource to help in the implementation of the Action Guide and to help maintain awareness of the overall response.

The order of the action items roughly follows the priority of the response actions on the Action Guides for the Facility Response Manager and the other responders. It is expected that some items will be completed while items higher on the list are not yet reported as complete just due to the time required to perform certain items.

Customization of the checklist improve can its usefulness. Site-specific terminology and additional actions that are already a part of the site response to an emergency can be added. The positions responsible for performing the action items could also be added to increase the usefulness. It is suggested to leave a few lines at the end of the list to allow actions that may be very specific to the particular emergency to be added as the Facility Response Manager determines.

Performed by: _____	**WORKSHEET B.1. SITE RADIATION ENVIRONMENT (Page 1 of 3)**	No. _____ Time and Date: _____

(worksheets from Ref. [19] may be substituted)

Permanently Installed Instruments:

Site Location	Type	Reading	Recorded by

Portable Instrument Readings:

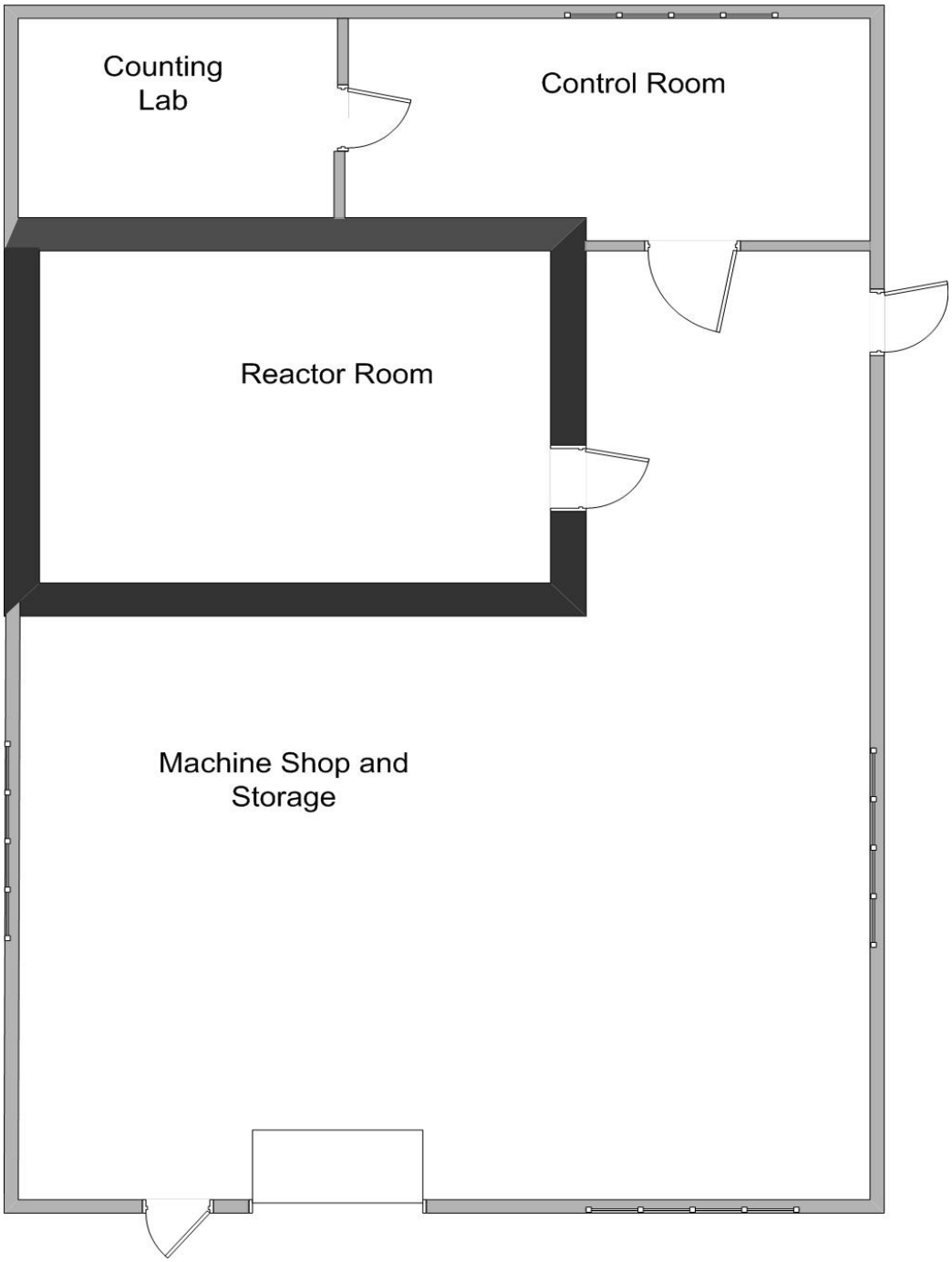
Site Location	Type	Reading	Recorded by

Ventilation System Activity

Site Location	Type	Reading	Recorded by

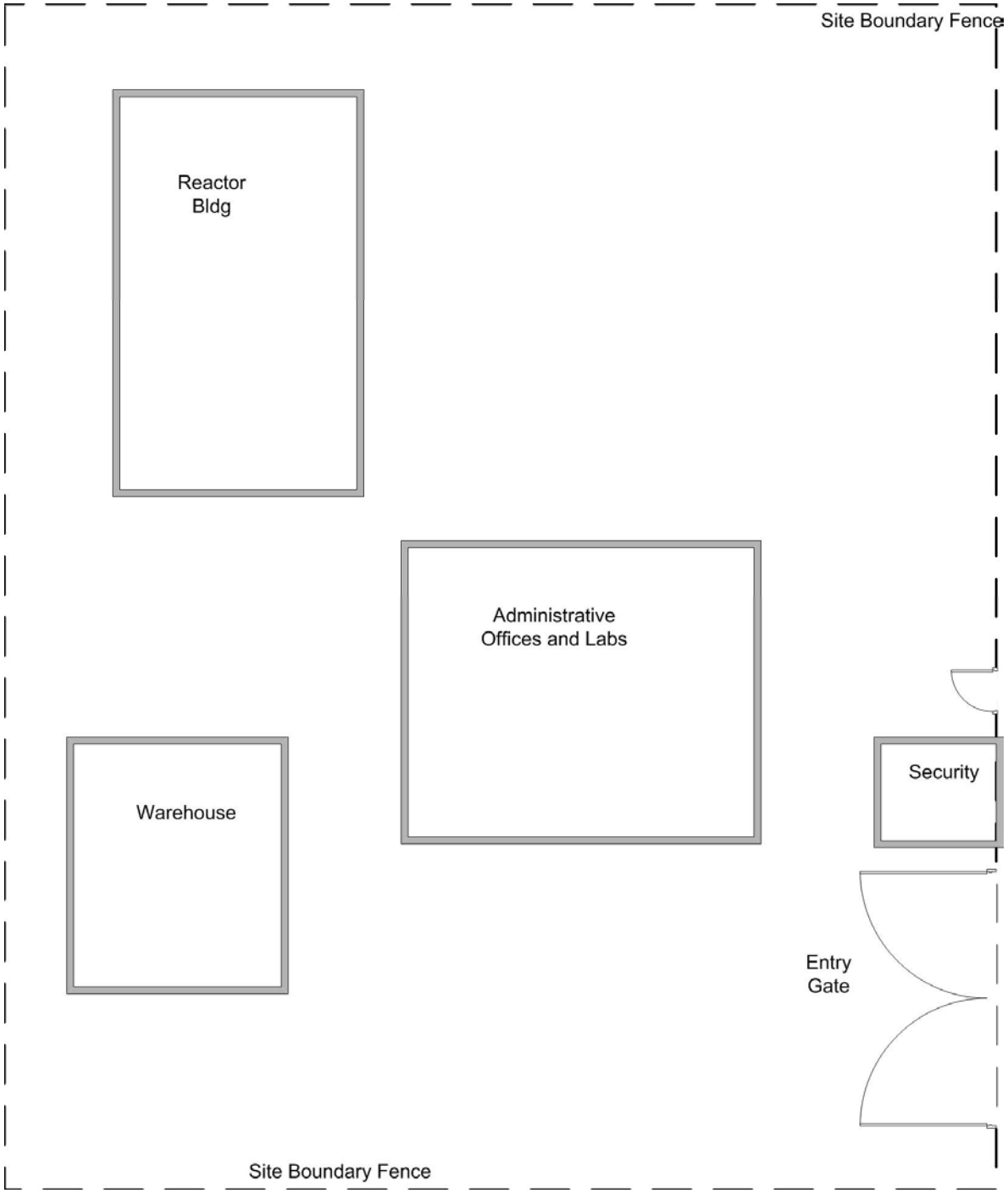
Performed by: _____	**WORKSHEET B.1. SITE RADIATION ENVIRONMENT (Page 2 of 3)**	No. _____ Time and Date: _____

(Replace with specific map, sketch below is an illustrative example)



Performed by: _____	**WORKSHEET B.1. SITE RADIATION ENVIRONMENT (Page 3 of 3)**	No. _____ Time and Date: _____

(Replace with specific site map, sketch below is an illustrative example)



Instructions for the use of Worksheet B.1. Site Radiation Environment

This is a multipage sample worksheet to record radiation monitoring results in and around the reactor. Page 1 of the worksheet provides a sample list of readings including permanently installed radiation detectors, some of which may be installed in ventilation systems, and portable instrument readings. The permanently installed instruments should be identified by name or location on preprinted copies of this page of the worksheet. That helps avoid confusion, and requires less time to provide information on the page. The right-most column provides a space for the individual who records the value to sign or initial.

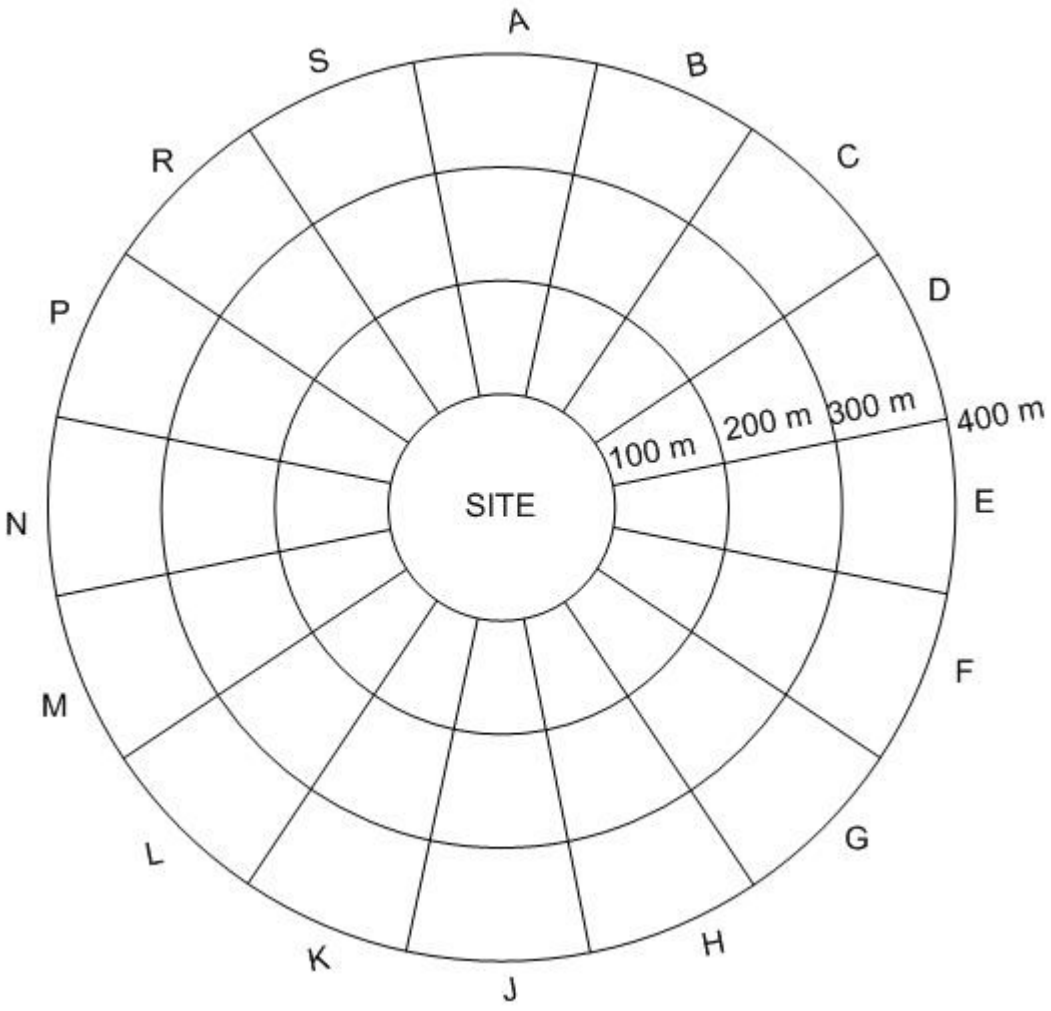
Portable instrument readings are often better displayed on building and site maps such as the examples on pages 2 and 3 of the worksheet. If the map format is chosen, then site-specific maps would replace the examples. Some sites may even choose to add additional pages. For example, a multireactor site may use the example pages 2 and 3, plus add a fourth page showing a map of the larger site and the other reactor locations.

The measurements most commonly used will be gamma dose rate values, however, contamination levels (measurements of both α and β particle emitting radionuclides) and airborne activity levels may be recorded depending upon the situation. Pages 2 and 3 suggest that a single map be used to show all readings with direct radiation and contamination differentiated by colour coding the numerical values. The worksheet should also agree on consistent units for all instrument readings of the same type. For example, it could be agreed that all gamma dose rates are recorded in μSv/h and all contamination levels in cps. That eliminates the need to write the units and makes the completed map more readable. This also corresponds to the units used by the OILs.

Since radiation readings may change with time during the emergency, the site needs to determine how often area surveys are repeated. It is recommended that a new map be prepared when revised survey information is obtained. Again, this helps to keep the survey map easier to read. An alternative method is to use sheets covered with plastic and write on them with a felt-tipped pen or a grease pencil that may be wiped off for a new reading when available. If that is selected, it is recommended that the map be photocopied to retain a record of the previous recorded values before replacing any numerical data.

Performed by: *Environmental Analyst*	**WORKSHEET B.2. NEAR-SITE DOSE RATE MEASUREMENTS 400 METRES (Page 1 of 2)**	No. _____

Prepared by: _____	Date: _____	Time: _____
Provide copies to:	Facility Response Manager	
Off-Site Authorities	Communicator	Projection Analyst
Radiological Protection Manager	Protective Action Manager	

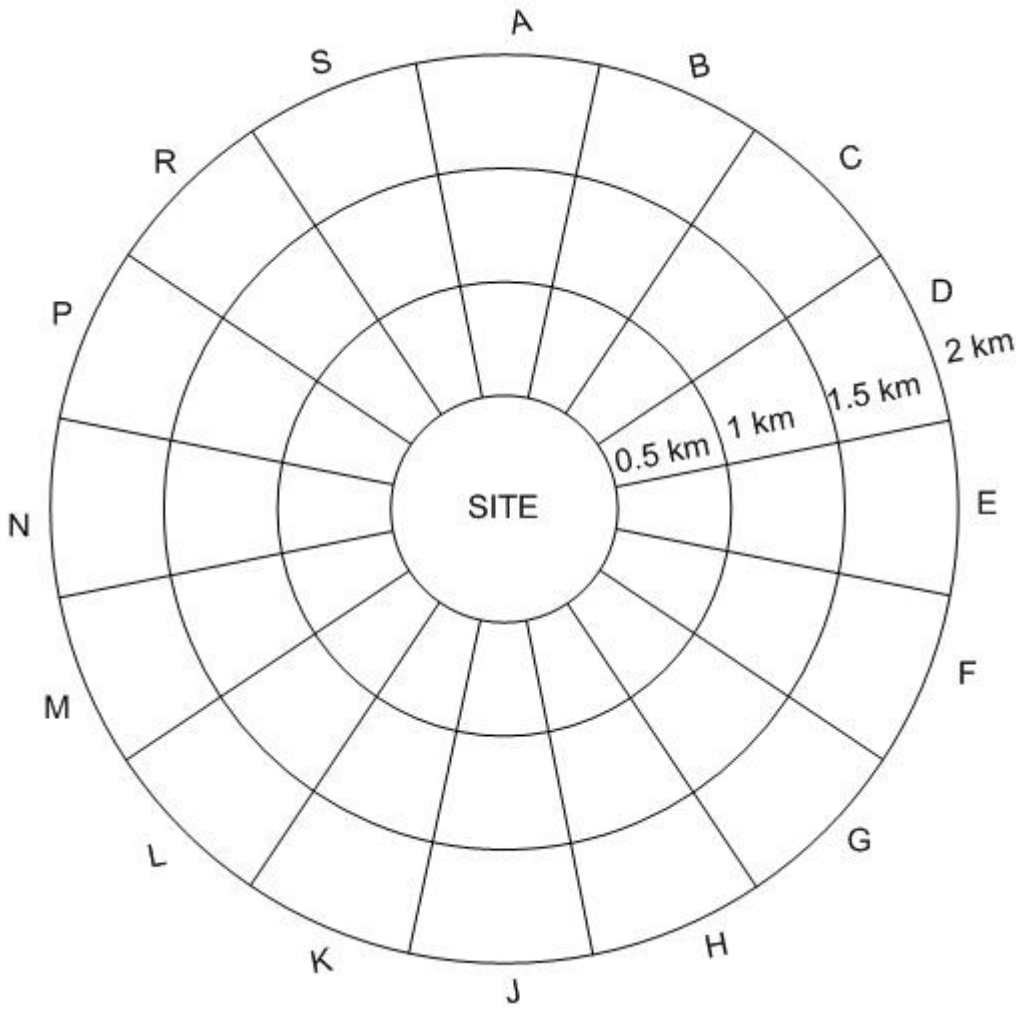


Instructions: Show highest confirmed reading in the sector. Show prevailing wind direction if the information is available. Readings that do not exceed background are not recorded, put B in the associated sector

Performed by: *Environmental Analyst*	**WORKSHEET B.2. NEAR-SITE DOSE RATE MEASUREMENTS 2 KILOMETRES (Page 2 of 2)**	No. _____

Prepared by: _____	Date: _____	Time: _____
Provide copies to:	Facility Response Manager	
Off-Site Authorities	Communicator	Projection Analyst
Radiological Protection Manager	Protective Action Manager	

For monitoring conducted from _____ to _____



Instructions: Show highest confirmed reading in the sector. Show prevailing wind direction if the information is available. Readings that do not exceed background are not recorded, put B in the associated sector.

Performed by: *Environmental Analyst*	**WORKSHEET B.3. FAR-FIELD DOSE RATE MEASUREMENTS 8 KILOMETRES**	No. _____

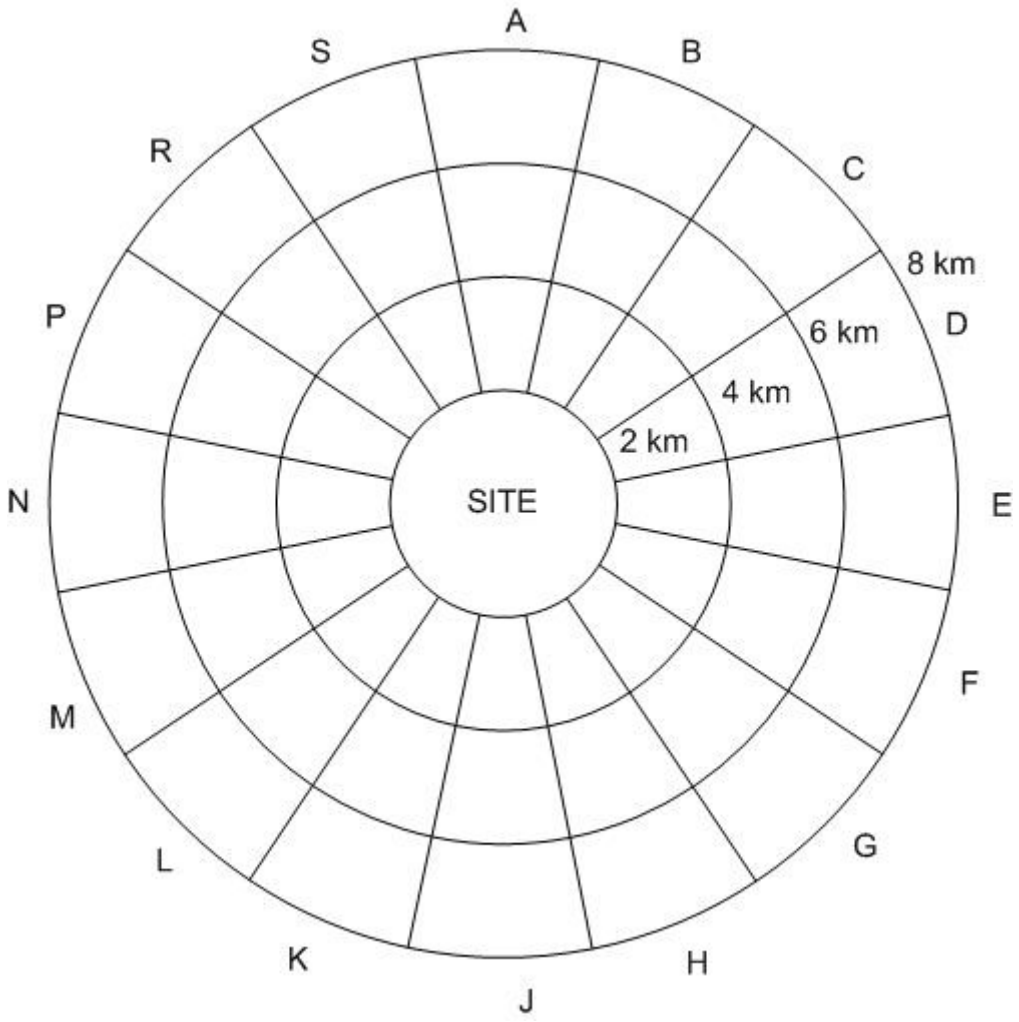
Prepared by: _____ Date: _____ Time: _____

Provide copies to: Facility Response Manager

Off-Site Authorities Communicator Projection Analyst

Radiological Protection Manager Protective Action Manager

For monitoring conducted from _____ to _____



Instructions: Show highest confirmed reading in the sector. Show prevailing wind direction if the information is available. Readings that do not exceed background are not recorded, put B in the associated sector.

Instructions for use of Worksheets B.2 and B.3. Near-Site Dose Rate Measurements 400 Metres and Far-Field Dose Rate Measurements 8 Kilometres

These two worksheets continue the record of radiation measurements beyond the site boundary. Measurements within the site boundary are recorded on Worksheet B.1. The ranges in these examples are 400 metres, 800 metres, 4 kilometres and 8 kilometres. The worksheets can easily be altered to provide any suitable range of monitored area. The site threat analysis should be reviewed to determine what ranges may be required. It is suggested that both a near field and a far field set of maps be available.

The primary purpose of these maps is to record environmental monitoring data so prompt decisions regarding urgent protective action. Displaying the information on a map makes it easier to see the affected areas and identifies the numbers to a specific part of the surrounding territory.

As with Worksheet B.1, it is recommended that standardized units, for example, gamma dose rates in μSv/h and alpha and beta measurements in cps, be used so only numbers have to be recorded on the map. This also corresponds to the units used by the OILs. Colour coding to distinguish gamma direct radiation levels from contamination levels can also aid the understanding of the scope and severity of the emergency.

To be completed by: *Radiological Protection Manager*	**WORKSHEET B.4. REGISTRY FORM FOR PERSONS INVOLVED IN EMERGENCY**	No. _____

Prepared By: _____ Date: _____

Provide copies to: ☐ Facility Response Manager

☐ Radiological Protection Manager Time: _____

Information about person involved in the emergency:

Full Name: _____

Date of Birth (DD/MM/YYYY): ____/____/_____ Age: _____ Sex: ☐ M ☐ F

ID Type and Number: _____

Current Local Full Address: _____

Telephone: _____

Current Permanent Full Address: _____

Telephone: _____

Member of: ☐ Public ☐ Facility Staff ☐ Emergency Services

Radiological Survey performed: ☐ Yes ☐ No (If Yes, attach Worksheet C.2 with results)

Decontamination done: ☐ Yes to level: _____ [ ] ☐ No

Units

Distance from initial event (or location when initial event occurred):

_____

Time of beginning of exposure (if any): _____ Time at end of exposure: _____

Duration of exposure: _____ minutes Position during exposure: _____

Remarks: _____

_____

Responder Signature: _____

Instructions for the use of Worksheet B.4. Registry Form for Persons Involved In Emergency

This form records contact information to enable future communication with individuals who have been involved in an emergency where follow up contact may be appropriate. Employees of the reactor will have similar information in personnel records, and for similar reasons. The individuals who were at the site when the emergency occurred as visitors or contractors performing work are the primary individuals for whom this registration is intended.

As much information as can be determined from interviewing the persons involved should be recorded. It may be useful for dose reconstruction, for example. Alternatively, it is a record that may determine the individuals were not affected at all by the emergency. The site should use judgement as to which emergencies should initiate the use of this form. Emergencies involving the release of radioactive material or unusual radiation levels in areas should clearly be ones that use the form since visitors or responders from off-site organizations may have received unmonitored radiation exposure. While not on the sample form, the site should consider asking the individual to sign the form to acknowledge the provided information, and then provide the individual a copy of the form for their own records.

The site should protect these records from disclosure in accordance with privacy laws applicable to the records.

The registration information includes a full name, contact information such as address and phone number, including current and permanent address, personal information such as National Identification number, Male or Female and age of the individual. The personal information may be useful to establish a priority for follow-up contact since younger individuals may be at more risk from radiation exposure than older individuals. The association with the site is also recorded in terms of site employees, member of the public as would be the situation for some visitors, or a member of the emergency service organization, for example the fire brigade, that responded to the emergency.

The additional information on the lower part of the form is intended to report the results of any radiation monitoring performed, including the need for and effectiveness of decontamination, if performed. Information on the person’s location relative to the location of the emergency and the time the individual was potentially exposed to radiation are recorded to permit dose reconstruction, if that is needed. The individual recording the information is requested to sign. As mentioned above, the individual being registered may also be asked to sign if the site considers that necessary.

To be Completed by: *Decontamination Team Lead*	**WORKSHEET B.5. VICTIM CONTAMINATION CONTROL RECORD (ON-SCENE ASSESSMENT)**	No. _____

Surveyed by: _____ Date: _____
(Full Name)

Provide to: □ Radiological Protection Manager Time: _____

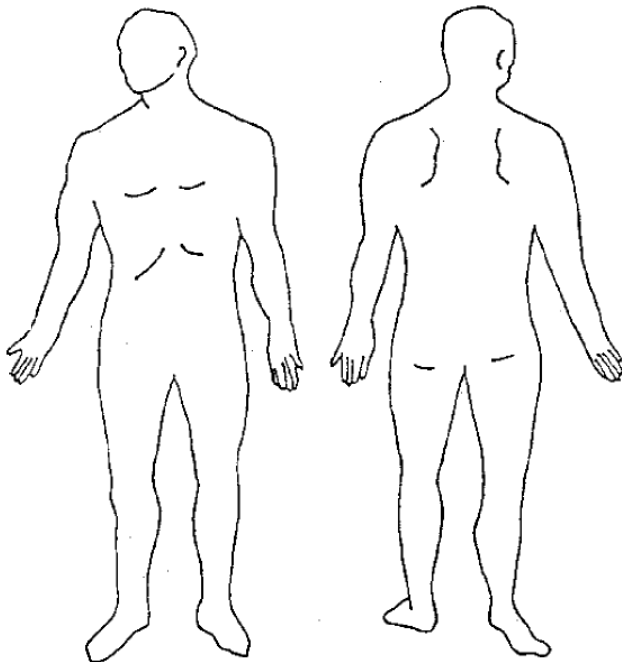
Name of _____ Sex: □ M □ F
Address:

Date of Measurement: _____/_____/_____ Time of Measurement: _____

Contamination Survey

Instrument Type: _____ Model: _____

Background Reading: _____ Detector Active Surface: _____cm^2



Remarks: Indicate Readings in the lines provided in the diagram. Indicate location of the readings by arrows. Only record readings greater than background.

Decontamination Procedures performed: □ Yes □ No

Results of thyroid Survey:

_____ [ ] _____ [ ]
(count rate from neck) Units (count rate from thigh) Units

_____ [ ] _____ [ ]
(background count rate) Units (net count rate) Units

Calibration coefficient: _____ Bq/unit of count rate Activity: _____ [Bq]

Further evaluation at medical facility necessary: □ Yes (send copy of worksheet with victim) □ No

Surveyors Signature: _____

Instructions for use of Worksheet B.5. Victim Contamination Control Record (On-Scene Assessment)

This form records contamination levels on individuals exposed to radioactive materials during an emergency. It is usually completed before any decontamination occurs. However, in some situations, that may not have been performed and the record should Note if any prior decontamination was attempted. If that decontamination was successful, then the record would show no or the remaining contamination.

It can also serve as a record of other monitoring for internal contamination if thyroid scanning equipment is available.

This record would be accompanied by a copy of Worksheet B.4, and the two should be attached to avoid having to record duplicate information, such as the individual's address.

If the individual is sent on to an off-site medical facility for medical treatment or decontamination, a copy of the worksheet should be provided to inform the receiving facility of contamination levels recorded at the scene.

The form records the name and an address for the individual for further contact. Information on the instrument used for the contamination monitoring is also recorded to allow assessment of the adequacy of the instrument and to determine the instrument calibration constant. The calibration constant is the instrument manufacturer's value to convert instrument count rate to Bq. This value is recorded at the bottom of the form and could be determined later.

The centre part of the form is used to record contamination levels measured on the individual. The left side is for contamination on the front of the body and the right side relates to the back. Contamination monitoring should concentrate on the areas of the body with the highest readings. It is also important to monitor areas where injuries have occurred as well as around the face where external contamination could be an indicator of ingested or inhaled contamination.

At the bottom of the form the results of decontamination, if attempted, can be recorded. Survey information after decontamination should be recorded as well, either on the original record or on a new sheet. The individual performing the monitoring is asked to sign the form.

If thyroid monitoring is performed, the net count rate from radioiodine in the thyroid is:

With a mix of radionuclides present:

Count rate from neck — count rate from thigh

With only radioiodine present:

Count rate from neck — background count rate

A more accurate assessment of thyroid dose may be determined by the procedures of Ref. [16].

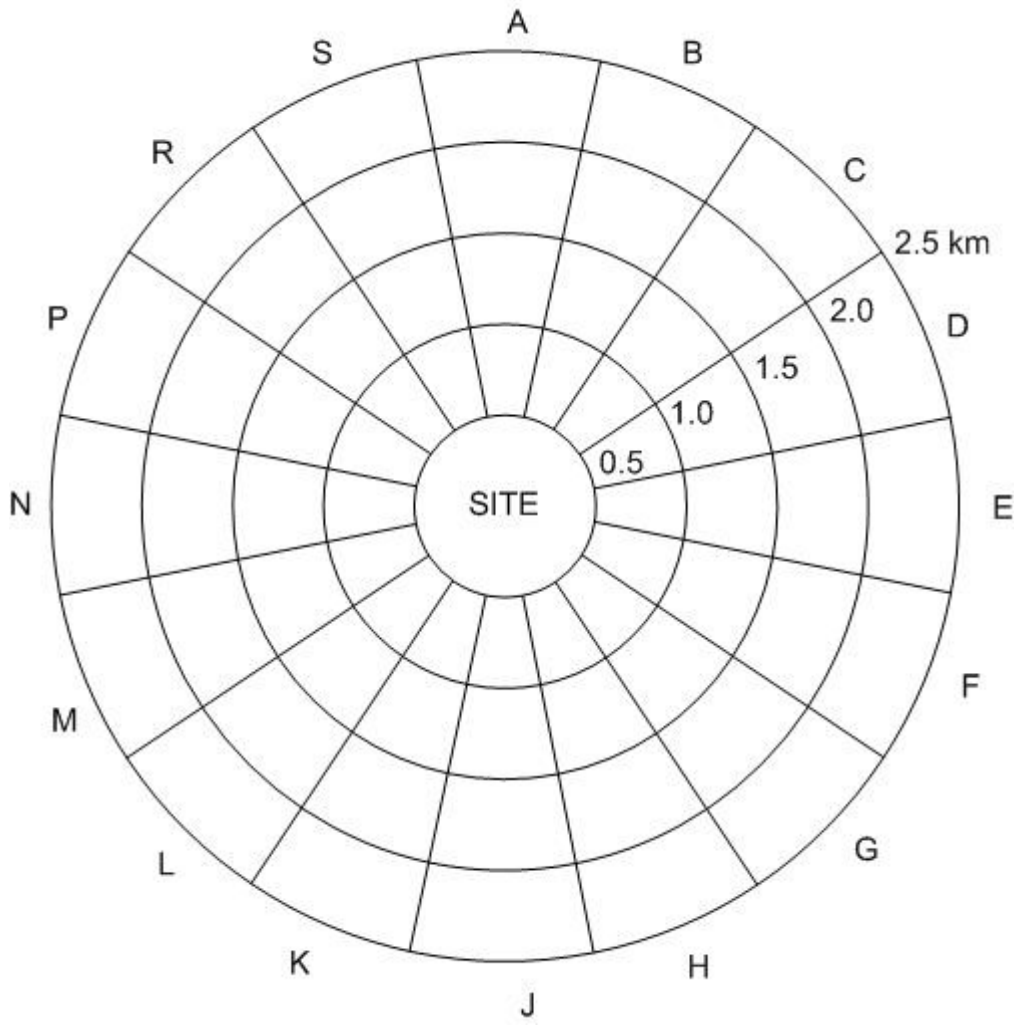
Performed by: *Protective Action Manager*	**WORKSHEET C.1. EVACUATION, THYROID BLOCKING, AND SHELTERING MAP**	No. _____

Prepared by: _____ Date: _____ Time: _____

Provide copies to:

Facility Response Manager Communicator

Off-Site Authorities Radiological Protection Manager



E	Evacuation	Recommended	Implemented
S	Sheltering	Recommended	Implemented
T	Thyroid Blocking	Recommended	Implemented

Remarks

Signature: _____

Instructions for use of Worksheet C.1. Evacuation, Thyroid Blocking, and Sheltering Map

The sector charts are just generic grids that should be used as overlays on actual maps of the area surrounding the reactor site. The wedge-shaped sector boundaries should be modified to follow existing roads, streams, or other features of the landscape to facilitate use. For example, the off-site authorities should realize just which section of the area needs to be evacuated when a particular sector is named. Sector A from 0.5 km to 2 km must correspond to a specific block of homes, even if it is not a wedge shaped block. This arrangement can only be achieved by close cooperation and extensive planning between the reactor site and the local authorities. Then both organizations need to have the exact same set of maps and sector overlays.

The scale on the overlay is whatever is appropriate for the use of the overlay. The suggested scale on the provided Worksheets is not necessarily the one that best fits, so it should be modified as necessary. An appropriate scale is the one that shows the area likely to be affected by an emergency at the reactor in that area. There may be more than one scale depending on the protective action that applies. Food restrictions, for one example, will apply to a larger area than evacuation. As the affected area becomes larger, the structure of each sector will have to be redrawn on a larger area map, again defining a particular sector by obvious landscape features.

The code letters (E, S, T and F) refer respectively to evacuation, sheltering, iodine thyroid blocking and food restrictions (includes locally grown foodstuffs, water from local streams or lakes, and milk from cows that have grazed in the sector). The affected sectors would be marked with the appropriate code letter to record the protective actions recommended for that sector. Refer to Tables C.2 and C.3 for the OIL values associated with these protective actions.

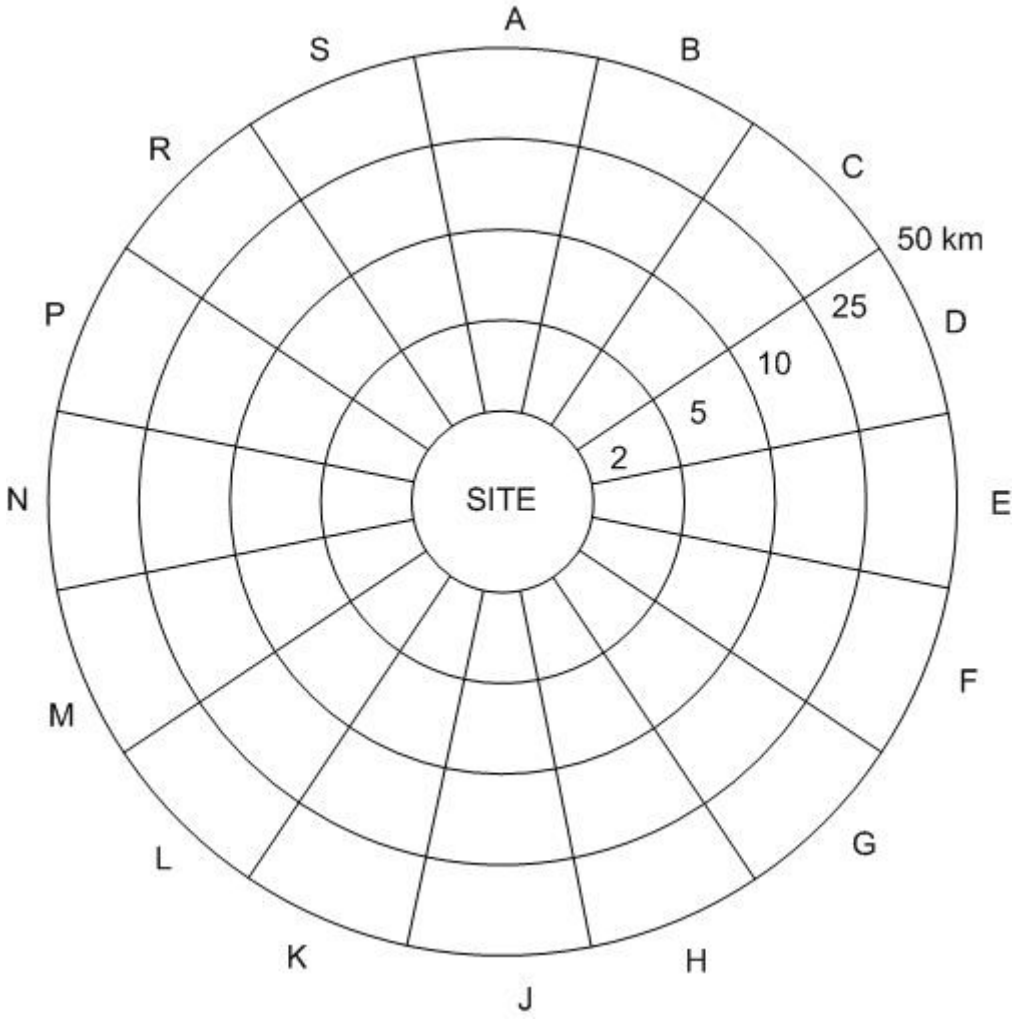
Performed by: *Protective Action Manager*	**WORKSHEET C.2. FOOD RESTRICTION AND RELOCATION MAP**	No. _____

Prepared by: _____ Date: _____ Time: _____

Provide copies to:

Facility Response Manager Communicator

Off-Site Authorities Radiological Protection Manager



R Relocation Recommended Implemented

F Food Restrictions Recommended Implemented

Remarks

Signature: _____

Instructions for use of Worksheet C.2. Food Restriction and Relocation Map

The sector charts are just generic grids that should be used as overlays on actual maps of the area surrounding the reactor site. The wedge-shaped sector boundaries should be modified to follow existing roads, streams, or other features of the landscape to facilitate use. For example, the off-site authorities should realize just which section of the area needs to be evacuated when a particular sector is named. Sector A from 0.5 km to 2 km must correspond to a specific block of homes, even if it is not a wedge shaped block. This arrangement can only be achieved by close cooperation and extensive planning between the reactor site and the local authorities. Then both organizations need to have the exact same set of maps and sector overlays.

The scale on the overlay is whatever is appropriate for the use of the overlay. The suggested scale on the provided Worksheets is not necessarily the one that best fits, so it should be modified as necessary. An appropriate scale is the one that shows the area likely to be affected by an emergency at the reactor in that area. There may be more than one scale depending on the protective action that applies. Food restrictions, for one example, will apply to a larger area than evacuation. As the affected area becomes larger, the structure of each sector will have to be redrawn on a larger area map, again defining a particular sector by obvious landscape features.

The code letters (E, S, T and F) refer respectively to evacuation, sheltering, iodine thyroid blocking and food restrictions (includes locally grown foodstuffs, water from local streams or lakes, and milk from cows that have grazed in the sector). The affected sectors would be marked with the appropriate code letter to record the protective actions recommended for that sector. Refer to Tables C.2 and C.3 for the OIL values associated with these protective actions.

Performed by: *Projection Analyst*	**WORKSHEET C.3. PROTECTIVE ACTION PROJECTIONS**	No. _____

Prepared by: _____ Date: _____ Time: _____

Provide copies to:

Facility Response Manager | Communicator | Protective Action Manager

Environmental Analyst | Radiological Protection Manager

PROJECTED EVACUATION DISTANCE BASED ON MEASURED DOSE RATE	
Measured Dose Rate: H_g = _____ mSv/h	Measured at X = __ ___ _ from release source
Rain in area: _____	Evacuation OIL = _____ mSv/h
Calculate X_P, projected distance, by formula below. Show calculation at the right.	

PROJECTED EVACUATION DISTANCE BASED ON MEASURED DOSE RATE	
Measured Dose Rate: H_g = _____ mSv/h	Measured at X = _____ from release source
Rain in area: _____	Evacuation OIL = _____ mSv/h
Calculate X_P, projected distance, by formula below. Show calculation at the right.	

PROJECTED RELOCATION DISTANCE BASED ON MEASURED DOSE RATE	
Measured Dose Rate: H_g = _____ mSv/h	Measured at X = _____ from release source
Rain in area: _____	Relocation OIL = _____ mSv/h
Calculate X_P, projected distance, by formula below. Show calculation at the right.	

PROJECTED RELOCATION DISTANCE BASED ON MEASURED DOSE RATE	
Measured Dose Rate: H_g = _____ mSv/h	Measured at X = _____ from release source
Rain in area: _____	Relocation OIL = _____ mSv/h
Calculate X_P, projected distance, by formula below. Show calculation at the right.	

No rain: $X_P = X \frac{H_g}{OIL}$	Rain: $X_P = X \sqrt{\frac{H_g}{OIL}}$

CAUTION: Do not send this worksheet to local authorities. No protective actions will be recommended from the calculations on this worksheet.

Instructions for use of Worksheet C.3. Protective Action Projections

This worksheet is used to estimate areas where monitoring for radioactive material should be performed. Based on measurements near the site, and given weather condition, a simple ratio method is applied to determine where additional readings above the applicable OIL could be expected. The projection is then used to build the monitoring plan. Urgent protective actions should not be based on these projections.

The calculation extrapolates measured dose at a specific location to a more distant location and provides the most distant location where specific OILs may be exceeded. For those locations where the OIL may be exceeded, a monitoring team should take measurements to determine if urgent protective actions are appropriate.

The form provides space for four projection calculations; two each for evacuation actions and for relocation calculations. This allows projections for best estimate projections and worst case projections, if both are being determined. Also if both are determined, the notation for best estimate or worst case should be added to the calculation. The extrapolation formulas at the bottom of the form are to be used. The formulas differ slightly for weather conditions of rain or no rain. Snowfall conditions are equivalent to rain.

Each calculation requires a measurement of the dose rate, H_g, at a specific distance, X, from the source of the radiation. The applicable OIL for the protective action is used in the calculation. These OIL values may be printed on the worksheet in advance since default OIL values will have been established in advance. The units for H_g and OIL must be the same.

The calculated value, X_p, in the same units as the distance X, is then the projected distance at which the measured dose rate will equal the OIL. Space is provided to record the calculation and its result. Note that this is an extrapolation based on local conditions and may differ from the actual conditions at a distance. However, the use of the projection is to establish where to measure, not to determine where to implement protective actions.

Performed by: RADIOLOGICAL PROTECTION MANAGER	**WORKSHEET C.4. ON-SITE PROTECTIVE ACTIONS**	No. _____ Time and Date: _____

Protective Action	Recommended and Comments		Implemented, Time and Date	
Evacuation of non-essential personnel	Yes	No	Yes	No
Self-reading Dosimetry	Yes	No	Yes	No
OIL Briefing	Yes	No	Yes	No
Respiratory Protection	Yes	No	Yes	No
Iodine Thyroid Blocking	Yes	No	Yes	No
Protective Clothing	Yes	No	Yes	No
Medical Evaluation and Follow-up	Yes	No	Yes	No
Whole Body Counting	Yes	No	Yes	No

Instruction for use of Worksheet C.4. On-site Protective Actions

This worksheet records the protective actions that are implemented on the site of the reactor emergency. Only those protective actions deemed necessary will be recorded here, so portions of the form may be unused. This is a record of what was implemented and when it was implemented. The emergency class or OILs (Tables C.1 or C.2) are used to determine what protective actions are necessary for a particular emergency.

Each potential protective action is provided a space to record if the action was recommended and when it was implemented, if it was. The comments section may be used to note supporting information, such as the area on the site where the protective action was implemented in situations where, for example, the entire site did not need to take a particular protective action.

The last two actions are not urgent protective actions, but are included for completeness if those specific longer term protective actions need to be recorded. It is more likely that only a few individuals involved in the emergency will be identified to require medical evaluation and follow-up or whole body counting.

Prepared by: *Protective Action Manager*	**WORKSHEET C.5. PREPARATION FOR OFF-SITE PROTECTIVE ACTIONS**	No. _____

CAUTION: Use this worksheet only to recommend ***preparations*** for off-site protective actions.

Prepared by: _____ Date: _____

Provide copies to: Time: _____

Facility Response | Radiological Protection Manager | Protective Action Manager

Communicator | Off-site Authorities | Other _____

Potential Protective Actions: Sheltering | Iodine Thyroid Blocking | Food, water, and milk Restrictions

Medical Registration | Evacuation | Relocation

Potentially Affected Area (attach the applicable sector map from Worksheet C.1 or C.2):

Conditions causing this warning:

Weather: Wind speed and direction _____ Temperature: _____°C Wind Chill _____°C

Precipitation: _____

Reviewed: _____ Approved: _____

Protective Action Manager | Facility Response Manager

Attachments:

Warning notice transmitted to _____ at _____

by _____

Signature

Instructions for use of Worksheet C.5. Preparation for Off-site Protective Actions

This worksheet records the potential protective actions that an off-site population may need to implement. The specific protective action is recorded and the area that would be affected is described, usually in terms of sectors, based on estimates of the sectors that would have radiation measurements in excess of established OIL values.

A space is provided to record the reasons for this warning. The information provided here will help the off-site authorities understand the situation better, and should be written in clear and concise plain language terms. The current weather conditions should be recorded. This also helps understand why particular areas were considered to be at risk and why not other areas. It also makes the off-site authorities aware that weather conditions are known to the site, and have been considered in the decision to request preparations for a particular protective action.

This form is used to communicate information to the off-site authorities and it is important that the Emergency Response Team validate the recommendation to give the off-site authorities the confidence that the decision comes from the highest level in the Emergency Response Team. Review by the Protective Action Manager and approval by the Facility Response Manager are the recommended signatures.

The attachments section is provided to list any such supplementary information. Plotted radiation values on sector maps may be one such attachment at the discretion of the site.

The last section is also important. The record of who was sent the warning and when it was sent keeps track of how the information is being transmitted to the off-site authorities.

Prepared by: *Protective Action Manager*	**WORKSHEET C.6. RECOMMENDED OFF-SITE PROTECTIVE ACTIONS**	No. _____

CAUTION: Use this worksheet only to recommend <u>implementation</u> of off-site protective actions.

Prepared by: _____ Date: _____

Provide copies to: Time: _____

Facility Response | Radiological Protection Manager | Protective Action Manager

Communicator | Off-site Authorities | Other _____

Protective Actions: Sheltering | Iodine Thyroid Blocking | Food, water, and milk Restrictions

Medical Registration | Evacuation | Relocation

Affected Area (attach the applicable sector map from Worksheet C.1 or C.2):

Conditions causing this recommendation to implement protective actions:

Weather: Wind speed and direction _____ Temperature: _____°C Wind Chill _____°C

Precipitation: _____

Reviewed: _____ Approved: _____

Protective Action Manager | Facility Response Manager

Attachments:

Recommendation transmitted to _____ at _____

by _____ Implementation started _____ Complete _____

Signature | Time/Date | Time/Date

Instructions for use of Worksheet C.6. Recommended Off-Site Protective Actions

This worksheet records the protective actions that should be implemented for an off-site population that the site has determined is at risk from radiation resulting from the emergency. The specific protective action is recorded and the area that would be affected is described, usually in terms of sectors, based on measurements that show radiation in excess of established OIL values. In contrast to Worksheet C.5, this worksheet proposes initiation by the off-site authorities of specific protective actions.

A space is provided to record the reasons for this warning. The information provided here will help the off-site authorities understand the situation better, and should be written in clear and concise plain language terms. The current weather conditions should be recorded. This also helps understand why protective action is necessary in some areas and why not other areas. It also makes the off-site authorities aware that weather conditions are known to the site, and have been considered in the decision to request a particular protective action.

This form is used to communicate information to the off-site authorities and it is important that the Emergency Response Team validate the recommendation to give the off-site authorities the confidence that the decision comes from the highest level in the Emergency Response Team. Review by the Protective Action Manager and approval by the Facility Response Manager are the recommended signatures.

The attachments section is provided to list any such supplementary information. Plotted radiation values on sector maps may be one such attachment at the discretion of the site.

The last section is also important. The record of who was sent the recommendation and when it was sent keeps track of how the information is being transmitted to the off-site authorities.

Performed by: *Nuclear Condition Analyst*	**WORKSHEET D.1. EMERGENCY CONDITION ASSESSMENT** (Revise if assessment or conditions change.)	No. _____

Prepared by: _____ Date: _____

Provide copies to: Time: _____

Facility Response Manager | Radiological Protection Manager | Protective Action Manager

Communicator | Plant Security Manager | Other _____

Type of Emergency: *[based on Table A.1 conditions]*
Emergency conditions:

From Procedure AG.A.1 Emergency Classification		Alert	Facility Emergency	Site Area Emergency	General Emergency
Reactor Condition:	Subcritical	Fuel damage:	No	Yes	Unknown
	Fully Shutdown	Fuel Covered	No	Yes	Unknown
	Critical at power level of _____				

Instructions for use of Worksheet D.1. Emergency Condition Assessment

This worksheet records the information available to the Emergency Response Team to allow them all to have the same set of facts concerning the emergency. The information necessary to describe the emergency condition is recorded and the classification of the emergency is assigned when classification has been accomplished.

Emergency classification should not be delayed to complete this Worksheet.

Classification should be complete within 15 minutes of declaring an emergency exists, and this form should not be allowed to delay that step in the response. Recording the type of emergency, and additional details of the emergency condition is a task that the Nuclear Condition Analyst should perform very quickly so all the response team can react to the known condition rather than to assumptions. The site may choose to add a list of potential emergencies based on reactor emergency procedures or other publications on the worksheet so that only a check off is needed to identify the type of emergency. Examples of the emergency type would be loss of decay heat removal capability, loss of electrical power, and others.

The reactor condition, including the state of fuel damage, if known, and heat removal by keeping the core covered are also recorded so significant pieces of information may be quickly determined by the response team members. The site may determine that additional key pieces of information should be added to this form depending on reactor systems for which the operational status needs to be clearly communicated.

The condition of “Fully Shutdown” depends on the definition of that condition in the reactor technical specifications or operating procedures and may differ from “Subcritical” based on the status of reactor control, instrumentation or other equipment. For example, the reactor will be subcritical when the neutron level is decreasing, even though control rods may still be withdrawn, but operating procedures may require that control rods are released, on the bottom, and the drive mechanisms are de-energized in order to consider the reactor fully shutdown. If the reactor remains critical, the power level is an important piece of information to record on the worksheet.

Since the emergency conditions may change, it is important to keep this form updated to those changes. A simple scheme of numbering each updated worksheet is proposed, but an alternative procedure may be implemented as the site finds convenient.

Performed by: *Nuclear Condition Analyst*	**WORKSHEET D.2. FUEL DAMAGE AND CONTAINMENT ASSESSMENT**	No. _____

Prepared by: _____ Date: _____

Provide copies to: Time: _____

Facility Response Manager Radiological Protection Manager Protective Action Manager

Communicator Plant Security Manager Other _____

Pool/Tank Water Level: _____ at _____ hours

Fraction of Core Uncovered: _____ Uncovered at _____ hours Recovered at _____ hours

Radiation level at the top of the reactor tank/pool _____ mSv/h; Normal value _____ mSv/h

Coolant piping radiation level _____ mSv/h, normal for this location _____ mSv/h

(Location for this measurement should be easily accessible; the, normal value should correspond to the value shortly after a reactor shutdown from power operation. A plot of shutdown radiation level versus time for a spot on the coolant piping may be more helpful.)

Coolant activity and normal values (*"normal" should be based on recent coolant samples)*

Coolant Activity	Normal	Measured
Gross Activity		
I-131		
Cs-134		
Cs-137		
Ba-140		
Other _____		

Coolant piping radiation levels should be measured with coolant circulation operating to obtain readings representative of the level of radioactivity in the coolant. If radiation exposures would be excessive to obtain radiation readings on coolant piping or a sample of coolant for activity analysis and the core has been uncovered, it may not be necessary to sample coolant or measure piping radiation levels to confirm that core damage has already occurred.

Continuous Air monitor _____ cps at _____hours; Normal for reactor condition _____ cps

Containment Pressure: _____ at _____ hours Design leak rate: _____

Stack air monitor _____ cps at _____ hours; Normal for reactor condition _____ cps

Containment boundary valves or other closure devices and position of each: (*The reactor site is expected to complete this part of the Worksheet by providing in advance a list here of the closure devices. Every closure device that, if left open, connects containment atmosphere to exterior atmosphere should be listed.)*

Closure Device	Position

Closure Device	Position

Instructions for the use of Worksheet D.2 . Fuel Damage and Containment Assessment

This worksheet is intended to record more detailed conditions concerning the reactor and containment conditions than that recorded on Worksheet D.1.

Emergency classification should not be delayed to complete this Worksheet.

Conditions which show or predict fuel failure are important to quickly be made visible to the entire response team and could determine on-site urgent protective actions and urgent protective action warnings or recommendations for off-site individuals. The presence of water over the core is one such piece of information. The site may wish to add additional items, such as operating status of decay heat removal systems. If the core does become uncovered, that needs to be recorded, as well as when it was recovered. Along with coolant activity, that information may help determine the extent of fuel damage.

Space is provided to record a few radiation monitors such as a building continuous air monitor, pool level radiation monitor and a stack monitor. The readings on these devices, if available, along with the normal readings for those locations helps determine the extent and severity of the emergency. The facility may add other permanently installed instruments, even though similar information is recorded on Worksheet B.1.

Measured fission product activity in the reactor coolant is the most sensitive method to assess fuel damage. Measuring radiation level on coolant piping may be a simpler method to quickly assess the presence of fuel damage. Radiation detectors installed on coolant piping, if available, would avoid radiation exposure to personnel if those radiation values needed to be measured to assess fuel damage during the emergency response. In order for that measurement to be useful, coolant needs to be circulating and the value needs to be compared to a normal value for the specific reactor condition. An even more useful set of information would be a graph of coolant piping radiation levels plotted against time after shutdown.

The form provides space to record the normal level of some nuclides of concern as well as the currently measured activity if a coolant sample was obtained and analysed.

The Nuclear Condition Analyst should also assess the reactor containment structure that is the last remaining boundary to keep fission products out of the environment. The site containment closure devices such as ventilation isolation dampers, doors, and valves that isolate system piping that penetrates containment should be provided on preprinted copies of this worksheet so the Nuclear Condition Analyst can determine the status of each one without overlooking one of the devices.

Performed by:	**WORKSHEET E.1. CALL LIST FOR OFF-SITE CONTACT POINTS**	No. _____

(Reactor site should replace Organizations with those applicable to their location and national requirements)

Agency/Support Organization	**Contact Information**
Police	
Security	
Fire Brigade	
National Nuclear Regulatory Organization	
Regional/Local Emergency Response Organization	
Ambulance Service	
Hospital	
Reactor/Site Management	
Off-site Public Information Coordinator	

Include contact information for all operators, radiological controls personnel and any other personnel who may be needed during an emergency.

Instructions for use of Worksheet E.1. Call List for Off-Site Contact Points

This is a list of contact information for notification of off-site authorities. It is prepared in advance of the emergency and ready to be used by the Communicator when the response team assembles. The agencies listed are examples of those the site may need to contact. Each site will generate a unique list depending upon who the site needs to contact. The specific contacts may differ depending upon the particular emergency. For example, security threats may require contact with organizations that would not be involved in a fire.

The site may also wish to provide a similar list for on-site contacts such as off duty personnel who have particular expertise that could be required to support the response, or other organizations that share the same site and need to be informed of the emergency.

Performed by: *Communicator*	**WORKSHEET E.2. EMERGENCY NOTIFICATION RECORD**	Date: _____ No.: _____

(Reactor Sites may wish to modify format, but still capture the time and date of notification and name of the person notified)

Name	Contact Number	Notified	Reason not notified
		Yes No Time _____	
		Yes No Time _____	
		Yes No Time _____	
		Yes No Time _____	
		Yes No Time _____	
		Yes No Time _____	
		Yes No Time _____	
		Yes No Time _____	
		Yes No Time _____	
		Yes No Time _____	
		Yes No Time _____	

Instructions for use of Worksheet E.2. Emergency Notification Record

This worksheet is used to record what notifications have been completed and when. It serves as the record of notification so duplicate contacts are avoided, and overlooked contacts can be quickly identified. The more detailed the record of who, by name and organization, was contacted and when will improve the usefulness of the worksheet. Space is provided to show why individuals intended to be contacted were not contacted.

APPENDICES TO PART 1

Appendix I

EMERGENCY RESPONSE EQUIPMENT

This table is a minimum list of equipment for the research reactor site emergency workers and was extracted from Ref. [2].

RADIATION PROTECTION EQUIPMENT FOR ON-SITE EMERGENCY WORKERS
Respiratory protection: self-contained breathing apparatus is most effective. Filter-canister masks properly fitted to trained individuals provide a good protection against radioactive iodine and particulate but are not effective against tritium.
Protective clothing must be based on the type of hazard. The high skin doses which can be received from beta radiation should be taken into consideration. For example, there should be no exposed skin; for fire fighters, protective suits should be non-plastic (or not of a material which melts on the skin); for personnel expected to perform hard work and/or get wet, suits should be waterproof. At a minimum there much be coveralls, booties, and gloves designed to protect from radioactive contamination.
Iodine thyroid blocking agent should be issued to all emergency workers prior to potential radioiodine exposures.
Dosimeters: each worker should wear thermoluminescent dosimeters in order to provide a record of the accumulated dose after the emergency. Self-reading (e.g. electronic) dosimeters (up to 250 mSv) should be available with the required supporting hardware, such as batteries or battery chargers, and readout/recording instrumentation.
Survey instruments: at least one person in each team should carry a very high dose rate meter (up to 10 Gy/h). Survey instruments must cover all ranges and detect alpha and beta emitters as well as gamma emitting nuclides. Contamination survey instruments must be available to monitor emergency workers on their exit from contaminated areas and to survey others for contamination from the initial event. These could include: hand-and-foot monitors, portal monitors, portable portal monitors, contamination probes (pancake probes) and scintillation probes. Care must be taken to avoid contaminating the probes. Spare batteries need to be provided for portable instruments.
Clothing: spare clothing and disposal facilities (plastic bags) should be available to replace contaminated clothing, as required.
Communication equipment that is operational in the areas where personnel may travel. These may include radio or cell phones, both provided with spare batteries
Flashlight or other portable lighting and spare batteries.

Appendices 15 and 16 of Ref. [2] suggest additional supplies that may need to be available depending upon the amount of decontamination or sampling that may be required. Also, some sites may wish to have a portable electrical generator with adequate fuel either on the site or stored at a nearby accessible location. All emergency equipment should be listed in the Emergency Plan, and the storage location shown on the list.

As a part of the site Quality Assurance plan the emergency equipment must be maintained by periodic inventories, replacement of perishable items, and instrument calibration and operability checks.

Appendix II

EMERGENCY WORKER BRIEFING

Emergency workers may consist of individuals from the reactor site, from off-site organizations, or both, depending on emergency. This can create a team of emergency workers with very different levels of familiarity with the reactor site. A thorough briefing should correct these different levels of knowledge. Further, the briefing needs to address specific duties and precautions, including exposure limits. Therefore, it is not useful to provide a detailed set of briefing words in this publication, but it is useful to detail the items that need to be included in the briefing. The Radiological Protection Manager is responsible for the conduct and quality of the briefing, though another person may deliver the actual content.

Briefing topics may include:

- The specific assigned task or tasks, the route to the location where the work is to be performed, the equipment provided to perform those tasks, including protective equipment and clothing, and the precautions associated with the specific tasks;
- Identification of the individuals assigned to the task and the responsible person for supervision of the task, including the reporting requirements to the supervisor;
- The expected radiation dose rates where the tasks are to be performed and radiation dose rates that, if encountered, should terminate the task until further planning is performed;
- The planned dose for the task, how that dose will be monitored, actions that can be taken to reduce the dose during task performance, and the risks associated with that level of radiation exposure;
- Communication procedures;
- Exposure guidance values from Table B.1 and a plain language description of the risks associated with doses in excess of 500 mSv;
- Reactor and other site conditions pertinent to task performance.

International standards require that individuals give informed consent prior to undertaking tasks where they may receive radiation doses in excess of the single year dose limit for occupational exposure [5]. Also, specific approval to exceed these limits must be provided by the Radiological Protection Manager. A briefing is the action that verifies the individuals involved understand and satisfies both requirements. Even when planned doses are well below 500 mSv, the briefing should include the risks associated with exposures above 500 mSv and with all the guidance values from Table B.1. An unexpected situation could occur where an emergency worker has to make an intervention decision due to discovery of new information or an injury to a co-worker.

Briefings benefit from active involvement of all the individuals involved. Suggested methods to provide this are to have the task supervisor provide the briefing and questioning the emergency workers for understanding during and at the conclusion of the briefing.

A debrief after the task is finished is equally important to determine what was accomplished and what planning or preparatory actions should be altered for future briefs.

Appendix III

CONTACT WITH THE MEDIA

The Facility Response Manager should plan to release information pertaining to the emergency and the emergency response soon after receiving verification that personnel on-site are safe and that injuries, if any, are being treated. The release should be written, provided to off-site authorities for review, and released by the off-site authorities, either locally or at the national level. While there is some urgency to prepare such a release, take all the time necessary to ensure it is accurate. Errors will be costly in both loss of confidence and recovery time to provide and explain corrections.

The arrangement with off-site authorities must be in place prior to an emergency, and tested during training exercises. The process cannot be created during the emergency and function efficiently. The off-site organization that provides information for release must be the only such official information source and must never release information that the Facility Response Manager has not reviewed. The public deserves to have prompt, accurate information written in plain language. Release to the media through a single source is the best choice.

Once an initial news release has occurred, planning for follow-up releases of new or expanded information is necessary. There is a tendency to delay the initial news release and get more information. That should be avoided. A preliminary, but prompt, release is better than a more complete release that is delayed. Anticipate providing additional details to supplement the original release with important information that was not available at the time of the first release. Subsequent releases may also address media questions that result from the first release.

The content of releases should truthfully provide information on the threat to individuals and actions being taken to reduce those threats or to verify that there is no such threat.

As well as providing correct information about the event throughout the emergency response, the site should immediately respond to incorrect information and rumours that misrepresent the nature and severity of the emergency.

Sample news releases are provided in Ref. [3], Appendix II, and in this Appendix. The sample news releases can be very helpful as examples if a similar sample release is prepared in advance for the research reactor. This not only saves time, but allows a clearly worded partial release to be prepared in advance, of course still requiring appropriate details of the event. One of the recurring problems with nuclear or radiological emergencies is that preparation of the news releases during the emergency response is competing with other emergency response activities and the releases often do not provide the intended message just due to a hasty choice of words. Additional information may be found in Ref. [2], Appendix 18 and Ref. [4], Appendix VII.

Sample Holding Statement
(For use before specific information is available):

Date: [date of issue]
Time: [time of issue]
[News Release Number]

[Organization name] reports that [nature of event] occurred at the [location] research reactor facility. [Insert statement clarifying the condition of the research reactor and whether the event occurred in the reactor or an associated facility]. The [event] occurred at [time] when [information on the event] and that [any initial measures] measures are being taken to protect [the public, responders, products, trade, or specify as appropriate]. The facility and [specify organizations involved in the response] planned response for this type of event is in progress [specify plan as appropriate] [and the public information centre has been activated]. [Organization name] has contacted [local authorities/regulator] and informed them of the event.

[Organization name] is coordinating its activities with responders now at the scene and other involved agencies [specify as appropriate]. Further information will be provided as it becomes available. [Provide details on timing of any updates or briefings and radio and TV stations or Internet locations where information will be released]. The next [briefing/update] will take place at [location and/or time].

_____

For further information:
Name [name of contact for the media]:
Title [title of media contact]:
Organization:
Telephone:
Mobile:
Email:
Website:

Sample News Release
(for a nuclear or radiological emergency at a research reactor):

Date: [date of issue] Time: [time of issue]
[News Release Number]

[Organization name] confirms that a [nature of event] occurred at the [name of facility] research reactor facility at [time] on [date]. [Insert statement clarifying the condition of the research reactor and whether the event occurred in the reactor or an associated facility]. The facility and [specify organizations involved in the response] planned response for this type of event is in progress [specify plan as appropriate] [and the public information centre has been activated]. [Organization name] contacted [local authorities/regulator] and informed them of the event.

[Organization name] is coordinating/has coordinated its activities with responders and other involved agencies [specify as appropriate]. The following actions have been/are being taken [e.g. evacuation on-site/off-site, surveys in public areas, sheltering, stable iodine, transport of injured people, decontamination of people/areas] to protect [the public, responders, products, trade, or specify as appropriate].

The public is advised to take the following actions [eliminate items that do not apply, add others if appropriate]:

- [If an airborne release is suspected (specify, depending on scenario)] the public within about [specify distance] of [specify local description – roads, districts – that will be understandable to the public] are advised on the following:
    - close outside windows and doors and turn off ventilation equipment that brings in outside air until otherwise instructed;
    - remain inside until instructed otherwise;
    - do not eat or drink anything that may have been contaminated (e.g. vegetables grown outside or rainwater) until informed otherwise;
    - make sure that children are not playing on the ground;
    - wash hands before eating;
    - avoid dusty areas or activities that will make dust;
- do not be concerned about those evacuated (they are not dangerous to be near);
- do not go to the scene to volunteer or to help. [Response organizations] are assisting the facility personnel. If assistance is needed, announcements will be made;
- check for information updates on [radio, TV, Internet].

If you have a health concern go to [once available specify a location away from the local hospital where monitoring will be performed and questions answered].

If you have any questions please call [give a hot line number where large number of calls will not interfere with the response].

Further information will be provided as it becomes available. [Provide details on timing of any updates or briefings and radio and TV stations or Internet locations where information will be released]. The next [briefing/update] will take place at [location and/or time].

———————

For further information:
Name [name of contact for the media]:
Title [title of media contact]:
Organization:
Telephone: (land line and mobile:
Email:
Website:

Sample News Release
(for a non-radiological event):

Date: [date of issue]

Time: [time of issue]

[News Release Number]

[Organization name] confirms that a [nature of event] occurred at the [name of facility] research reactor facility at [time] on [date]. The research reactor is operating safely, the event did not involve any radioactive materials and there is no radiation threat to the public or the facility staff. The facility and [specify organizations involved in the response] planned response for this type of event is in progress [specify plan as appropriate], [fire/police/ambulance responded and the public information centre has been activated]. [Organization name] contacted [local authorities/regulator] and informed them of the event.

[Select one of the following paragraphs as appropriate to the event]

Further information will be provided as it becomes available. [Provide details on timing of any updates or briefings and radio and TV stations or Internet locations where information will be released]. The next [briefing/update] will take place at [location and/or time].

[or]

[Organization name] thanks the [responding organizations] for their assistance. Efforts are now focussed on restoring the facility back to normal operation. Please contact [Organization name] with any further enquiries regarding this event,

_____

For further information:
Name [name of contact for the media]:
Title [title of media contact]:
Organization:
Telephone: (land line and mobile:
Email:
Website:

Appendix IV

DETERMINATION OF THE UPZ SIZE FOR THREAT CATEGORY II RESEARCH REACTORS

The IAEA suggests a range of sizes for the UPZ for Threat Category II facilities, including research reactors, in Ref. [2] and Appendix II of Ref. [6]. A range of UPZ sizes is shown to cover the range of power levels for reactors in Threat Categories II. Further guidance in Ref. [6] suggests a facility specific analysis should be performed to determine the UPZ size for research reactors due to the wide variation in reactor design and operating parameters. The UPZ is not defined for Threat Category III research reactors.

Little guidance for a facility specific analysis is provided. This Appendix gives a general description of the method of establishing the size of the UPZ. This method may also be used to confirm that emergencies at Threat Category III research reactors do not cause any radiological threats to individuals beyond the site boundary and that emergencies at Threat Category II research reactors do not create threats of deterministic health effects to individuals beyond the site boundary.

The process requires that the research reactor facility determine an appropriate source term for a release to the environment in case of an emergency. The source term for a Threat Category II research reactor should conform to the Emergency Action Level that represents a General Emergency, even though the sequence of events causing a release to the environment represents a low probability chain of events. Core damage at a level that could occur, even if unlikely, and an early release to the environment are recommended for the considered source term. Emergencies involving research experiments that contain radioactive materials should also be considered as a potential source term. More than one emergency scenario should be analysed to determine the range of zone sizes for different source terms. Development of a source term for research reactor accidents is discussed in Ref. [20]. Consultation with off-site authorities, both local and national, can be valuable to select the specific scenario that will be used to determine the zone size.

The choice of software to project levels of exposure is important because it must be able to provide output that may be compared to generic criteria for protective actions among the public. The specific computer software may even be stipulated by national regulations. InterRAS software is available through the IAEA and is able to perform the necessary calculations. InterRAS is described in Appendix II of Ref. [1].

The facility should also choose representative weather conditions, that is, representative values for wind speed, precipitation and stability class. The calculations to develop the suggested zone sizes in Ref. [6] were performed with average meteorological conditions (2 m/s wind speed and stability class D) and no precipitation. In general, higher wind velocities will reduce the dose at a specific location since the plume passes more quickly (inhalation and cloudshine doses are reduced) and deposition is less (groundshine dose is reduced). More stable atmosphere increases dose within the plume since there is less mixing between the plume of radioactive gases and airborne particles and the surrounding atmosphere. Multiple dose assessment calculations should be performed with the source term and different weather conditions that may occur to evaluate the range of the zone sizes for possible weather conditions. The final choice of weather conditions would be selected from the facility specific analysis calculations based on a judgement of what conditions would be representative of actual conditions. This may be the average of the likely range of conditions, the most frequently encountered conditions, or some other selection criteria. The zone sizes should be

based on that set of weather conditions judged to be representative. The calculations with other weather conditions can serve as information to be considered as additional response guidance during an emergency when the actual weather conditions are known.

With the chosen source term and representative weather conditions, dose assessment calculations are examined for comparison to generic criteria for protective actions to prevent radiation-induced health effects. All areas where calculated doses would result in deterministic health effects should be within the site boundary for Threat Category II and III research reactors. Table 2 in Ref. [12] provides generic criteria for protective actions to prevent the development of deterministic health effects. Table 3 of Ref. [12] establishes generic criteria for protective actions reasonably limiting stochastic health effects. The criteria for projected dose in the first 7 days from this table should be used to establish the UPZ boundary. This area should be within the site boundary for Threat Category III research reactors. National legislation or regulations may establish different criteria for prevention of radiation-induced health effects.

It may be impractical to completely adhere to only radiological criteria when setting the zone boundaries. Some non-radiological considerations are discussed in Ref. [2].

The final adjustments to the zone boundaries are made to more easily identify the boundaries with local features and landmarks. Examples of these are roads, administrative boundaries, for example, village limits, and geographical features such as rivers or streams. Any readily identifiable landmark, clearly recognized by the population, may be used to set a boundary. The boundary adjustments must involve local officials to gain their acceptance and understanding of the location and purpose of the boundaries.

When the dose assessment analysis is being performed for the selected source term and weather conditions, some calculations should be done to assess ground contamination that may render locally grown foods unusable due to contamination. Table II-1 of Ref. [12] provides default Operational Intervention Levels for food restrictions based on measured radiation from ground deposition. InterRAS may be suitable for these calculations; however, the software does not provide results beyond 50 km from the release point.

It is also important to remember that the analysis work to identify the UPZ is an emergency preparedness and planning activity. The zone boundaries must be defined before the emergency, and the off-site emergency plans recognize the boundaries and the size of the population within the boundaries so arrangements for implementing protective actions can be established. The determination of protective actions in the UPZ during an emergency will be based on environmental measurements. Environmental monitoring may indicate the need for protective actions beyond the predetermined zone boundaries, or may show that protective actions are appropriate in smaller areas than expected.

PART 2:
RESPONSE TO A NUCLEAR OR RADIOLOGICAL EMERGENCY AT THREAT CATEGORY III RESEARCH REACTORS

ACTION GUIDES

AG.A.1. FACILITY RESPONSE MANAGER

When to apply the Action Guide:

In case of any radiation emergency at a research reactor

ACTIONS

Assess the situation and classify the emergency

- Receive a briefing from the individual(s) who discovered the emergency or the Facility Response Manager if relieving that individual.
- Question thoroughly to understand the scope of the emergency.

NOTE

Activating the Facility Response Manager position is the transition from normal reactor operations to site emergency response.

- Verify the appropriate reactor emergency operating procedure is in progress or is complete.
- Consider immediately requesting assistance appropriate to the event, for example the fire brigade or police.
- Classify the emergency as an Alert or as a Facility Emergency. Emergency classification is expected within 15 minutes of identification that an emergency exists. Table A.1 provides guidance. If it is unclear which class best fits the conditions, classify as Facility Emergency.
- Assemble the necessary emergency response team and initiate the response using Table A.2 to determine priorities.
- Record the facility conditions on Worksheet A.3.
- Worksheet A.2 is an action item checklist that may be of assistance.

Establish Communications

- Notify on-site personnel of the emergency and the emergency class.
- Initiate on-site protective actions with recommendations from the Radiological Protection Manager.
- Review status of Priority 2 and 3 actions with the Radiological Protection Manager.
- Establish communications with off-site authorities to keep them informed and provide emergency responder protective actions and exposure guidelines. Worksheet C.1 contains the necessary contact information.

NOTE

Additional support comes from off-site when the on-site resources are inadequate for the situation. Keeping those resource providers updated helps them anticipate and assemble that support.

Follow the activities of the other responders

- Review Worksheet C.2 for a record of notifications completed by the Communicator.
- Review responsibilities with staff and request periodic briefings and status reports. Update those reviews as additional responders arrive and are assigned duties.
- Periodically review the classification based on the conditions. New information can change the classification; these reviews ensure that the classification remains appropriate given the new information.

NOTE

New information can change the classification; these reviews ensure that the classification remains appropriate given the new information.

- Maintain a record of information and the decisions resulting from that information. Use this record as briefing material for the next Facility Response Manager.

Transition to recovery actions

- Assemble a team appropriate to the recovery actions when the situation has been fully assessed and the emergency response actions have stabilized the situation.

TABLE A.1: SYMPTOM BASED EMERGENCY CLASSIFICATION TABLE FOR THREAT CATEGORY III RESEARCH REACTORS

Review this table and compare to the existing emergency conditions. Classification is based on the more severe emergency class for the conditions. Facility Emergency is more severe than Alert.

(Revise as necessary to reflect research reactor site parameters.)

For the following entry condition:	Declare a Facility Emergency if:	Declare an Alert if:
CRITICAL SAFETY FUNCTION IMPAIRMENT		
Failure to stop nuclear reaction	Failure to scram when above 5% *[or insert site specific power level]* power and abnormal conditions indicate automatic or manual scram is necessary	Inability to achieve the fully shutdown condition defined in reactor operating procedures
Inadequate Decay Heat Removal[17]		Decay heat removal not operable or operating at less than design value
Loss of facility electrical power[18]		AC or DC power needed for safety systems and their supporting systems operation is lost or reduced to a single source
Loss or degraded control of safety systems[19]		Safety system was inoperative when the reactor was operating and design limits possibly were exceeded
LOSS OF FISSION PRODUCT BARRIERS		
Abnormal I-131 in coolant or presence of elevated delayed neutrons in coolant or Airborne activity in Reactor Hall	*[Determine a site specific airborne activity from fission products in the Reactor Hall such that the design basis release rate from containment causes on-site radiation levels that exceed the evacuation OIL at any on-site area]*	Abnormal radiation level increase at the purification system or Long term trend indicating gradual increase of I-131 activity in coolant

[17] Facilities that do not require active decay heat removal because passive losses to ambient air or coolant are sufficient to avoid fuel damage should consider deleting this emergency.

[18] This is intended to apply to a loss of all power sources needed to control and monitor the reactor as well as prevent discharges of radioactive materials from the facility. Site specific power sources should be provided here to clarify what situation constitutes a loss of facility power.

[19] The intent is to include both the safety systems that automatically shutdown the reactor and those that prevent fuel damage after the reactor has been shutdown. If reactor experiment assemblies require safety systems to prevent release of reactivity, those should also be included. Reactor specific system names should be used to prevent misunderstanding.

TABLE A.1: SYMPTOM BASED EMERGENCY CLASSIFICATION TABLE FOR THREAT CATEGORY III RESEARCH REACTORS

Review this table and compare to the existing emergency conditions. Classification is based on the more severe emergency class for the conditions. Facility Emergency is more severe than Alert.

(Revise as necessary to reflect research reactor site parameters.)

For the following entry condition:	Declare a Facility Emergency if:	Declare an Alert if:
Containment[20] barrier damaged	Containment unable to perform design function and a fission product release from the fuel is occurring or is imminent	Containment unable to perform design function and the reactor is shutdown
RADIATION LEVELS		
High radiation levels[21]	Abnormal radiation level increase (>100X) detected on multiple instruments, or Abnormal radiation levels greater than 1 mSv/h in occupied spaces such as the Control Room	Abnormal radiation level increase (>10X) detected on multiple instruments, or Abnormal radiation levels greater than 0.1 mSv/h
Elevated Reactor Hall radiation levels and evidence of fuel damage *Note: Inconsistent monitor readings could result from incomplete mixing or a failed monitor or by seeing radiation from a contaminated system nearby[22]. Analogue monitors may show high, low or centre range if they fail.*	[Determine a site specific radiation level from fission products in the containment/confinement such that the design basis release rate from containment causes on-site radiation levels that exceed the Table B.3 evacuation OIL in any on-site area]	Radiation level increase greater than 0.10 mSv/h *[or insert site specific dose rate]*
Unplanned reactor power excursion	Power transient to *(insert power level predicted to cause fuel failure)*	Power transient causes an unexpected automatic scram
High dose rates at or beyond the site boundary.	*[Determine a site specific radiation level at the site boundary based on the design basis accident]*	Dose rates at or beyond the site boundary greater than 10μSv/h *[or insert site specific reading indicating 100 times background]*

[20] Containment refers to either confinement structure or containment structure

[21] The facility may choose a different increase multiple and/or list specific instruments.

[22] Radiation from a contaminated system nearby could also affect the radiation monitors inside the containment.

TABLE A.1: SYMPTOM BASED EMERGENCY CLASSIFICATION TABLE FOR THREAT CATEGORY III RESEARCH REACTORS

Review this table and compare to the existing emergency conditions. Classification is based on the more severe emergency class for the conditions. Facility Emergency is more severe than Alert.

(Revise as necessary to reflect research reactor site parameters.)

For the following entry condition:	**Declare a Facility Emergency if:**	**Declare an Alert if:**
Airborne effluent release rates exceed release limits.	Effluent monitor readings for more than 15 minutes greater than ...*[insert site specific list of effluent monitors and readings indicating that in 4 hours the on-site doses will be greater than 0.10 of the intervention levels for urgent protective actions assuming average meteorological conditions*]	Effluent monitor exceeds allowed release activity limit
Inadvertent release of radioactive material or unplanned overexposure of personnel	Event causes or has the potential to cause individual personal exposures in excess of 50 mSv in a short period of time *(or lesser site-specific value denoting an unplanned exposure in excess of the permissible annual dose limit)*	Event causes or has the potential to cause individual personal exposures in excess of 20 mSv in a short period of time *(or lesser site-specific value denoting an unplanned exposure in excess of the permissible average annual dose limit)*
SECURITY, FIRE, NATURAL DISASTERS AND OTHER EVENTS		
Security event (intruder or terrorist attack)	Security event, actual or threatened, that could result in damage to any safety system or the reactor	Credible security threat to the reactor or reactor safety systems
Toxic or flammable gas		Toxic or flammable gas detected in the facility
Fire or explosion	Occurs in a facility building and has the potential to release radioactive material	Fire or explosion potentially affecting areas containing safety systems
Flooding in the reactor building		Flooding that has the potential to affect safety and control systems

TABLE A.1: SYMPTOM BASED EMERGENCY CLASSIFICATION TABLE FOR THREAT CATEGORY III RESEARCH REACTORS

Review this table and compare to the existing emergency conditions. Classification is based on the more severe emergency class for the conditions. Facility Emergency is more severe than Alert.

(Revise as necessary to reflect research reactor site parameters.)

For the following entry condition:	**Declare a Facility Emergency if:**	**Declare an Alert if:**
Major natural or external disaster such as: Earthquake Tornado Flood High winds Vehicle or airplane crash Hurricane Tsunami Storm surge Lightening Strike	Natural or other disasters resulting in damage to reactor systems or building	Natural or other disasters that threaten the plant, such as: Events beyond the design basis of the facility Events resulting in actual or potential loss of access to the facility for an extensive period of time
Facility Senior Operator concern	Conditions that warrant taking protective actions on-site	Abnormal conditions warranting immediate additional assistance for the on-site personnel
Radioactive material control	Loss of control of a dangerous source[23] on the site	Loss of control of or access to fuel not installed in the reactor or loss of control of any radioactive material
Human Error[24]		Error results in violation of reactor operating limits and conditions or damages an experimental apparatus and Has the potential to cause overexposure to personnel on-site, or a release to the environment
Unexpected media or public inquiry		Inquiry requests information on a perceived or real emergency
Injured Person(s)		Individual(s) injured and/or contaminated with off-site treatment and/or decontamination required

[23] Appendix 8 of Ref. [2] and Ref. [15] provide the information to determine the amount considered dangerous for many nuclides.

[24] Human error resulting in a Facility Emergency would be expected to create conditions included in another set of Entry Conditions.

TABLE A.1: SYMPTOM BASED EMERGENCY CLASSIFICATION TABLE FOR THREAT CATEGORY III RESEARCH REACTORS

Review this table and compare to the existing emergency conditions. Classification is based on the more severe emergency class for the conditions. Facility Emergency is more severe than Alert.

(Revise as necessary to reflect research reactor site parameters.)

For the following entry condition:	Declare a Facility Emergency if:	Declare an Alert if:
Loss of Communication		Events resulting in actual or potential loss of communication with the facility for an extensive period of time
Reactor Scram		Unplanned reactor scram or shutdown for an unknown reason
FUEL HANDLING, EXPERIMENTAL EQUIPMENT AND SPENT FUEL POOL EVENTS		
Fuel handling or experiment abnormality[25]	Abnormal radiation level increase on multiple monitors	Damage to fuel element, control rod, or experiment assembly
Abnormal refuelling or irradiated fuel condition	Loss of ability to maintain water level above the irradiated fuel	Damage to irradiated fuel, but the fuel remains covered with water

[25] The intent is to define emergencies that involve moving fuel or operating experiment devices without reactor operation and subsequently cause an unsafe condition or an emergency to occur. An inadvertent criticality or damage that releases radioactive material from an experiment are possible emergencies that would meet these conditions.

TABLE A.2: EMERGENCY RESPONSE PRIORITIES

Priority	Action	Response Time Objectives	Responsibility
1	Classify emergency based on nuclear and radiological conditions	Initial classification complete within 15 minutes of recognizing the emergency, thereafter on-going basis	Facility Response Manager
	Notify on-site individuals and facility management	Complete within 15 minutes of classification	Facility Response Manager
	Determine urgent protective actions for on-site personnel	Immediately after classification, complete implementation within 1 hour	Radiological Protection Manager
	Activate on-site Emergency Response Team	Determine needed support and request immediately after classification; complete within 2 hours	Facility Response Manager
	Obtain support of off-site emergency services	Request support as soon as the need is recognized	Facility Response Manager
2	Deploy on-site environmental monitoring teams	Within 30 minutes of classification, complete within 2 hours	Radiological Protection Manager
	Notify off-site authorities	Complete within 1 hour of classification	Facility Response Manager
	Evaluate on-site protective actions	As on-site environmental monitoring results are available	Radiological Protection Manager
3	Verify no off-site radiological exposure	Complete within 2 hours after classification	Radiological Protection Manager

AG.B.1. RADIOLOGICAL PROTECTION MANAGER

ACTIONS

- Obtain a briefing on reactor conditions and radiological conditions from the previous Radiological Protection Manager.
- Verify expected activity for the next shift with the Facility Response Manager.
- Initiate/Continue actions from Table A.2, Emergency Response Priorities. Verify accountability of all personnel on the reactor site.
- Recommend to the Facility Response Manager on-site protective actions from Table B.2 based on the emergency class. Record the recommended protective actions on Worksheet B.2.
- As the first step in determining on-site radiological conditions, determine radiation dose rates at permanently installed radiation detectors and the accessible prearranged locations in the facility.

NOTE

Normal radiation levels can be recorded at permanently installed radiation detectors and specific prearranged locations and then compared to measurements at those locations during an emergency to help assess the severity of the emergency.

- Develop a plan for environmental monitoring priorities, or continue an existing plan, based on the specific event and the emergency class.
- Identify and request additional radiological support from the Facility Response Manager as required.

CAUTION

Only volunteers may exceed occupational exposure limits and only the Radiological Protection Manager may authorize this exposure. Guidance for briefings is provided in Appendix II.

- Brief Emergency Workers on Guidance Values for Limiting Exposure of Emergency Workers from Table B.1. Authorize volunteers to exceed radiation doses in excess of occupational exposure limitations.
- Communicate the monitoring plan to the Monitoring Team Lead and confirm initiation of the monitoring.
- Verify that the Monitoring Team Lead understands when monitoring data is to be immediately brought to the attention of the rest of the Emergency Response Team.
- Assess all personnel for injuries, radiation exposure, contamination, and usefulness in the response actions.
- Ensure no individuals leave the facility area until they are recorded on Worksheet C.4 and they are no longer needed. Worksheet C.4 provides the needed information for future contact, if required.
- Record radiological data on Worksheet B.1 as appropriate.

- Update radiological data as conditions change.
- Expect radiation readings to decrease due to decay as time passes. If not, then investigate more closely, there could be unrecognized releases occurring.
- Evaluate radiological data to determine if the current protective actions are appropriate. Table B.3 provides protective actions based on site radiation environment. Recommend changes to the Facility Response Manager and update Worksheet B.3.
- Initiate Priority 3 actions from Table A.2. Subsequent radiological measurements should attempt to determine a safety perimeter, defined as ≤10 μSv/h (*or site-specific value*) and no ground contamination.

NOTE

No off-site exposure is expected. This step verifies that this assumption is correct. It also defines the boundary of the site area affected by the emergency.

- Periodically evaluate the current protective actions and radiological environment to determine any appropriate changes to the protective actions.
- Record major actions, decisions and recommendations in a logbook.

TABLE B.1: GUIDANCE VALUES FOR RESTRICTING EXPOSURE OF EMERGENCY WORKERS [12]

Tasks	Guidance value[a]
Lifesaving actions	$H_P(10)$[b] < 500 mSv This value may be exceeded under the circumstances in which the expected benefits to others clearly outweigh the emergency worker's own health risks, and the emergency worker volunteers to take the action and understands and accepts this health risk
Actions to prevent severe deterministic effects and actions to prevent the development of catastrophic conditions that could significantly affect people and the environment	$H_P(10)$ < 500 mSv
Actions to avert a large collective dose	$H_P(10)$ < 100 mSv

[a] These values apply only for the dose from exposure to external penetrating radiation. Doses from exposure to non-penetrating external radiation and from intake or skin contamination need to be prevented by all possible means. If this is not feasible, the effective dose and the equivalent dose to an organ that are received have to be limited to minimize the health risk to the individual in line with the risk associated with the guidance values given here.

[b] $H_p(10)$ is the personal dose equivalent $H_p(d)$ where d = 10 mm.

TABLE B.2: PROTECTIVE ACTIONS BASED ON EMERGENCY CLASSIFICATION

Protective Actions	Classification	
	Alert	Facility Emergency
Evacuate or shelter non-essential personnel		
Provide essential personnel with self-reading dosimetry[26,27]		
Provide respiratory protection[28]		
Provide protective clothing[29]		

[26] A self-reading dosimeter is only necessary for emergencies initiated or accompanied by high radiation alarms.

[27] Remind personnel to frequently read the dosimeter and replace or reset at ¾ full scale.

[28] Respiratory protection is recommended when high airborne activity is reported by any instrument, or if toxic gas or fumes are present.

[29] Provide protective clothing when appropriate to prevent skin contamination to individuals entering or remaining in the emergency area for essential tasks such as radiation environment measurements or operation of safety equipment.

OIL	OIL value	Response action (as appropriate) if the OIL is exceeded
Environmental measurements		
OIL1	Gamma (γ) 1000 μSv/h at 1 m from surface or a source 2000 cps direct beta (β) surface contamination measurement[e] 50 cps direct alpha (α)surface contamination measurement[f]	• Immediately evacuate or provide substantial shelter[a] • Provide for decontamination of evacuees[b] • Reduce inadvertent ingestion[c] • Stop consumption of local produce[d], rainwater and milk from animals grazing in the area • Register and provide for a medical examination of evacuees • If a person has handled a source with a dose rate equal to or exceeding the 1000 μSv/h at 1 m[e] provide an immediate medical examination
OIL2	Gamma (γ) 100 μSv/h at 1 m from surface or a source 200 cps direct beta particle (β) surface contamination measurement[f] 10 cps direct alpha particle (α) surface contamination measurement[f]	• Stop consumption of local produce[d], rainwater and milk from animals grazing in the area until it has been screened and contamination levels have been assessed using OIL5 and OIL6 • Temporarily relocate those living in the area; before relocation reduce inadvertent ingestion[c]. Register and estimate the dose to those in the area before relocation to determine if medical screening is warranted. Relocation of the areas with the highest potential exposure should begin within days • If a person has handled a source with a dose rate equal to or exceeding the 100 μSv/h at 1 m[e], provide medical examination evaluation; any pregnant women who have handled such a source should receive an immediate medical evaluation and dose assessment
OIL3	Gamma (γ) 1 μSv/h at 1 m from surface 20 cps direct beta (β) surface contamination measurement[f, i] 2 cps direct alpha (α) surface contamination measurement[f, i]	• Stop consumption of non-essential[g] local produce[d], rainwater and milk from animals[h] grazing in the area until it has been screened and contamination levels have been assessed using OIL5 and OIL6 • Screen local produce, rainwater and milk from animals[h] grazing in the area at least 10 times the distance to which OIL3 is exceeded and assess samples using OIL5 and OIL6 • Consider providing iodine thyroid blocking[j] for fresh fission products[k] and for iodine contamination if replacement for essential[g] local produce or milk is not immediately available • Estimate the dose of those who may have consumed food milk or rainwater from the area where restrictions were implemented to determine if medical screening is warranted
Skin contamination		
OIL4	Gamma (γ) 1 μSv/h at 10 cm from the skin 1000 cps direct beta (β) skin contamination measurement[f] 50 cps direct alpha (α) skin contamination measurement[f]	• Provide for skin decontamination[b] and reduce inadvertent ingestion[c] • Register and provide for a medical examination

Note: The OILs should be revised as soon as it is known which radionuclides are actually involved. The OILs should also be revised, if necessary, as part of the preparedness process, to be more consistent with the instruments to be used during the response. However, the default OILs in this table can be used without revision to make a conservative assessment immediately.

a Inside closed halls of large multi-storey buildings or large masonry structures and away from walls or windows.

b If immediate decontamination is not practicable, advise evacuees to change their clothing and shower as soon as possible. Guidance for performing decontamination may be found in Refs [16] and [17].

c Advise evacuees not to drink, eat or smoke and keep hands away from the mouth until hands are washed.

d Local produce is food that is grown in open spaces that may be directly contaminated by the release and that is consumed within weeks (e.g. vegetables).

e This external dose rate criterion applies only to sealed dangerous sources and does not need to be revised in an emergency.

f Performed using good contamination monitoring practice.

g Restricting essential foods could result in severe health effects (e.g. severe malnutrition), and therefore essential foods should be restricted only if replacement food is available.

h Use 10% of OIL 3 for milk from small animals (e.g. goats) grazing in the area.

i Deposition by rain of short lived naturally occurring radon progeny can result in count rates of four or more times the background count rate. These rates should not be confused with the deposition rates due to the emergency. Count rates due to radon progeny will decrease rapidly after the rain stops and should be back to typical background levels within a few hours.

j Only for several days and only if replacement food is not available.

k Fission products that were produced within the last month, thus containing large amounts of iodine.

Criteria to determine suitability of instruments for Table B.3 may be found in Ref. [12]**.**

AG.C.1. MONITORING TEAM LEADER

ACTIONS

- Review logs and current worksheets to become familiar with emergency response status.
- Receive a briefing from the departing Radiological Protection Manager and Monitoring Team Leader that covers completed tasks for the prior shift and the planned tasks for the shift.
- Obtain work direction and personnel assignments from the Radiological Protection Manager.

CAUTION

Only volunteers may exceed occupational exposure limits and only the Radiological Protection Manager may authorize this exposure.

- Brief the assigned personnel using the guidance in Appendix II as to their duties and responsibilities using Appendix II.
- Determine what personal protective equipment is required based on the expected radiation levels and current protective actions.
- Verify suitability of equipment for the assigned tasks including verification of the proper instruments, calibration status of them and additional materials needed.
- Perform the assigned tasks.
- Promptly report unusual or unexpected radiation readings to the Radiological Protection Manager.
- Update Worksheet B.1 when new information is available.

AG.C.2. DECONTAMINATION TEAM LEADER

ACTIONS

- Review logs and current worksheets to become familiar with the Emergency response status and the current radiological environment.
- Receive a briefing from the departing Radiological Protection Manager and Decontamination Team Leader.
- Obtain work direction and personnel assignments from the Radiological Protection Manager.

CAUTION

Only volunteers may exceed occupational exposure limits and only the Radiological Protection Manager may authorize this exposure.

- Brief the assigned personnel as to their duties and responsibilities using Appendix II.
- Determine what personal protective equipment is required based on the expected radiation levels and current protective actions.
- Verify suitability of equipment for the assigned tasks including verification of the proper instruments, calibration status of them and additional materials needed.
- Perform the assigned tasks.
- Complete Worksheet C.3 for any individuals examined for contamination. A copy should be provided to the off-site medical facility if the individual is transported for decontamination or medical attention.
- Obtain concurrence from the Radiological Protection Manager for transfers to off-site for medical treatment or decontamination.

NOTE

This is not intended to delay timely transfer, but to ensure the Radiological Protection Manager remains aware of the status of personnel who are on the site.

- Contaminated individuals sent off-site for medical first-aid and/or decontamination should be accompanied by an escort with suitable radiation monitoring equipment.

AG.C.3. COMMUNICATOR

ACTIONS

- Review logs and current worksheets to become familiar with the emergency response status.
- Receive a briefing from the Facility Response Manager.
- When all shift changes have been completed, verify that Worksheet A.1 has been updated, or update the worksheet.
- Perform notifications as directed by the Facility Response Manager using Worksheet C.1 for contact information. Maintain Worksheet C.2 to make sure a necessary notification is not overlooked.
- With guidance from the Facility Response Manager, prepare initial and subsequent public information releases for review and approval of the Facility Response Manager or a designated alternate.

CAUTION

Reviews with off-site authorities are to allow them to propose revisions to the information. Off-site authorities should be reminded to not release any information unless the Facility Response Manager has authorized the release.

- Review pending information releases with off-site authorities.
- Release information to the public when authorized by the Facility Response Manager.

NOTE

Prompt and correct information is important to prevent inappropriate public response to the emergency.

- Initiate updates to off-site contacts as directed by the Facility Response Manager when significant information becomes available or changes.
- Bring new information from off-site to the attention of the Facility Response Manager.
- Keep the Facility Response Manager apprised of off-site responses and requests for information.

AG.D.1. PLANT SECURITY MANAGER

ACTIONS

- Review logs and current worksheets to become familiar with the emergency response status.
- Obtain a briefing on site security, reactor conditions and radiological conditions from the previous Plant Security Manager.
- Verify expected activity for the next shift with the Facility Response Manager.
- Initiate/Continue actions from the site Security Plan in such a way that they are coordinated with other response actions (response procedures).
- Verify the appropriate radiological protection for site Security personnel based on reactor conditions.
- When emergency assistance is requested from off-site, inform the entry gate personnel of the expected arrival time and which emergency service is expected, such as fire truck, ambulance, or others. Direct the entry gate personnel to maintain a record of these arrivals for later registration on Worksheet C.4.

NOTE

Off-site assistance is expected to be requested quickly once the need is recognized. Verify with the Facility Response Manager such requests need to be provided to the site Security personnel.

- Ensure that individuals leave the site only when the Radiological Protection Manager has confirmed the individuals are not required for the emergency response and are not contaminated or injured.
- Report to the Facility Response Manager when the requested off-site emergency responders have arrived.
- Prepare and deliver periodic briefings on the site security situation as requested by the Facility Response Manager
- Maintain a record of information and the decisions resulting from that information. Use this record as briefing material for the next Plant Security Manager.

WORKSHEETS

Performed by: *Facility Response Manager*	**WORKSHEET A.1. RESPONSE ORGANIZATION ASSIGNMENTS** (Updated worksheet should be filled out completely)	No. _____

Prepared by: _____ (full name)

Date: _____

Time: _____

Provide copies to:

Assigned personnel

Off-site Officials

Position	Person Assigned	Signature
Facility Response Manager		
Radiological Protection Manager		
Monitoring Team Leader		
Incident Commander of the first responders		
Communicator		
Decontamination Team Leader		
Plant Security Manager		

Remarks:

Instruction for the use of Worksheet A.1. Response Organization Assignments

This worksheet provides the members of the Emergency Response Team and the Off-site Officials with a list of who, by name, is assigned to the response team positions. For emergencies that are quickly resolved, there may be only one such worksheet needed for the response. Emergency conditions that are extended to more than a single shift will prepare a new worksheet each shift to keep the information correct for the individuals on the shift.

Customization may consist of adding the names of the additional positions on the response team if the particular site assigns additional positions. The Distribution list for copies may need to be altered if there are additional positions. Similarly, site terminology for the names of the positions may be used.

Completed by: *Facility Response Manager*	**WORKSHEET A.2. FACILITY RESPONSE MANAGER'S CHECKLIST**	

Action Item	Complete
Mitigate the initiating event	
Classify event	
Mobilize full emergency response team if necessary	
Notify on-site officials	
Account for all on-site personnel	
Implement urgent protective actions on-site	
Identify injured and/or contaminated individuals	
Notify off-site authorities, request necessary support	
Measure on-site dose rates	
Map on-site contamination	
Re-evaluate on-site protective actions	
Arrange for first aid of injured	
Alert hospital if medical transport is necessary, identify radiological escort	
Initiate decontamination of personnel	
Verify no off-site radiation	
Develop initial public statement and establish contact with media	
Additional Actions (list below):	

Instructions for use of Worksheet A.2. Facility Response Manager's Checklist

This checklist is intended to be a one page list of actions that the Facility Response Manager would follow as the response to an emergency is conducted. The checklist is not a substitute for the Facility Response Manager Action Guide, but a resource to help in the implementation of the Action Guide and to help maintain awareness of the overall response.

The order of the action items roughly follows the priority of the response actions on the Action Guides for the Facility Response Manager and the other responders. It is expected that some items will be completed while items higher on the list are not yet reported as complete just due to the time required to perform certain items.

Customization of the checklist may be useful. Site-specific terminology and additional actions that are already a part of the site response to an emergency can be added. The positions responsible for performing the action items could also be added to increase the usefulness. It is suggested to leave a few lines at the end of the list to allow actions that may be very specific to the particular emergency to be added as the Facility Response Manager determines.

Performed by: *Facility Response Manager*	**WORKSHEET A.3. EMERGENCY CONDITION ASSESSMENT** (Revise if assessment or conditions change.)	No. _____

Prepared by: _____ Date: _____

Provide copies to: Time: _____

Facility Response Manager Radiological Protection Manager Other _____

Type of Emergency: _____ _____ _____ _____ _____
Emergency conditions:

From Procedure AG.A.1 Emergency Classification Alert Facility Emergency		
Reactor Condition:	Subcritical	Fuel damage: No Yes Unknown
	Fully Shutdown	Fuel Covered: No Yes Unknown
	Critical at power level of _____	

Instructions for use of Worksheet A.3. Emergency Condition Assessment

This worksheet records the information available to the Emergency Response Team to allow them all to have the same set of facts concerning the emergency. The information necessary to describe the emergency condition is recorded and the classification of the emergency is assigned when classification has been accomplished.

Emergency classification should not be delayed to complete this Worksheet.

Classification should be complete within 15 minutes of declaring an emergency exists, and this form should not be allowed to delay that step in the response. Recording the type of emergency, and additional details of the emergency condition, is a task that the Facility Response Manager should perform very quickly so all the response team can react to the known condition rather than to assumptions. The site may choose to add a list potential emergencies based on reactor emergency procedures or other publication on the worksheet so that only a check off is needed to identify the type of emergency.

The reactor condition, including the state of fuel damage, if known, and heat removal by keeping the core covered are also recorded so significant pieces of information may be quickly determined by the response team members. The site may determine that additional key pieces of information should be added to this form depending on reactor systems whose status needs to be clearly communicated.

The condition of “Fully Shutdown” depends on the definition of that condition in the reactor technical specifications or operating procedures and may differ from “Subcritical” based on the status of reactor control, instrumentation or other equipment. For example, the reactor will be subcritical when the neutron level is decreasing, even though control rods may still be withdrawn, but operating procedures may require that control rods are released, on the bottom, and the drive mechanisms are de-energized in order to consider the reactor fully shutdown.

If the reactor remains operating, the operating power level is added to the worksheet for information.

Since the emergency conditions may change, it is important to keep this form updated to those changes. A simple numbering scheme is proposed, but an alternative procedure may be implemented as the site finds convenient.

Worksheet D.2 in Part 1 of this publication may suggest additional information to be recorded as part of evaluating the reactor condition.

Performed by: _____	**WORKSHEET B.1. SITE RADIATION ENVIRONMENT** **Page 1 of 3**	No. _____ Time and Date: _____

(worksheets from Ref. [19] may be substituted)

Permanently Installed Instruments:

Site Location	Type	Reading	Recorded by

Portable Instrument Readings:

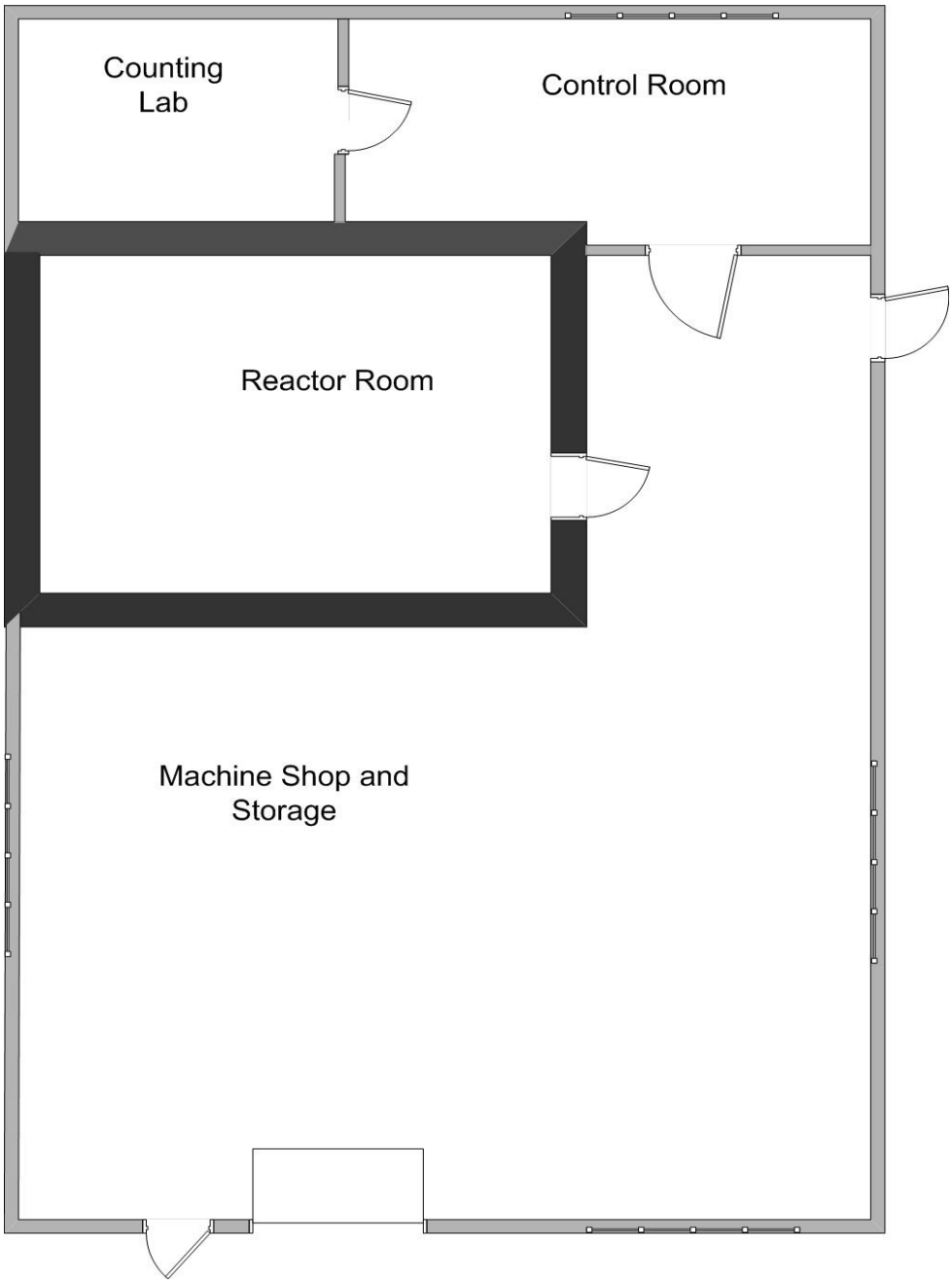
Facility Location	Type	Reading	Recorded by

Ventilation System Activity

Site Location	Type	Reading	Recorded by

Performed by: _____	**WORKSHEET B.1. SITE RADIATION ENVIRONMENT** **Page 2 of 3**	No. _____ Time and Date: _____

(replace with specific map, sketch below is an illustrative example)



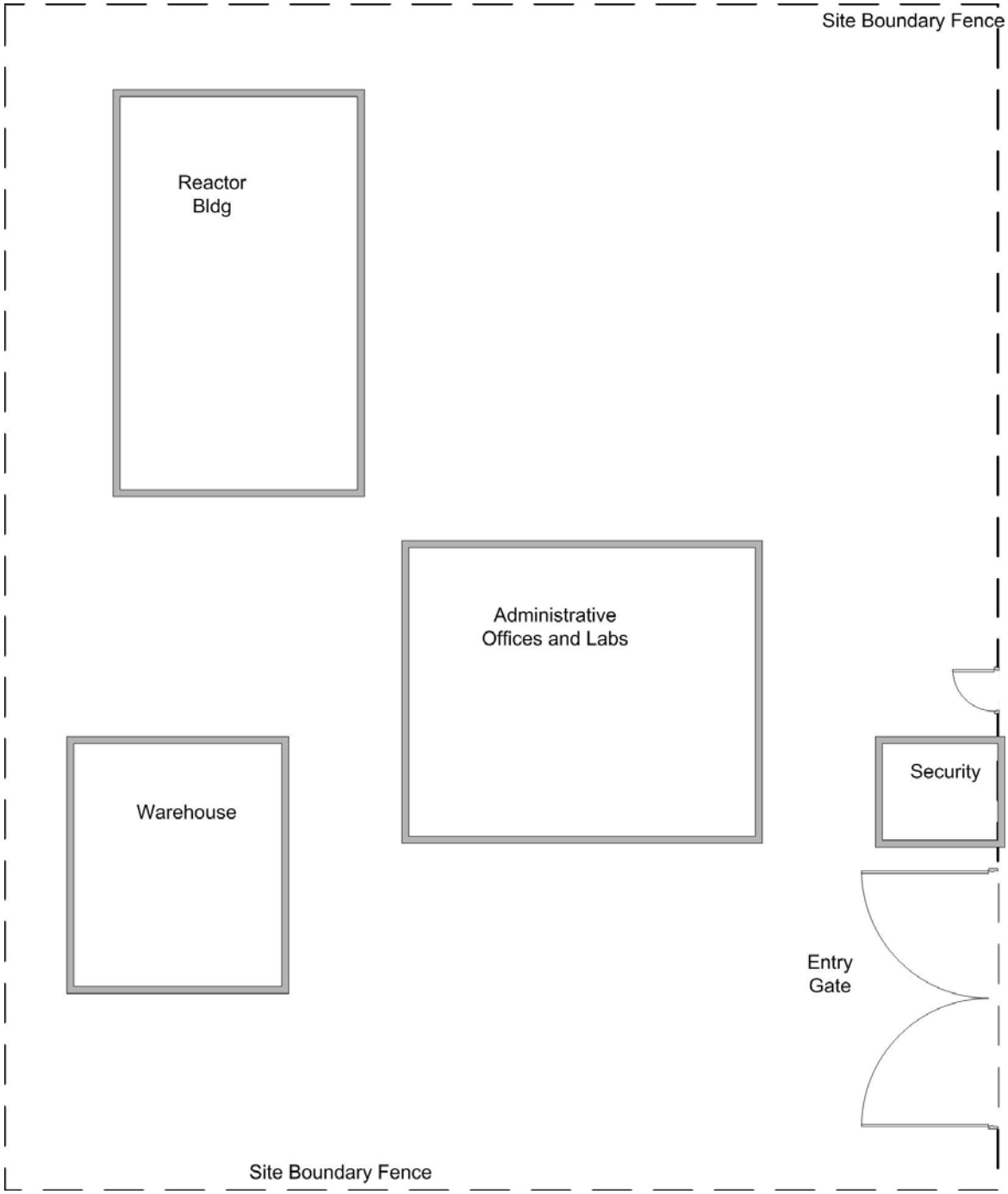
Values from resurvey on both maps should be recorded with complete rewrite, no cross-outs or overwrites.

Record Radiation Measurements:
Direct β-γ dose rate in Red
Contamination levels in Black

Data Recorded:
Date: _____
Time: _____

Performed by: _____	**WORKSHEET B.1. SITE RADIATION ENVIRONMENT** **Page 3 of 3**	No. _____ Time and Date: _____

(replace with specific site map, sketch below is an illustrative example)



Record Radiation Measurements:
Direct β-γ in Red
Contamination levels in Black

Data Recorded:
Date: _____
Time: _____

Instructions for the use of Worksheet B.1. Site Radiation Environment

This is a multipage sample worksheet to record radiation monitoring results in and around the reactor. The worksheet uses a combination of lists of readings on page 1 and building and site maps on pages 2 and 3, but other visual display methods may be used. If the map format is chosen, then site-specific displays would replace the sample worksheets. Some sites may even chose to add additional pages. For example, a multireactor site may use the sample pages 2 and 3, plus add a fourth page showing a map of the larger site and the other reactor locations.

The measurements most commonly used will be gamma dose rate values, however, contamination levels (measurements of both α and β particle emitting radionuclides) and airborne activity levels may be recorded depending upon the situation. Pages 2 and 3 suggest that a single map be used to show all readings with direct radiation and contamination differentiated by colour coding the numerical values. The worksheet should also agree on consistent units for all reading of the same type. For example, it could be agreed that all gamma dose rates are recorded in μSv/h and all contamination levels in cps. That eliminates the need to write the units and makes the completed map more readable. This also conforms to the units used by the OILs.

Since radiation readings may change with time during the emergency, the site needs to determine how often area surveys are repeated. It is recommended that a new map be prepared when revised survey information is obtained. Again, this helps to keep the survey map easier to read. An alternative method is to use sheets covered with plastic and write on then with a felt-tipped pen that may be wiped off for a new reading when available. If that is selected, it is recommended that the map be photocopied to retain a record of the previous recorded values before replacing any numerical data.

Performed by: *Radiological Protection Manager*	**WORKSHEET B.2. ON-SITE PROTECTIVE ACTIONS**	No. _____ Time and Date: _____

Protective Action	Recommended and Comments		Implemented, Time and Date	
Evacuation of non-essential personnel	Yes	No	Yes	No
Self-reading Dosimetry	Yes	No	Yes	No
OIL Briefing	Yes	No	Yes	No
Respiratory Protection	Yes	No	Yes	No
Iodine Thyroid Blocking	Yes	No	Yes	No
Protective Clothing	Yes	No	Yes	No
Medical Evaluation and Follow-up	Yes	No	Yes	No
Whole Body Counting	Yes	No	Yes	No

Instruction for use of Worksheet B.2. On-Site Protective Actions

This worksheet records the protective actions that are implemented on the site of the reactor emergency. Only those protective actions deemed necessary will be recorded here, so portions of the form may be unused. This is a record of what was implemented and when it was implemented. The emergency class or OILs (Tables B.2 or B.3) are used to determine what protective actions are necessary for a particular emergency.

Each potential protective action is provided a space to record if the action was recommended and when it was implemented, if it was. The comments section may be used to **NOTE** supporting information, such as the area on the site where the protective action was implemented in situations where, for example, the entire site did not need to take a particular protective action.

The last two actions are not urgent protective actions, but are included for completeness if those specific longer term protective actions need to be recorded. It is more likely that only a few individuals involved in the emergency will be identified to require medical follow-up or whole body counting.

Prepared by: _____	**WORKSHEET C.1. CALL LIST FOR OFF-SITE CONTACT POINTS**	Effective Date: _____

Agency/Support Organization	**Contact Information**
Police	
Security	
Fire Brigade	
National Nuclear Regulatory Organization	
Regional/Local Emergency Response Organization	
Ambulance Service	
Hospital	
Reactor/Site Management	

Include contact information for all operators, radiological controls personnel and any other personnel who may be needed during an emergency.

Instructions for use of Worksheet C.1. Call List for Off-Site Contact Points

This is a list of contact information for notification of off-site authorities. It is prepared in advance of the emergency and ready to be used by the Communicator when the response team assembles. The agencies listed are examples of those the site may need to contact. Each site will generate a unique list depending upon who the site needs to contact. The specific contacts may differ depending upon the particular emergency. For example, security threats may require contact with organizations that would not be involved in a fire.

The site may also wish to provide a similar list for on-site contacts such as off duty personnel who have particular expertise that could be required to support the response, or other organizations that share the same site and need to be informed of the emergency.

Performed by: *Communicator*	**WORKSHEET C.2. EMERGENCY NOTIFICATION RECORD**	No. _____

Name	Contact Number	Notified	Reason not notified
		Yes No Time _____	
		Yes No Time _____	
		Yes No Time _____	
		Yes No Time _____	
		Yes No Time _____	
		Yes No Time _____	
		Yes No Time _____	
		Yes No Time _____	
		Yes No Time _____	
		Yes No Time _____	
		Yes No Time _____	

Instructions for use of Worksheet C.2. Emergency Notification Record

This worksheet is used to record what notifications have been completed and when. It serves as the record of notification so duplicate contacts are avoided, and overlooked contacts can be quickly identified. The more detailed the record of who, by name and organization, was contacted and when will improve the usefulness of the worksheet. Space is provided to show why individuals intended to be contacted were not contacted also helps the entire response team understand how the information on the emergency has been provided to other organizations.

To be Completed by: *Decontamination Team Leader*	**WORKSHEET C.3. VICTIM CONTAMINATION CONTROL RECORD (ON-SCENE ASSESSMENT)**	No. _____

Surveyed by: _____ (Full Name) Date: _____

Provide to: □ Radiological Protection Manager Time: _____

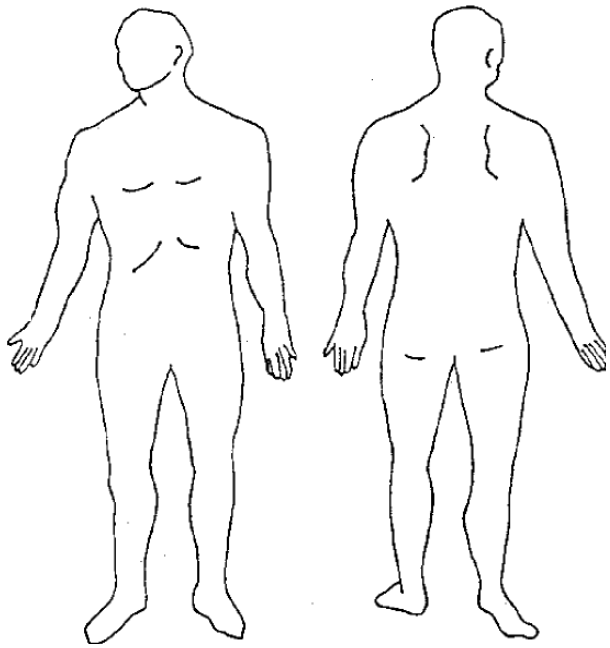
Name of Address: _____ Sex: □ M □ F

Date of Measurement: _____/_____/_____ Time of Measurement: _____

Contamination Survey

Instrument Type: _____ Model: _____

Background Reading: _____ Detector Active Surface: _____cm^2



Remarks: Indicate Readings in the lines provided in the diagram. Indicate location of the readings by arrows. Only record readings greater than background.

Decontamination Procedures performed: □ Yes □ No

Results of thyroid Survey: _____ [ ] (count rate from neck) Units _____ [ ] (count rate from thigh) Units

_____ [ ] (background count rate) Units _____ [ ] (net count rate) Units

Calibration coefficient: _____ Bq/unit of count rate Activity: _____ [Bq]

Further evaluation at medical facility necessary: □ Yes (send copy of worksheet with victim) □ No

Surveyors Signature: _____

Instructions for use of Worksheet C.3. Victim Contamination Control Record (On-Scene Assessment)

Tis form records contamination levels on individuals exposed to radioactive materials during an emergency. It is usually completed before any decontamination occurs. However, in some situations, that may not have been performed and the record should Note if any prior decontamination was attempted. If that decontamination was successful, then the record would show no or the remaining contamination.

It can also serve as a record of other monitoring for internal contamination if thyroid scanning equipment is available.

This record would be accompanied by a copy of Worksheet C.4, and the two could be attached to avoid having to record duplicate information, such as the individual's address.

If the individual is sent on to an off-site medical facility for medical treatment or decontamination, a copy of the worksheet should be provided to inform the receiving facility of contamination levels recorded at the scene.

The form records the name and an address for the individual for further contact. Information on the instrument used for the contamination monitoring is also recorded to allow assessment of the adequacy of the instrument and to determine the instrument calibration constant. The calibration constant is the instrument manufacturer's value to convert cps to Bq. This value is recorded at the bottom of the form and could be determined later.

The centre part of the form is used to record contamination levels measured on the individual. The left side id for contamination on the front of the body and the right side relates to the back. Contamination monitoring should concentrate on the areas of the body with the highest readings. It is also important to monitor areas where injuries have occurred as well as around the face where external contamination could be an indicator of ingested or inhaled contamination.

At the bottom of the form the results of decontamination, if attempted, can be recorded. Survey information after decontamination should be recorded as well, either on the original record or on a new sheet. The individual performing the monitoring is asked to sign the form.

If thyroid monitoring is performed, the net count rate from radioiodine in the thyroid is:

With a mix of radionuclides present:

Count rate from neck — count rate from thigh

With only radioiodine present:

Count rate from neck — background count rate

A more accurate assessment of thyroid dose may be determined by the procedures of Ref. [16].

To be completed by: *Radiological Protection Manager*	**WORKSHEET C.4. REGISTRY FORM FOR PERSONS INVOLVED IN EMERGENCY**	No. _____

Prepared By: _____ Date: _____

Provide copies to: ☐ Facility Response Manager

☐ Radiological Protection Manager Time: _____

Information about person involved in the emergency:

Full Name:

_____

Date of Birth (DD/MM/YYYY): ____/____/_____ Age: _____ Sex: ☐ M ☐ F

ID Type and Number:

_____

Current Local Full Address:

_____

Telephone: _____

Current Permanent Full Address:

_____

Telephone: _____

Member of: ☐ Public ☐ Facility Staff ☐ Emergency Services

Radiological Survey performed: ☐ Yes ☐ No (If Yes, attach Worksheet C.2 with results)

Decontamination done: ☐ Yes to level: _____ [ ] ☐ No
Units

Distance from initial event (or location when initial event occurred):

_____

Time of beginning of exposure (if any): _____: Time at end of exposure: _____

Duration of exposure: _____ minutes: Position during exposure: _____

Remarks:

_____

_____

_____

Responder Signature: _____

Instructions for the use of Worksheet C.4. Registry Form for Persons Involved in Emergency

This form records the contact information to enable future communication with individuals who have been involved in an emergency where follow up contact may be appropriate. Employees of the reactor will have similar information in personnel records, and for similar reasons. The individuals who were at the site when the emergency occurred as visitors or contractors performing work are the primary individuals for whom this registration is intended.

As much information as can be determined from interviewing the persons involved should be recorded. It may be useful for dose reconstruction, for example. Alternatively, it is a record that may determine the individuals were not affected at all by the emergency. The site should use judgement as to which emergencies should initiate the use of this form. Emergencies involving the release of radioactive material or unusual radiation levels in areas should clearly be ones that use the form since visitors or responders from off-site organizations may have received unmonitored radiation exposure. While not on the sample form, the site should consider asking the individual to sign the form to acknowledge the provided information, and then provide the individual a copy of the form for their own records.

The site should protect these records from disclosure in accordance with privacy laws applicable to the records.

The registration information includes a full name, contact information such as address and phone number, including current and permanent address, personal information such as Male or Female and age of the individual. The personal information may be useful to establish a priority for follow-up contact since younger individuals may be at more risk from radiation exposure than older individuals. The association with the site is also recorded in terms of site employees, member of the public as would be the situation for some visitors, or a member of the emergency service organization, for example the fire brigade, that responded to the emergency.

The additional information on the lower part of the form is intended to report the results of any radiation monitoring performed, including the need for and effectiveness of decontamination, if performed. Information on the person’s location relative to the location of the emergency and the time the individual was potentially exposed to radiation are recorded to permit dose reconstruction, if that is needed. The individual recording the information is requested to sign. As mentioned above, the individual being registered may also be asked to sign if the site considers that necessary.

APPENDICES TO PART 2

Appendix I

EMERGENCY RESPONSE EQUIPMENT

This is a minimum list of equipment for the research reactor site emergency workers and was extracted from Ref. [2].

RADIATION PROTECTION EQUIPMENT FOR ON-SITE EMERGENCY WORKERS
Respiratory protection: self-contained breathing apparatus is most effective. Filter-canister masks properly fitted to trained individuals provide a good protection against radioactive iodine and particulate but are not effective against tritium.
Protective clothing must be based on the type of hazard. The high skin doses which can be received from beta radiation should be taken into consideration. For example, there should be no exposed skin; for fire fighters, protective suits should be non-plastic (or not of a material which melts on the skin); for personnel expected to perform hard work and/or get wet, suits should be waterproof. At a minimum there much be coveralls, booties, and gloves designed to protect from radioactive contamination.
Iodine thyroid blocking agent should be issued to all emergency workers prior to potential radioiodine exposures.
Dosimeters: each worker should wear thermoluminescent dosimeters in order to provide a record of the accumulated dose after the emergency. Self-reading (e.g. electronic) dosimeters (up to 250 mSv) should be available with the required supporting hardware, such as batteries or battery chargers, and readout/recording instrumentation.
Survey instruments: at least one person in each team should carry a very high dose rate meter (up to 10 Gy/h). Survey instruments must cover all ranges and detect alpha and beta emitters as well as gamma emitting nuclides. Contamination survey instruments must be available to monitor emergency workers on their exit from contaminated areas and to survey others for contamination from the initial event. These could include: hand-and-foot monitors, portal monitors, portable portal monitors, contamination probes (pancake probes) and scintillation probes. Care must be taken to avoid contaminating the probes. Spare batteries need to be provided for portable instruments.
Clothing: spare clothing and disposal facilities (plastic bags) should be available to replace contaminated clothing, as required.
Communication equipment that is operational in the areas where personnel may travel. These may include radio or cell phones, both provided with spare batteries
Flashlight or other portable lighting and spare batteries.

Appendix 15 and 16 of Ref. [2] suggest additional supplies that may need to be available depending upon the amount of decontamination or sampling that may be required. Also, some sites may wish to have a portable electrical generator with adequate fuel either on the site or stored at a nearby accessible location. All emergency equipment should be listed, preferably in the Emergency Plan, and the storage location shown on the list.

As a part of the site Quality Assurance plan the emergency equipment must be maintained by periodic inventories, replacement of perishable items, and instrument calibration and operability checks.

Appendix II

EMERGENCY WORKER BRIEFING

Emergency workers may consist of individuals from the reactor site, from off-site organizations, or both, depending on emergency. This can create a team of emergency workers with very different levels of familiarity with the reactor site. A thorough briefing should correct these different levels of knowledge. Further, the briefing needs to address specific duties and precautions, including exposure limits. Therefore, it is not useful to provide a detailed set of briefing words in this publication, but it is useful to detail the items that need to be included in the briefing. The Radiological Protection Manager is responsible for the conduct and quality of the briefing, though another person may deliver the actual content.

Briefing topics may include:

- The specific assigned task or tasks, the route to the location where the work is to be performed, the equipment provided to perform those tasks, including protective equipment and clothing, and the precautions associated with the specific tasks;
- Identification of the individuals assigned to the task and the responsible person for supervision of the task, including the reporting requirements to the supervisor;
- The expected radiation dose rates where the tasks are to be performed and radiation dose rates that, if encountered, should terminate the task until further planning is performed;
- The planned dose for the task, how that dose will be monitored, actions that can be taken to reduce the dose during task performance, and the risks associated with that level of radiation exposure;
- Communication procedures;
- Exposure guidance values from Table B.1 and a plain language description of the risks associated with doses in excess of 500 mSv;
- Reactor and other site conditions pertinent to task performance.

International standards require that individuals give informed consent prior to undertaking tasks where they may receive radiation doses in excess of the single year dose limit for occupational exposure [5]. Also, specific approval to exceed these limits must be provided by the Radiological Protection Manager. A briefing is the action that verifies the individuals involved understand and satisfies both requirements. Even when planned doses are well below 500 mSv, the briefing should include the risks associated with exposures above 500 mSv and with all the guidance values from Table B.1. An unexpected situation could occur where an emergency worker has to make an intervention decision due to discovery of new information or an injury to a co-worker.

Briefings benefit from active involvement of all the individuals involved. Suggested methods to provide this are to have the task supervisor provide the briefing and questioning the emergency workers for understanding during and at the conclusion of the briefing.

A debrief after the task is finished is equally important to determine what was accomplished and what planning or preparatory actions should be altered for future briefs.

Appendix III

CONTACT WITH THE MEDIA

The Facility Response Manager should plan to release information pertaining to the emergency and the emergency response soon after receiving verification that personnel on-site are safe and that injuries, if any, are being treated. The release should be written, provided to off-site authorities for review, and released by the off-site authorities, either locally or at the national level. While there is some urgency to prepare such a release, take all the time necessary to ensure it is accurate. Errors will be costly in both loss of confidence and recovery time to provide and explain corrections.

The arrangement with off-site authorities must be in place prior to an emergency, and tested during training exercises. The process cannot be created during the emergency and function efficiently. The off-site organization that provides information for release must be the only such official information source and must never release information that the Facility Response Manager has not reviewed. The public deserves to have prompt, accurate information written in plain language. Release to the media through a single source is the best choice.

Once an initial news release has occurred, planning for follow-up releases of new or expanded information is necessary. There is a tendency to delay the initial news release and get more information. That should be avoided. A preliminary, but prompt, release is better than a more complete release that is delayed. Anticipate providing additional details to supplement the original release with important information that was not available at the time of the first release. Subsequent releases may also address media questions that result from the first release.

The content of releases should truthfully provide information on the threat to individuals and actions being taken to reduce those threats or to verify that there is no such threat.

As well as providing correct information about the event throughout the emergency response, the site should immediately respond to incorrect information and rumours that misrepresent the nature and severity of the emergency.

Sample news releases are provided in Ref. [3], Appendix II, and in this Appendix. The sample news releases can be very helpful as examples if a similar sample release is prepared in advance for the research reactor. This not only saves time, but allows a clearly worded partial release to be prepared in advance, of course still requiring appropriate details of the event. One of the recurring problems with nuclear or radiological emergencies is that preparation of the news releases during the emergency response is competing with other emergency response activities and the releases often do not provide the intended message just due to a hasty choice of words. Additional information may be found in Ref. [2], Appendix 18, and Ref. [4], Appendix VII.

Sample Holding Statement
(For use before specific information is available):

Date: [date of issue]
Time: [time of issue]
[News Release Number]

[Organization name] reports that [nature of event] occurred at the [location] research reactor facility. [Insert statement clarifying the condition of the research reactor and whether the event occurred in the reactor or an associated facility]. The [event] occurred at [time] when [information on the event] and that [any initial measures] measures are being taken to protect [the public, responders, products, trade, or specify as appropriate]. The facility and [specify organizations involved in the response] planned response for this type of event is in progress [specify plan as appropriate] [and the public information centre has been activated]. [Organization name] has contacted [local authorities/regulator] and informed them of the event.

[Organization name] is coordinating its activities with responders now at the scene and other involved agencies [specify as appropriate]. Further information will be provided as it becomes available. [Provide details on timing of any updates or briefings and radio and TV stations or Internet locations where information will be released]. The next [briefing/update] will take place at [location and/or time].

_____

For further information:
Name [name of contact for the media]:
Title [title of media contact]:
Organization:
Telephone:
Mobile:
Email:
Website:

Sample News Release
(for a nuclear or radiological emergency at a research reactor):

Date: [date of issue] Time: [time of issue]
[News Release Number]

[Organization name] confirms that a [nature of event] occurred at the [name of facility] research reactor facility at [time] on [date]. [Insert statement clarifying the condition of the research reactor and whether the event occurred in the reactor or an associated facility]. The facility and [specify organizations involved in the response] planned response for this type of event is in progress [specify plan as appropriate] [and the public information centre has been activated]. [Organization name] contacted [local authorities/regulator] and informed them of the event.

[Organization name] is coordinating/has coordinated its activities with responders and other involved agencies [specify as appropriate]. The following actions have been/are being taken [e.g. evacuation on-site/off-site, surveys in public areas, sheltering, stable iodine, transport of injured people, decontamination of people/areas] to protect [the public, responders, products, trade, or specify as appropriate].

The public is advised to take the following actions [eliminate items that do not apply, add others if appropriate]:

- [If an airborne release is suspected (specify, depending on scenario)] the public within about [specify distance] of [specify local description – roads, districts – that will be understandable to the public] are advised on the following:
    - close outside windows and doors and turn off ventilation equipment that brings in outside air until otherwise instructed;
    - remain inside until instructed otherwise;
    - do not eat or drink anything that may have been contaminated (e.g. vegetables grown outside or rainwater) until informed otherwise;
    - make sure that children are not playing on the ground;
    - wash hands before eating;
    - avoid dusty areas or activities that will make dust;
- do not be concerned about those evacuated (they are not dangerous to be near);
- do not go to the scene to volunteer or to help. [Response organizations] are assisting the facility personnel. If assistance is needed, announcements will be made;
- check for information updates on [radio, TV, Internet].

If you have a health concern go to [once available specify a location away from the local hospital where monitoring will be performed and questions answered].

If you have any questions please call [give a hot line number where large number of calls will not interfere with the response].

Further information will be provided as it becomes available. [Provide details on timing of any updates or briefings and radio and TV stations or Internet locations where information will be released]. The next [briefing/update] will take place at [location and/or time].

———————

For further information:
Name [name of contact for the media]:
Title [title of media contact]:
Organization:
Telephone: (land line and mobile:
Email:
Website:

Sample News Release
(for a non-radiological event):

Date: [date of issue]

Time: [time of issue]

[News Release Number]

[Organization name] confirms that a [nature of event] occurred at the [name of facility] research reactor facility at [time] on [date]. The research reactor is operating safely, the event did not involve any radioactive materials and there is no radiation threat to the public or the facility staff. The facility and [specify organizations involved in the response] planned response for this type of event is in progress [specify plan as appropriate], [fire/police/ambulance responded and the public information centre has been activated]. [Organization name] contacted [local authorities/regulator] and informed them of the event.

[Select one of the following paragraphs as appropriate to the event]

Further information will be provided as it becomes available. [Provide details on timing of any updates or briefings and radio and TV stations or Internet locations where information will be released]. The next [briefing/update] will take place at [location and/or time].

[or]

[Organization name] thanks the [responding organizations] for their assistance. Efforts are now focussed on restoring the facility back to normal operation. Please contact [Organization name] with any further enquiries regarding this event,

_____

For further information:
Name [name of contact for the media]:
Title [title of media contact]:
Organization:
Telephone: (land line and mobile:
Email:
Website:

LIST OF ABBREVIATIONS

AC	Alternating current
ACPR	Annular Core Pulse Reactor
DC	Direct Current
Er-U-ZrH	Erbium-Uranium-Zirconium Hydride
HEU	Highly enriched uranium
LEU	Low enriched uranium
OIL	Operational Intervention Level
PAZ	Precautionary action zone
SNAP	Space Nuclear Auxiliary Power reactor programme
SPERT	Special Power Excursion Reactor Test
TRIGA	Training, Research, Isotope General Atomic reactor design
UPZ	Urgent protective action planning zone
USAEC	United States Atomic Energy Commission
U-ZrH	Uranium-Zirconium Hydride

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Generic Assessment Procedures for Determining Protective Actions during a Reactor Emergency, IAEA-TECDOC-955, IAEA, Vienna, (1997).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Method for Developing Arrangements for Response to a Nuclear or Radiological Emergency, (Updating IAEA-TECDOC-953) IAEA-EPR-METHOD 2003, IAEA, Vienna (2003).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Manual for First Responders to a Radiological Emergency, IAEA-EPR-FIRST RESPONDERS, IAEA, Vienna (2006).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Generic Procedures for Assessment and Response during a Radiological Emergency, IAEA-TECDOC-1162, IAEA, Vienna (2000).

[5] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS OFFICE FOR THE COORDINATION OF HUMANITARIAN AFFAIRS, WORLD HEALTH ORGANIZATION, Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GS-R-2, IAEA, Vienna (2002).

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Arrangements for Preparedness for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GS-G-2.1, IAEA, Vienna (2007).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Research Reactors, IAEA Safety Standards Series No. NS-R-4, IAEA, Vienna (2005).

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Generic Procedures for Response to a Nuclear or Radiological Emergency at TRIGA Research Reactors, IAEA-EPR-RESEARCH REACTOR, ATTACHMENT, IAEA, Vienna (2011).

[9] INTERNATIONAL ATOMIC ENERGY AGENCY Safety Glossary, Terminology Used in Nuclear Safety and Radiation Protection, IAEA, Vienna (2007).

[10] INTERNATIONAL ATOMIC ENERGY AGENCY, Code of Conduct on the Safety of Research Reactors, IAEA, Vienna (2006).

[11] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Analysis for Research Reactors, IAEA Safety Reports Series No. 55, IAEA, Vienna (2008).

[12] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, PAN AMERICAN HEALTH ORGANIZATION, WORLD HEALTH ORGANIZATION, Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GSG-2, IAEA, Vienna (2011).

[13] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Assessing Dose of the Representative Person for the Purpose of Radiation Protection of the Public and The Optimization of Radiological Protection: Broadening the Process, ICRP Publication 101, Pergamon Press, Oxford (2006)

[14] INTERNATIONAL ATOMIC ENERGY AGENCY, Preparation, Conduct and Evaluation of Exercises to Test Preparedness for a Nuclear or Radiological Emergency, IAEA-EPR-EXERCISE 2005, IAEA, Vienna (2005).
[15] INTERNATIONAL ATOMIC ENERGY AGENCY, Dangerous quantities of radioactive material, IAEA-EPR-D-VALUES 2006, IAEA, Vienna (2006).
[16] INTERNATIONAL ATOMIC ENERGY AGENCY, Generic Procedures for Medical Response during a Nuclear or Radiological Emergency, IAEA-EPR-MEDICAL 2005, IAEA, Vienna (2005).
[17] NATIONAL COUNCIL ON RADIATION PROTECTION, Management of Persons Contaminated With Radionuclides: Handbook, NCRP Report No. 161, Bethesda, Md., (2009).
[18] JOINT FAO/WHO FOOD STANDARDS PROGRAMME, CODEX ALIMENTARIUS COMMISSION, Codex General Standard for Contaminants and Toxins in Foods, Schedule 1 – Radionuclides, CODEX STAN 193-1995, CAC, Rome (2006).
[19] INTERNATIONAL ATOMIC ENERGY AGENCY, Generic Procedures for Monitoring in a Nuclear or Radiological Emergency, IAEA-TECDOC-1092, IAEA, Vienna (2000).
[20] INTERNATIONAL ATOMIC ENERGY AGENCY, Derivation of the Source Term and Analysis of the Radiological Consequences of Research Reactor Accidents, Safety Reports Series No. 53, IAEA, Vienna (2008).

CONTRIBUTORS TO DRAFTING AND REVIEW

Berthelot, L	International Atomic Energy Agency
Buglova, E.	International Atomic Energy Agency
Diakov, O.	Institute for Nuclear Research, Ukraine
Gulay, Y	International Atomic Energy Agency
Grant, C.	University of the West Indies, Jamaica
Hryczuk, A.	Institute of Atomic Energy, Poland
Kenny, P	International Atomic Energy Agency
Kutkov, V	International Atomic Energy Agency
McKenna, T.	International Atomic Energy Agency
Medich, D.	University of Massachusetts Lowell, United States of America
Sapozhnikov, A.	Federal Service for Environment, Technological and Nuclear Supervision (Rostechnadzor), Russian Federation
Shokr, A.	International Atomic Energy Agency
Torres Oviedo, G.	Comisión Chilena de Energía Nuclear, Chile
Van Balen, P.	Nuclear Research and Consultancy Group (NRG), Netherlands
Zagyvai, P.	Budapest University of Technology and Economics, Hungary

Consultancy Meetings

29 June – 3 July 2009, Vienna, Austria

7 – 11 December 2009, Vienna, Austria

Pilot Use and Revision of the Manual

Workshop on Generic Procedures for Response to Emergencies at Research Reactors,
19 – 23 October 2009, Vienna, Austria

National Training Course for Research Reactor Emergency Preparedness,
25 – 29 January 2010, Santiago, Chile

IAEA
International Atomic Energy Agency

Where to order IAEA publications

In the following countries IAEA publications may be purchased from the sources listed below, or from major local booksellers. Payment may be made in local currency or with UNESCO coupons.

AUSTRALIA
DA Information Services, 648 Whitehorse Road, MITCHAM 3132
Telephone: +61 3 9210 7777 • Fax: +61 3 9210 7788
Email: service@dadirect.com.au • Web site: http://www.dadirect.com.au

BELGIUM
Jean de Lannoy, avenue du Roi 202, B-1190 Brussels
Telephone: +32 2 538 43 08 • Fax: +32 2 538 08 41
Email: jean.de.lannoy@infoboard.be • Web site: http://www.jean-de-lannoy.be

CANADA
Bernan Associates, 4501 Forbes Blvd, Suite 200, Lanham, MD 20706-4346, USA
Telephone: 1-800-865-3457 • Fax: 1-800-865-3450
Email: customercare@bernan.com • Web site: http://www.bernan.com

Renouf Publishing Company Ltd., 1-5369 Canotek Rd., Ottawa, Ontario, K1J 9J3
Telephone: +613 745 2665 • Fax: +613 745 7660
Email: order.dept@renoufbooks.com • Web site: http://www.renoufbooks.com

CHINA
IAEA Publications in Chinese: China Nuclear Energy Industry Corporation, Translation Section, P.O. Box 2103, Beijing

CZECH REPUBLIC
Suweco CZ, S.R.O., Klecakova 347, 180 21 Praha 9
Telephone: +420 26603 5364 • Fax: +420 28482 1646
Email: nakup@suweco.cz • Web site: http://www.suweco.cz

FINLAND
Akateeminen Kirjakauppa, PO BOX 128 (Keskuskatu 1), FIN-00101 Helsinki
Telephone: +358 9 121 41 • Fax: +358 9 121 4450
Email: akatilaus@akateeminen.com • Web site: http://www.akateeminen.com

FRANCE
Form-Edit, 5, rue Janssen, P.O. Box 25, F-75921 Paris Cedex 19
Telephone: +33 1 42 01 49 49 • Fax: +33 1 42 01 90 90
Email: formedit@formedit.fr • Web site: http://www. formedit.fr

Lavoisier SAS, 145 rue de Provigny, 94236 Cachan Cedex
Telephone: + 33 1 47 40 67 02 • Fax +33 1 47 40 67 02
Email: romuald.verrier@lavoisier.fr • Web site: http://www.lavoisier.fr

GERMANY
UNO-Verlag, Vertriebs- und Verlags GmbH, Am Hofgarten 10, D-53113 Bonn
Telephone: + 49 228 94 90 20 • Fax: +49 228 94 90 20 or +49 228 94 90 222
Email: bestellung@uno-verlag.de • Web site: http://www.uno-verlag.de

HUNGARY
Librotrade Ltd., Book Import, P.O. Box 126, H-1656 Budapest
Telephone: +36 1 257 7777 • Fax: +36 1 257 7472 • Email: books@librotrade.hu

INDIA
Allied Publishers Group, 1st Floor, Dubash House, 15, J. N. Heredia Marg, Ballard Estate, Mumbai 400 001,
Telephone: +91 22 22617926/27 • Fax: +91 22 22617928
Email: alliedpl@vsnl.com • Web site: http://www.alliedpublishers.com

Bookwell, 2/72, Nirankari Colony, Delhi 110009
Telephone: +91 11 23268786, +91 11 23257264 • Fax: +91 11 23281315
Email: bookwell@vsnl.net

ITALY
Libreria Scientifica Dott. Lucio di Biasio “AEIOU”, Via Coronelli 6, I-20146 Milan
Telephone: +39 02 48 95 45 52 or 48 95 45 62 • Fax: +39 02 48 95 45 48
Email: info@libreriaaeiou.eu • Website: www.libreriaaeiou.eu

JAPAN
Maruzen Company, Ltd., 13-6 Nihonbashi, 3 chome, Chuo-ku, Tokyo 103-0027
Telephone: +81 3 3275 8582 • Fax: +81 3 3275 9072
Email: journal@maruzen.co.jp • Web site: http://www.maruzen.co.jp

REPUBLIC OF KOREA
KINS Inc., Information Business Dept. Samho Bldg. 2nd Floor, 275-1 Yang Jae-dong SeoCho-G, Seoul 137-130
Telephone: +02 589 1740 • Fax: +02 589 1746 • Web site: http://www.kins.re.kr

NETHERLANDS
De Lindeboom Internationale Publicaties B.V., M.A. de Ruyterstraat 20A, NL-7482 BZ Haaksbergen
Telephone: +31 (0) 53 5740004 • Fax: +31 (0) 53 5729296
Email: books@delindeboom.com • Web site: http://www.delindeboom.com

Martinus Nijhoff International, Koraalrood 50, P.O. Box 1853, 2700 CZ Zoetermeer
Telephone: +31 793 684 400 • Fax: +31 793 615 698
Email: info@nijhoff.nl • Web site: http://www.nijhoff.nl

Swets and Zeitlinger b.v., P.O. Box 830, 2160 SZ Lisse
Telephone: +31 252 435 111 • Fax: +31 252 415 888
Email: infoho@swets.nl • Web site: http://www.swets.nl

NEW ZEALAND
DA Information Services, 648 Whitehorse Road, MITCHAM 3132, Australia
Telephone: +61 3 9210 7777 • Fax: +61 3 9210 7788
Email: service@dadirect.com.au • Web site: http://www.dadirect.com.au

SLOVENIA
Cankarjeva Zalozba d.d., Kopitarjeva 2, SI-1512 Ljubljana
Telephone: +386 1 432 31 44 • Fax: +386 1 230 14 35
Email: import.books@cankarjeva-z.si • Web site: http://www.cankarjeva-z.si/uvoz

SPAIN
Díaz de Santos, S.A., c/ Juan Bravo, 3A, E-28006 Madrid
Telephone: +34 91 781 94 80 • Fax: +34 91 575 55 63
Email: compras@diazdesantos.es, carmela@diazdesantos.es, barcelona@diazdesantos.es, julio@diazdesantos.es
Web site: http://www.diazdesantos.es

UNITED KINGDOM
The Stationery Office Ltd, International Sales Agency, PO Box 29, Norwich, NR3 1 GN
Telephone (orders): +44 870 600 5552 • (enquiries): +44 207 873 8372 • Fax: +44 207 873 8203
Email (orders): book.orders@tso.co.uk • (enquiries): book.enquiries@tso.co.uk • Web site: http://www.tso.co.uk

On-line orders
DELTA Int. Book Wholesalers Ltd., 39 Alexandra Road, Addlestone, Surrey, KT15 2PQ
Email: info@profbooks.com • Web site: http://www.profbooks.com

Books on the Environment
Earthprint Ltd., P.O. Box 119, Stevenage SG1 4TP
Telephone: +44 1438748111 • Fax: +44 1438748844
Email: orders@earthprint.com • Web site: http://www.earthprint.com

UNITED NATIONS
Dept. I004, Room DC2-0853, First Avenue at 46th Street, New York, N.Y. 10017, USA
(UN) Telephone: +800 253-9646 or +212 963-8302 • Fax: +212 963-3489
Email: publications@un.org • Web site: http://www.un.org

UNITED STATES OF AMERICA
Bernan Associates, 4501 Forbes Blvd., Suite 200, Lanham, MD 20706-4346
Telephone: 1-800-865-3457 • Fax: 1-800-865-3450
Email: customercare@bernan.com · Web site: http://www.bernan.com

Renouf Publishing Company Ltd., 812 Proctor Ave., Ogdensburg, NY, 13669
Telephone: +888 551 7470 (toll-free) • Fax: +888 568 8546 (toll-free)
Email: order.dept@renoufbooks.com • Web site: http://www.renoufbooks.com

Orders and requests for information may also be addressed directly to:

Marketing and Sales Unit, International Atomic Energy Agency
Vienna International Centre, PO Box 100, 1400 Vienna, Austria
Telephone: +43 1 2600 22529 (or 22530) • Fax: +43 1 2600 29302
Email: sales.publications@iaea.org • Web site: http://www.iaea.org/books

11-25931

EPR-RESEARCH REACTOR

2011

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA