

SAFETY



SERIES

No. 32

Planning for the Handling of Radiation Accidents

A MANUAL PUBLISHED ON BEHALF OF
ILO, FAO, WHO and IAEA



INTERNATIONAL ATOMIC ENERGY AGENCY

VIENNA, 1969

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PLANNING FOR THE HANDLING OF RADIATION ACCIDENTS

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FOREWORD

The developing atomic energy programmes and the widespread use of radiation sources in medicine, agriculture, industry and research have had admirable safety records. Throughout the world the number of known accidents in which persons have been exposed to harmful amounts of ionizing radiation is relatively small, and only a few deaths have occurred. Meticulous precautions are being taken to maintain this good record in all work with radiation sources and to keep the exposure of persons as low as practicable.

In spite of all the precautions that are taken, accidents may occur and they may be accompanied by the injury or death of persons and damage to property. It is only prudent to take those steps that are practicable to prevent accidents and to plan in advance the emergency action that would limit the injuries and damage caused by those accidents that do occur. Emergency plans should be sufficiently broad to cover unforeseen or very improbable accidents as well as those that are considered credible.

Some accidents may involve only the workers in an establishment, those working directly with the source and possibly their colleagues. Other accidents may have consequences, notably in the form of radioactive contamination of the environment, that affect the general public, possibly far from the site of the accident.

The preparation of plans for dealing with radiation accidents is therefore obligatory both for the various authorities that are responsible for protecting the health and the food and water supplies of the public, and for the operator of an installation containing radiation sources.

The International Atomic Energy Agency, the Food and Agriculture Organization of the United Nations and the World Health Organization engaged the services of Mr. W.T.L. Neal (UK), Mr. D.J. Nelson (USA) and Mr. L.C. Watson (Canada) as consultants to prepare a draft manual to give guidance on the preparation of such plans.

This draft then formed the working paper for a panel of experts later convened jointly by the IAEA, FAO and WHO. At this stage the International Labour Organisation expressed a wish to be fully associated with the further preparation of the manual and this approach was welcomed by the other sponsoring organizations. The text prepared at the panel meeting was reviewed and put into its final form by Mr. M.A. Bell (USA) on behalf of the four organizations.

A number of specimen emergency plans that illustrate the recommendations of the manual were later made available through the members of the panel and are presented in an annex to the main text.

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1. INTRODUCTION

1.1. *Purpose and scope of the manual*

The purpose of this manual is to give practical guidance to those public authorities and others who are responsible for preparing emergency plans for the handling of radiation accidents with the aim of minimizing the resulting exposure of workers and of members of the public, and of reducing as far as practicable any damage to property. This guidance must necessarily be of a general nature as it is not possible to predict with any precision the form which an accident will take or the consequences which may result.

The scope of the manual is restricted to those topics that are directly related to the preparation of the emergency plans. Where possible, any background information that is necessary is provided by reference to other publications. Where this is not possible, explanatory material is provided to enable the reader to relate the presentation to his particular circumstances.

The manual provides an outline of plans that should be prepared before any operation with radiation sources begins so that adequate procedures can be followed if an accident should occur.

Attention is directed primarily to land-based facilities and radiation sources that are transported on land, and is focussed on major accidents such as those that may occur in nuclear reactor plants and nuclear fuel reprocessing plants. General guidance is provided however, which can be applied to other types of facilities such as ships operated by nuclear power, sea-based isotopic power generators and radiation sources transported on water or in the air. Plans for handling on-site accidents may also be required for small facilities in which relatively low-activity radiation sources are used. Situations of this type are not considered in detail as it is very unlikely that such accidents could give rise to off-site problems for which special emergency planning would be required.

A number of specimen emergency plans provided by the panel members are included in the Annex. These examples have not been discussed by the panel and are presented merely as examples of existing plans.

1.2. *Explanation of terms used*

Many of the physical and radiological terms used in this manual are defined in the IAEA Basic Safety Standards [1] and in the

recommendations of the ICRP [2] and the ICRU [3]. However, when used in this manual, the terms listed below are defined as follows:

Radiation source	Radioactive material or an apparatus capable of producing ionizing radiation
Operator	The person or authority in charge of an establishment where radiation sources are present
Public authority	Persons representing or acting for the public (e.g. national and local authorities such as licensing and regulatory bodies, public health, labour, food and agriculture, atomic energy, fire, police)
Radiation accident	An abnormal event, leading to the loss of control over a radiation source, which could directly or indirectly involve hazards to life, health or property
On-site accident	A radiation accident that occurs within an establishment and whose consequences involve only those persons and property for which the operator is responsible
Off-site accident	A radiation accident whose consequences extend beyond the boundaries of an establishment and which could involve members of the public or their property, or a radiation accident that occurs in places which are not under the jurisdiction of an operator
Exposure	Exposure of man to ionizing radiation
Contamination	Contamination of man, animals, equipment and the environment by radioactive substances
Plans and planning	In all cases these terms refer to emergency plans and planning
Foreseen types of radiation accidents	Abnormal events which have been identified for a facility and that, if not corrected, could lead to an unintentional exposure or release of radioactive material
Unforeseen types of radiation accidents	Abnormal events which have not been identified for a facility

Foreseen types of emergencies

Emergency situations associated with foreseen types of accidents.

2. RESPONSIBILITY FOR THE CONTROL OF RADIATION SOURCES

Responsibility for the control of radiation sources within a country devolves upon both the public authorities of that country and the operators of establishments in which the sources are present. As part of that responsibility each must endeavour to ensure the safety of the sources by all means, including the location of installations, adequate design and construction of facilities and safe operating procedures.

2.1. *The public authorities*

The government of the country should designate and define the functions of those public authorities that will have responsibilities in connection with the control of radiation sources and in dealing with radiation accidents. Those authorities should:

- a) Arrange, by a system of licensing, or other form of regulation, means for controlling the use of radiation sources within the country
- b) Prescribe standards, or guidelines, for levels of exposure, contamination and risk, and bring them to the attention of the various groups that will deal directly with radiation accidents
- c) Establish lines of authority among national bodies, assigning the actions to be taken by these bodies in protecting the employees and the public in the event of a radiation accident that extends beyond or occurs outside the boundaries of an establishment
- d) Define the authority which should be notified when any radiation accident has occurred
- e) Establish, where appropriate, the necessary liaison with national authorities in neighbouring countries to ensure notification of accidents whose consequences might extend beyond the national boundaries
- f) Determine, and periodically review, the number of trained personnel needed within the state, and, if the number available is insufficient, arrange for the necessary training

g) Determine, and periodically review, the availability and location of trained personnel, measuring instruments and protective equipment, communications systems, medical services and laboratory services.

2.2. *The operator*

Responsibility for immediate action following an accident originating within an establishment devolves upon the operator. This responsibility will be delegated through the various levels of supervision to the individual employee, who should be suitably trained and practised to take appropriate action if an accident should occur.

The operator should establish, according to the requirements of his work and the regulations applied by the public authorities, an internal organization that will:

a) Ensure that he is prepared, within the limits imposed by his resources, to deal with any accident that may occur within his premises

b) Arrange for assistance from public authorities and from other off-site organizations for dealing with accidents whose consequences do not extend off-site, but which are beyond his resources

c) Provide immediate notification of the designated public authority of accidents whose consequences extend, or could extend, off-site

d) Provide assistance to the public authority as required

e) Provide notification of designated public authorities of all accidents in accordance with a prearranged system

f) Keep adequate records, and make an analysis, of any radiation accidents that occur.

3. RADIATION ACCIDENTS AND THEIR CONTROL

3.1. *Classification and characteristics of radiation accidents*

3.1.1. Classification

For assistance in the development of plans for dealing with different types of radiation accidents, it is convenient to classify such accidents in broad categories. Some classifications may, of course, be more convenient than others for a particular purpose. For example,

such categories as public safety accidents, economic accidents, industrial personnel accidents, and minor operational mishaps or incidents have also been used. However, in the allocation of responsibilities for handling the consequences of accidents and the giving of guidance in planning it is convenient to divide them into two classes as follows:

a) On-site accidents, which originate within, and whose consequences are confined to, an establishment to which access is controlled and in which radiation control measures are applied

b) Off-site accidents which either originate within but whose consequences are not or may not be confined to an establishment, or which originate in areas that are not under the jurisdiction of an operator.

3.1.2. Characteristics

The following brief list of characteristics of radiation accidents is based on the type of personnel radiation exposure that might be expected and the length of time over which it might continue if protective actions were not taken in accordance with plans drawn up in advance. It should be pointed out that any one of the following characteristics will not necessarily be completely representative and that many accidents will exhibit combinations of these characteristics.

3.1.2.1. External exposure — short-term

External exposure for a short period of time, lasting from seconds to one or two hours,

- a) over a relatively small geographical area as, for example, in a limited criticality accident which occurs within a building and which does not lead to any significant dispersal of radionuclides. An extended criticality accident which leads to dispersal of radionuclides would fall in one of the other categories listed below
- b) over an extended area as, for example, from a passing cloud containing radioactive substances released from a reactor or chemical processing plant.

3.1.2.2. External exposure — protracted

External exposure for a protracted period of time, lasting from hours to days or more,

- a) over a limited area as, for example, from a temporarily misplaced, inadequately shielded source of gamma radiation

- b) over a larger area as, for example, from radionuclides dispersed as the result of a fire or explosion.

3.1.2.3. Internal exposure — short-term intake

Internal exposure, following intake for a brief period of time,

- a) over a limited area, as for example from inhalation by a few persons of a radioactive aerosol before its presence is detected
- b) over an extended area, as for example from inhalation from a passing cloud containing radioactive substances.

3.1.2.4. Internal exposure — protracted intake

Internal exposure, following intake for a protracted period of time,

- a) over a limited area, as for example chronic exposure through inhalation of an undetected radioactive aerosol in a room where radioactive materials are not expected to be present
- b) over an extensive area, as for example by consumption of food-stuffs contaminated by radionuclides of long half-life.

It must be emphasized that any radiation injuries may be accompanied by other types of injuries such as wounds, burns and bone fractures.

3.1.3. Relationship of classification and characteristics to planning

Accidents exhibiting the characteristics, or combinations of the characteristics, listed above call for different types of protective actions to minimize their effects and these factors must be reflected in the plans prepared for dealing with them. An accident falling into category 3.1.2.1 (a) above will call for a plan that may have complex features because of the nature of the exposures incurred, but it may require the evacuation of only a small portion of the operator's premises. Accidents may exhibit many combinations of these characteristics and as far as possible these must be assessed in advance.

It devolves upon an operator to predict the magnitude and probability of occurrence of accidents that he can foresee and thus to estimate the area that may be involved. The operator's prediction should be independently reviewed by the public authority which has been given responsibility for control of the use of radiation sources within the country. For this prediction the operator must know the

types of radiation sources present and the inventory of radioactive materials in all parts of his plant at any given time.¹ He must use this information in conjunction with his intimate knowledge of the plant and equipment and the operations undertaken to forecast the possible consequences of foreseeable accidents. In assessing the areas that may be affected, use must be made of all other relevant information including hydrological and geological and, in particular, any meteorological information that is available.

When an evaluation of a foreseeable accident suggests that it might affect persons or property beyond the boundaries of his site, it is imperative that the plan be evaluated by the public authorities to assess off-site consequences and the necessary protective action.

3.2. *Control of radiation accidents*

3.2.1. On-site accidents

Each operator of an establishment has a responsibility to reduce as far as practicable any risks to his employees and other persons. He must ensure that proper procedures are available and if an accident should occur he must take immediate steps to protect his employees.

When the consequences of an accident are limited to a site, the actions required to deal with them fall primarily within the jurisdiction of the operator. He should have available, either from his own resources or, by prearrangement, from other sources of assistance, sufficient facilities, equipment and personnel to bring the situation under control and subsequently to restore the situation to an acceptable condition.

The plans should be sufficiently broad in scope to enable the emergency procedures to meet the situation arising from an unforeseen type of accident.

The plans should also be flexible and, while providing for some prescribed action to be taken immediately after the discovery of an accident, they should enable the subsequent actions to be suited to the nature and severity of that particular event.

3.2.2. Off-site accidents

3.2.2.1. Accidents whose consequences extend beyond the site

If the consequences of an accident extend beyond, or could extend beyond, the boundaries of a site, the operator must immediately

¹ General information on the relative inventories of different types of facilities is given in Ref. [4].

inform the appropriate public authorities in the pre-arranged manner. Those authorities should have made arrangements, as part of their overall plans, to deal with the consequences of accidents that fall within their jurisdiction. There should, in all cases, be close co-operation between the operator and these public authorities. However, situations may arise where, from the nature of the accident, prompt action is required if the hazard to the public is to be kept to a minimum. Under these circumstances, it may fall to the operator to make decisions that would normally not lie within his jurisdiction. Where such circumstances can be foreseen, the form of action to which these decisions could lead should be agreed upon with those public authorities that would normally carry responsibility for that type of action. The action itself should if possible be taken by a branch of the public authority, such as the police, that is normally engaged in public control work.

Care must be taken to avoid any undue alarm that might cause public confusion or panic which might well be more harmful than the effects of the radiation. The importance of a timely psychological approach to the public in the handling of serious radiation accidents cannot be overemphasized.

3.2.2.2. Accidents occurring in areas which are not under the jurisdiction of an operator

When an accident occurs in an area that is not within a site controlled by an operator, as in the case, for example, of a transport accident, a fire in a storage facility, or the loss of a sealed source, the first official persons to learn that radiation sources are involved will probably be employees of public authorities such as police or fire services. A suitable plan should be made in advance to enable those persons to call upon experts for immediate and authoritative advice. The plan should be very flexible and should enable any available resources to be called upon as required.

4. ORGANIZATION FOR HANDLING RADIATION ACCIDENTS

4.1. *General organization*

Emergency plans are usually based upon foreseen types of accidents and the assumption is made that the risks evaluated would be similar to those that might arise in unforeseen types of accidents.

But it should be borne in mind that accidents of an unforeseen type, involving even greater risks, cannot be excluded, though their probability of occurrence will be low. In any event, the effective handling of radiation accidents and their consequences may call for liaison and close co-operation between various responsible public authorities and the operators of establishments as well as co-operation between countries. An effective organization must exist as a basis for ensuring effective co-operative action and the utilization of all available sources of assistance.

The main responsibility for controlling the use of radiation sources within a country should be assigned to one public authority. During the review process, this authority would be expected to consult and collaborate with other public authorities who have responsibilities for certain aspects of the uses of radiation sources or emergency planning [5]. It would then devolve upon that authority to review the plans for proposed installations and to approve their construction and operation. The authority would also have to assure itself that other public authorities, as appropriate, and the operators have developed organizations for preparing and implementing plans to prevent and to limit the consequences of all types of credible radiation accidents.

Where the consequences of an accident could extend across national boundaries, arrangements should be made in advance between competent national authorities of the countries involved and possibly intergovernmental and international organizations to ensure the protection of the populations involved. For example, a national organization would also be required to co-ordinate emergency action with that of a neighbouring country if the consequences of a radiation accident could extend to that country.

4.2. National and international organizations

The key to success in minimizing the effects of a large radiation accident is the ability of a country to bring into immediate service its national resources in accordance with an established overall plan. Where the consequences of an accident could extend across national boundaries, arrangements should be made in advance between competent national authorities and/or international organizations to ensure the protection of the populations involved. National governmental authorities must undertake the planning for the protection of the public

in the event of large radiation accidents. The national plan should be the responsibility of the national public authority designated by the government to administer the national radiation emergency plan. This includes the co-ordination of intergovernmental relationships in a plan that provides for unity of national action under the direction of the most appropriate national public authority. Since the public health and safety could be involved, it is also appropriate to plan for using the national governments, resources to cope with large radiation accidents.

Where the possibility exists for a country to be called upon by a neighbouring country for assistance, the national planning should provide for the procedures to make national resources available if requested. If a national government believes that it may require radiation emergency assistance from another country, the national plan should provide for requesting and using such assistance.

Through diplomatic channels and with the guidance and assistance of international organizations such as FAO, WHO and the IAEA, a national government that contemplates the possible need for assistance from outside its country may negotiate international agreements for mutual assistance. It is noted, however, that some degree of assistance might be obtained through international organizations, such as the WHO, FAO and the IAEA or under existing agreements for technical information exchange, without any radiation emergency assistance agreement between the assisting and assisted countries. Through the joint efforts of FAO, WHO and the IAEA, information [6] is available that generally describes the resources that could be sent from different countries to cope with radiation emergencies outside the country and their resources and internal organizations for meeting radiation emergencies within their countries.

4.3. The public authority's organization

The responsible public authority should provide an organization that will ensure, first, that the necessary plans are prepared and action undertaken by operators and any other responsible bodies, and second, that the responsible authority itself can carry out any action that devolves upon it. Generally, the action to be taken by the responsible public authority may increase with the severity of an accident, and will increase with the extent to which the consequences of an accident extend beyond the boundaries of an operator's site. If a transport accident should occur, action by the responsible public authority is required immediately.

4.3.1. Establishment of controls

The authority should establish an inventory of radiation sources and a system of authorization for their transport and their use under specific conditions and at specific locations. The authorization system will usually provide for a review and evaluation of the safety analysis prepared by the operator and of the plans prepared by him for preventing accidents and for dealing with emergencies that may occur on his site. It will also provide for prompt notification to the appropriate public authority of accidents whose consequences might affect the public and of timely notification of those accidents which do not affect the public.

4.3.2. Co-ordination between public authorities

The responsible authority should ensure that all other appropriate public authorities are brought into the planning organization. Such bodies could include the public health, food and agriculture, and atomic energy authorities, weather forecasting services, civil defence, police, and medical, hospital and ambulance services. Elements that should be considered in the organization include the location of emergency assistance personnel that can respond quickly to notification of an accident and provide services for local public bodies and operators.

4.3.3. Formulation of plans

The authority should ensure that an adequate study is made of environmental factors and populations at risk, and that prompt and effective accident reporting procedures and plans for protective action have been established. It is desirable that a group of specialists be designated by the public authority to act on its behalf, for example, to assist in formulating plans and to give guidance and co-ordinate emergency action. The plans should include arrangements for communication and liaison with operators, for the notification and co-ordination of all field operations (including radiological assistance) by the various public bodies, for training of personnel and for providing the necessary facilities and instrumentation.

The plans should also include an inventory of all appropriate resources available within the country, a programme of environmental monitoring services and analytical facilities, and arrangements with hospitals and medical services.