Chapter 13 Emergencies

Despite all the safety measures applied in using radiation and radioactive materials, accidents can happen.

An emergency may arise at a nuclear installation and lead to the accidental release of radioactive material, its dispersion beyond the boundary of the site, and the need for urgent measures to protect the public. In some circumstances, the release may be brief, in others prolonged. Significant accidents have happened in 1957 at Windscale (in the UK) and at Kyshtym (then USSR, now Russian Federation), in 1979 at Three Mile Island (USA) and in 1986 at Chernobyl (then USSR, now Ukraine). Although such accidents may be rare, it is prudent to be prepared for them.

Much more common are emergencies involving radiation sources from medical, industrial, research, and military applications. Over recent years, the IAEA has received an average of three or four reports each year of emergencies where people have been exposed to high doses because such sources have been lost, stolen, abandoned, or operated wrongly. Since the 1987 accident at Goiânia, Brazil, in which four people died from exposure due to a medical radiation source found in an abandoned building, there have been more than a dozen fatal accidents worldwide involving radiation sources. *(see Table on page 66)*

Demolition and removal of rubble from a house contaminated during the Goiânia accident

The Tokaimura accident in 1999 was unusual in that it involved a sustained nuclear reaction, started inadvertently in chemical processing of enriched uranium . The only release of radioactive material was a very small amount of very short-lived radionuclides. The radiological hazard in this accident was the direct radiation — especially the neutron radiation — coming from the vessel in which the reaction was taking place. Because it was not foreseen that such a reaction could happen, the building did not have the protective shielding that would have been present in a nuclear power plant, and so the radiation caused significant doses outside the building.

Because some types of emergency can have consequences outside the country where the accident occurs, there are legally binding international agreements relating to emergencies. All of the countries with operating nuclear power plants (and more than 50 others) are parties to the Convention on Early Notification of a Nuclear Accident, which requires them to notify nearby countries if they have an accident that might affect those countries. They must also notify the IAEA, who will then help to disseminate

information about the situation. Over 80 countries are also party to the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, whereby they undertake to provide assistance in such an emergency if any country requests it. Again, the IAEA has an important role defined by the Convention, to disseminate information and co-ordinate assistance.

Nuclear emergencies

To ensure that there is adequate protection against accidents, national nuclear licensing authorities require detailed safety analyses of major nuclear installations such as reactors. These analyses identify potential accident sequences that might lead to the release of radionuclides. Emergency plans are based on consideration of the sequence leading to the largest release that can reasonably be foreseen, but they could be strengthened and extended in the unlikely event of a more severe accident.

Should an accident occur at a reactor, for example, various radionuclides in gaseous, volatile, or particulate form could be expelled to the atmosphere. They would then be carried away in a radioactive plume by the wind and be dispersed and diluted. Some would fall to the ground, particularly if it were raining. The concentration of radionuclides in the air would decrease rapidly downwind from the site, as would the resulting hazard. Even so, appreciable quantities of radionuclides could be deposited on the ground at considerable distances.

Depiction of plume dispersion and deposition

Radioactive material carried by wind

Direct radiation

Inhalation

Rain washing material out of plume

Contamination of food

Direct radiation from contamination

Countermeasures

It may be necessary to take action to reduce the radiation dose to the people living near to an accident site. Various countermeasures could be undertaken singly or in combination. Some of these measures — urgent countermeasures — really need to be initiated before there is a release of radioactive material, if they are to be effective. This means that decisions must be taken on the basis of what is happening at the plant (and what is predicted to happen), rather than waiting until a release is detected. This could sometimes mean that countermeasures are taken as a precaution that might turn out to have been unnecessary, but this is preferable to acting too late.

People may be advised to stay indoors or even leave home until the plume has blown over or the release has been stopped. People could take non-radioactive iodine tablets to prevent radioactive iodine reaching the thyroid gland. It may also be necessary to introduce temporary restrictions on the distribution of milk and vegetables and other foods produced locally. Some simple countermeasures might be taken after the plume has passed, such as hosing roads and paths or cutting and removing grass from gardens so as to remove surface activity.

When the emergency has passed, it may be necessary to introduce other countermeasures during a prolonged recovery period so as to protect the public from the residual activity.

There are elaborate and well-rehearsed plans for dealing with nuclear emergencies in countries with nuclear installations and also in many other countries that might be affected by an accident in a neighbouring country. Every nuclear site should have an emergency plan and let the local people know about it. The plan will involve the operator's staff, the local governmental authorities and the emergency services. National government departments and agencies will also become involved: each will deploy its radiological resources and expertise.

A typical emergency plan would envisage the following sequence of events. In the early stages of an accident, the operator will advise the police on measures to protect the public. Soon a co-ordinating centre away from the site will be set up at which those people with defined responsibilities and technical advisors will decide upon actions to protect the public. These will include environmental monitoring, as well as appropriate countermeasures. Arrangements will be made to brief the news media.

As noted above, because nuclear accidents can affect large areas, the Convention on Early Notification of a Nuclear Accident also requires any country having an accident that could affect its neighbours to notify the IAEA and any countries that could be affected.

The need for emergency planning is not restricted to nuclear installations. Wherever radiation sources are used there should be appropriate contingency plans to cope with the types of emergency that could happen. These need not be on the scale required for a nuclear power plant, but they should address any accidents that could conceivably occur.

Intervention standards

Taking countermeasures after accidents is another example of the procedure that ICRP calls intervention. We have seen in Chapter 5 that intervention must be justified and optimized. It is only necessary to add that countermeasures must be taken to avoid doses high enough to cause obvious injury in anyone exposed — but especially children.

The BSS specify intervention levels of dose for the introduction of countermeasures to protect the public. These are used to identify which actions would be most suitable in particular circumstances.

International intervention levels for countermeasures

Countermeasure	*Organ*	*Dose level to be averted*
Sheltering	*Whole body (effective)*	*10 mSv in 2 days*
Evacuation	*Whole body (effective)*	*50 mSv in 1 week*
Iodine administration	*Thyroid*	*100 mGy*

Action levels for some foods and for water (Bq/kg)

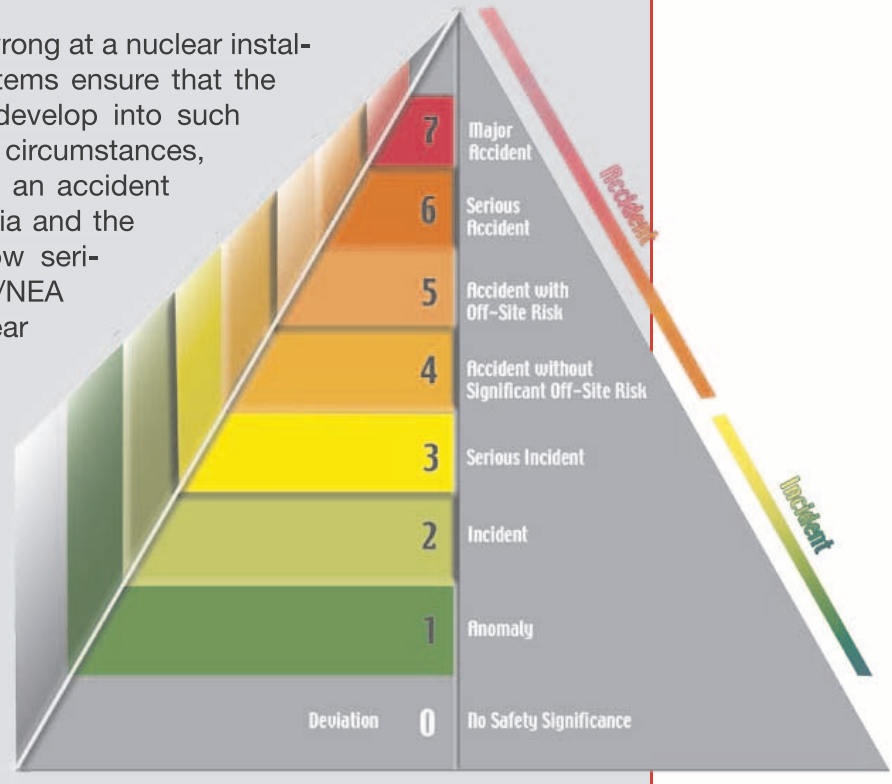
Important radionuclides	*Milk, infant foods and drinking water (Bq/kg)*	*Other foods (Bq/kg)*
Strontium-90		*100*
Iodine-131	*100*	
Plutonium-239	*1*	*10*
Caesium-137	*1000*	*1000*

Source: The International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Schedule V, Table V-I

One outcome of the Chernobyl accident was the introduction of action levels for radioactive contamination of food by the Codex Alimentarius Commission of the FAO and WHO. These action levels, set out for the first year following an accident, are for international trade purposes, but also provide useful guidance to national authorities on local consumption of food products.

Public information

In most cases, when something goes wrong at a nuclear installation, the various levels of safety systems ensure that the situation is controlled and does not develop into such an accident. It is only in very unlikely circumstances, where several safety systems fail, that an accident (event) may result. To provide the media and the public with a simple indication of how serious an event is, the IAEA and OECD/NEA have developed the International Nuclear Event Scale (INES). Events are rated on a scale of zero to seven: a rating of zero means that there was a problem but that the safety systems worked properly and corrected it before there was any risk to workers or the public, whereas a rating of seven means a major nuclear disaster on the scale of the 1986 Chernobyl accident.



The International Nuclear Event Scale (INES)

For prompt communication of safety significance

Other radiological emergencies

As with nuclear accidents, there are two sides to dealing with the risk of emergencies involving radioactive sources: doing as much as possible to prevent accidents, but also being prepared to respond should an accident happen.

Accidents involving radioactive sources can be prevented by ensuring that only those who are properly qualified and trained use and look after the sources. Established procedures should be followed to make sure that the source is used correctly and is not lost, damaged or stolen, or otherwise allowed out of the responsible user's control. This requires that national authorities have a proper and reliable system in place to keep track of where sources are and who is responsible for them. Over the past few years, the IAEA, through its technical co-operation programme, has made significant efforts to help countries develop such systems for controlling the sources under their jurisdiction. Despite some progress accidents continue to occur, indicating that there is still work to be done.

When accidents do occur, measures may be needed to recover control of the source involved and make it safe, to treat people who have been exposed as a result of the accident, and to investigate how the accident happened and hence learn how accidents can be avoided in the future. In many recent cases of this type, the countries concerned have requested assistance from the IAEA under the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency to carry out one or more of these measures.

The IAEA is helping Georgia search for radioactive sources abandoned in remote areas
P. Pavlicek/IAEA