NAIR Technical Handbook 2002 Edition

Technical Handbook on the National Arrangements for Incidents involving Radioactivity

N P McColl and P Kruse

Approval: April 2002
Publication: May 2002
£10.00
ISBN 0 85951 478 1

EXECUTIVE SUMMARY

This Technical Handbook contains information for radiation specialists participating in the National Arrangements for Incidents involving Radioactivity (NAIR). Together with the NAIR Users Handbook 2000 edition, it updates and replaces the NAIR Handbook published in 1995. The Users Handbook was designed for those who might seek assistance through NAIR, principally the police or other emergency services. Both Handbooks are reproduced on the NRPB website (www.nrpb.org) and are available from NRPB.

The Users Handbook 2000 Edition introduced changes to the NAIR alerting mechanism, introducing a single contact number to replace the large array of numbers published in previous editions of the NAIR Handbook. The single contact number is continuously manned by the UK Atomic Energy Authority Constabulary. The new arrangements have a number of benefits:

a better records are kept of NAIR activation,
b contact details of all NAIR respondents are checked and updated at least annually,
c environment agencies are automatically alerted,
d NAIR Handbooks may be more widely disseminated since they no longer contain operational details.

Other operational aspects of NAIR remain the same, based on Stage 1 and Stage 2 assistance being available to the police.

Changes to the complement of establishments providing assistance under the Arrangements are fairly infrequent and that has been the case during the period since the last Handbook revision. The current number of participating establishments in the Arrangements is 85, comprising 58 hospital medical physics departments and 27 nuclear sites and others.

The Handbook no longer includes lists of designated hospitals to which contaminated or irradiated casualties should be referred. Health authorities, boards and departments retain responsibilities for identifying these.

A specific transport emergency plan, RADSAFE, has been introduced since publication of the previous NAIR Handbook. RADSAFE meets the statutory obligations of and provides response to transport incidents involving consignments of its constituent members who together comprise the major UK transporters of radioactive material and include major organisations involved in the nuclear and radioisotope production industries. The RADSAFE consortium made their shared alerting telephone number available for NAIR use. While RADSAFE and NAIR will remain distinct arrangements, there are areas of commonality that have been exploited to the benefit of both sets of arrangements.

The Handbook has been prepared and published by NRPB, which is responsible for co-ordinating the Arrangements. Comments or queries regarding its contents should be directed to the NAIR Co-ordinator, NRPB, Chilton, Didcot, Oxon OX11 0RQ, or by email to nair@nrpb.org. For more information about NAIR, including ongoing issues, please refer to the NAIR area of the NRPB website (www.nrpb.org).

ACKNOWLEDGEMENTS

NRPB wishes to express its gratitude to all who have contributed information for this Handbook. Particular thanks are due to Amersham Health plc who supplied much of the material for the photographs.

NRPB would also like to acknowledge the vital and continuing role played by the participants in the Arrangements.

CONTENTS

1 ADMINISTRATIVE ASPECTS

1.1 Purpose and scope

Radioactive materials are used for a wide variety of purposes in industry, medicine, research and teaching, etc. They also arise as wastes from the nuclear power industry and there are many thousands of transport movements of radioactive materials associated with these activities during any year.

Incidents and mishaps are bound to occur, as in any human activity. For circumstances where the potential for such occurrences is reasonably foreseeable there is generally a statutory obligation on users/operators to have and to maintain suitable contingency arrangements for the protection of both employees and the general public. Experience has shown that incidents occur that cannot immediately be identified as attributable to the activities of a particular operator (such as the finding of lost sources/containers in a public place). Hoax incidents need to be identified as such. Incidents occur for which prearranged and well-intentioned contingency plans fail to function satisfactorily or prove to be inadequate. The National Arrangements for Incidents involving Radioactivity (NAIR) were devised to ensure that for incidents in any of these circumstances appropriate resources are available to the civil police for providing necessary protection for the general public.

NAIR should properly be viewed as national arrangements providing a 'long-stop' to other emergency plans. They are not normally intended to operate in circumstances where detailed preplanning for emergencies exists, eg for activities of major nuclear sites. Neither is it intended that the Arrangements should apply to industrial or other premises where radioactive sources are regularly held. Operators of these sites should have specific contingency plans to meet their statutory obligations.

Despite these normal exceptions, the police may invoke NAIR in any circumstances where there is felt to be a genuine need for radiological assistance and particularly where other plans have failed to operate properly or where unreasonable delays are being experienced in effecting them.

The Arrangements have been devised around the provision of assistance to the civil police since that body will normally be among the first to be informed of an incident in a public place, and it is in any case the police who have prime responsibility for ensuring the safety of the general public. However, other organisations such as fire and rescue services, the British Transport police, and airport and docks police may all encounter incidents involving radioactivity. Whenever the public is considered at risk from the incident these organisations may also call upon NAIR assistance through the police.

1.2 General form

For the purpose of the Arrangements, Great Britain is divided into areas of assistance based on police forces. Assistance is provided in two stages, as follows.

Stage 1

Stage 1 assistance is provided by a radiation expert, who with the aid of relatively simple monitoring equipment can form a view of whether a hazard exists and can advise the police on the appropriate action to take. The expert will have limited resources and will normally only be able to carry out small recovery operations. They will not be equipped to cope with an incident involving the spread of contamination unless it is of a very minor nature. Where the incident is beyond their capability to restore they will advise the police to obtain Stage 2 assistance. At the same time they will advise the police on the steps that should be taken to prevent undue exposure of members of the public by the erection of barriers, etc, or on covering and containing contaminated material to prevent its spread.

Assistance under Stage 1 is provided by hospital physicists, and by health physicists from major nuclear, radiopharmaceutical sites and government and similar organisations.

Stage 2

This stage of assistance is provided by all the major nuclear establishments throughout Great Britain and is intended to provide more extensive resources for handling an incident. Stage 2 assistance will normally comprise a team of up to four people as the situation requires, with adequate, readily available transport, suitable monitoring equipment, special clothing and decontamination facilities. The team will include operational health physicists able to work without supervision and capable of instructing non-technical personnel. A link to base, by means of their own resources or those of the police, enables further resources to be called upon as necessary.

1.3 Co-ordination

Responsibility for co-ordination of the Arrangements was initially (in 1964) vested in the Department of Education and Science for England and Wales and in the Scottish Home and Health Department for Scotland. Following the establishment of the National Radiological Protection Board in 1971, the responsibility for co-ordinating the Arrangements, throughout Great Britain, was transferred to NRPB.

1.4 Experience of the Arrangements to date

The Arrangements described in this Handbook have now been in operation for 35 years and over 350 incidents have been handled under them. By far the majority of incidents dealt with can, in relation to the associated radiation hazard, be described as trivial. For example, around one-third of the incidents have been associated with the careless use of radioactive markings, and in some cases, their deliberate misuse (to perpetrate a hoax). The triviality of many incidents dealt with under NAIR should not be seen, however, to diminish the value of the Arrangements. The high public and media interest in radiation matters has given rise to a situation where the alarm caused by, and publicity given to, incidents involving radioactive materials is often unrelated to the degree of real or potential hazard. In such a climate, the local and relatively speedy availability of expert advice to the police helps to ensure that incidents of little radiological consequence do not give rise to unnecessary concern.

Over a number of years there has been a significant fall-off in the number of occasions per year on which NAIR has been invoked. This may have resulted from a real reduction in the number of incidents occurring but it could also reflect an increasing user awareness of the statutory need to develop his own contingency plans. In order to maintain awareness and familiarity with the Arrangements, training courses are arranged by NRPB. Participating organisations and police forces should contact NRPB (or see www.nrpb.org) for further details.

2 OPERATIONAL ASPECTS

2.1 Civil police

The Arrangements have been formulated around the provision of radiological advice and assistance to the civil police for incidents involving radioactivity and for which no alternative source of assistance is readily available. When faced with an incident involving radioactivity in a public place the police should first establish, either by questioning the driver or examining the carrier's paperwork in the case of a transport accident, or by contacting constabulary headquarters in other circumstances, whether any prearranged contingency plans exist to deal with the incident. If no such plans exist, then NAIR should be invoked.

Action under NAIR should normally be initiated by a telephoned request for help to the UKAEA Constabulary Force Communication Centre (FCC) on 0800 834 153. The FCC will record details of the incident and contact information to be passed onto the NAIR respondent. The FCC will then contact the nearest participating Stage 1 establishment closest (in travelling-time) to the incident, as ascertained from the call-out lists. If the participating establishment, for any reason, were unable to respond to the assistance requested, the FCC would seek assistance from an alternative establishment in the call-out list. The FCC would pass on all the details to the NAIR stage 1 respondent and ask them to contact the officer requesting assistance. The FCC would also contact the officer requesting assistance passing on the Stage 1 respondents details, thus ensuring contact was not lost between those requesting assistance and those providing it. The FCC would also contact the appropriate environment agency.

Depending on the information received, the Stage 1 participant will normally be able to form a view as to whether he can cope entirely with the incident with his own resources or whether the Stage 2 participant should be requested to attend. Where the latter is the case it may still be of value to the police to request the attendance of the Stage 1 participant, if only to acquire advice on early action pending the arrival of the Stage 2 team which will normally have a greater distance to travel. Occasionally there will also be incidents, such as a major spillage of radioactive materials on a public highway, where it is clear to the police from the outset that Stage 2 assistance will be required. In such circumstances the police should, without delay, request Stage 2 assistance via the FCC, but the police should consider the potential advantage of requesting the attendance of a Stage 1 participant where this will result in the earlier availability of expert advice.

When requesting assistance under NAIR the police should, when appropriate, offer assistance to participants to enable them to reach the scene of an incident as quickly as possible, particularly if the incident cannot be reached by road. In the unlikely event that a NAIR incident involves serious risk to the public, the NAIR respondent should expect the response to follow a multi-agency model outlined in Dealing with Disaster[*] (or Dealing with Disasters Together[†] in Scotland).

2.2 Participants

The general roles of Stage 1 and Stage 2 participants providing assistance under the Arrangements have been outlined in Section 1.2. Some further salient points concerning those roles are given here.

In circumstances where a Stage 1 participant has attended an incident and advised the police that Stage 2 assistance be requested, it is obviously desirable for that participant to communicate a technical 'situation report' to the Stage 2 team before the latter leaves base, in order that a judgement can be made on the total resources required to deal with the incident.

When asked by the police to comment on the seriousness of an incident participants should limit their remarks to an assessment of the potential hazard in terms that will enable the police to form a judgement on the relative risks of

[*] Dealing with Disaster (Third Edition), Home Office.
[†] Dealing with Disasters Together, Scottish Executive Justice Department.

particular actions. They should, as far as practicable, avoid direct contact with media representatives and refer any such approaches to the police officer co-ordinating the situation.

The role of participants is essentially to advise the police on the immediate situation, and to provide assistance as required to cope with the situation and prevent deterioration. It is not part of the NAIR participants duty to organise substantial recovery operations or to carry out large-scale decontamination. This should be the subject of further consultation and decision by the appropriate authorities and the responsible operator. As stated earlier the appropriate environment agency is contacted as part of the call out routine. Under their role as regulator for the disposal of radioactive materials they will be able to provide advice on the most suitable route for disposal.

Recommendations on instruments and equipment and further technical information for the guidance of participants are provided in the latter sections of this Handbook, which cover:

a radiological protection in NAIR incidents,
b instruments and equipment,
c radionuclide data and suitable detectors,
d package and source identification,
e disposal of radioactive materials involved in NAIR incidents.

Each participating establishment should ensure that communication arrangements at its establishment enable assistance to be provided to the police under these Arrangements *at all times*. Regular checks should be made by participants that telephone switchboard personnel responding to calls on the numbers provided are fully aware of how to raise the necessary assistance. Establishments should also ensure that all changes of telephone numbers, addresses or, indeed, any changes which could prejudice the establishment's ability to respond to a request are reported promptly to NRPB headquarters. As part of the NRPB role as co-ordinator of the NAIR scheme, NRPB will contact all responding organisations on a six monthly basis to ensure that all contact numbers are current and up to date. This information is then passed to the FCC to update their records.

2.3 Relationship of the police to other organisations

It is to be hoped, and certainly expected, that no incident handled under NAIR will be of such magnitude as to be classed as a disaster, or even as a major incident. For illustrative purposes, however, the following brief outline is given of the relationship of the police with other local authority emergency services in the context of a major incident where many of or all the emergency services would be actively engaged.

Normally, it is accepted that the police will take on the co-ordinating role at any major incident. There are certain functions and responsibilities on behalf of the other services that only the police can fulfil. There are circumstances, however, in which the fire service needs to take the lead; for example, if there is a large fire associated with an incident, then clearly the need to contain and extinguish the fire is paramount and the senior fire officer would be expected to assume the co-ordinating role in the immediate vicinity.

In practice, and depending on the size and scope of the operation necessary to deal with an incident, the efforts of all the services involved (police, fire, ambulance, medical and possibly local authority and public health officials) are co-ordinated by a team of the senior officers from the main services, led by the senior police officer present. Each service carries out the tasks appropriate to its expertise. The fire service, apart from fire-fighting, has a major role to play in the rescue of trapped or injured victims and it is equipped with a variety of emergency apparatus. The ambulance and medical services would be concerned with the speedy removal of the injured and with urgent initial medical treatment of casualties. The police would be responsible for the cordoning of the area, the establishment of priority routes for ambulances and other emergency vehicles, the control of traffic around the area, the evacuation of threatened buildings, and all other duties and tasks on and around the site that the other services cannot undertake.

NAIR respondents should be aware of and expect to take guidance from those agencies that might be carrying out their regulatory function that might include the preservation of evidence.

From the above it should be clear that the role of participants volunteering assistance to the police under NAIR should be confined to the provision of technical advice and assistance to the police. The police will at all times retain responsibility for implementing any actions associated with this advice to protect the general public.

2.4 Casualties

Subject to any immediate life-saving and rescue measures, including the removal of obvious (non-contaminated) casualties to the nearest hospital, special care should be given to the handling of people who are likely to have been contaminated by radioactive material or who may have been exposed to very high levels of radiation. Local Health Authorities and Boards are responsible for designating hospitals prepared to accept casualties of this nature.

2.5 Reporting of incidents

To keep the effectiveness of the Arrangements under review it is necessary for participating organisations to let NRPB have reports of incidents as soon as practicable after the call-out. It would help for the information to be supplied in the following standard form:

- a date, time and location of incident,
- b nature of incident and details of request for assistance,
- c assessment of radiological hazard,
- d nature of assistance given,
- e effectiveness of the Arrangements,
- f general comments.

For record purposes, and more particularly for training seminars reviewing experience under the Arrangements, photographs relating to incidents are particularly welcomed by NRPB. Incident information should be sent to the NAIR Co-ordinator, NRPB, Chilton, Didcot, Oxon OX11 0RQ, or by email to nair@nrpb.org.

3 RADIOLOGICAL PROTECTION IN NAIR INCIDENTS

3.1 Dose limitation

Radiological protection in NAIR incidents should be aimed at the control of doses to individuals, including NAIR participants themselves, members of the emergency services, and members of the public.

NAIR participants are unlikely to become involved in the early phases of an accident where there may be 'conventional' threats to life and limb, ie not primarily involving radiation hazards. Radiation exposures of rescuers are very much a matter of judgement, according to the specific circumstances; the fire and rescue services, members of which are the most likely to be involved at this stage of an incident, have developed their own guidelines for such incidents.

All other exposures during a NAIR incident should be planned. Planning should be concerned with balancing radiation risks against inconvenience and disruption, during the time it takes to restore the situation to normal. In other words, NAIR participants should use their professional judgement to keep doses as low as reasonably achievable and within any relevant dose limits.

In the vast majority of situations, it should be possible to control doses to a very small fraction of the dose limit for members of the public. In exceptional situations where this might not be so, any measures that might result in higher doses should be carefully considered before being proposed to the police.

Proposals for the control of radiation exposures should be discussed thoroughly with the police. NAIR participants understand the radiation risks; the police have the ultimate responsibility for deciding what measures will be taken, and for dealing with the disruption that might ensue. A plain recommendation may be accepted at face value, almost regardless of the disruption it may cause, so it is for the NAIR participant to make a proposal and invite discussion.

Once decided upon, the measures to be taken will tend to become formalised, and will be difficult to change until the entire incident is over. It is very important to take enough time to discuss what should be done, and to get it right first time.

3.2 External irradiation

As explained in Section 6, appreciable dose rates may be measurable at the surfaces of intact transport packages, and greatly increased levels of external radiation may occur if the shielding is breached around either sealed or unsealed sources.

Doses from external irradiation can be controlled by the usual combinations of shielding, distance and exposure time, bearing in mind that the exposure is temporary. NAIR participants and members of the police and emergency services may need to remain in the vicinity for some time, while members of the public will not, so exposures of the public may not be the limiting factor in deciding what measures should be taken.

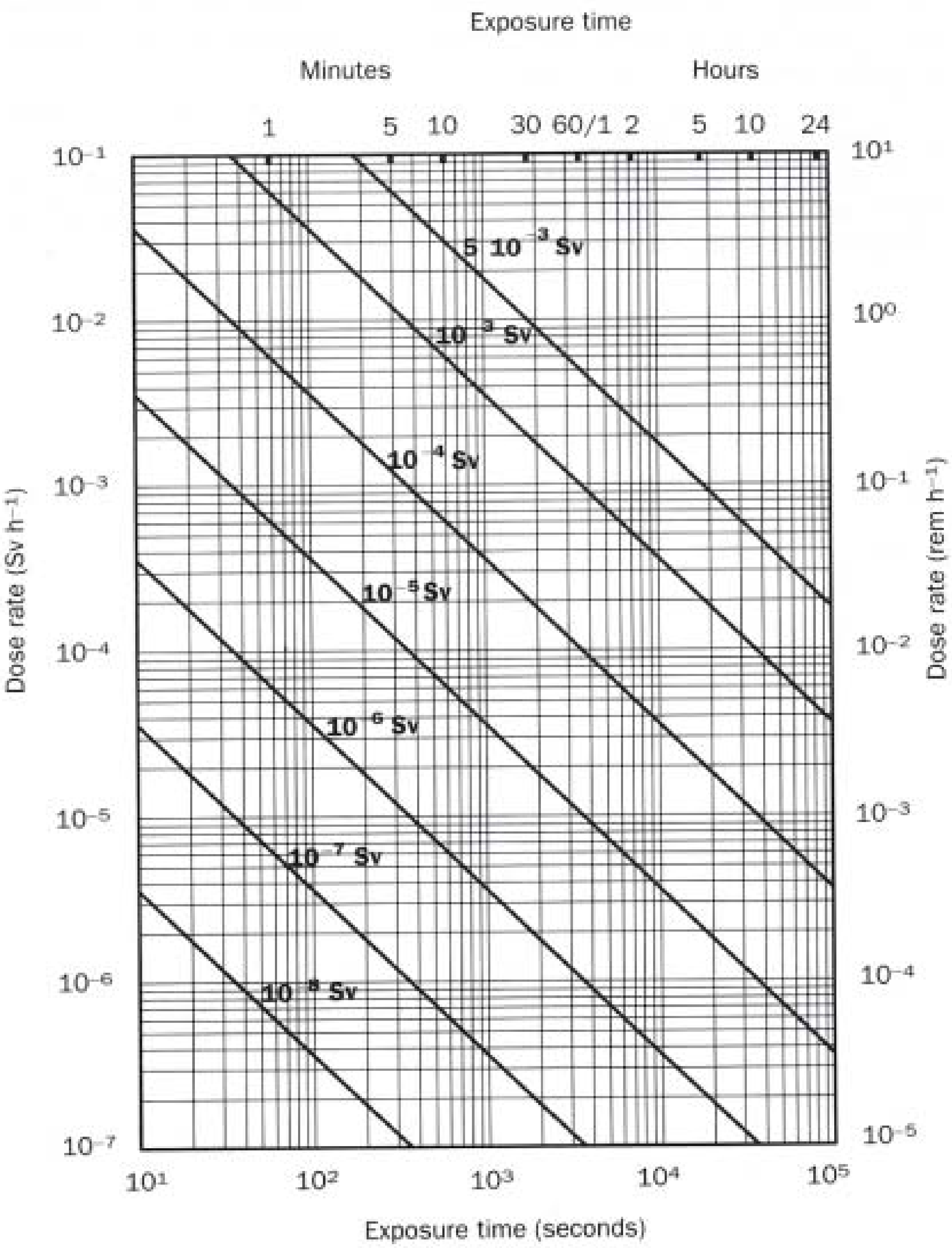
For example, in a roadside accident that has exposed a source that cannot be immediately recovered, a no-stopping zone could be enforced by police stationed at such a distance either side of the accident that they could stay for several hours. Doses to the police would be controlled mainly by distance, and doses to the public by time.

The following graph can be used to estimate the size of exclusion areas or no-stopping zones. In the former case, it would be appropriate to assume continuous exposure for several hours; in the latter, it may be possible to time how long it takes to pass through the no-stopping area, applying judgement about the risk if anyone did stop for a longer period.

3.3 Contamination incidents

The packaging of unsealed sources is intended to make the risk of significant environmental contamination after an accident extremely low. Even if a package is crushed flat, the activity from a broken container should be retained by absorbent material within the packaging (Section 6).

If an accident does give rise to environmental contamination, there is a possibility of intake by inhalation or ingestion, leading in some cases to prolonged internal exposure. Even minor external contamination of skin, clothing, etc, is likely to cause considerable disquiet.



Graph showing total dose and relationship between dose rate and exposure time

NAIR Stage 1 participants should first of all verify that contamination has actually spread from the package to the environment, and should check whether it is removable, eg by a wipe test. If not, the appropriate control measures would be those for external irradiation.

If any removable contamination is found, the entire area where removable contamination is detectable above background should be isolated from the public, unless disruption would be exceptionally severe. Short-lived radionuclides may offer a little more latitude in this respect.

To deal with a contamination incident, NAIR Stage 1 participants should call immediately for Stage 2 support, unless they have both the experience and the resources for environmental decontamination and monitoring. Authorisation is required for the disposal of radioactive waste, so the appropriate authorising agency (Section 7) should be involved.

The Stage 1 participant should remain at the incident at least until Stage 2 support has arrived and has been briefed.

In any case, the affected area will need to be monitored after decontamination, and Stage 2 participants are equipped to do this. The area should, if readily achievable, be decontaminated down to background levels.

4 INSTRUMENTS AND EQUIPMENT

Sections 1–3 of this chapter are intended primarily for the information of those NAIR Stage 1 participants whose normal work does not require training to deal with a wide range of emergencies. Almost all Stage 2 participants, however, will have received such training. Section 4 discusses the special equipment requirements for Stage 2 participants.

4.1 Uses of instruments

The purpose of instrumentation in a Stage 1 call-out is to determine whether any radiological hazard does in fact exist, and to make a reasonable but not especially accurate estimate of its magnitude. The instruments which participants use in their normal work are often usable for NAIR incidents as well. However, the following points related to the NAIR function may be borne in mind when considering new purchases or replacements.

4.1.1 Identifying and locating sources of radiation

Many NAIR incidents involve suspected sources of radiation. It is important to establish quickly whether these objects are in fact radioactive. Other incidents may involve searching for lost sources of radiation, which could be either unshielded or still in their containers.

The best instruments for either purpose are those with large sodium-iodide (NaI) detectors. Sensitive Geiger-Müller (GM) and proportional counter instruments are useful substitutes, although they are about an order of magnitude less sensitive than NaI scintillators to 1 MeV gamma radiation.

To help in searching through outdoor wreckage, or in other difficult conditions, the instrument should have a loud audio output.

4.1.2 Measuring gamma dose rate

Most of the instruments of the type mentioned above are difficult to use for quantitative measurements because they all exhibit a strong change in response with gamma energy, and calibration is not readily feasible if the radionuclides are unfamiliar or unknown. Measurements are best made with an energy compensated instrument which has a uniform response from about 50 keV upwards. Such instruments typically use energy compensated GM tubes, ionisation chambers, plastic scintillators or proportional counters.

The instrument should be capable of measuring dose rates from 1 μSv h^{-1} upwards. An instrument using a single energy compensated GM detector will typically measure up to 1 or 10 mSv h^{-1}, which should be an adequate range for NAIR use. Some dual detector instruments can cover from 1 μSv h^{-1} up to 1 Sv h^{-1} or more. GM-tube instruments are generally smaller and lighter than the other types, and normally have an audio output. However, energy compensated GM instruments will not measure gamma and x-ray energies below about 50 keV, and are incapable of measuring beta dose rate.

Ionisation chamber instruments are less easy to use at low dose rates than GM tubes; they suffer more from changes in temperature and humidity, and are less robust. However, they will operate at gamma energies down to 10 keV, which is useful for nuclides such as ^{99m}Tc and ^{125}I, and can normally be used for measuring beta dose rate as well.

Scintillation instruments are very sensitive and can cover a wide range of gamma dose rates, at energies down to about 30 keV, but they tend to be heavy and are not useful for beta radiation.

4.1.3 Measuring beta dose rate

Pure beta-emitting sources are less common than gamma emitters, but can be encountered in beta backscatter and thickness gauges. Ionisation chamber instruments can be used, as well as thin end window GM tubes.

4.1.4 Measuring beta contamination

Beta contamination could be encountered in accidents involving radio-pharmaceuticals or other radiochemicals. Suitable instruments are those using thin end window GM tubes, beta scintillation detectors or proportional counters with aluminised plastic or titanium windows.

The most serious problem in using these instruments is likely to be damage to the window, leading to total failure of GM and proportional types, or serious light sensitivity in scintillation detectors. When checking for beta contamination it will often be necessary to take a wipe sample and monitor it away from any other source of gamma or x-rays.

Tritium is particularly difficult to detect because of its very soft beta emission. The most suitable instruments are windowless gas flow proportional counters, but in practice it is probably satisfactory to rely upon liquid scintillation counting of wipes, after the event.

4.1.5 Measuring x-ray dose rates and contamination

X-ray emitters are very common in radiopharmaceuticals. Suitable instruments include thin sodium-iodide detectors and xenon-filled proportional counters. Suspected contamination by x-ray emitters will almost always require taking a wipe sample and monitoring it away from other sources of radiation, including the suspect package itself.

4.1.6 Measuring alpha contamination

Hazards from alpha emitters arise only in respect of contamination. It should be noted that any form of dirt, grease or water on the suspect surface will significantly absorb alpha radiation and great care needs to be taken in measuring actual contamination levels. Suitable instruments include thin-windowed zinc sulphide scintillation counters and thin-windowed refillable proportional counters. Thin end window GM tubes are also satisfactory for levels down to about 5 Bq cm^{-2}.

4.1.7 Specific radionuclides and instruments

Section 5 gives more detailed information on the suitability of various types of detector for specific radionuclides.

Further guidance on currently available instruments of various types may be obtained from NRPB. This includes a comprehensive report on the "Guidance on the Choice, Use and Maintenance of Hand-held Radiation Monitoring Equipment"*. This report is available on the NRPB website (www.nrpb.org).

* Burgess P H. Guidance on the Choice, Use and Maintenance of Hand-held Radiation Monitoring Equipment. Chilton, NRPB-R326 (2001).

4.2 Preparation and maintenance

When an instrument has been selected for NAIR use, it is suggested that a card be compiled listing the responses to:

a hard gamma radiation,
b hard and soft beta dose rate,
c hard and soft beta contamination,
d x-ray and low energy gamma contamination, especially ^{125}I and ^{99m}Tc,
e alpha contamination.

The card should also state what batteries are required, including the alternative type numbers. Spare batteries and the tools required to change them should form part of the 'NAIR kit' (see Section 4.3), and batteries should be replaced routinely, every six months or so. Instruments for NAIR should preferably use batteries that can be replaced at any electrical shop or motorway service area.

Not all instruments used for NAIR will have been designed for outdoor use. Plastic bags can be used to protect instruments against rain and contamination. They are also useful for protecting thin window detectors against damage from grass stalks, road chippings, etc, provided that the radiations in question are reasonably penetrating (gamma or beta > 1 MeV).

4.3 Stage 1 'NAIR kit'

NAIR Stage 1 participants will usually assemble a kit containing most of the equipment needed to respond quickly to a call-out.

The instruments used for NAIR incidents are often the ones in daily use by the participants, or standby instruments that are kept in case of breakdowns. Although instruments could be set aside specifically for NAIR, that would only be justifiable if they are surplus to normal requirements. A possible compromise (if funds allow) would be to purchase and set aside a simple end window GM instrument that will meet most of the requirements of NAIR.

Instruments designated for NAIR should be tested regularly if they are not in day-to-day use.

Other useful equipment that should form part of a permanent 'NAIR kit' includes notebooks, waterproof pens, a hand torch and a familiar pocket calculator (with fresh and spare batteries for each), a steel tape measure, plastic bags, PVC tape for sealing bags, and filter papers for taking wipes. A lead pot and tongs are useful for recovering small gamma sources; a pot with 25 mm walls is reasonably portable and offers a useful degree of shielding.

In addition to the normal personal TLD or film badge, it is desirable to carry a direct reading dosemeter such as a QFE or, even better, an active alarm dosemeter.

The NAIR kit should include protective clothing that is waterproof, visible and easily decontaminated if necessary, along with gloves, wellington boots and a safety helmet.

A mobile phone, with which the respondent is familiar and knows the number, is also useful. Additionally, if time allows, a camera should be included as an aid to recording the incident.

4.4 Stage 2 equipment

Participants in NAIR Stage 2 are generally the major nuclear establishments in the UK. As part of their own emergency preparations, these sites have mobile equipment and staff trained to deal with serious incidents and their resources are made available to the NAIR scheme.

Most NAIR Stage 2 participants will use a site emergency vehicle that will already be equipped to meet the particular requirements at that site. However, NAIR incidents may be of a different nature from those anticipated for the home site, and may occur some distance away.

To assist each establishment in supplementing, if necessary, the equipment normally carried in its emergency vehicles, this section outlines the overall requirements for NAIR Stage 2 support in a wide range of incidents.

4.4.1 Instruments

- a two long-reach gamma dose rate meters reading up to 1 Sv h^{-1},
- b two ion chamber instruments reading up to at least 10 mSv h^{-1},
- c two high level hand held GM-based dose rate instruments which cover the range 50 μSv h^{-1} to 0.5 Sv h^{-1},
- d two low level GM-based instruments operating from background levels up to at least 50 μSv h^{-1},
- e two sensitive sodium-iodide scintillator instruments,
- f two beta contamination monitors covering energies from 150 keV upwards, and levels down to a few Bq cm^{-2}; suitable instruments include large end window GM detectors, scintillation probes and thin-windowed proportional counters,
- g two alpha contamination monitors based on either scintillation detectors or thin-windowed refillable proportional counters,
- h six alarm dosemeters,
- i air sampler and counting equipment,
- j check sources for above instruments,
- k spare batteries and cables (where appropriate) should be carried for all the instruments listed.

4.4.2 Protective equipment

A major contamination incident may involve the NAIR Stage 2 team in supervising other workers in the clean-up operation, who will also need protective clothing. Therefore, in addition to protective clothing to fit the team members themselves, plus spares, it is suggested that about six more sets should be available in assorted sizes.

Protective clothing should include coveralls, boots, outdoor overshoes, gloves, safety helmets, respirators and breathing apparatus (for trained staff only). Spares should be carried for consumable items such as gloves, overshoes and respirator filter packs.

4.4.3 Other equipment

This list includes specialised equipment, but not items that could reasonably be obtained through the police and emergency services:

a filter papers and boxes of tissues,
b long- and short-reach tongs and tweezers,
c lead shielding container, eg 25 mm wall thickness,
d resealable plastic bags of all sizes, including strong sacks for removal of contaminated material,
e notebooks, pencils, pens and waterproof markers,
f high visibility waistcoats, extra large to fit over protective clothing,
g rolls of PVC tape and radioactive area marking tape,
h surveyor's tape measure,
i calculator and health physics data books,
j 1 : 50 000 Ordnance Survey maps of the entire area served,
k tool kit,
l first aid kit,
m camera and spare film,
n torches (with spare batteries and bulbs).

If operating some distance from the home site, good communications with base will be important. According to the area served, a mobile telephone may be useful, or assistance may need to be obtained from the police.

5 RADIONUCLIDE DATA AND GUIDE TO SUITABLE DETECTORS

The wide variety of uses for radioactive material is reflected in the large number of radionuclides that could become involved in NAIR incidents.

The table in this section gives the half-lives of virtually all these nuclides, and their most prominent emissions. Taking into account the nature of these emissions and the capabilities of various types of instrument (as discussed in Section 4), the table also indicates which instruments would be suitable for making measurements of dose rate and of contamination.

Key to table

Nuclide data

* Includes emissions from decay products that are likely to be present and are not shown in the table separately.

↲ Decays to progeny shown.

Suitability of instruments

R = Recommended.

S = Recommended when the low energy x-rays or the beta emissions from the source are shielded either by packaging or because the material is in the form of an encapsulated source.

U = Usable in the absence of recommended equipment.

P = Precautions required: results depend critically on instrument adjustment.

– = Not suitable.

Under the dose rate column a long bar ———— indicates no external hazard.

Radionuclide data and guide to suitable detectors

Nuclide		Half-life	Prominent radiations and maximum energies (MeV)	Suitability for dose rate measurements				Suitability for contamination measurements						
				Energy compensated GM	End window GM	Ionisation chamber	Plastic scintillator	End window GM	Full energy β scint	High energy β scint	Xe-filled proportional	Refillable proportional	α scint	NaI scint
Hydrogen-3	H-3	12.3 y	β^- 0.019	—	—	—	—	-	-	-	-	-	-	-
Beryllium-7	Be-7	53.3 d	γ 0.48	R	U	R	R	-	-	-	R	-	-	R
Carbon-14	C-14	$5.7\ 10^3$ y	β^- 0.156	-	R	R	-	R	R	-	R	R	-	-
Sodium-22	Na-22	2.6 y	β^+ 0.55, γ 1.28	S	U	R	S	R	R	-	R	R	-	-
Sodium-24	Na-24	15.0 h	β^- 1.4, γ 1.4, 2.8	S	U	R	S	R	R	R	R	R	-	U
Phosphorus-32	P-32	14.3 d	β^- 1.7	-	R	R	-	R	R	R	R	R	-	U
Sulphur-35	S-35	87.5 d	β^- 0.17	-	R	R	-	R	R	-	R	R	-	-
Chlorine-36	Cl-36	$3.0\ 10^5$ y	β^- 0.71	-	R	R	-	R	R	-	R	R	-	-
Potassium-42	K-42	12.4 h	β^- 3.6, γ 1.5	S	U	R	S	R	R	R	R	R	-	U
Calcium-45	Ca-45	163.0 d	β^- 0.26	-	R	R	-	R	R	-	R	R	-	-
Calcium-47*	Ca-47	4.5 d	β^- 0.69 (82%), 2.0 (18%) γ 1.3	S	U	R	S	R	R	-	R	R	-	-
Scandium-46	Sc-46	83.8 d	β^- 0.36, γ 1.0	S	U	R	S	R	R	-	R	R	-	-
Chromium-51	Cr-51	27.7 d	x 0.005, γ 0.3	S	U	R	S	-	-	-	P	-	-	P
Manganese-54	Mn-54	312.5 d	γ 0.8	R	U	R	R	-	-	-	P	-	-	P
Iron-55	Fe-55	2.7 y	X 0.006	-	U	R	-	-	-	-	P	-	-	P
Iron-59	Fe-59	45.1 d	β^- 0.4, γ 1.2	S	U	R	S	R	R	-	R	R	-	-
Cobalt-56	Co-56	78.8 d	β^+ 1.5, γ 1-3	S	U	R	S	-	-	-	-	-	-	R
Cobalt-57	Co-57	271.4 d	γ 0.13	R	U	R	R	-	-	-	P	-	-	P
Cobalt-58	Co-58	70.8 d	β^+ 0.5, γ 0.8	S	U	R	S	U	U	-	P	U	-	P
Cobalt-60	Co-60	5.3 y	β^- 0.3, γ 1.3	S	U	R	S	R	R	-	R	R	-	-

Radionuclide data and guide to suitable detectors *(continued)*

Nuclide		Half-life	Prominent radiations and maximum energies (MeV)	Suitability for dose rate measurements				Suitability for contamination measurements						
				Energy compensated GM	End window GM	Ionisation chamber	Plastic scintillator	End window GM	Full energy β scint	High energy β scint	Xe-filled proportional	Refillable proportional	α scint	NaI scint
Nickel-63	Ni-63	100.0 y	β^- 0.066	-	U	R	-	-	P	-	-	P	-	-
Zinc-65	Zn-65	243.8 d	γ 1.1	R	U	R	R	-	-	-	R	U	-	P
Selenium-75	Se-75	119.8 d	γ 0.1-0.4	R	U	R	R	-	-	-	R	-	-	R
Bromine-82	Br-82	1.5 d	β^- 0.4, γ 0.5-1.5	S	U	R	S	R	R	-	R	R	-	-
Krypton-85	Kr-85	10.7 y	β^- 0.7	-	U	R	-	-	-	-	-	-	-	-
Rubidium-86	Rb-86	18.7 d	β^- 1.8, γ 1.1	S	U	R	S	R	R	R	R	R	-	-
Strontium-85*	Sr-85	64.8 d	γ 0.5	R	U	R	R	-	-	-	R	-	-	R
Strontium-89*	Sr-89	50.5 d	β^- 1.5	-	R	R	-	R	R	R	R	R	-	U
Strontium-90	Sr-90	29.1 y	β^- 0.5	-	R	R	-	R	R	-	R	R	-	-
Yttrium-88	Y-88	106.6 d	γ 1.8	R	U	R	R	-	-	-	R	-	-	R
Yttrium-90	Y-90	2.7 d	β^- 2.3	-	R	R	-	R	R	R	R	R	-	U
Yttrium-91	Y-91	58.5 d	β^- 1.5	-	R	R	-	R	R	R	R	R	-	U
Zirconium-95	Zr-95	64.0 d	β^- 0.4, γ 0.7	S	U	R	S	R	R	-	R	R	-	-
Niobium-95	Nb-95	35.2 d	β^- 0.16, γ 0.76	S	U	R	S	R	R	-	R	R	-	-
Molybdenum-99	Mo-99	2.8 d	β^- 1.2, γ 0.7	S	U	R	S	R	R	R	R	R	-	U
Technetium-99	Tc-99	2.1 10^5 y	β^- 0.3	-	R	R	-	R	R	-	R	R	-	-
Technetium-99m	Tc-99m	6.0 h	γ 0.14	R	U	R	R	-	-	-	-	-	-	R
Ruthenium-103*	Ru-103	39.4 d	β^- 0.2, γ 0.5	S	U	R	S	R	R	-	R	R	-	-
Ruthenium-106*	Ru-106	1.0 y	β^- 1.5-3.6, γ 0.5-2.9	S	U	R	S	R	R	R	R	R	-	U
Silver-110m*	Ag-110m	249.9 d	β^- 0.5, γ 0.6-1.5	S	U	R	S	R	R	R	R	R	-	U
Cadmium-109	Cd-109	1.3 y	x 0.02, γ 0.09	S	U	R	S	-	-	-	-	-	-	R
Indium-111	In-111	2.8 d	x 0.02, γ 0.2	S	U	R	S	-	-	-	R	-	-	R

Radionuclide data and guide to suitable detectors *(continued)*

Nuclide		Half-life	Prominent radiations and maximum energies (MeV)	Suitability for dose rate measurements				Suitability for contamination measurements						
				Energy compensated GM	End window GM	Ionisation chamber	Plastic scintillator	End window GM	Full energy β scint	High energy β scint	Xe-filled proportional	Refillable proportional	α scint	NaI scint
Tin-113*	Sn-113	115.1 d	x 0.02, γ 0.4	S	U	R	S	-	-	-	R	-	-	R
Tin-119m*	Sn-119m	293.0 d	x 0.02	-	U	R	U	-	-	-	R	-	-	R
Antimony-124	Sb-124	60.2 d	β^- 0.1-2.3, γ 0.6	S	U	R	S	R	R	U	R	R	-	U
Antimony-125*	Sb-125	2.7 y	β^- 0.6, γ 0.6	S	U	R	S	R	-	-	-	-	-	-
Iodine-125	I-125	60.1 d	x, γ 0.03	-	U	R	U	-	-	-	R	-	-	R
Iodine-129	I-129	$1.6\ 10^7$ y	β^- 0.15, X 0.03	-	U	R	S	R	R	-	R	R	-	R
Iodine-131*	I-131	8.0 d	β^- 0.6, γ 0.4	S	U	R	S	R	R	-	R	R	-	-
Xenon-133	Xe-133	5.3 d	β^- 0.3, γ 0.08	S	U	R	S	-	-	-	-	-	-	-
Caesium-134	Cs-134	2.1 y	β^- 0.6, γ 0.7	S	U	R	S	R	R	-	R	R	-	-
Caesium-137*	Cs-137	30.0 y	β^- 0.5, γ 0.7	S	U	R	S	R	R	-	R	R	-	-
Barium-133	Ba-133	10.7 y	γ 0.3	R	U	R	R	-	-	-	R	-	-	R
Barium-140	Ba-140	12.7 d	β^- 1.0, γ 0.5	S	U	R	S	R	R	U	R	R	-	U
Lanthanum-140	La-140	1.7 d	β^- 1-2, γ 0.3-2.5	S	U	R	S	R	R	R	R	R	-	U
Cerium-139	Ce-139	137.7 d	γ 0.2	R	U	R	R	-	-	-	R	-	-	R
Cerium-141	Ce-141	32.5 d	β^- 0.5, γ 0.15	S	U	R	S	R	R	-	R	R	-	-
Cerium-144*	Ce-144	284.9 d	β^- 3, γ 1-2	S	U	R	S	R	R	-	R	R	-	-
Promethium-147	Pm-147	2.6 y	β^- 0.2	-	R	R	-	R	R	-	R	R	-	-
Samarium-151	Sm-151	89.9 y	β^- 0.6	-	U	R	-	R	R	U	R	R	-	-
Europium-152	Eu-152	13.3 y	β^- 0.7, γ 0.3-1.3	S	U	R	S	U	U	-	R	U	-	R
Gadolinium-153	Gd-153	242.0 d	x, γ 0.04-0.1	R	U	R	R	-	-	-	R	-	-	R
Terbium-160	Tb-160	72.3 d	β^- 0.5-1, γ 0.1-1.3	S	U	R	S	R	R	U	R	R	-	-

Radionuclide data and guide to suitable detectors *(continued)*

Nuclide		Half-life	Prominent radiations and maximum energies (MeV)	Suitability for dose rate measurements: Energy compensated GM	End window GM	Ionisation chamber	Plastic scintillator	Suitability for contamination measurements: End window GM	Full energy β scint	High energy β scint	Xe-filled proportional	Refillable proportional	α scint	NaI scint
Thulium-170	Tm-170	128.6 d	β^- 1, x, γ 0.01-0.08	S	U	R	S	R	R	U	R	R	-	-
Ytterbium-169	Yb-169	32.0 d	x, γ 0.01-0.3	R	U	R	R	R	R	-	R	R	-	R
Tungsten-185	T-185	75.1 d	β^- 0.4	-	R	R	-	R	R	-	R	R	-	-
Iridium-192	Ir-192	74.0 d	β^- 0.7, γ 0.5	S	U	R	S	R	R	-	R	R	-	-
Gold-198	Au-198	2.7 d	β^- 1, γ 0.4	S	U	R	S	R	R	U	R	R	-	U
Gold-199	Au-199	3.1 d	β^- 0.4, γ 0.2	S	U	R	S	R	R	-	R	R	-	-
Mercury-203	Hg-203	46.6 d	β^- 0.2, γ 0.3	S	U	R	S	R	R	-	R	R	-	-
Thallium-204	Tl-204	3.8 y	β^- 0.8	-	R	R	-	R	R	U	R	R	-	U
Lead-210*	Pb-210	22.3 y	β^- 0.06, γ 0.05	S	U	R	S	-	-	-	U	-	-	U
Polonium-210	Po-210	1384.d	α	—	—	—	—	-	-	-	-	R	R	-
Radium-226*	Ra-226	1.6 10^3 y	α, β^- 3, γ 0.2-2	S	U	R	S	R	R	R	R	U	U	-
Thorium-228*	Th-228	1.9 y	α, β^- 2, γ 0.1-3	S	U	R	S	U	U	-	-	R	R	-
Thorium-232*	Th-232	1.41 10^{10} y	α, β^- 2, γ 0.5-2	-	-	-	-	U	U	-	-	R	R	-
Uranium-238*	U-238	4.5 10^9 y	α, β^- 2, γ 0.1-2	S	U	R	S	U	U	-	-	R	R	-
Neptunium-237*	Np-237	2.1 10^6 y	α, γ 0.03-0.4	S	U	R	S	U	U	-	-	R	R	-
Plutonium-238	Pu-238	87.7 y	α	—	—	—	—	U	U	-	-	R	R	-
Plutonium-239	Pu-239	2.4 x 10^4 y	α, x 0.01–0.02	S	U	S	S	U	-	-	-	R	R	U
Americium-241	Am-241	432.0 y	α, γ 0.06	R	U	R	R	-	-	-	-	R	R	U
Curium-244	Cm-244	18.1 y	α	—	—	—	—	U	U	-	-	R	R	-
Californium-252*	Cf-252	2.6 y	α, n 2, γ	R	U	R	R	U	U	-	-	R	R	-

6 PACKAGE AND SOURCE IDENTIFICATION

6.1 Introduction

The transport of radioactive materials is governed by strict regulations*, aimed at providing protection according to the hazard that the contents would present if a package were to be involved in an accident. The greater the potential hazard, the greater the built-in protection required by the regulations.

Correctly packaged radioactive material requires no special countermeasures for the protection of the public or the emergency services. Even if a package has been involved in an accident, no countermeasures are required unless the package itself has been damaged. Minor traffic accidents are unlikely to damage a package sufficiently to create a significant radiological hazard. Nevertheless, any such presumption should be checked by measurements at the scene of the accident.

The regulations specify standards for packages containing radioactive material, and how they must be labelled. An ability to recognise and interpret the type of package and its label can provide considerable guidance to both NAIR participants and the police. Various standards of package are designated, with differing capabilities of surviving accidents, because the greater the quantity and radiotoxicity of the contents, the greater will be the need to preserve the integrity of the package. In increasing order of robustness, the five recognised categories of package are Excepted, Industrial, Type A, Type B and Type C.

Package labelling depends mainly on the dose rate at or close to the surface of the package. The resulting category of the transport label may govern what type of transport can be used, how several radioactive packages may be loaded together, or whether the package can be included in a mixed consignment with other commodities. For packages containing fissile material a criticality safety index label is also required.

Some forms of packaging are for transport only, and are intended to be discarded or returned empty. However, a portable instrument that contains a radioactive source may also be a transport package in its own right. Some instruments require an additional carrying case to complete the transport package.

6.2 Excepted packages

Excepted packages provide no special protection for the radioactive contents. This standard of packaging is used for very small quantities of radionuclides that would present negligible hazard if the package were destroyed. Excepted packages must have a surface dose rate less than 5 μSv h^{-1}. They carry no

* Transport regulations in the UK are based on the IAEA Regulations for the Safe Transport of Radioactive Material (Vienna, IAEA Safety Standards Series No. TS-R-1, 1996 Edition Revised, 2000).

6 PACKAGE AND SOURCE IDENTIFICATION

6.1 Introduction

The transport of radioactive materials is governed by strict regulations*, aimed at providing protection according to the hazard that the contents would present if a package were to be involved in an accident. The greater the potential hazard, the greater the built-in protection required by the regulations.

Correctly packaged radioactive material requires no special countermeasures for the protection of the public or the emergency services. Even if a package has been involved in an accident, no countermeasures are required unless the package itself has been damaged. Minor traffic accidents are unlikely to damage a package sufficiently to create a significant radiological hazard. Nevertheless, any such presumption should be checked by measurements at the scene of the accident.

The regulations specify standards for packages containing radioactive material, and how they must be labelled. An ability to recognise and interpret the type of package and its label can provide considerable guidance to both NAIR participants and the police. Various standards of package are designated, with differing capabilities of surviving accidents, because the greater the quantity and radiotoxicity of the contents, the greater will be the need to preserve the integrity of the package. In increasing order of robustness, the five recognised categories of package are Excepted, Industrial, Type A, Type B and Type C.

Package labelling depends mainly on the dose rate at or close to the surface of the package. The resulting category of the transport label may govern what type of transport can be used, how several radioactive packages may be loaded together, or whether the package can be included in a mixed consignment with other commodities. For packages containing fissile material a criticality safety index label is also required.

Some forms of packaging are for transport only, and are intended to be discarded or returned empty. However, a portable instrument that contains a radioactive source may also be a transport package in its own right. Some instruments require an additional carrying case to complete the transport package.

6.2 Excepted packages

Excepted packages provide no special protection for the radioactive contents. This standard of packaging is used for very small quantities of radionuclides that would present negligible hazard if the package were destroyed. Excepted packages must have a surface dose rate less than 5 μSv h^{-1}. They carry no

* Transport regulations in the UK are based on the IAEA Regulations for the Safe Transport of Radioactive Material (Vienna, IAEA Safety Standards Series No. TS-R-1, 1996 Edition Revised, 2000).

external radioactive label but the package must be marked with the relevant United Nations (UN) number.

UN Numbers are used on dangerous goods labels and consist of a four-digit number assigned by the UN Committee of Experts on the Transport of Dangerous Goods. UN Numbers are assigned to one substance or a group of substances with similar hazardous properties.

Figure 1 shows a typical Excepted package. The absence of a label on the box should be noted. As with many radiopharmaceutical kits, this package includes several non-radioactive items.

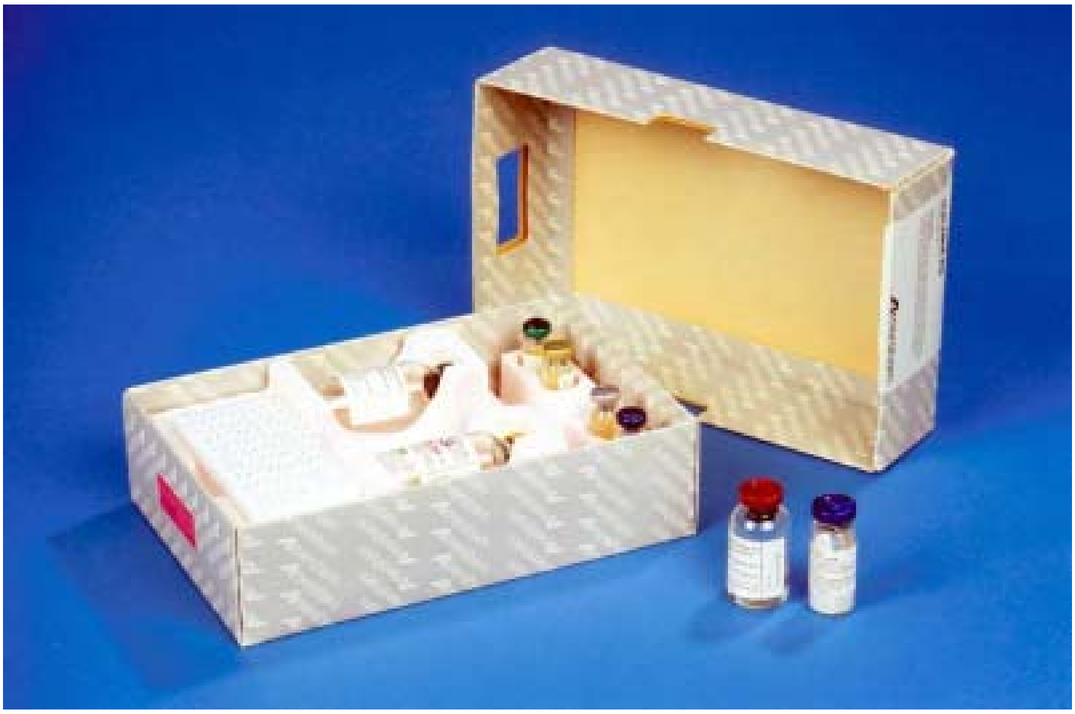


FIGURE 1 Excepted package, with no external label

6.3 Industrial packages

Industrial packages normally contain physically large items of low specific activity, eg chemicals containing naturally occurring radionuclides, or surface contaminated objects. The packaging may take the form of stout lined sacks, metal or other types of drum, or even bulk tanks. Such packaging is generally intended only to prevent the loss of contents under normal conditions of transport, although some industrial packages are required to be more robust.

Industrial packages or their containers should be labelled either Low Specific Activity (LSA) or Surface Contaminated Object (SCO).

Industrial packages include bulk consignments of low-level radioactive waste, or of thorium or uranium compounds. (***Note*** Uranium hexafluoride, while subject to the transport regulations, should be treated primarily as a hazardous chemical.)

6.4 Type A packages

Type A packages are intended to provide adequate safeguards of containment and shielding for radioactive materials, in the normal transport environment including minor mishaps. The acceptance procedures for Type A packages include a drop test, a compression test and a penetration test, each of which takes place after the package has been sprayed with water for at least an hour. Experience has shown that many packages comfortably exceed the requirements of the statutory tests. Even so, the transport regulations limit the quantities of radionuclides that can be carried in Type A packages.

Each package carries a radioactive label. As well as indicating that the contents of the packages are radioactive, the label bears a category (I, II or III, in red) that is related to the dose rates at or close to the surface. The table shows how the transport categories are determined. If a package that has been involved in an accident appears intact, or has suffered only superficial damage, and also the measured dose rates correspond with the category on the label, there is no need to invoke countermeasures for the protection of the public and emergency services.

Figure 2 shows a selection of Type A packages and labels. The category I label has an all-white background, while the background to the trefoil on category II and III labels is yellow. Note that the size of the package bears no obvious relationship to the category on the label. All packages are additionally marked Type A with the relevant UN number and proper shipping name.

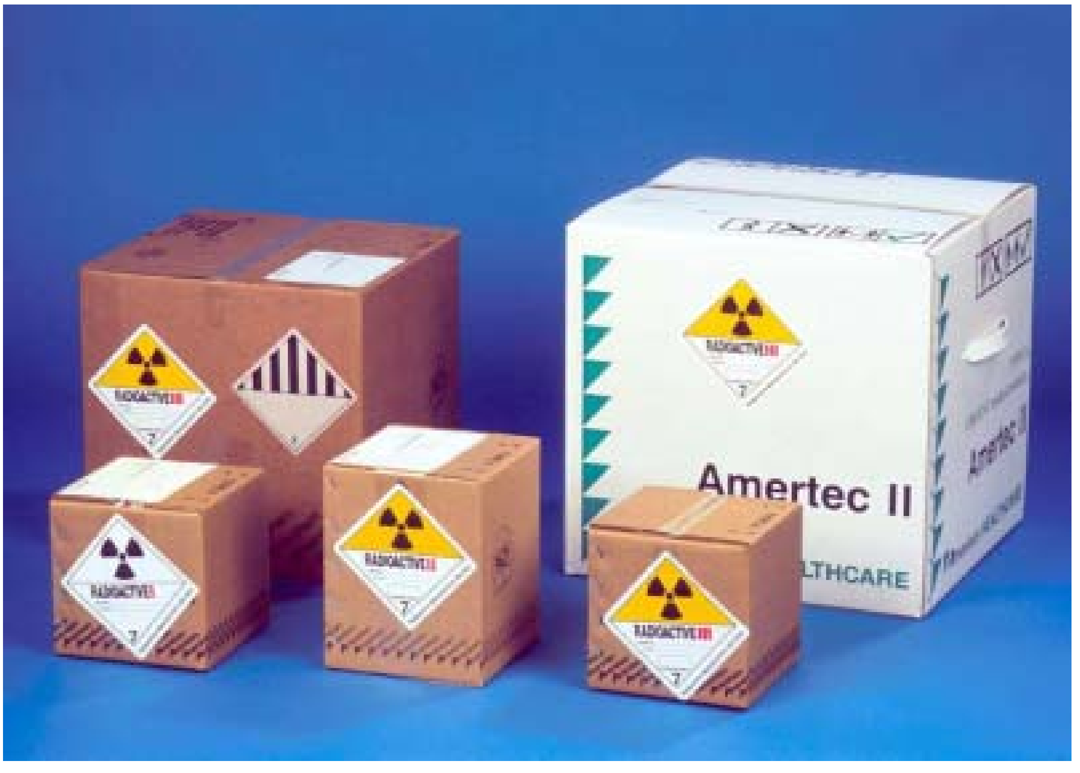


FIGURE 2 Selection of Type A packages and `Radioactive' labels

Figure 3 shows the contents of a typical Type A transport package for a radioactive liquid. The sealed vial of liquid is contained within a lead shielded inner container incorporating a secondary seal so that in the event of leakage from the primary container, the product will be retained within this inner container. The inner container is cushioned between two expanded polystyrene mouldings to absorb any shocks due to impact or crushing. An outer corrugated fibreboard case completes the Type A package. Experience shows that packages of this type can survive being run over by a truck. However, it might not survive such an accident followed by an intense fire, and this is recognised in the regulations that place limits on quantities that can be transported in a Type A package.

FIGURE 3 Type A packaging for a liquid source

Labelling of transport packages

	Maximum radiation level at surface		Maximum radiation level at 1 m	
Label category	mSv h^{-1}	mrem h^{-1}	mSv h^{-1}	mrem $h^{-1\infty}$
I (white label)	0.005	0.5	–	–
II (yellow label)	0.5	50	0.01	1
III (yellow label)	2	200	0.1	10

$^{\infty}$ = Transport Index.

Another common kind of Type A package contains a technetium-99m generator for use in hospitals. The generator uses molybdenum-99 (half-life 2.75 days) on an ion-exchange column, from which the technetium-99m decay product (half-life 6 hours) can be drawn as required. A typical technetium-99m generator kit is shown in Figure 4. The generator is housed in a carrying case, and vials for the technetium-99m are supplied with separate labels to be affixed after filling.

Molybdenum-99 is the main source of external dose, and packaged generators normally fall in transport category III.

The soil density and moisture probe shown in Figure 5 contains two radioactive sources, and requires its carrying case in order to qualify as a Type A transport package. So, although the instrument carries a trefoil and a Radioactive sign, the Radioactive II label and Type A marking are to be found on the outer case.

FIGURE 4 Technetium-99m generator and packaging

6.5 Type B packages

Type B packages are intended to withstand severe accident conditions. To become an accepted design, a package must withstand successively a drop test, a puncture test and a fire test, and a separate package must also withstand a water immersion test. The large transport flasks used by the nuclear power industry are Type B packages, but the Type B packages that are more likely to be encountered in NAIR incidents are much smaller.

Figure 6 shows a general-purpose Type B package. Typically, the radioactive material in its own lead-shielding container is placed inside a lead pot that is sealed with an O-ring.

Labelling of Type B containers follows the same categories I–III as for Type A (see the table). Additionally, a Type B container carries a fireproof and waterproof trefoil symbol, and is marked 'Type B' with the relevant UN number and proper shipping name.

FIGURE 5 Soil density and moisture probe with its carrying case, together forming a Type A transport package

FIGURE 6 General-purpose Type B package

Figure 7 shows a typical gamma radiography source container. This is a Type B package in its own right, and is marked as such. In transport, the source (foreground, left-hand end) is locked and sealed in the centre of the depleted uranium shielding container.

6.6 Type C packages

Type C packages are capable of withstanding severe accident conditions in air transport. The Type C package provides similar protection for air transport when compared with a Type B package in a severe surface mode accident. Enhanced tests are required for Type C packages. These packages are a recent addition to the regulations and likely to be rarely encountered.

6.7 Placarding of vehicles, freight containers and tanks

As well as labelling of the packages themselves, the transport regulations in certain circumstances require placarding of vehicles and containers.

Freight containers or tanks should also be placarded with the United Nations Commodity Number describing the contents, which the police and fire services can interpret. A list of the UN numbers commonly used in the transport of radioactive materials is given in the appendix.

FIGURE 7 Gamma radiography source container – for transport, the source (foreground, left hand end) is locked in the centre of the shielding container

FIGURE 8 Placard for vehicles, freight containers and tanks

Road vehicles should carry a warning placard (Figure 8) on each side and the rear, and information for emergency response. Packages transported by road require a consignor's certificate giving details of the material being carried; in most cases the driver will carry a copy. Railway vehicles carrying radioactive materials together with parcels or other goods are not required to be placarded.

Vehicles carrying Excepted packages are not required to be placarded; nor are the packages themselves labelled externally but they will display the relevant UN number.

6.8 Unpackaged and lost sources

Not all NAIR incidents will involve properly packaged sources. Participants may be called to incidents involving lost sources, or gamma radiography sources that cannot be returned to their shielding containers (although site radiographers should be trained to deal with this). Instruments containing radioactive sources can also be damaged while in use, eg soil density and moisture probes have been run over by road rollers. If such incidents happen in or near to public places, the police could well invoke NAIR.

Radioactive sources come in all manner of physical forms, and if separated from their packaging they will probably not be marked in any way. Without the aid of an appropriate survey instrument, a purely visual search for a lost source of unknown appearance is unlikely to be successful.

6.9 Empty packaging

Many NAIR incidents are found to involve empty packaging. These should have had their warning notices removed and replaced by a label saying ‘Empty – Having Contained Radioactive Material’. There are regulatory requirements concerning the obscuring, removal and misuse of ‘Radioactive’ labels. Where failure to follow these regulations results in unnecessary effort on the part of NAIR participants it may be desirable to point this out to the police and the appropriate government department.

7 DISPOSAL OF RADIOACTIVE MATERIALS INVOLVED IN NAIR INCIDENTS

A small proportion of incidents involve radioactive material whose ownership is untraceable. NAIR participants may be required to advise what should be done with the radioactive materials involved in an incident. They are not responsible for the clean up or removal and disposal of wastes arising as a result of a NAIR callout.

Both Environment Agency (EA) and Scottish Environment Protection Agency (SEPA) have established arrangements for the removal of radioactive wastes arising from NAIR incidents in England / Wales and Scotland respectively.

In respect of the EA disposal arrangements, it should be noted that:

a the arrangement is only intended to cover the general, small arisings of radioactive waste under the NAIR scheme, there being a limit on the liability which will be met by the Environment Agency contract with Safeguard International,

b the contract provides for removal of waste from NAIR incidents occurring since April 2000,

c the Environment Agency will continue to investigate vigorously any suspected breach of the Radioactive Substances Act 1993, including circumstances where these arrangements are used,

d the Environment Agency recognises the valuable public service that NAIR has provided for many years and supports the scheme from the Agency's perspective of environmental concern and interest, rather than any statutory or other obligation.

The alerting arrangements for obtaining NAIR assistance provide automatic notification of the relevant environment agency. In the event of a NAIR incident occurring in England or Wales and an EA representative not being available at the scene, NAIR respondents and/or the police may obtain radioactive waste disposal assistance via the Environment Agency Emergency Hotline (tel: 0800 80 70 60).

Once EA is satisfied that the incident is a genuine NAIR event, predetermined procedures will be used to effect the removal of the radioactive material.

7.1 Transport consignments

Responsibility for packages in transit should be indicated in the transport documentation. If packages involved in NAIR incidents are found after inspection and radiological survey to be undamaged, they can be sent onwards in the care of those responsible. If packages have suffered damage the police will require advice on storage until the responsible party can be contacted to arrange collection.

7.2 Unknown ownership

If the owner of a radioactive source is unknown, the police should contact the appropriate environment agency. The Agency will advise what should be done with the source, and will be endeavour to trace its owner.

As all NAIR participants will be aware, the Radioactive Substances Act 1993 requires specific authorisation from the appropriate Agency, before any radioactive material (with minor exceptions) may be disposed of as waste.

7.3 Environmental contamination

A NAIR incident involving significant environmental contamination will probably require Stage 2 participation. The Stage 2 participant should contact the appropriate Agency for advice on the disposal of any contaminated material removed from the scene of the incident.

7.4 Emergency disposals

Most NAIR incidents do not give rise to environmental radioactive contamination. The standard NAIR alerting mechanism (via UKAEA constabulary on 0800 834153) includes automatic notification to either Environment Agency (EA) if the incident is in England or Wales or Scottish Environment Protection Agency (SEPA) if the incident is in Scotland. The relevant environment agency has responsibility for ensuring mitigation of the environmental effects following such an incident. This could involve advising on appropriate decontamination and disposal of waste arising from the incident; advising on measures to minimise further environmental contamination and granting emergency authorisations.

APPENDIX

UNITED NATIONS (UN) NUMBERS

UN Numbers commonly used in the transport of radioactive materials *(taken from TS-R-1, Regulations for the Safe Transport of Radioactive Material, 1996 Edition, Revised)*

Schedule*	UN Number	Description	Subsidiary risk
1	2910	Radioactive material, Excepted Package - limited quantity of material	
2	2911	Radioactive material, Excepted Package - instruments or articles	
3	2909	Radioactive material, Excepted Package - articles manufactured from natural uranium or depleted uranium or natural thorium	
4	2908	Radioactive material, Excepted Package - empty packaging	
5	2912	Radioactive material, low specific activity (LSA-I), Non-fissile or fissile-excepted	
6	3321	Radioactive material, low specific activity (LSA-Ii), non-fissile or fissile-excepted	
7	3322	Radioactive material, low specific activity (LSA-Iii), non-fissile or fissile-excepted	
8	2913	Radioactive material, surface contaminated objects (SCO-I Or SCO-Ii), non fissile or fissile-excepted	
9	2915	Radioactive material, Type A Package, non-special form, non-fissile or fissile-excepted	
9	3332	Radioactive material, Type A Package, special form non-fissile or fissile-excepted	
10	2916	Radioactive material, Type B(U) Package, non-fissile or fissile-excepted	
11	2917	Radioactive material, Type B(M) Package, non-fissile or fissile-excepted	
12	3323	Radioactive material, Type C Package, non-fissile or fissile-excepted	
14	2919	Radioactive material, transported under special arrangement, non fissile or fissile-excepted	
†	2978	Radioactive material, uranium hexafluoride non-fissile or fissile-excepted	Corrosive (UN Class 8)
6+13	3324	Radioactive material, low specific activity (LSA-Ii), fissile	
7+13	3325	Radioactive material, low specific activity (LSA-Iii), fissile	
8+13	3326	Radioactive material, surface contaminated objects (SCO-I or SCO-Ii), fissile	
9+13	3327	Radioactive material, Type A Package, fissile non-special form	
9+13	3333	Radioactive material, Type A Package, special form, fissile	
10+13	3328	Radioactive material, Type B(U) Package, fissile	
11+13	3329	Radioactive material, Type B(M) Package, fissile	
12+13	3330	Radioactive material, Type C Package, fissile	
14+13	3331	Radioactive material, transported under special arrangement, fissile	
†+13	2977	Radioactive material, uranium hexafluoride, fissile	Corrosive (UN Class 8)

* The schedules of requirements for the transport of specified types of radioactive material consignments provide a summary of the main provisions within the regulations as described in TS-R-1.
† UN2977 and UN2978 are special cases without a unique relationship with the schedules.