Code of practice for the protection of persons exposed to ionising radiations in research and teaching.

DEPARTMENT OF EMPLOYMENT
AND PRODUCTIVITY

Code of Practice

for the protection of persons exposed to Ionising Radiations in Research & Teaching

LONDON
HER MAJESTY'S STATIONERY OFFICE
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DEPARTMENT OF EMPLOYMENT
AND PRODUCTIVITY

MINISTRY OF HEALTH AND SOCIAL SERVICES
NORTHERN IRELAND

Code of Practice

for the Protection of Persons Exposed to Ionising Radiations in Research and Teaching

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HER MAJESTY'S STATIONERY OFFICE
1968

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INTRODUCTION

This Code is issued by the Secretary of State for Employment and Productivity and the Minister of Health and Social Services, Northern Ireland. It has been prepared by a Panel appointed by the Radioactive Substances Advisory Committee with the following terms of reference:

'To consider, in relation to persons working in research laboratories, teaching laboratories (other than schools) and research establishments (other than hospital research establishments), the safety and health questions arising from the use of ionising radiations, and to report.'

It is intended to apply to a wide range of research work and teaching, such as that under the control of the universities, medical schools, technical colleges, Government Departments, the United Kingdom Atomic Energy Authority and industry generally.

The Code has been drawn up in the light of the recommendations of the International Commission on Radiological Protection and of the views of the Medical Research Council's Committee on Protection against Ionising Radiations. It is designed to harmonise with related factory legislation and with the Code for Medical and Dental Practice which has been drawn up by another Panel of the Radioactive Substances Advisory Committee. Close regard has also been paid to the Code of Practice for University Laboratories published in February 1961 by the Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom.[1]

General principles of protection are given in Parts 1–6 and 11–14; Parts 7–10 give guidance on certain special types of work. It is important that each person concerned should read the Parts of the Code dealing with precautions of general application as well as any sections of particular interest to him.

A great deal of relevant information will also be found in a handbook of radiological data to be issued by the Radioactive Substances Advisory Committee for use with this and related Codes.

This Code cannot be so detailed as to deal adequately with every set of circumstances that may arise, and it may well be necessary for certain users to obtain more specialised advice. Information may be obtained from the Advisory and Information Unit of the Department of Employment and Productivity, 1 Chepstow Place, London W2 or from the Radiological Protection Service, Clifton Avenue, Belmont, Sutton, Surrey. In Northern Ireland, similar information may be obtained from the Chief Inspector of Factories, Ministry of Health and Social Services, Dundonald House, Upper Newtownards Road, Belfast, BT4 3SF.

[1]Replaced in 1966 by "Radiological Protection in Universities".

NOTE

In this Code the word 'must' is used to indicate essential requirements; the word 'should' to indicate desirable requirements. Certain other terms have the special meanings set out in the Definitions (pages 39-41).

PART 1

SCOPE OF THE CODE

1.1 Establishments

1.1.1 This Code applies to all research laboratories, research establishments and teaching laboratories in which ionising radiations are used or radioactive substances are present with the exception of:

(i) establishments subject to the Factories Act;

(ii) hospital research establishments to which the Code for Medical and Dental Practice applies; and

(iii) educational establishments working within the systems of authorisation of the Department of Education and Science and the Scottish Education Department for schools and for colleges requiring only low levels of activity. If neutron sources are used, however, the Code does apply.

1.2 Hazards

1.2.1 The provisions of this Code relate to hazards arising from:

(i) any radioactive substances, whether sealed or unsealed; and

(ii) any machines or apparatus which emit ionising radiations, including apparatus in which charged particles are accelerated by a voltage of not less than five kilovolts,

except in the cases of minimal hazard set out in the following paragraphs.

1.2.2 The provisions of the Code are not intended to apply to the following:

(i) sealed sources at or near the surface of which the dose rate of ionising radiations does not exceed ten millirads in air per hour, provided:

(a) such sealed sources are not placed together in such a way that the collective dose rate at or near the surface exceeds ten millirads in air per hour; and

(b) the Controlling Authority is satisfied that no significant whole body dose will have been received by any person from any such source or sources (this will normally be so when the surface area involved is less than 10 square centimetres)

but in establishments to which the Code applies for other reasons the dose rate from such sources must be taken into account;

(ii) any room or store in which the unsealed radioactive substances amount to less than one microcurie of a Class I radionuclide, 10 microcuries of Class II and III radionuclides and 100 microcuries of Class IV radionuclides (see Appendix 3 for Classification Tables of radionuclides);

(iii) television apparatus used only for the reception of visual images when operated at a voltage of not more than 20 kilovolts, unless the dose rate at the outer surface of the cabinet exceeds 0·75 millirads in air per hour;

(iv) luminised watches and clocks;

(v) luminised instruments from which no person is liable to receive a whole body dose of more than 0·5 rems in the year;

(vi) incandescent mantles;

(vii) fired ceramic articles made wholly or partly from thorium dioxide;

(viii) any alloy containing as its sole radioactive constituent 4 per cent. or less by weight of natural thorium or compounds of thorium;

(ix) any natural or depleted uranium compound where used as a pigment and not containing any significant amount of any other radioactive substance; and

(x) any amounts not exceeding 10 kilograms of salts of natural thorium or natural uranium used as a chemical reagent and not containing any significant amount of any other radioactive substance.

1.3 Persons

1.3.1 This Code applies to all persons within an establishment covered by the Code who are exposed to ionising radiations arising within the establishment, except persons exposed to ionising radiations for diagnostic or therapeutic purposes, to whom the Code for Medical and Dental Practice applies.

PART 2

ADMINISTRATIVE ORGANISATION

2.1 Allocation of responsibility

2.1.1 The primary responsibility for the implementation of this Code rests with the Controlling Authority (see definition, page 39).

2.1.2 For this purpose the Controlling Authority must provide an administrative organisation in which the responsibility for radiological safety at each level of control is clearly defined. Examples of such organisations are given in Appendix 4.

2.2 Radiological Safety Officers

2.2.1 The Controlling Authority must appoint a sufficient number of Radiological Safety Officers to carry out the duties specified in this Code.

2.2.2 The Radiological Safety Officers must be chosen with regard to their technical qualifications and experience and to their general health and the suitability of their personality. The appointment of Radiological Safety Officers should be reviewed periodically so that the Controlling Authority is satisfied of the continued suitability of the persons chosen.

2.2.3 Appropriate training in radiological health and safety must be arranged for Radiological Safety Officers unless the Controlling Authority is satisfied that they already have the necessary knowledge and experience.

2.3 Local rules

2.3.1 The Controlling Authority must arrange for local rules, consistent with the principles of this Code, to be drawn up setting out clearly and precisely the procedure in force in the particular establishment and the names and duties of the persons responsible for the various aspects of safety precautions. Any person to whom the Controlling Authority allocates special responsibilities for health and safety must be given a clear written statement of his duties, and must acknowledge its receipt.

2.4 Responsibility of individuals

2.4.1 *It must be impressed on every individual working with ionising radiations or radioactive substances that he has a duty to protect both himself and others from any hazard arising from his work and that he must not expose himself or others to ionising radiations to a greater extent than is reasonably necessary for the purposes of his work.*

2.5 Designation

2.5.1 The Controlling Authority must determine in respect of all persons coming within the scope of the Code (see paragraph 1.3.1)

whether or not they shall be 'designated' as specified in paragraph 2.5.3. The Controlling Authority should ensure that the designation of each individual is kept under review.

2.5.2 Designated persons will be subject to personal monitoring (see paragraphs 5.3.1 to 5.3.10) and medical supervision (see Part 6) and may be permitted to receive doses up to the higher levels set out in Table I of Appendix 1.

2.5.3 All persons working in controlled areas (see definition, page 39) in:

(i) work associated with sealed sources, unsealed radioactive substances or machines or apparatus emitting ionising radiations or immediately ancillary work; or

(ii) the cleaning of active areas or the cleaning of plant, apparatus, equipment, materials or articles which are contaminated or are suspected to be contaminated

must be 'designated' unless they are engaged on an approved scheme of work as defined in paragraph 2.5.4.

2.5.4 An approved scheme of work is one where the Controlling Authority, having taken account of the advice of the Radiological Safety Officer, is satisfied that the operating and working conditions and the system of control and instruction are such that a person working in accordance with the scheme is most unlikely to receive more than three-tenths of the annual maximum permissible doses set out in Appendix 1, Table I, and that there is adequate protection against contamination from any unsealed radioactive substances. (For the purpose of whole body doses, the MPD is to be taken as 5 rems.) The essential features of the approved scheme must be set out clearly in writing so that they may be seen by the persons engaged in it.

2.6 Marking of controlled areas

2.6.1 The Controlling Authority must arrange for all controlled areas within the establishment to be identified and suitably marked. (See also paragraphs 9.2.4 and 9.2.5.)

2.7 Records

2.7.1 The Controlling Authority must arrange (in accordance with the paragraphs set out below) for the following records to be kept:

Radiation dose record	(see paragraphs 5.4.1–5.4.3 and 5.4.6)
Transfer record	(see paragraphs 5.4.4–5.4.6)
Cases of contamination of skin, hair and clothing	(see paragraph 5.4.7)

Tests of monitoring instruments	(see paragraph 5.5.2)
Health record	(see paragraphs 6.5.1–6.5.3)
Sealed sources stock record	(see paragraph 8.1.7)
Unsealed sources stock record	(see paragraph 9.6.1)
Leakage test	(see paragraph 8.2.3)
Investigations of emergencies	(see paragraph 11.4.8)

PART 3

SUITABILITY OF BUILDINGS

3.1 Wherever possible, work with ionising radiations and radioactive substances should be done in buildings designed or properly adapted for the purpose. For the higher levels of activity this is essential. The following paragraphs indicate some of the considerations to be taken into account during the initial planning of such buildings. Details of the internal design and equipment of laboratories or controlled areas are dealt with in paragraphs 9.3.1 to 9.3.5, and paragraphs 9.4.1 and 9.4.2 are also relevant.

3.2 At the planning stage, authoritative advice should be obtained (e.g. from the Radiological Protection Service[1]) on the location, design and construction of buildings and their associated services to ensure that they meet the standards laid down in this Code including provisions for dealing with emergencies.

3.3 Particular regard should be paid to the following:

(i) the need to reduce to the minimum the radiation dose to persons outside as well as to those within the establishment;

(ii) control of access;

(iii) arrangements for accommodation for protective clothing;

(iv) washing facilities;

(v) provision of adequate ventilation;

(vi) storage of radioactive substances;

(vii) disposal of radioactive waste; and

(viii) the need to minimise fire risks.

In view of the risk of dispersal of radioactive substances, fire precautions are of particular importance. The Chief Fire Officer for the County or County Borough (in Scotland, the Firemaster) will be willing to advise on this (see Part 11).

[1]For address, see Introduction, last paragraph.

PART 4

PRECAUTIONS OF GENERAL APPLICATION

4.1 Instruction

4.1.1 The Controlling Authority must ensure that all persons within the establishment who are liable to be exposed to ionising radiations are instructed about the hazards they may meet and about the precautions to be observed. All authorised visitors to controlled areas should be informed as necessary of the precautions to be observed.

4.2 Limitation of exposure

4.2.1 Every effort must be made to keep exposure to ionising radiations to the lowest practicable level. Persons whether designated or not must not be exposed to ionising radiations to a greater extent than is necessary and they must not in any case be intentionally subjected to any radiation doses in excess of those laid down in Appendix 1.

4.2.2 In view of the particular importance of restricting doses received by young persons, the Controlling Authority must supervise carefully their conditions of work. Persons under the age of 16 must not in any circumstances engage in work which would require them to be designated.

4.3 Protective measures

4.3.1 *Introduction*

4.3.1.1 The following paragraphs set out some basic principles of protection against ionising radiations. The measures taken to implement these principles will depend on the circumstances and may be considered under two headings:

(i) measures to minimise the dose of ionising radiations received from any source outside the body (protection against external radiation; and

(ii) measures to minimise the deposition within the body of radioactive substances whether by inhalation, by ingestion or by other means (protection against internal radiation).

The first applies to sealed sources, machines emitting ionising radiations and unsealed radioactive substances; the second arises in connection with unsealed radioactive substances.

4.3.2 *Protection against external radiation*

4.3.2.1 The basic methods of protection against external radiation are:

(i) reostrictin of the strength of every source;

(ii) shielding of sources;[1]

(iii) distance from the sources; and

(iv) restriction of the period of exposure.

The protection necessary in any particular situation to ensure that doses are kept below the maximum permissible levels (see Appendix 1) may be achieved by one or more of these methods.

4.3.2.2 Restriction of the strength of sources to the minimum consistent with the requirements of the work will always be the first precaution, except where more than a proportionate saving in time of exposure can be achieved by the use of more powerful sources.

4.3.2.3 Undoubtedly the best method of protection is to ensure that the apparatus is adequately shielded (see definition, page 39). Where reliance is placed for this purpose on distance, the area in which there is likely to be a radiation hazard must be clearly marked and identified by warning notices and where possible should be separated by a physical barrier.

4.3.2.4 No person, other than the subject of a radiological examination, may place any part of his body within any useful beam (see definition, page 41) and due regard must be paid to any scattered radiation.[2]

4.3.2.5 All persons should be kept as far away from the source as is reasonably practicable,[2] even when it is adequately shielded. A substantial reduction in radiation levels is achieved by increasing the distance, though the inverse square law applies strictly only to point objects and point sources.

4.3.2.6 Facilities for remote handling or remote control of radioactive substances or materials being irradiated should therefore be provided as a routine measure, except for sources where the surface dose and/or the nature of the radiations are such that they can be safely handled with gloved hands.

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[1]There are British Standards:

BS 4094: Part I 1966 'Data on shielding from Ionising Radiation' Part I is shielding from gamma radiation.

BS 4097: 1966 'Gamma radiography exposure containers and their source holder's.

[2]Under certain conditions of work the phenomenon of air-shine (sometimes referred to as sky-shine) must be taken into account. Where this is a possibility a careful survey will be required.

4.3.2.7 To reduce the time of exposure to the minimum, work should be carefully planned in advance. It may well be desirable to have trial runs using a dummy source or without exposing the source or energising the machine.

4.3.2.8 Special problems arising in connection with certain types of apparatus are discussed in Part 7.

4.3.3 *Protection against internal radiation*

4.3.3.1 The basic methods of protection against internal radiation are:

(i) use of material of the minimum radiotoxicity;
(ii) presence in the laboratory of the minimum quantities;
(iii) containment;
(iv) cleanliness; and
(v) use, where necessary, of protective equipment.

4.3.3.2 Where the nature of the work allows any choice of material the comparative toxicities should be taken into account in relation to the amounts which would be required. Where necessary, and particularly in the case of the longer lived nuclides of uranium, the chemical toxicity as well as the radiotoxicity should be taken into account.

4.3.3.3 In order to achieve proper containment, all work with radioactive substances should be segregated from other work, preferably in rooms reserved solely for it. If such segregation is not practicable special care must be taken to achieve equivalent standards of safety; certain additional precautions necessary for the containment of unsealed radioactive substances are dealt with in Part 9.

4.3.3.4 Working methods which tend to cause dust or which involve the risk of spills should, where possible, be avoided.

4.3.3.5 Laboratory surfaces and equipment should be easy to clean and to decontaminate both during normal work and during maintenance operations. Further information about standards of design and equipment for laboratories is given in section 9.3.

4.3.3.6 Protective equipment (see definition, page 40) must be provided where necessary to prevent as far as possible contamination of the skin, hairy and ordinary clothing. It must be worn by all persons working with unsealed radioactive substances and, if there is a risk of contamination, by persons carrying out maintenance or repair work.

4.3.3.7 The protective equipment must include a sufficient supply of suitable breathing apparatus where there is liable to be a hazard from gaseous or airborne radioactive substances.

PART 5

CONTROL OF EFFECTIVENESS OF PROTECTIVE MEASURES

5.1 Introduction

5.1.1 The effectiveness of protective measures must be assessed by regular monitoring both of the working environment and of the persons concerned. In each case it is necessary to assess the levels of external radiation and the amount of any contamination that may be present (see sections 5.2 and 5.3).

5.1.2 Instruments and other facilities required for monitoring must be made available by the Controlling Authority (see section 5.5).

5.2 Monitoring of working environment

5.2.1. The working environment should be surveyed from time to time to determine as appropriate:

(i) the levels of external radiation;

(ii) the levels of contamination of the surfaces in the laboratory including personal protective equipment; and

(iii) the concentration of radioactive substances in the laboratory atmosphere.

5.2.2 The surveys must be carried out by a Responsible Person (see definition, page 40) who knows how to use the monitoring instruments and how to interpret their readings.

5.2.3 When the results of the surveys show either a level of external radiation such that the maximum permissible doses given in Appendix 1 may be exceeded or contamination in excess of the levels given in Appendix 2 action must be taken to reduce the hazard before normal work is resumed (see Part 4).

5.3 Personal monitoring

5.3.1 Each designated person must, except as mentioned in the following sentence, wear either a suitable photographic film in an appropriate holder or other suitable dosemeter to measure the cumulative doses of external radiation he receives. In cases of exposure to fast neutrons or to low energy beta radiation, e.g. from tritium, carbon 14 and sulphur 35, special measuring techniques are necessary. Advice can be obtained from the Advisory and Information Unit of the Department of Employment and Productivity or from the Radiological Protection Service[1].

[1]For addresses, see Introduction, last paragraph.

5.3.2 The film badge or other dosemeter should normally be worn on the chest b ut in some circumstances it will be necessary to measure, in addition, the dose to some other part of the body (e.g. to the fingers or the wrist) where this is likely to be critical.

5.3.3 If the Radiological Safety Officer so advises, a personal ionisation chamber must be carried in addition to a film badge or other dosemeter in order to provide an immediate indication of the dose received.

5.3.4 It is the responsibility of the individual concerned to wear the dosemeter provided in accordance with paragraph 5.3.1 and, if appropriate, a personal ionisation chamber as in paragraph 5.3.3 during the whole time that he may be exposed to ionising radiations in the establishment. The loss of, or damage to, film badges or other measuring devices must be reported immediately to the Responsible Person appointed by the Controlling Authority for this purpose.

5.3.5 If so advised by the Radiological Safety Officer the Controlling Authority should extend any of the foregoing requirements to persons who have not been designated.

5.3.6 The film badge or other dosemeter must be examined periodically under arrangements made by the Controlling Authority (see paragraph 5.5.4).

5.3.7 In addition to personal monitoring by film badges and other measuring devices, the levels of contamination of the skin, hair and clothing must be checked as necessary to ensure that any excess contamination is detected without delay. Any case of excess contamination must be reported to the Responsible Person whose name should be prominently displayed wherever such monitoring is usually carried out.

5.3.8 Where significant amounts of more hazardous materials such as plutonium, radium, strontium, polonium, caesium or radioiodine are being used, it will be advisable to arrange regular evluation of the amounts of radioactive substances in the body by measurement of the amounts being excreted or by other appropriate means. Advice on the necessary measures can be obtained from the Advisory and Information Unit of the Department of Employment and Productivity or from the Radiological Protection Service[1].

5.3.9 If there is reason to think that a designated person or any other person required to wear a personal monitoring device has received an external radiation dose significantly greater or less than that indicated by his film badge or other dosemeter, an investigation must be made[2] and, where found to be the case, a special entry

[1]For addresses, see Introduction, last paragraph.

[2]Advice on this can be obtained, if necessary, as in paragraph 5.3.8.

approved by the Controlling Authority must be made in the radiation dose record kept in accordance with paragraph 5.4.1.

5.3.10 Similarly, where there is reason to think that any person (whether designated or not):

(i) has received an external radiation dose in excess of the maximum levels permitted for him as in Appendix 1; or

(ii) has contaminated any part of his body to a level exceeding ten times the permitted level shown in Appendix 2 and such contamination has persisted for more than three days; or

(iii) has ingested, inhaled or otherwise absorbed a significant amount of any radioactive substance,

an investigation must be made[1] and, where found to be necessary, a special entry approved by the Controlling Authority must be made in the radiation dose record kept in accordance with paragraph 5.4.1; in the case of a person who has not been designated a radiation dose record must be specially created for this purpose. See also paragraphs 6.2.3.1 and 11.3.7–11.4.3 for other action which may be necessary.

5.4 Records of personal radiation doses

5.4.1 A separate radiation dose record must be maintained for each designated person. It should show any dose received as a result of previous work with ionising radiations whether in the establishment or elsewhere (see paragraph 5.4.4) and the doses received in each calendar quarter [2] together with the cumulative dose. When it is possible to estimate the dose received from radionuclides in the body this should also be noted. A specimen form of radiation dose record[3] is available on sale from Her Majesty's Stationery Office.

5.4.2 Where a designated person is working with ionising radiations for more than one Controlling Authority, arrangements must be made for one or other of the Authorities to maintain a complete radiation dose record for that person.

5.4.3 The radiation dose record provides a continuous check on the extent of the radiation doses received and acts as a useful pointer to the efficacy of the safety measures in force. It must be available for inspection by the Medical Adviser (see definition, page 40), the Radiological Safety Officer and the individual concerned.

5.4.4 A summary of the radiation dose record (known as a 'transfer record') must be handed to each designated person (or other person

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[1]Advice on this can be obtained, if necessary, as in paragraph 5.3.8.

[2]A calendar quarter has been suggested instead of 13 consecutive weeks as being more convenient but if doses are being accumulated at grossly irregular rates, the 13 week period should be used and cumulative doses calculated more frequently, e.g., weekly.

[3]Radiation Dose Record, form F.2065 (in Northern Ireland, form N.I.2065).

for whom one has been prepared as in paragraph 5.3.10) when he finally leaves the establishment so that he can produce it on taking up work involving exposure to ionising radiations elsewhere. A specimen form of transfer record[1] is available on sale from Her Majesty's Stationery Office.

5.4.5 The Controlling Authority should make appropriate enquiries to ascertain whether a designated person has worked elsewhere with ionising radiations and, if so, must if possible obtain a transfer record for him.

5.4.6 The radiation dose records and the transfer records relating to previous exposure must be retained by the Controlling Authority for a period of 30 years after the last entry.

5.4.7 A separate record (retained for two years) should be kept of cases of contamination of skin, hair and clothing which cannot be reduced by first-aid measures to a level below that given in Appendix 2. The record should indicate the cause of the contamination, the action taken to deal with it and the length of time during which the excess contamination lasted.

5.5 Monitoring instruments and facilities

5.5.1 The Controlling Authority must make available efficient monitoring instruments of types suitable for environmental surveys and assessment of contamination. Where possible the user should be able to make a quick and simple check of the instrument's performance.

5.5.2 The Controlling Authority must ensure that the instruments are tested and calibrated by a suitably qualified person when they are first taken into use and that they are re-tested and re-calibrated at least annually. The instruments must be properly maintained; after the repair of any defect that would affect their accuracy, they must be re-tested. Records should be maintained of the dates and results of all tests and kept for two years after the last entry.

5.5.3 Films and film holders must be provided for personal monitoring (see paragraph 5.3.1).

5.5.4 Arrangements must be made for the films to be examined at appropriate intervals by the Radiological Protection Service[2] or in another qualified laboratory[3]. The Controlling Authority must obtain from the Director of the Radiological Protection Service or of the laboratory a certificate giving details of the radiation dose received by the wearer as indicated by the results of the examination of each film.

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[1]Transfer Record, form F.2066 (in Northern Ireland, form N.I.2066).

[2]For address, see Introduction, last paragraph.

[3]A list of suitable laboratories can be obtained from the Advisory and Information Unit of the Department of Employment and Productivity, or in Northern Ireland the Ministry of Health and Social Security (for addresses, see Introduction, last paragraph).

PART 6

MEDICAL SUPERVISION

6.1 Arrangements for medical supervision

6.1.1 The Controlling Authority must arrange for the medical supervision of persons in the establishment by a qualified Medical Adviser[1]. His functions, as set out in the following paragraphs, will include medical examination of designated persons, recommendation as to fitness for work as a designated person, advice on arrangements for first aid and control of health records and making arrangements with a local hospital for dealing with cases following an emergency (see Part 11).

6.1.2 The Controlling Authority should provide facilities for the Medical Adviser to familiarise himself with the conditions of work in the establishment and for his being able to work closely with the Radiological Safety Officer.

6.2 Medical examination of designated persons

6.2.1 *Initial examination*

6.2.1.1 No person may be engaged on work which will require him to become a designated person unless, within the previous fourteen months, he has been medically examined in the manner described in the following paragraphs and declared fit for such work.

6.2.1.2 The medical examination must include a blood examination[2] consisting of or including:

(i) in the case of red blood cells, a measurement of the packed cell volume;

(ii) in the case of white blood cells an estimate of the number present per cubic millimetre of whole blood;

(iii) a differential white cell count;

(iv) a search for abnormal cells and a description of any seen;

(v) an estimation of the haemoglobin in grammes per one hundred millilitres of whole blood;

and any special examination (including any additional blood examination) which the Medical Adviser may recommend.

6.2.1.3 This blood test is not necessary if the person has at any time undergone a suitable blood examination, an adequate report

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[1]Appendix 5 gives some examples of how medical supervision can be arranged.

[2]A list of hospitals at which this examination can be carried out is available on request from the Advisory and Information Unit of the Department of Employment and Productivity or in Northern Ireland the Ministry of Health and Social Services (for addresses, see Introduction, last paragraph).

of the results of which is available and known to the Medical Adviser.

6.2.2 *Annual re-examination*

6.2.2.1 Every designated person should be re-examined annually to check continued fitness for such work, unless it is clear from personal monitoring that he is receiving no more than three-tenths of the annual maximum permissible doses set out in Appendix 1, Table I. (For the purpose of whole body doses, the MPD is to be taken as 5 rems.) The nature of the re-examination will be determined by the Medical Adviser, and will not necessarily include a haemotological examination.

6.2.3 *Special re-examination*

6.2.3.1 If the Medical Adviser so recommends, e.g. in the event of an occurrence as in paragraph 5.3.9 or paragraph 5.3.10, arrangements must be made for the persons concerned to be medically examined without delay.

6.3 Suspension from work as a designated person

6.3.1 When the Medical Adviser so recommends in writing, the Controlling Authority must ensure that a person is suspended from his work as a designated person and is not allowed to resume such work without the written approval of the Medical Adviser. He may however continue to work with ionising radiations with the consent of the Medical Adviser provided he does not receive more than three-tenths of the annual maximum permissible doses set out in Appendix 1, Table I. (For the purpose of whole body doses, the MPD is to be taken as 5 rems.)

6.4 Advice on provision of first aid

6.4.1 In addition to arranging for medical examination of persons within the establishment the Medical Adviser should advise on the provision of suitable first-aid facilities and on the training of persons in charge of first aid.

6.5 Records of examinations

6.5.1 To enable the health of designated persons to be kept under progressive review the Controlling Authority must arrange for records to be kept of all medical examinations, including blood examinations and other special examinations. These records must be retained for 30 years after the last entry.

6.5.2 The health records should contain:

(i) name, address, date of birth and occupation of person concerned;

(ii) dates and results of medical examinations;

(iii) dates and results of blood examinations and any other special

investigations, together with the name and address of the laboratory or other person making the examination or investigation;

(iv) recommendations of fitness for employment as a designated person; and

(v) certificates of suspension, if any, from work as a designated person on medical grounds.

6.5.3 Detailed records of medical examinations must be safeguarded as confidential documents and must be under the control of the Medical Adviser.

PART 7

SPECIAL PRECAUTIONS: X-RAY INSTALLATIONS AND OTHER APPARATUS EMITTING IONISING RADIATIONS

7.1 Introduction

7.1.1 This Part of the Code is concerned with special precautions to be observed in the use of the following apparatus and similar types:

(i) X-ray equipment, e.g. for radiography, fluoroscopy, crystallography, microanalysis, etc.;

(ii) other apparatus in which electrons are accelerated by voltages exceeding 5 kilovolts and which emit ionising radiations, e.g. electron microscopes, cathode-ray tubes, magnetrons, klystrons, vacuum-tube rectifiers and gas-filled tubes (such as thyratrons and gas-filled rectifiers); and

(iii) particle accelerators.

This list is not intended to be exhaustive, but rather to give examples of the sort of apparatus in question.

7.1.2 This Part of the Code is not concerned with apparatus in which a sealed radioactive substance is used as a source of ionising radiations, which is the subject of Part 8.

7.1.3 The following paragraphs deal first with general precautions common to all apparatus with which this Part is concerned and subsequently with additional precautions to be observed in the use of particular types of such apparatus.

7.2 Precautions common to apparatus of all types

7.2.1 The precautions set out in this Part of the Code are additional to those described in Part 4 (and in particular sub-section 4.3.2) which apply to any source of external radiation.

7.2.2 The installation of any apparatus designed specifically for the purpose of producing ionising radiations should be subject to prior approval of the specification by the Radiological Safety Officer. The completed installation should be checked against that specification.

7.2.3 As far as practicable, the apparatus itself should be so designed as to be adequately shielded whilst in use; if this is not practicable the best alternative is to use the apparatus only within an enclosure such that all persons are adequately shielded against all

radiations, including scattered radiation as well as the useful beam. Where this is not reasonably practicable, the area in which there is liable to be a radiation hazard must be identified by warning notices and clearly marked, if possible by physical barriers.

7.2.4 When the apparatus is used inside an enclosure or marked area the control panel should be outside the enclosure or area.

7.2.5 All persons should be excluded from the enclosure or marked area as long as the apparatus is emitting ionising radiations, except where this is unavoidable because of the requirements of the work.

7.2.6 Where it is essential for any person to enter or remain in the enclosure or area while the apparatus is emitting significant levels of ionising radiation, the shielding and operating conditions should be such that the radiation doses received by such persons are not in excess of those laid down in Appendix 1[1].

7.2.7 Arrangements must be made to ensure that persons within an enclosure can shut off quickly all sources of ionising radiation from within the enclosure, can leave the enclosure without delay and can, if necessary, obtain immediate help from outside the enclosure.

7.2.8 When the apparatus is about to be energised adequate warning should be given to all persons in the vicinity. This should be done by warning lights or audible signals, or both. One or other warning signal, or both, should continue to operate while the apparatus is energised. Where practicable, these warnings should operate automatically and be so designed as to 'fail to safety'.

7.2.9 With certain types of apparatus precautions must be taken against radiations which continue to be emitted after the energising current has been switched off.

7.2.10 Whenever apparatus is altered, modified or moved in such a way that the shielding is or may be reduced, the apparatus should be monitored before further use.

7.3 X-ray equipment

7.3.1 In addition to the general precautions set out above, the following measures must be observed in using X-ray equipment.

7.3.2 All X-ray tubes should be mounted in a protective housing such that the leakage radiation is kept as low as is reasonably practicable and at the maximum rated voltage and current does not, except as mentioned in the following sentence, exceed one rad/hour at a distance of one metre from the target. Where, exceptionally, it is impracticable to shield to this level, because of the very high voltage or current ratings, access to the equipment must be so restricted as to ensure adequare shielding.

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[1]There are British Standards (BS 2606 and BS 3783) for lead rubber gloves/aprons respectively.

7.3.3 Before the equipment is used the following arrangements must be made:

(i) the useful beam must be directed away from adjacent occupied areas;

(ii) the useful beam must be limited in size by the use of collimating and shielding devices; and

(iii) the radiation output must be kept as low as is consistent with the nature of the work to be performed by adjustment of the voltage, current and length of time for which the equipment is energised.

7.3.4 No person, other than the subject of radiological examination, may place any part of his body within the useful beam. If it is necessary to move materials during irradiation, this must be done by remote control.

7.4 X-ray fluoroscopy

7.4.1 In addition to the relevant precautions set out above for X-ray equipment in general, the following precautions should be observed in fluoroscopy.

7.4.2 Fluoroscopes should be installed in a cabinet providing adequate shielding and should be so designed that the X-ray tube cannot be energised while any part of the cabinet is open.

7.4.3 The design should ensure that the useful beam cannot fall outside the screen. Where reasonably practicable, the screen should be viewed indirectly, i.e. by the use of inclined mirrors or by image intensification. Otherwise it may be viewed directly through a window giving adequate shielding (see also paragraphs 4.3.2.4 and 7.2.10).

7.4.4 Hand fluoroscopes must not be used because of the risk of accidental exposure to the useful beam and to scattered radiation.

7.4.5 Full operating conditions for fluoroscopes must be set out in local rules. These must provide the greatest practicable degree of protection to the operator and particular attention should be given to the danger from scattered or reflected radiation.

7.4.6 The operator should accustom his eyes to darkness for a period of not less than ten minutes before making a fluoroscopic examination, in order to reduce the time during which the equipment needs to be energised and so reduce the dose received.

7.5 X-ray crystallography

7.5.1 Particular care is needed in the use of X-ray crystallographic equipment because the very high dose rates near the target can cause injury in a very short time. The following precautions should therefore be observed in addition to those for X-ray equipment in general set out in section 7.3.

7.5.2 It is particularly important to ensure that the fingers and other parts of the body cannot be inserted in the useful beam. Each port or aperture of the X-ray tube housing should be provided with an automatic beam shutter and so arranged that it can only be opened when the collimating system is in place.

7.5.3 Where an X-ray diffraction camera or a split collimating system is used, the useful beam passing between the X-ray tube aperture and the camera or collimating system should be completely enclosed so as to provide adequate shielding.

7.6 Particle accelerators

7.6.1 In this section are included such machines as Van de Graaff electrostatic generators, neutron generators, linear accelerators, cyclotrons, betatrons, synchro-cyclotrons, synchrotrons and proton synchrotrons.

7.6.2 As these machines give rise to very specialised and difficult safety problems, the Controlling Authority must have available staff competent to assess the hazards involved and advise on the protective measures to be taken. These must include the precautions common to all apparatus with which this Part of the Code is concerned (see section 7.2) and the special measures set out below.

7.6.3 These machines must always be adequately shielded or installed in a special enclosure, as described in paragraphs 7.2.3 and 7.2.4. Effective interlocks must be provided so that the apparatus has to be switched off before any door of the enclosure is opened and cannot be switched on so long as the door is open. There are advantages in arranging that any person who may have to enter the enclosure carries the switch key.

7.6.4 It should be borne in mind that the radiations in the neighbourhood of this type of machine are extremely complex. In many circumstances, small changes in operating conditions may produce disproportionately large changes in radiation hazard and the nature of the radiation beam will change on absorption (e.g. electron diffusion from X-ray traps). The Radiological Safety Officer should therefore ensure that the operating characteristics are notified to all persons concerned and significant changes notified to the person in charge of the machine.

7.6.5 It will be essential to monitor neighbouring areas that are likely to be occupied during the operation of these machines in order that any unexpected distribution of radiation may be detected.

7.6.6 The shielding requirements for this type of machine will depend on the nature and direction not only of the useful beam, but also of the scattered and secondary radiations.

7.6.7 Shielding design should allow sufficient space around the

machine for the modifications of research programmes, the maintenance of electronic equipment, the detection of vacuum leakage and the installation of targets.

7.6.8 Additional precautions must be taken when necessary against the considerable amounts of induced radioactivity that may be present in the air and on parts of the machine, shielding structural materials or targets. The hazard from induced radioactivity in the air may be removed by the provision of effective ventilation, e.g. by mechanical exhaust draught to the open air (see paragraph 9.3.4). In the case of other induced radioactivity being detected, specialist advice should be obtained before any person is permitted to re-enter the area.

7.6.9 If any person has to enter an area in which the permitted levels of atmospheric contamination by radioactive gas or aerosols are likely to be exceeded, he must wear protective clothing and breathing apparatus appropriate to the hazards present. In some cases, regular monitoring of the atmosphere may be necessary.

7.6.10 It is particularly important to ensure as far as possible by monitoring and control of exposure that no person entering the enclosure in which such a machine is installed can receive more than his maximum permissible dose.

7.6.11 These machines may present electrical, mechanical[1] and chemical hazards (e.g. from ozone and oxides of nitrogen) and special risks of fire and explosion (e.g. which may arise in the cooling system forming part of the high vacuum equipment).

[1]See National Bureau of Standards Handbook No. 63 'Protection against Neutron Radiation up to Thirty Million Electron Volts'.

PART 8

SPECIAL PRECAUTIONS: SEALED SOURCES

8.1 Construction and care

8.1.1 In addition to the general safety precautions set out in Part 4, special precautions are necessary in the use of radioactive substances in the form of sealed sources and are in many respects similar to those required for apparatus producing or emitting ionising radiations (see especially paragraphs 7.2.3–7.2.10). Certain other special precautions are also necessary and these are outlined in the following paragraphs.

8.1.2 The immediate container or the bonding of every sealed source must be of adequate mechanical strength for the conditions of use and free from any defect which might allow the release of radioactive substances or cause damage to the source.

8.1.3 Except where the nature of the source renders this impracticable, a distinguishing number or other identifying mark must be on or attached to every sealed source.

8.1.4 All protective receptacles used to contain individual sealed sources should be marked with distinctive markings[1] so that they can easily be identified. Information regarding the nature and activity of the source should also be marked on the receptacle.

8.1.5 When not in use every sealed source must be securely stored (see Part 12).

8.1.6 If a sealed source is broken or lost the Responsible Person must be informed immediately.

8.1.7 A record should be kept of every sealed source (except those exempt from the provisions of the Code by paragraph 1.2.2) in the establishment giving:

(i) its distinguishing number or other identifying mark;

(ii) the date of receipt in the establishment;

(iii) the nature of the radioactive substance in it and, where practicable, the activity (in curies); and

(iv) the date and manner of its disposal when it leaves the establishment.

This record should be kept for two years after disposal of the source.

8.2 Inspection for leakage

8.2.1 Every sealed source must be tested for leakage or surface contamination by a qualified expert at least once every two years and

[1]There is a British Standard specification for this—BS 3510: 1968.

immediately if it is suspected that any radioactive substance may be leaking from it.

8.2.2 If a source is leaking the Responsible Person must be notified immediately. The source must be placed in a leakproof container and the area in which it has been used and any person who has used it must be checked for contamination. The possibility that some radioactive substance may have become airborne must be taken into consideration and if necessary emergency procedures must be put into operation (see Part 11). In no circumstances must the source be used again until any necessary repairs have been effected.

8.2.3 A record, to be kept for three years after the last entry in it, should be made of every test undertaken.

8.3 Shielding

8.3.1 Wherever practicable sealed sources should be shielded according to the general principles set out in paragraph 4.3.2.3.

8.3.2 Where distance is used for shielding, particularly for high activity sources, provision must be made for remote control methods for exposing the source and returning it to its protective container.

8.3.3 Where a sealed source is being used as a static eliminator, or as a thickness, density or level gauge or similar device, it must, as well as being adequately shielded as required by paragraph 7.2.3, also be provided with a cover plate or shutter to enable the useful beam to be attenuated so far as is reasonably practicable during any intervals when it is not performing any useful function. Arrangements should also be made to protect the unshielded portion of such sealed sources against accidental damage.

8.3.4 Where high activity high energy beta sources (e.g. strontium 90) are used, appropriate shielding against the associated bremsstrahlung should be provided.

8.3.5 In the case of a neutron source, shielding must take account of both neutrons and any gamma rays.

8.3.6 Where very large sources of several hundred curies are used the design of the plant becomes of the utmost importance and specialist advice should be obtained (e.g. from the Radiological Protection Service or the Advisory and Information Unit[1]).

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[1]For addresses, see Introduction, last paragraph.

PART 9

SPECIAL PRECAUTIONS: UNSEALED RADIOACTIVE SUBSTANCES

9.1 Introduction

9.1.1 In addition to the general safety precautions set out in Part 4, special precautions against the hazards of internal as well as external radiation are required when working with unsealed radioactive substances. The degree of hazard and therefore the extent of the precautions to be taken will vary according to the total activity, the radiotoxicity, the chemical toxicity and other chemical and physical properties of the substances as well as the nature of the operations[1].

9.2 Classification of controlled areas

9.2.1 Special areas to be known as controlled areas (see definition, page 39) must be set aside for work with unsealed radioactive substances. Such areas should be clearly marked.

9.2.2 Each controlled area, with the exception mentioned in paragraph 9.2.3, must be classified by the Controlling Authority in consultation with the Radiological Safety Officer in accordance with the definitions. The classification of these areas is in line with the principle of maximum containment set out in paragraphs 4.3.3.1 and 4.3.3.3 and takes account of the need to limit the dose rate where there is a possible external radiation risk.

9.2.3 With the prior approval of the Radiological Safety Officer, work with very small amounts of certain radioactive tracers (other than alpha-emitters) may be carried out in areas not defined as controlled areas. In such circumstances the normal procedures for any mildly toxic substances should be observed.

9.2.4 Warning notices must be displayed at or near the boundaries of total enclosures and active and radiation areas. Where it becomes necessary to classify an area as an active or radiation area because of tracer work, the notices must be displayed while the work is in progress and so long afterwards as the contamination exceeds the lowest levels specified in Appendix 2.

9.2.5 The approval of the Radiological Safety Officer must be obtained before alterations are made to the classification of a controlled area.

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[1]It is worth noting that under certain circumstances unsealed sources may become bonded with other materials in such a manner that there is no significant contamination hazard; it will then be appropriate, under rigidly defined conditions, to treat them as if they were sealed sources and to apply the relevant precautions.

9.3 Design and equipment of controlled areas

9.3.1 The design and equipment of controlled areas should take account of the degree of hazard involved in the work. Work with highly active materials requires special buildings conforming to the general principles set out in Part 3 of this Code. Where material of only low levels of activity is used, few modifications to a normal chemical laboratory will be needed.

9.3.2 In areas in which materials of high activity are used it is important that all surfaces should be of proper construction and kept in good repair. Floors, walls, ceilings and furniture should have a smooth impervious surface so that they can easily be cleaned, and any gaps in floor coverings should be effectively sealed.

9.3.3 The design of the laboratory should eliminate as far as possible ledges and inaccessible places liable to collect dust. Only essential furniture and fittings should be allowed in the laboratory and should be designed so as to limit contamination as far as possible.

9.3.4 An appropriate degree of containment must be provided. Ideally, all operations with unsealed radioactive substances should be carried out in a total enclosure, e.g. in a glove box. This must be done where dangerous substances, such as plutonium, are used except where very small amounts are involved. Where less toxic substances are used, it may be sufficient to provide a partial enclosure, e.g. a fume cupboard. Both total enclosures and partial enclosures must have an efficient mechanical exhaust draught and, except in the case of very small amounts, the effluent air should discharge through filters which will trap radioactive material.

9.3.5 The details covering the type of construction of equipment, the lay-out of apparatus, etc. would obviously vary from area to area and will depend largely on the type of experimental work being done. The advice of the Radiological Safety Officer should be sought in all cases before the lay-out of a laboratory is planned or altered.

9.4 Personal protective equipment

9.4.1 Personal protective equipment (see definition, page 40) has the dual function of protecting the wearer and preventing the spread of contamination outside the working area. It should be provided for all persons entering controlled areas where there is a risk of contamination. It should not be worn outside controlled areas except in an emergency (see Part 11).

9.4.2 Suitable accommodation must be provided for changing and for storage of protective clothing. This should preferably be separate from the ordinary cloak-room and should be cleaned at sufficiently frequent intervals to avoid accumulation of contamination. When

associated with an active area, the change-room should be so situated as to form the normal route to and from the area.

9.4.3 Protective clothing should be of such a type as to prevent contamination of the skin, hair or personal clothing in excess of the permitted levels shown in Appendix 2.

9.4.4 Where it is needed, suitable breathing apparatus must be provided to prevent the inhalation or ingestion of significant amounts of radioactive materials. It must be regularly examined, cleaned and tested by a Responsible Person.

9.4.5 Arrangements should be made for protective clothing and breathing apparatus to be monitored at sufficiently frequent intervals to ensure early detection of contamination in excess of the levels shown in Appendix 2. Clothing contaminated in excess of the appropriate level must be placed in a special container to prevent the spread of contamination. If the contamination exceeds the higher levels in Appendix 2 the clothing should be specially treated; if the contamination is below the higher levels but in excess of the lower levels in Appendix 2, the clothing may be sent to a public laundry in specially labelled containers. If it is not possible to reduce the contamination below the lower levels by such means, the clothing should be treated as radioactive waste (see definition, page 40).

9.5 Methods of work in controlled areas

9.5.1 Methods of work with unsealed radioactive substances must be agreed to by the Radiological Safety Officer before being introduced. They must be in accordance with the basic principles of protection set out in Part 4 of this Code, special attention being paid to the measures of protection against internal radiation set out in section 4.3.3. In addition, the following precautions must be observed.

9.5.2 Where fissile materials are handled, attention must be paid to the criticality hazard (see Part 10).

9.5.3 Particular care should be taken that apparatus in which unsealed radioactive substances are used is as safe as is practicable. The types of containers used, for example, should be chosen to minimise the risk of accidental spills or breakages.

9.5.4 Apparatus, equipment or containers used in connection with unsealed radioactive substances should not be used for any other purpose, without first being checked for contamination and, if necessary, decontaminated.

9.5.5 The mouth must not be allowed to come into contact with any apparatus. Pipettes, for example, must be operated by other means.

9.5.6 Appropriate precautions should be taken to avoid excessive pressures arising inside vessels containing unsealed radioactive substances.

9.5.7 Benches and tables should be kept free from materials or articles not required for current operations.

9.5.8 When not in use, unsealed radioactive substances must be kept in appropriate containers clearly marked[1] so that they may be readily identified.

9.5.9 When not needed in the laboratory, radioactive substances should be stored in accordance with the principles laid down in Part 12.

9.6 Stock records

9.6.1 Records should be kept of all stocks of unsealed radioactive substances to which the Code applies (see paragraph 1.2.2). The records should be kept up to date and should where appropriate indicate:

(i) the nature and activity (in curies) of the substance;
(ii) the date of receipt;
(iii) the place of storage or use; and
(iv) the date and manner of disposal.

These records should be kept for two years after the date of the last entry.

9.6.2 If the accounting system for unsealed radioactive substances gives reason for believing that any significant amount has been lost or mislaid, the Radiological Safety Officer must be notified without delay.

9.7 Control of contamination

9.7.1 Wherever unsealed radioactive substances are used, there is a risk of spreading contamination in the normal course of operations as well as through spills or breakages. Any such contamination can be transferred to the skin where it not only presents a source of radiation near the body, but also may, by transfer to the mouth, lead in turn to the intake of radioactive substances into the body.

9.7.2 Surveys to check the levels of contamination in the laboratory must be made sufficiently frequently to detect any excess contamination without undue delay. Procedures will depend on the type of controlled area, the equipment used and the sources of potential contamination. The advice of the Radiological Safety Officer should be sought in all cases.

9.7.3 Maximum permissible levels of contamination for laboratories, stores, apparatus and equipment, as well as for personal pro-

[1]There is a British Standard specification for this—BS 3510: 1968.

tective equipment, personal clothing and parts of the body are set out in Appendix 2, which also gives guidance on the methods of assessment to be used in various circumstances.

9.7.4 Where excessive contamination is revealed by the survey it must be reduced. This can be done by the methods described in Appendix 6, or the contaminated article can be contained until radioactive decay has rendered it safe. Alternatively, e.g. in the case of contamination by the long-lived radionuclides, the contaminated article may be treated as radioactive waste (see Part 14).

9.7.5 Exceptionally, equipment which cannot be decontaminated may continue to be used in a total enclosure or fume cupboard subject to any special precautions made necessary by the nature of the contaminated equipment.

9.8 Cessation of use of controlled areas

9.8.1 When an area ceases to be used as a controlled area, the following procedure must be adopted:

(i) the Controlling Authority must be notified of the change of classification;

(ii) pending decontamination, only persons authorised by the Radiological Safety Officer may be allowed to enter the area; and

(iii) the area must be decontaminated, under the supervision of the Radiological Safety Officer, either by treatment to reduce contamination to a level permitted for a non-classified area (see Appendix 2) or by isolation and marking of the area until such time as the radioactive substance has decayed below the permitted level.

9.9 Cleaning of controlled areas

9.9.1 The routine cleaning of controlled areas must be done sufficiently frequently so that the level of residual contamination in them does not remain above the level given in Appendix 2. Methods must be used which avoid the spread of contamination and the dispersal of unsealed radioactive substances either within the area or outside it. It must be borne in mind that liquids that have been used in the cleaning of controlled areas may become radioactive and so require treatment as radioactive waste (see Part 14).

9.9.2 Mops, cloths, scrubbing brushes and any other articles used for cleaning controlled areas should be clearly marked and must not be used for any other purpose.

9.9.3 When not in use, cleaning materials should be secured in a store reserved for the purpose within the area.

9.9.4 The cleaning materials should be monitored at intervals and, where necessary, decontaminated or disposed of as radioactive waste (see Part 14).

9.10 Personal hygiene

9.10.1 In order to prevent ingestion, inhalation or other absorption of radioactive substances special attention must be paid to personal hygiene.

9.10.2 Eating and drinking, smoking, taking snuff and the application of cosmetics must not take place in active areas.

9.10.3 Before any person working in an active area leaves the area for any purpose whatsoever (e.g. to go to the lavatory, to eat, or at the end of the day's work) he should remove his protective clothing and gloves (if worn) and wash. After washing he should check for contamination as required by paragraph 5.3.7.

9.10.4 Ordinary handkerchiefs must not be used by persons working in active areas. Paper handkerchiefs must be provided and used and, after use, disposed of as radioactive waste (see Part 14).

9.10.5 Cuts or other breaks in the skin must be covered before any work with unsealed radioactive substances is undertaken. The covering should be approved by the Responsible Person. Particular care must be taken in the case of a break in the skin on the hand or forearm.

9.10.6 If any cut or break in the skin is incurred while at work with unsealed radioactive substances, the wound should immediately be irrigated with water or saline solution, care being taken to limit any spread of contamination on the skin. Both the area of the wound and the object which caused it should be monitored. The Radiological Safety Officer and the Medical Adviser should be informed as soon as possible.

9.11 Washing facilities

9.11.1 Easily accessible washing facilities must be provided for the use of all persons engaged on work with radioactive substances. The facilities must include clean running hot and cold or warm water, soap, nail brushes and a sufficient supply of clean towels; the advantages of using paper towels should be considered. Where highly active substances are used, foot- or arm-operated taps are very desirable. Wash basins, taps, plugs and nail brushes should be monitored at appropriate intervals.

PART 10

SPECIAL PRECAUTIONS: NUCLEAR REACTORS AND CRITICALITY EXPERIMENTS

10.1 Nuclear Installations Act 1965

10.1.1 Under the Nuclear Installations Act 1965, a licence[1] granted by the Minister of Power (in Scotland the Secretary of State and in Northern Ireland the Minister of Commerce) is required before work can be begun on nuclear reactors (including zero energy reactors), critical experiments, sub-critical experiments using enriched uranium and certain other installations where enriched uranium and irradiated nuclear fuel are handled or stored. The conditions of the licence require inspection and testing during construction and the submission of detailed operating procedures in the interests of safety, taking account of the provisions of this Code. At the earliest possible stage in planning any work for which a licence under the Act may be required, the Controlling Authority should consult the Inspectorate of Nuclear Installations at the Ministry of Power. (The Inspectorate also advises the Secretary of State for Scotland.)

[1]The licensing provisions of the Nuclear Installations Act 1965 do not extend to the U.K.A.E.A. or to Government Departments.

PART 11

EMERGENCY PROCEDURE

11.1 Introduction

11.1.1 In this Part emergency means any event which has caused or is capable of causing an unplanned excessive exposure to ionising radiations or radioactive substances.

11.1.2 The local rules (see paragraph 2.3.1) must include provision for:

(i) preparation for dealing with an emergency;

(ii) action to be taken during an emergency; and

(iii) action to be taken when the immediate emergency is over, in accordance with the principles set out in the following paragraphs.

11.2 Preparations for dealing with an emergency

11.2.1 Instructions on the action to be taken in an emergency must be drawn up to cover all the points dealt with in section 11.3 and, in particular, the pre-determined plan for emergency exposure (see paragraph 11.3.3). They must be seen and read by all persons who may be concerned. The instructions must be reviewed periodically and revised as necessary and practice exercises should be held to test the effectiveness of the arrangements and to ensure that all persons concerned know what action to take in an emergency.

11.2.2 Care should be taken to ensure that there are adequate means of escape in the event of a fire or other emergency, but the local rules should make clear the circumstances in which emergency exits are to be used. Prior contact should be made with the Chief Fire Officer of the County or County Borough (in Scotland, the Firemaster) to afford firemen the opportunity of visiting the establishment to obtain information about the layout of the premises and about warning measures, signals, etc. The Chief Fire Officer or Firemaster will also advise about first-aid and fire-fighting equipment suitable for the risk in the area concerned.

11.2.3 Notices must be posted in or near every controlled area showing:

(i) the system of warning persons in the vicinity;

(ii) the system of contacting the Radiological Safety Officer or other responsible person to whom the emergency should be notified immediately;

(iii) arrangements for calling the fire brigade and medical services; and

(iv) the location and method of use of emergency equipment including fire fighting equipment.

11.2.4 Arrangements must be made for the notification of the appropriate authorities by the Radiological Safety Officer or other responsible person in the event of an emergency. These may include the fire brigade, ambulance service, the Medical Adviser and, in the event of an area outside the establishment being affected, the police and the Medical Officer of Health.

11.2.5 An up-to-date list of all places in the establishment where there are radiation hazards, showing in particular the exact location of, and means of access to, all rooms likely to contain radioactive materials, should be kept where it is readily available in the event of fire or other emergency. The Chief Fire Officer or Firemaster should be given a copy of this list.

11.2.6 The following equipment should be kept available for use in an emergency:

(i) personal protective equipment, including protective clothing, gloves, footwear and breathing apparatus (see paragraphs 4.3.3.6 and 4.3.3.7);
(ii) absorbent material for wiping up spills;
(iii) cleaning equipment reserved for the purpose of cleaning in the active area;
(iv) barriers or means for roping off affected areas;
(v) appropriate warning notices;
(vi) receptacles for contaminated articles together with means of shielding them;
(vii) portable monitoring equipment including personal monitoring devices;
(viii) non-porous floor covering, e.g. Kraft paper (to be used only after any liquid spill has been cleared up); and
(ix) fire-fighting equipment.

11.3 Action during an emergency

11.3.1 The best course of action in an emergency depends very much on local circumstances and the nature of the emergency. Local rules should incorporate the following requirements in a form suited to the circumstances and sort of emergency likely to arise.

11.3.2 In some circumstances the most urgent need would be to summon the fire services or medical assistance; otherwise the normal priorities would be:

(i) to warn persons in the immediate vicinity of the accident;
(ii) to notify the Radiological Safety Officer or some other specified responsible person who can issue further warnings and summon further aid as required; and
(iii) to attempt to deal with the emergency or render first aid or to evacuate the area as dictated by circumstances.

11.3.3 Where measures to deal with an emergency involve the risk of exposure to abnormally high radiation doses, they should be carried out in accordance with a pre-determined plan drawn up on the basis that no individual will, as the result of such exposure, receive a whole body dose in excess of 12 rems. (See Appendix 1, Table I, Note 5.)

11.3.4 Where the person in charge decides that it is not necessary immediately to evacuate the area (see paragraph 11.3.5), attempts should normally be made in the case of solids and liquids to limit the dispersal of the radioactive substance or in the case of radioactive gases or vapour to disperse them as quickly as possible.

11.3.5 In the case of serious spills, e.g. those believed to involve more than one hundred microcuries of a Class I radionuclide, ten millicuries of a Class II radionuclide, one curie of a Class III radionuclide or one hundred curies of a Class IV radionuclide or, in the case of gaseous radioactive substances, one tenth of those amounts (see Appendix 3 for classification tables of radionuclides), immediate consideration should be given by the person in charge to the prompt evacuation of the laboratory.

11.3.6 If the evacuation of the laboratory is required, the following action should be taken where time permits:

(i) in the case of an emergency arising from an apparatus producing ionising radiations, the apparatus should be switched off at once;

(ii) where sealed sources are involved they should, if possible, be returned to their containers or provided with a temporary shielding; and

(iii) except where there is radioactive gas to be dispersed, all laboratory services except lighting, but including mechanical ventilation, should be switched off, and all doors and windows should be closed.

If radioactive gas is to be dispersed, mechanical ventilation and lighting should be switched on, and, with discretion, doors and windows should be left open.

11.3.7 Contaminated persons should not proceed far into the inactive area until they have been monitored and, if necessary, decontaminated. The treatment of serious injuries must, however, take precedence over decontamination and containment of contamination.

11.3.8 Providing the wearer is not injured, all clothing contaminated in an emergency should be removed immediately and left in or near the affected area. Contaminated parts of the body should be washed thoroughly until either monitoring shows that contamination will not be significantly reduced by this method or there is danger of

roughening or breaking of the skin which would allow contamination to enter the blood stream. If contamination still exceeds the maximum permissible level, the advice of the Medical Adviser and of the Radiological Safety Officer should be sought. In the meantime, any contaminated wound however trivial should be irrigated with water or saline solution, care being taken to limit any spread of contamination to other parts of the skin.

11.4 Action when the immediate emergency is over

11.4.1 The medical surveillance of injured persons must take account of any residual contamination.

11.4.2 If it is suspected that any person has acquired a significant body burden of radionuclides action must be taken as in paragraph 5.3.10 and the person must be placed under medical surveillance.

11.4.3 Similarly, action must be taken as in paragraph 5.3.10 if it is suspected that any person has received a dose of external radiation which either:

(i) exceeds 10 rems in the case of a dose to parts of the body other than the hands, forearms, feet and ankles from all or any one or more of the following – X-rays, gamma rays and neutrons; or

(ii) in any other case exceeds the doses permitted as in Appendix 1.

11.4.4 Appropriate action must be taken to contain and clear up the contamination of the working area according to the circumstances. Some methods of decontamination are given in Appendix 6.

11.4.5 Any apparatus should be examined for defects before it is re-energised and working positions should be monitored.

11.4.6 Entry to the affected area should be restricted to properly trained and equipped persons until declared safe by the Responsible Person for the resumption of normal work.

11.4.7 It is important to estimate the dose received by each person and which part of the body is involved; the Controlling Authority must arrange for any special medical examination of the affected persons which the Medical Adviser recommends.

11.4.8 The Radiological Safety Officer must carry out a full investigation of the emergency and keep a written record of his investigation, and must make a report to the Controlling Authority with recommendations for avoiding a recurrence.

PART 12

STORAGE OF SEALED SOURCES OF IONISING RADIATIONS AND UNSEALED RADIOACTIVE SUBSTANCES

12.1 When not in use, sealed sources and unsealed radioactive substances should be securely stored. Stores should be in the charge of a Responsible Person and radioactive substances should only be moved into and out of the place of storage with his authority.

12.2 Places of storage must be sited and designed so as to ensure that both during storage, and in the course of transfer to and from store, sources do not give rise to excessive exposure of any person. The protection provided must be such that no person receives in this way more than a small fraction of his permissible dose.

12.3 When radioactive gas, dust or vapour is liable to be present, the place of storage should be efficiently ventilated to the outside air by mechanical means.

12.4 The place of storage should be chosen and the store constructed so as to minimise the risk from fire or flooding. Advice on these matters may be sought from the Chief Fire Officer or Firemaster.

12.5 A suitable warning notice must be displayed where it can easily be read outside the place of storage (see also paragraph 9.5.8) except where the levels of radioactivity do not warrant it.

PART 13

TRANSPORT

13.1 The principles laid down in this Code should be applied with special care in the transport of radioactive substances within the establishment[1].

13.2 The carriage of radioactive substances outside the establishment may be governed by Regulations, Codes of Practice or conditions of acceptance according to the means of transport. Advice should be obtained in the case of transport by:

(i) road[2], sea or air, from the Ministry of Transport, St. Christopher House, Southwark Street, London, S.E.1;

(ii) rail[2], from British Railways;

(iii) ports, from the appropriate Port Authority; and

(iv) post, from the General Post Office. and

[1]There is a British Standard BS 3895 Part I 'Methods for the Assessment of Packaging for the Transport of Radioactive Materials'.

[2]In the case of transport by road or rail within Northern Ireland advice should be obtained from the Ministry of Home Affairs, Stormont, Belfast, 4.

PART 14

DISPOSAL OF RADIOACTIVE WASTE

14.1 The Controlling Authority must arrange for the safe disposal of any radioactive waste that may arise. The amount of radioactive waste should be kept to a minimum at all times.

14.2 Research establishments should consult the Ministry of Housing and Local Government, the Scottish Development Department or the Ministry of Health and Social Services for Northern Ireland (as appropriate) at an early stage about any proposed use of radioactive substances which may give rise to radioactive waste.

14.3 Under the Radioactive Substances Act 1960, all establishments[1] keeping and using radioactive materials (subject to certain exceptions) are required to register with the Minister of Housing and Local Government (or in Scotland the Secretary of State and in Northern Ireland the Minister of Health and Social Services). *They are also required to obtain authorisations from the Minister for the accumulation and disposal of radioactive waste.* It should be noted that the terms 'radioactive material' and 'radioactive waste' as defined in the Radioactive Substances Act 1960 have a wider meaning than the corresponding terms in this Code of Practice and that premises and materials which are, for example, exempted from the provisions of the Code under paragraphs 1.1.1 and 1.2.2 may still be subject to the registration and authorisation provisions of the Act unless they are exempted from these requirements by Order. An explanatory memorandum on the 1960 Act has been published for the guidance of users of radioactive materials. It includes a description of the procedure to be followed in submitting applications for registration and authorisation[2].

14.4 Guidance on the special problem of the temporary preservation of radioactive animal carcasses prior to disposal is given in Appendix 7.

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[1]Crown Establishments (other than National Health Service Hospitals) are in general exempt from the registration and authorisation requirements in the Act but similar standards of control as are imposed on other users of radioactive materials are applied to Crown Establishments by administrative means.

[2]Copies may be obtained from Her Majesty's Stationery Office or through any bookseller (price 1s. 6d.).

DEFINITIONS OF TERMS USED IN THE CODE WITH A SPECIAL MEANING

Adequate shielding

Shielding or a demarcating barrier around a source of ionising radiations such that the radiation dose rate outside the shielding or demarcating barrier, averaged over any one minute, would not exceed 0·75 millirems per hour OR, where only designated persons are affected, 2·5 millirems per hour.

Contamination

Contamination by radioactive substances on any surface, including the skin, hair and clothing of persons and any part of absorbent objects or materials.

Controlled areas

All areas included in any of the following classifications:

(i) *Total enclosures:* areas which are enclosed so as to prevent the escape of unsealed radioactive substances into any working area and from which all persons are excluded except for necessary maintenance work under conditions approved by the Radiological Safety Officer.

(ii) *Active areas:* areas, other than total enclosures and fume cupboards, in which there is, or under normal operating conditions is liable to be:

(*a*) contamination in excess of the lowest level specified in Appendix 2; or

(*b*) airborne or gaseous radioactive substances in the atmosphere to such an extent that persons employed in the area are likely to inhale, ingest or absorb a significant amount.

(iii) *Radiation areas:* any other areas in which the radiation dose rate averaged over any one minute exceeds 0·75 millirems per hour, otherwise than infrequently and transiently.

Controlling Authority

The body, person or persons ultimately responsible for the control of the establishment.

Designated person

A person designated by the Controlling Authority as in paragraphs 2.5.1–2.5.3.

Ionising radiations

Electromagnetic radiation (X- or gamma rays) or corpuscular radiations (alpha particles, beta particles, electrons, positrons, pro-

tons, neutrons or heavy particles) which are capable of producing ions directly or indirectly.

Medical Adviser

A fully registered medical practitioner who is appointed by the Controlling Authority to be responsible for the medical supervision of persons engaged in work with ionising radiations in the establishment.

Personal protective equipment

Clothes or appliances intended to be worn or used with the object of:

(i) preventing the inhalation, ingestion or other absorption into the body of radioactive substances (for example, breathing apparatus), or
(ii) preventing the contamination of the skin, hair or clothing, or
(iii) limiting exposure to ionising radiations (for example, eye shield).

Radioactive substance

Any substance which consists of or contains radionuclides, whether natural or artificial, and whose activity exceeds 0·002 of a microcurie per gramme of substance: in the case of a chain of radionuclides, consisting of a parent and daughters, the only nuclide to be taken into consideration is that having the highest activity of those present.

Note: This definition is not in the same terms as that used in the Radioactive Substances Act 1960, for the purposes of disposal of radioactive waste.

Radioactive waste

(i) Any substance or article that is required under the provisions of this Code to be treated as waste (see Part 14); and
(ii) any of the following that is contaminated or that consists of or contains any unsealed radioactive substance:
  (*a*) any scrap material, effluent or other unwanted surplus substance (for example, radioactive animal carcasses no longer required); and
  (*b*) any substance or article which is to be disposed of because it is broken, worn out or otherwise spoilt, if it is not practicable to reduce the contamination on it below the permitted levels (see Appendix 2) (for example, if the contaminant is long lived).
  (See Note to definition of radioactive substance.)

Responsible person

A person appointed by the Controlling Authority to have such special responsibilities under this Code as may be specified by the Controlling Authority.

Sealed source

Any radioactive substance sealed in a container (otherwise than solely for the purpose of storage, transport or disposal) or bonded wholly within material including the immediate container or the bonding: it does not include any nuclear fuel element or any radioactive substance inside a nuclear reactor.

Unsealed radioactive substance

Any radioactive substance which is not a sealed source.

Useful beam

That part of the primary radiation from a machine which passes through the aperture, cone or other device for collimating the beam; and any ionising radiations from a sealed source that can be employed for the purposes for which the sealed source is used.

APPENDIX 1

MAXIMUM PERMISSIBLE DOSES

The values for the maximum permissible doses given in Table I are based on the recommendations of the International Commission on Radiological Protection adopted in September 1965[1] and take account of the views of the Medical Research Council's Committee on Protection against Ionising Radiations.

The figures in Table I are based on the expression of 'dose equivalent' in rems, in which the quality factors given in Tables II and III for known types of radiation are taken into account.

Table I

MAXIMUM PERMISSIBLE ORGAN and TISSUE DOSES

Exposed part of the body	Maximum permissible doses for adults exposed in the course of their work
Gonads and red bone marrow (and, in the case of uniform irradiation, the wholy body)	5 (N-18) rems (See Note 2) 3 rems/calendar quarter
Skin and bone (except the skin and bone of the hands, forearms, feet and ankles), thyroid	15 rems/calendar quarter 30 rems/year
Other single organs	8 rems/calendar quarter 15 rems/year
Hands, forearms, feet and ankles	40 rems/calendar quarter 75 rems/year

Notes on Table I

(1) In order to provide flexibility for the maximum permissible dose for exposure involving the whole body where the gonads and the red bone marrow are the critical organs, the quarterly quota may be repeated in each quarter of the year provided that the total dose accumulated at any age over 18 years does not exceed 5(N–18) rems where N is the age in years (part of a year counting as a year).

(2) Women should be occupationally employed only under conditions where the whole body dose is limited to 1·3 rems a calendar quarter, corresponding to 5 rems a year delivered at an even rate.

(3) In the case of any female person whom the Controlling Authority knows, or has reasonable cause to believe, to be pregnant, the dose from all or any one or more of the following, that is to say, X-rays, gamma rays and neutrons, during the remaining period of her pregnancy must not exceed one rem.

[1]Pergamon Press 1966.

(4) Where a person has previously been engaged in work of a type which would have required him to be designated had it been covered by this Code, but no information is available as to the doses actually received, a dose, at the rate of 5 rems a year to the gonads, red bone marrow and whole body should be assumed for the period during which he was engaged on such work.

(5) When a person begins to be occupationally exposed before reaching 18 years of age, the dose to the gonads and the red bone marrow must not exceed 5 rems in any one year under age 18, and the dose accumulated by the age of 30 must not exceed 60 rems.

(6) Where a radiation dose received by accident or during an emergency results in the maximum permissible dose laid down in Table I being exceeded, the situation should be reviewed by the Controlling Authority, acting with the advice of the Medical Adviser and such other expert advice as they may require[1]. The worker may still be allowed to continue routine work if there is no objection from the medical standpoint, due account having been taken of his previous exposure, health, age and special skills, as well as his social and economic responsibilities.

[1]This advice can be obtained from the Advisory and Information Unit of the Department of Employment and Productivity or in Northern Ireland the Ministry of Health and Social Services or from the Radiological Protection Service—for addresses, see Introduction, last paragraph.

Table II

VALUES OF QUALITY FACTOR USED IN CALCULATING DOSE EQUIVALENT

Radiation	Quality factor
X-rays, gamma rays, electrons and beta rays of E_{max} greater than 30KeV	1·0
Beta rays of E_{max} not greater than 30KeV	1·7
Naturally occurring alpha particles	10
Heavy recoil nuclei	20

APPENDIX 2

MAXIMUM PERMISSIBLE LEVELS OF SURFACE CONTAMINATION

The maximum permissible levels of contamination of surfaces (other than fixed contamination) are as follows:

Type of surface	Maximum permissible level (microcuries per square centimetre)		
Surfaces of: Interiors and contents of total and partial enclosures	The minimum that is reasonably practicable		
Surfaces of: Active areas (other than partial enclosures) and plant, apparatus, equipment (including personal protective equipment), materials and articles within active areas	From alpha emitters of the Table in Appendix 3		From emitters other than those specified in the preceding two columns
	In Class I	In Class II-IV	
	10^{-4}	10^{-3}	10^{-3}
Surfaces of the body	10^{-5}	10^{-5}	10^{-4}
All other surfaces	10^{-5}	10^{-4}	10^{-4}

Method of assessment

1 Where contamination can be rubbed off on to absorbent material, it should be assumed, in the absence of specific data, that one-tenth of the removable contamination has been transferred to the paper from the area that has been rubbed.

2 Results of measurements of contamination of floors, ceilings or walls may be averaged over any area not exceeding 1,000 square centimetres. In the case of contamination of other surfaces the results may be averaged over an area not exceeding 300 square centimetres.

3 The results of measurements of the parts of the body may be averaged over an area not exceeding 100 square centimetres, or in the case of the hands over the whole area of the hand.

Fixed contamination

Any contamination that is fixed and cannot be removed by normal methods must be adequately shielded except during ultimate removal.

APPENDIX 3

CLASSIFICATION TABLES OF RADIONUCLIDES

The Medical Research Council has adopted the Classification of Radionuclides according to toxicity proposed by the I.A.E.A. in 1963 (Technical Reports Series No. 15). The list is given in the table below.

('m' indicates metastable state)

Class I Radionuclides (High Toxicity)

RADIONUCLIDE	SYMBOL	MASS NUMBER
Lead	Pb	210
Polonium	Po	210
Radium	Ra	223
Radium	Ra	226
Radium	Ra	228
Actinium	Ac	227
Thorium	Th	227
Thorium	Th	228
Thorium	Th	230
Protoactinium	Pa	231
Uranium	U	230
Uranium	U	232
Uranium	U	233
Uranium	U	234
Neptunium	Np	237
Plutonium	Pu	238
Plutonium	Pu	239
Plutonium	Pu	240
Plutonium	Pu	241
Plutonium	Pu	242
Americium	Am	241
Americium	Am	243
Curium	Cm	242
Curium	Cm	243
Curium	Cm	244
Curium	Cm	245
Curium	Cm	246
Californium	Cf	249
Californium	Cf	250
Californium	Cf	252

Class II Radionuclides (Medium Toxicity—Upper Sub-Group A)

RADIONUCLIDE	SYMBOL	MASS NUMBER
Sodium	Na	22
Chlorine	Cl	36
Calcium	Ca	45
Scandium	Sc	46
Manganese	Mn	54
Cobalt	Co	60
Strontium	Sr	89
Strontium	Sr	90
Yttrium	Y	91

Radionuclide	Symbol	Mass Number
Zirconium	Zr	95
Ruthenium	Ru	106
Silver	Ag	110m
Cadmium	Cd	115m
Indium	In	114m
Antimony	Sb	124
Antimony	Sb	125
Tellurium	Te	127m
Tellurium	Te	129m
Iodine	I	126
Iodine	I	131
Iodine	I	133
Caesium	Cs	134
Caesium	Cs	137
Barium	Ba	140
Cerium	Ce	144
Europium	Eu	152 (13 years)
Europium	Eu	154
Terbium	Tb	160
Thulium	Tm	170
Hafnium	Hf	181
Tantallum	Ta	182
Iridium	Ir	192
Thallium	Tl	204
Bismuth	Bi	207
Bismuth	Bi	210
Astatine	At	211
Lead	Pb	212
Radium	Ra	224
Actinium	Ac	228
Protoactinium	Pa	230
Thorium	Th	234
Uranium	U	236
Berkelium	Bk	249

Class III Radionuclides (Medium Toxicity—Lower Sub-Group B)

Radionuclide	Symbol	Mass Number
Beryllium	Be	7
Carbon	C	14
Fluorine	F	18
Sodium	Na	24
Chlorine	Cl	38
Silicon	Si	31
Phosphorus	P	32
Sulphur	S	35
Argon	A	41
Potassium	K	42
Calcium	Ca	47
Scandium	Sc	47
Scandium	Sc	48
Vanadium	V	48
Chromium	Cr	51
Manganese	Mn	52
Manganese	Mn	56
Iron	Fe	55
Iron	Fe	59
Cobalt	Co	57
Cobalt	Co	58
Nickel	Ni	63

Radionuclide	Symbol	Mass Number
Nickel	Ni	65
Copper	Cu	64
Zinc	Zn	65
Zinc	Zn	69m
Gallium	Ga	72
Arsenic	As	73
Arsenic	As	74
Arsenic	As	76
Arsenic	As	77
Selenium	Se	75
Bromine	Br	82
Krypton	Kr	85m
Krypton	Kr	87
Rubidium	Rb	86
Strontium	Sr	85
Strontium	Sr	91
Strontium	Sr	92
Yttrium	Y	90
Yttrium	Y	92
Yttrium	Y	93
Zirconium	Zr	97
Niobium	Nb	93m
Niobium	Nb	95
Molybdenum	Mo	99
Technetium	Tc	96
Technetium	Tc	97m
Technetium	Tc	97
Technetium	Tc	99
Ruthenium	Ru	97
Ruthenium	Ru	103
Ruthenium	Ru	105
Rhodium	Rh	105
Palladium	Pd	103
Palladium	Pd	109
Silver	Ag	105
Silver	Ag	111
Cadmium	Cd	109
Cadmium	Cd	115
Indium	In	115m
Tin	Sn	113
Tin	Sn	125
Antimony	Sb	122
Tellurium	Te	125m
Tellurium	Te	127
Tellurium	Te	129
Tellurium	Te	131m
Tellurium	Te	132
Iodine	I	132
Iodine	I	134
Iodine	I	135
Xenon	Xe	135
Caesium	Cs	131
Caesium	Cs	136
Barium	Ba	131
Lanthanum	La	140
Cerium	Ce	141
Cerium	Ce	143
Praseodymium	Pr	142
Praseodymium	Pr	143
Neodymium	Nd	147
Neodymium	Nd	149

Radionuclide	Symbol	Mass Number
Promethium	Pm	147
Promethium	Pm	149
Samarium	Sm	151
Samarium	Sm	153
Europium	Eu	152 (9·2 hours)
Europium	Eu	155
Gadolinium	Gd	153
Gadolinium	Gd	159
Dysprosium	Dy	165
Dysprosium	Dy	166
Holmium	Ho	166
Erbium	Er	169
Erbium	Er	171
Thulium	Tm	171
Ytterbium	Yb	175
Lutecium	Lu	177
Tungsten	W	181
Tungsten	W	185
Tungsten	W	187
Rhenium	Re	183
Rhenium	Re	186
Rhenium	Re	188
Osmium	Os	185
Osmium	Os	191
Osmium	Os	193
Iridium	Ir	190
Iridium	Ir	194
Platinum	Pt	191
Platinum	Pt	193
Platinum	Pt	197
Gold	Au	196
Gold	Au	198
Gold	Au	199
Mercury	Hg	197
Mercury	Hg	197m
Mercury	Hg	203
Thallium	Tl	200
Thallium	Tl	201
Thallium	Tl	202
Lead	Pb	203
Bismuth	Bi	206
Bismuth	Bi	212
Radon	Rn	220
Radon	Rn	222
Thorium	Th	231
Protoactinium	Pa	233
Neptunium	Np	239

Class IV Radionuclides (Low Toxicity)

Radionuclide	Symbol	Mass Number
Hydrogen	H	3
Argon	A	37
Cobalt	Co	58m
Nickel	Ni	59
Zinc	Zn	69
Germanium	Ge	71
Krypton	Kr	85
Strontium	Sr	85m
Rubidium	Rb	87

Radionuclide	Symbol	Mass Number
Yttrium	Y	91m
Zirconium	Zr	93
Niobium	Nb	97
Technetium	Tc	96m
Technetium	Tc	99m
Rhodium	Rh	103m
Indium	In	113m
Indium	In	115
Iodine	I	129
Xenon	Xe	131m
Xenon	Xe	133
Caesium	Cs	134m
Caesium	Cs	135
Samarium	Sm	147
Rhenium	Re	187
Osmium	Os	191m
Platinum	Pt	193m
Platinum	Pt	197m
Thorium	Th	232
Natural Thorium	Th-Nat	
Uranium	U	235
Uranium	U	238
Natural Uranium	U-Nat	

Note: The I.A.E.A. classification does not list 7 radionuclides which are being used in the U.K. On the basis of R.P.S. calculations of $m.p.c._{air}$ for these seven, their classification will be:

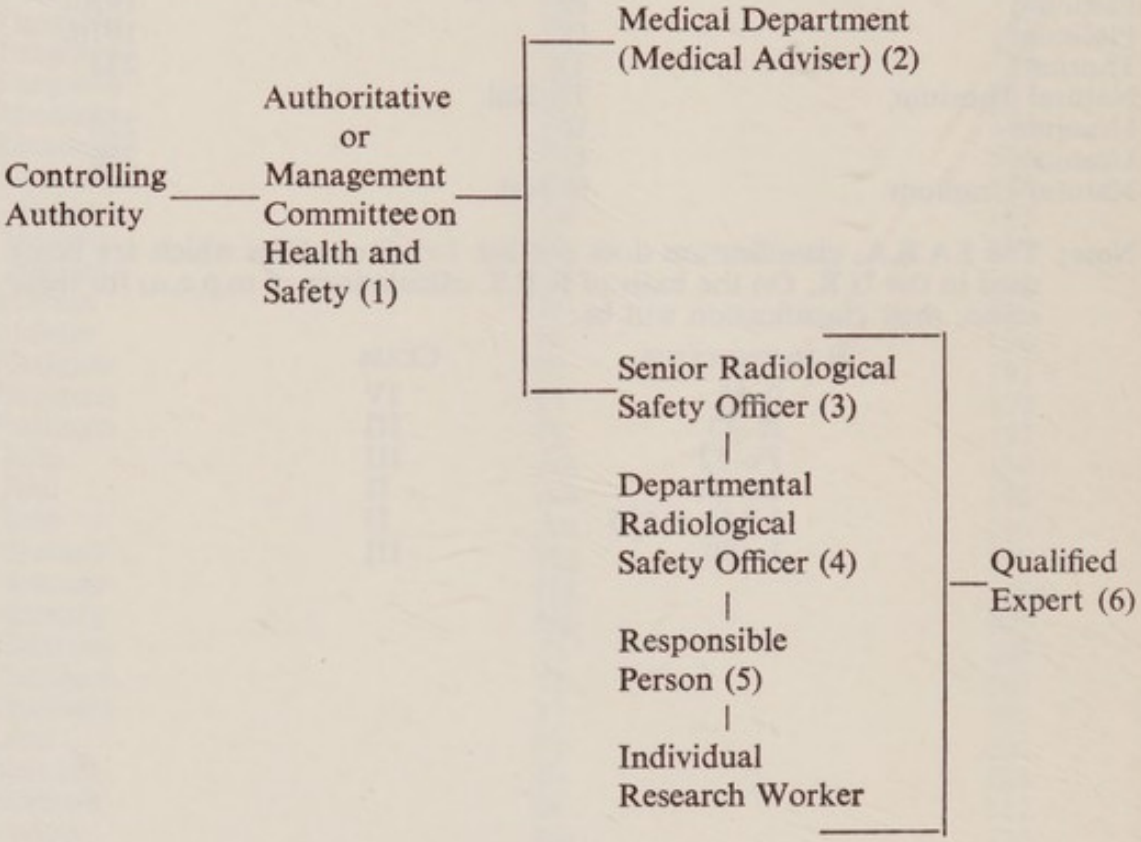
Radionuclide	Class
0–15	IV
K–43	III
Fe–52	III
Co–56	II
I–124, I–125	II
I–130	III

APPENDIX 4

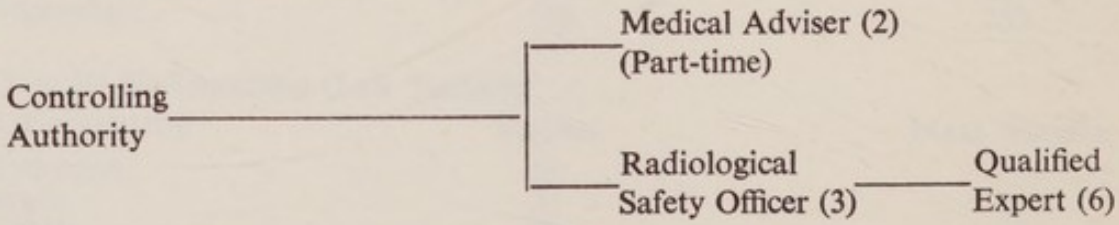
ADMINISTRATIVE ORGANISATION

Examples are given below of the type of administrative organisation which the Controlling Authority should set up to arrange the necessary protective measures in the establishment. The type of organisation appropriate to any establishment will depend upon its size, the normal pattern of management and the scale on which radioactive substances are used.

1 Large establishment



2 Small establishment



(1) *Authoritative or Management Committee*

In a large establishment it will probably be advisable to appoint a Management Committee with overall responsibility under the Controlling Authority for the safety and health of all persons in it.

The function of the Committee will be to ensure that the provisions of this Code and of any local rules in force are carried out and to co-ordinate the activities of the Medical Adviser and the Radiological Safety Officers.

(2) *Medical Adviser*

The duties of a medical adviser are described in Part 6.

(3) *Radiological Safety Officer*

The Radiological Safety Officer will be responsible under the Management Committee or the Controlling Authority as the case may be for all safety aspects of radiological protection.

(4) *Departmental Supervisors or Departmental Radiological Safety Officers*

In large establishments it may be necessary to appoint deputies to the Radiological Safety Officer who will be in charge of safety protection in individual departments or buildings.

(5) *Responsible Person*

It may be necessary to appoint one or more persons to whom certain responsibilities under the Code and under local rules, will be assigned (e.g. monitoring surveys and special duties in an emergency).

(6) *Qualified Expert*

Persons with suitable qualifications should be available to carry out certain special duties such as the testing of monitoring instruments. They need not necessarily be members of the staff of the establishment.

APPENDIX 5

ARRANGEMENTS FOR MEDICAL SUPERVISION

APPOINTMENT OF MEDICAL PRACTITIONER

1 Research Establishments employing medical staff. Where medical staff with knowledge of the radiological hazards likely to arise are already employed in the establishment they will naturally be the people to exercise the medical supervision required by this Code.

2 Research Establishments linked with a Medical School or an adjoining Hospital. A suitable means of obtaining medical supervision for a University would be to make an arrangement with the medical authorities of the school or hospital. Otherwise, HM Medical Inspector of Factories for the area will be glad to suggest names of doctors who might be approached to undertake part-time medical supervision, or the address of the Appointed Factory Doctor for the district can be obtained from the local District Inspector of Factories. In Northern Ireland the Chief Inspector of Factories will supply this information.

3 Research Establishments associated with factories subject to the Factories Act. All factories subject to the Factories Act will have an Appointed Factory Doctor (either the works doctor or the Appointed Factory Doctor for the district). If the factory is using sealed sources or unsealed radioactive substances, the Appointed Factory Doctor will be carrying out for the factory workers concerned the provisions of the Ionising Radiations (Sealed Sources) Regulations 1961 and/or (when they become law) the Unsealed Radioactive Substances Regulations, which are analogous to the provisions of this Code for research workers. Arrangements should, therefore, be made for the Appointed Factory Doctor to extend his responsibilities to the research workers. Even if the factory is not using sealed sources or unsealed radioactive substances, the Appointed Factory Doctor is probably the most suitable person to undertake the medical supervision of research workers engaged on work with ionising radiations.

4 Government Departments outside the scope of the Factories Act. Government Departments, other than Service laboratories, should arrange with the Treasury Medical Adviser for medical supervision to be provided by a doctor holding an appointment in the Treasury Medical Service. In Service laboratories, arrangements will be made through the appropriate Service Medical Department.

5 Local Government Departments outside the scope of the Factories Act. Local Government Authorities will probably wish to arrange the provision of medical supervision through their Medical Officers of Health.

6 Technical Colleges. In maintained and assisted colleges, medical supervision should be arranged with the Principal School Medical Officer, but in areas where he is not also the Medical Officer of Health of the local Health Authority, the latter should be consulted. Independent colleges should consult the Medical Officer of Health of the local Health Authority.

Note: HM Factory Inspectorate has prepared a memorandum of advice about the medical supervision of workers using ionising radiations. This has been issued to all Appointed Doctors under the Ionising Radiations (Sealed Sources) Regulations 1961 and to Appointed Factory Doctors under the Factories Act. Any doctor holding a comparable appointment in an establishment covered by this Code can obtain a copy on application to HM Chief Inspector of Factories, 1 Chepstow Place, London, W2, or in Northern Ireland the Chief Inspector of Factories, Ministry of Health and Social Service, Dundonald House, Upper Newtownards Road, Belfast, BT4 3SF. The subject is also discussed in the 'Second Report on Medical Supervision in Radiation Work' prepared by W.H.O. Expert Committee on Radiation (W.H.O. Technical Report Series, 1960 No. 196) obtainable from HM Stationery Office, Box 569, London, S.E.1, price 1s. 9d. and the I.A.E.A. Medical Addendum to the Manual on the Safe Handling of Radioisotopes (I.A.E.A. Safety Series, No.3).

APPENDIX 6

METHODS OF DECONTAMINATING LABORATORIES

A survey will indicate the areas requiring decontamination and such areas should be clearly delineated. The areas should be decontaminated promptly to prevent the spread of contamination. The decontamination procedures should be carefully planned and correct materials selected. Personnel should wear appropriate protective clothing.

In general wet methods should always be used to prevent the dispersal of dust. If because of special circumstances dry methods cannot be avoided, special precautions will be necessary (e.g. special vacuum cleaners with filters).

Methods

1 Spilt liquid should be absorbed on paper tissue or 'Vermiculite'.

Where dry material has been spilt and there is loose particulate contamination the best method of decontamination may well be the application of a strippable coating by brush or spray. This coating will hold the contaminant and prevent the dispersal (provided that the method chosen does not disturb the loose contaminant). When dry, the coating is stripped off taking the adhering contaminant with it. Self-adhesive tapes can also be applied to non-porous surfaces for the removal of loosely held dust.

2 For the second stage of decontamination, the use of damp swabs is preferable to uncontrolled sluicing to prevent spread of contamination. The actual method to be used and the appropriate agent will depend to some extent on the ease of removal of the remaining contamination and the methods set out below are arranged in order, to deal with increasingly difficult circumstances:

(i) Treat with a suitable detergent which may be in the form of a cream to prevent the spread of the contamination by splashing. Swabbing or light scrubbing may also be necessary.

(ii) Scrub lightly with a complexing solution. If an application of a thickened complexing agent is used it should be left on the surface for a few hours before rinsing off. The addition of pigment will help to identify the areas to which the decontaminant has been applied.

(iii) Swab or scrub with mild abrasive pastes containing complexing agents.

(iv) Where none of the above methods is successful and the contamination still remains, it will be necessary to treat the surface by more vigorous scrubbing and abrasion or more severe treatment,

e.g. by planing off wood surfaces and chipping away concrete and brick surfaces. In such cases it will be necessary to restore the original surface before work is recommenced.

The following table indicates some of the available decontaminating agents that may be found useful for various surfaces and materials.

Type of surface or equipment	Decontamination agent	Treatment
Walls, floors etc. Contaminated clothing	Suitable detergents or wetting agents (Simple detergents are not satisfactory and it is preferable to add a little E.D.T.A.[1])	A first method for particularly greasy or dirty surfaces. Use a 0·5% solution with swabbing or scrubbing action or in a washing machine for clothing.
Textiles Plastics Paints Rubber Metals	Complexing solutions (Combinations of citric acid, E.D.T.A. etc.)	Use in the form of a cream or immerse articles in tanks for periods up to several hours. (0·8% solution at elevated temperatures.)
Linoleum	Organic solvents	To remove the normal waxed coating.
Machine tools	Solvents (Proprietary grease or emulsifying solvents)	Apply directly to heavily oiled and greasy surfaces with a cloth or brush. Emulsifying solvents may be rinsed off with water.

Repeat any of the above if necessary but if this does not remove the contamination satisfactorily, apply mild abrasive cleaners (proprietary brands) with a cloth to the affected surface.

Glassware	Acids Chromic acid	Use in the normal way.
Stainless Steel	Sulphuric acid	These dissolve the contaminated surface taking it into solution.
Mild steel and light alloys	Sulphuric acid with inhibitors	
Ferrous metals	Nitric acid/Sodium-fluoride Proprietary rust removers	
Painted surfaces	Paint removers Solvent strippers Alkaline strippers	Use in difficult cases where the paint itself has to be removed.

[1]Ethylene diamine tetra acetic acid.

APPENDIX 7

TEMPORARY PRESERVATION OF RADIOACTIVE ANIMAL CARCASSES UNTIL SUFFICIENT RADIOACTIVE DECAY HAS TAKEN PLACE FOR DISPOSAL

Carcasses weighing less than approximately 3·5 kilograms

The carcass or tissue may be placed in a polythene bag with fresh bleaching powder and dry 'Vermiculite' (a commercial expanded mica). If the polythene bag is then heat-sealed and the carcass tumbled about in the mixture until it is thoroughly dusted, decomposition will be prevented for a considerable time. The following additional action is essential to the success of this process:

(i) the open end of the bag (which should be made of the heavier gauge, 250–500, of polythene) should be folded back in a double cuff fold outwards to protect the surfaces to be sealed from dust and inorganic matter;

(ii) the weight of the bleaching powder and dry 'Vermiculite' should each be not less than one-fifth of the weight of the carcass. This represents, in practice, a volume of about 300 ml and 1,500 ml respectively per kilogram weight of carcass;

(iii) it is desirable to slit the carcass ventrally along the midline, if this has not already been done, before placing it in the bag;

(iv) the animal's claws sould be cut and the feet of the carcass should be bound with adhesive tape, lint or bandage before it is placed in the bag, to avoid the possible penetration of the bag. For the same reason it is unwise to sever the feet with bone forceps lest sharp splinters are left;

(v) if the carcass is soiled with tissue fluid or blood, it should be dusted with bleaching powder and allowed to cool before being placed in the bag. This avoids the development of heat inside the bag due to the rapid interaction of the bleaching powder and organic matter. Heating may also be avoided by applying dry 'Vermiculite' to the opened carcass; the finer grades of this material absorb about four times their own weight of fluid and thus the interaction with the bleaching powder is slowed down; and

(vi) the bag should be sealed with only a small amount of air included, but in expelling the air, care should be taken not to blow dust on the surfaces to be sealed. For further information, see Boursnell, J. C. and Gleeson-White, M. H. Nature, Lond. 179, 54, 1957.

Carcasses weighing more than approximataly 3·5 kilograms

The method described above is also effective for animal carcasses weighing slightly more than 3·5 kilograms provided they have been carefully eviscerated, but larger carcasess require different treatment, as follows:

(i) the carcass should be eviscerated and the intestines, liver and stomach slit open;

(ii) the chest cavity should be cut wide open and the lungs and heart slit; the latter sometimes allows a useful measure of exsanguination; and

(iii) the carcass should then be stored in a strong plastic dustbin with a well-fitting lid and 40% formalin solution added to cover the carcass completely.

Note: Care in following the above directions will ensure that there is no putrefaction;

(iv) the bins must be stored at a properly-appointed place away from sunlight and heat and identified by a label showing the nature and approximate quantity of the radioactive material contained;

(v) storage should last until the level of the radioactivity is sufficiently low to permit the fluid to be poured down the drain and the carcass to be incinerated in the normal way; and

(vi) owing to selective accumulation of certain isotopes by certain organs it is not always necessary to preserve the complete carcass; the organs concerned should be removed for storage as above but it may be safe to incinerate the remainder of the carcass immediately.

Further advice on the disposal of radioactive carcasses can be obtained from the Ministry of Housing and Local Government (in Scotland, the Scottish Development Department and in Northern Ireland, the Ministry of Health and Social Services).

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