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RADIOLOGICAL SAFETY REGULATIONSfor OPERATION GRAPPLEIssued by

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Health Physics Adviser
Group Leader Health Physics Group
Health Physics Representative
Safety Officer
Fire Officer
Medical Officer
Security Officer
Fire Station
Ambulance
Health Physics
Trials H.Q.,

RADIOLOGICAL SAFETY REGULATIONS

GRAPPLE

1. INTRODUCTION

- 1.1 Radiation which may be encountered during the Trial may be α particles, β particles, γ rays and neutrons. Under properly controlled conditions work involving exposure to these radiations can be carried on in perfect safety.

Excessive exposure however may result in serious damage to the human body.

The danger is particularly insidious because the effects are not immediately felt and damage may only become apparent after a period of years. Damage may arise not only from external exposure but from irradiation of internal organs as a result of ingestion, inhalation, injection into the bloodstream through cuts and abrasions, or even by absorption through an intact skin.

- 1.2 The maximum permissible levels of the various radiations and radioactive substances are based on the recommendations of the International Commission on Radiological Protection and of the International Commission on Radiological Units, and have been approved by the U.K.A.E.A. and other authorities concerned. These are the levels to be used throughout the Trial.

- 1.3 It is emphasized that these are maxima and every endeavour must be made to keep the average exposure as low as possible.

- 1.4 The object of these regulations is to ensure complete protection both of staff and of the general public, whilst imposing the minimum interference with work. To this end, the regulations will, at all times, apply to all who are concerned with the trial.

- 1.5 Advice on the applicability and interpretation of these regulations will be given by the Group Leader R.M., who is Health Physics Adviser to the Scientific Director. For implementation a Health Controller will be appointed from the R.M. Group from each island. The Health Controllers will also be Health Physics Advisors to the respective Scientific Superintendents.

Where the terms 'Health Controller' or 'Scientific Superintendent' occur in the singular in the following, they are to be regarded as applying equally to the two sites.

2. SPECIFICATION OF MAXIMUM PERMISSIBLE LEVELS

2.1 External Radiations

For external radiation the maximum permissible levels will be:-

2.1.1 β and γ Radiation

(a) A normal working rate as defined in the current "Recommendations of the International Commission on Radiological Protection". This is at present (November 1956)

1.5 rep/week of which the γ radiation component must not exceed 0.3r week.

The dose to the eyes must not exceed 0.3 rem/week.

(b) A lower integrated dose of up to 15 rep of which the Gamma radiation components must not exceed 3r.

This dose will be applied only with the express permission of the appropriate Health Controller and will be given only where he regards it as necessary for the smooth running of the operations.

Except as provided for under (c) or (d) below, personnel who have received this dose will not be subjected to further exposure until their average exposure is below 1.5 rep/week of which the Gamma component shall not exceed 0.3r/week.

(c) A higher integrated dose of up to 50 rep of which the Gamma radiation component must not exceed 10r.

This dose will be applied only in cases where it is necessary in order to recover important records and information which might otherwise be lost, and will require the express personal permission of the Scientific Superintendent of the area concerned after consultation with his Health Physics Adviser and Medical Adviser.

Except as provided for under (d) below, personnel who have received this dose will not be subjected to further exposure until their average exposure is below the level given in (b).

(d) A special higher integrated dose of up to 75 rep of which the gamma radiation component must not exceed 25r.

This dose shall be applicable only in cases where it is necessarily involved in operations essential to the success of the trial and only to personnel who are not normally exposed to radiation, and then only with the express personal permission of the Scientific Director after consultation with the Health Physics Adviser and the Medical Adviser.

Personnel who have received this dose will not be subjected to further exposure during a period of three years.

2.1.2 Neutron Radiation

The maximum permissible levels will be as defined in the current recommendations of the "International Commission on Radiological Protection". These are at present (November 1956):

The dose to the tissue 2 cm below the skin surface must be less than 30 millirads/week. This figure, for a 40hr week is given by the neutron fluxes below

Neutrons of energy 0.25	eV	-	2000 neutrons/cm ² /sec
Neutrons of energy 10	eV	-	2000 neutrons/cm ² /sec
Neutrons of energy 10	KeV	-	1000 neutrons/cm ² /sec
Neutrons of energy 0.1	MeV	-	200 neutrons/cm ² /sec
Neutrons of energy 0.5	MeV	-	80 neutrons/cm ² /sec
Neutrons of energy 1	MeV	-	60 neutrons/cm ² /sec
Neutrons of energy 2	MeV	-	40 neutrons/cm ² /sec
Neutrons of energy 3-10	MeV	-	30 neutrons/cm ² /sec

2.1.3 α Radiation

α particles present no external hazard as they are unable to penetrate the outer layers of undamaged skin.

2.2 Internal Radiations

The maximum permissible level of ingestion, inhalation and injection are based on the equivalent doses to tissue, but are dependent on biological factors which vary with the material.

2.2.1 The maximum permissible levels will be:

(a) For individual isotopes, or mixtures of isotopes except weapon debris

The concentrations shall be those in Appendix I for the materials concerned.

(b) For Weapon Debris

(1) In Water (a) α emitters 10^{-7} $\mu\text{c/cc}$

(b) β - γ emitters 6×10^{-4} $\mu\text{c/cc}$ for debris less than 30 days old.
 1×10^{-6} $\mu\text{c/cc}$ for debris more than 30 days old.

(ii) In Air (a) α emitters. The concentrations shall be that in Appendix I for the most hazardous material likely to be found

(b) β - γ emitters. The concentrations shall be those given by the expression

$$\frac{3.0 \times 10^{-6}}{T} \mu\text{c/cc}$$

Where T is the time after the explosion in hours for times between $T = 0.25$ and $T = 5040$ (210 days).

For times after 210 days the value given for Sr^{90} shall be used namely 6×10^{-10} $\mu\text{c/cc}$

If the age of the debris is in doubt, the value given for Sr^{90} i.e. 6×10^{-10} $\mu\text{c/cc}$ shall be used.

The maximum permissible levels applicable to inhalation hazards are based on a regular exposure of 56 hours/week. If these hours are not applicable the levels should be varied in inverse proportion to the duration of exposure.

2.3 Contamination Levels

Contamination can be fixed or loose.

2.3.1 In the case of benches, clothing, etc., contamination can be regarded as fixed when a smear test (see Appendix II) gives values below the maximum permissible levels. In the case of hands and body it is defined as that which remains after washings in accordance with the instructions laid down in Appendix III.

2.3.2 The maximum permissible levels of fixed surface contamination will be as follows:

α	Microcuries/cm ²
600 disintegrations/min on both sides of one hand	1×10^{-6}
20 disintegrations/min/cm ² , clothing, benches, equipment, etc.	1×10^{-5}
400 disintegrations/min/cm ² , fume cupboards	2×10^{-4}

β-γ

Microcuries/cm²

6,000 disintegrations/min on both sides of one hand	1×10^{-5}
400 disintegrations/min/cm ² , clothing	2×10^{-4}
8,000 disintegrations/min/cm ² , fume cupboards benches equipment etc.	4×10^{-3}

2.3.3 The maximum permissible levels for loose contamination will be:

α

Microcuries/cm²

5 disintegrations/min/"smear"	1.5×10^{-8}
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β-γ

20 disintegrations/min/"smear"	6×10^{-8}
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2.3.4 The Health Controller must be informed when contamination levels exceed those given in paras 2.3.2 and 2.3.3 and he will lay down the conditions under which work may proceed in the areas affected.

3. CLASSIFICATION OF AREAS

3.1 All parts of the Test Area will be classified according to the nature of the work which may be done in that particular part.

3.2 The system of classification and nomenclature which will be used is as follows:

3.2.1 NON-ACTIVE Areas

A NON-ACTIVE area is one in which the maximum radiation levels must be less than 1/10 of those laid down in para. 2 for ACTIVE areas and there is no detectable loose activity. No special radiation precautions will be necessary.

3.2.2 ACTIVE AREAS

Those in which there may be some radiation risk and where precautions appropriate to the degree of risk must be taken. There will be three categories:

- (a) BLUE Area - Risk of penetrating radiation but not of inhalation, ingestion or injection. No special clothing.
- (b) RED Area - Risk of penetrating radiation and of slight inhalation, ingestion and injection. Protective clothing will be worn in accordance with Health Physics recommendations for the particular area.
- (c) YELLOW Area - Risk of a serious inhalation, ingestion, injection or penetrating radiation hazard. Fully protective clothing must be worn.

3.2.3 The classification of an Area will be laid down by the Health Physics Representative who must be informed prior to any proposed change in the work which might affect the classification. The Health Physics Representative will review the classifications periodically.

3.2.4 Signs showing the classification and having a patch of the appropriate colour will be displayed at all entrances to any ACTIVE area.

All areas not classified in this way will be NON-ACTIVE areas and these will not have any special marking.

- 3.3 No person will be allowed to enter RED or BLUE areas without permission of the Scientist, or other Officer, in charge of the Area concerned. No person will be allowed to enter a YELLOW area without permission of the Health Control Officer in charge.

When it is necessary to carry out any building, engineering or other maintenance work in any ACTIVE area, a Permit to Work Certificate must first be raised through the Trials H.Q., who will consult the Health Physics Adviser or Representative, where necessary.

4. FILM BADGES

All personnel who have duties in an Active Area will wear a Personal Monitoring Film at all times. Others will wear a Film on occasions when they are exposed to radiation.

5. PROTECTIVE CLOTHING

- 5.1.1 All radiation protective clothing will be white, and will be distinguished by red epaulettes or a red triangle as appropriate.

- 5.1.2 The wearing of the approved protective clothing with film badges and dosimeters as specified in the appropriate parts of the regulations is compulsory.

- 5.1.3 To assist the rigid enforcement of these rules under no circumstances will radiation protective clothing be issued for other purposes.

5.2 Degree of Protection

- 5.2.1 Workers in BLUE Areas - No special protective clothing necessary.

- 5.2.2 Workers in RED Areas - Approved Lab. coats or overalls, shoes or overshoes. The above is general for all RED Areas but in certain special cases additional clothing will be specified by the Health Physics Representative. When worn in ACTIVE Areas Lab. coats and overalls must be kept fastened at all times.

- 5.2.3 Workers in YELLOW Areas - Complete change of all clothing into the fully protective items provided.

5.3 Laundering and Disposal

- 5.3.1 Once an article becomes unserviceable it will not be returned to stores but will be disposed of as contaminated waste.

- 5.3.2 Protective clothing will be sent only to the special laundry provided. Rubber gloves from RED Areas will not be sent to the laundry but will be cleaned by the users.

6. USE AND STORAGE OF RADIOACTIVE MATERIALS

No radioactive material will be used in NON-ACTIVE Areas. Sealed sources may be used in carrying out calibrations provided the Health Physics Representatives have been informed and BLUE area warning signs have been erected.

6.2 Materials which are completely sealed so as to prevent any escape of active materials may be used, or stored, in any ACTIVE area. Adequate precautions must be taken to ensure that the dose received by workers in that area is within the limits laid down and to prevent the dose rate at any point outside the ACTIVE area from exceeding one tenth of the maximum permissible.

6.3.1 Use or storage of radioactive materials other than as stated above is permitted only in RED or YELLOW areas.

6.3.2 In RED Areas no radioactive material will be exposed unnecessarily to the air of the Laboratory.

6.4 Details of special precautions required for particular materials and areas will be laid down as appropriate by the Health Controller who will maintain a record of all radioactive sources and materials in use or in store.

7. TRANSIT OF RADIOACTIVE MATERIALS

Transit of radioactive materials through internal NON-ACTIVE areas is permitted, provided they are in properly designed and sealed containers which will effectively prevent escape of the material and which are themselves externally clean, and that the Health Physics Representatives have been informed previously. The transit should be uninterrupted and adequate precautions must be taken to ensure that the γ - ray dose does not exceed 200 milliroentgens/hour at the surface, nor 10 milliroentgens/hour at one metre, and the neutron dose rate does not exceed 30 neutrons/cm²/sec. at the surface. Transit of containers where the dose rate exceeds any one of these limits will be permitted only with prior approval of the Health Physics Representative.

7.2 Transit of radioactive materials to and from the Test Area is governed by any International, U.K. and Australian Government Regulations currently in force, by the Regulations of any other Government concerned, and by any Instructions, currently in force, issued by D.A.W.R.E., RAE/A.W.R.E., the Health Physics Adviser (see Appendix IV), or the Scientific Superintendent.

8. Laboratory Waste

8.1 All solid waste will be segregated into the following four categories.

(i) Highly active waste, i.e. above one millicurie.

(ii) Low activity waste non-combustible.

(iii) Low activity waste combustible.

(iv) Used paper towels.

Category (i) waste must be sealed in rigid containers and held safely by the originator until proper arrangements have been made for its disposal. The contents and the approximate levels of activity must be marked on the outside.

Bins suitably labelled will be kept in all laboratories and workrooms where categories (ii), (iii) and (iv) are likely to arise. Low activity articles too large to be placed in the bins will be wrapped in impervious material in such a way as to prevent the escape of active material, and will have their contents and approximate levels of activity marked on the outside.

9. MONITORING

- 9.1 The object of radiation monitoring is to ensure the protection of workers and to prevent interference with scientific work due to contamination.

Health Physics Representatives will provide complete monitoring facilities for personal use.

A Health Physics Representative will be available in all "active" areas to advise and assist where called upon.

9.2 Personal Monitoring

- 9.2.1 Personal monitoring must primarily be the individual's responsibility.
- 9.2.2 Gamma ray dosage will be measured by means of film badges which will be worn as laid down in para. 4.
- 9.2.3 All persons, before leaving an ACTIVE area will monitor themselves by means of the instruments provided, to ensure that the contamination levels laid down are not exceeded.
- 9.2.4 For special operations, where high dose rates are anticipated personal ionization chambers will be worn. Special film badges will be worn when required by the Health Physics Representative.

9.3 Area Monitoring

- 9.3.1 Air sampling will be carried out in all laboratories and work rooms where there is normally a potential inhalation risk. For special operations or where an unusual inhalation risk is anticipated additional samples will be taken.
- 9.3.2 Neutron and gamma ray levels will be measured continuously where necessary.
- 9.3.3 The Officer-in-Charge will ensure that regular contamination checks are made to ensure that levels of activity are below the maximum values laid down.

In addition periodic surveys will be made by Health Physics Representatives.

9.4 Monitoring of Active Waste

Solid waste containers will be monitored and decontaminated if necessary before being taken from an ACTIVE Area.

9.5 Monitoring of Vehicles and Equipment

All equipment and vehicles, including ships and aircraft will be monitored and decontaminated if necessary before being taken out of an ACTIVE area.

Equipment will not be moved into a less active area unless it is monitored, decontaminated if necessary, and given a Health Physics clearance certificate. Articles must not be moved into a BLUE or a NON-ACTIVE area if there is any detectable loose activity.

10. MEDICAL SURVEILLANCE

The Medical Officer must be consulted in all medical aspects of Radiation Safety.

No person will be allowed to work in an ACTIVE area, or with radioactive materials, who has not previously been cleared for such work by a special medical examination either immediately prior to the Trial, or immediately prior to his first exposure during the Trial.

11. ACCIDENTS AND FIRST AID

- 11.1 If anyone thinks he may have inhaled, ingested or otherwise absorbed (e.g. through cuts etc.) any radioactive material he must at once:

- (i) Take emergency action.
- (ii) Report to the Health Controller or the Medical Officer (through his Officer-in-Charge if the accident occurs on duty)

- 11.2 If the skin is accidentally cut, or scratched, during work in ACTIVE areas the cut should be placed, if possible, under running water within 15 seconds and held there whilst the whole wound area is scrubbed with a soaped brush for at least five minutes. The flow of blood should be encouraged by mild pressure above the wound. The surrounding skin should be monitored and washing continued until this is inactive.

A sterile dressing, not a strip of dressing of the Elastoplast type, may be used as a temporary cover until qualified medical attention has been received.

The object causing the wound will be kept and tested for contamination.

- 11.3 If anyone spills any radioactive material he must, unless in a YELLOW area.

- (i) Ask all staff to vacate the area.
- (ii) Limit the spread of contamination
- (iii) Report immediately to a Health Physics Representative.

In a Yellow area he must mark the boundaries of the spill and report to a Health Physics Representative.

12. STORAGE AND USE OF PERSONAL EFFECTS

Eating, smoking, drinking and the storing of food, drink and tobacco anywhere in ACTIVE areas, other than BLUE areas is forbidden.

13. HAZARDS FROM WEAPON DEBRIS

- 13.1 There may be certain radioactive hazards associated with explosion clouds or fall-out from the clouds. The Health Physics Adviser will obtain from the Radiation Measurements Group, the Theoretical Predictions Group and the Meteorological Service all data required to maintain effective control over the hazards due to such clouds and fall-out.

- 13.2 All aircraft, vessels and vehicles used in connection with the Operation will be governed by such instructions as may be issued by the Health Physics Adviser with regard to radiological safety. Where aircraft, vehicles or personnel have been in, or are likely to go into, areas which may have been contaminated, all personnel concerned must report at once to a Health Physics Representative who will arrange to check, to decontaminate if necessary, and grant clearances and give such other instructions as may be necessary.

- 13.3 Advice on other matters concerning Radiological Safety outside the Test Area will be called for from the Health Physics Adviser as necessary.

14. RESPONSIBILITIES

14.1 The Individuals

Any person coming into contact with radioactive materials or entering active areas is personally responsible for complying with these regulations and other relevant regulations and instructions

14.2 The Officer in Charge of any Task is responsible for ensuring:

- 14.2.1 That these regulations and other relevant regulations and instructions together with any additional requirements applicable to his task are brought to the notice of all his staff, and that they clearly understand the measures involved in any work that they have to do.
- 14.2.2 That these regulations are rigorously observed.
- 14.2.3 That the Health Physics Representatives and the Medical Officer are informed in advance of any proposed work which may affect the Radiological Safety arrangements in any way.
- 14.2.4 That any accidents or abnormal circumstances are reported immediately to the Scientific Superintendent, the Health Physics Adviser, the Medical Officer and where applicable to O.C.'s Service Units.
- 14.2.5 That Health Physics Representatives are kept fully informed of all active sources in use by his staff or under his control.

14.3 Officers Commanding Service Units etc.

The Officers in Command of the various Service units, ships, aircraft and detachments and Groups engaged in the trial will ensure that these regulations and any instructions of the Health Physics Adviser and all other relevant regulations and instructions are enforced and are brought to the notice of all personnel under their command and their visitors.

14.4 The Health Physics Adviser is responsible for:

- 14.4.1 Radiological control of all movements into, out of or within YELLOW areas and radiological supervision in all ACTIVE areas.
- 14.4.2 Maintenance of records of individual exposures, and of the locations of ACTIVE Areas, materials and sources.
- 14.4.3 Prompt investigation of all accidents and abnormal circumstances reported to him.
- 14.4.4 Advice on all aspects of radiological safety and issue on behalf of the Scientific Superintendent of special instructions as required.

14.5 The Scientific Superintendent will ensure that:

- 14.5.1 These regulations, together with any instructions issued by his Health Physics Adviser under the authority para. 14.4 above, are enforced and are brought to the notice of all staff employed on the Trial, including Service Units etc. and all visitors.
- 14.5.2 Test explosions involving Radioactive materials are carried out only under prescribed conditions and under Meteorological conditions, such that windborne explosion debris falls within the permissible firing arcs laid down for the Trial or test concerned.

15. SHORT TITLE AND ABBREVIATION

- 15.1 The short title for these Regulations shall be the Radiological Safety Regulations (Grapple).
- 15.2 The authorised abbreviation for use in References shall be R.S.R.G/57 (1) where the number of parentheses refers to the Edition and the number preceding it refers to the year of issue.

16. Amendments

D.A.W.R.F. is authorised to issue any amendments necessary to keep these regulations consistent with current Regulations, Instructions and Codes of Practice issued by the various Government, International and other organisations concerned and also any amendments necessary to maintain consistency with the overall organisation of the Trial.

APPENDIX I

MAXIMUM PERMISSIBLE CONCENTRATIONS

1. The concentrations shown below shall be the maximum permissible levels for the various isotopes mentioned, when found during the Trial. The values are based on recommendations of the International Commission on Radiological Protection and of the International Commission on Radiological Units.
2. When using these levels it must be remembered that the inhalation levels are based on a working week of 56 hours spent in the Active areas. For differing exposure times the levels will be inversely proportional to the exposure times, e.g. for a 24 hour daily exposure the level in air for Sr90 will be 2×10^{-10} $\mu\text{c}/\text{cc}$, instead of 6×10^{-10} $\mu\text{c}/\text{cc}$.

Maximum Permissible Concentrations		
Radio Isotopes	Water ($\mu\text{c}/\text{cc}$)	Air ($\mu\text{c}/\text{cc}$)
H ³	0.2	3×10^{-5}
C ¹⁴ (CO ₂)	3×10^{-3}	3×10^{-5}
Na ²⁴	8×10^{-3}	3×10^{-6}
A ⁴¹	5×10^{-4}	1.5×10^{-6}
Ca ⁴⁵	10^{-4}	2.4×10^{-8}
Sr ⁸⁹	7×10^{-5}	6×10^{-8}
Sr ⁹⁰ + Y ⁹⁰	8×10^{-7}	6×10^{-10}
Y ⁹¹	3×10^{-4}	2.7×10^{-8}
Ru ¹⁰⁶ + Rh ¹⁰⁶	10^{-4}	6×10^{-8}
I ¹³¹	6×10^{-5}	1.8×10^{-8}
Cs ¹³⁷ + Ba ¹³⁷	2×10^{-3}	6×10^{-7}
Ba ¹⁴⁰ + La ¹⁴⁰	2×10^{-4}	5×10^{-8}
Ce ¹⁴⁴ + Pr ¹⁴⁴	10^{-4}	6×10^{-9}
Po ²¹⁰ + Pr ¹⁴⁴	3×10^{-6}	3×10^{-10}
Po ²²²	-	3×10^{-7}
Ra ²²⁶ + 55% d.p.	4×10^{-8}	2.4×10^{-11}
Ac ²²⁷ + d.p.	5×10^{-7}	1.2×10^{-11}
Th ²³² Natural	4×10^{-7}	9×10^{-11}
Th ²³⁴ + Pa ²³⁴	2×10^{-4}	3×10^{-8}
U Natural	2×10^{-6}	9×10^{-11}
U ²³³	3×10^{-6}	9×10^{-11}
Pu ²³⁹	3×10^{-6}	6×10^{-12}
Weapon Debris	See note 1 below	See note 1 below
Any fission mixture (except from weapons) and any mixture of β - γ	10^{-7}	3×10^{-9}
A mixture of emitters	10^{-7}	1.5×10^{-11}
	See note 5 below	See note 5 below

Notes

1. Weapon Debris - the maximum permissible levels are to be:
 - (a) In water - (i) α emitters 10^{-7} $\mu\text{c}/\text{cc}$
 (ii) β - γ emitters Less than 30 days old 6×10^{-4} $\mu\text{c}/\text{cc}$
 More than 30 days old 1×10^{-6} $\mu\text{c}/\text{cc}$

/(b)

(b) In air - (i) α emitters

The concentration shown above for the most hazardous material likely to be found.

(ii) β - γ emitters

$$15 \text{ mins} - 210 \text{ days m.p.l.} = \frac{3.0 \times 10^{-6} \mu\text{c/cc}}{T}$$

where T = Time in hours since the explosion
Above 210 days $6 \times 10^{-10} \mu\text{c/cc}$.

2. The figures given refer to the parent element. Where there is a daughter element, it is assumed that it reaches equilibrium with the parent after it is taken into the body. However, the figure of $3 \times 10^{-7} \mu\text{c/cc}$ for Radon refers to Rn + daughter products in the inhaled air and is thus an exception to the above rule.
3. The curie of natural uranium is considered to correspond to 3.7×10^{10} dis/sec. from U^{238} , 3.7×10^{10} dis/sec. from U^{234} and 9×10^8 dis/sec. from U^{235} . It is considered that none of the other daughter products of U^{238} is present at the time of ingestion or inhalation.
4. The curie of natural Thorium is considered to correspond to 3.7×10^{10} dis/sec. from Th^{232} and 3.7×10^{10} dis/sec. from Th^{230} . It is considered that none of the other daughter products of Th^{232} is present at the time of ingestion or inhalation.
5. The last two values listed are for "unidentified beta or gamma emitters" and unidentified alpha emitters". They are safe for use over short periods of time (a few months) regardless of the radioactive contaminants. They are safe for indefinite use with the following exceptions:
 - (a) $10^{-7} \mu\text{c/cc}$ of water is safe for any mixture of beta gamma emitters and all alpha emitters except Ra^{226} .
 - (b) $3 \times 10^{-9} \mu\text{c/cc}$ of air is safe for any mixture of beta gamma emitters except Sr^{90} .
 - (c) $1.5 \times 10^{-11} \mu\text{c/cc}$ of air is safe for any mixture of alpha emitters except Pu^{239} and Ac^{227} .
 - (d) Fission products arising from nuclear explosions are covered under Note 1 above.

APPENDIX II

METHOD OF MAKING SMEAR TESTS

A Whatman No.1 (5.5 cm) filter paper is used for this test.

The paper is slightly bent around the second finger by the two adjacent fingers so that a small area in the centre of the paper is brought into contact with the surface. It is then rubbed lightly over the area or object being checked.

For Flat Surfaces

Rub paper in a circular motion covering an area of approximately six inches diameter, i.e. approximately 180 - 200 cm².

For Irregular Shaped Objects: Door Handles, Telephones, etc.

Lightly rub paper over whole surface (if small enough), otherwise take a series covering the whole surface.

These "smears" are then placed in a standard type alpha or beta/gamma counter and counted.

Results are usually expressed as disintegrations/minute having applied the necessary factors for counter efficiency.

APPENDIX III

REMOVAL OF RADIOACTIVE CONTAMINATION FROM HANDS

In many cases contamination will be removed by a normal washing of the hands in tepid water using a mild soap.

DO NOT RINSE HANDS IN WASHINGS AS THIS IS LIKELY TO BE CONTAMINATED.

If this procedure is not enough to remove contamination then scrubbing is necessary.

For this you should use the special brush provided in active change rooms.

A convenient routine for scrubbing hands is to start by scrubbing one thumb, being sure to brush all surface; proceed to the space between the thumb and first finger and similarly to each finger and the webs between the fingers.

Close fingers tightly together and scrub in a downward direction from approximately one inch above the wrist, giving attention to the back and palm of the hand, and finally additional scrubbing of the nails and cuticles.

Rinse hands, as before, in fresh water direct from the tap.

This nail brush is most effective when used lightly; any extra pressure of this brush on the hands will only result in bending the bristles out of shape.

Always scrub in a direction away from the body into the basin. This is to prevent splashing of possibly contaminated liquid on your clothes or the floor.

IN ORDER TO PREVENT THE TRANSFER OF ACTIVITY FROM ONE SECTION OF THE HAND TO ANOTHER. THE BRUSH SHOULD BE WASHED IN FRESH WATER AND FRESH SOAP APPLIED AT LEAST THREE TIMES DURING THE SCRUBBING OF EACH HAND.

If the above procedure is not successful, then it should be repeated.

It is advisable to rub a small quantity of ROSALEX No.4 on the hands after a vigorous scrubbing to soften the hands and prevent chapping.

DO NOT USE THIS CREAM BEFORE YOU HAVE SATISFIED YOURSELF THAT YOUR HANDS ARE FREE FROM CONTAMINATION.

It will probably not be necessary to use any more than the above scrubbing, but if contamination is very persistent more drastic techniques are available.

Whether these are used should be decided jointly by the Medical Officer and the Health Controller.

A P P E N D I X I V

1. The only published regulations in the United Kingdom governing the carriage of Radioactive material are those made by the Ministry of Civil Aviation, which are in close agreement with the International recommendations. Regulations governing other forms of Transport have not yet been made. Codes of Practice recommended by A.E.R.E. Harwell have however been adopted by the authorities concerned in the U.K. All regulations and Codes of Practice extant in the U.K. are given in para. 3 below. Health Physics must be consulted about the arrangements for each consignment and will issue any necessary certificates.
2. Where consignments do not comply with the regulations or Codes of Practice, special arrangements must be made with the carrier concerned. Such consignments invariably require one or two escorts. The Health Physics authorities at the Establishment originating the consignment must be consulted about the arrangements for all such consignments, and will, in consultation with the consignor and the carrier, issue written instructions governing the carriage of the particular items.

3 (i) TRANSPORT OF RADIOACTIVE MATERIALS BY RAIL (Code of Practice)

The basic requirement for rail transport is that the radiation at any point on the outer surface of the container may not exceed certain limits; as an interim measure, the railways are accepting packages which fall into two classes:

Class I. Radiation at any point on the surface not greater than 10 milliroentgens per 24 hours.

Class II Radiation at any point on the surface greater than 10 milliroentgens per 24 hours, but not exceeding 100 milliroentgens per eight hours.

Special labels are used to designate these two classes. A class I package does not have to be separated from other freight carried in passenger trains, and is treated by the railways as an ordinary package, except that prior notice must be given to the railway authorities at the station from which it is to be consigned.

Class II packages have to be stowed in passenger trains at least 4 feet from any other goods. The label is designed so that this requirement is brought to the notice of all railway officials handling the package. Prior notice must be given to the railways and on some routes at least .48 hours notice is required.

In order that an adequate check may be kept on the transport of these materials they are usually classed as "Insured Goods" under a special rate. Packages are signed for at the consigning station, and should only be set by direct through routes to their destination.

Arrangements must be made for the immediate collection at the destination and railways will not in any circumstances transport radioactive materials by their own vans. This means that the person to whom the isotopes are consigned should be notified in advance of the time of arrival of the train, and must be able to collect the material at this time from the station.

(ii) TRANSPORT OF RADIOACTIVE MATERIALS BY ROAD (Code of Practice)

- (a) The radiation level at the driver's seat, or at any seat occupied by a passenger, must be below 100 milliroentgens per eight hours ($12\frac{1}{2}$ mr/hr).
- (b) The radiation limit at any point on the outside of the car must be below 200 milliroentgens per hour.

- (c) A notice should be carried in the car stating that radioactive materials are being transported, and are packed in containers in the luggage compartments (or appropriate wording as applicable). An address and telephone number should be given, in order that the police may contact the owners of the vehicle immediately if there is an accident. As an example, the following is a copy of the notice carried by A.R.E. cars:

WARNING
THIS CAR IS CARRYING
RADIOACTIVE MATERIAL
THE MATERIAL IS PACKED IN SEALED CONTAINERS
THE CONTAINERS ARE SAID TO HANDLE FOR
SHORT PERIODS PROVIDED THEY ARE UNDOUBTED
IN CASE OF ACCIDENT TO THIS CAR
COMMUNICATE AT ONCE WITH

Telephone Number:

(iii) TRANSPORT OF RADIOACTIVE MATERIALS BY SEA (Code of Practice)

- (a) Detailed regulations covering the transport of radioactive materials by sea have not yet been published but shipments are permitted subject to the approval of the U.K. Ministry of Transport and in Australia the Department of Defence Production and the State Government concerned.

Gamma radiation should not exceed 200 milliroentgens per hour at any point on the surface of the outside shipping container and 10 milliroentgens per hour at a distance of 1 yard from the container.

- (b) Applications to the Ministry should include the following information:-
- (a) Details of radioactive material including half life.
 - (b) Details of packing used.
 - (c) Radiation at surface of container in milliroentgens per hour
 - (d) Radiation at 1 yard from surface of container in milliroentgens per hour
- (c) Radioactive materials are classified in the U.K. as "Category X-Other Dangerous Goods", as defined in the Merchant Shipping (Dangerous Goods) Rules, 1952. The provisions of Statutory Instrument 1952 No.1977, issued by the U.K. Minister of Transport make it unlawful for dangerous goods to be taken on board any ship unless the owner or master of the ship has been supplied with a declaration of identity, packing and marking of the goods by the shipper. The use of the following standard form of declaration has been agreed by the U.K. Ministry of Transport.

"The herein-mentioned hazardous cargo is described and classified as set out in para.2(1) of the Merchant Shipping (Dangerous Goods) Rules 1952 and we declare that the marking and packing of the goods are in accordance with paras.3 and 4 of the Rules which are reproduced in sub para. (iii) (d) below.

- (d) Paras. 2, 3 and 4 of the Merchant Shipping (Dangerous Goods) Rules
2. -(1) It shall be unlawful for dangerous goods to be taken on board any ship to which this Rule applies for carriage in the ship unless the shipper of the goods has furnished the owner or master of the ship with a statement in writing of the identity of the goods and of the nature of the danger to which the goods give rise, indicating to which of the following categories the goods belong:

- (i) Explosives.
- (ii) Compressed, liquified and dissolved gases.
- (iii) Corrosives.
- (iv) Poisons.
- (v) Substances giving off inflammable vapours.
- (vi) Substances which become dangerous by interaction with water or air.
- (vii) Strong oxidising agents.
- (viii) Substances which are liable to spontaneous combustion.
- (ix) Laboratory chemicals and medicinal preparations in limited quantities.
- (x) Other dangerous goods.

For the purpose of these Rules a laboratory chemical or medicinal preparation shall be treated as being in a limited quantity if and only if the quantity of that chemical or preparation is a limited quantity for the purposes of Section 10 of the Report of the Department Committee appointed by the Minister of Transport to consider the Existing Rules relating to the Carriage of Dangerous Goods and Explosives in Ships, dated 13th November, 1951

- (2) The master of the ship shall cause a list to be carried in the ship setting forth, in accordance with the information furnished under the foregoing provisions of this Rule, the dangerous goods carried in the Ship on the voyage in which she is currently engaged.

Marking

- (3) It shall be unlawful for dangerous goods, being goods contained in a vehicle, receptacle or package, to be taken on board a ship to which this Rule applies for carriage in that ship unless the vehicle, receptacle or package in which the goods are contained is clearly marked with a distinctive label or stencil purporting to indicate the nature of the danger to which the goods give rise, and if the goods are taken on board the ship at any port in the United Kingdom or within the territorial waters of the United Kingdom a label or stencil purporting to indicate the identity of the goods.

Where goods are taken on board a ship together with the vehicle in which they are contained, or where goods are taken on board a ship together with the receptacle in which they are contained, being a receptacle which is an additional body for a vehicle and is constructed or adapted for the purpose of being taken on or off the vehicle with goods contained therein, nothing in the foregoing provisions of this Rule shall be taken to require any such receptacle or any package in which the goods in the vehicle may be contained, or, as the case may be, any package in which the goods in the receptacle may be contained, to be also marked.

Packing and Carriage in Bulk

- 4. - (1) It shall be unlawful for dangerous goods being goods which are not loaded in bulk, to be taken on board any ship to which this Rule applies for carriage in that ship if the owner of the ship or any of his servants or agents knows or ought to know that the goods are not packed in a manner adequate to withstand the ordinary risks of handling and transport by sea having regard to their nature:

Provided that in any proceedings against an owner or master in respect of a failure to comply with the provisions of this paragraph, it shall be a good defence to prove that before the goods were taken on board the ship:

- (a) The owner or master was furnished with a statement in writing by the shipper to the effect that the goods were packed in accordance with the requirements of this paragraph and

- (b) neither the owner nor any of his servants or agents knew that the goods were not so packed.
 - (2) It shall be unlawful for dangerous goods to be loaded in bulk into any ship to which this Rule applies for carriage in that ship if the owner of the ship or any of his servants or agents know or ought to know that the goods cannot safely be carried in bulk to the destination to which they are consigned.
- (iv) TRANSPORT OF RADIOACTIVE MATERIALS BY AIR - MINISTRY OF CIVIL AVIATION REGULATIONS

The following conditions have been adopted by the United Kingdom to govern the carriage of radioactive materials in aircraft. These conditions are basically the same as the conditions recommended by the International Air Transport Association and adopted by the majority of airline companies. Radioactive materials are not classed as dangerous goods as defined in the Air Navigation Order 1949 unless the amount of radioactivity exceeds the maxima stated in the conditions below.

Conditions governing carriage of radioactive materials in aircraft

- (a) The carriage of radioactive materials is permitted in any aircraft in or over the United Kingdom and in any aircraft registered in the United Kingdom when flying outside the United Kingdom subject to compliance with the under-mentioned conditions.
- (b) Radioactive materials are defined as any material or combination of materials which spontaneously emit ionizing radiation. For the purpose of these conditions, radioactive materials are divided into three groups by the type of radiation emitted at any time during carriage as follows:
 - (i) Group I radioactive materials are those materials which emit any gamma radiation, either alone or with electrically charged particles or corpuscles.
 - (ii) Group II radioactive materials are those materials which emit neutrons and either or both of the types of radiation characteristic of Group I radioactive materials.
 - (iii) Group III radioactive materials are those materials which emit only electrically charged particles or corpuscles (i.e. alpha and/or beta radiation).
- (c) A unit of gamma radiation mentioned in these conditions means one milliroentgen per hour at a distance of one metre for "hard gamma" radiation (1 mrhm), i.e. the amount of gamma radiation which will have the same effect on sensitive photographic film as 1 milliroentgen per hour at a distance of one metre of "hard gamma" radiation of radium filtered through $\frac{1}{2}$ inch of lead.
- (d) The maximum quantity of radioactive materials contained in one package for conveyance by either passenger or cargo aircraft shall be 2000 millicuries and the maximum amount of radiation shall be 10 units. Not more than 40 units of radioactive materials Group I and II shall be carried on any one aircraft, provided that no quantity limitation is prescribed for Group III materials.
- (e) All radioactive materials must be packed in sealed inner metal containers. Where the material is liquid it must in addition be packed in tight glass, earthenware, or other suitable inside containers surrounded on all sides, and within the shield, by sufficient absorbent material to absorb the entire contents. The outside shipping container must be a strong, rigid container having a minimum dimension of 4 inches on any one side, and of such design that the gamma radiation will not exceed 200 milliroentgens per hour or equivalent at any point of readily accessible surface.

(f) Radioactive material consignments must be shielded in such a manner that the shield will maintain its efficiency under conditions normally incident to carriage as follows:

- (i) Group I. The shield must be lead or other suitable material of such thicknesses that at all times gamma radiation at 1 metre does not exceed 10 milliroentgens per hour and must also be sufficient to prevent the escape of primary corpuscular radiation to the exterior of the outside shipping container.
- (ii) Group II. The shield must be such that at all times the radiation measured at right angles to any point on the long axis of the shipping container shall not exceed 10 mrhm of gamma radiation, or its physical equivalent in electrically charged corpuscular radiation, or neutron radiation which is the physical equivalent of 2 mrhm of gamma radiation. Where more than one type of radiation is present their total must not exceed the above limits.
- (iii) Group III. The shield must be such as to prevent the escape of primary corpuscular radiation to the exterior of the container, and secondary radiation at the surface of the container must not exceed 10 milliroentgens per 24 hours, at any time during carriage.

(g) The following statement signed by the shipper or his authorised agent must accompany each package of radioactive material:

"This is to certify that the contents of this package are properly described by name and are packed and marked and are in proper conditions for carriage by air according to the regulations relating to the carriage of radioactive material published by.....(carrier(s)).....and otherwise comply with such regulations. This consignment is within the limitations prescribed for passenger-carrying aircraft."

(h) All packages of radioactive materials in Groups I and II shall have attached a label worded as follows:

"Do not place undeveloped film within 15 feet of this container.
Radioactive material.
Group I or II.
No person shall remain within 3 feet of this container unnecessarily.

Principal radioactive content.....

Activity of contents.....millicuries

Radiation units in this package.....

Not more than 40 units shall be loaded in one aircraft or held at one location or point."

(j) The label may be varied in respect of consignments of Group I material handled solely by either the British Overseas Airways Corporation or the British European Airways Corporation where the total number of units carried in one aircraft does not exceed four*. In these circumstances, where the number of units is one or under, the words "15 feet", "3 feet" and "40 units" may be replaced by "5 feet", "1 foot" and "1 unit" respectively. Where the number of units is over one but does not exceed four, the words "15 feet", "3 feet" and "40 units" may be replaced by "10 feet", "2 feet" and "4 units" respectively.

*Note In Australia aircraft of the internal airlines may carry a maximum of two packets containing RA materials.

(k) All packages of radioactive materials in Group III shall have attached a label worded as follows:

"Handle carefully
Radioactive material
Group III
Contents.....
Emitting corpuscular rays only."

WING TIP SERVICE

Limited amounts of gamma emitting radioactive materials can be transported without lead shielding, in the wing tips of DC4 aircraft operated by South African Airways to South Africa, and in Argonaut aircraft operated by British Overseas Airways Corporation to the Near East, Middle East, Far East and South America. The maximum amount of radioactivity permitted depends upon the intensity of gamma radiation and flying time involved, but in no case can it exceed 300 millicuries. A standard size cylindrical wing-tip container, 1.7 inches diameter and 5.2 inches length, is in use which automatically restricts the physical quantities of materials which can be transported in this manner. Nevertheless, small amounts of radioactive materials can be transported long distances by wing-tip service at a lower cost than that involving the orthodox use of lead pots and wooden boxes.

Special handling procedures are used in the wing-tip service. Aircraft are loaded and unloaded by the airlines or their agents, but users must possess a suitable shielding container into which the wing-tip cylinder containing the radioactive material can be loaded at airport of arrival and transported safely to its final destination.

(v) POSAL TRANSPORT OF RADIOACTIVE MATERIALS (Code of Practice)

- (i) The packages used must have been approved by the G.P.O. Engineering Section.
- (ii) That the radiation at any point on the surface of the package is not greater than 10 milliroentgens per 24 hours.

4. REFERENCES.

(a) Published in the United Kingdom

- (1) A.E.R.E. Radioactive Materials and Stable Isotopes Catalogue No.3, July 1954.
- (2) Merchant Shipping (Dangerous Goods) Rules, 1952. Statutory Instrument 1952 No.1977
- (3) Ministry of Transport - The Carriage of Dangerous Goods and Explosives in Ships (The Blue Book)
- (4) Ministry of Civil Aviation - Conditions governing the carriage of radioactive materials in aircraft.
- (5) Recommendations of the International Commission on Radiological Protection.

(b) Published in Australia