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ROYAL AUSTRALIAN AIR FORCE

MEDICAL BRANCH

MEDICAL MEMORANDUM

No 13.

(132/1/1295)

Declassified [redacted] 22/[redacted]

Department of Air
Melbourne S.C.1

27th July, 1956

The following Medical Memorandum in hereby promulgated for information and guidance and necessary action by all medical officers.

R.A.A.F.

RADIOLOGICAL SAFETY REGULATIONS

Introduction

Undue exposure of the body to ionising radiation may have serious consequences on health. The risk of such exposure has greatly increased in recent years with the ever increasing applications of atomic energy.

R.A.A.F. personnel who are posted to units connected with atomic energy trials may run the risk of exposure to ionising radiation. further, since radio-active sources are now being used to train personnel in defence against harmful radiation from atomic weapons, this could similarly be a health hazard.

SERIOUSNESS OF RADIOLOGICAL HAZARDS

The serious nature of radiological hazards calls for the most scrupulous observance of precautions. Radium, for instance, is continuously active, sending off radiations at all times, and precautions must constantly be observed to protect personnel and equipment.

In order that personnel working in a radio-active area may be properly informed as to the hazards and the safety measures to be observed, initial and continued indoctrination must be provided. It is particularly important that persons in immediate charge of working parties be aware of their specific responsibilities with regard to the supervision and execution of safety measures.

Various aspects of radiological safety, particularly maximum permissible exposure levels (MPE), are constantly being studied and revised, and changes will be necessary for some time to come. As quickly as possible such changes will be issued in conection with this memorandum.

The maximum permissible levels listed in this memorandum are based primarily on the recommendations of the International Commission on Radiological Protection published in British Journal of Radiology, Supplement No.6 (1955) and on similar recommendations made by the Medical Research Council. They have been endorsed by the Health Panel of the Authority

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at a meeting with the consultants to the Project Health Committee.

All exposures to radiation and to radio-active substances must be kept to the lowest practicable levels and no unnecessary exposures should be incurred. No exposure may exceed the permissible levels detailed below.

It shall be understood that, unless stated otherwise, all maximum permissible levels refer to the total exposure of the part of the body under consideration, as a result of simultaneous or successive exposures to one or more types of radiation from external or internal sources. In general, therefore, exposures of all kinds must be treated as additive in effect unless stated otherwise or unless, in a particular case, the exposures can be shown to be different parts of the body.

Nature of Examination.

Scope. The pre-employment examination will be a complete physical examination, including blood examination, urinalysis, breath samples, and chest X-ray. If a similar examination has been conducted within the past six months, it will be accepted, provided a record of such examination is available as part of the individual's record".

"If a similar physical examination has been conducted within the past six months and an X - Ray of chest within the past twelve months, it will be accepted, provided a record of such examination is available as part of the individual's record".

History. During the :-

(a)

(b) Any previous unusual radiation exposure (occupational)

(c) Any doses previously received as a result of X-ray diagnostic examinations or radiation therapy (including infancy and childhood).

Blood Examination.

A complete blood count, including a leukocyte differential count will be made on three successive days prior to lunch for the purpose of establishing a normal baseline for later use in the evaluation and detection of early radiation injury.

Urinalysis.

At present facilities for radio-chemical urinalysis are not available, but when this is possible it should be done in the case of persons who have previously been engaged in handling radioactive substances.

Breath Samples.

When facilities are available at the Commonwealth X-ray and Radium Laboratories breath samples for the determination of radon concentration shall be taken for personnel who will be engaged in the handling of radium salts or compounds which are not hermetically sealed.

PHYSICAL REQUIREMENTS.

General.

The general [illegible] standard.

Disqualifying Findings.

In addition to failure to meet the general physical requirements the following findings are considered disqualifying.

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Exposed Wounds.
Exposed wounds (whether lacerations, abrasions, or ulcerations) are considered disqualifying for personnel handling radi-active materials which are not hermetically sealed. Personnel with exposed wounds or open lesions are never to be permitted to work in a contaminated area.

Blood Abnormalities.
Total white blood cells counts below 4,000 or above 12,000 are disqualifying.
In cases where abnormal white cell counts may be due to transient diseases or other temporary conditions, re-examinations shall be made upon recovery.
Also disqualifying are total red blood cell counts below 3.5 million or above 6.5 million and persistently abnormal leukocyte differential counts.

Urine.
The presence of plutonium, uranium, or radio-active rare earths in the urine disqualifies a person for employment.

Breath.
The presence of more than 5×10^{-13} curie per litre of radon in expired air is disqualifying.

Other.
Any evidence of previous radiation injury which is considered disqualifying by the medical examiner shall bar a person from employment.

Follow up Examination.

When Conducted.
Personnel engaged in work involving regular exposure to ionising radiation or handling of radio-active materials shall be re-examined at the discretion of the [illegible] at intervals of not more than 4 months.

Nature of Signs
"After personnel are removed from any further risk of such radiation such personnel will receive a complete follow-up examination every six months for a period of two years."
[illegible] such as lack of vitality, loss of appetite, weight loss, cracking of the skin on fingers, and excessive longitudinal corrugation and brittleness of the finger nails. These findings shall be recorded on Form A.F. Med. 12 and record of exposure to radiation form.

Tests for Chronic Radiation.

Blood Counts.
Complete blood counts, including leukocyte differential counts, shall be made when indicated, at intervals not greater than 4 months. The specimens shall be collected immediately prior to lunch.

Urinalysis.
Where appropriate, radi-chemical urinalysis shall be made at intervals of 4 months.

Breath Samples.
When facilities are available breath samples shall be collected at intervals of six months from personnel engaged in the handling of radium salts or radium compounds which are not hermetically sealed.

Exceptions.
Chest X-rays and routine urinalysis are not considered an essential part of the re-examination of individuals engaged in working with radio-active materials or radiation unless specifically indicated.

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SPE[illegible]L OR EMERGENCY EXAMINATIONS

Over-Exposure to External Radiation.
An individual receiving external radiation greater than 25 [illegible] gens in a single exposure requires immediate hospital evaluation.

Possible Over-Exposure to Internal Radiation.
In the event of personnel who may possibly be exposed to ingestion or inhalation of significent amounts of radio-active material, special radio-chemical examinations shall be performed as indicated.

Abnormal Findings.
Individuals showing abnormal findings in any special or routine follow-up examinations shall be removed from further exposure to radiation and given an exhaustive examination. A full report on each known case will be submitted as soon as possible to the Director-General of Medical Services.

Examination Findings.
The results of physical and laboratory examinations given preliminary to the individual's commencing work, also interim and final examination shall be recorded on the Personal Record of Exposure to Radiation form, A.F. Med.12 and Form P/M.5 where applicable.

Duplicates of the Personal Record of Exposure to Radiation form shall be forwarded normally every three months to the Director-General of Medical Services through the usual channels. Originals of the above mentioned form will be placed in the members A.F. Med.4.

A copy of the new form - "Personal Record Of Exposure to Radiation" is at Appendix "A".

MAXIMUM PERMISSIBLE LEVELS OF OCCUPATIONAL EXPOSURE TO EXTERNAL RADIATION

Whole Body Exposure.
Exposure of the trunk, not necessarily involving exposure of the extremities, shall be deemed to be whole body exposure.

Exposure to Gamma Radiation up to 3 MeV.
0.3 rads per week measured in air at the surface of the body or in free air.

The Rad.
The unit of absorbed dose, is 100 ergs per gramme of absorbing material and may be taken as numerically equivalent to the roentgen for protection purposes for gamma radiation up to 3 MeV.

Exposure to Gamma Radiation above 3MeV.
0.3 rads per week in any part of the body. The corresponding weekly dose in air at the surface of the body will be less than 0.3 rads per week.

Exposure to Beta Radiation.
1.5 rads per week measured in air at the surface of the body. Additional protection of the eyes must be provided in cases where the weekly dose is regularly above 2 MeV, in order to reduce the dose to the lens of the eye to the maximum permissible dose of 0.3 rads per week.

Exposure to Neutrons up to 10 MeV.
Exposure to the neutron fluxes, averaged over a period of 40 hours per week, listed in Table 1.

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Table 1

Neutron Energy	Neutron Flux ($n/cm^2/sec$)
Thermal to 10 eV	2000
10 KeV	1000
0.1 MeV	200
0.5 MeV	80
1.0 MeV	60
2.0 MeV	40
3 to 10 MeV	30

Partial Exposure of the Body.
The term partial exposure is used to mean exposure of the hands and forearms, feet and ankles and head and neck.

The following maximum permissible exposures include any exposure due to whole body irradiation and may be applied whether or not whole body exposure is also incurred.

Partial Exposure to Gamma Rays up to 3 MeV.
Hands and forearms, feet and ankles - 1.5 rads per week in air at the surface of the tissue.

Head and neck, excluding eyes - 1.5 rads per week in air at the surface of the tissue.

Eyes - 0.3 rads per week in the lens.

Partial Exposure to Gamma Rays above 3 MeV. As for whole body.

Partial Exposure to Beta Rays. As for whole body.

Partial Exposure to Neutrons up to 10 MeV. As for whole body.

Exposure to Mixture of Beta and Gamma Radiation.
In cases when the beta exposure of the lens of the eye is negligible the maximum permissible dose measured in air at the surface of the body is 1.5 rads per week, of which not more than 0.3 rads per week shall be due to gamma radiation.

In cases where the beta exposure of the lens of the eyes can be neglected, and cannot be assessed, the maximum permissible weekly is 0.3 rads per week in air at the surface of the body.

Permissible Dose Rates.
No upper limit to the radiation dose rate has yet been laid down, provided that the maximum permissible weekly doses are not exceeded. However, because of the difficulty of keeping adequate control of exposure times, exposure to dose rates above 10 rads per hour should deliberately incurred only in exceptional circumstances. In this context, dose rate is taken as the mean dose rate over a few seconds.

Although weekly doses, rather than dose rates, should be used in evaluating possible hazards, it is often convenient in the course of measurements to consider a dose rate of 10 milli-rads per hour in air as a level equivalent to the maximum permissible level of 300 millirads per week in tissue for occupational gamma exposure of the whole body.

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Table 2.

Maximum Permissible Concentrations in Air and Water.

Nuclide	Continuous m.p.c. (Parent uc/ml)		40 hr week m.p.c. (Parent dis/min/m3)
	Water	Air	Air
H^3 (as H_2O)	0.2	10^{-5}	7×10^{7}
C^{14} (as CO_2)	3×10^{-3}	10^{-5}	7×10^{7}
Na^{24}	8×10^{-3}	10^{-6}	7×10^{6}
P^{32}	2×10^{-4}	10^{-7}	7×10^{5}
A^{41}	5×10^{-4}	5×10^{-7}	3×10^{6}
Ca^{45}	10^{-4}	8×10^{-9}	5×10^{4}
Co^{60}	4×10^{-4}	8×10^{-8}	5×10^{5}
Cu^{64}	5×10^{-3}	9×10^{-7}	6×10^{6}
Sr^{89}	7×10^{-5}	2×10^{-8}	10^{5}
Sr^{90} (+Y^{90})	8×10^{-7}	2×10^{-10}	10^{3}
Zr^{95} (+Nb^{95})	6×10^{-4}	8×10^{-8}	5×10^{5}
Ru^{106}(+Rh^{106})	10^{-4}	2×10^{-8}	10^{5}
I^{131}	6×10^{-5}	6×10^{-9}	4×10^{4}
Cs^{137}(+Ba^{137})	2×10^{-3}	2×10^{-7}	10^{6}
Ce^{144}(+Pr^{144})	10^{-4}	2×10^{-9}	10^{4}
Au^{198}	6×10^{-4}	10^{-7}	7×10^{5}
Po^{210}	3×10^{-6}	10^{-10}	700
Rn^{222} + dr	-	10^{-7} (total uc)	7×10^{5} (total disintegrations)
Ra^{226} (+dr)	4×10^{-8}	8×10^{-12}	50
Ac^{227} (+dr)	3×10^{-6}	4×10^{-12}	30
Th natural	5×10^{-7}	3×10^{-11}	400
U. natural	2×10^{-6}	3×10^{-11}	400 (total disintergrat
U. enriched	4×10^{-6} (total uc)	6×10^{-11} (total uc)	400 (total disintergrat
U^{233}	3×10^{-6}	3×10^{-11}	200
Pu^{239}	3×10^{-6}	2×10^{-12}	10
Any fission product mixture	10^{-7}	10^{-9}	7×10^{3}
Any mixture of a emitters	10^{-7}	5×10^{-12}	30

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Over exposures.

As far as is practicable any of the weekly doses listed must be treated as the maximum permissible dose in any one week, some degree of averaging over successive weeks will, however, sometimes be necessary.

In the case of any exceptional exposure of a radiological worker in any one week to a dose in excess of the maximum permissible weekly amount recommended by the International Commission on Radiological Protection, an average weekly dose shall be assessed for the irradiation of the worker during the 13 weeksprior to , and including, the week in which overexposure occurs. If this average value exceeds the maximum permissible weekly value, the worker shall be placed under medical supervision and his duties shall be re-arranged so as to involve considerably less exposure for a compensatory period. If the average weekly value of the 13 weeks in question is less than the maximum permissible weekly value, the worker can contiue on normal duties.

MAXIMUM PERMISSIBLE LEVELS OF OCCUPATIONAL EXPOSURE TO RADIO-ACTIVE SUBSTANCES IN AIR AND WATER.

Occupational maximum permissible levels are usually estimated for contiuous exposure. For occupational exposure limited to 40 hours per week the figures may be increased by a factor of three.

Maximum Permissible Concentrations.

A few more useful figures are listed in Table 2.

Some beta emitters in chemical forms insoluble in lung fluids have lower maximum permissible concentrations in air than those tabulated

All the figures tabulated have been rounded off to one significant figure.

All the figures tabulated refer to average concentrations. NO particular harm is to be expected if these values are exceeded for a short period of time - a few weeks, and no readily detectable biological damage is expected to result if the average body burdens or the average concentrations over a long period do not exceed the maximum permissible values. In particular, exposures of individuals for a few days to air and water concentrations 10 times those listed would not be any cause for alarm provided the average concentration over any interval of a year does not exceed these recommended values.

The figures quoted for unidentified mixtures of fission products and of alpha emitters should not be used for periods of more than a few months unless seperate consideration can be given to the concentrations of radium 226, plutonium 239, actinium 227 and stronium 90.

Over Exposures.

Because and individual's integrated exposure to radioactive substances cannot be assessed by any convenient form of personnel monitoring, efforts must be made to avoid high transient concentrations. However, such transient concentrations need be treated as significant overexposures only if they are likely to result in a body burden in excess of the maximum permissible, or in a tissue dose which exceeds weekly dose when averaged over 13 weeks.

Average concentrationsof radio-active substances in drinking water and air must be controlled to levels below the appropriate maximum permissible levels. Alternatively, if this is impracticable, the water must be declared unfit for drinking

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access to the area in which there is contaminated air must be controlled so that the average daily intake is less than the maximum permissible daily intake. The maximum permissible daily intake can be obtained from the "continuous m.p.l." column of Table 2 by assuming a daily intake (24 hours) of cubic metres of air.

MAXIMUM PERMISSIBLE LEVELS OF SURFACE CONTAMINATION BY RADIO-ACTIVE CONTAMINANTS.

The basic maximum permissible levels of surface contamination are expressed as microcuries per unit area. In practice it is convenient to relate those to counting rates on the commonly available contamination monitors. The relationship depends on the energy of the radiation emitted by the contaminant and on the physical state of the surface as well as on the way in which the monitor is used. The figures shown in Table 3 are typical and may be used to convert the basic m.p.l's. to counting rates

Table 3

Conversion Table

Typical Counting Rates Equivalent to a Uniform Surface Contamination of 10^{-4} uc/cm^2

Type of Probe	Counting rate (counts per sec.)
Type ~~1021~~ 1257c Standard beta	5
Standard alpha	3
End Window beta	1.5
Type ~~1027~~ 1257k Standard beta	5
Standard alpha	3
Standard alpha, selected and modified.	10
Type ~~1021~~ 1257c Floor probe, alpha	30
Large area floor probe, beta	25

Hands.

The following maximum permissible levels for hand contamination apply to any contaminant and to prolonged periods. They apply to contamination during working hours and also to residual contamination. The main limitation is set by irradiation of the skin and since exposure to external radiation may also be incurred the levels should be regarded as far as practicable as upper limits rather than average maximum permissible levels.

Alpha Active Contaminants

10^{-5} microcuries per hand or 1 m.p.l. on installed hand monitors.

Beta Active Contaminants

3×10^{-2} microcuries per hand or 1 m.p.l. on installed hand monitors.

Skin on Other Parts of Body

Alpha Active Contaminants

3×10^{-6} microcuries per square centimetre (uc/cm^2) averaged over 30 cm^2

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Be Active Contaminants

10^{-4} uc/cm^2 averaged over 30 cm^2

Inanimate Surfaces.

Radio-active contamination on inanimate surfaces is not a direct danger to health unless it causes levels of external radiation or of radio-active materials in air to exceed the maximum permissible levels, or unless it may be directly, or indirectly, ingested. The maximum permissible levels of surface contamination in Table 4 are such that in no normal circumstances will any of the basic maximum permissible weekly doses be exceeded and in many circumstances they will not be approached. Thus, although the levels in Table 4 should not normally be exceeded, higher levels may be acceptable in particular cases where, because of adequate control measures, or for other reasons the basic maximum permissible weekly doses are not exceeded. In particular, contamination levels in areas accessible only to people suitably protected by special protective clothing, e.g. pressurised suits, may properly be allowed to exceed the levels in Table 4.

Table 4

Summary of m.p.l.'s of Surface Contamination

Site	Size of affected area	Contaminants	M.P.L. (uc/cm^2)
Inactive Locations and Blue Contamination Areas	Widespread Areas	Pu Ra Ac Po	10^{-5}
		Other Alphas	10^{-4}
		All Betas	10
	Limited Areas (see note 1)	Pu Ra Ac Po	10^{-4}
		Other Alphas	10^{-3}
		All Betas	10^{-3}
Red Contamination Areas	Any size of area	Pu Ra Ac Po	10^{-4}
		Other Alphas	10^{-3}
		All Betas	10^{-3}

Notes:

Blue Contamination areas are those in which contamination is unlikely to reach hazardous levels.

Red Contamination Areas are those in which the normal procedure in the area may sometimes give rise to Hazardous levels of contamination of surfaces and of inhaled air.

Limited areas are those covering less than about 100 cm^2 in each square metre of surface. The relaxation for such areas should be applied with discretion, particularly if the surface is liable to frequent handling.

Articles below 1 m.p.l. (Blue contamination area, may be regarded as free from significant contamination and may be removed to inactive locations.

All figures in Table 4 apply to contamination which is only loosely attached to the surface. When the future use of an article is known it may be possible to allow a relaxation for firmly fixed contamination

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A the figures in Table 4 are based on the need for safeguard ha... In practice they prove adequate in most cases to avoid interferenc... with technical work. However, in few cases where very sensitive me... ments of radiation are involved additional care should be taken t... rol the entry of articles from Restricted Areas.

MAXIMUM PERMISSIBLE LEVELS OF NON-OCCUPATIONAL EXPOSURE TO RADIATION AND RADIO-ACTIVE SUBSTANCES.

The exposure of individual members of the general public ... any other workers, who have not been declared fit for occupational ... sure to radiation shall be known as non-occupational exposure.

In the case of prolonged non-occupational exposure to ma... permissible levels shall be reduced by a factor of not less th... ow those accepted for occupational exposure

RELATIVE BIOLOGICAL EFFECTIVENESS

The relative biological effectiveness (RBE) applicable to expos... ure to radiation from external sources is given in Table 5.

Table 5

RBE VALUES

Radiation	RBE	Biological effect
X-rays, gamma rays electrons, and beta rays of all energies.	1.0	Whole-body-irradi... (blood forming org... critical).
Fast neutrons and protons up to 10 MeV	10	
Naturally occuring alpha particles	Compare with 0.1 microcurie Ra, otherwise =10.	Carcinogenesis
Heavy recoil nuclei	20	Cataract formati...

The following are the approximate values of dose received b... nearer skin surfaces in diagnosite X-ray Examinations.

Chest, posterior - anterior	0.1r
Chest " (photofluroscopic X-Ray)	1.0r
Lumbar spine, anterior-posterior	1.5r
" " , lateral	5.7r
Pelvis	1.1r
Pregnancy, anterior - posterior	3.6r
Kidney - ureter - bladder	1.2r
Women	1.3r
Gastro - intestinal series (6 films)	4.0r
Gall - bladder	0.6r
Extremities	0.3r
Skull, posterior - anterior	1.3r

AIR BOARD ORDER SECTION 125/54

RADIOLOGICAL SAFETY IN RELATION TO THE RESULTS OF ATOMIC EXPLOSIONS

A.B.O. "A"125/54 is being amended to include revelant information covered in this memorandum.

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