INTERNATIONAL ATOMIC ENERGY AGENCY
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION

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College on Medical Physics

(10 October - 4 November 1988)

Medical Physicist and Radiation Accidents

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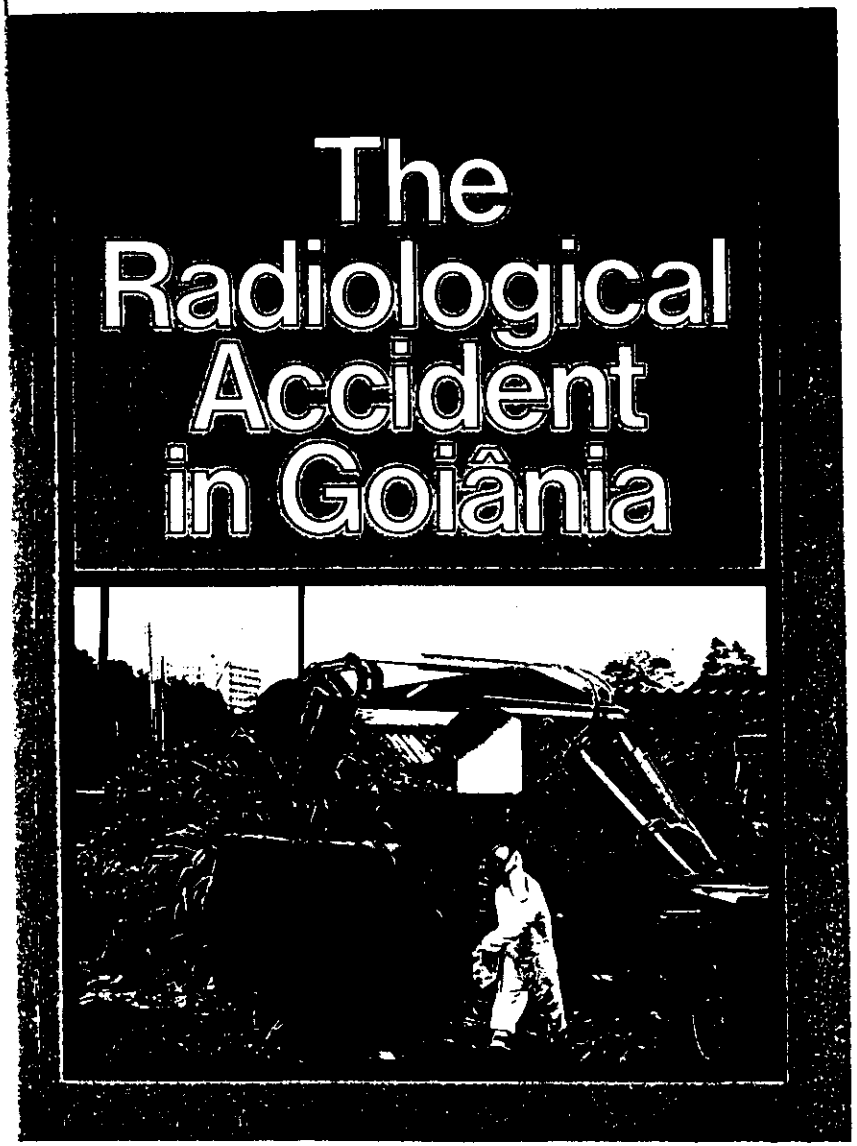

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SERIOUS RADIATION ACCIDENTS REPORTED (1945 - 1987)*

Type of facility	No. of events	Overexposures**	Deaths
Nuclear facilities	27 (34%)	272 (64%)	35 (59%)
Non-nuclear facilities			
Industry	42 (52%)	84 (20%)	20 (34%)
Research	7 (9%)	10 (2%)	- (-)
Medical	4 (5%)	62 (14%)	4 (7%)
	80 (100%)	428 (100%)	59 (100%)

*Taken from IAEA Report "The radiological accident in Goiania, Brazil", STI/PUB 815, ISBN 52-0-129088-8, Vienna (1988).

**An overexposure is taken here as exposure of the whole body forming organs or other critical organs to 0.25 Sv or more; of skin to 6 Sv or more; other external exposure of 0.75 Sv or more; and internal contamination of half or more of the "maximum permissible organ burden". (The concept of the "maximum permissible organ burden" has now been superseded by the concept of the "annual limit of intake").The table excludes patient related events and off-site exposures at Chernobyl.

ATAL RADIATION ACCIDENTS REPORTED (1945 - 1987)*

ar	Location	Radiation source	Fatalities	
			Worker	Public
45	Los Alamos, USA	Critical assembly	1	
46	Los Alamos, USA	Critical assembly	1	
58	Vinca, Yugoslavia	Experimental reactor	1	
58	Los Alamos, USA	Critical assembly	1	
61	Switzerland	Tritiated paint	1	
62	Mexico City, Mexico	Lost radiography source		4
63	China	Seed irradiator		2
64	Germany,Federal Rep.of	Tritiated paint	1	
64	Rhode Island, USA	Uranium recovery plant	1	
75	Brescia, Italy	Food irradiator	1	
78	Algeria	Lost radiography source		1
81	Oklahoma, USA	Industrial radiography	1	
82	Norway	Instrument sterilizer	1	
83	Constituyentes, Argentina	Research reactor	1	
84	Morocco	Lost radiography source		8
86	Chernobyl, USSR	Nuclear power plant	29	
87	Goiania, Brazil	Removed teletherapy source		4
otal: 18 events with 59 fatalities			40	19

n nuclear facilities and non-nuclear industry, research and medicine
xcluding patient related events). Taken from IAEA Report "The radiological

(4) Information that could be valuable in the assessment of abnormal exposures will come from the clinical course of the exposed workers, from biological and biochemical studies, from physical dosimetry and from statements made by persons actually or potentially exposed. No one member of the radiation protection team needs to have a detailed knowledge of all these aspects but there must be general understanding of them by all members of the team supported by close collaboration between those with differing responsibilities.

(11) The higher the estimated dose, the more important becomes the need for accuracy of dose estimation through the combination of clinical, biological, biochemical and physical assessments. If clinical signs and symptoms become apparent these may be a more important guide to initial treatment than the early estimate of dose. Depending on the early estimates of the dose and their accuracy, a decision will have to be made on the possible reconstruction of the circumstances of the abnormal exposure. Such reconstructions will sometimes be simple, but, in other cases, may involve a major research effort. Each case should be considered on its merits.

Physical dosimetry for external exposure

(14) Personal dosimeters normally provide an indication of the dose to an exposed worker only at a single part of the body. Such information may not be representative of an abnormal exposure incurred by a worker. Accordingly, the data obtained from a personal dosimeter worn by a worker incurring an abnormal exposure should be interpreted with care and in the light of information about the circumstances of exposure. If any form of reconstruction of the abnormal exposure is made, it should be directed towards providing information on the radiation fields, so that the absorbed dose and the mean quality factor in the body may be obtained. In the case of exposure to neutrons, activation products in the body or its components (e.g. blood or hair) or items carried on the body (e.g. metal objects) will be useful in supplementing the more routine forms of personal dosimetry and in identifying those who have been exposed to high levels.

(15) If preliminary assessments suggest that the dose to the exposed worker has been high, then a detailed evaluation of the dose received by the exposed worker should be treated as an urgent investigational problem with additional staff assigned to the investigation if necessary.

(16) The importance of physical dosimetry, as a contribution to the medical care of the worker incurring abnormal external exposure, will depend on the level of dose and the availability to the physician of other information. Any early indication of grossly non-uniform irradiation will be particularly valuable.

Physical dosimetry for internal exposure

(17) Valuable information about the degree of internal contamination, and hence about the committed dose, may be obtained by the use of a wound probe, an external probe, an organ scanner, or of a whole body monitor. Data obtained by such direct measurement methods should be supplemented, as appropriate, by the radiochemical assay of urine and faecal samples and, in some cases, blood samples. Arrangements should be made to obtain the required samples. The frequency of subsequent sampling should be based on the results obtained in the radiochemical assays of the samples taken in the first few days.

EXPECTED RISK TO SPECIFIC ORGANS AND TISSUES FROM THERAPEUTIC IRRADIATION

(86) Radiation therapy, particularly for neoplastic diseases, often requires doses sufficiently high that risk of clinically significant injury is not always avoidable. The risk(s) may be either of a stochastic or nonstochastic type (*ICRP Publication 26*, para. 7). While nonstochastic effects are most likely to occur within the direct treatment beams where radiation doses are greatest, the stochastic effects, e.g. cancer or hereditary detriment, may result from radiation in the direct beams or from scattered or leakage radiation outside the direct beams. Every organ or tissue will suffer clinically significant injury if irradiated with a sufficiently high dose.

Digestive system

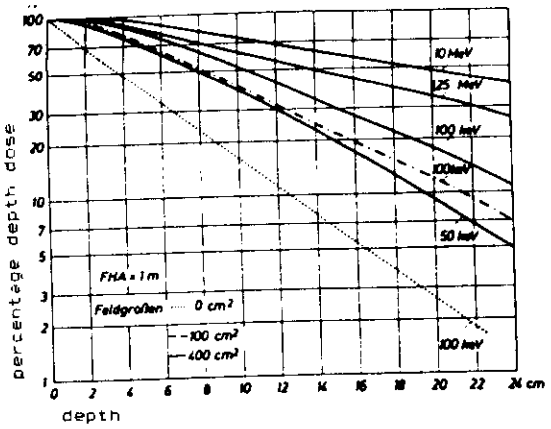
(88) The squamous cell mucosa of the oral cavity, pharynx, oesophagus and anus resembles skin in its response to therapeutic irradiation, while the glandular mucosa of the stomach and small and large intestines is less tolerant of radiation exposure (Roswit *et al.*, 1972; UNSCEAR 1982).

(89) In the normal adult the epithelium lining the small intestine is the most rapidly renewed tissue in the body. New epithelial cells are formed by division of precursor cells deep in the intestinal crypts. They migrate up the crypts to cover the projecting villi, being shed into the intestinal contents at the end of a life of only 6–7 days. Irradiation of the small intestine may result in the temporary or permanent cessation of division in the crypt "stem" cells and, as the villus cells are shed, causes the villi to shorten as a result of the failure of new epithelial cells to appear. Reduction in villus height decreases the surface area available for absorption of intestinal contents. If sufficient bowel is involved, the clinical syndrome of increased rate of transit, diarrhoea, and malabsorption may result. Irradiation of the whole small bowel with a single dose in excess of 10 Gy will result in death due to loss of the epithelial covering of the intestinal lumen. Fractionated doses of up to 40–45 Gy/30 fractions/70 days to the whole intestine may be tolerated with only transient diarrhoea.

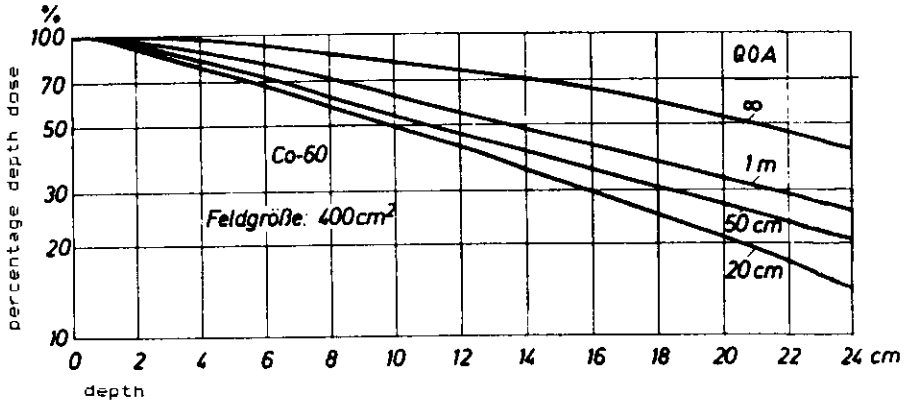
Nonstochastic Radiation Injury to Normal Tissues and Organs

Skin

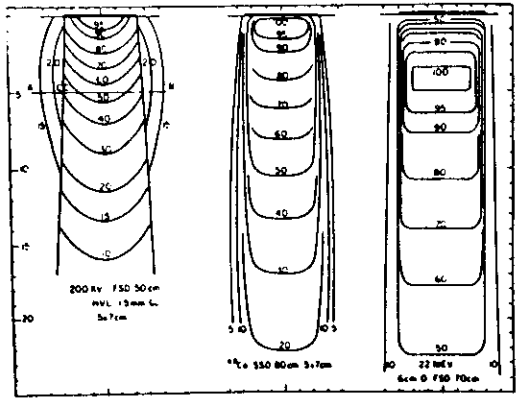
(87) Visible effects in the skin, such as altered pigmentation, may occur after irradiation with cumulative absorbed doses of 15–20 Gy, even when the total dose is delivered in fractionated doses over weeks to limited areas of skin (Wells and Charles, 1979). During irradiation by a single radiation beam with x rays of an energy of ≤ 400 keV (see para. 21) the maximum dose is delivered to the skin; the total radiation dose that can be delivered without severe late changes is approximately that which produces early (up to about 2 weeks after exposure) dry or moist desquamation of the epithelium.



Influence of energy and field size on depth dose



Influence of souce distance on depth dose



Fixed field isodosen

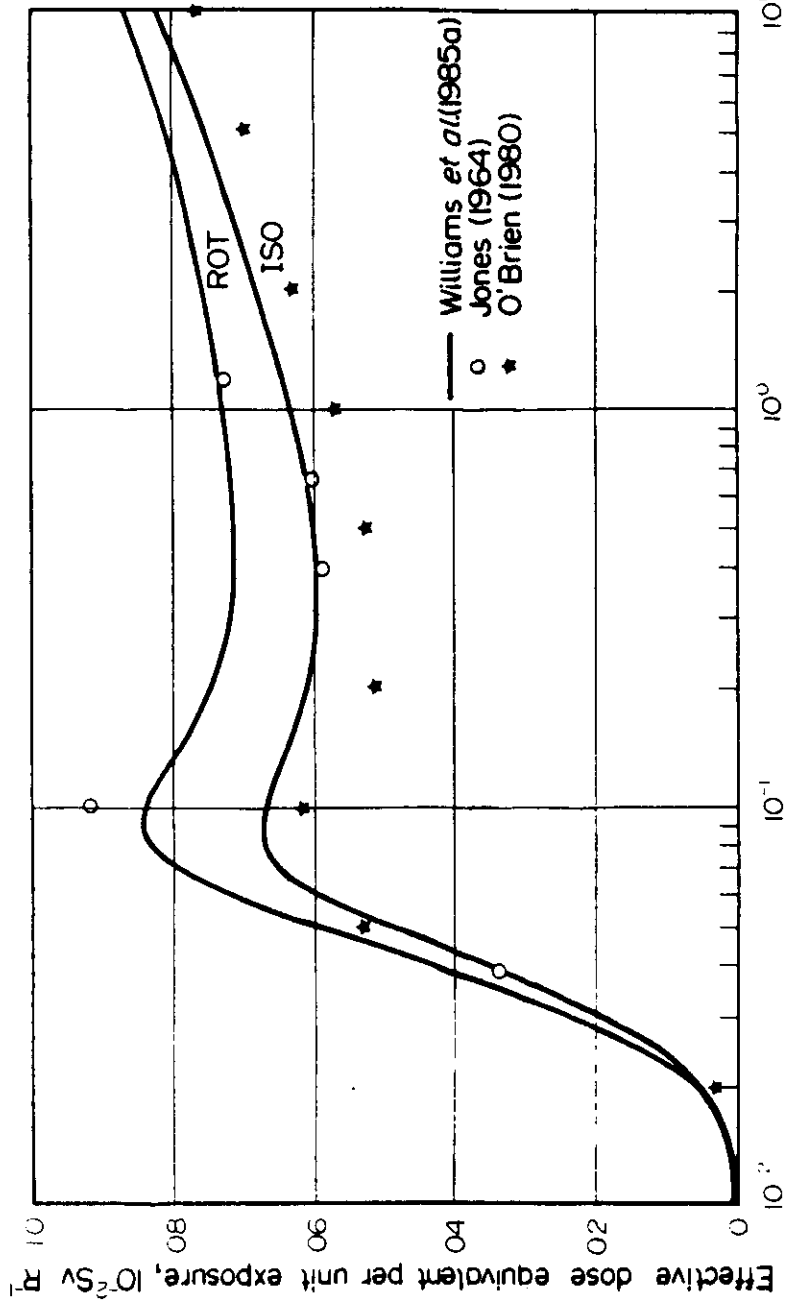


Fig. 4b Effective dose equivalent per unit exposure in free air for photons incident on various geometries on an anthropomorphic phantom. See footnotes of Table 3 for further information

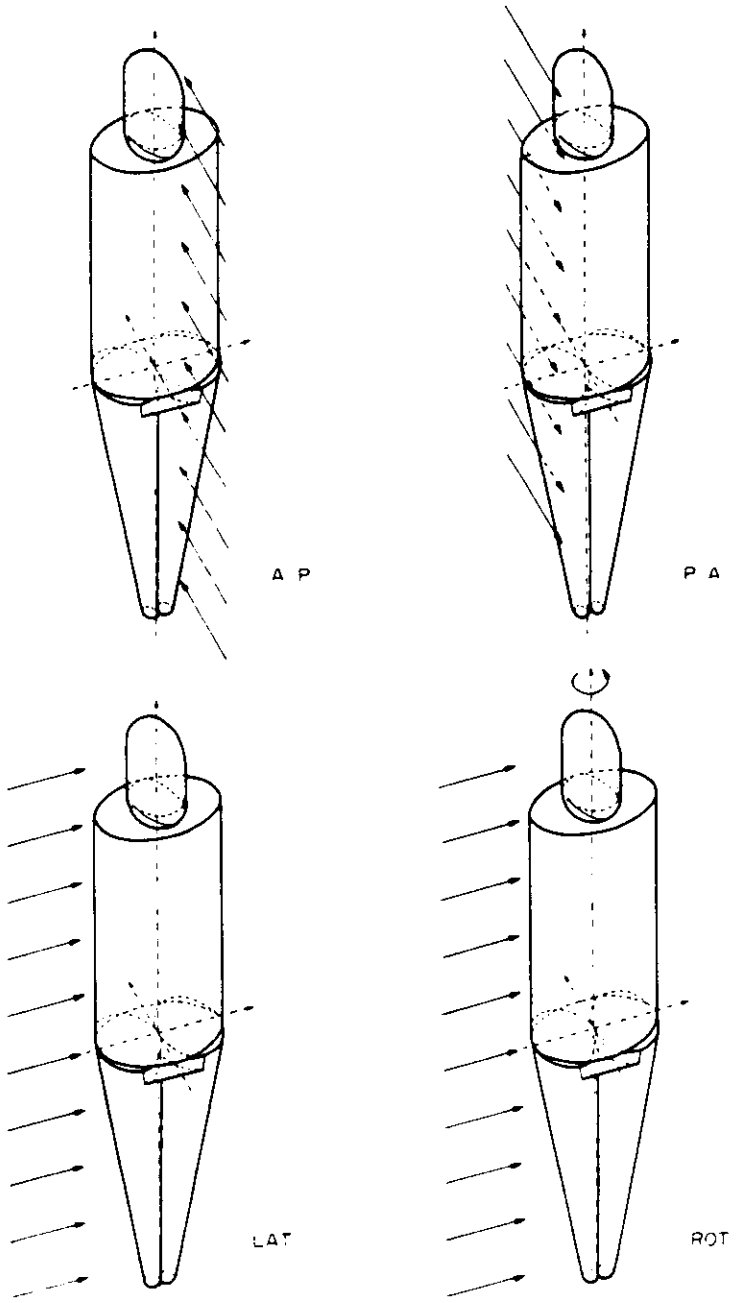


Fig. 1. Some irradiation geometries with an anthropomorphic phantom

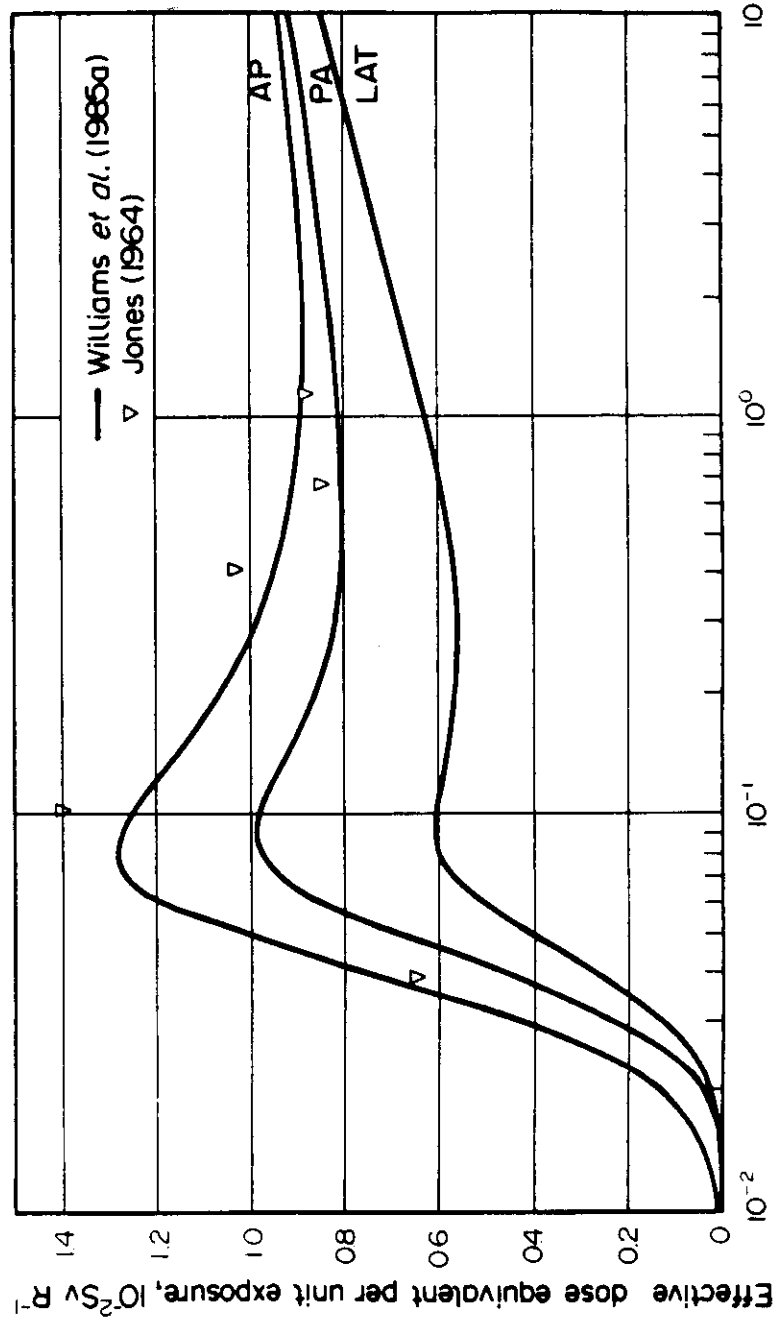


Fig. 3a Effective dose equivalent per unit exposure in free air for photons incident in various geometries on an anthropomorphic phantom. See footnotes of Table 3 for further information.

THE EFFECTIVE DOSE EQUIVALENT H_e

The risk weighted body dose equivalent H_{eff} was first numerically specified by the effective dose equivalent H_E,

and $$\frac{f_T}{\sum_T f_T} = \frac{f_T}{f_{WB}} = w_T \text{ from ICRP 26}$$

where $\sum_T f_T = f_{WB} = 1.65 \times 10^{-2}\ Sv^{-1}$.

The total body detriment G is, therefore, in this case $G = 1.65 \times 10^{-2}$. H_E with the effective dose equivalent H_E in sievert.

Weighting factors w_T from ICRP 26, weighting factors w_T^* of specific organ groups and corresponding sum of risk factors.

Tissue	w_T	w_T^*											
Age (years)	ICRP 26	10♂	10♀	20♂	20♀	30♂	30♀	40♂	40♀	50♂	50♀	60♂	60♀
RBM	0.12	1.10	0.09	0.10	0.08	0.15	0.12	0.23	0.15	0.33	0.20	0.41	0.27
Breast	0.15	0	0.19	0	0.21	0	0.31	0	0.37	0	0.43	0	0.46
Lung	0.12	0.10	0.09	0.10	0.08	0.14	0.11	0.17	0.11	0.16	0.09	0.15	0.07
Thyroid	0.03	0.02	0.02	0.02	0.02	0.03	0.03	0.04	0.03	0.04	0.02	0.04	0.02
Bone surface	0.03	0.02	0.02	0.02	0.02	0.03	0.03	0.04	0.03	0.04	0.02	0.04	0.02
Skin	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	<0.005	<0.005
Remainder	0.30	0.25	0.21	0.25	0.21	0.33	0.25	0.43	0.28	0.40	0.23	0.35	0.16
Gonads	0.24	0.50	0.37	0.50	0.37	0.31	0.14	0.08	0.02	0.02	0	0	0
ICRP 26/27 $\sum_T f_T$ (mSv^{-1})	16.5	25.9	30.0	19.7	23.9	13.3	16.8	8.72	13.1	5.81	10.2	2.70	6.00

NCRP REPORT No. 52

CESIUM-137 FROM THE ENVIRONMENT TO MAN: METABOLISM AND DOSE

Recommendations of the
NATIONAL COUNCIL ON RADIATION
PROTECTION AND MEASUREMENTS

Issued January 15, 1977

National Council on Radiation Protection and Measurements
7910 WOODMONT AVENUE / WASHINGTON, D.C. 20014

NCRP REPORT No. 87

Use of Bioassay Procedures for Assessment of Internal Radionuclide Deposition

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