UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

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Dear Bob:

The enclosed Table I lists the results of occupational MPC_a computations made for us some time ago by ORNL, and which we had provided to you and other members of our Interagency Committee. The specific radionuclides listed in this Table are those which your staff had informed us were of specific interest to NRC. We may be asking ORNL to compute the MPC_a for a few additional radionuclides. Please let me know which other ones are also of special interest to NRC at this time. Thanks.

Sincerely,

Luis F. Garcia
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Enclosure

ORNL TRIAL RUNS

1. Calculate maximum air concentrations for standard annual occupational conditions (MPC_a) using new dosimetric and metabolic models employed for ICRP-30.

2. Run four cases, involving two basic approachs, as follows:

Case A. Critical Organ Approach (using current RPG's)

Calculate MPC_a based on dose to the single limiting organ, using the current RPG's, namely:

whole body, red bone marrow, gonads, or lens of eye	5 rems/y
thyroid, bone surfaces, skin(whole body)	30 rems/y
other organs	15 rems/y

Case B. Additive Risk Approach (using 3 modified ICRP-26 schemes).

Use the general constraints

$$\sum_i w_i H_i \leq 5 \text{ rems/y}, \quad \text{and} \quad H_j \leq L_j,$$

where gonads and lens of eye are not included in the sum, and the values of w_i and L_j are as follows:

Organ i	w_i
Breast	0.20
Red Bone Marrow	0.16
Lung	0.15
Thyroid	0.04
Bone Surfaces	0.04
Skin	0.01
Other Organs*	0.40

*Applies only to the 5 maximum-dosed other organs, each being given a weighting factor of 0.08.

The limits L_j are to be applied as three separate cases:

	Organ j	L_j
Case B1.	gonads, lens of eye	5 rems/y
	all others	50 rems/y
Case B2.	gonads, lens of eye	5 rems/y
	all others	30 rems/y
Case B3.	Use Case A RPG's for L_j.	

3. Run the above cases for as many as possible of the following radionuclides:

P-32	Mn-54	Mn-56	Co-58	Co-60	Sr-89
Sr-90	Zr-95	Nb-95	Mo-99	I-125	I-129
I-131	I-133	Cs-137	Th-228	Th-232	U-234
U-235	U-238	Pu-238	Pu-239	Am-241.	

4. Tabulation of Results

Tabulate results for above 4 cases, together with corresponding MPC_a's in ICRP-2 (or 10 CFR 20) and ICRP-30, for comparison purposes.

Table 1. MPC_a (μCi/cc) Values From ORNL Trial Runs

Nuclide		ICRP-30[a]	Critical Organ	Additive Risk Approach[a] S_1	S_2	S_2	ICRP-2
P-32	D	4(-7)[b]	9(-8) R. Marrow	3(-7)	A 3(-7)	9(-8) R. Marrow	7(-8) Bone
	W	2(-7)	6(-8) Lungs	1(-7)	R 1(-7)	6(-8) Lungs	8(-8) Lungs
Mn-54	D	4(-7)	4(-7) R. Marrow	4(-7)	S 4(-7)	4(-7) R. Marrow	4(-7) Liver
	W	3(-7)	3(-7) Lungs	3(-7)	R 3(-7)	3(-7) Lungs	4(-8) Lungs
Mn-56	D	6(-6)	4(-6) Lungs	5(-6)	R 5(-6)	4(-6) Lungs	8(-7) LLI
	W	9(-6)	3(-6) Lungs	5(-6)	R 5(-6)	3(-6) Lungs	5(-7) LLI
Co-58	W	5(-7)	2(-7) Lungs	3(-7)	L 3(-7)	2(-7) Lungs	8(-7) LLI
	Y	3(-7)	1(-7) Lungs	2(-7)	R 2(-7)	1(-7) Lungs	5(-8) Lungs
Co-60	W	7(-8)	5(-8) Lungs	5(-8)	L 5(-8)	5(-8) Lungs	3(-7) LLI
	Y	1(-8)	5(-9) Lungs	8(-9)	L 8(-9)	5(-9) Lungs	9(-9) Lungs
Sr-89	D	4(-7)	1(-7) R. Marrow	3(-7)	R 3(-7)	1(-7) R. Marrow	3(-8) Bone
	Y	6(-8)	2(-8) Lungs	4(-8)	S 4(-8)	2(-8) Lungs	4(-8) Lungs
Sr-90	D	8(-9) B. Surf.	2(-9) R. Marrow	6(-9)	S 5(-9) B. Surf.	2(-9) R. Marrow	3(-10) Bone
	Y	2(-9)	6(-10) Lungs	1(-9)	L 1(-9) Lungs	6(-10) Lungs	3(-9) Lungs
Zr-95	D	5(-8) B. Surf.	3(-8) B. Surf.	5(-8) B. Surf.	L 3(-8) B. Surf.	3(-8) B. Surf.	1(-7) T. Body
	W	2(-7)	9(-8) Lungs	1(-7)	1(-7)	9(-8) Lungs	
	Y	1(-7)	4(-8) Lungs	7(-8)	R 7(-8)	4(-8) Lungs	3(-8) Lungs
Nb-95	W	5(-7)	3(-7) Lungs	4(-7)	L 4(-7)	3(-7) Lungs	5(-7) T. Body
	Y	5(-7)	2(-7) Lungs	3(-7)	R 4(-7)	2(-7) Lungs	1(-7) Lungs
Mo-99	D	1(-6)	9(-7) Liver	8(-7)	R 8(-7)	8(-7)	7(-7) Kidney
	Y	6(-7)	3(-7) LLI	4(-7)	R 4(-7)	3(-7) LLI	2(-7) LLI
I-125	D	3(-8) Thyroid	2(-8) Thyroid	3(-8) Thyroid	R 2(-8) Thyroid	2(-8) Thyroid	5(-8) Thyroid
I-129	D	4(-9) Thyroid	2(-9) Thyroid	4(-9) Thyroid	S 2(-9) Thyroid	2(-9) Thyroid	2(-9) Thyroid
I-131	D	2(-8) Thyroid	1(-8) Thyroid	2(-8) Thyroid	R 1(-8) Thyroid	1(-8) Thyroid	2(-8) Thyroid
I-133	D	1(-7) Thyroid	7(-8) Thyroid	1(-7) Thyroid	R 7(-8) Thyroid	7(-8) Thyroid	3(-8) Thyroid
Cs-134	D	4(-8)	4(-8) Gonads	4(-8) Gonads	S 4(-8) Gonads	4(-8) Gonads	1(-8) T. Body
Cs-137	D	6(-8)	6(-8) Gonads	6(-8) Gonads	S 6(-8) Gonads	6(-8) Gonads	6(-8) T. Body
Ce-144	W	1(-8)	7(-9) Liver	8(-9)	8(-9)	7(-9) Liver	1(-8) Liver
	Y	6(-9)	2(-9) Lungs	4(-9)	4(-9) Lungs	2(-9) Lungs	6(-9) Lungs
Ra-226	W	3(-10)	1(-10) Lungs	2(-10)	2(-10)	1(-10) Lungs	3(-11) Lungs
Th-228	W	4(-12) B. Surf.	2(-12) B. Surf.	4(-12) B. Surf.	L 2(-12) B. Surf.	2(-12) B. Surf.	9(-12) Bone
	Y	7(-12)	2(-12) Lungs	5(-12)	L 5(-12)	2(-12) Lungs	6(-12) Lungs
Th-232	W	5(-13) B. Surf.	3(-13) B. Surf.	5(-13) B. Surf.	L 3(-13) B. Surf.	3(-13) B. Surf.	2(-12) Bone
	Y	1(-12) B. Surf.	7(-13) B. Surf.	1(-12) B. Surf.	7(-13) B. Surf.	7(-13) B. Surf.	1(-11) Lungs
U-234	D	5(-10) B. Surf.	3(-10) B. Surf.	5(-10) B. Surf.	3(-10) B. Surf.	3(-10) B. Surf.	6(-10) Bone
	W	3(-10)	1(-10) Lungs	2(-10)	2(-10)	1(-10) Lungs	
	Y	2(-11)	6(-12) Lungs	1(-11)	1(-11) Lungs	6(-12) Lungs	1(-10) Lungs
U-235	D	6(-10) B. Surf.	3(-10) B. Surf.	6(-10) B. Surf.	3(-10) B. Surf.	3(-10) B. Surf.	5(-10) Kidney
	W	3(-10)	1(-10) Lungs	2(-10)	2(-10)	1(-10) Lungs	
	Y	2(-11)	6(-12) Lungs	1(-11)	1(-11) Lungs	6(-12) Lungs	1(-10) Lungs
U-238	D	6(-10) B. Surf.	4(-10) B. Surf.	6(-10) B. Surf.	4(-10) B. Surf.	4(-10) B. Surf.	7(-11) Kidney
	W	3(-10)	1(-10) Lungs	2(-10)	2(-10)	1(-10) Lungs	
	Y	2(-11)	6(-12) Lungs	1(-11)	1(-11) Lungs	6(-12) Lungs	1(-10) Lungs
Pu-238	W	3(-12) B. Surf.	2(-12) B. Surf.	3(-12) B. Surf.	S 2(-12) B. Surf.	2(-12) B. Surf.	2(-12) Bone
	Y	7(-12) B. Surf.	4(-12) B. Surf.	5(-12)	L 4(-12) B. Surf.	4(-12) B. Surf.	3(-11) Lungs
Pu-239	W	2(-12) B. Surf.	1(-12) B. Surf.	2(-12) B. Surf.	L 1(-12) B. Surf.	1(-12) B. Surf.	2(-12) Bone
	Y	6(-12) B. Surf.	4(-12) B. Surf.	5(-12)	L 4(-12) B. Surf.	4(-12) B. Surf.	4(-11) Lungs
Am-241	W	2(-12) B. Surf.	1(-12) B. Surf.	2(-12) B. Surf.	L 1(-12) B. Surf.	1(-12) B. Surf.	5(-12) Bone

[a] If no organ is noted the MPC value is based on stochastic considerations.

[b] Read 4(-7) as 4×10^{-7}.

6-29-79
Rea

CALCULATION OF DAC'S

Tissue	Risk Factor	Severity Coefficient	Dose Conv. (rem/μCi)	Deposition	(μCi)
...ovals (genetic), first two generations	F_1				
...ovals (genetic), succeeding generations	φ_1	s_1	D_1	f_1	I
...e bone marrow, fatal cancer	F_2				
...e bone marrow, non-fatal cancer	φ_2	s_2	D_2	f_2	I
..., fatal cancer	F_3				
..., non-fatal cancer	φ_3	s_3	D_3	f_3	I
..., fatal cancer	F_4				
... non-fatal cancer	φ_4	s_4	D_4	f_4	I
...ng, fatal cancer	F_5				
...g, non-fatal cancer	φ_5	s_5	D_5	f_5	I
...st, fatal cancer	F_6				
...st, non-fatal cancer	φ_6	s_6	D_6	f_6	I
...ther tissues combined, fatal cancer	F_7				
...ther tissues combined, non-fatal cancer	φ_7	s_7	D_7	f_7	I

I = quantity inhaled

R_i = risk to all tissue
$= D_i f_i I (F_i + s_i \varphi_i)$

R_T = total risk from inhalation of I μCi
$= I \sum_{i=1}^{7} f_i D_i (F_i + s_i \varphi_i)$

If R_T is set equal to the risk for whole-body exposure to 5 rems, I becomes the ALI:

F_{wb} = risk factor for fatal cancer from whole-body exposure

φ_{wb} = risk factor for non-fatal cancer from whole-body exposure

F_S = risk factor for genetic effects, all generations, from whole-body exposure

$$ALI = \frac{5 \cdot 0.5 (F_{wb} + s_{wb} \varphi_{wb} + F_S)}{\sum_{i=1}^{7} f_i D_i (F_i + s_i \varphi_i)}$$

$$DAC = \frac{ALI}{2.4 \times 10^9 \text{ cm}^3}$$

To ensure that no organ receives a dose commitment greater than its limit (present):

Let L_i = dose limit (annual), for ith organ

$= D_i f_i (ALI)^*$

$$ALI^* = \frac{L_i}{f_i D_i}$$

Calculate ALI^* for each tissue. If any $ALI^* < ALI$, use the lowest $ALI^* < ALI$ to calculate the DAC.

Tissue	S_i
Genetic Effects (from 3rd generation on)	0.8
Red Bone Marrow (non-fatal cancer)	0.3
Bone (non-fatal cancer)	0.5
Lung (non-fatal cancer)	0.5
Thyroid (non-fatal cancer)	0.1
Breast (non-fatal cancer)	0.4
All other Tissues Combined (non-fatal cancers)	0.3
Whole-Body (non-fatal cancers)	0.3

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ROUGH DRAFT

JUN 27 1979

PRELIMINARY DRAFT OCCUPATIONAL GUIDANCE

It is recommended that:

1. There should be no individual occuptional exposure or activity resulting in such exposure if it is not expected to result in a benefit which is judged to exceed the radiation detriment.

2. Positive efforts should be made to assure that the collective dose from any such justified activity is maintained at a level as low as is reasonably achievable.

3. The radiation dose to individuals should not exceed the Radiation Protection Guides specified below, and every effort should be made to encourage the maintenance of such doses as far below these Guides as is reasonably achievable.

4. The following annual Radiation Protection Guides (RPG's) and minimum radiation protection requirements for their application, together with the basic principles stated above, should be adopted as the basic system of dose limitation for occupational radiation exposures:

a. Radiation Protection Guides

	Dose Equivalent (rem) in a year
Whole Body	5
Specific Organs(c):	
Gonads	5
Lens of Eye	15
Skin	30
Other Organs(i)	15(25)

Doses to more than any single organ should be subject to the following additional limitations:

(NOTE: For the purpose of this draft, two alternatives are presented below.)

Alternative "A"

$\sum_{i=1}^{3} (1/3)H_i \leq RPG_{wb}$, and $H_c \leq RPG_c$, where H is the dose equivalent, and the subscripts wb, c, and i refer to whole-body and organ types c and i, respectively; and the summation over H_i is limited to the three organs of type i receiving the largest doses.

Alternative "B"

$H_g = \sum_i (R_i/R_{wb})H_i \leq RPG_{wb}$, provided $H_{i,c} \leq RPG_{i,c}$, where H is the dose equivalent, R is the risk of (lethal) cancer induction for exposure over an occupational lifetime, and the subscripts wb, c, and i refer to whole-body and organs c and i, respectively.

b. Minimum radiation protection requirements should be established and maintained at the user level. These requirements should be classified in ranges of dose appropriate to the individual occupational situations involving radiation exposure of workers. The following ranges and requirements are recommended:

Range A (0 - 0.1 RPG):

(1) Exposures justified and as low as is reasonably achievable.

(2) Individual and area monitoring as required to assure doses are within the range and are as low as is reasonably achievable.

(3) Basic knowledge of the actual and potential radiation levels and hazards specific to the job and the applicable radiation protection practices.

Range B (0.1 - 0.3 RPG):

Requirements (1) - (3), plus:

(4) Professional radiation protection supervision as required to assure individual and collective exposures are as low as is reasonably achievable.

(5) Mandatory individual monitoring and annual recordkeeping.

(6) Informed ~~consent~~ ~~of~~ acceptance by women of reproductive capacity.

Range C (0.3 - 1.0 RPG):

Requirements (1) - (6), plus:

(7) Prior justification of need and provision of professional radiation protection supervision on a task basis to assure individual and collective exposures are as low as is reasonably achievable.

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(8) Supplementary individual monitoring on a task basis, and maintenance of ~~a record of~~ accumulated doses from occupational exposures since age 18.

(9) Formal consideration of individual's age and accumulated lifetime dose. Although no specific lifetime (age 18 to 65) accumulated dose limit is recommended, every effort should be made to maintain accumulated lifetime doses as low as is reasonably achievable, with the objective of maintaining them below 100 rems.

5. The term "Radioactivity Intake Factor" (RIF) should be adopted for Federal use in providing radiation protection for exposure due to intake of radionuclides. This quantity is defined as the intake of any specific radionuclide for which the committed dose equivalent satisfies the Guides and limitations specified in recommendation 4(a). Its use should be subject to the operational radiation protection requirements specified in recommendation 4(b) for the Radiation Protection Guides.

6. In keeping with past practice, occupational exposure of minors should be limited to Range A.

7. Women of reproductive capacity should be encouraged to maintain their exposures within Range A, and exposures in Range B or C should be permitted only under the condition of informed ~~consent~~ acceptance regarding increased risks to the fetus.

8. The Federal agencies should apply these Radiation Protection Guides with judgment and discretion, in order that reasonable assurance is provided in the attainment of the desired goal of protecting workers from the deleterious effects of radiation. The Guides may be exceeded only after the Federal agency having jurisdiction over the matter has carefully considered the specific reasons for doing so in light of these recommendations.

The following notes provide additional clarification of the above recommendations:

(1) The term "occupational radiation exposure" refers to exposure of an individual as a consequence of gainful employment, as either an employee or self-employed person, to ionizing radiation from sources other than (a) normal natural background and (b) purposeful exposure as a patient of practitioners of the healing arts. These recommendations apply to all occupational exposures during normal peacetime activities, with one exception: occupational exposure of individuals to radon daughter products in mining operations continue to be subject to separate Federal radiation protection guidance (36 F.R. 12921).

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(2) The term "Radiation Protection Guide" is defined as the upper limit of ~~the range of limiting~~ occupational doses ~~for specific exposure situations~~, ~~starting from zero~~, which may be received by an individual, or committed by uptake of radionuclides by an individual, in any year.

(3) Planned emergency exposures are outside the scope of this guidance; ~~for such situations agencies should continue their present practices~~.

(4) Overexposures are not addressed by this guidance. The equitable handling of such cases is the responsibility of users and the Federal agencies operating within the general radiation protection principles provided above.

(5) Limits for periods less or greater than one year are not provided by these recommendations. Such limits may, however, be derived for operational use by the Federal agencies when necessary and appropriate. Such limits should be designed to preserve the flexibility for maintaining as low as is reasonably achievable exposure provided by these recommendations.

(6) In cases where both external and internal doses are involved, the requirements of recommendations 4 and 5 may be satisfied by the assumption that the RIF is equivalent to the whole body RPG and a requirement that the sum of external and internal exposures satisfy the whole body RPG.