EP note 1

Environmental Protection Note No. 1
Derived Concentration Guides for Accelerator-Produced Radionuclides in Surface Water Discharges and Drinking Water

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Introduction

The operations of DOE and its contractors are governed by applicable laws and regulations and, secondarily, by any DOE orders which may be applicable. This note documents a recent investigation of the origins of certain standards for radionuclides in surface water discharges and in drinking water which are given in the Fermilab Radiation Guide. I have studied these in light of the applicable laws and regulations and have concluded that some changes in these values, as currently tabulated, are appropriate.

Historical Development

For a number of years, DOE based standards for radionuclides in water upon a standard table used throughout the regulatory community. This table is most completely stated as Table II of Appendix B of 10 CFR Part 20, *Standards for Protection Against Radiation* . This part of the Code of Federal Regulations is specifically identified with the requirements of Nuclear Regulatory Commission licensees. The table presents data in two columns; column I of which concerns the doses delivered to occupational users, while column II is the concentration of individual radionuclides in water which would result in a whole body dose of 500 mrem per year to an individual using the water for his/her regular drinking water supply. (Column II is more pertinent to environmental protection interest.) For mixtures of n radionuclides, the relationship of the concentrations present in the water, C_i, to the concentration guide limit appropriate to any consideration, L_i, must be controlled so as to satisfy the following condition:

$$\sum_{i=1}^{n} \frac{C_i}{L_i} < 1.$$

The values in this table were adapted from the reference *Maximum Permissible Body Burdens and Maximum Permissible concentration of Radionuclides in Air or Water for Occupational Exposure* , NBS Handbook 69 as amended in August, 1963, U. S. Department of Commerce. This table was incorporated essentially *verbatim* into DOE Orders 5480.1 (implemented September 12, 1980) and 5480.1A (implemented August 13, 1981), as the

standards for discharges into surface waters. The 500 mrem/year criterion was only permitted to be applied for situations in which the exposure of identifiable individuals was involved. For waters discharged in any other way, the DOE Orders made it clear that the derived concentration guide should be scaled to 170 mrem per year.

For drinking water in community water systems, much more stringent standards have been developed by the U. S. Environmental Protection Agency under the Clean Water Act and stated in 40 CFR 141.16 *National Primary Drinking Water Standards*. These standards limit the whole body or organ dose equivalent to 4 mrem per year based on a 2 liter per day drinking water intake for all radionuclides encountered (using the weighted-sum condition stated above). The methodology of NBS 69 is to be used to calculate the dose equivalents except for two radionuclides, ^{3}H and ^{90}Sr. For these, specific values are given. For ^{3}H (the only one of the two of relevance as an accelerator-produced radionuclide) the concentration guide for drinking water is specifically listed as 20 pCi/ml. This drinking water limit is used in calculations of the production of radioactivity in groundwater aquifers, for example. Assessments at Fermilab have been done in a conservative manner (quite correctly, in my view) in that we have basically assumed all aquifers to be community water supplies, thus ignoring technicalities of the definition of a "community" water supply which may exclude individual users from coverage by the regulation. This limit of 4 mrem/year has been used in this manner since our receipt of this particular regulation and its announcement as policy to the Laboratory in a memorandum to Division/Section Heads from A. L. Read dated April 5, 1979 entitled "Regulations on Exposure from Drinking Water".

The Department of Energy, by memorandum transmitted from A. E. Mravca to L. Coulson dated November 14, 1985 entitled "Radiation Standards for Protection of the Public in the Vicinity of the Department of Energy (DOE) Facilities" stated that the above DOE orders (specifically 5480.1A) would be revised to reflect new guidance based in ICRP Reports 26 and 30 concerning internal exposures. This memorandum limited effective does equivalents to individuals by all pathways to 100 mrem/year for prolonged exposures and appended an additional reference (in draft form) to determine the dose equivalent per uptake. DOE Order 5480.1A was superceded by DOE Order 5480.11 effective January 1, 1989. The "additional reference" was published in July 1988 as DOE/EH-0071, *Internal Dose Conversion Factors for Calculation of Dose to the Public* by the Assistant Secretary for Environment, Safety and Health. In the preamble to this document, it is stated that the contents were adopted on August 5, 1985. This document gives 50-year committed effective dose equivalents per μCi of uptake based upon the methodologies of ICRP 26 and ICRP

30. The above-mentioned 100 mrem/year limit is included in this publication. The use of the tables based on NBS69 and supplied with the former DOE orders is explicitly "repealed".

In following the above guidance from DOE, Fermilab revised Tables 2 and 3 in Chapter 13 of the *Fermilab Radiation Guide* (Fifth Edition, march, 1988). The derived concentration guides for accelerator-produced radionuclides in air and water are given in the following table. Because of the specific guidance, the drinking water concentration guide for ^{3}H was retained as 20 pCi/ml.

Derived Concentration Guides in Surface Water for the General Population

Radionuclide	Concentration Guide (pCi/ml)
^{3}H	2000
^{7}Be	1000
^{22}Na	10
^{45}Ca	50
^{54}Mn	50
^{60}Co	5

Derived Concentration Guides in Drinking Water

Radionuclide	Concentration Guide (pCi/ml)
^{3}H	20.0
^{7}Be	40.0
^{22}Na	0.4
^{45}Ca	2.0
^{54}Mn	2.0
^{60}Co	0.2

Comparison of Derived Concentration Guides using the Two Methods

In order to further my understanding, I attempted to calculate the derived concentration guides using the two different methods. The first table is based on the method most recently prescribed by DOE (labeled DOE-ICRP 26&30) while the second is derived from the older method based on NBS69 (labeled NBS69 Methodology).

DOE-ICRP 26&30 Methodology

Nuclide	rem/μCi	μCi/rem	100 mrem pCi/ml	4 mrem pCi/ml	Rounded pCi/ml *Surface*	Rounded pCi/ml *Drinking*
^{3}H	6.30E-05	15873.02	2174.39	86.98	2000	90
^{7}Be	1.10E-04	9090.91	1245.33	49.81	1000	40
^{22}Na	1.20E-02	83.33	11.42	0.46	10	0.4
^{45}Ca	3.00E-03	333.33	45.66	1.83	50	2
^{54}Mn	2.70E-03	370.37	50.74	2.03	50	2
^{60}Co	2.60E-02	38.46	5.27	0.21	5	0.2

NBS69 Methodology

Nuclide	μCi/ml 500 mrem	pCi/ml 170 mrem	pCi/ml 100 mrem	pCi/ml 4 mrem	Rounded pCi/ml *Surface*	Rounded pCi/ml *Drinking*
^{3}H	3.00E-03	1020.00	600.00	24.00	1000	20
^{7}Be	2.00E-03	680.00	400.00	16.00	700	10
^{22}Na	3.00E-05	10.20	6.00	0.24	10	0.2
^{45}Ca	9.00E-06	3.06	1.80	0.07	2	0.1
^{54}Mn	1.00E-04	34.00	20.00	0.80	40	1
^{60}Co	3.00E-05	10.20	6.00	0.24	10	0.2

The DOE table starts with an assessment of committed effective dose equivalent expressed in units of rem/μCi taken directly from DOE/EH-0071. These are then converted to concentrations giving various annual committed effective dose equivalents by dilution of the activity in 2 liters of water per day. Thus one achieves the values for surface (100 mrem/yr) and drinking (4 mrem/yr) waters. The final two columns present these results rounded off. (For both methodologies, it is made clear that values to 2 significant figures generally show exceed the precision of the dose assessments, so rounding off is a reasonable approach.) The NBS69 table starts with concentrations in units of μCi/ml equivalent to 500 mrem/yr. These are then converted to various lower annual whole body dose equivalents (170, 100, and 4) and the rounded-off values used for surface and drinking water limits are based on the 170 mrem/yr and 4 mrem/yr values, respectively. For both methods, where the soluble form of the radionuclide or some other consideration makes a difference, the more restrictive value is used.

Conclusions

Examination of the tables indicates significant discrepancies, which is understandable since the ICRP 26&30 methodology represents approximately 20 years of advancement in the science of internal exposure calculations. In general, higher concentrations are allowable under the newer method. Nevertheless, the Clean Water Act is the "law of the land", regardless of DOE Orders. At the present time, a complete revision of 10 CFR Part 20 is under review. When it is implemented, it will most likely incorporate the new methodology. It is not clear when 40 CFR Part 141.16 will next be updated. It may well be that the less restrictive values of the concentrations, in the present climate of public opinion, are a serious impediment to acceptance of these revisions. Given this situation, I recommend that the Fermilab Radiation Guide be changed to use the values derived from NBS 69 in the two tables in Chapter 13. Adherence to this criterion will keep us in compliance with the EPA's rules concerning drinking water limits while also keeping us in compliance with the DOE guidance restricting one to 100 mrem/yr for surface water releases. The single exception for these nuclides is the surface water limit for ^{60}Co, which has a larger concentration guide in the NBS 69 scheme. For that entry, I recommend the value derived from DOE/EH-0071 be used, and properly footnoted.

It is clear that surface water releases near these limits almost never occur at Fermilab. Calculation of doses, if it is ever necessary, due to any such release should probably be done only after receiving written confirmation of the proper method to use from DOE. I believe we are well advised to continue using the NBS69 drinking water limits as our criterion for groundwater.