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MURLEY, T. E. Document Control Branch (Document Control Desk)

SUBJECT: Requests approval of util method of disposing waste oil contaminated w/low levels of radioactivity. Tables 1 & 2 re storage of contaminated oil & supporting info also encl. Fee paid.

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INDIANA & MICHIGAN ELECTRIC COMPANY

P.O. BOX 16631
COLUMBUS, OHIO 43216

August 28, 1987

AEP:NRC:1034

Donald C. Cook Nuclear Plant Units 1 and 2
Docket Nos. 50-315 and 50-316
License Nos. DPR-58 and DPR-74
DISPOSAL OF CONTAMINATED WASTE OIL AT
THE DONALD C. COOK NUCLEAR PLANT UNITS 1 AND 2

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555

Attn: T. E. Murley

Dear Dr. Murley:

As requested by Mr. D. L. Wigginton of your staff, this letter provides information concerning I&MECo's past method of disposing of waste oil contaminated with low levels of radioactivity and requests approval to use this method in the future. This request resulted from a July 17, 1987 phone conversation in which we informed Mr. Wigginton of concerns raised in a recent audit performed at the Cook Plant by AEP's Nuclear Safety and Design Review Committee (NSDRC). These concerns are associated with the practice of disposing of contaminated waste oil by mixing it with uncontaminated fuel oil and then burning it in the auxiliary boiler system (an unmonitored release pathway). The following discussion provides the results of an investigation performed in response to the NSDRC audit team concerns and presents a technical evaluation of this issue that forms the basis for justification of our request that NRC approve the use of this method of contaminated waste oil disposal in the future.

The investigation of the NSDRC audit team concern showed that contaminated waste oil was transferred to the (uncontaminated) auxiliary boiler fuel oil tanks on eleven occasions during the period January 1980 to June 1985. This practice has now been prohibited pending resolution of the NSDRC audit team's concerns. This mixture of contaminated waste oil and uncontaminated fuel oil was then burned when the auxiliary boiler was operated. The principal source of contaminated oil is the oil used for primary system pump motor bearing lubrication. We also have some contaminated oil from a variety of sources in the auxiliary building. All contaminated oil is generated during normal maintenance-related activities performed on motors, pumps, and other mechanical devices.

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Although the oil is contaminated with radioactive material, levels of such contamination are very low, and when the waste oil/fuel oil mixture is burned, the resulting releases are well within limits specified by current regulations.

In reviewing the potential regulatory concerns specifically associated with this method of contaminated waste oil disposal, we considered that the following regulations were applicable at the Cook Plant:

1. 10 CFR 20.106(a):

   20.106 Radioactivity in effluents to unrestricted areas.

   (a) A licensee shall not possess, use, or transfer licensed material so as to release to an unrestricted area radioactive material in concentrations which exceed the limits specified in Appendix B, Table II of this part, except as authorized pursuant to Part 20.302 or paragraph (b) of this section. For purposes of this section concentrations may be averaged over a period not greater than one year.

   A copy of 10 CFR 20 Appendix B (cited above) is included as Attachment 1 to this submittal. Part 20.302 is cited in Item 2 below.

2. 10 CFR 20.302(a):

   20.302 Method for obtaining approval of proposed disposal procedures.

   (a) Any licensee or applicant for a license may apply to the Commission for approval of proposed procedures to dispose of licensed material in a manner not otherwise authorized in the regulations in this chapter. Each application should include a description of the licensed material and any other radioactive material involved, including the quantities and kinds of such material and the levels of radioactivity involved, and the proposed manner and conditions of disposal. The application should also include an analysis and evaluation of pertinent information as to the nature of the environment, including topographical, geological, meteorological, and hydrological characteristics; usage of ground and surface waters in the general area; the nature and location of other potentially affected facilities; and procedures to be observed to minimize the risk of unexpected or hazardous exposures.

3. 10 CFR 20.305:

20.305 Treatment or disposal by incineration.

No licensee shall treat or dispose of licensed material by incineration except for materials listed under Part 20.306 or as specifically approved by the Commission pursuant to Parts 20.106(b) and 20.302.

We believe that the requirements of 10 CFR 50 Appendix I associated with doses to individuals in unrestricted areas also apply. A copy of this appendix is included in Attachment 2 to this submittal. In addition to these regulations, our investigation identified two NRC IE Information Notices relevant to disposal of contaminated waste oil by burning. These Information Notices (IE Information Notice 83-05, "Obtaining Approval for Disposing of Very Low-Level Radioactive Waste - 10 CFR Section 20.302" and IE Information Notice 83-33, "Nonrepresentative Sampling of Contaminated Oil") are included as Attachments 3 and 4 to this submittal. Evaluation of the regulatory requirements identified above disclosed that radioactivity releases resulting from burning of the contaminated waste oil were accounted for in our Semi-Annual Radioactive Effluent Release Reports, always below the 10 CFR 20, Appendix B limits for radioactivity releases in air to unrestricted areas, and in conformance with the requirements of 10 CFR 50, Appendix I for annual doses to individuals in unrestricted areas. However, no formal documentation was found to indicate that the NRC had approved the practice of disposing of this waste oil by incineration. We believe such approval is required by 10 CFR 20.302 and 10 CFR 20.305.

Due to an administrative oversight, we believe that a request for approval to dispose of contaminated waste oil by burning was not requested as suggested by Information Notice 83-05. In the case of Information Notice 83-33, a review for Cook Plant applicability was performed and as a result of the review our sampling procedure was revised to provide additional assurance that representative samples are taken. Our sampling procedure requires taking a sample from the bottom of the contaminated waste oil storage tank in order to obtain a sample which we believe is a conservative (i.e., worst-case) representation of the tank contents.

In response to the requirements of 10 CFR 20.302, the information presented below provides an analysis and evaluation of the impact on public health and safety of the burning of the contaminated oil and a description of the procedures we will use prior to such burning. Based on the information presented below, we have concluded that burning oil in the manner indicated will not result in releases that exceed the requirements of 10 CFR 20 for releases in air to unrestricted areas, and hence we considered this method of disposal acceptable. Further, these releases are included in the total radioactivity inventory reported at the Cook Plant in our semiannual reports, and hence, by the information contained in that report, we also consider the requirements of 10 CFR 50, Appendix I to have been met.

The information concerning the nature of the environment suggested by 10 CFR 20.302 is included in our Updated Final Safety Analysis Report (Chapters 1 and 2). Minor modifications to this information are addressed in the semiannual effluent release reports, which are updated on a regular basis in accordance with the requirements of 10 CFR 50.36a(a)2. Both of these documents have been transmitted to the NRC. A list of transmittals associated with these activities is included in Attachment 5 to this letter.

Contaminated waste oil is initially collected in 55 gallon drums, sampled, then transferred to a waste oil storage tank. Our sampling procedure requires the waste oil storage tank to be sampled for isotopic analysis every seven days or as requested by the plant Environmental Section after waste oil is added, or prior to transfer of the waste oil to the auxiliary boiler fuel oil tanks. Details of the volume of contaminated waste oil placed in the auxiliary boiler fuel oil tanks since 1980, as well as the details of isotopic analysis performed on the contaminated waste oil, are provided in Tables 1 and 2 respectively. As shown in Table 1, the volume of contaminated waste oil placed in the (uncontaminated) auxiliary boiler fuel oil tanks ranged from 300 to 1500 gallons. The contaminated waste oil was added to an uncontaminated fuel oil volume of between 39,920 and 100,000 gallons, depending on the date the transfer was made.

We have performed an analysis using the data presented in Tables 1 and 2 to quantify the radioactivity concentration in the releases resulting from burning of contaminated waste oil. As was pointed out above, the total radioactivity release has been accounted for in our semiannual effluent release reports; however, since the auxiliary boiler stack exhaust is not monitored for radioactivity, an assessment was performed, as part of our technical evaluation, to ensure that the concentration limits of 10 CFR 20, Appendix B would not be exceeded and hence that no adverse effects to the public health and safety would result from this method of disposal.

In general, the radioactivity concentration in the contaminated waste oil is reduced by dilution upon transfer to the uncontaminated fuel oil tanks. Further dilution is provided when the waste oil/fuel oil mix is burned and the combustion by-products are released through the auxiliary boiler stack. Our method of analysis, therefore, was to calculate the dilution factors for the mixing of the contaminated waste oil with uncontaminated fuel oil (giving the radioactivity concentration in the liquid waste oil/fuel oil mixture) then calculating the airborne radioactivity in the stack exhaust considering the volume of air necessary to burn a given volume of the waste oil/fuel oil mix. Since fuel oil tank volume information was not available for the June 1985 transfer and therefore the dilution provided by the volume of fuel oil in the fuel oil tanks at the time of transfer could not be established, we believed that an analysis of the amount of radioactivity released by burning this batch of waste oil, assuming no dilution in the uncontaminated fuel oil, would represent a conservative assessment of the upper limit for the radioactivity concentration released from the auxiliary boiler stack on any occasion. Our analysis showed that the stack exhaust air would provide a dilution factor of approximately 7500

for complete combustion of the waste oil/fuel oil mixture. This dilution factor is actually the calculated value of the volume of air required to achieve complete combustion of a unit volume of the waste oil/fuel oil mixture, based on the chemical reaction describing the complete combustion of hydrocarbons. We also assumed that 100% of the radioactivity in this mixture would be released in the auxiliary boiler stack exhaust. We believe that applying the dilution factor calculated for complete combustion of the waste oil/fuel oil mixture is conservative, since in practice approximately 20% excess air (which provides additional dilution) is used in operating the auxiliary boiler. In our calculation of release concentration we have not taken credit for this excess air.

For the mix of radionuclides present in the contaminated waste oil that was transferred to the (uncontaminated) fuel oil tanks in June 1985 (see Table 2), assuming no dilution of the contaminated waste oil in the uncontaminated fuel oil, the airborne radioactivity concentration in the auxiliary boiler stack exhaust was calculated to be approximately 50% of the 10 CFR 20, Appendix B maximum permissible concentration (MPC) in air released to unrestricted areas.

We believe, as stated previously, that this represents the limiting case for release of radioactivity, since no credit has been taken for dilution of the contaminated waste oil in the volume of uncontaminated fuel oil contained in the auxiliary boiler fuel oil tanks at the time of transfer. We therefore believe that concentrations of radioactivity released from burning the other waste oil batches identified in Tables 1 and 2 were substantially lower than the release concentration from the burning of the June 1985 waste oil volume calculated on the assumptions stated above. We expect that radioactivity concentrations in future volumes of waste oil to be burned in the auxiliary boiler will be typical of those shown in Table 2 for batches previously added to the auxiliary boiler fuel oil tanks. Future releases from this pathway will continue to be accounted for, as in the past, in our semiannual reports, including an evaluation of the effects on public health and safety. On this basis, since previous release concentrations have been well within the 10 CFR 20, Appendix B MPCs for air and this effluent pathway has been included in our Semi-Annual Radioactive Effluent Release Reports with no identified adverse effect on the health and safety of the public, we believe that continuing this practice in the future will similarly not result in adverse effects to the public. We therefore believe this evaluation provides adequate justification for our request for NRC approval to use this method of contaminated waste oil disposal in the future.

It should be noted that no waste oil has been transferred to the auxiliary boiler fuel oil tanks since June 1985. We also do not intend to dispose of additional contaminated waste oil in this manner until we receive NRC approval to do so. However, we anticipate that the waste oil storage tank will be filled to capacity in the near future, at which point we will need to take some action to dispose of the tank contents. Therefore, as suggested by IE Information Notice 83-05, we request NRC approval to dispose of contaminated waste oil by incineration in the

auxiliary boiler system. We will need this approval by November 1, 1987 in order to allow us to dispose of accumulated waste oil in an orderly manner.

Pursuant to 10 CFR 170.12(c) we have enclosed a check for $150.00 for the requested review.

This document has been prepared following Corporate procedures which incorporate a reasonable set of controls to insure its accuracy and completeness prior to signature by the undersigned.

Very truly yours,

M. P. Alexich
Vice President

cm
Attachments
cc: John E. Dolan
W. G. Smith, Jr. - Bridgman
R. C. Callen
G. Bruchmann
G. Charnoff
NRC Resident Inspector - Bridgman
A. B. Davis - Region III

TABLE 1

CONTAMINATED WASTE OIL PLACED IN THE
AUXILIARY BOILER FUEL OIL TANKS

DATE	WASTE OIL VOLUME(GAL)	WASTE OIL STORAGE TANK SAMPLE ANALYSIS ID	FUEL OIL VOLUME(GAL)
01/10/80	1500	61861	59,730
01/15/80	1500	61938	39,920
07/05/80	300	66230	45,240
08/12/80	800	95608H	96,480
10/25/80	1500	98878H	82,330
05/27/81	1250	71842	85,200
10/23/81	1500	9262R	87,350
07/22/82	1100	20185R	93,220
03/16/83	700	29052R	94,960
12/13/83	1300	38607R	100,000
06/04/85	1300	61031R	Unavailable

TABLE 2

WASTE OIL STORAGE TANK SAMPLE ISOTOPIC ANALYSIS RESULTS PRIOR TO TRANSFER TO AUXILIARY BOILER FUEL OIL TANKS

DATE	LAB ANALYSIS ID.	ISOTOPE	CONCENTRATION (uci/ml)
01/10/80	61861	Cs-134	2.09 E-6
		Cs-137	3.55 E-6
01/15/80	61938	Cs-134	1.94 E-6
		Cs-137	3.39 E-6
07/05/80	66230	Cs-134	8.72 E-6
		Cs-137	1.64 E-5
		Co-60	4.83 E-7
08/12/80	95608H	Cs-134	2.49 E-6
		Cs-137	5.76 E-6
		Co-60	7.89 E-7
10/25/80	98878H	Xe-133	6.96 E-6
		Cs-134	1.16 E-6
		Cs-137	2.81 E-6
		Mn-54	1.38 E-6
		Co-60	2.29 E-5
05/27/81	71842	Cs-134	2.10 E-5
		Cs-137	5.67 E-5
		Co-58	4.90 E-6
		Mn-54	4.93 E-6
		Co-60	1.19 E-4
10/23/81	9262R	Cs-134	1.46 E-5
		Cs-137	4.25 E-5
		Co-58	1.54 E-6
		Mn-54	2.25 E-6
		Co-60	4.72 E-5
07/22/82	20185R	Xe-133	6.16 E-7
		Cs-134	1.07 E-6
		Ag-110m	3.16 E-6
		Cs-137	2.14 E-6
		Zr-97	2.91 E-7
		Nb-95	6.92 E-7
		Co-58	3.27 E-6
		Cs-136	2.39 E-7
		Co-60	3.65 E-6

DATE	LAB ANALYSIS ID.	ISOTOPE	CONCENTRATION (uci/ml)
03/16/83	29052R	Ag-110m	3.45 E-6
		Co-58	8.26 E-7
		Co-60	1.73 E-6
		Cs-134	4.93 E-7
		Nb-95	5.19 E-7
		Nb-97	1.29 E-5
		Sr-92	1.71 E-6
12/13/83	38607R	Co-60	2.03 E-7
		Cs-134	8.73 E-7
		Cs-137	2.33 E-6
06/04/85	61031R	Co-60	6.46 E-7
		Cs-134	1.64 E-6
		Cs-137	4.29 E-6

Attachment 1 to AEP:NRC:1034

10 CFR 20 Appendix B

APPENDIX B

Concentrations in Air and Water Above Natural Background

[See notes at end of appendix]

Element (atomic number)	Isotope		Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Actinium (89)	Ac 227	S	2×10^{-12}	6×10^{-3}	8×10^{-14}	2×10^{-4}
		I	3×10^{-11}	9×10^{-3}	9×10^{-13}	3×10^{-4}
	Ac 228	S	8×10^{-9}	3×10^{-3}	3×10^{-9}	9×10^{-5}
		I	2×10^{-8}	3×10^{-3}	6×10^{-10}	9×10^{-5}
Americium (95)	Am 241	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		* I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	Am 242m	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	3×10^{-10}	3×10^{-3}	9×10^{-12}	9×10^{-5}
	Am 242	S	4×10^{-8}	4×10^{-2}	1×10^{-9}	1×10^{-4}
		I	5×10^{-8}	4×10^{-2}	2×10^{-9}	1×10^{-4}
	Am 243	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	Am 244	S	4×10^{-8}	1×10^{-1}	1×10^{-9}	5×10^{-3}
		I	2×10^{-7}	1×10^{-1}	8×10^{-9}	5×10^{-3}
Antimony (51)	Sb 122	S	2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-5}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
	Sb 124	S	2×10^{-7}	7×10^{-4}	5×10^{-9}	2×10^{-5}
		I	2×10^{-8}	7×10^{-4}	7×10^{-10}	2×10^{-5}
	Sb 125	S	5×10^{-8}	3×10^{-3}	2×10^{-9}	1×10^{-4}
		I	3×10^{-8}	3×10^{-3}	9×10^{-10}	1×10^{-4}
Argon (18)	A 37	Sub[2]	6×10^{-3}		1×10^{-4}	
	A 41	Sub	2×10^{-8}		4×10^{-10}	
Arsenic (33)	As 73	S	2×10^{-6}	1×10^{-2}	7×10^{-8}	5×10^{-4}
		I	4×10^{-7}	1×10^{-2}	1×10^{-8}	5×10^{-4}
	As 74	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	5×10^{-5}
		I	1×10^{-7}	2×10^{-3}	4×10^{-9}	5×10^{-5}
	As 76	S	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
		I	1×10^{-7}	6×10^{-4}	3×10^{-9}	2×10^{-5}
	As 77	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
Astatine (85)	At 211	S	7×10^{-9}	5×10^{-5}	2×10^{-10}	2×10^{-6}
		I	3×10^{-8}	2×10^{-4}	1×10^{-9}	7×10^{-6}
Barium (56)	Ba 131	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-4}
		I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
	Ba 140	S	1×10^{-7}	8×10^{-4}	4×10^{-9}	3×10^{-5}
		I	4×10^{-8}	7×10^{-4}	1×10^{-9}	2×10^{-5}
Berkelium (97)	Bk 249	S	9×10^{-9}	2×10^{-2}	3×10^{-10}	6×10^{-4}
		I	1×10^{-7}	2×10^{-2}	4×10^{-9}	6×10^{-4}
	Bk 250	S	1×10^{-7}	6×10^{-3}	5×10^{-9}	2×10^{-4}
		I	1×10^{-7}	6×10^{-3}	4×10^{-9}	2×10^{-4}
Beryllium (4)	Be 7	S	6×10^{-7}	3×10^{-2}	2×10^{-8}	2×10^{-3}
		I	1×10^{-6}	5×10^{-2}	4×10^{-8}	2×10^{-3}
Bismuth (83)	Bi 206	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
		I	1×10^{-7}	1×10^{-3}	5×10^{-9}	4×10^{-5}
	Bi 207	S	2×10^{-7}	2×10^{-3}	6×10^{-9}	6×10^{-5}
		I	1×10^{-7}	2×10^{-3}	5×10^{-10}	6×10^{-5}
	Bi 210	S	6×10^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-5}
		I	6×10^{-8}	1×10^{-3}	2×10^{-10}	4×10^{-5}
	Bi 212	S	1×10^{-7}	1×10^{-3}	3×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

See notes at end of appendix)

Element (atomic number)	Isotope	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Bromine (35)	Br 82	S	1×10^{-6}	8×10^{-3}	4×10^{-8}	3×10^{-4}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
Cadmium (48)	Cd 109	S	5×10^{-8}	5×10^{-5}	2×10^{-9}	2×10^{-6}
		I	7×10^{-8}	5×10^{-5}	3×10^{-9}	2×10^{-6}
	Cd 115m	S	4×10^{-8}	7×10^{-6}	1×10^{-9}	3×10^{-7}
		I	4×10^{-8}	7×10^{-6}	1×10^{-9}	3×10^{-7}
	Cd 115	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	3×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
Calcium (20)	Ca 45	S	3×10^{-8}	3×10^{-6}	1×10^{-9}	9×10^{-8}
		I	1×10^{-7}	5×10^{-3}	4×10^{-9}	2×10^{-4}
	Ca 47	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	5×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	3×10^{-5}
Californium (98)	Cf 249	S	2×10^{-12}	1×10^{-6}	5×10^{-14}	4×10^{-8}
		I	1×10^{-10}	7×10^{-6}	3×10^{-12}	2×10^{-7}
	Cf 250	S	5×10^{-12}	4×10^{-6}	2×10^{-13}	1×10^{-7}
		I	1×10^{-10}	7×10^{-6}	3×10^{-12}	3×10^{-7}
	Cf 251	S	2×10^{-12}	1×10^{-6}	6×10^{-14}	4×10^{-8}
		I	1×10^{-10}	8×10^{-6}	3×10^{-12}	3×10^{-7}
	Cf 252	* S	6×10^{-12}	2×10^{-6}	2×10^{-13}	7×10^{-8}
		* I	3×10^{-10}	2×10^{-6}	1×10^{-12}	7×10^{-8}
	Cf 253	S	8×10^{-10}	4×10^{-3}	3×10^{-11}	1×10^{-6}
		I	8×10^{-10}	4×10^{-3}	3×10^{-11}	1×10^{-4}
	Cf 254	S	5×10^{-12}	4×10^{-9}	2×10^{-13}	1×10^{-7}
		I	5×10^{-12}	4×10^{-6}	2×10^{-13}	1×10^{-7}
Carbon (6)	C 14	S	4×10^{-6}	2×10^{-3}	1×10^{-7}	8×10^{-4}
	(CO_2)	Sub	5×10^{-6}		1×10^{-6}	
Cerium (58)	Ce 141	S	4×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	2×10^{-7}	3×10^{-3}	5×10^{-9}	9×10^{-5}
	Ce 143	S	3×10^{-7}	1×10^{-3}	9×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
	Ce 144	S	1×10^{-8}	3×10^{-6}	3×10^{-10}	1×10^{-7}
		I	6×10^{-9}	3×10^{-6}	2×10^{-10}	1×10^{-7}
Cesium (55)	Cs 131	S	1×10^{-5}	7×10^{-3}	4×10^{-7}	2×10^{-3}
		I	3×10^{-6}	3×10^{-3}	1×10^{-7}	9×10^{-4}
	Cs 134m	S	4×10^{-5}	2×10^{-1}	1×10^{-6}	6×10^{-3}
		I	6×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
	Cs 134	S	4×10^{-8}	3×10^{-6}	1×10^{-9}	9×10^{-8}
		I	1×10^{-8}	1×10^{-3}	4×10^{-10}	4×10^{-5}
	Cs 135	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	9×10^{-8}	7×10^{-3}	3×10^{-9}	2×10^{-4}
	Cs 136	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	9×10^{-5}
		I	2×10^{-7}	2×10^{-3}	6×10^{-9}	6×10^{-5}
	Cs 137	S	6×10^{-8}	4×10^{-6}	2×10^{-9}	2×10^{-7}
		I	1×10^{-8}	1×10^{-3}	5×10^{-10}	4×10^{-5}
Chlorine (17)	Cl 36	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
		I	2×10^{-6}	2×10^{-3}	8×10^{-10}	6×10^{-5}
	Cl 38	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	7×10^{-8}	4×10^{-4}
Chromium (24)	Cr 51	S	1×10^{-5}	5×10^{-2}	4×10^{-7}	2×10^{-3}
		I	2×10^{-6}	5×10^{-2}	8×10^{-8}	2×10^{-3}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

[See notes at end of appendix]

Element (atomic number)	Isotope		Table I, Column 1 Air (μCi/ml)	Table I, Column 2 Water (μCi/ml)	Table II, Column 1 Air (μCi/ml)	Table II, Column 2 Water (μCi/ml)
Cobalt (27)	Co 57	S	3×10^{-6}	2×10^{-3}	1×10^{-7}	5×10^{-6}
		I	2×10^{-7}	1×10^{-4}	6×10^{-9}	4×10^{-6}
	Co 58m	S	2×10^{-4}	8×10^{-2}	6×10^{-7}	3×10^{-3}
		I	9×10^{-6}	6×10^{-3}	3×10^{-7}	2×10^{-3}
	Co 58	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-6}	3×10^{-3}	2×10^{-7}	9×10^{-4}
	Co 60	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	5×10^{-4}
		I	9×10^{-7}	1×10^{-3}	3×10^{-10}	3×10^{-4}
Copper (29)	Cu 64	S	2×10^{-6}	1×10^{-3}	7×10^{-8}	3×10^{-4}
		I	1×10^{-6}	6×10^{-4}	4×10^{-8}	2×10^{-4}
Curium (96)	Cm 242	S	1×10^{-10}	7×10^{-8}	4×10^{-12}	2×10^{-8}
		I	2×10^{-10}	7×10^{-8}	6×10^{-12}	2×10^{-8}
	Cm 243	S	6×10^{-12}	1×10^{-8}	2×10^{-13}	5×10^{-9}
		I	1×10^{-10}	7×10^{-8}	3×10^{-12}	2×10^{-8}
	Cm 244	S	9×10^{-12}	2×10^{-8}	3×10^{-13}	7×10^{-9}
		I	1×10^{-10}	8×10^{-8}	3×10^{-12}	3×10^{-8}
	Cm 245	S	3×10^{-12}	1×10^{-8}	2×10^{-13}	4×10^{-9}
		I	1×10^{-10}	8×10^{-8}	4×10^{-12}	3×10^{-8}
	Cm 246	S	5×10^{-12}	1×10^{-8}	2×10^{-13}	4×10^{-9}
		I	1×10^{-10}	8×10^{-8}	4×10^{-12}	3×10^{-8}
	Cm 247	S	5×10^{-12}	1×10^{-8}	2×10^{-13}	4×10^{-9}
		I	1×10^{-10}	6×10^{-8}	4×10^{-12}	2×10^{-8}
	Cm 248	S	6×10^{-13}	1×10^{-8}	2×10^{-14}	4×10^{-9}
		I	1×10^{-11}	4×10^{-8}	4×10^{-13}	1×10^{-8}
	Cm 249	S	1×10^{-6}	6×10^{-3}	4×10^{-7}	2×10^{-3}
		I	1×10^{-6}	6×10^{-3}	4×10^{-7}	2×10^{-3}
Dysprosium (66)	Dy 165	S	3×10^{-6}	1×10^{-3}	9×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-3}	7×10^{-8}	4×10^{-4}
	Dy 166	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-4}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-4}
Einsteinium (99)	Es 253	S	8×10^{-10}	7×10^{-6}	3×10^{-11}	2×10^{-6}
		I	6×10^{-10}	7×10^{-6}	2×10^{-11}	2×10^{-6}
	Es 254m	S	5×10^{-8}	5×10^{-6}	2×10^{-9}	2×10^{-6}
		I	6×10^{-8}	5×10^{-6}	2×10^{-9}	2×10^{-6}
	Es 254	S	2×10^{-11}	4×10^{-6}	6×10^{-13}	1×10^{-6}
		I	1×10^{-10}	4×10^{-6}	4×10^{-12}	1×10^{-6}
	Es 255	S	5×10^{-10}	8×10^{-6}	2×10^{-11}	3×10^{-6}
		I	4×10^{-10}	8×10^{-6}	1×10^{-11}	3×10^{-6}
Erbium (68)	Er 169	S	6×10^{-6}	3×10^{-3}	2×10^{-7}	9×10^{-4}
		I	4×10^{-6}	3×10^{-3}	1×10^{-7}	9×10^{-4}
	Er 171	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Europium (63)	Eu 152	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-4}
	(T/2 = 9.2 hrs)	I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-4}
	Eu 152	S	1×10^{-8}	2×10^{-3}	4×10^{-10}	8×10^{-4}
	(T/2 = 13 yrs)	I	2×10^{-8}	2×10^{-3}	6×10^{-10}	8×10^{-4}
	Eu 154	S	4×10^{-8}	6×10^{-4}	1×10^{-9}	2×10^{-4}
		I	7×10^{-8}	6×10^{-4}	2×10^{-9}	2×10^{-4}
	Eu 155	S	9×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-4}
		I	7×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-4}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See notes at end of appendix)

Element (atomic number)	Isotope		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
		†	Air (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Fermium (100)	Fm 254	S	6×10^{-6}	4×10^{-3}	2×10^{-9}	1×10^{-6}
		I	7×10^{-8}	4×10^{-5}	2×10^{-9}	1×10^{-6}
	Fm 255	S	2×10^{-6}	1×10^{-3}	6×10^{-10}	3×10^{-6}
		I	1×10^{-8}	1×10^{-5}	4×10^{-10}	3×10^{-6}
	Fm 256	S	3×10^{-5}	3×10^{-3}	1×10^{-10}	9×10^{-7}
		I	2×10^{-7}	3×10^{-5}	6×10^{-11}	9×10^{-7}
Fluorine (9)	F 18	S	5×10^{-6}	2×10^{-3}	2×10^{-7}	8×10^{-6}
		I	3×10^{-6}	1×10^{-3}	9×10^{-8}	5×10^{-6}
Gadolinium (64)	Gd 153	S	2×10^{-7}	6×10^{-5}	8×10^{-9}	2×10^{-6}
		I	9×10^{-8}	6×10^{-5}	3×10^{-9}	2×10^{-6}
	Gd 159	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	4×10^{-7}	2×10^{-5}	1×10^{-8}	8×10^{-5}
Gallium (31)	Ga 72	S	2×10^{-7}	1×10^{-5}	8×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-5}	6×10^{-9}	4×10^{-5}
Germanium (32)	Ge 71	S	1×10^{-5}	5×10^{-3}	4×10^{-7}	2×10^{-5}
		I	6×10^{-6}	5×10^{-5}	2×10^{-7}	2×10^{-5}
Gold (79)	Au 196	S	1×10^{-6}	5×10^{-5}	4×10^{-8}	2×10^{-6}
		I	6×10^{-7}	4×10^{-5}	2×10^{-8}	1×10^{-6}
	Au 198	S	3×10^{-7}	2×10^{-5}	1×10^{-8}	5×10^{-5}
		I	2×10^{-7}	1×10^{-5}	8×10^{-9}	5×10^{-5}
	Au 199	S	1×10^{-6}	5×10^{-5}	4×10^{-8}	2×10^{-6}
		I	8×10^{-7}	4×10^{-5}	3×10^{-8}	2×10^{-6}
Hafnium (72)	Hf 181	S	4×10^{-6}	2×10^{-3}	1×10^{-7}	7×10^{-5}
		I	7×10^{-8}	2×10^{-5}	3×10^{-9}	7×10^{-5}
Holmium (67)	Ho 166	S	2×10^{-7}	9×10^{-6}	7×10^{-9}	3×10^{-6}
		I	2×10^{-7}	9×10^{-6}	6×10^{-9}	3×10^{-6}
Hydrogen (1)	H3	S	5×10^{-6}	1×10^{-3}	2×10^{-7}	3×10^{-5}
		I	5×10^{-6}	1×10^{-3}	2×10^{-7}	3×10^{-5}
		Sub	2×10^{-5}		4×10^{-5}	
Indium (49)	In 113m	S	8×10^{-6}	4×10^{-3}	3×10^{-7}	1×10^{-5}
		I	7×10^{-6}	4×10^{-3}	2×10^{-7}	1×10^{-5}
	In 114m	S	1×10^{-6}	5×10^{-6}	4×10^{-9}	2×10^{-7}
		I	2×10^{-6}	5×10^{-6}	7×10^{-10}	2×10^{-7}
	In 115m	S	2×10^{-6}	1×10^{-3}	8×10^{-9}	4×10^{-6}
		I	2×10^{-6}	1×10^{-3}	6×10^{-9}	4×10^{-6}
	In 115	S	2×10^{-7}	3×10^{-3}	9×10^{-9}	9×10^{-5}
		I	3×10^{-6}	3×10^{-3}	1×10^{-8}	9×10^{-5}
Iodine (53)	I 125	S	5×10^{-9}	4×10^{-7}	8×10^{-11}	2×10^{-7}
		I	2×10^{-7}	6×10^{-7}	6×10^{-9}	2×10^{-6}
	I 126	S	8×10^{-9}	5×10^{-7}	9×10^{-11}	3×10^{-7}
		I	3×10^{-7}	3×10^{-7}	1×10^{-8}	9×10^{-5}
	I 129	S	2×10^{-9}	1×10^{-7}	2×10^{-11}	6×10^{-8}
		I	7×10^{-8}	6×10^{-7}	2×10^{-9}	2×10^{-6}
	I 131	S	9×10^{-9}	6×10^{-7}	1×10^{-10}	3×10^{-7}
		I	3×10^{-8}	2×10^{-7}	1×10^{-9}	6×10^{-5}
	I 132	S	2×10^{-8}	2×10^{-7}	3×10^{-9}	8×10^{-6}
		I	9×10^{-7}	5×10^{-7}	3×10^{-8}	2×10^{-6}
	I 133	S	3×10^{-8}	2×10^{-6}	4×10^{-10}	1×10^{-6}
		I	2×10^{-7}	1×10^{-7}	7×10^{-9}	4×10^{-5}
	I 134	S	5×10^{-7}	4×10^{-3}	6×10^{-9}	2×10^{-3}

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Concentrations In Air and Water Above Natural Background—Continued

[See notes at end of appendix]

Element (atomic number)	Isotope	†	Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
			Air (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Iodine (53)	I 134	I	3×10^{-6}	2×10^{-3}	1×10^{-7}	6×10^{-6}
	I 135	S	1×10^{-7}	7×10^{-6}	1×10^{-7}	4×10^{-6}
		I	4×10^{-7}	2×10^{-3}	1×10^{-7}	7×10^{-3}
Iridium (77)	Ir 190	S	1×10^{-6}	6×10^{-3}	4×10^{-7}	2×10^{-6}
		I	4×10^{-7}	5×10^{-3}	1×10^{-7}	2×10^{-6}
	Ir 192	S	1×10^{-7}	1×10^{-3}	4×10^{-7}	4×10^{-3}
		I	3×10^{-7}	1×10^{-3}	9×10^{-10}	4×10^{-3}
	Ir 194	S	2×10^{-7}	1×10^{-3}	8×10^{-7}	3×10^{-3}
		I	2×10^{-7}	9×10^{-6}	5×10^{-7}	3×10^{-3}
Iron (26)	Fe 55	S	9×10^{-7}	2×10^{-3}	3×10^{-7}	8×10^{-6}
		I	1×10^{-6}	7×10^{-3}	3×10^{-7}	2×10^{-3}
	Fe 59	S	1×10^{-7}	2×10^{-3}	5×10^{-7}	6×10^{-3}
		I	5×10^{-7}	2×10^{-3}	2×10^{-7}	5×10^{-3}
Krypton (36)	Kr 85m	Sub	6×10^{-6}		1×10^{-7}	
	Kr 85	Sub	1×10^{-5}		3×10^{-7}	
	Kr 87	Sub	1×10^{-6}		2×10^{-7}	
	Kr 88	Sub	1×10^{-6}		2×10^{-7}	
Lanthanum (57)	La 140	S	2×10^{-7}	7×10^{-6}	5×10^{-7}	2×10^{-3}
		I	1×10^{-7}	7×10^{-6}	4×10^{-7}	2×10^{-3}
Lead (82)	Pb 203	S	3×10^{-6}	1×10^{-3}	9×10^{-8}	4×10^{-6}
		I	2×10^{-6}	1×10^{-3}	6×10^{-8}	4×10^{-6}
	Pb 210	S	1×10^{-10}	4×10^{-6}	4×10^{-12}	1×10^{-7}
		I	2×10^{-10}	5×10^{-3}	8×10^{-12}	2×10^{-6}
	Pb 212	S	2×10^{-8}	6×10^{-6}	6×10^{-10}	2×10^{-3}
		I	2×10^{-8}	5×10^{-6}	7×10^{-10}	2×10^{-3}
Lutetium (71)	Lu 177	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-6}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-6}
Manganese (25)	Mn 52	S	2×10^{-7}	1×10^{-3}	7×10^{-8}	3×10^{-3}
		I	1×10^{-7}	9×10^{-6}	5×10^{-8}	3×10^{-3}
	Mn 54	S	4×10^{-7}	4×10^{-3}	1×10^{-7}	1×10^{-6}
		I	4×10^{-7}	3×10^{-3}	1×10^{-7}	1×10^{-6}
	Mn 56	S	8×10^{-7}	4×10^{-3}	3×10^{-7}	1×10^{-6}
		I	5×10^{-7}	3×10^{-3}	2×10^{-7}	1×10^{-6}
Mercury (80)	Hg 197m	S	7×10^{-7}	6×10^{-3}	3×10^{-7}	2×10^{-6}
		I	8×10^{-7}	5×10^{-3}	3×10^{-7}	2×10^{-6}
	Hg 197	S	1×10^{-6}	9×10^{-3}	4×10^{-7}	3×10^{-6}
		I	3×10^{-6}	1×10^{-3}	9×10^{-7}	3×10^{-6}
	Hg 203	S	7×10^{-8}	5×10^{-6}	2×10^{-7}	2×10^{-3}
		I	1×10^{-7}	3×10^{-3}	4×10^{-7}	1×10^{-6}
Molybdenum (42)	Mo 99	S	7×10^{-7}	3×10^{-3}	3×10^{-7}	2×10^{-6}
		I	2×10^{-7}	1×10^{-3}	7×10^{-8}	4×10^{-3}
Neodymium (60)	Nd 144	S	8×10^{-11}	2×10^{-3}	3×10^{-11}	7×10^{-3}
		I	3×10^{-10}	2×10^{-3}	1×10^{-11}	8×10^{-3}
	Nd 147	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-3}
		I	2×10^{-7}	2×10^{-3}	8×10^{-8}	6×10^{-3}
	Nd 149	S	2×10^{-6}	8×10^{-3}	6×10^{-8}	3×10^{-6}
		I	1×10^{-6}	8×10^{-3}	5×10^{-8}	3×10^{-6}

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Concentrations in Air and Water Above Natural Background—Continued

(See notes at end of appendix)

Element (atomic number)	Isotope		Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Neptunium (93)	Np 237	S	4 × 10⁻¹²	9 × 10⁻³	1 × 10⁻¹³	3 × 10⁻⁴
		I	1 × 10⁻¹⁰	9 × 10⁻⁴	4 × 10⁻¹²	3 × 10⁻³
	Np 239	S	8 × 10⁻⁷	4 × 10⁻³	3 × 10⁻⁸	1 × 10⁻⁴
		I	7 × 10⁻⁷	4 × 10⁻³	2 × 10⁻⁸	1 × 10⁻⁴
Nickel (28)	Ni 59	S	5 × 10⁻⁷	6 × 10⁻³	2 × 10⁻⁸	2 × 10⁻⁴
		I	8 × 10⁻⁷	6 × 10⁻²	3 × 10⁻⁸	2 × 10⁻³
	Ni 63	S	6 × 10⁻⁸	8 × 10⁻⁴	2 × 10⁻⁹	3 × 10⁻⁵
		I	3 × 10⁻⁷	2 × 10⁻³	1 × 10⁻⁸	7 × 10⁻⁵
	Ni 65	S	9 × 10⁻⁷	4 × 10⁻³	3 × 10⁻⁸	1 × 10⁻⁴
		I	5 × 10⁻⁷	3 × 10⁻³	2 × 10⁻⁸	1 × 10⁻⁴
Niobium (Columbium) (41)	Nb 93m	S	1 × 10⁻⁷	1 × 10⁻³	4 × 10⁻⁹	4 × 10⁻⁵
		I	2 × 10⁻⁷	1 × 10⁻²	5 × 10⁻⁹	4 × 10⁻⁴
	Nb 95	S	5 × 10⁻⁷	3 × 10⁻³	2 × 10⁻⁸	1 × 10⁻⁴
		I	1 × 10⁻⁷	3 × 10⁻³	3 × 10⁻⁹	1 × 10⁻⁴
	Nb 97	S	6 × 10⁻⁶	3 × 10⁻²	2 × 10⁻⁷	9 × 10⁻⁴
		I	5 × 10⁻⁶	3 × 10⁻²	2 × 10⁻⁷	9 × 10⁻⁴
Osmium (76)	Os 185	S	5 × 10⁻⁷	2 × 10⁻³	2 × 10⁻⁸	7 × 10⁻⁵
		I	5 × 10⁻⁶	2 × 10⁻³	2 × 10⁻⁹	7 × 10⁻⁵
	Os 191m	S	2 × 10⁻⁵	7 × 10⁻²	6 × 10⁻⁷	3 × 10⁻³
		I	9 × 10⁻⁶	7 × 10⁻²	3 × 10⁻⁷	2 × 10⁻³
	Os 191	S	1 × 10⁻⁶	5 × 10⁻³	4 × 10⁻⁸	2 × 10⁻⁴
		I	4 × 10⁻⁶	5 × 10⁻³	1 × 10⁻⁸	2 × 10⁻⁴
	Os 193	S	4 × 10⁻⁷	2 × 10⁻³	1 × 10⁻⁸	6 × 10⁻⁵
		I	3 × 10⁻⁷	2 × 10⁻³	9 × 10⁻⁹	5 × 10⁻⁵
Palladium (46)	Pd 103	S	1 × 10⁻⁶	1 × 10⁻²	5 × 10⁻⁸	3 × 10⁻⁴
		I	7 × 10⁻⁷	8 × 10⁻³	3 × 10⁻⁸	3 × 10⁻⁴
	Pd 109	S	6 × 10⁻⁷	3 × 10⁻³	2 × 10⁻⁸	9 × 10⁻⁵
		I	4 × 10⁻⁷	2 × 10⁻³	1 × 10⁻⁸	7 × 10⁻⁵
Phosphorus (15)	P 32	S	7 × 10⁻⁸	5 × 10⁻⁴	2 × 10⁻⁹	2 × 10⁻⁵
Platinum (78)	Pt 191	S	8 × 10⁻⁷	4 × 10⁻³	3 × 10⁻⁸	1 × 10⁻⁴
		I	6 × 10⁻⁷	3 × 10⁻³	2 × 10⁻⁸	1 × 10⁻⁴
	Pt 193m	S	7 × 10⁻⁶	3 × 10⁻²	2 × 10⁻⁷	1 × 10⁻³
		I	5 × 10⁻⁶	3 × 10⁻²	2 × 10⁻⁷	1 × 10⁻³
	★ Pt 193	S	1 × 10⁻⁶	3 × 10⁻²	4 × 10⁻⁸	9 × 10⁻⁴
		I	3 × 10⁻⁶	5 × 10⁻³	1 × 10⁻⁷	2 × 10⁻⁴
	Pt 197m	S	6 × 10⁻⁶	3 × 10⁻²	2 × 10⁻⁷	1 × 10⁻³
		I	5 × 10⁻⁶	3 × 10⁻²	2 × 10⁻⁷	9 × 10⁻⁴
	Pt 197	S	8 × 10⁻⁷	4 × 10⁻³	3 × 10⁻⁸	1 × 10⁻⁴
		I	6 × 10⁻⁷	3 × 10⁻³	2 × 10⁻⁸	1 × 10⁻⁴
Plutonium (94)	Pu 238	S	2 × 10⁻¹²	1 × 10⁻⁴	7 × 10⁻¹⁴	5 × 10⁻⁶
		I	3 × 10⁻¹¹	8 × 10⁻⁴	1 × 10⁻¹²	3 × 10⁻³
	Pu 239	S	2 × 10⁻¹²	1 × 10⁻⁴	6 × 10⁻¹⁴	5 × 10⁻⁶
		I	4 × 10⁻¹¹	8 × 10⁻⁴	1 × 10⁻¹²	3 × 10⁻³
	Pu 240	S	2 × 10⁻¹²	1 × 10⁻⁴	6 × 10⁻¹⁴	5 × 10⁻⁶
		I	4 × 10⁻¹¹	8 × 10⁻⁴	1 × 10⁻¹²	3 × 10⁻³
	Pu 241	S	9 × 10⁻¹⁰	7 × 10⁻³	3 × 10⁻¹¹	2 × 10⁻⁴
		I	4 × 10⁻⁸	4 × 10⁻³	1 × 10⁻⁹	1 × 10⁻⁴

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(See notes at end of appendix)

Element (atomic number)	Isotope	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Plutonium (94)	Pu 242	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	5×10^{-6}
		I	4×10^{-11}	9×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 243	S	2×10^{-6}	1×10^{-2}	6×10^{-8}	3×10^{-4}
		I	2×10^{-6}	1×10^{-2}	8×10^{-8}	3×10^{-4}
	Pu 244	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	4×10^{-6}
		I	3×10^{-11}	3×10^{-4}	1×10^{-12}	1×10^{-5}
Polonium (84)	Po 210	S	5×10^{-10}	2×10^{-2}	2×10^{-11}	7×10^{-7}
		I	2×10^{-10}	8×10^{-4}	7×10^{-12}	3×10^{-5}
Potassium (19)	K 42	S	2×10^{-6}	9×10^{-3}	7×10^{-8}	3×10^{-4}
		I	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
Praseodymium (59)	Pr 142	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	2×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-5}
	Pr 143	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	5×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	5×10^{-5}
Promethium (61)	Pm 147	S	6×10^{-8}	6×10^{-3}	2×10^{-9}	2×10^{-4}
		I	1×10^{-7}	6×10^{-3}	3×10^{-9}	2×10^{-4}
	Pm 149	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
Protoactinium (91)	Pa 230	S	2×10^{-9}	7×10^{-3}	6×10^{-11}	2×10^{-4}
		I	8×10^{-10}	7×10^{-3}	3×10^{-11}	2×10^{-4}
	Pa 231	S	1×10^{-12}	3×10^{-3}	4×10^{-14}	9×10^{-7}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	2×10^{-5}
	Pa 233	S	6×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-4}
		I	2×10^{-7}	3×10^{-3}	6×10^{-9}	1×10^{-4}
Radium (88)	Ra 223	S	2×10^{-9}	2×10^{-3}	6×10^{-11}	7×10^{-7}
		I	2×10^{-10}	1×10^{-4}	8×10^{-12}	4×10^{-6}
	Ra 224	S	5×10^{-9}	7×10^{-3}	2×10^{-10}	2×10^{-6}
		I	7×10^{-10}	2×10^{-4}	2×10^{-11}	5×10^{-6}
	Ra 226	S	3×10^{-11}	4×10^{-7}	3×10^{-13}	3×10^{-6}
		I	5×10^{-11}	9×10^{-4}	2×10^{-12}	3×10^{-5}
	Ra 228	S	7×10^{-11}	8×10^{-7}	2×10^{-12}	3×10^{-6}
		I	4×10^{-11}	7×10^{-4}	1×10^{-12}	3×10^{-5}
Radon (86)	Rn 220	S	3×10^{-7}		1×10^{-8}	
	Rn 222 [1]	***	*** 3×10^{-8}		3×10^{-9}	
Rhenium (75)	Re 183	S	3×10^{-6}	2×10^{-2}	9×10^{-8}	6×10^{-4}
		I	2×10^{-7}	8×10^{-3}	5×10^{-9}	3×10^{-4}
	Re 186	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
	Re 187	S	9×10^{-6}	7×10^{-2}	3×10^{-7}	3×10^{-3}
		I	5×10^{-7}	4×10^{-3}	2×10^{-8}	2×10^{-3}
	Re 188	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
Rhodium (45)	Rh 103m	S	8×10^{-8}	4×10^{-1}	3×10^{-9}	1×10^{-2}
		I	6×10^{-8}	3×10^{-1}	2×10^{-9}	1×10^{-2}
	Rh 105	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Rubidium (37)	Rb 86	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
		I	7×10^{-8}	7×10^{-4}	2×10^{-9}	2×10^{-5}
	Rb 87	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	7×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

[See notes at end of appendix]

Element (atomic number)	Isotope		Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Ruthenium (44)	Ru 97	S	2×10^{-6}	1×10^{-2}	8×10^{-6}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	6×10^{-6}	3×10^{-4}
	Ru 103	S	5×10^{-7}	2×10^{-3}	2×10^{-6}	8×10^{-5}
		I	8×10^{-6}	2×10^{-3}	3×10^{-6}	8×10^{-5}
	Ru 105	S	7×10^{-7}	3×10^{-3}	2×10^{-6}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-6}	1×10^{-4}
	Ru 106	S	8×10^{-8}	4×10^{-4}	3×10^{-6}	1×10^{-5}
		I	6×10^{-6}	3×10^{-4}	2×10^{-10}	1×10^{-5}
Samarium (62)	Sm 147	S	7×10^{-11}	2×10^{-3}	2×10^{-12}	6×10^{-5}
		I	3×10^{-10}	2×10^{-3}	9×10^{-12}	7×10^{-5}
	Sm 151	S	6×10^{-6}	1×10^{-2}	2×10^{-6}	4×10^{-4}
		I	1×10^{-7}	1×10^{-2}	5×10^{-6}	4×10^{-4}
	Sm 153	S	5×10^{-7}	2×10^{-3}	2×10^{-6}	8×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-6}	8×10^{-5}
Scandium (21)	Sc 46	S	2×10^{-7}	1×10^{-3}	8×10^{-7}	4×10^{-5}
		I	2×10^{-6}	1×10^{-3}	8×10^{-10}	4×10^{-5}
	Sc 47	S	6×10^{-7}	3×10^{-3}	2×10^{-6}	9×10^{-5}
		I	5×10^{-7}	3×10^{-3}	2×10^{-6}	9×10^{-5}
	Sc 48	S	2×10^{-7}	8×10^{-4}	6×10^{-7}	3×10^{-5}
		I	1×10^{-7}	8×10^{-4}	5×10^{-7}	3×10^{-5}
Selenium (34)	Se 75	S	1×10^{-6}	9×10^{-3}	4×10^{-6}	3×10^{-4}
		I	1×10^{-7}	8×10^{-3}	4×10^{-7}	3×10^{-4}
Silicon (14)	Si 31	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
		I	1×10^{-6}	6×10^{-3}	3×10^{-6}	2×10^{-4}
Silver (47)	Ag 105	S	6×10^{-7}	3×10^{-3}	2×10^{-6}	1×10^{-4}
		I	8×10^{-6}	3×10^{-3}	3×10^{-6}	1×10^{-4}
	Ag 110m	S	2×10^{-7}	9×10^{-4}	7×10^{-7}	3×10^{-5}
		I	1×10^{-6}	9×10^{-4}	3×10^{-10}	3×10^{-5}
	Ag 111	S	3×10^{-7}	1×10^{-3}	1×10^{-6}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-7}	4×10^{-5}
Sodium (11)	Na 22	S	2×10^{-7}	1×10^{-3}	6×10^{-7}	4×10^{-5}
		I	9×10^{-6}	9×10^{-4}	3×10^{-10}	3×10^{-5}
	Na 24	S	1×10^{-6}	6×10^{-3}	4×10^{-6}	2×10^{-4}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
Strontium (38)	Sr 85m	S	4×10^{-6}	2×10^{-2}	1×10^{-6}	7×10^{-5}
		I	3×10^{-6}	2×10^{-2}	1×10^{-6}	7×10^{-5}
	Sr 85	S	2×10^{-7}	3×10^{-3}	8×10^{-7}	1×10^{-4}
		I	1×10^{-6}	5×10^{-3}	4×10^{-6}	2×10^{-4}
	Sr 89	S	3×10^{-8}	3×10^{-4}	3×10^{-10}	3×10^{-6}
		I	4×10^{-8}	8×10^{-4}	1×10^{-6}	3×10^{-5}
	Sr 90	S	1×10^{-8}	1×10^{-3}	3×10^{-11}	3×10^{-7}
		I	5×10^{-8}	1×10^{-3}	2×10^{-10}	4×10^{-5}
	Sr 91	S	4×10^{-7}	2×10^{-3}	2×10^{-6}	7×10^{-5}
		I	3×10^{-7}	1×10^{-3}	9×10^{-7}	5×10^{-5}
	Sr 92	S	4×10^{-7}	2×10^{-3}	2×10^{-6}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-6}	6×10^{-5}
Sulfur (16)	S 35	S	3×10^{-7}	2×10^{-3}	9×10^{-7}	6×10^{-5}
		I	3×10^{-7}	8×10^{-3}	9×10^{-7}	3×10^{-4}
Tantalum (73)	Ta 182	S	4×10^{-8}	1×10^{-3}	1×10^{-7}	4×10^{-5}
		I	2×10^{-8}	1×10^{-3}	7×10^{-10}	4×10^{-5}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

[See notes at end of appendix]

Element (atomic number)	Isotope		Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Technetium (43)	Tc 96m	S	8×10^{-7}	4×10^{-3}	3×10^{-9}	1×10^{-5}
		I	3×10^{-7}	3×10^{-3}	1×10^{-9}	1×10^{-5}
	Tc 96	S	6×10^{-7}	3×10^{-3}	2×10^{-9}	1×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-10}	5×10^{-6}
	Tc 97m	S	2×10^{-6}	1×10^{-2}	8×10^{-9}	4×10^{-5}
		I	2×10^{-7}	5×10^{-3}	5×10^{-9}	2×10^{-5}
	Tc 97	S	1×10^{-5}	5×10^{-2}	4×10^{-7}	2×10^{-3}
		I	3×10^{-7}	2×10^{-3}	1×10^{-9}	8×10^{-6}
	Tc 99m	S	4×10^{-5}	2×10^{-1}	1×10^{-6}	6×10^{-4}
		I	1×10^{-5}	8×10^{-2}	5×10^{-7}	3×10^{-3}
	Tc 99	S	2×10^{-6}	1×10^{-2}	7×10^{-8}	3×10^{-4}
		I	6×10^{-6}	3×10^{-2}	2×10^{-7}	2×10^{-4}
Tellurium (52)	Te 125m	S	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
	Te 127m	S	1×10^{-7}	2×10^{-3}	5×10^{-9}	6×10^{-5}
		I	4×10^{-6}	2×10^{-2}	1×10^{-7}	5×10^{-4}
	Te 127	S	2×10^{-6}	8×10^{-3}	6×10^{-8}	3×10^{-4}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Te 129m	S	8×10^{-8}	1×10^{-3}	3×10^{-9}	3×10^{-5}
		I	3×10^{-6}	6×10^{-3}	1×10^{-7}	2×10^{-4}
	Te 129	S	5×10^{-6}	2×10^{-2}	2×10^{-7}	8×10^{-4}
		I	4×10^{-6}	2×10^{-2}	1×10^{-7}	8×10^{-4}
	Te 131m	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
	Te 132	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
Terbium (65)	Tb 160	S	1×10^{-7}	1×10^{-3}	3×10^{-9}	4×10^{-5}
		I	3×10^{-8}	1×10^{-3}	1×10^{-9}	4×10^{-5}
Thallium (81)	Tl 200	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	1×10^{-6}	7×10^{-3}	4×10^{-8}	2×10^{-4}
	Tl 201	S	2×10^{-6}	9×10^{-3}	7×10^{-8}	3×10^{-4}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Tl 202	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	2×10^{-7}	2×10^{-3}	8×10^{-9}	7×10^{-5}
	Tl 204	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-4}
		I	3×10^{-6}	2×10^{-2}	9×10^{-8}	6×10^{-4}
Thorium (90)	Th 227	S	3×10^{-10}	5×10^{-6}	1×10^{-11}	2×10^{-7}
		I	2×10^{-10}	5×10^{-6}	6×10^{-12}	2×10^{-7}
	Th 228	S	9×10^{-13}	2×10^{-6}	3×10^{-13}	7×10^{-8}
		I	6×10^{-13}	4×10^{-6}	2×10^{-13}	1×10^{-7}
	Th 230	S	2×10^{-12}	5×10^{-6}	8×10^{-14}	2×10^{-7}
		I	1×10^{-11}	9×10^{-6}	3×10^{-13}	3×10^{-7}
	Th 231	S	1×10^{-6}	7×10^{-3}	5×10^{-8}	2×10^{-4}
		I	1×10^{-6}	7×10^{-3}	4×10^{-8}	2×10^{-4}
	Th 232	S	3×10^{-11}	5×10^{-7}	1×10^{-12}	2×10^{-8}
		I	2×10^{-11}	1×10^{-7}	1×10^{-12}	4×10^{-8}
	Th natural	S	6×10^{-11}	6×10^{-8}	2×10^{-12}	2×10^{-8}
		I	6×10^{-11}	6×10^{-6}	2×10^{-12}	2×10^{-8}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

[See notes at end of appendix]

Element (atomic number)	Isotope		Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Thorium (90)	Th 234	S	6×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
		I	3×10^{-8}	5×10^{-4}	1×10^{-9}	2×10^{-5}
Thulium (69)	Tm 170	S	4×10^{-8}	1×10^{-3}	1×10^{-9}	5×10^{-5}
		I	3×10^{-8}	1×10^{-3}	1×10^{-9}	5×10^{-5}
	Tm 171	S	1×10^{-7}	1×10^{-2}	4×10^{-9}	5×10^{-4}
		I	2×10^{-7}	1×10^{-2}	8×10^{-9}	5×10^{-4}
Tin (50)	Sn 113	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	9×10^{-5}
		I	5×10^{-8}	2×10^{-3}	2×10^{-9}	8×10^{-5}
	Sn 125	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-4}
		I	8×10^{-8}	5×10^{-4}	3×10^{-9}	2×10^{-4}
Tungsten (Wolfram) (74)	W 181	S	2×10^{-6}	1×10^{-3}	8×10^{-8}	4×10^{-4}
		I	1×10^{-7}	1×10^{-3}	4×10^{-9}	3×10^{-4}
	W 185	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
	W 187	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
Uranium (92)	U 230	S	3×10^{-10}	1×10^{-4}	1×10^{-11}	5×10^{-6}
		I	1×10^{-10}	1×10^{-4}	4×10^{-12}	5×10^{-6}
	U 232	S	1×10^{-10}	8×10^{-5}	3×10^{-12}	3×10^{-6}
		I	3×10^{-11}	8×10^{-5}	9×10^{-13}	3×10^{-6}
	U 233	S	5×10^{-10}	9×10^{-4}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
**	U 234	S[4]	6×10^{-10}	9×10^{-4}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
**	U 235	S[4]	5×10^{-10}	8×10^{-4}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	U 236	S	6×10^{-10}	1×10^{-3}	2×10^{-11}	4×10^{-5}
		I	1×10^{-10}	1×10^{-3}	4×10^{-12}	3×10^{-5}
**	U 238	S[4]	7×10^{-11}	1×10^{-3}	3×10^{-12}	4×10^{-5}
		I	1×10^{-10}	1×10^{-3}	5×10^{-12}	4×10^{-5}
	U 240	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	3×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	3×10^{-5}
**	U-natural	S[4]	1×10^{-10}	1×10^{-3}	5×10^{-12}	3×10^{-5}
		I	1×10^{-10}	1×10^{-3}	5×10^{-12}	3×10^{-5}
Vanadium (23)	V 48	S	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
		I	6×10^{-8}	8×10^{-4}	2×10^{-9}	3×10^{-5}
Xenon (54)	Xe 131m	Sub	2×10^{-5}		4×10^{-7}	
	Xe 133	Sub	1×10^{-5}		3×10^{-7}	
	Xe 133m	Sub	1×10^{-5}		3×10^{-7}	
	Xe 135	Sub	4×10^{-6}		1×10^{-7}	
Ytterbium (70)	Yb 175	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Yttrium (39)	Y 90	S	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
		I	1×10^{-7}	6×10^{-4}	3×10^{-9}	2×10^{-5}
	Y 91m	S	2×10^{-5}	1×10^{-1}	8×10^{-7}	3×10^{-3}
		I	2×10^{-5}	1×10^{-1}	6×10^{-7}	3×10^{-3}
	Y 91	S	4×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-5}
		I	3×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-5}
	Y 92	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Y 93	S	2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-5}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}

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Concentrations in Air and Water Above Natural Background—Continued

Element (atomic number)	Isotope [1]		Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Zinc (30)	Zn 65	S	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
		I	6×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}
	Zn 69m	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Zn 69	S	7×10^{-6}	3×10^{-2}	2×10^{-7}	2×10^{-3}
		I	9×10^{-6}	3×10^{-2}	3×10^{-7}	2×10^{-3}
Zirconium (40)	Zr 93	S	1×10^{-7}	2×10^{-3}	4×10^{-9}	8×10^{-4}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-4}
	Zr 95	S	1×10^{-7}	2×10^{-3}	4×10^{-9}	6×10^{-5}
		I	3×10^{-8}	2×10^{-3}	1×10^{-9}	6×10^{-5}
	Zr 97	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-3}
		I	9×10^{-8}	5×10^{-4}	3×10^{-9}	2×10^{-3}
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than 2 hours.		Sub	1×10^{-6}		3×10^{-8}	
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hours.			3×10^{-9}	9×10^{-3}	1×10^{-10}	3×10^{-6}
Any single radionuclide not listed above, which decays by alpha emission or spontaneous fission.			6×10^{-11}	4×10^{-7}	2×10^{-12}	3×10^{-8}

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[1] Soluble (S), Insoluble (I)
[2] "Sub" means that values given are for submersion in a semi-infinite cloud of airborne material.

[1] These radon concentrations are appropriate for protection from radon-222 combined with its short-lived daughters. Alternatively, the value in Table I may be replaced by one-third (⅓) "working level." (A "working level" is defined as any combination of short-lived radon-222 daughters, polonium-218, lead-214, bismuth-214 and polonium-214, in one liter of air, without regard to the degree of equilibrium, that will result in the ultimate emission of 1.3×10^5 MeV of alpha particle energy.) The Table II value may be replaced by one-thirtieth (1/30) of a "working level." The limit on radon-222 concentrations in restricted areas may be based on an annual average.

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[4] For soluble mixtures of U-238, U-234 and U-235 in air chemical toxicity may be the limiting factor. If the percent by weight (enrichment) of U-235 is less than 5, the concentration value for a 40-hour workweek, Table I, is 0.2 milligrams uranium per cubic meter of air average. For any enrichment, the product of the average concentration and time of exposure during a 40-hour workweek shall not exceed 8×10^{-9} SA μCi-hr/ml, where SA is the specific activity of the uranium inhaled. The concentration value for Table II is 0.007 milligrams uranium per cubic meter of air. The specific activity for natural uranium is 6.77×10^{-7} curies per gram U. The specific activity for other mixtures of U-238, U-235 and U-234, if not known, shall be:

$SA = 3.6 \times 10^{-7}$ curies/gram U U-depleted

$SA = (0.4 + 0.38\,E + 0.034\,E^2)\,10^{-6}$ $E \geq 0.72$

where E is the percentage by weight of U-235, expressed as percent.

39 FR 23990

* Amended 37 FR 23319.
** Amended 39 FR 23990; footnote redesignated 40 FR 50704.
*** Amended 40 FR 50704.
† Amended 38 FR 29314.
‡ Amended 39 FR 2546.1; redesignated 40 FR 50704.

NOTE TO APPENDIX B

Note: In any case where there is a mixture in air or water of more than one radionuclide, the limiting values for purposes of this Appendix should be determined as follows:

1. If the identity and concentration of each radionuclide in the mixture are known, the limiting values should be derived as follows: Determine, for each radionuclide in the mixture, the ratio between the quantity present in the mixture and the limit otherwise established in Appendix B for the specific radionuclide when not in a mixture. The sum of such ratios for all the radionuclides in the mixture may not exceed "1" (i.e., "unity").

EXAMPLE: If radionuclides A, B, and C are present in concentrations C_A, C_B, and C_C, and if the applicable MPC's are MPC_A, and MPC_B, and MPC_C respectively, then the concentrations shall be limited so that the following relationship exists:

$$\frac{C_A}{MPC_A} + \frac{C_B}{MPC_B} + \frac{C_C}{MPC_C} \leq 1$$

If either the identity or concentration of any radionuclide in the mixture is not known, the limiting values for purposes of this Appendix B are:

a. For purposes of Table I, Col. 1—6×10^{-12}
b. For purposes of Table I, Col. 2—4×10^{-7}
c. For purposes of Table II, Col. 1—2×10^{-14}
d. For purposes of Table II, Col. 2—3×10^{-9}

2. If any of the conditions specified below are met, the corresponding values specified below may be used in lieu of those specified in paragraph 2 above.

a. If the identity of each radionuclide in the mixture is known but the concentration of one or more of the radionuclides in the mixture is not known, the concentration limit for the mixture is the limit specified in Appendix "B" for the radionuclide in the mixture having the lowest concentration limit; or

b. If the identity of each radionuclide in the mixture is not known, but it is known that certain radionuclides specified in Appendix "B" are not present in the mixture, the concentration limit for the mixture is the lowest concentration limit specified in Appendix "B" for any radionuclide which is not known to be absent from the mixture; or

c. Element (atomic number) and isotope	Table I		Table II	
	Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)	Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
If it is known that Sr 90, I 125, I 126, I 129, I 131, I 133, table II only), Pb 210, Po 210, At 211, Ra 223, Ra 224, Ra 226, Ac 227, Ra 228, Th 230, Pa 231, Pa 233, Th-nat, Cm 248, Cf 254, and Fm 256 are not present		9×10^{-8}		3×10^{-8}
If it is known that Sr 90, I 125, I 126, I 129, I 131, I 133, table II only), Pb 210, Po 210, Ra 223, Ra 224, Ra 226, Ra 228, Pa 231, Th-nat, Cm 248, Cf 254, and Fm 256 are not present		6×10^{-8}		2×10^{-8}
If it is known that Sr 90, I 125, I 126, I 129, table II only), Pb 210, Ra 226, Ra 228, Cm 248, and Cf 254 are not present		2×10^{-8}		6×10^{-9}
If it is known that I 129, table II only), Ra 226, and Ra 228 are not present		3×10^{-8}		1×10^{-8}
If it is known that alpha-emitters and Sr 90, I 129, Pb 210, Ac 227, Ra 228, Pa 230, Pu 241, and Cf 249 are not present	3×10^{-8}		1×10^{-10}	
If it is known that alpha-emitters and Pb 210, Ac 227, Ra 228, and Pu 241 are not present	3×10^{-10}		1×10^{-11}	
If it is known that alpha-emitters and Ac 227 are not present	3×10^{-11}		1×10^{-12}	
If it is known that Ac 227, Th 230, Pa 231, Pu 238, Pu 239, Pu 240, Pu 242, Pu 244, Cm 248, Cf 249 and Cf 251 are not present	3×10^{-12}		1×10^{-13}	

4. If a mixture of radionuclides consists of uranium and its daughters in ore dust prior to chemical separation of the uranium from the ore, the values specified below may be used for uranium and its daughters through radium-226, instead of those from paragraphs 1, 2, or 3 above.

a. For purposes of Table I, Col. 1—1×10^{-10} μCi/ml gross alpha activity; or 5×10^{-14} μCi/ml natural uranium; or 75 micrograms per cubic meter of air natural uranium.

b. For purposes of Table II, Col. 1—3×10^{-12} μCi/ml gross alpha activity; or 2×10^{-13} μCi/ml natural uranium; or 3 micrograms per cubic meter of air natural uranium.

5. For purposes of this Note, a radionuclide may be considered as not present in a mixture if (a) the ratio of the concentration of that radionuclide in the mixture (C_A) to the concentration limit for that radionuclide specified in Table II of Appendix B (MPC_A) does not exceed 1/10 (i.e. $\frac{C_A}{MPC_A} \leq \frac{1}{10}$) and (b) the sum of such ratios for all the radionuclides considered as not present in the mixture does not exceed 1/4 (i.e. $\frac{C_A}{MPC_A} + \frac{C_B}{MPC_B} + \cdots \leq 1/4$).

Attachment 2 to AEP:NRC:1034

10 CFR 50 Appendix I

4. There must be substantial advantages to be gained, such as reduced power outages or reduced personnel exposure to radiation, as a direct result of not requiring surveillance capsules in all reactors in the set.

III. Report of Test Results

A. Each capsule withdrawal and the test results must be the subject of a summary technical report to be submitted, as specified in § 50.4, within one year after capsule withdrawal unless an extension is granted by the Director, Office of Nuclear Reactor Regulation. [51 FR 40303]

B. The report must include the data required by ASTM E 185, as specified in paragraph II.B.1 of this Appendix, and the results of all fracture toughness tests conducted on the beltline materials in the irradiated and unirradiated conditions. [48 FR 24008]

C. If a change in the Technical Specifications is required, either in the pressure-temperature limits or in the operating procedures required to meet the limits, the expected date for submittal of the revised Technical Specifications must be provided with the report. [48 FR 24008]

APPENDIX I—NUMERICAL GUIDES FOR DESIGN OBJECTIVES AND LIMITING CONDITIONS FOR OPERATION TO MEET THE CRITERION "AS LOW AS IS REASONABLY ACHIEVABLE" FOR RADIOACTIVE MATERIAL IN LIGHT-WATER-COOLED NUCLEAR POWER REACTOR EFFLUENTS

[40 FR 5844]

SECTION I. *Introduction.* Section 50.34a provides that an application for a permit to construct a nuclear power reactor shall include a description of the preliminary design of equipment to be installed to maintain control over radioactive materials in gaseous and liquid effluents produced during normal reactor operations, including expected operational occurrences. In the case of an application filed on or after January 2, 1971, the application must also identify the design objectives, and the means to be employed, for keeping levels of radioactive material in effluents to unrestricted areas as low as practicable.

Section 50.36a contains provisions designed to assure that releases of radioactive material from nuclear power reactors to unrestricted areas during normal reactor operations, including expected operational occurrences, are kept as low as practicable.

This appendix provides numerical guides for design objectives and limiting conditions for operation to assist applicants for, and holders of, licenses for light-water-cooled nuclear power reactors in meeting the requirements of §§ 50.34a and 50.36a that radioactive material in effluents released from these facilities to unrestricted areas be kept as low as is reasonably achievable. Design objectives and limiting conditions for operation conforming to the guidelines of this appendix shall be deemed a conclusive showing of compliance with the "as low as is reasonably achievable" requirements of 10 CFR 50.34a and 50.36a. Design objectives and limiting conditions for operation differing from the guidelines may also be used, subject to a case-by-case showing of a sufficient basis for the findings of "as low as is reasonably achievable" required by §§ 50.34a and 50.36a. The guides presented in this appendix are appropriate only for light-water-cooled nuclear power reactors and not for other types of nuclear facilities.

[40 FR 19439]

SEC. II. *Guides on design objectives for light-water-cooled nuclear power reactors licensed under 10 CFR Part 50.* The guides on design objectives set forth in this section may be used by an applicant for a permit to construct a light-water-cooled nuclear power reactor as guidance in meeting the requirements of § 50.34a(a). The applicant shall provide reasonable assurance that the following design objectives will be met.

A. The calculated annual total quantity of all radioactive material above background[1] to be released from each light-water-cooled nuclear power reactor to unrestricted areas will not result in an estimated annual dose or dose commitment from liquid effluents for any individual in an unrestricted area from all pathways of exposure in excess of 3 millirems to the total body or 10 millirems to any organ.

B.1. The calculated annual total quantity of all radioactive material above background to be released from each light-water-cooled nuclear power reactor to the atmosphere will not result in an estimated annual air dose from gaseous effluents at any location near ground level which could be occupied by individuals in unrestricted areas in excess of 10 millirads for gamma radiation or 20 millirads for beta radiation.

2. Notwithstanding the guidance of paragraph B.1:

(a) The Commission may specify, as guidance on design objectives, a lower quantity of radioactive material above background to be released to the atmosphere if it appears that the use of the design objectives in paragraph B.1 is likely to result in an estimated annual external dose from gaseous effluents to any individual in an unrestricted area in excess of 5 millirems to the total body; and

[40 FR 5847]

(b) Design objectives based upon a higher quantity of radioactive material above background to be released to the atmosphere than the quantity specified in paragraph B.1 will be deemed to meet the requirements for keeping levels of radioactive material in gaseous effluents as low as is reasonably achievable if the applicant provides reasonable assurance that the proposed higher quantity will not result in an estimated annual external dose from gaseous effluents to any individual in unrestricted areas in excess of 5 millirems to the total body or 15 millirems to the skin.

[40 FR 19439]

C. The calculated annual total quantity of all radioactive iodine and radioactive material in particulate form above background to be released from each light-water-cooled nuclear power reactor in effluents to the atmosphere will not result in an estimated annual dose or dose commitment from such radioactive iodine and radioactive material in particulate form for any individual in an unrestricted area from all pathways of exposure in excess of 15 millirems to any organ.

D. In addition to the provisions of paragraphs A, B, and C above, the applicant shall include in the radwaste system all items of reasonably demonstrated technology that, when added to the system sequentially and in order of diminishing cost-benefit return, can for a favorable cost-benefit ratio effect reductions in dose to the population reasonably expected to be within 50 miles of the reactor. As an interim measure and until establishment and adoption of better values (or other appropriate criteria), the values $1000 per total body man-rem and $1000 per man-thyroid-rem (or such lesser values as may be demonstrated to be suitable in a particular case) shall be used in this cost-benefit analysis. [40 FR 19439]

The requirements of this paragraph D need not be complied with by persons who have filed applications for construction permits which were docketed on or after January 2, 1971, and prior to June 4, 1976, if the radwaste systems and equipment described in the preliminary or final safety analysis report and amendments thereto satisfy the Guides on Design Objectives for Light-Water-Cooled Nuclear Power Reactors proposed in the Concluding Statement of Position of the Regulatory Staff in Docket-RM-50-2 dated February 20, 1974, pp. 25-30, reproduced in the Annex to this Appendix I. [40 FR 40816]

[40 FR 19439]

SEC. III. *Implementation.* A.1. Conformity with the guides on design objectives of Section II shall be demonstrated by calculational procedures based upon models and data such that the actual exposure of an individual through appropriate pathways is unlikely to be substantially underestimated, all uncertainties being considered together. Account shall be taken of the cumulative effect of all sources and pathways within the plant contributing to the particular type of effluent being considered. For determination of design objectives in accordance with the guides of Section II, the estimations of exposure shall be made with respect to such potential land and water usage and food pathways as could actually exist during the term of plant operation: *Provided,* That, if the requirements of paragraph B of Section III are fulfilled, the applicant shall be deemed to have complied with the requirements of paragraph C of Section II with respect to radioactive iodine if estimations of exposure are made on the basis of such food pathways and individual receptors as actually exist at the time the plant is licensed.

2. The characteristics attributed to a hypothetical receptor for the purpose of estimating internal dose commitment shall take into account reasonable deviations of individual habits from the average. The applicant may take account of any real phenomenon or factors actually affecting the estimate of radiation exposure, including the characteristics of the plant, modes of discharge of radioactive materials, physical processes tending to attenuate the quantity of radioactive material to which an individual would be exposed, and the effects of averaging exposures over times during which determining factors may fluctuate.

B. If the applicant determines design objectives with respect to radioactive iodine on the basis of existing conditions and if potential changes in land and water usage and food pathways could result in exposures in excess of the guideline values of paragraph C of Section II, the applicant shall provide reasonable assurance that a monitoring and surveillance program will be performed to determine:

1. The quantities of radioactive iodine actually released to the atmosphere and deposited relative to those estimated in the determination of design objectives:

[1] Here and elsewhere in this appendix background means radioactive materials in the environment and in the effluents from light-water-cooled power reactors not generated in, or attributable to, the reactors of which specific account is required in determining design objectives.

40 FR 19439

2. Whether changes in land and water usage and food pathways which would result in individual exposures greater than originally estimated have occurred; and

3. The content of radioactive iodine and foods involved in the changes, if and when they occur.

40 FR 58847

SEC. IV. *Guides on technical specifications for limiting conditions for operation for light-water-cooled nuclear power reactors licensed under 10 CFR Part 50.* The guides on limiting conditions for operation for light-water-cooled nuclear power reactors set forth below may be used by an applicant for a license to operate a light-water-cooled nuclear power reactor as guidance in developing technical specifications under § 50.36a(a) to keep levels of radioactive materials in effluents to unrestricted areas as low as is reasonably achievable.

Section 50.36a(b) provides that licensees shall be guided by certain considerations in establishing and implementing operating procedures specified in technical specifications that take into account the need for operating flexibility and at the same time assure that the licensee will exert his best effort to keep levels of radioactive material in effluents as low as is reasonably achievable. The guidance set forth below provides additional and more specific guidance to licensees in this respect.

Through the use of the guides set forth in this Section it is expected that the annual releases of radioactive material in effluents from light-water-cooled nuclear power reactors can generally be maintained within the levels set forth as numerical guides for design objectives in Section II.

At the same time, the licensee is permitted the flexibility of operation, compatible with considerations of health and safety, to assure that the public is provided a dependable source of power even under unusual operating conditions which may temporarily result in releases higher than such numerical guides for design objectives but still within levels that assure that the average population exposure is equivalent to small fractions of doses from natural background radiation. It is expected that in using this operational flexibility under unusual operating conditions, the licensee will exert his best efforts to keep levels of radioactive material in effluents within the numerical guides for design objectives.

42 FR 20138

A. If the quantity of radioactive material actually released in effluents to unrestricted areas from a light-water-cooled nuclear power reactor during any calendar quarter is such that the resulting radiation exposure, calculated on the same basis as the respective design objective exposure, would exceed one-half the design objective annual exposure derived pursuant to Sections II and III, the licensee shall: [1]

1. Make an investigation to identify the causes for such release rates;

2. Define and initiate a program of corrective action; and

51 FR 40030

3. Report these actions as specified in § 50.4, within 30 days from the end of the quarter during which the release occurred.

40 FR 19439

B. The licensee shall establish an appropriate surveillance and monitoring program to:

1. Provide data on quantities of radioactive material released in liquid and gaseous effluents to assure that the provisions of paragraph A of this section are met;

2. Provide data on measurable levels of radiation and radioactive materials in the environment to evaluate the relationship between quantities of radioactive material released in effluents and resultant radiation doses to individuals from principal pathways of exposure; and

3. Identify changes in the use of unrestricted areas (e.g., for agricultural purposes) to permit modifications in monitoring programs for evaluating doses to individuals from principal pathways of exposure.

C. If the data developed in the surveillance and monitoring program described in paragraph B of this section and in paragraph B of Section III or from other monitoring programs show that the relationship between the quantities of radioactive material released in liquid and gaseous effluents and the dose to individuals in unrestricted areas is significantly different from that assumed in the calculations used to determine design objectives pursuant to Sections II and III, the Commission may modify the quantities in the technical specifications defining the limiting conditions for operation in a license authorizing operation of a light-water-cooled nuclear power reactor.

SEC. V. *Effective dates.* A. The guides for limiting conditions for operation set forth in this appendix shall be applicable in any case in which an application was filed on or after January 2, 1971, for a permit to construct a light-water-cooled nuclear power reactor.

B. For each light-water-cooled nuclear power reactor constructed pursuant to a permit for which application was filed prior to January 2, 1971, the holder of the permit or a license, authorizing operation of the reactor shall, within a period of twelve months from June 4, 1975, file with the Commission:

40 FR 58847

1. Such information as is necessary to evaluate the means employed for keeping levels of radioactivity in effluents to unrestricted areas as low as is reasonably achievable, including all such information as is required by § 50.34a (b) and (c) not already contained in his application; and

2. Plans and proposed technical specifications developed for the purpose of keeping releases of radioactive materials to unrestricted areas during normal reactor operations, including expected operational occurrences, as low as is reasonably achievable.

CONCLUDING STATEMENT OF POSITION OF THE REGULATORY STAFF (DOCKET-RM-50-2)

GUIDES ON DESIGN OBJECTIVES FOR LIGHT-WATER-COOLED NUCLEAR POWER REACTORS

A. For radioactive material above background [1] in liquid effluents to be released to unrestricted areas:

1. The calculated annual total quantity of all radioactive material from all light-water-cooled nuclear power reactors at a site should not result in an annual dose or dose commitment to the total body or to any organ of an individual in an unrestricted area from all pathways of exposure in excess of 5 millirems; and

40 FR 40816

2. The calculated annual total quantity of radioactive material, except tritium and dissolved gases, should not exceed 5 curies for each light-water-cooled reactor at a site.

3. Notwithstanding the guidance in paragraph A.2. for a particular site, if an applicant for a permit to construct a light-water-cooled nuclear power reactor has proposed baseline in-plant control measures [2] to reduce the possible sources of radioactive material in liquid effluent releases and the calculated quantity exceeds the quantity set forth in paragraph A.2. the requirements for design objectives for radioactive material in liquid effluents may be deemed to have been met provided:

51 FR 40030

a. The applicant submits, as specified in § 50.4, an evaluation of the potential for effects from long-term buildup on the environment in the vicinity of the site of radioactive material, with a radioactive half-life greater than one year, to be released; and

40 FR 40816

b. The provisions of paragraph A.1 are met.

B. For radioactive material above background in gaseous effluents the annual total quantity of radioactive material to be released to the atmosphere by all light-water-cooled nuclear power reactors at a site:

1. The calculated annual air dose due to gamma radiation at any location near ground level which could be occupied by individuals at or beyond the boundary of the site should not exceed 10 millirads; and

2. The calculated annual air dose due to beta radiation at any location near ground level which could be occupied by individuals at or beyond the boundary of the site should not exceed 20 millirads.

3. Notwithstanding the guidance in paragraphs B.1 and B.2, for a particular site:

a. The Commission may specify, as guidance on design objectives, a lower quantity of radioactive material above background in gaseous effluents to be released to the atmosphere if it appears that the use of the design objectives described in paragraphs B.1 and B.2 is likely to result in an annual dose to an individual in an unrestricted area in excess of 5 millirems to the total body or 15 millirems to the skin; or

[1] "Background," means the quantity of radioactive material in the effluent from light-water-cooled nuclear power reactors at a site that did not originate in the reactors.

[2] Such measures may include treatment of clear liquid waste streams (normally tritiated, nonaerated, low conductivity equipment drains and pump seal leakoff), dirty liquid waste streams (normally nontritiated, aerated, high conductivity building sumps, floor and sample station drains), steam generator blowdown streams, chemical waste streams, low purity and high purity liquid streams (resin regenerate and laboratory wastes), as appropriate for the type of reactor.

[1] Section 50.36a(a)(2) requires the licensee to submit certain reports to the Commission with regard to the quantities of the principal radionuclides released to unrestricted areas. It also provides that, on the basis of such reports and any additional information the Commission may obtain from the licensee and others, the Commission may from time to time require the license to take such action as the Commission deems appropriate.

40 FR 58847

b. Design objectives based on a higher quantity of radioactive material above background in gaseous effluents to be released to the atmosphere than the quantity specified in paragraphs B.1 and B.2 may be deemed to meet the requirements for keeping levels of radioactive material in gaseous effluents as low as is reasonably achievable if the applicant provides reasonable assurance that the proposed higher quantity will not result in annual doses to an individual in an unrestricted area in excess of 5 millirems to the total body or 15 millirems to the skin.

40 FR 40816

C. For radioactive iodine and radioactive material in particulate form above background released to the atmosphere:

1. The calculated annual total quantity of all radioactive iodine and radioactive material in particulate form from all light-water-cooled nuclear power reactors at a site should not result in an annual dose or dose commitment to any organ of an individual in an unrestricted area from all pathways of exposure in excess of 15 millirems. In determining the dose or dose commitment the portion thereof due to intake of radioactive material via the food pathways may be evaluated at the locations where the food pathways actually exist; and

2. The calculated annual total quantity of iodine-131 in gaseous effluents should not exceed 1 curie for each light-water-cooled nuclear power reactor at a site.

3. Notwithstanding the guidance in paragraphs C.1 and C.2 for a particular site, if an applicant for a permit to construct a light-water-cooled nuclear power reactor has proposed baseline in-plant control measures[1] to reduce the possible sources of radioactive iodine releases, and the calculated annual quantities taking into account such control measures exceed the design objective quantities set forth in paragraphs C.1 and C.2, the requirements for design objectives for radioactive iodine and radioactive material in particulate form in gaseous effluents may be deemed to have been met provided the calculated annual total quantity of all radioactive iodine and radioactive material in particulate form that may be released in gaseous effluents does not exceed four times the quantity calculated pursuant to paragraph C.1.

[1]Such in-plant control measures may include treatment of steam generator blowdown tank exhaust, clean steam supplies for turbine gland seals, condenser vacuum systems, containment purging exhaust and ventilation exhaust systems and special design features to reduce contaminated steam and liquid leakage from valves and other sources such as sumps and tanks, as appropriate for the type of reactor.

38 FR 1385

APPENDIX J

PRIMARY REACTOR CONTAINMENT LEAKAGE TESTING FOR WATER-COOLED POWER REACTORS

I. Introduction.
II. Explanation of terms.
III. Leakage test requirements.
A. Type A test.
B. Type B test.
C. Type C test.
D. Periodic retest schedule.
IV. Special test requirements.
A. Containment modifications.
B. Multiple leakage-barrier containments.
V. Inspection and reporting of tests.
A. Containment inspection.
B. Report of test results.

I. INTRODUCTION

One of the conditions of all operating licenses for water-cooled power reactors as specified in § 50.54(o) is that primary reactor containments shall meet the containment leakage test requirements set forth in this appendix. These test requirements provide for preoperational and periodic verification by tests of the leak-tight integrity of the primary reactor containment, and systems and components which penetrate containment of water-cooled power reactors, and establish the acceptance criteria for such tests. The purposes of the tests are to assure that (a) leakage through the primary reactor containment and systems and components penetrating primary containment shall not exceed allowable leakage rate values as specified in the technical specifications or associated bases and (b) periodic surveillance of reactor containment penetrations and isolation valves is performed so that proper maintenance and repairs are made during the service life of the containment, and systems and components penetrating primary containment. These test requirements may also be used for guidance in establishing appropriate containment leakage test requirements in technical specifications or associated bases for other types of nuclear power reactors.

II. EXPLANATION OF TERMS

A. "Primary reactor containment" means the structure or vessel that encloses the components of the reactor coolant pressure boundary, as defined in § 50.2(v), and serves as an essentially leak-tight barrier against the uncontrolled release of radioactivity to the environment.

B. "Containment isolation valve" means any valve which is relied upon to perform a containment isolation function.

C. "Reactor containment leakage test program" includes the performance of Type A, Type B, and Type C tests, described in II.F, II.G, and II.H, respectively.

D. "Leakage rate" for test purposes is that leakage which occurs in a unit of time, stated as a percentage of weight of the original content of containment air at the leakage rate test pressure that escapes to the outside atmosphere during a 24-hour test period.

E. "Overall integrated leakage rate" means that leakage rate which obtains from a summation of leakage through all potential leakage paths including containment welds, valves, fittings, and components which penetrate containment.

F. "Type A Tests" means tests intended to measure the primary reactor containment overall integrated leakage rate (1) after the containment has been completed and is ready for operation, and (2) at periodic intervals thereafter.

G. "Type B Tests" means tests intended to detect local leaks and to measure leakage across each pressure-containing or leakage-limiting boundary for the following primary reactor containment penetrations:

1. Containment penetrations whose design incorporates resilient seals, gaskets, or sealant compounds, piping penetrations fitted with expansion bellows, and electrical penetrations fitted with flexible metal seal assemblies.

2. Air lock door seals, including door operating mechanism penetrations which are part of the containment pressure boundary.

3. Doors with resilient seals or gaskets except for seal-welded doors.

4. Components other than those listed in II.G.1, II.G.2, or II.G.3 which must meet the acceptance criteria in III.B.3.

H. "Type C Tests" means tests intended to measure containment isolation valve leakage rates. The containment isolation valves included are those that:

1. Provide a direct connection between the inside and outside atmospheres of the primary reactor containment under normal operation, such as purge and ventilation, vacuum relief, and instrument valves;

2. Are required to close automatically upon receipt of a containment isolation signal in response to controls intended to effect containment isolation;

3. Are required to operate intermittently under postaccident conditions; and

4. Are in main steam and feedwater piping and other systems which penetrate containment of direct-cycle boiling water power reactors.

I. Pa (p.s.i.g.) means the calculated peak containment internal pressure related to the design basis accident and specified either in the technical specification or associated bases.

J. Pt (p.s.i.g.) means the containment vessel reduced test pressure selected to measure the integrated leakage rate during periodic Type A tests.

K. La (percent/24 hours) means the maximum allowable leakage rate at pressure Pa as specified for preoperational tests in the technical specifications or associated bases, and as specified for periodic tests in the operating license.

38 FR 4385

L. Ld (percent/24 hours) means the design leakage rate at pressure, Pa, as specified in the technical specifications or associated bases.

M. Lt (percent/24 hours) means the maximum allowable leakage rate at pressure Pt derived from the preoperational test data as specified in III.A.4.(a)(iii).

N. Lam, Ltm (percent/24 hours) means the total measured containment leakage rates at pressure Pa and Pt, respectively, obtained from testing the containment with components and systems in the state as close as practical to that which would exist under design basis accident conditions (e.g., vented, drained, flooded or pressurized).

O. "Acceptance criteria" means the standard against which test results are to be compared for establishing the functional acceptability of the containment as a leakage limiting boundary.

III. LEAKAGE TESTING REQUIREMENTS

A program consisting of a schedule for conducting Type A, B, and C tests shall be developed for leak testing the primary reactor containment and related systems and components penetrating primary containment pressure boundary.

Upon completion of construction of the primary reactor containment, including installation of all portions of mechanical, fluid, electrical, and instrumentation systems penetrating the primary reactor containment pressure boundary, and prior to any reactor operating period, preoperational and periodic leakage rate tests, as applicable, shall be conducted in accordance with the following:

A. *Type A test*—1. *Pretest requirements.* (a) Containment inspection in accordance with V.A. shall be performed as a prerequisite to the performance of Type A tests. During the period between the initiation of the containment inspection and the performance of the Type A test, no repairs or adjustments shall be made so that the containment can be tested in as close to the "as is" condition as practical. During the period between the

Attachment 3 to AEP:NRC:1034

IE Information Notice 83-05

Attachment 3 to AEP:NRC:1034A

AEP:NRC:1034 dated August 28, 1987

27 pp.

INDIANA & MICHIGAN ELECTRIC COMPANY

P.O. BOX 16631
COLUMBUS, OHIO 43216

August 28, 1987

AEP:NRC:1034

Donald C. Cook Nuclear Plant Units 1 and 2
Docket Nos. 50-315 and 50-316
License Nos. DPR-58 and DPR-74
DISPOSAL OF CONTAMINATED WASTE OIL AT
THE DONALD C. COOK NUCLEAR PLANT UNITS 1 AND 2

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555

Attn: T. E. Murley

Dear Dr. Murley:

As requested by Mr. D. L. Wigginton of your staff, this letter provides information concerning I&MECo's past method of disposing of waste oil contaminated with low levels of radioactivity and requests approval to use this method in the future. This request resulted from a July 17, 1987 phone conversation in which we informed Mr. Wigginton of concerns raised in a recent audit performed at the Cook Plant by AEP's Nuclear Safety and Design Review Committee (NSDRC). These concerns are associated with the practice of disposing of contaminated waste oil by mixing it with uncontaminated fuel oil and then burning it in the auxiliary boiler system (an unmonitored release pathway). The following discussion provides the results of an investigation performed in response to the NSDRC audit team concerns and presents a technical evaluation of this issue that forms the basis for justification of our request that NRC approve the use of this method of contaminated waste oil disposal in the future.

The investigation of the NSDRC audit team concern showed that contaminated waste oil was transferred to the (uncontaminated) auxiliary boiler fuel oil tanks on eleven occasions during the period January 1980 to June 1985. This practice has now been prohibited pending resolution of the NSDRC audit team's concerns. This mixture of contaminated waste oil and uncontaminated fuel oil was then burned when the auxiliary boiler was operated. The principal source of contaminated oil is the oil used for primary system pump motor bearing lubrication. We also have some contaminated oil from a variety of sources in the auxiliary building. All contaminated oil is generated during normal maintenance-related activities performed on motors, pumps, and other mechanical devices.

U V

Although the oil is contaminated with radioactive material, levels of such contamination are very low, and when the waste oil/fuel oil mixture is burned, the resulting releases are well within limits specified by current regulations.

In reviewing the potential regulatory concerns specifically associated with this method of contaminated waste oil disposal, we considered that the following regulations were applicable at the Cook Plant:

1. 10 CFR 20.106(a):

   20.106 Radioactivity in effluents to unrestricted areas.

   (a) A licensee shall not possess, use, or transfer licensed material so as to release to an unrestricted area radioactive material in concentrations which exceed the limits specified in Appendix B, Table II of this part, except as authorized pursuant to Part 20.302 or paragraph (b) of this section. For purposes of this section concentrations may be averaged over a period not greater than one year.

   A copy of 10 CFR 20 Appendix B (cited above) is included as Attachment 1 to this submittal. Part 20.302 is cited in Item 2 below.

2. 10 CFR 20.302(a):

   20.302 Method for obtaining approval of proposed disposal procedures.

   (a) Any licensee or applicant for a license may apply to the Commission for approval of proposed procedures to dispose of licensed material in a manner not otherwise authorized in the regulations in this chapter. Each application should include a description of the licensed material and any other radioactive material involved, including the quantities and kinds of such material and the levels of radioactivity involved, and the proposed manner and conditions of disposal. The application should also include an analysis and evaluation of pertinent information as to the nature of the environment, including topographical, geological, meteorological, and hydrological characteristics; usage of ground and surface waters in the general area; the nature and location of other potentially affected facilities; and procedures to be observed to minimize the risk of unexpected or hazardous exposures.

3. 10 CFR 20.305:

20.305 Treatment or disposal by incineration.

No licensee shall treat or dispose of licensed material by incineration except for materials listed under Part 20.306 or as specifically approved by the Commission pursuant to Parts 20.106(b) and 20.302.

We believe that the requirements of 10 CFR 50 Appendix I associated with doses to individuals in unrestricted areas also apply. A copy of this appendix is included in Attachment 2 to this submittal. In addition to these regulations, our investigation identified two NRC IE Information Notices relevant to disposal of contaminated waste oil by burning. These Information Notices (IE Information Notice 83-05, "Obtaining Approval for Disposing of Very Low-Level Radioactive Waste - 10 CFR Section 20.302" and IE Information Notice 83-33, "Nonrepresentative Sampling of Contaminated Oil") are included as Attachments 3 and 4 to this submittal. Evaluation of the regulatory requirements identified above disclosed that radioactivity releases resulting from burning of the contaminated waste oil were accounted for in our Semi-Annual Radioactive Effluent Release Reports, always below the 10 CFR 20, Appendix B limits for radioactivity releases in air to unrestricted areas, and in conformance with the requirements of 10 CFR 50, Appendix I for annual doses to individuals in unrestricted areas. However, no formal documentation was found to indicate that the NRC had approved the practice of disposing of this waste oil by incineration. We believe such approval is required by 10 CFR 20.302 and 10 CFR 20.305.

Due to an administrative oversight, we believe that a request for approval to dispose of contaminated waste oil by burning was not requested as suggested by Information Notice 83-05. In the case of Information Notice 83-33, a review for Cook Plant applicability was performed and as a result of the review our sampling procedure was revised to provide additional assurance that representative samples are taken. Our sampling procedure requires taking a sample from the bottom of the contaminated waste oil storage tank in order to obtain a sample which we believe is a conservative (i.e., worst-case) representation of the tank contents.

In response to the requirements of 10 CFR 20.302, the information presented below provides an analysis and evaluation of the impact on public health and safety of the burning of the contaminated oil and a description of the procedures we will use prior to such burning. Based on the information presented below, we have concluded that burning oil in the manner indicated will not result in releases that exceed the requirements of 10 CFR 20 for releases in air to unrestricted areas, and hence we considered this method of disposal acceptable. Further, these releases are included in the total radioactivity inventory reported at the Cook Plant in our semiannual reports, and hence, by the information contained in that report, we also consider the requirements of 10 CFR 50, Appendix I to have been met.

The information concerning the nature of the environment suggested by 10 CFR 20.302 is included in our Updated Final Safety Analysis Report (Chapters 1 and 2). Minor modifications to this information are addressed in the semiannual effluent release reports, which are updated on a regular basis in accordance with the requirements of 10 CFR 50.36a(a)2. Both of these documents have been transmitted to the NRC. A list of transmittals associated with these activities is included in Attachment 5 to this letter.

Contaminated waste oil is initially collected in 55 gallon drums, sampled, then transferred to a waste oil storage tank. Our sampling procedure requires the waste oil storage tank to be sampled for isotopic analysis every seven days or as requested by the plant Environmental Section after waste oil is added, or prior to transfer of the waste oil to the auxiliary boiler fuel oil tanks. Details of the volume of contaminated waste oil placed in the auxiliary boiler fuel oil tanks since 1980, as well as the details of isotopic analysis performed on the contaminated waste oil, are provided in Tables 1 and 2 respectively. As shown in Table 1, the volume of contaminated waste oil placed in the (uncontaminated) auxiliary boiler fuel oil tanks ranged from 300 to 1500 gallons. The contaminated waste oil was added to an uncontaminated fuel oil volume of between 39,920 and 100,000 gallons, depending on the date the transfer was made.

We have performed an analysis using the data presented in Tables 1 and 2 to quantify the radioactivity concentration in the releases resulting from burning of contaminated waste oil. As was pointed out above, the total radioactivity release has been accounted for in our semiannual effluent release reports; however, since the auxiliary boiler stack exhaust is not monitored for radioactivity, an assessment was performed, as part of our technical evaluation, to ensure that the concentration limits of 10 CFR 20, Appendix B would not be exceeded and hence that no adverse effects to the public health and safety would result from this method of disposal.

In general, the radioactivity concentration in the contaminated waste oil is reduced by dilution upon transfer to the uncontaminated fuel oil tanks. Further dilution is provided when the waste oil/fuel oil mix is burned and the combustion by-products are released through the auxiliary boiler stack. Our method of analysis, therefore, was to calculate the dilution factors for the mixing of the contaminated waste oil with uncontaminated fuel oil (giving the radioactivity concentration in the liquid waste oil/fuel oil mixture) then calculating the airborne radioactivity in the stack exhaust considering the volume of air necessary to burn a given volume of the waste oil/fuel oil mix. Since fuel oil tank volume information was not available for the June 1985 transfer and therefore the dilution provided by the volume of fuel oil in the fuel oil tanks at the time of transfer could not be established, we believed that an analysis of the amount of radioactivity released by burning this batch of waste oil, assuming no dilution in the uncontaminated fuel oil would represent a conservative assessment of the upper limit for the radioactivity concentration released from the auxiliary boiler stack on any occasion. Our analysis showed that the stack exhaust air would provide a dilution factor of approximately 7500

for complete combustion of the waste oil/fuel oil mixture. This dilution factor is actually the calculated value of the volume of air required to achieve complete combustion of a unit volume of the waste oil/fuel oil mixture, based on the chemical reaction describing the complete combustion of hydrocarbons. We also assumed that 100% of the radioactivity in this mixture would be released in the auxiliary boiler stack exhaust. We believe that applying the dilution factor calculated for complete combustion of the waste oil/fuel oil mixture is conservative, since in practice approximately 20% excess air (which provides additional dilution) is used in operating the auxiliary boiler. In our calculation of release concentration we have not taken credit for this excess air.

For the mix of radionuclides present in the contaminated waste oil that was transferred to the (uncontaminated) fuel oil tanks in June 1985. (see Table 2), assuming no dilution of the contaminated waste oil in the uncontaminated fuel oil, the airborne radioactivity concentration in the auxiliary boiler stack exhaust was calculated to be approximately 50% of the 10 CFR 20, Appendix B maximum permissible concentration (MPC) in air released to unrestricted areas.

We believe, as stated previously, that this represents the limiting case for release of radioactivity, since no credit has been taken for dilution of the contaminated waste oil in the volume of uncontaminated fuel oil contained in the auxiliary boiler fuel oil tanks at the time of transfer. We therefore believe that concentrations of radioactivity released from burning the other waste oil batches identified in Tables 1 and 2 were substantially lower than the release concentration from the burning of the June 1985 waste oil volume calculated on the assumptions stated above. We expect that radioactivity concentrations in future volumes of waste oil to be burned in the auxiliary boiler will be typical of those shown in Table 2 for batches previously added to the auxiliary boiler fuel oil tanks. Future releases from this pathway will continue to be accounted for, as in the past, in our semiannual reports, including an evaluation of the effects on public health and safety. On this basis, since previous release concentrations have been well within the 10 CFR 20, Appendix B MPCs for air and this effluent pathway has been included in our Semi-Annual Radioactive Effluent Release Reports with no identified adverse effect on the health and safety of the public, we believe that continuing this practice in the future will similarly not result in adverse effects to the public. We therefore believe this evaluation provides adequate justification for our request for NRC approval to use this method of contaminated waste oil disposal in the future.

It should be noted that no waste oil has been transferred to the auxiliary boiler fuel oil tanks since June 1985. We also do not intend to dispose of additional contaminated waste oil in this manner until we receive NRC approval to do so. However, we anticipate that the waste oil storage tank will be filled to capacity in the near future, at which point we will need to take some action to dispose of the tank contents. Therefore, as suggested by IE Information Notice 83-05, we request NRC approval to dispose of contaminated waste oil by incineration in the

auxiliary boiler system. We will need this approval by November 1, 1987 in order to allow us to dispose of accumulated waste oil in an orderly manner.

Pursuant to 10 CFR 170.12(c) we have enclosed a check for $150.00 for the requested review.

This document has been prepared following Corporate procedures which incorporate a reasonable set of controls to insure its accuracy and completeness prior to signature by the undersigned.

Very truly yours,

M. P. Alexich
Vice President

cm
Attachments
cc: John E. Dolan
W. G. Smith, Jr. - Bridgman
R. C. Callen
G. Bruchmann
G. Charnoff
NRC Resident Inspector - Bridgman
A. B. Davis - Region III

TABLE 1

CONTAMINATED WASTE OIL PLACED IN THE
AUXILIARY BOILER FUEL OIL TANKS

DATE	WASTE OIL VOLUME(GAL)	WASTE OIL STORAGE TANK SAMPLE ANALYSIS ID	FUEL OIL VOLUME(GAL)
01/10/80	1500	61861	59,730
01/15/80	1500	61938	39,920
07/05/80	300	66230	45,240
08/12/80	800	95608H	96,480
10/25/80	1500	98878H	82,330
05/27/81	1250	71842	85,200
10/23/81	1500	9262R	87,350
07/22/82	1100	20185R	93,220
03/16/83	700	29052R	94,960
12/13/83	1300	38607R	100,000
06/04/85	1300	61031R	Unavailable

TABLE 2

WASTE OIL STORAGE TANK SAMPLE ISOTOPIC ANALYSIS RESULTS PRIOR TO TRANSFER TO AUXILIARY BOILER FUEL OIL TANKS

DATE	LAB ANALYSIS ID.	ISOTOPE	CONCENTRATION (uci/ml)
01/10/80	61861	Cs-134	2.09 E-6
		Cs-137	3.55 E-6
01/15/80	61938	Cs-134	1.94 E-6
		Cs-137	3.39 E-6
07/05/80	66230	Cs-134	8.72 E-6
		Cs-137	1.64 E-5
		Co-60	4.83 E-7
08/12/80	95608H	Cs-134	2.49 E-6
		Cs-137	5.76 E-6
		Co-60	7.89 E-7
10/25/80	98878H	Xe-133	6.96 E-6
		Cs-134	1.16 E-6
		Cs-137	2.81 E-6
		Mn-54	1.38 E-6
		Co-60	2.29 E-5
05/27/81	71842	Cs-134	2.10 E-5
		Cs-137	5.67 E-5
		Co-58	4.90 E-6
		Mn-54	4.93 E-6
		Co-60	1.19 E-4
10/23/81	9262R	Cs-134	1.46 E-5
		Cs-137	4.25 E-5
		Co-58	1.54 E-6
		Mn-54	2.25 E-6
		Co-60	4.72 E-5
07/22/82	20185R	Xe-133	6.16 E-7
		Cs-134	1.07 E-6
		Ag-110m	3.16 E-6
		Cs-137	2.14 E-6
		Zr-97	2.91 E-7
		Nb-95	6.92 E-7
		Co-58	3.27 E-6
		Cs-136	2.39 E-7
		Co-60	3.65 E-6

DATE	LAB ANALYSIS ID.	ISOTOPE	CONCENTRATION (uci/ml)
03/16/83	29052R	Ag-110m	3.45 E-6
		Co-58	8.26 E-7
		Co-60	1.73 E-6
		Cs-134	4.93 E-7
		Nb-95	5.19 E-7
		Nb-97	1.29 E-5
		Sr-92	1.71 E-6
12/13/83	38607R	Co-60	2.03 E-7
		Cs-134	8.73 E-7
		Cs-137	2.33 E-6
06/04/85	61031R	Co-60	6.46 E-7
		Cs-134	1.64 E-6
		Cs-137	4.29 E-6

Attachment 1 to AEP:NRC:1034

10 CFR 20 Appendix B

APPENDIX B

Concentrations in Air and Water Above Natural Background

[See notes at end of appendix]

Element (atomic number)	Isotope [1]		Table I, Column 1 Air (μCi/ml)	Table I, Column 2 Water (μCi/ml)	Table II, Column 1 Air (μCi/ml)	Table II, Column 2 Water (μCi/ml)
Actinium (89)	Ac 227	S	2×10^{-12}	6×10^{-9}	8×10^{-14}	2×10^{-9}
		I	3×10^{-11}	9×10^{-9}	9×10^{-13}	3×10^{-9}
	Ac 228	S	8×10^{-9}	3×10^{-7}	3×10^{-9}	9×10^{-8}
		I	2×10^{-8}	3×10^{-7}	6×10^{-10}	9×10^{-8}
Americium (95)	Am 241	S	6×10^{-12}	1×10^{-8}	2×10^{-13}	4×10^{-9}
		★ I	1×10^{-10}	8×10^{-9}	4×10^{-12}	3×10^{-8}
	Am 242m	S	6×10^{-12}	1×10^{-8}	2×10^{-13}	4×10^{-9}
		I	3×10^{-10}	3×10^{-8}	9×10^{-12}	9×10^{-8}
	Am 242	S	4×10^{-9}	4×10^{-8}	1×10^{-9}	1×10^{-8}
		I	5×10^{-9}	4×10^{-8}	2×10^{-9}	1×10^{-8}
	Am 243	S	6×10^{-12}	1×10^{-8}	2×10^{-13}	4×10^{-9}
		I	1×10^{-10}	8×10^{-9}	4×10^{-12}	3×10^{-8}
	Am 244	S	4×10^{-8}	1×10^{-7}	1×10^{-7}	5×10^{-8}
		I	2×10^{-7}	1×10^{-7}	8×10^{-7}	5×10^{-8}
Antimony (51)	Sb 122	S	2×10^{-7}	8×10^{-8}	6×10^{-9}	3×10^{-8}
		I	1×10^{-7}	8×10^{-8}	5×10^{-9}	3×10^{-8}
	Sb 124	S	2×10^{-7}	7×10^{-8}	5×10^{-9}	2×10^{-8}
		I	2×10^{-8}	7×10^{-8}	7×10^{-10}	2×10^{-8}
	Sb 125	S	5×10^{-7}	3×10^{-7}	2×10^{-8}	1×10^{-8}
		I	3×10^{-8}	3×10^{-7}	9×10^{-10}	1×10^{-8}
Argon (18)	A 37	Sub [2]	6×10^{-3}		1×10^{-4}	
	A 41	Sub	2×10^{-6}		4×10^{-8}	
Arsenic (33)	As 73	S	2×10^{-6}	1×10^{-7}	7×10^{-8}	5×10^{-8}
		I	4×10^{-7}	1×10^{-7}	1×10^{-8}	5×10^{-8}
	As 74	S	3×10^{-7}	2×10^{-7}	1×10^{-8}	5×10^{-8}
		I	1×10^{-7}	2×10^{-7}	4×10^{-9}	5×10^{-8}
	As 76	S	1×10^{-7}	6×10^{-8}	4×10^{-9}	2×10^{-8}
		I	1×10^{-7}	6×10^{-8}	3×10^{-9}	2×10^{-8}
	As 77	S	5×10^{-7}	2×10^{-7}	2×10^{-8}	8×10^{-8}
		I	4×10^{-7}	2×10^{-7}	1×10^{-8}	8×10^{-8}
Astatine (85)	At 211	S	7×10^{-9}	5×10^{-8}	2×10^{-10}	2×10^{-8}
		I	3×10^{-8}	2×10^{-7}	1×10^{-9}	7×10^{-8}
Barium (56)	Ba 131	S	1×10^{-6}	5×10^{-8}	4×10^{-9}	2×10^{-8}
		I	4×10^{-7}	5×10^{-8}	1×10^{-8}	2×10^{-8}
	Ba 140	S	1×10^{-7}	8×10^{-8}	4×10^{-9}	3×10^{-8}
		I	4×10^{-8}	7×10^{-8}	1×10^{-9}	2×10^{-8}
Berkelium (97)	Bk 249	S	9×10^{-10}	2×10^{-7}	3×10^{-11}	6×10^{-8}
		I	1×10^{-7}	2×10^{-7}	4×10^{-9}	6×10^{-8}
	Bk 250	S	1×10^{-7}	6×10^{-8}	5×10^{-9}	2×10^{-8}
		I	1×10^{-6}	6×10^{-8}	4×10^{-8}	2×10^{-8}
Beryllium (4)	Be 7	S	6×10^{-6}	5×10^{-7}	2×10^{-7}	2×10^{-8}
		I	1×10^{-6}	5×10^{-7}	4×10^{-8}	2×10^{-8}
Bismuth (83)	Bi 206	S	2×10^{-7}	1×10^{-7}	6×10^{-9}	4×10^{-8}
		I	1×10^{-7}	1×10^{-7}	5×10^{-9}	4×10^{-8}
	Bi 207	S	2×10^{-7}	2×10^{-7}	6×10^{-9}	6×10^{-8}
		I	1×10^{-7}	2×10^{-7}	5×10^{-10}	6×10^{-8}
	Bi 210	S	6×10^{-9}	1×10^{-7}	2×10^{-10}	4×10^{-8}
		I	6×10^{-9}	1×10^{-7}	2×10^{-10}	4×10^{-8}
	Bi 212	S	1×10^{-7}	1×10^{-7}	3×10^{-9}	4×10^{-8}
		I	2×10^{-7}	1×10^{-7}	7×10^{-9}	4×10^{-8}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See notes at end of appendix)

Element (atomic number)	Isotope [1]		Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Bromine (35)	Br 82	S	1×10^{-6}	8×10^{-3}	4×10^{-8}	3×10^{-4}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
Cadmium (48)	Cd 109	S	5×10^{-8}	5×10^{-5}	2×10^{-9}	2×10^{-6}
		I	7×10^{-8}	5×10^{-5}	3×10^{-9}	2×10^{-6}
	Cd 115m	S	4×10^{-8}	7×10^{-6}	1×10^{-9}	3×10^{-7}
		I	4×10^{-8}	7×10^{-6}	1×10^{-9}	3×10^{-7}
	Cd 115	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	3×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
Calcium (20)	Ca 45	S	3×10^{-8}	3×10^{-6}	1×10^{-9}	9×10^{-8}
		I	1×10^{-7}	5×10^{-5}	4×10^{-9}	2×10^{-6}
	Ca 47	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	5×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	3×10^{-5}
Californium (98)	Cf 249	S	2×10^{-12}	1×10^{-8}	5×10^{-14}	4×10^{-8}
		I	1×10^{-10}	7×10^{-6}	3×10^{-12}	2×10^{-7}
	Cf 250	S	5×10^{-12}	4×10^{-8}	2×10^{-13}	1×10^{-7}
		I	1×10^{-10}	7×10^{-6}	3×10^{-12}	3×10^{-7}
	Cf 251	S	2×10^{-12}	1×10^{-8}	6×10^{-14}	4×10^{-8}
		I	1×10^{-10}	8×10^{-6}	3×10^{-12}	3×10^{-7}
	Cf 252	* S	6×10^{-12}	2×10^{-8}	2×10^{-13}	7×10^{-8}
		* I	3×10^{-11}	2×10^{-6}	1×10^{-12}	7×10^{-8}
	Cf 253	S	8×10^{-10}	4×10^{-3}	3×10^{-11}	1×10^{-4}
		I	8×10^{-10}	4×10^{-3}	3×10^{-11}	1×10^{-4}
	Cf 254	S	5×10^{-12}	4×10^{-8}	2×10^{-13}	1×10^{-7}
		I	5×10^{-12}	4×10^{-8}	2×10^{-13}	1×10^{-7}
Carbon (6)	C 14	S	4×10^{-6}	2×10^{-2}	1×10^{-7}	8×10^{-4}
	(CO_2)	Sub	5×10^{-6}		1×10^{-6}	
Cerium (58)	Ce 141	S	4×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	2×10^{-7}	3×10^{-3}	5×10^{-9}	9×10^{-5}
	Ce 143	S	3×10^{-7}	1×10^{-3}	9×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
	Ce 144	S	1×10^{-8}	3×10^{-6}	3×10^{-10}	1×10^{-7}
		I	6×10^{-9}	3×10^{-6}	2×10^{-10}	1×10^{-7}
Cesium (55)	Cs 131	S	1×10^{-6}	7×10^{-2}	4×10^{-8}	2×10^{-3}
		I	3×10^{-6}	3×10^{-2}	1×10^{-7}	9×10^{-4}
	Cs 134m	S	4×10^{-6}	2×10^{-1}	1×10^{-6}	6×10^{-3}
		I	6×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
	Cs 134	S	4×10^{-8}	3×10^{-6}	1×10^{-9}	9×10^{-8}
		I	1×10^{-8}	1×10^{-3}	4×10^{-10}	4×10^{-5}
	Cs 135	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	9×10^{-8}	7×10^{-3}	3×10^{-9}	2×10^{-4}
	Cs 136	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	9×10^{-5}
		I	2×10^{-7}	2×10^{-3}	6×10^{-9}	6×10^{-5}
	Cs 137	S	6×10^{-8}	4×10^{-6}	2×10^{-9}	2×10^{-7}
		I	1×10^{-8}	1×10^{-3}	5×10^{-10}	4×10^{-5}
Chlorine (17)	Cl 36	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
		I	2×10^{-8}	2×10^{-3}	8×10^{-10}	6×10^{-5}
	Cl 38	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	7×10^{-8}	4×10^{-4}
Chromium (24)	Cr 51	S	1×10^{-5}	5×10^{-2}	4×10^{-7}	2×10^{-3}
		I	2×10^{-6}	5×10^{-2}	8×10^{-8}	2×10^{-3}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See notes at end of appendix)

Element (atomic number)	Isotope [1]		Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Cobalt (27)	Co 57	S	3×10^{-6}	2×10^{-2}	1×10^{-7}	5×10^{-4}
		I	2×10^{-7}	1×10^{-2}	6×10^{-9}	4×10^{-4}
	Co 58m	S	2×10^{-5}	8×10^{-2}	6×10^{-7}	3×10^{-3}
		I	9×10^{-6}	6×10^{-2}	3×10^{-7}	2×10^{-3}
	Co 58	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-6}	3×10^{-3}	2×10^{-7}	9×10^{-5}
	Co 60	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	5×10^{-5}
		I	9×10^{-9}	1×10^{-3}	3×10^{-10}	3×10^{-5}
Copper (29)	Cu 64	S	2×10^{-6}	1×10^{-2}	7×10^{-8}	3×10^{-4}
		I	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
Curium (96)	Cm 242	S	1×10^{-10}	7×10^{-6}	4×10^{-12}	2×10^{-3}
		* I	2×10^{-10}	7×10^{-6}	6×10^{-12}	2×10^{-3}
	Cm 243	S	6×10^{-12}	1×10^{-6}	2×10^{-13}	5×10^{-6}
		I	1×10^{-10}	7×10^{-6}	3×10^{-12}	2×10^{-3}
	Cm 244	S	9×10^{-12}	2×10^{-6}	3×10^{-13}	7×10^{-6}
		I	1×10^{-10}	8×10^{-6}	3×10^{-12}	3×10^{-3}
	Cm 245	S	5×10^{-12}	1×10^{-6}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-6}	4×10^{-12}	3×10^{-3}
	Cm 246	S	5×10^{-12}	1×10^{-6}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-6}	4×10^{-12}	3×10^{-3}
	Cm 247	S	5×10^{-12}	1×10^{-6}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	6×10^{-6}	4×10^{-12}	2×10^{-3}
	Cm 248	S	6×10^{-13}	1×10^{-5}	2×10^{-14}	4×10^{-7}
		I	1×10^{-11}	4×10^{-5}	4×10^{-13}	1×10^{-6}
	Cm 249	S	1×10^{-5}	6×10^{-2}	4×10^{-7}	2×10^{-3}
		I	1×10^{-5}	6×10^{-2}	4×10^{-7}	2×10^{-3}
Dysprosium (66)	Dy 165	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	7×10^{-8}	4×10^{-4}
	Dy 166	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
Einsteinium (99)	Es 253	S	8×10^{-10}	7×10^{-6}	3×10^{-11}	2×10^{-3}
		I	6×10^{-10}	7×10^{-6}	2×10^{-11}	2×10^{-3}
	Es 254m	S	5×10^{-9}	5×10^{-6}	2×10^{-10}	2×10^{-3}
		I	6×10^{-9}	5×10^{-6}	2×10^{-10}	2×10^{-3}
	Es 254	S	2×10^{-11}	4×10^{-6}	6×10^{-13}	1×10^{-3}
		I	1×10^{-10}	4×10^{-6}	4×10^{-12}	1×10^{-3}
	Es 255	S	5×10^{-10}	8×10^{-6}	2×10^{-11}	3×10^{-3}
		I	4×10^{-10}	8×10^{-6}	1×10^{-11}	3×10^{-3}
Erbium (68)	Er 169	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	4×10^{-7}	3×10^{-3}	1×10^{-8}	9×10^{-5}
	Er 171	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Europium (63)	Eu 152	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	(T/2 = 9.2 hrs)	I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Eu 152	S	1×10^{-8}	2×10^{-3}	4×10^{-10}	8×10^{-5}
	(T/2 = 13 yrs)	I	2×10^{-8}	2×10^{-3}	6×10^{-10}	8×10^{-5}
	Eu 154	S	4×10^{-9}	6×10^{-4}	1×10^{-10}	2×10^{-5}
		I	7×10^{-9}	6×10^{-4}	2×10^{-10}	2×10^{-5}
	Eu 155	S	9×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-4}
		I	7×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-4}

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Concentrations in Air and Water Above Natural Background—Continued

[See notes at end of appendix]

Element (atomic number)	Isotope[1]		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
		†	Air (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Fermium (100)	Fm 254	S	6×10^{-6}	4×10^{-3}	2×10^{-9}	1×10^{-6}
		I	7×10^{-6}	4×10^{-3}	2×10^{-9}	1×10^{-6}
	Fm 255	S	2×10^{-6}	1×10^{-3}	6×10^{-10}	3×10^{-7}
		I	1×10^{-6}	1×10^{-3}	4×10^{-10}	3×10^{-7}
	Fm 256	S	3×10^{-5}	3×10^{-3}	1×10^{-10}	9×10^{-7}
		I	2×10^{-5}	3×10^{-3}	6×10^{-11}	9×10^{-7}
Fluorine (9)	F 18	S	5×10^{-6}	2×10^{-3}	2×10^{-7}	8×10^{-6}
		I	3×10^{-6}	1×10^{-3}	9×10^{-8}	5×10^{-6}
Gadolinium (64)	Gd 153	S	2×10^{-7}	6×10^{-3}	8×10^{-9}	2×10^{-6}
		I	9×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-6}
	Gd 159	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-6}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-6}
Gallium (31)	Ga 72	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-6}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-6}
Germanium (32)	Ge 71	S	1×10^{-5}	5×10^{-3}	4×10^{-7}	2×10^{-5}
		I	6×10^{-6}	5×10^{-3}	2×10^{-7}	2×10^{-5}
Gold (79)	Au 196	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-6}
		I	6×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-6}
	Au 198	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	5×10^{-6}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-6}
	Au 199	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-6}
		I	8×10^{-7}	4×10^{-3}	3×10^{-8}	2×10^{-6}
Hafnium (72)	Hf 181	S	4×10^{-6}	2×10^{-3}	1×10^{-9}	7×10^{-7}
		I	7×10^{-6}	2×10^{-3}	3×10^{-9}	7×10^{-7}
Holmium (67)	Ho 166	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-6}
		I	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-6}
Hydrogen (1)	H3	S	5×10^{-6}	1×10^{-1}	2×10^{-7}	3×10^{-5}
		I	5×10^{-6}	1×10^{-1}	2×10^{-7}	3×10^{-5}
		Sub	2×10^{-5}		4×10^{-7}	
Indium (49)	In 113m	S	8×10^{-6}	4×10^{-3}	3×10^{-7}	1×10^{-6}
		I	7×10^{-6}	4×10^{-3}	2×10^{-7}	1×10^{-6}
	In 114m	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-6}
		I	2×10^{-8}	5×10^{-4}	7×10^{-10}	2×10^{-6}
	In 115m	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-6}
		I	2×10^{-6}	1×10^{-2}	6×10^{-8}	4×10^{-6}
	In 115	S	2×10^{-7}	3×10^{-3}	9×10^{-9}	9×10^{-7}
		I	3×10^{-6}	3×10^{-3}	1×10^{-8}	9×10^{-7}
Iodine (53)	I 125	S	5×10^{-8}	4×10^{-5}	8×10^{-11}	2×10^{-7}
		I	2×10^{-7}	6×10^{-5}	6×10^{-9}	2×10^{-6}
	I 126	S	8×10^{-9}	5×10^{-5}	9×10^{-11}	3×10^{-7}
		I	3×10^{-7}	3×10^{-3}	1×10^{-8}	9×10^{-7}
	I 129	S	2×10^{-8}	1×10^{-5}	2×10^{-11}	6×10^{-8}
		I	7×10^{-8}	6×10^{-5}	2×10^{-9}	2×10^{-6}
	I 131	S	9×10^{-9}	6×10^{-5}	1×10^{-10}	3×10^{-7}
		I	3×10^{-7}	2×10^{-3}	1×10^{-9}	6×10^{-7}
	I 132	S	2×10^{-7}	2×10^{-3}	3×10^{-9}	8×10^{-6}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-5}
	I 133	S	3×10^{-8}	2×10^{-4}	4×10^{-10}	1×10^{-6}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-6}
	I 134	S	5×10^{-7}	4×10^{-3}	6×10^{-9}	2×10^{-5}

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Concentrations in Air and Water Above Natural Background—Continued

[See notes at end of appendix]

Element (atomic number)	Isotope [1]		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
		†	Air (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Iodine (53)	I 134	I	3×10^{-6}	2×10^{-3}	1×10^{-7}	6×10^{-6}
	I 135	S	1×10^{-7}	7×10^{-4}	1×10^{-7}	4×10^{-6}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
Iridium (77)	Ir 190	S	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
		I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
	Ir 192	S	1×10^{-7}	1×10^{-3}	4×10^{-9}	4×10^{-5}
		I	3×10^{-8}	1×10^{-3}	9×10^{-10}	4×10^{-5}
	Ir 194	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	3×10^{-5}
		I	2×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-5}
Iron (26)	Fe 55	S	9×10^{-7}	2×10^{-3}	3×10^{-8}	8×10^{-5}
		I	1×10^{-6}	7×10^{-3}	3×10^{-8}	2×10^{-4}
	Fe 59	S	1×10^{-7}	2×10^{-3}	5×10^{-9}	6×10^{-5}
		I	5×10^{-8}	2×10^{-3}	2×10^{-9}	5×10^{-5}
Krypton (36)	Kr 85m	Sub	6×10^{-6}		1×10^{-7}	
	Kr 85	Sub	1×10^{-5}		3×10^{-7}	
	Kr 87	Sub	1×10^{-6}		2×10^{-8}	
	Kr 88	Sub	1×10^{-6}		2×10^{-8}	
Lanthanum (57)	La 140	S	2×10^{-7}	7×10^{-4}	5×10^{-9}	2×10^{-5}
		I	1×10^{-7}	7×10^{-4}	4×10^{-9}	2×10^{-5}
Lead (82)	Pb 203	S	3×10^{-6}	1×10^{-3}	9×10^{-8}	4×10^{-5}
		I	2×10^{-6}	1×10^{-3}	6×10^{-8}	4×10^{-5}
	Pb 210	S	1×10^{-10}	4×10^{-6}	4×10^{-12}	1×10^{-7}
		I	2×10^{-10}	5×10^{-3}	8×10^{-12}	2×10^{-4}
	Pb 212	S	2×10^{-6}	6×10^{-4}	6×10^{-10}	2×10^{-5}
		I	2×10^{-8}	5×10^{-4}	7×10^{-10}	2×10^{-5}
Lutetium (71)	Lu 177	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Manganese (25)	Mn 52	S	2×10^{-7}	1×10^{-3}	7×10^{-9}	3×10^{-5}
		I	1×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-5}
	Mn 54	* S	4×10^{-7}	4×10^{-3}	1×10^{-8}	1×10^{-4}
		I	4×10^{-8}	3×10^{-3}	1×10^{-9}	1×10^{-4}
	Mn 56	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Mercury (80)	Hg 197m	S	7×10^{-7}	6×10^{-3}	3×10^{-8}	2×10^{-4}
		I	8×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Hg 197	S	1×10^{-6}	9×10^{-3}	4×10^{-8}	3×10^{-4}
		I	3×10^{-6}	1×10^{-2}	9×10^{-8}	5×10^{-4}
	Hg 203	S	7×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
Molybdenum (42)	Mo 99	S	7×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
Neodymium (60)	Nd 144	S	8×10^{-11}	2×10^{-3}	3×10^{-12}	7×10^{-5}
		I	3×10^{-10}	2×10^{-3}	1×10^{-11}	8×10^{-5}
	Nd 147	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	2×10^{-3}	8×10^{-9}	6×10^{-5}
	Nd 149	S	2×10^{-6}	8×10^{-3}	6×10^{-8}	3×10^{-4}
		I	1×10^{-6}	8×10^{-3}	5×10^{-8}	3×10^{-4}

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(See notes at end of appendix)

Element (atomic number)	Isotope		Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Neptunium (93)	Np 237	S	4×10^{-12}	9×10^{-5}	1×10^{-13}	3×10^{-6}
		I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
	Np 239	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	7×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-4}
Nickel (28)	Ni 59	S	5×10^{-7}	6×10^{-3}	2×10^{-8}	2×10^{-4}
		I	8×10^{-7}	6×10^{-3}	3×10^{-8}	2×10^{-4}
	Ni 63	S	6×10^{-8}	8×10^{-4}	2×10^{-9}	3×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
	Ni 65	S	9×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Niobium (Columbium) (41)	Nb 93m	S	1×10^{-7}	1×10^{-2}	4×10^{-9}	4×10^{-4}
		I	2×10^{-7}	1×10^{-2}	5×10^{-9}	4×10^{-4}
	Nb 95	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	1×10^{-7}	3×10^{-3}	3×10^{-9}	1×10^{-4}
	Nb 97	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
		I	5×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
Osmium (76)	Os 185	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	5×10^{-8}	2×10^{-3}	2×10^{-9}	7×10^{-5}
	Os 191m	S	2×10^{-5}	7×10^{-2}	6×10^{-7}	3×10^{-3}
		I	9×10^{-6}	7×10^{-2}	3×10^{-7}	2×10^{-3}
	Os 191	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-4}
		I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
	Os 193	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	3×10^{-7}	2×10^{-3}	9×10^{-9}	5×10^{-5}
Palladium (46)	Pd 103	S	1×10^{-6}	1×10^{-2}	5×10^{-8}	3×10^{-4}
		I	7×10^{-7}	8×10^{-3}	3×10^{-8}	3×10^{-4}
	Pd 109	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
Phosphorus (15)	P 32	S	7×10^{-6}	5×10^{-4}	2×10^{-9}	2×10^{-5}
		I	8×10^{-6}	7×10^{-4}	3×10^{-9}	2×10^{-5}
Platinum (78)	Pt 191	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
	Pt 193m	S	7×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
		I	5×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
*	Pt 193	S	1×10^{-5}	3×10^{-2}	4×10^{-7}	9×10^{-4}
		I	3×10^{-6}	5×10^{-2}	1×10^{-6}	2×10^{-3}
	Pt 197m	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
		I	5×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
	Pt 197	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Plutonium (94)	Pu 238	S	2×10^{-12}	1×10^{-4}	7×10^{-14}	5×10^{-6}
		I	3×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 239	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	5×10^{-6}
		I	4×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 240	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	5×10^{-6}
		I	4×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 241	S	9×10^{-11}	7×10^{-3}	3×10^{-12}	2×10^{-4}
		I	4×10^{-9}	4×10^{-2}	1×10^{-9}	1×10^{-3}

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(See notes at end of appendix)

Element (atomic number)	Isotope [1]		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
		†	Air (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Plutonium (94)	Pu 242	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	5×10^{-6}
		I	4×10^{-11}	9×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 243	S	2×10^{-6}	1×10^{-2}	6×10^{-8}	3×10^{-4}
		I	2×10^{-6}	1×10^{-2}	8×10^{-8}	3×10^{-4}
	Pu 244	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	4×10^{-6}
		I	3×10^{-11}	3×10^{-4}	1×10^{-12}	1×10^{-5}
Polonium (84)	Po 210	S	3×10^{-10}	2×10^{-3}	2×10^{-11}	7×10^{-5}
		I	2×10^{-10}	8×10^{-4}	7×10^{-12}	3×10^{-5}
Potassium (19)	K 42	S	2×10^{-6}	9×10^{-3}	7×10^{-8}	3×10^{-4}
		I	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
Praseodymium (59)	Pr 142	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	2×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-5}
	Pr 143	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	5×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	5×10^{-5}
Promethium (61)	Pm 147	S	6×10^{-8}	6×10^{-3}	2×10^{-9}	2×10^{-4}
		I	1×10^{-7}	6×10^{-3}	3×10^{-9}	2×10^{-4}
	Pm 149	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
Protoactinium (91)	Pa 230	S	2×10^{-9}	7×10^{-3}	6×10^{-11}	2×10^{-4}
		I	8×10^{-10}	7×10^{-3}	3×10^{-11}	2×10^{-4}
	Pa 231	S	1×10^{-12}	3×10^{-3}	4×10^{-14}	9×10^{-7}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	2×10^{-5}
	Pa 233	S	6×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-4}
		I	2×10^{-7}	3×10^{-3}	6×10^{-9}	1×10^{-4}
Radium (88)	Ra 223	S	2×10^{-9}	2×10^{-3}	6×10^{-11}	7×10^{-5}
		I	2×10^{-10}	1×10^{-4}	8×10^{-12}	4×10^{-6}
	Ra 224	S	5×10^{-9}	7×10^{-3}	2×10^{-10}	2×10^{-4}
		I	7×10^{-10}	2×10^{-4}	2×10^{-11}	5×10^{-6}
	Ra 226	S	3×10^{-11}	4×10^{-7}	3×10^{-12}	3×10^{-8}
		I	5×10^{-11}	9×10^{-4}	2×10^{-12}	3×10^{-5}
	Ra 228	S	7×10^{-11}	8×10^{-7}	2×10^{-12}	3×10^{-8}
		I	4×10^{-11}	7×10^{-4}	1×10^{-12}	3×10^{-5}
Radon (86)	Rn 220	S	3×10^{-7}		1×10^{-8}	
	Rn 222 [3]	***	***		3×10^{-9}	
Rhenium (75)	Re 183	S	3×10^{-6}	2×10^{-2}	9×10^{-8}	6×10^{-4}
		I	2×10^{-7}	8×10^{-3}	5×10^{-9}	3×10^{-4}
	Re 186	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
	Re 187	S	9×10^{-6}	7×10^{-2}	3×10^{-7}	3×10^{-3}
		I	5×10^{-7}	4×10^{-3}	2×10^{-8}	2×10^{-4}
	Re 188	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
Rhodium (45)	Rh 103m	S	8×10^{-5}	4×10^{-1}	3×10^{-6}	1×10^{-2}
		I	6×10^{-5}	3×10^{-1}	2×10^{-6}	1×10^{-2}
	Rh 105	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Rubidium (37)	Rb 86	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
		I	7×10^{-8}	7×10^{-4}	2×10^{-9}	2×10^{-5}
	Rb 87	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	7×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}

[3] *** 3×10^{-8}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See notes at end of appendix)

Element (atomic number)	Isotope [1]		Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Ruthenium (44)	Ru 97	S	2×10^{-6}	1×10^{-2}	8×10^{-9}	4×10^{-6}
		I	2×10^{-6}	1×10^{-2}	6×10^{-9}	3×10^{-6}
	Ru 103	S	5×10^{-7}	2×10^{-3}	2×10^{-9}	8×10^{-7}
		I	8×10^{-8}	2×10^{-3}	3×10^{-9}	8×10^{-7}
	Ru 105	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-6}
		I	5×10^{-7}	3×10^{-3}	2×10^{-9}	1×10^{-6}
	Ru 106	S	8×10^{-8}	4×10^{-6}	3×10^{-9}	1×10^{-7}
		I	6×10^{-9}	3×10^{-6}	2×10^{-10}	1×10^{-7}
Samarium (62)	Sm 147	S	7×10^{-11}	2×10^{-3}	2×10^{-12}	6×10^{-7}
		I	3×10^{-10}	2×10^{-3}	9×10^{-12}	7×10^{-7}
	Sm 151	S	6×10^{-8}	1×10^{-2}	2×10^{-9}	4×10^{-6}
		I	1×10^{-7}	1×10^{-2}	5×10^{-9}	4×10^{-6}
	Sm 153	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-7}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-7}
Scandium (21)	Sc 46	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-7}
		I	2×10^{-6}	1×10^{-3}	8×10^{-10}	4×10^{-7}
	Sc 47	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-7}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-7}
	Sc 48	S	2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-7}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-7}
Selenium (34)	Se 75	S	1×10^{-6}	9×10^{-3}	4×10^{-8}	3×10^{-6}
		I	1×10^{-7}	8×10^{-3}	4×10^{-9}	3×10^{-6}
Silicon (14)	Si 31	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-6}
		I	1×10^{-6}	6×10^{-3}	3×10^{-8}	2×10^{-6}
Silver (47)	Ag 105	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-6}
		I	8×10^{-8}	3×10^{-3}	3×10^{-9}	1×10^{-6}
	Ag 110m	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-7}
		I	1×10^{-8}	9×10^{-4}	3×10^{-10}	3×10^{-7}
	Ag 111	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	4×10^{-7}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-7}
Sodium (11)	Na 22	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-7}
		I	9×10^{-9}	9×10^{-4}	3×10^{-10}	3×10^{-7}
	Na 24	S	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-6}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-7}
Strontium (38)	Sr 85m	S	4×10^{-5}	2×10^{-1}	1×10^{-6}	7×10^{-5}
		I	3×10^{-5}	2×10^{-1}	1×10^{-6}	7×10^{-5}
	Sr 85	S	2×10^{-7}	3×10^{-3}	8×10^{-9}	1×10^{-6}
		I	1×10^{-7}	5×10^{-3}	4×10^{-9}	2×10^{-6}
	Sr 89	S	3×10^{-8}	3×10^{-4}	3×10^{-10}	3×10^{-6}
		I	4×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-7}
	Sr 90	S	1×10^{-9}	1×10^{-4}	3×10^{-11}	3×10^{-7}
		I	5×10^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-7}
	Sr 91	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-7}
		I	3×10^{-7}	1×10^{-3}	9×10^{-9}	5×10^{-7}
	Sr 92	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-7}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-7}
Sulfur (16)	S 35	S	3×10^{-7}	2×10^{-3}	9×10^{-9}	6×10^{-7}
		I	3×10^{-7}	8×10^{-3}	9×10^{-9}	3×10^{-6}
Tantalum (73)	Ta 182	S	4×10^{-8}	1×10^{-3}	1×10^{-9}	4×10^{-7}
		I	2×10^{-8}	1×10^{-3}	7×10^{-10}	4×10^{-7}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

[See notes at end of appendix]

Element (atomic number)	Isotope		Table I, Column 1 Air (μCi/ml)	Table I, Column 2 Water (μCi/ml)	Table II, Column 1 Air (μCi/ml)	Table II, Column 2 Water (μCi/ml)
Technetium (43)	Tc 96m	S	8×10^{-6}	4×10^{-1}	3×10^{-6}	1×10^{-2}
		I	3×10^{-6}	3×10^{-1}	1×10^{-6}	1×10^{-2}
	Tc 96	S	6×10^{-7}	3×10^{-2}	2×10^{-7}	1×10^{-3}
		I	2×10^{-7}	1×10^{-2}	8×10^{-9}	5×10^{-4}
	Tc 97m	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-3}
		I	2×10^{-7}	5×10^{-3}	5×10^{-9}	2×10^{-4}
	Tc 97	S	1×10^{-5}	5×10^{-2}	4×10^{-7}	2×10^{-3}
		I	3×10^{-7}	2×10^{-2}	1×10^{-8}	8×10^{-4}
	Tc 99m	S	4×10^{-5}	2×10^{-1}	1×10^{-6}	6×10^{-3}
		I	1×10^{-5}	8×10^{-2}	5×10^{-7}	3×10^{-3}
	Tc 99	S	2×10^{-6}	1×10^{-2}	7×10^{-8}	3×10^{-4}
		I	6×10^{-6}	5×10^{-3}	2×10^{-7}	2×10^{-4}
Tellurium (52)	Te 125m	S	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
	Te 127m	S	1×10^{-7}	2×10^{-3}	5×10^{-9}	6×10^{-5}
		I	4×10^{-8}	2×10^{-3}	1×10^{-9}	5×10^{-5}
	Te 127	S	2×10^{-6}	8×10^{-3}	6×10^{-8}	3×10^{-4}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Te 129m	S	8×10^{-8}	1×10^{-3}	3×10^{-9}	3×10^{-5}
		I	3×10^{-8}	6×10^{-4}	1×10^{-9}	2×10^{-5}
	Te 129	S	5×10^{-6}	2×10^{-2}	2×10^{-7}	8×10^{-4}
		I	4×10^{-6}	2×10^{-2}	1×10^{-7}	8×10^{-4}
	Te 131m	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
	Te 132	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
Terbium (65)	Tb 160	S	1×10^{-7}	1×10^{-3}	3×10^{-9}	4×10^{-5}
		I	3×10^{-8}	1×10^{-3}	1×10^{-9}	4×10^{-5}
Thallium (81)	Tl 200	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	1×10^{-6}	7×10^{-3}	4×10^{-8}	2×10^{-4}
	Tl 201	S	2×10^{-6}	9×10^{-3}	7×10^{-8}	3×10^{-4}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Tl 202	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	2×10^{-7}	2×10^{-3}	8×10^{-9}	7×10^{-5}
	Tl 204	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	3×10^{-8}	2×10^{-3}	9×10^{-10}	6×10^{-5}
Thorium (90)	Th 227	S	3×10^{-10}	5×10^{-4}	1×10^{-11}	2×10^{-5}
		I	2×10^{-10}	5×10^{-4}	6×10^{-12}	2×10^{-5}
	Th 228	S	9×10^{-13}	2×10^{-4}	3×10^{-13}	7×10^{-6}
		I	6×10^{-13}	4×10^{-4}	2×10^{-13}	1×10^{-5}
	Th 230	S	2×10^{-13}	5×10^{-5}	8×10^{-14}	2×10^{-6}
		I	1×10^{-11}	9×10^{-4}	3×10^{-13}	3×10^{-5}
	Th 231	S	1×10^{-6}	7×10^{-3}	5×10^{-8}	2×10^{-4}
		I	1×10^{-6}	7×10^{-3}	4×10^{-8}	2×10^{-4}
	Th 232	S	3×10^{-11}	5×10^{-5}	1×10^{-12}	2×10^{-6}
		I	3×10^{-11}	1×10^{-3}	1×10^{-12}	4×10^{-5}
	Th natural	S	6×10^{-11}	6×10^{-5}	2×10^{-12}	2×10^{-6}
		I	6×10^{-11}	6×10^{-4}	2×10^{-12}	2×10^{-5}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See notes at end of appendix)

Element (atomic number)		Isotope	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Thorium (90)		Th 234	S	6×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
			I	3×10^{-8}	5×10^{-4}	1×10^{-9}	2×10^{-5}
Thulium (69)		Tm 170	S	4×10^{-8}	1×10^{-3}	1×10^{-9}	5×10^{-5}
			I	3×10^{-8}	1×10^{-3}	1×10^{-9}	5×10^{-5}
		Tm 171	S	1×10^{-7}	1×10^{-2}	4×10^{-9}	5×10^{-4}
			I	2×10^{-7}	1×10^{-2}	8×10^{-9}	5×10^{-4}
Tin (50)		Sn 113	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	9×10^{-5}
			I	5×10^{-8}	2×10^{-3}	2×10^{-9}	8×10^{-5}
		Sn 125	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-5}
			I	8×10^{-8}	5×10^{-4}	3×10^{-9}	2×10^{-5}
Tungsten (Wolfram) (74)		W 181	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
			I	1×10^{-7}	1×10^{-2}	4×10^{-9}	3×10^{-4}
		W 185	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
			I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
		W 187	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
			I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
Uranium (92)		U 230	S	3×10^{-10}	1×10^{-4}	1×10^{-11}	5×10^{-6}
			I	1×10^{-10}	1×10^{-4}	4×10^{-12}	5×10^{-6}
		U 232	S	1×10^{-10}	8×10^{-4}	3×10^{-12}	3×10^{-5}
			I	3×10^{-11}	8×10^{-4}	9×10^{-13}	3×10^{-5}
		U 233	S	5×10^{-10}	9×10^{-4}	2×10^{-11}	3×10^{-5}
			I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
	**	U 234	S[4]	6×10^{-10}	9×10^{-4}	2×10^{-11}	3×10^{-5}
			I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
	**	U 235	S[4]	5×10^{-10}	8×10^{-4}	2×10^{-11}	3×10^{-5}
			I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
		U 236	S	6×10^{-10}	1×10^{-3}	2×10^{-11}	4×10^{-5}
			I	1×10^{-10}	1×10^{-3}	4×10^{-12}	3×10^{-5}
	**	U 238	S[4]	7×10^{-11}	1×10^{-3}	3×10^{-12}	4×10^{-5}
			I	1×10^{-10}	1×10^{-3}	5×10^{-12}	4×10^{-5}
		U 240	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	3×10^{-5}
			I	2×10^{-7}	1×10^{-3}	6×10^{-9}	3×10^{-5}
	**	U-natural	S[4]	1×10^{-10}	1×10^{-3}	5×10^{-12}	3×10^{-5}
			I	1×10^{-10}	1×10^{-3}	5×10^{-12}	3×10^{-5}
Vanadium (23)		V 48	S	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
			I	6×10^{-8}	8×10^{-4}	2×10^{-9}	3×10^{-5}
Xenon (54)		Xe 131m	Sub	2×10^{-5}		4×10^{-7}	
		Xe 133	Sub	1×10^{-6}		3×10^{-7}	
		Xe 133m	Sub	1×10^{-5}		3×10^{-7}	
		Xe 135	Sub	4×10^{-6}		1×10^{-7}	
Ytterbium (70)		Yb 175	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
			I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Yttrium (39)		Y 90	S	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
			I	1×10^{-7}	6×10^{-4}	3×10^{-9}	2×10^{-5}
		Y 91m	S	2×10^{-6}	1×10^{-1}	8×10^{-7}	3×10^{-3}
			I	2×10^{-6}	1×10^{-1}	6×10^{-7}	3×10^{-3}
		Y 91	S	4×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-5}
			I	3×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-5}
		Y 92	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
			I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		Y 93	S	2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-5}
			I	1×10^{-7}	8×10^{-4}	3×10^{-9}	3×10^{-5}

[25 FR 10914]

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

Element (atomic number)	Isotope [1]		Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Zinc (30)	Zn 65	S	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
		I	6×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}
	Zn 69m	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Zn 69	S	7×10^{-6}	5×10^{-2}	2×10^{-7}	2×10^{-3}
		I	9×10^{-6}	5×10^{-2}	3×10^{-7}	2×10^{-3}
Zirconium (40)	Zr 93	S	1×10^{-7}	2×10^{-3}	4×10^{-9}	8×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
	Zr 95	S	1×10^{-7}	2×10^{-3}	4×10^{-9}	6×10^{-5}
		I	3×10^{-8}	2×10^{-3}	1×10^{-9}	6×10^{-5}
	Zr 97	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-5}
		I	9×10^{-8}	5×10^{-4}	3×10^{-9}	2×10^{-5}
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than 2 hours.		Sub	1×10^{-6}		3×10^{-8}	
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hours.			3×10^{-9}	9×10^{-5}	1×10^{-10}	3×10^{-6}
Any single radionuclide not listed above, which decays by alpha emission or spontaneous fission.			6×10^{-13}	4×10^{-7}	2×10^{-14}	3×10^{-8}

[1] Soluble (S); Insoluble (I).

[2] "Sub" means that values given are for submersion in a semispherical infinite cloud of airborne material.

[3] These radon concentrations are appropriate for protection from radon-222 combined with its short-lived daughters. Alternatively, the value in Table I may be replaced by one-third (⅓) "working level." (A "working level" is defined as any combination of short-lived radon-222 daughters, polonium-218, lead-214, bismuth-214 and polonium-214, in one liter of air, without regard to the degree of equilibrium, that will result in the ultimate emission of 1.3×10^{5} MeV of alpha particle energy.) The Table II value may be replaced by one-thirtieth (1/30) of a "working level." The limit on radon-222 concentrations in restricted areas may be based on an annual average.

40 FR 50704

[4] For soluble mixtures of U-238, U-234 and U-235 in air chemical toxicity may be the limiting factor. If the percent by weight (enrichment) of U-235 is less than 5, the concentration value for a 40-hour workweek, Table I, is 0.2 milligrams uranium per cubic meter of air average. For any enrichment, the product of the average concentration and time of exposure during a 40-hour workweek shall not exceed 8×10^{-3} SA μCi-hr/ml, where SA is the specific activity of the uranium inhaled. The concentration value for Table II is 0.007 milligrams uranium per cubic meter of air. The specific activity for natural uranium is 6.77×10^{-7} curies per gram U. The specific activity for other mixtures of U-238, U-235 and U-234, if not known, shall be:

$SA = 3.6 \times 10^{-7}$ curies/gram U (U-depleted $E \geq 0.72$)

$SA = (0.4 + 0.38\,E + 0.0034\,E^2)\ 10^{-6}$

where E is the percentage by weight of U-235, expressed as percent.

39 FR 23990

*Amended 37 FR 23319.
**Amended 39 FR 23990; footnote redesignated 40 FR 50704.
***Amended 40 FR 50704.
†Amended 38 FR 29314.
‡Amended 39 FR 2546.3; redesignated 40 FR 50704.

25 FR 10914

NOTE TO APPENDIX B

[25 FR 10914]

NOTE: In any case where there is a mixture in air or water of more than one radionuclide, the limiting values for purposes of this Appendix should be determined as follows:

1. If the identity and concentration of each radionuclide in the mixture are known, the limiting values should be derived as follows: Determine, for each radionuclide in the mixture, the ratio between the quantity present in the mixture and the limit otherwise established in Appendix B for the specific radionuclide when not in a mixture. The sum of such ratios for all the radionuclides in the mixture may not exceed "1" (i.e., "unity").

EXAMPLE: If radionuclides A, B, and C are present in concentrations C_A, C_B, and C_C and if the applicable MPC's, are MPC_A, and MPC_B, and MPC_C respectively, then the concentrations shall be limited so that the following relationship exists:

$$\frac{C_A}{MPC_A}+\frac{C_B}{MPC_B}+\frac{C_C}{MPC_C}\leq 1$$

2. If either the identity or the concentration of any radionuclide in the mixture is not known, the limiting value for purposes of Appendix B shall be:

[30 FR 15801]

a. For purposes of Table I, Col. 1—6×10^{-12}
b. For purposes of Table I, Col. 2—4×10^{-7}
c. For purposes of Table II, Col. 1—2×10^{-14}
d. For purposes of Table II, Col. 2—3×10^{-9}

[26 FR 11046]

3. If any of the conditions specified below are met, the corresponding values specified below may be used in lieu of those specified in paragraph 2 above.

a. If the identity of each radionuclide in the mixture is known but the concentration of one or more of the radionuclides in the mixture is not known, the concentration limit for the mixture is the limit specified in Appendix "B" for the radionuclide in the mixture having the lowest concentration limit; or

b. If the identity of each radionuclide in the mixture is not known, but it is known that certain radionuclides specified in Appendix "B" are not present in the mixture, the concentration limit for the mixture is the lowest concentration limit specified in Appendix "B" for any radionuclide which is not known to be absent from the mixture; or

[30 FR 15801]

c. Element (atomic number) and isotope	Table I		Table II	
	Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)	Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
If it is known that Sr 90, I 125, I 126, I 129, I 131, (I 133, table II only), Pb 210, Po 210, At 211, Ra 223, Ra 224, Ra 226, Ac 227, Ra 228, Th 230, Pa 231, Th 232, Th-nat, Cm 248, Cf 254, and Fm 256 are not present	.....	2×10^{-8}	.....	3×10^{-8}
If it is known that Sr 90, I 125, I 126, I 129, (I 131, I 133, table II only), Pb 210, Po 210, Ra 223, Ra 226, Ra 228, Pa 231, Th-nat, Cm 248, Cf 254, and Fm 256 are not present	.....	6×10^{-8}	.....	2×10^{-6}
If it is known that Sr 90, I 129, (I 125, I 126, I 131, table II only), Pb 210, Ra 226, Ra 228, Cm 248, and Cf 254 are not present	.....	2×10^{-7}	.....	6×10^{-6}
If it is known that (I 129, table II only), Ra 226, and Ra 228 are not present	.....	3×10^{-7}	.....	1×10^{-5}
If it is known that alpha-emitters and Sr 90, I 129, Pb 210, Ac 227, Ra 226, Pa 230, Pu 241, and Bk 249 are not present	3×10^{-9}	.....	1×10^{-14}	.....
If it is known that alpha-emitters and Pb 210, Ac 227, Ra 226, and Pu 241 are not present	3×10^{-10}	.....	1×10^{-13}	.....
If it is known that alpha-emitters and Ac 227 are not present	3×10^{-11}	.....	1×10^{-12}	.....
If it is known that Ac 227, Th 230, Pa 231, Pu 238, Pu 239, Pu 240, Pu 242, Pu 244, Cm 248, Cf 249 and Cf 251 are not present	3×10^{-12}	.....	1×10^{-13}	.....

[40 FR 50704]

4. If a mixture of radionuclides consists of uranium and its daughters in ore dust prior to chemical separation of the uranium from the ore, the values specified below may be used for uranium and its daughters through radium-226, instead of those from paragraphs 1, 2, or 3 above.

[39 FR 23990]

a. For purposes of Table I, Col. 1—1×10^{-10} μCi/ml gross alpha activity; or 5×10^{-13} μCi/ml natural uranium; or 75 micrograms per cubic meter of air natural uranium.

b. For purposes of Table II, Col. 1—3×10^{-12} μCi/ml gross alpha activity; or 2×10^{-13} μCi/ml natural uranium; or 3 micrograms per cubic meter of air natural uranium.

[26 FR 11046]

5. For purposes of this Note, a radionuclide may be considered as not present in a mixture if (a) the ratio of the concentration of that radionuclide in the mixture (C_A) to the concentration limit for that radionuclide specified in Table II of Appendix B (MPC_A) does not exceed 1/10 (i.e. $\frac{C_A}{MPC_A}\leq\frac{1}{10}$) and (b) the sum of such ratios for all the radionuclides considered as not present in the mixture does not exceed 1/4 (i.e. $\frac{C_A}{MPC_A}+\frac{C_B}{MPC_B}+\cdots\leq\frac{1}{4}$).

Attachment 2 to AEP:NRC:1034

10 CFR 50 Appendix I

4. There must be substantial advantages to be gained, such as reduced power outages or reduced personnel exposure to radiation, as a direct result of not requiring surveillance capsules in all reactors in the set. [38 FR 24008]

III. Report of Test Results

A Each capsule withdrawal and the test results must be the subject of a summary technical report to be submitted, as specified in § 50.4, within one year after capsule withdrawal unless an extension is granted by the Director, Office of Nuclear Reactor Regulation. [51 FR 40303]

B. The report must include the data required by ASTM E 185, as specified in paragraph II.B.1 of this Appendix, and the results of all fracture toughness tests conducted on the beltline materials in the irradiated and unirradiated conditions.

C. If a change in the Technical Specifications is required, either in the pressure-temperature limits or in the operating procedures required to meet the limits, the expected date for submittal of the revised Technical Specifications must be provided with the report. [38 FR 24008]

APPENDIX I—NUMERICAL GUIDES FOR DESIGN OBJECTIVES AND LIMITING CONDITIONS FOR OPERATION TO MEET THE CRITERION "AS LOW AS IS REASONABLY ACHIEVABLE" FOR RADIOACTIVE MATERIAL IN LIGHT-WATER-COOLED NUCLEAR POWER REACTOR EFFLUENTS

SECTION I. *Introduction.* Section 50.34a provides that an application for a permit to construct a nuclear power reactor shall include a description of the preliminary design of equipment to be installed to maintain control over radioactive materials in gaseous and liquid effluents produced during normal reactor operations, including expected operational occurrences. In the case of an application filed on or after January 2, 1971, the application must also identify the design objectives, and the means to be employed, for keeping levels of radioactive material in effluents to unrestricted areas as low as practicable.

Section 50.36a contains provisions designed to assure that releases of radioactive material from nuclear power reactors to unrestricted areas during normal reactor operations, including expected operational occurrences, are kept as low as practicable.

This appendix provides numerical guides for design objectives and limiting conditions for operation to assist applicants for, and holders of, licenses for light-water-cooled nuclear power reactors in meeting the requirements of §§ 50.34a and 50.36a that radioactive material in effluents released from these facilities to unrestricted areas be kept as low as is reasonably achievable. Design objectives and limiting conditions for operation conforming to the guidelines of this appendix shall be deemed a conclusive showing of compliance with the "as low as is reasonably achievable" requirements of 10 CFR 50.34a and 50.36a. Design objectives and limiting conditions for operation differing from the guidelines may also be used, subject to a case-by-case showing of a sufficient basis for the findings of "as low as is reasonably achievable" required by §§ 50.34a and 50.36a. The guides presented in this appendix are appropriate only for light-water-cooled nuclear power reactors and not for other types of nuclear facilities. [40 FR 58847]

SEC. II. *Guides on design objectives for light-water-cooled nuclear power reactors licensed under 10 CFR Part 50.* The guides on design objectives set forth in this section may be used by an applicant for a permit to construct a light-water-cooled nuclear power reactor as guidance in meeting the requirements of § 50.34a(a). The applicant shall provide reasonable assurance that the following design objectives will be met. [40 FR 19439]

A. The calculated annual total quantity of all radioactive material above background[1] to be released from each light-water-cooled nuclear power reactor to unrestricted areas will not result in an estimated annual dose or dose commitment from liquid effluents for any individual in an unrestricted area from all pathways of exposure in excess of 3 millirems to the total body or 10 millirems to any organ.

B.1. The calculated annual total quantity of all radioactive material above background to be released from each light-water-cooled nuclear power reactor to the atmosphere will not result in an estimated annual air dose from gaseous effluents at any location near ground level which could be occupied by individuals in unrestricted areas in excess of 10 millirads for gamma radiation or 20 millirads for beta radiation.

2. Notwithstanding the guidance of paragraph B.1:

(a) The Commission may specify, as guidance on design objectives, a lower quantity of radioactive material above background to be released to the atmosphere if it appears that the use of the design objectives in paragraph B.1 is likely to result in an estimated annual external dose from gaseous effluents to any individual in an unrestricted area in excess of 5 millirems to the total body; and [40 FR 19439]

(b) Design objectives based upon a higher quantity of radioactive material above background to be released to the atmosphere than the quantity specified in paragraph B.1 will be deemed to meet the requirements for keeping levels of radioactive material in gaseous effluents as low as is reasonably achievable if the applicant provides reasonable assurance that the proposed higher quantity will not result in an estimated annual external dose from gaseous effluents to any individual in unrestricted areas in excess of 5 millirems to the total body or 15 millirems to the skin. [40 FR 58847]

C. The calculated annual total quantity of all radioactive iodine and radioactive material in particulate form above background to be released from each light-water-cooled nuclear power reactor in effluents to the atmosphere will not result in an estimated annual dose or dose commitment from such radioactive iodine and radioactive material in particulate form for any individual in an unrestricted area from all pathways of exposure in excess of 15 millirems to any organ. [40 FR 19439]

D. In addition to the provisions of paragraphs A, B, and C above, the applicant shall include in the radwaste system all items of reasonably demonstrated technology that, when added to the system sequentially and in order of diminishing cost-benefit return, can for a favorable cost-benefit ratio effect reductions in dose to the population reasonably expected to be within 50 miles of the reactor. As an interim measure and until establishment and adoption of better values (or other appropriate criteria), the values $1000 per total body man-rem and $1000 per man-thyroid-rem (or such lesser values as may be demonstrated to be suitable in a particular case) shall be used in this cost-benefit analysis. [40 FR 19439]

The requirements of this paragraph D need not be complied with by persons who have filed applications for construction permits which were docketed on or after January 2, 1971, and prior to June 4, 1976, if the radwaste systems and equipment described in the preliminary or final safety analysis report and amendments thereto satisfy the Guides on Design Objectives for Light-Water-Cooled Nuclear Power Reactors proposed in the Concluding Statement of Position of the Regulatory Staff in Docket-RM-50-2 dated February 20, 1974, pp. 25-30, reproduced in the Annex to this Appendix I. [40 FR 40816]

SEC. III. *Implementation.* A.1. Conformity with the guides on design objectives of Section II shall be demonstrated by calculational procedures based upon models and data such that the actual exposure of an individual through appropriate pathways is unlikely to be substantially underestimated, all uncertainties being considered together. Account shall be taken of the cumulative effect of all sources and pathways within the plant contributing to the particular type of effluent being considered. For determination of design objectives in accordance with the guides of Section II, the estimations of exposure shall be made with respect to such potential land and water usage and food pathways as could actually exist during the term of plant operation: *Provided*, That, if the requirements of paragraph B of Section III are fulfilled, the applicant shall be deemed to have complied with the requirements of paragraph C of Section II with respect to radioactive iodine if estimations of exposure are made on the basis of such food pathways and individual receptors as actually exist at the time the plant is licensed. [40 FR 19439]

2. The characteristics attributed to a hypothetical receptor for the purpose of estimating internal dose commitment shall take into account reasonable deviations of individual habits from the average. The applicant may take account of any real phenomenon or factors actually affecting the estimate of radiation exposure, including the characteristics of the plant, modes of discharge of radioactive materials, physical processes tending to attenuate the quantity of radioactive material to which an individual would be exposed, and the effects of averaging exposures over times during which determining factors may fluctuate.

B. If the applicant determines design objectives with respect to radioactive iodine on the basis of existing conditions and if potential changes in land and water usage and food pathways could result in exposures in excess of the guideline values of paragraph C of Section II, the applicant shall provide reasonable assurance that a monitoring and surveillance program will be performed to determine:

1. The quantities of radioactive iodine actually released to the atmosphere and deposited relative to those estimated in the determination of design objectives;

[1] Here and elsewhere in this appendix background means radioactive materials in the environment and in the effluents from light-water-cooled power reactors not generated in, or attributable to, the reactors of which specific account is required in determining design objectives.

40 FR 19439

2. Whether changes in land and water usage and food pathways which would result in individual exposures greater than originally estimated have occurred; and

3. The content of radioactive iodine and foods involved in the changes, if and when they occur.

40 FR 58847

SEC. IV. *Guides on technical specifications for limiting conditions for operation for light-water-cooled nuclear power reactors licensed under 10 CFR Part 50.* The guides on limiting conditions for operation for light-water-cooled nuclear power reactors set forth below may be used by an applicant for a license to operate a light-water-cooled nuclear power reactor as guidance in developing technical specifications under § 50.36a(a) to keep levels of radioactive materials in effluents to unrestricted areas as low as is reasonably achievable.

Section 50.36a(b) provides that licensees shall be guided by certain considerations in establishing and implementing operating procedures specified in technical specifications that take into account the need for operating flexibility and at the same time assure that the licensee will exert his best effort to keep levels of radioactive material in effluents as low as is reasonably achievable. The guidance set forth below provides additional and more specific guidance to licensees in this respect.

Through the use of the guides set forth in this Section it is expected that the annual releases of radioactive material in effluents from light-water-cooled nuclear power reactors can generally be maintained within the levels set forth as numerical guides for design objectives in Section II.

At the same time, the licensee is permitted the flexibility of operation, compatible with considerations of health and safety, to assure that the public is provided a dependable source of power even under unusual operating conditions which may temporarily result in releases higher than such numerical guides for design objectives but still within levels that assure that the average population exposure is equivalent to small fractions of doses from natural background radiation. It is expected that in using this operational flexibility under unusual operating conditions, the licensee will exert his best efforts to keep levels of radioactive material in effluents within the numerical guides for design objectives.

42 FR 20138

A. If the quantity of radioactive material actually released in effluents to unrestricted areas from a light-water-cooled nuclear power reactor during any calendar quarter is such that the resulting radiation exposure, calculated on the same basis as the respective design objective exposure, would exceed one-half the design objective annual exposure derived pursuant to Sections II and III, the licensee shall: [1]

1. Make an investigation to identify the causes for such release rates;

2. Define and initiate a program of corrective action; and

51 FR 40303

3. Report these actions as specified in § 50.4, within 30 days from the end of the quarter during which the release occurred.

40 FR 19439

B. The licensee shall establish an appropriate surveillance and monitoring program to:

1. Provide data on quantities of radioactive material released in liquid and gaseous effluents to assure that the provisions of paragraph A of this section are met;

2. Provide data on measurable levels of radiation and radioactive materials in the environment to evaluate the relationship between quantities of radioactive material released in effluents and resultant radiation doses to individuals from principal pathways of exposure; and

3. Identify changes in the use of unrestricted areas (e.g., for agricultural purposes) to permit modifications in monitoring programs for evaluating doses to individuals from principal pathways of exposure.

C. If the data developed in the surveillance and monitoring program described in paragraph B of this section and in paragraph B of Section III or from other monitoring programs show that the relationship between the quantities of radioactive material released in liquid and gaseous effluents and the dose to individuals in unrestricted areas is significantly different from that assumed in the calculations used to determine design objectives pursuant to Sections II and III, the Commission may modify the quantities in the technical specifications defining the limiting conditions for operation in a license authorizing operation of a light-water-cooled nuclear power reactor.

SEC. V. *Effective dates.* A. The guides for limiting conditions for operation set forth in this appendix shall be applicable in any case in which an application was filed on or after January 2, 1971, for a permit to construct a light-water-cooled nuclear power reactor.

B. For each light-water-cooled nuclear power reactor constructed pursuant to a permit for which application was filed prior to January 2, 1971, the holder of the permit or a license, authorizing operation of the reactor shall, within a period of twelve months from June 4, 1975, file with the Commission:

40 FR 58847

1. Such information as is necessary to evaluate the means employed for keeping levels of radioactivity in effluents to unrestricted areas as low as is reasonably achievable, including all such information as is required by § 50.34a (b) and (c) not already contained in his application; and

2. Plans and proposed technical specifications developed for the purpose of keeping releases of radioactive materials to unrestricted areas during normal reactor operations, including expected operational occurrences, as low as is reasonably achievable.

CONCLUDING STATEMENT OF POSITION OF THE REGULATORY STAFF (DOCKET-RM-50-2)
GUIDES ON DESIGN OBJECTIVES FOR LIGHT-WATER-COOLED NUCLEAR POWER REACTORS

40 FR 40816

A. For radioactive material above background [1] in liquid effluents to be released to unrestricted areas:

1. The calculated annual total quantity of all radioactive material from all light-water-cooled nuclear power reactors at a site should not result in an annual dose or dose commitment to the total body or to any organ of an individual in an unrestricted area from all pathways of exposure in excess of 5 millirems; and

2. The calculated annual total quantity of radioactive material, except tritium and dissolved gases, should not exceed 5 curies for each light-water-cooled reactor at a site.

3. Notwithstanding the guidance in paragraph A.2. for a particular site, if an applicant for a permit to construct a light-water-cooled nuclear power reactor has proposed baseline in-plant control measures [2] to reduce the possible sources of radioactive material in liquid effluent releases and the calculated quantity exceeds the quantity set forth in paragraph A.2, the requirements for design objectives for radioactive material in liquid effluents may be deemed to have been met provided:

51 FR 40303

a. The applicant submits, as specified in § 50.4, an evaluation of the potential for effects from long-term buildup on the environment in the vicinity of the site of radioactive material, with a radioactive half-life greater than one year, to be released; and

40 FR 40816

b. The provisions of paragraph A.1 are met.

B. For radioactive material above background in gaseous effluents the annual total quantity of radioactive material to be released to the atmosphere by all light-water-cooled nuclear power reactors at a site:

1. The calculated annual air dose due to gamma radiation at any location near ground level which could be occupied by individuals at or beyond the boundary of the site should not exceed 10 millirads; and

2. The calculated annual air dose due to beta radiation at any location near ground level which could be occupied by individuals at or beyond the boundary of the site should not exceed 20 millirads.

3. Notwithstanding the guidance in paragraphs B.1 and B.2, for a particular site:

a. The Commission may specify, as guidance on design objectives, a lower quantity of radioactive material above background in gaseous effluents to be released to the atmosphere if it appears that the use of the design objectives described in paragraphs B.1 and B.2 is likely to result in an annual dose to an individual in an unrestricted area in excess of 5 millirems to the total body or 15 millirems to the skin; or

[1] "Background," means the quantity of radioactive material in the effluent from light-water-cooled nuclear power reactors at a site that did not originate in the reactors.

[2] Such measures may include treatment of clear liquid waste streams (normally tritiated, nonaerated, low conductivity equipment drains and pump seal leakoff), dirty liquid waste streams (normally nontritiated, aerated, high conductivity building sumps, floor and sample station drains), steam generator blowdown streams, chemical waste streams, low purity and high purity liquid streams (resin regenerate and laboratory wastes), as appropriate for the type of reactor.

[1] Section 50.36a(a)(2) requires the licensee to submit certain reports to the Commission with regard to the quantities of the principal radionuclides released to unrestricted areas. It also provides that, on the basis of such reports and any additional information the Commission may obtain from the licensee and others, the Commission may from time to time require the license to take such action as the Commission deems appropriate.

40 FR 58847

b. Design objectives based on a higher quantity of radioactive material above background in gaseous effluents to be released to the atmosphere than the quantity specified in paragraphs B.1 and B.2 may be deemed to meet the requirements for keeping levels of radioactive material in gaseous effluents as low as is reasonably achievable if the applicant provides reasonable assurance that the proposed higher quantity will not result in annual doses to an individual in an unrestricted area in excess of 5 millirems to the total body or 15 millirems to the skin.

40 FR 40816

C. For radioactive iodine and radioactive material in particulate form above background released to the atmosphere:

1. The calculated annual total quantity of all radioactive iodine and radioactive material in particulate form from all light-water-cooled nuclear power reactors at a site should not result in an annual dose or dose commitment to any organ of an individual in an unrestricted area from all pathways of exposure in excess of 15 millirems. In determining the dose or dose commitment the portion thereof due to intake of radioactive material via the food pathways may be evaluated at the locations where the food pathways actually exist; and

2. The calculated annual total quantity of iodine-131 in gaseous effluents should not exceed 1 curie for each light-water-cooled nuclear power reactor at a site.

3. Notwithstanding the guidance in paragraphs C.1 and C.2 for a particular site, if an applicant for a permit to construct a light-water-cooled nuclear power reactor has proposed baseline in-plant control measures [1] to reduce the possible sources of radioactive iodine releases, and the calculated annual quantities taking into account such control measures exceed the design objective quantities set forth in paragraphs C.1 and C.2, the requirements for design objectives for radioactive iodine and radioactive material in particulate form in gaseous effluents may be deemed to have been met provided the calculated annual total quantity of all radioactive iodine and radioactive material in particulate form that may be released in gaseous effluents does not exceed four times the quantity calculated pursuant to paragraph C.1.

[1] Such in-plant control measures may include treatment of steam generator blowdown tank exhaust, clean steam supplies for turbine gland seals, condenser vacuum systems, containment purging exhaust and ventilation exhaust systems and special design features to reduce contaminated steam and liquid leakage from valves and other sources such as sumps and tanks, as appropriate for the type of reactor.

38 FR 4385

APPENDIX J

PRIMARY REACTOR CONTAINMENT LEAKAGE TESTING FOR WATER-COOLED POWER REACTORS

I. Introduction.
II. Explanation of terms.
III. Leakage test requirements.
A. Type A test.
B. Type B test.
C. Type C test.
D. Periodic retest schedule.
IV. Special test requirements.
A. Containment modifications.
B. Multiple leakage-barrier containments.
V Inspection and reporting of tests.
A. Containment inspection.
B. Report of test results.

I. INTRODUCTION

One of the conditions of all operating licenses for water-cooled power reactors as specified in § 50.54(o) is that primary reactor containments shall meet the containment leakage test requirements set forth in this appendix. These test requirements provide for preoperational and periodic verification by tests of the leak-tight integrity of the primary reactor containment, and systems and components which penetrate containment of water-cooled power reactors, and establish the acceptance criteria for such tests. The purposes of the tests are to assure that (a) leakage through the primary reactor containment and systems and components penetrating primary containment shall not exceed allowable leakage rate values as specified in the technical specifications or associated bases and (b) periodic surveillance of reactor containment penetrations and isolation valves is performed so that proper maintenance and repairs are made during the service life of the containment, and systems and components penetrating primary containment. These test requirements may also be used for guidance in establishing appropriate containment leakage test requirements in technical specifications or associated bases for other types of nuclear power reactors.

II. EXPLANATION OF TERMS

A. "Primary reactor containment" means the structure or vessel that encloses the components of the reactor coolant pressure boundary, as defined in § 50.2(v), and serves as an essentially leak-tight barrier against the uncontrolled release of radioactivity to the environment.

B. "Containment isolation valve" means any valve which is relied upon to perform a containment isolation function.

C. "Reactor containment leakage test program" includes the performance of Type A, Type B, and Type C tests, described in II F, II.G, and II.H, respectively.

D. "Leakage rate" for test purposes is that leakage which occurs in a unit of time, stated as a percentage of weight of the original content of containment air at the leakage rate test pressure that escapes to the outside atmosphere during a 24-hour test period.

E. "Overall integrated leakage rate" means that leakage rate which obtains from a summation of leakage through all potential leakage paths including containment welds, valves, fittings, and components which penetrate containment.

F. "Type A Tests" means tests intended to measure the primary reactor containment overall integrated leakage rate (1) after the containment has been completed and is ready for operation, and (2) at periodic intervals thereafter.

G. "Type B Tests" means tests intended to detect local leaks and to measure leakage across each pressure-containing or leakage-limiting boundary for the following primary reactor containment penetrations:

1. Containment penetrations whose design incorporates resilient seals, gaskets, or sealant compounds, piping penetrations fitted with expansion bellows, and electrical penetrations fitted with flexible metal seal assemblies.

2. Air lock door seals, including door operating mechanism penetrations which are part of the containment pressure boundary.

3. Doors with resilient seals or gaskets except for seal-welded doors.

4. Components other than those listed in II.G.1, II.G.2, or II.G.3 which must meet the acceptance criteria in III.B.3.

H. "Type C Tests" means tests intended to measure containment isolation valve leakage rates. The containment isolation valves included are those that:

1. Provide a direct connection between the inside and outside atmospheres of the primary reactor containment under normal operation, such as purge and ventilation, vacuum relief, and instrument valves;

2. Are required to close automatically upon receipt of a containment isolation signal in response to controls intended to effect containment isolation;

3. Are required to operate intermittently under postaccident conditions; and

4. Are in main steam and feedwater piping and other systems which penetrate containment of direct-cycle boiling water power reactors.

I. Pa (p.s.i.g.) means the calculated peak containment internal pressure related to the design basis accident and specified either in the technical specification or associated bases.

J. Pt (p.s.i.g.) means the containment vessel reduced test pressure selected to measure the integrated leakage rate during periodic Type A tests.

K. La (percent/24 hours) means the maximum allowable leakage rate at pressure Pa as specified for preoperational tests in the technical specifications or associated bases, and as specified for periodic tests in the operating license.

L. Ld (percent/24 hours) means the design leakage rate at pressure, Pa, as specified in the technical specifications or associated bases.

M. Lt (percent/24 hours) means the maximum allowable leakage rate at pressure Pt derived from the preoperational test data as specified in III.A.4.(a) (iii).

N. Lam, Ltm (percent/24 hours) means the total measured containment leakage rates at pressure Pa and Pt, respectively, obtained from testing the containment with components and systems in the state as close as practical to that which would exist under design basis accident conditions (e.g., vented, drained, flooded or pressurized).

O. "Acceptance criteria" means the standard against which test results are to be compared for establishing the functional acceptability of the containment as a leakage limiting boundary.

III. LEAKAGE TESTING REQUIREMENTS

A program consisting of a schedule for conducting Type A, B, and C tests shall be developed for leak testing the primary reactor containment and related systems and components penetrating primary containment pressure boundary.

Upon completion of construction of the primary reactor containment, including installation of all portions of mechanical, fluid, electrical, and instrumentation systems penetrating the primary reactor containment pressure boundary, and prior to any reactor operating period, preoperational and periodic leakage rate tests, as applicable, shall be conducted in accordance with the following:

A. *Type A test*—1. *Pretest requirements.* (a) Containment inspection in accordance with V.A. shall be performed as a prerequisite to the performance of Type A tests. During the period between the initiation of the containment inspection and the performance of the Type A test, no repairs or adjustments shall be made so that the containment can be tested in as close to the "as is" condition as practical. During the period between the