SUMMARY OF RADIOLOGICAL SURVEY

OF NL INDUSTRIES NIAGARA FALLS PLANT,

SPRING 1979

May 1979

FINAL REPORT

by

DAVID W. LEIGH

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1. INTRODUCTION

In May 1979 a complete radiological survey was conducted of the NL Industries, Inc. Niagara Falls, New York manufacturing site. The manufacturing process used beach sands containing naturally occurring radioactive materials for the production of rare earth chemicals. Radiation surveys were performed throughout the site to determine the levels of residual contamination of the site from these natural radionuclides. Samples of air, groundwater and soil were taken and analyzed to determine concentrations of these radioactive materials in the environment. Surveys of ambient radiation levels were also made at the site perimeter and at key manufacturing points on the site.

Current information was gathered concerning established radiation and concentration limits for materials allowed to be released to the public. The criteria are used to evaluate the radiological profile of the site and to determine if additional surveys are required. Results of this comparison indicate that concentrations of radioactive materials in air, groundwater and soil are well within the strictest release criteria. Radiation surveys along the site perimeter and on the site area are in the range of normal background. One measurement inside the manufacturing warehouse which is used to store all product materials only slightly exceeds the strictest reference criteria.

2. BACKGROUND INFORMATION

2.1 Site Description and History

The NL Industries site consists of approximately 28 acres fronting on Hyde Park Boulevard and lying wholly within the town of Niagara Falls, New York. (See Figure 1.) Slightly less than one half of the site is improved with manufacturing, warehousing and transportation facilities. [redacted] contains obsolete equipment and [redacted] wastes.

The western, improved section is relatively flat, and the site in general slopes from the southeast corner to the north and west at the rate of approximately one foot per 100 feet. Surface water drains in a northerly direction into Bloody Run Creek. The creek flows east to west along the northern boundary and turns north at about mid-point of the property line. The ground is relatively level bedrock covered with clays and about one and one-half feet of loam.

The NL Industries Niagara Falls site was used for the manufacture of rare earth chemicals derived from various beach sand components. These sands which are used in the rare earth process contain natural radioactivity. The naturally occurring radioactive materials in these sands are thorium (Th) and uranium (U) and their radioactive decay products, or daughters, including radium (Ra) and its daughter, radon (Rn), the only decay product present as a gas.

2.2 Radiological Release Criteria

Because of the presence of beach sands and waste sands at rare earth processing facilities, attention has recently been focused on the environmental radiological impact of this industry. In assessing these types of sites various standards and rules have been used to formulate release criteria. These criteria are generally accepted as sufficient requirements for the release of materials and the decontrol of areas, and for the protection of man and the environment from unnecessary radiation. Appropriate criteria for the assessment of the NL Industries Niagara site have been derived from the references and are tabulated in Table 1 for concentration of radioactivity in soil, air and groundwater samples and ambient radiation levels.

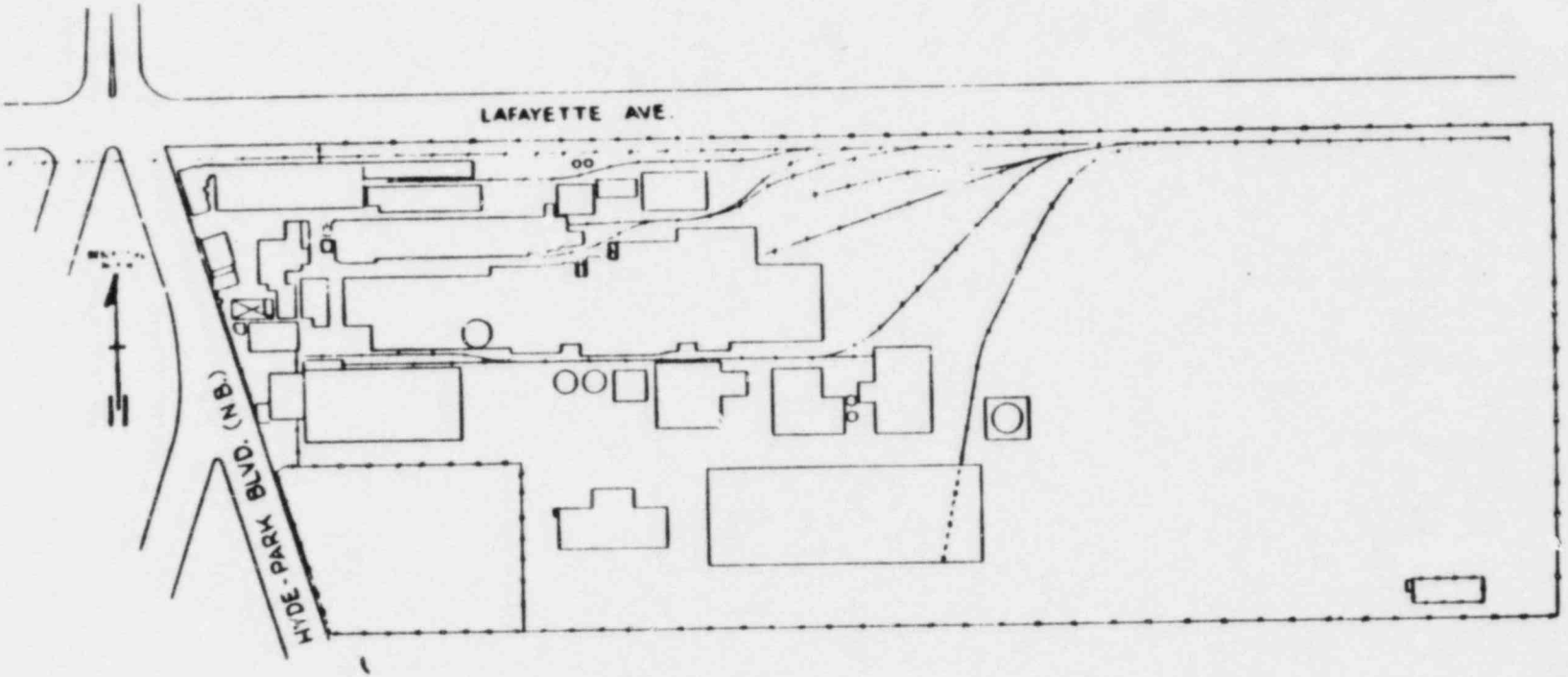


Figure 1. NL Industries, Inc. Niagara Falls, New York site

TABLE 1

SUMMARY OF REFERENCE CRITERIA LIMITS FOR
ACCEPTABLE RADIATION LEVELS AND CONCENTRATIONS IN SOIL, WATER AND AIR
FOR UNCONTROLLED AREAS

Reference	Soil	Water	Air	Radiation Level
Ref. 2, Eng, et al Oregon DEQ EPA Region II	5 pCi/g Th-232 5 pCi/g Ra-226	30 pCi/l Ra-226	.03 Working Level (WL) radon	.057 mR/hr
Ref. 3, 12NYCRR38	.05% by weight source material (5000 pCi/g Th-232)	2000 pCi/l Th(natural)[1] 7000 pCi/l Th-228 [1] 2000 pCi/l Th-230 [1] 2000 pCi/l Th-232 [1] 30 pCi/l Ra-226 [1] 2×10^4 pCi/l U(natural)[1]	3000 pCi/m^3 Rn-222	.057 mR/hr for unlimited exposure .25 mR/hr for 40 hour/week exposure
Ref. 4, WS Task 2 10CFR40.4 (preferred criteria) DOT and US Army	150 pCi/g U-238 2000 pCi/g source material			
Healy Canada	2000 pCi/g U-238		.02 WL Rn	.05 mR/hr indoors .1 mR/hr outdoors
Grand Junction Co. (US Surgeon General)			.01 WL	.05 mR/hr

[1] In soluble form. Limits for insoluble forms of these nuclides are the same or higher than the limits for the soluble form.

3. RADIATION SURVEYS

A variety of radiation surveys and environmental samples were taken throughout the site to assure that any environmental contamination from the materials used or stored on the site would be detected.

3.1 Purpose of Surveys

The three primary pathways for radioactive materials into the environment are air, water and soil; therefore, sampling procedures included all of these. In addition, ambient radiation levels were determined. All samples taken were analyzed for the appropriate isotopes of uranium, thorium and radium in soil, and for radon in air. Onsite sampling locations were selected to most likely represent sources of contaminated water, soil and air.

Background samples and measurements, which were identical to actual samples but without the source of contamination, were taken for air and soil samples and radiation levels to determine natural environmental levels of radiation. By comparing samples with backgrounds a more accurate assessment of actual contamination from other sources can be made.

The samples were taken and analyzed to conform to the release criteria as established in the references. A comparison of the worst cases found and the strictest criteria limits is tabulated for easy reference in Table 2.

3.2 Soil Samples - Methods and Results

To obtain soil samples a backhoe was used to make excavations in eight locations on the waste disposal area. Figure 2 illustrates the excavation locations. Holes were dug to a depth slightly below visible groundwater, to the limit of the reach of the hoe, or until the machine encountered bedrock which it could not penetrate. The excavations were visually checked for stratification and samples of each type of soil were taken in holes where distinct layers were evident. A total of fourteen soil samples were collected from the eight holes and were split and analyzed by two independent laboratories. Table 3 shows the results of the soil sample analyses for each of the samples. Hole number 5 is considered a representative background sample, as soil conditions indicated that the ground in this area had not been disturbed and preliminary radiation surveys of this excavation were of normal background levels.

Results of soil sample analyses indicate that uranium, thorium and radium concentrations present in the soil are very low and well within limits of the strictest criteria.

TABLE 2

COMPARISON TABLE

of Strictest criteria limits for acceptable radiation levels and concentrations in soil, water and air for release to general public and worst cases found in surveys of NL Industries site.

	WORST CASES	STRICTEST CRITERIA	REFERENCE
1. SOIL SAMPLES			
Holes 3, 6b)	1.0 ± 0.1 pCi/g Ra-226	5 pCi/g Ra-226	(2)
Hole 6b)	1.1 ± 0.9 pCi/g Th-228		
Hole 2b)	2.2 ± 2.0 pCi/g Th-230		
Hole 2a)	1.2 ± 1.2 pCi/g Th-232	5 pCi/g Th-232	(2)
Holes 2a) and b)	5 ± 5 pCi/g U	150 pCi/g U(natural)	(4)
2. WATER SAMPLES			
Hole 2	2.0 pCi/l Ra-226	30 pCi/l Ra-226	(3)
Hole 2	1.6 ± 1.0 pCi/l Th-228	7000 pCi/l Th-228	(3)
Hole 6	0.6 ± 0.6 pCi/l Th-230	2000 pCi/l Th-230	(3)
Hole 2	0.7 ± 0.6 pCi/l Th-232	2000 pCi/l Th-232	(3)
Hole 2	20 ± µg/l U	2000 pCi/l U(natural) (6000 µg/l)[1]	(3)
3. AIR SAMPLES			
On site, location 8 (warehouse)	130 ± 10 pCi/m^3 Rn-222	3000 pCi/m^3 Rn-222	(3)
Site Perimeter	.0013 ± .0001 WL Rn-222	.01 WL	(4)
4. RADIATION LEVELS			
On site, location 8 (warehouse)	.06 mR/hr	.05 mR/hr	(4)
Site Perimeter, location 11	.02 mR/hr	.05 mR/hr	(4)

[1] 2000 pCi/l U(natural) converted to µg/l by use of special curie unit, which is used to relate activity of uranium in equilibrium with its daughters and in natural concentrations of isotopes to mass.

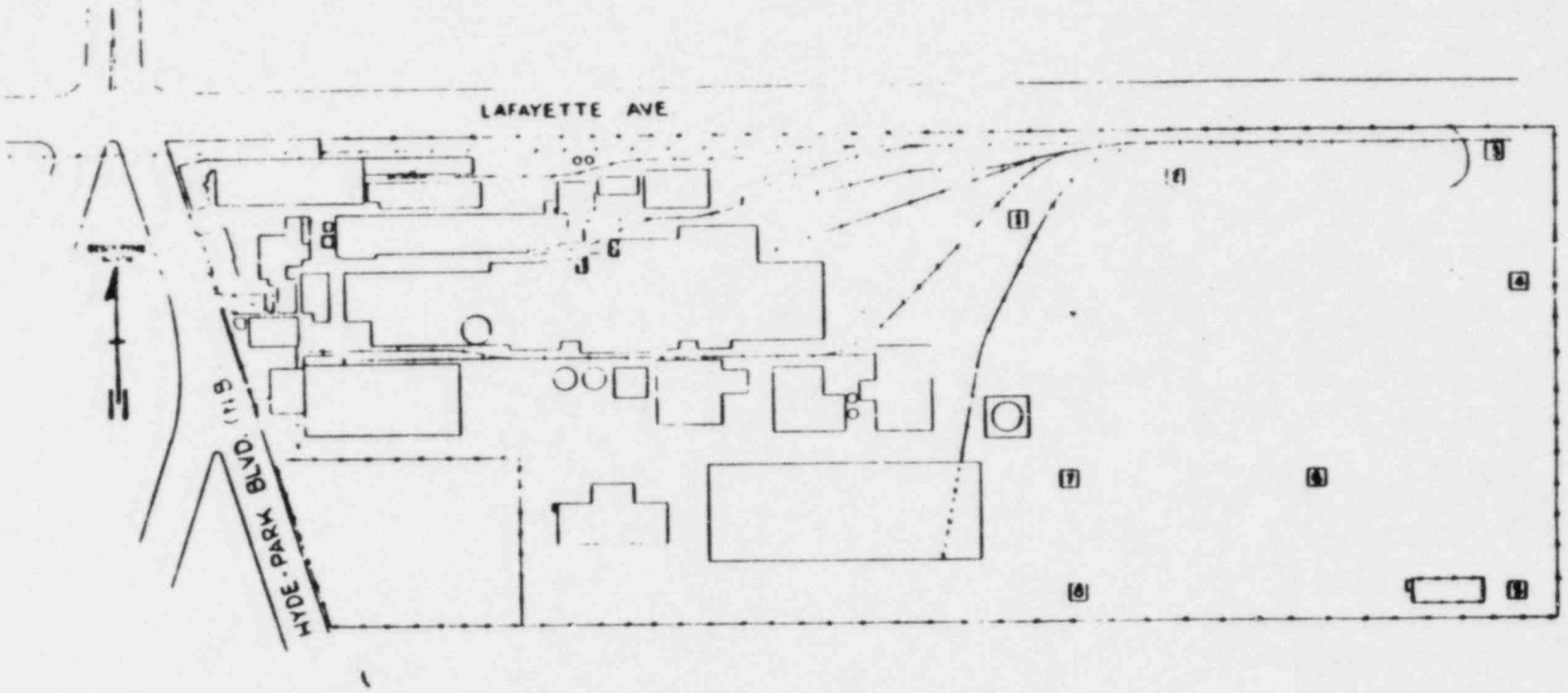


Figure 2. Location of soil sample sites

TABLE 3

CONCENTRATIONS OF URANIUM, THORIUM AND RADIUM IN SOIL SAMPLES[1]

Excavation Hole No.	Sample Identification	Radium-226 pCi/g	Thorium-228 pCi/g	Thorium-230 pCi/g	Thorium-232 pCi/g	Fluorometric Uranium µg/g
1	a) 1 foot level	0.5 ± 0.01	0.6 ± 0.5	0.4 ± 0.4	0.5 ± 0.5	2 ± 2
	b) 8 foot level	0.2 ± 0.01	0.3 ± 0.3	0.3 ± 0.2	0.3 ± 0.3	2 ± 1
2	a) top	0.3 ± 0.04	0.8 ± 0.7	2 ± 2	1 ± 1	5 ± 5
	b) bottom	0.3 ± 0.01	0.5 ± 0.5	0.7 ± 0.7	0.5 ± 0.5	5 ± 5
3	Single sample	1.0 ± 0.1	0.6 ± 0.6	1 ± 1	0.6 ± 0.6	1 ± 1
4[3]						
5	(Background)	0.4 ± 0.01	0.5 ± 0.5	0.4 ± 0.4	0.4 ± 0.4	1 ± 1
6	a) black soil	0.7 ± 0.02	0.5 ± 0.5	0.5 ± 0.5	0.5 ± 0.5	0.9 ± 0.9
	b) brown soil	1.0 ± 0.1	1.1 ± 0.9	0.9 ± 0.7	1.0 ± 0.8	1 ± 1
	c) red soil	0.5 ± 0.01	0.3 ± 0.3	0.3 ± 0.2	0.3 ± 0.2	0.9 ± 0.8
	d) tan soil	0.3 ± 0.04	0.8 ± 0.5	0.3 ± 0.2	0.7 ± 0.7	2 ± 2
7	Single sample	0.8 ± 0.01	0.3 ± 0.3	0.4 ± 0.3	0.3 ± 0.3	0.8 ± 0.7
8	a) black soil	1.0 ± 0.1	0.5 ± 0.4	0.5 ± 0.4	0.4 ± 0.3	2 ± 2
	b) bottom	0.04 ± 0.01	0.6 ± 0.6	0.6 ± 0.6	0.2 ± 0.2	2 ± 2
	c) brown soil	0.7 ± 0.01	0.2 ± 0.2	0.2 ± 0.2	0.2 ± 0.1	1 ± 1

(1) Error terms given for each sample are the 95% confidence limit (2σ) for that measurement.

(2) Data shown only for Lab 2. Lab 1 analysis was performed at a level of sensitivity inadequate to measure the concentrations present.

(3) No soil sample analyzed from hole #4.

3. RADIATION SURVEYS (Continued)

3.3 Water Samples - Methods and Results

Groundwater samples were obtained from test wells which were dug at the eight excavation sites with a rotary drill. These locations are shown in Figure 3. Groundwater along the northern side of the property had a pungent odor and oily character which may indicate incursion of chemicals from the adjacent landfill. At three locations rock was encountered before groundwater was found. Water samples were analyzed by two independent laboratories for uranium, thorium and radium. Results of water sample analyses are presented in Table 4. All concentrations are within the range of accepted criteria and are in some cases less than 1/1000 of the recommended release level.

3.4 Air Samples - Methods and Results

Air samples were taken at a variety of locations throughout the site to sample for radon gas. A total of 16 samples were taken all along the site boundary at approximately 300' intervals, and eight additional samples were taken at key manufacturing sites inside buildings in the improved section. See Figure 4 for air sampling locations. A background sample was taken in a remote area approximately one mile northeast of the NL Industries location.

Air samples were taken by positioning a Staplex high volume air sampler on a tripod to approximate a breathing zone sample. Air samples were counted for alpha particle activity as described in Appendix A, and radon concentration in air was determined according to Appendix C.II.

Results of air sample analyses are listed in Tables 5A and 5B. Results are tabulated both in units of radioactivity per unit volume (picocuries per cubic meter) and working levels (WL) so that comparison with reference criteria is more straightforward. Air samples indicate that all airborne concentrations of radon gas are well within recommended criteria for both onsite and perimeter surveys.

3.5 Radiation Measurements - Methods and Results

Measurements of ambient radiation levels were taken at each location where air sampling was performed. (See Figure 5.) Radiation surveys were taken with a PRM-7 micro-R meter held at approximately waist level. Survey protocols are described in Appendix A and instrument specifications and calculations are described in Appendix B and CI respectively. The background measurement was taken offsite at the same remote area as the air sample background.

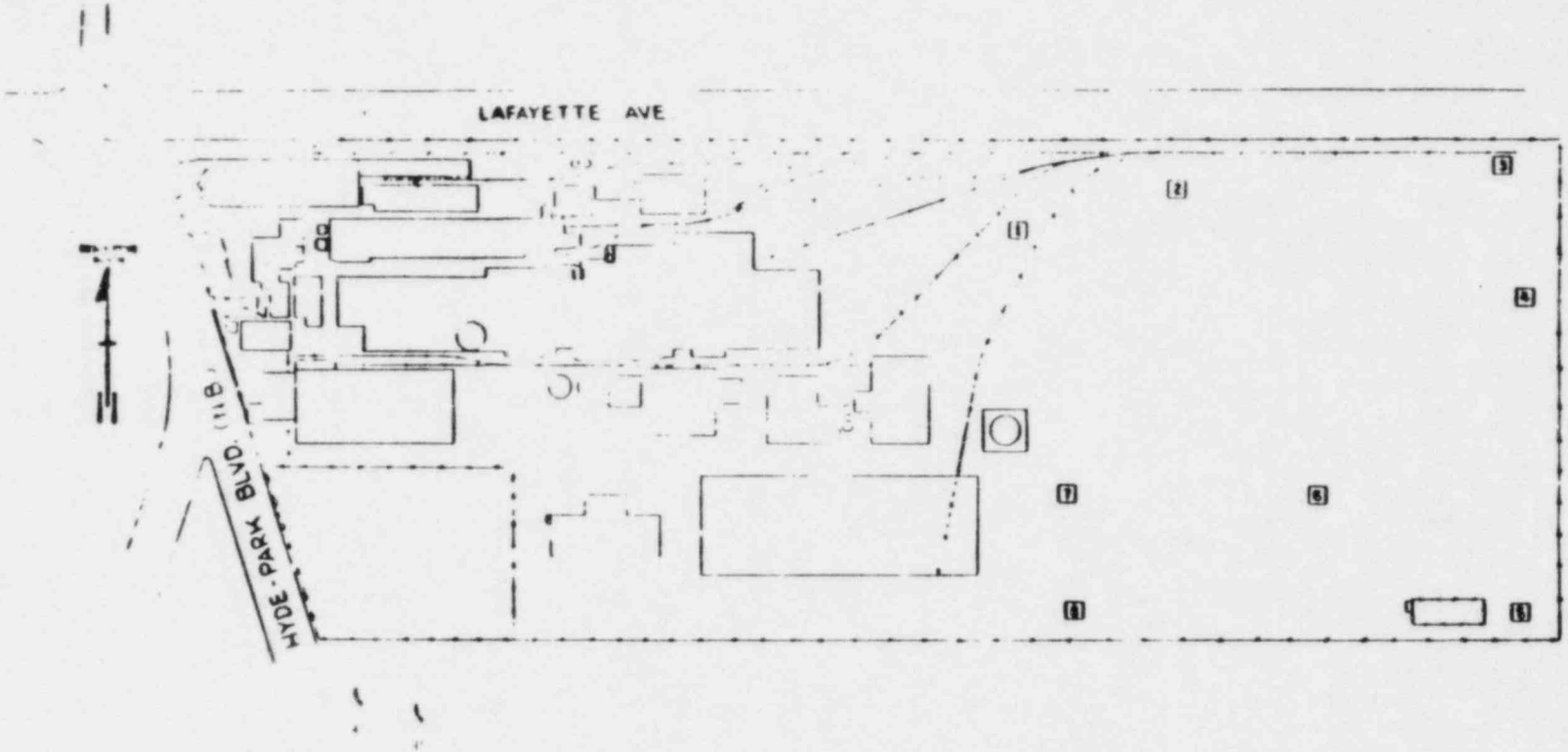


Figure 3. Location of water sample sites

TABLE 4

CONCENTRATIONS OF URANIUM, THORIUM AND RADIUM IN GROUNDWATER SAMPLES[1]

Excavation Hole No.	Ft. Below Surface	Radium-226 pCi/l	Thorium-228 pCi/l	Thorium-230 pCi/l	Thorium-232 pCi/l	Fluorometric Uranium µg/l
1	8	0.6	0.5 ± 0.8	0.3 ± 0.5	0.6	9
2	6	2.0	1.6 ± 1.0	0.5 ± 0.9	0.7 ± 0.6	20
3	3	0.5	0.6	0.6	0.6	5
4[2]						
5[2]						
6	10	1.0	0.6	0.6 ± 0.6	0.4 ± 0.4	8
7	5.8	0.6	0.6 ± 0.4	0.6	0.6	5
8[2]						

(1) Error terms given for each sample are the 95% confidence limit (2σ) for that measurement.

(2) Groundwater not encountered at this location.

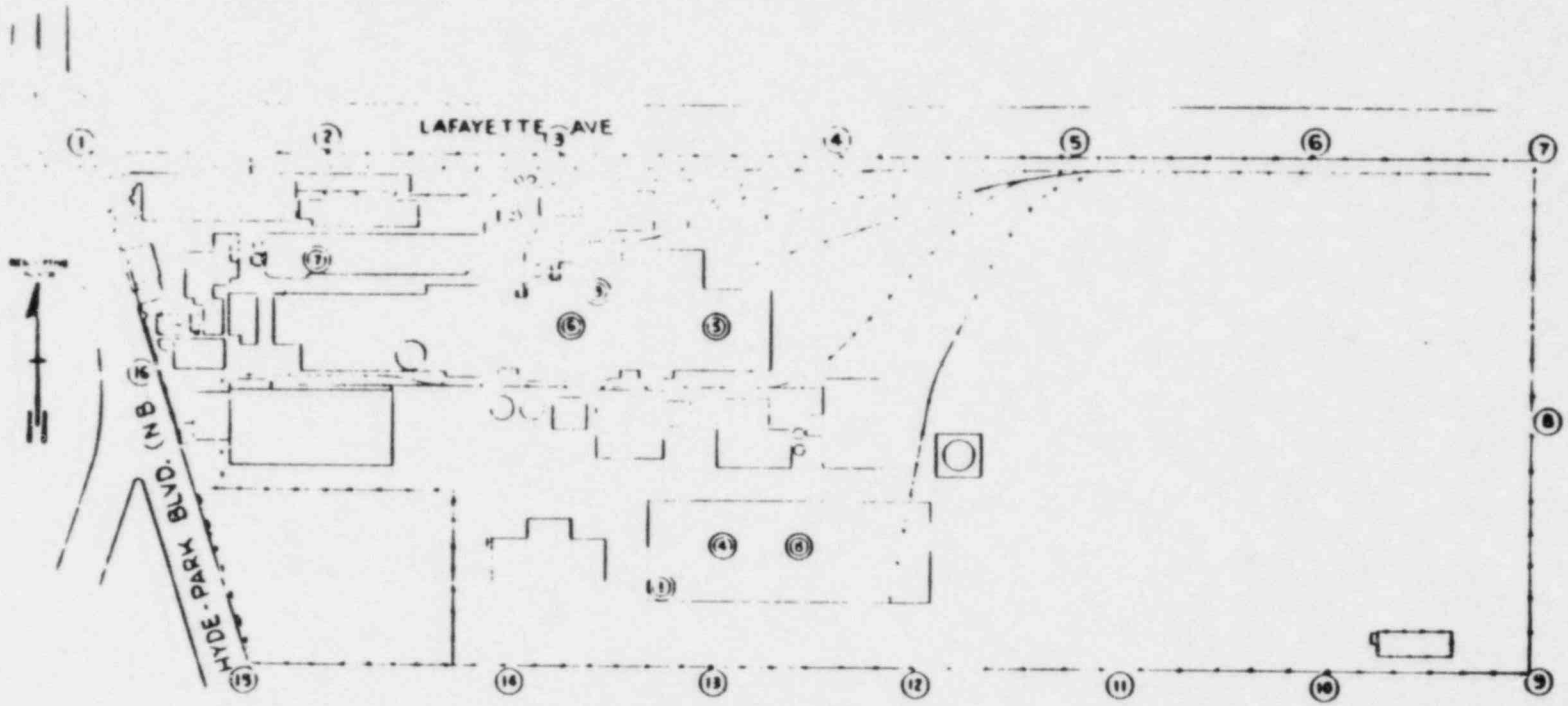


Figure 4. Location of air sample sites at perimeter and at manufacturing areas

TABLE 5A

RESULTS OF AIR SAMPLE ANALYSIS FOR RADON CONCENTRATION IN AIR ALONG SITE PERIMETER

	Sample Location	Radon Concentration in Air	
		pCi/m^3	Working Level (WL)[1]
1	NE Corner	< 5	$< 5 \times 10^{-5}$
2		< 5	$< 5 \times 10^{-5}$
3		< 5	$< 5 \times 10^{-5}$
4		< 5	$< 5 \times 10^{-5}$
5		< 5	$< 5 \times 10^{-5}$
6		< 5	$< 5 \times 10^{-5}$
7	NW Corner	< 5	$< 5 \times 10^{-5}$
8		< 5	$< 5 \times 10^{-5}$
9	SW Corner	< 5	$< 5 \times 10^{-5}$
10		< 5	$< 5 \times 10^{-5}$
11		< 5	$< 5 \times 10^{-5}$
12		< 5	$< 5 \times 10^{-5}$
13		< 5	$< 5 \times 10^{-5}$
14		< 5	$< 5 \times 10^{-5}$
15	SE Corner	< 5	$< 5 \times 10^{-5}$
16		< 5	$< 5 \times 10^{-5}$

(1) Working Level (WL): 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 emission of 1.3×10^5 MeV of alpha particle energy.

TABLE 5B

RESULTS OF AIR SAMPLE ANALYSIS FOR RADON CONCENTRATIONS IN AIR AT ONSITE LOCATIONS[1]

Sample Location No. and Description	Radon Concentration in Air	
	pCi/m^3	Working Level (WL)[2]
1 Warehouse Ramp	50 ± 20	.0005 ± .0002
2 Building 134	19 ± 6	.00019 ± .00006
3 Building 133	14 ± 5	.00014 ± .00005
4 Warehouse	80 ± 20	.0008 ± .0002
5 Building 143	15 ± 6	.00015 ± .00006
6 Building 123	28 ± 9	.00028 ± .00009
7 Building 115	13 ± 5	.00013 ± .00005
8 Warehouse	130 ± 10	.0013 ± .0001

(1) Error terms given for each sample are the 95% confidence limit (2σ) for that measurement.

(2) Working Level (WL): 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 emission of 1.3×10^5 MeV of alpha particle energy.

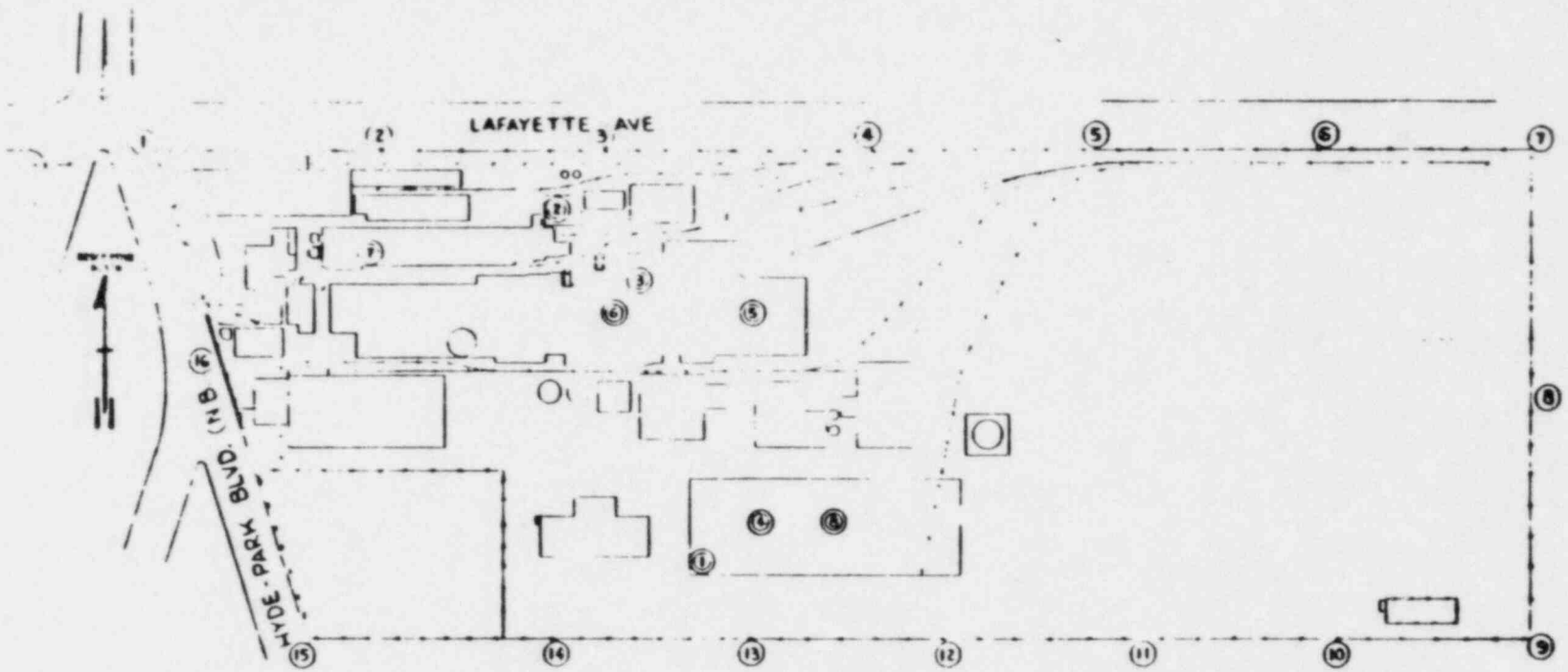


Figure 5. Location of ambient radiation measurement sites at perimeter and at manufacturing areas

3. RADIATION SURVEYS (Continued)

Results of these measurements are listed in Tables 6A and 6B. All perimeter surveys showed radiation levels near background. Onsite surveys in general were also in the range of natural background. One survey taken inside the warehouse which is used to store product materials slightly exceeds the accepted release criteria. However, this level of exposure rate is within dose limits set in New York State Department of Labor Rule 12NYCRR38 for 40 hour/week exposure.

TABLE 6A

AMBIENT RADIATION MEASUREMENTS TAKEN ALONG SITE PERIMETER

Perimeter Location	Ambient Radiation Levels mR/hr	mR/hr Above Bkg.(1)
1 NE Corner	.007	.001
2	.009	.003
3	.022	.016
4	.015	.009
5	.020	.014
6	.012	.006
7 NW Corner	.010	.004
8	.013	.007
9 SW Corner	.007	.001
10	.007	.001
11	.028	.022
12	.022	.016
13	.028	.022
14	.015	.009
15 SE Corner	.008	.002
16	.008	.002

(1) Background = .006 mR/hr

TABLE 6B

AMBIENT RADIATION MEASUREMENTS TAKEN AT ONSITE LOCATIONS

Location	Ambient Radiation Levels (1) mR/hr	mR/hr Above Bkg.
1 Warehouse Ramp	.007	0
2 Building 134	.020	.007
3 Building 133	.014	.001
4 (2) Warehouse	-	-
5 Building 143	.013	0
6 Building 123	.026	.013
7 Building 115	.022	.009
8 Warehouse	.065	.052

(1) Background = .013 mR/hr.

(2) No radiation measurement taken at location 4.

4. CONCLUSIONS

A comprehensive radiological survey of the NL Industries Niagara Falls site indicates that radiation and contamination levels at the site are within accepted release limits. A single radiation measurement inside the product storage warehouse slightly exceeded the strictest release criteria but was within limits for 40 hour week exposure. All air, groundwater and soil samples were significantly lower than any recommended release limit and in most cases are less than one-tenth of the appropriate limit. The need for additional radiological surveys is not indicated by results contained in this report.

REFERENCES

1. Ahlquist, A. John, C. John Umbarger and Alan K. Stoker, Los Alamos Scientific Laboratory, P. O. Box 1663 MS 490, Los Alamos, New Mexico 87545, "Recent Developments for Field Monitoring of Alpha-Emitting Contaminants in the Environment".

2. Eng, Jeanette, New Jersey Department of Environmental Protection, Donald W. Hendricks, ORP-Las Vegas Facility, USEPA, Joyce Feldman and Paul A. Giardina, Radiation Branch, USEPA Region II, "Low Level Radioactive Waste From Rare Metals Processing Facilities", and references therein.

3. State of New York, 12NYCRR38, "Ionizing Radiation Protection".

4. Weldon Springs Task 2, June 19, 1977, "Decontamination Criteria for Weldon Spring Chemical Plant" and references therein.

5. United States Nuclear Regulatory Commission 10CFR20, "Standards for Protection Against Radiation".

APPENDIX A

SURVEY PROTOCOL

A. Ambient Gamma Radiation Measurements Using Eberline PRM-7 Micro "R" Meter.

1. Check high voltage.

2. Check response to Cs-137 button source on X 500 range by placing radiation symbol of source in contact with meter adjust screw; meter should read 165 $\mu R\ h^{-1}$.

3. Take readings on X 50 range or most sensitive range and rapid response.

B. Airborne Concentrations of Rn-222 and Daughters Using Eberline PRS-1/AC-3-8 Alpha Scintillation Probe in Conjunction with High Volume Air Sampler.

1. Assure that instrument settings on PRS-1 are:

   a. Threshold = 0.30 volts.
   b. Voltage = 900 volts.
   c. Mode = gross.

2. Check out instrument:

   a. Turn select switch to HV and note voltage of $\sim$ 900 indicating that battery is satisfactory.

   b. Turn select switch to 0.5 minute count, place source in firm contact with scintillator probe, press reset button, and note count of about 775 counts in 0.5 minutes.

   c. Take 5 minute background count with select switch set at 5 minute count interval. Subtract this count from filter counts to obtain the net alpha counts, C_α.

3. For each sampling location, place a clean filter in the filter holder and take a 5 minute air sample with the high volume sampler noting the sampling flow rate F in ft^3/min.

4. Place the alpha scintillation probe in direct contact with the approximate center of the filter sample.

5. Set the counting interval on the PRS-1 at 5 minutes.

6. Begin counting the filter sample by pressing the reset button at 2 minutes post the end of sampling.

7. Record the gross sample count obtained and subtract the 5 minute background count to obtain the net alpha counts C_α observed in 5 minutes.

8. Calculate the number of working levels (WL) of Rn-222 daughters from:

$$\# \text{ WL} = 1.8 \times 10^{-4} \frac{C_\alpha}{F} (c)^{-1} (ft^3\ m^{-1}).$$

Portable Micro "R" Meter, Model PRM-7

GENERAL DESCRIPTION

The Micro R Meter Model PRM-7 is a self-contained instrument, ruggedized and splashproof for use in field monitoring of fine variations of gamma radiation. An internally mounted 1 inch x 1 inch NaI (Tl) scintillator, coupled to a photomultiplier tube, offers optimum performance in counting low level radiation fields from typical natural background (10 micro R/hr) up to 5000 micro R/hr (5 mR/hr) cesium-137 equivalent.

The PRM-7 operates over four linear ranges; 0-25, 0-50, 0-500, 0-5000 micro R/hr. An internally mounted speaker provides a clear, audible signal which enhances the locating of gamma radiation fields above natural background. The die cast cover, drawn can, cast closed loop handle, meter lamp and ruggedized meter form a tough, rugged, lightweight instrument designed for field operation.

The PRM-7 is energy dependent. It is factory calibrated to ^{137}Cs.

The Micro R Meter Model PRM-7 comes ready to operate with carbon zinc batteries, carrying strap and technical manual.

SPECIFICATIONS

READOUT

METER: Ruggedized with BATTery OK limits and scales of 0-25, 0-50 micro R/hr and a high voltage scale. Scale length is 2.38" (6 cm).

METER LAMP: Meter lamp provided with ON-OFF switch.

RANGE: Switch controlled 25, 50, 500 and 5000 micro R/hr.

LINEARITY: Within ±5% of full scale (±2% typcial) when driven with a repetitive signal.

RESPONSE TIME: Continuously variable by a front panel control from approximately 10 seconds to 2 seconds measured to 90% of final meter reading.

SPEAKER: 2 inch diameter internally mounted. ON-OFF switch provided.

VOLTAGE COEFFICIENT: Meter reading changes less than 2% with battery voltage from 2.2 to 3.1 volts.

DETECTOR

PHOTOMULTIPLIER TUBE: End window, S-11 photocathode, nominal 1" diameter.

OPERATING VOLTAGE: Normally between +900 and +1200 volts.

MAXIMUM VOLTAGE: +1500 volts.

CURRENT DRAIN: Approximately 110 megohm resistance string yields 10 microamps at 1100 volts.

CRYSTAL: NaI(Tl) 1 inch x 1 inch.

LOW VOLTAGE POWER SUPPLY

BATTERIES: Two "D" size cells held by internal captive holders.

VOLTAGE REQUIREMENT: 1.6 maximum to 1.1 minimum volts per cell.

LIFE: Variable, depending on cell type, age, temperature, high voltage setting, etc. Typical life with new cells at room temperature with meter lamp off - carbon zinc cells, 225 hours; alkaline cells, 270 hours.

HIGH VOLTAGE SUPPLY

RANGE: Variable by an internal control from less than 500V to more than 1200V.

VOLTAGE DEPENDENCE: High voltage will change less than ±3% with battery voltage from 2.2 to 3.1 volts.

ENVIRONMENTAL

SPLASHPROOF: Use of O-ring seals throughout.

TEMPERATURE: The instrument is operational from 0°F to +140°F (-18°C to 60°C). The battery type used limits the low temperature performance because of terminal voltage decrease and internal impedance increase. For prolonged operation at low temperatures, alkaline cells are recommended.

MECHANICAL

DIMENSIONS: Approximately 4" W x 8" L x 7.5" H (10 cm W x 20 cm L x 19 cm H) including handle.

WEIGHT: Approximately 4 lbs. 10 oz. (2.1 Kg) including carbon zinc batteries.

eberline P.O. Box 2108, Santa Fe, New Mexico 87501 (505) 471-3232 TWX: 910-985-0678

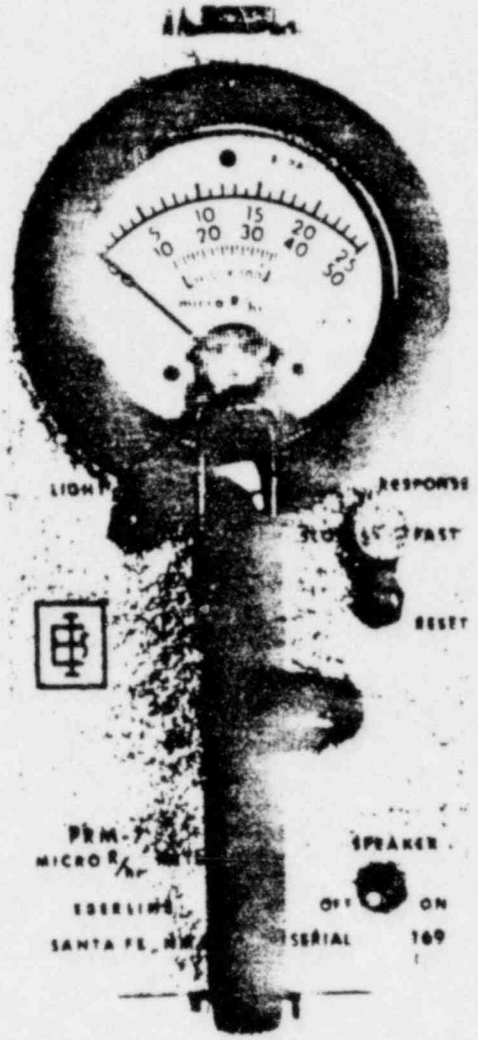
June 1, 1977

Portable Micro "R" Meter

PRM-7

Built-in Speaker

Detector Crystal Location



DESIGNED FOR FIELD MONITORING
RUGGED
SPLASHPROOF
BUILT-IN SPEAKER
LIGHTED METER
DISPLAYS HIGH VOLTAGE

eberline

"RASCAL"
Model PRS-1 and PRS-2

GENERAL DESCRIPTION

The RASCAL PRS-1 is a compact portable, digital display instrument with selectable ratemeter or scaler functions. The instrument is rugged and splashproof with its own internal battery power supply. Included in the instrument is a variable high voltage power supply, pulse amplifier with single channel pulse height analysis, six decade liquid crystal display, crystal-controlled time base, working level calibration function, built-in speaker and a self-contained rechargeable battery pack. All circuits are solid state with extensive use of CMOS integrated circuits for low power consumptions and to enhance reliability.

The Model PRS-2 instrument is similar to the PRS-1, except it does not have the pulse height analysis capability.

Both instruments are designed to be used with most detectors, Eberline scintillation, Geiger-Mueller, or proportional probes.

Both instruments have a digital readout of the internal high voltage power supply.

SPECIFICATIONS

HIGH VOLTAGE: Regulated, adjustable by a front panel control to approximately 1500V and can supply a 100 megohm load. A volt meter position on the range switch provides a digital indication of the voltage. The supply (EIC Model P-201A) is a plug-in module for ease of maintenance.

COUNT RATE METER: True digital computing circuitry is used to provide six decades of count rate information in counts per minute. A front panel switch selects a preset number of counts; 10, 100, 1000 or 10,000 for computation. The least number of counts selected provides the fastest answer and the greatest number of counts selected provides the more accurate answer. The compute time is fixed at 3 seconds.

SCALER: Six decades of digital information with fixed timed positions of 0.5, 1, 2 and 5 minutes plus manual and stop. The display may indicate each increment of count or the display may be updated at the end of the count period as selected by an internal switch. A front panel control is provided for a variable reset rate of approximately 1 to 10 seconds or the control may be switched off.

CALIBRATION FUNCTION: The calibration function provides a means of converting the count rate information, in counts per minute, to a working level information, such as mR/hr, or to correct for probe efficiency. A rate multiplier board with selectable multiplication from 9.99 to 0.01 is provided as a standard item with the instrument. A rate divider board with selectable division from 00.1 to 99.9 is available as an option. All controls for the calibration function are internal.

DISPLAY: A liquid crystal display is used for low power consumption and continuous display of data. The display has six digits, nine legends and three decimal points. Five legends, "CPM", "CPS", "mR/hr", and "mREM/hr" plus the three decimal points are selected for display by internal switches. The remaining legends, "Count", "Compute", and "Batt OK" are controlled by the circuit logic of the instrument. A light, controlled by a panel-mounted push button switch, is provided for instrument use in low ambient light.

AMPLIFIER: Charge sensitive type approximately 2×10^{-14} to 2×10^{-13} coulombs (approximately equivalent to, from 1 millivolt to 10 millivolts on voltage sensitive input). The amplifier board (EIC P-8B) is a plug-in module for ease of maintenance.

Continued on following page

eberline P.O. Box 2108, Santa Fe, New Mexico 87501 (505) 471-3232 TWX: 910-985-0678

"RASCAL", MODEL PRS-1 AND PRS-2 (continued)

THRESHOLD: PRS-1: Adjustable by a 10-turn front panel control form 0 to 1.0 volt. PRS-2: Adjustable by a single-turn, screwdriver adjust, front panel control from 0 to 1.0 volt.

WINDOW (PRS-1 ONLY): Adjustable by a 10-turn front panel control from 0 to 1.0 volt, always constant above threshold. A "PHA-GROSS" switch provides cross counting by disabling the window.

TIME BASE: Quartz crystal controlled for an accuracy of greater than .01% over wide temperature and battery conditions, the time base provides all timing signals for the count rate meter and scaler functions of the instrument.

SPEAKER: The speaker and the speaker control switch are mounted on the front panel.

RESET: Resets both count rate meter and scaler functions.

DETECTOR CONNECTOR: Eberline type CJ-1, waterproof connector mates with CP-1.

POWER: Rechargeable Gel-Cel® battery provides approximately 75 hours of continuous operation between charging (an optional battery pack is available for five Ni-Cd. rechargeable "D" size batteries, or five "D" size non-rechargeable batteries, for approximately 200 hours of continuous operation).

BATTERY CHARGER CONNECTOR: Miniature phone jack.

BATTERY CHARGER: Recharges batteries in 14 hours.

MECHANICAL:

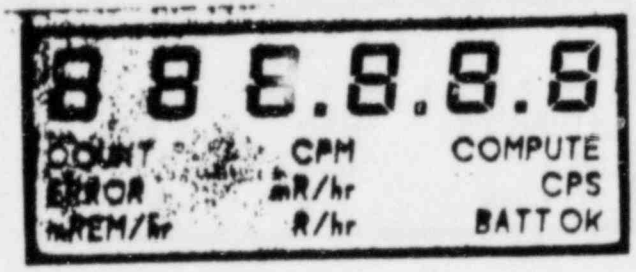
Size: 7-3/4" H x 9-1/2" L x 4" W (19.7 x 24.1 x 10.2 cm).

Weight: Approximately 5 lbs. (2.3 Kg).

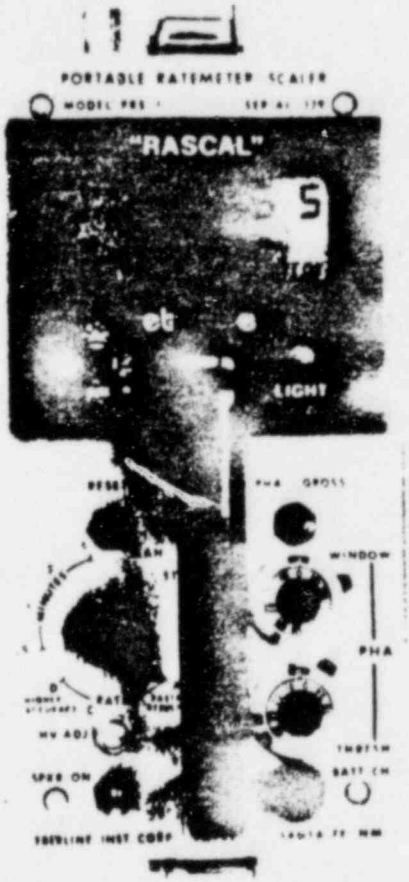
TEMPERATURE: Operational from 0° to 140°F (-18° to 60°C).

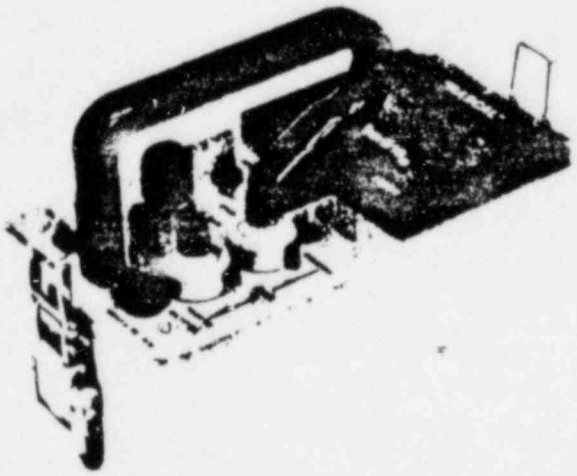
ACCESSORIES: Carrying strap.

"RASCAL"



PRS Legends and Digits





- RATEMETER
- SCALER
- SINGLE CHANNEL ANALYZER
- HIGH VOLTAGE DISPLAY
- LIGHTED DISPLAY
- OPERATES WITH PROPORTIONAL, SCINTILLATION AND GEIGER DETECTORS
- BUILT-IN SPEAKER
- LIQUID CRYSTAL DISPLAY HAS SIX DIGITS, NINE LEGENDS, AND THREE DECIMAL POINTS

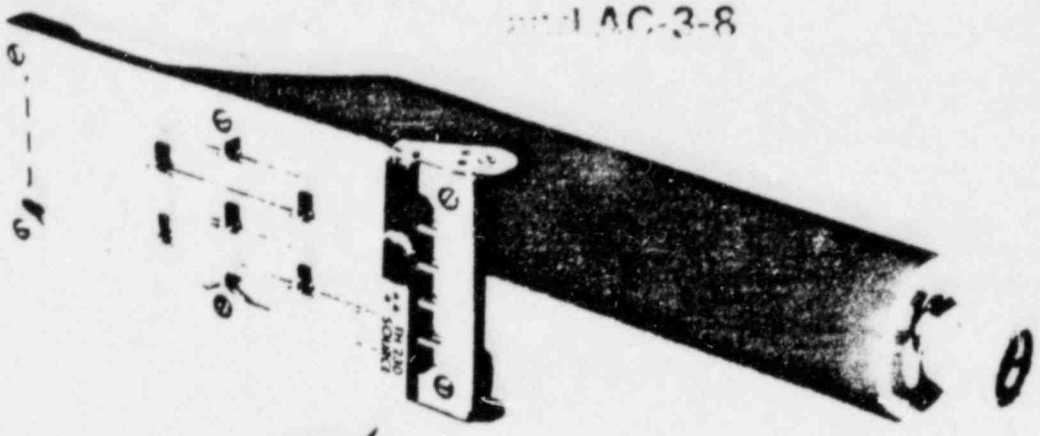
eberline

PRS-1

Alpha Scintillation Probes

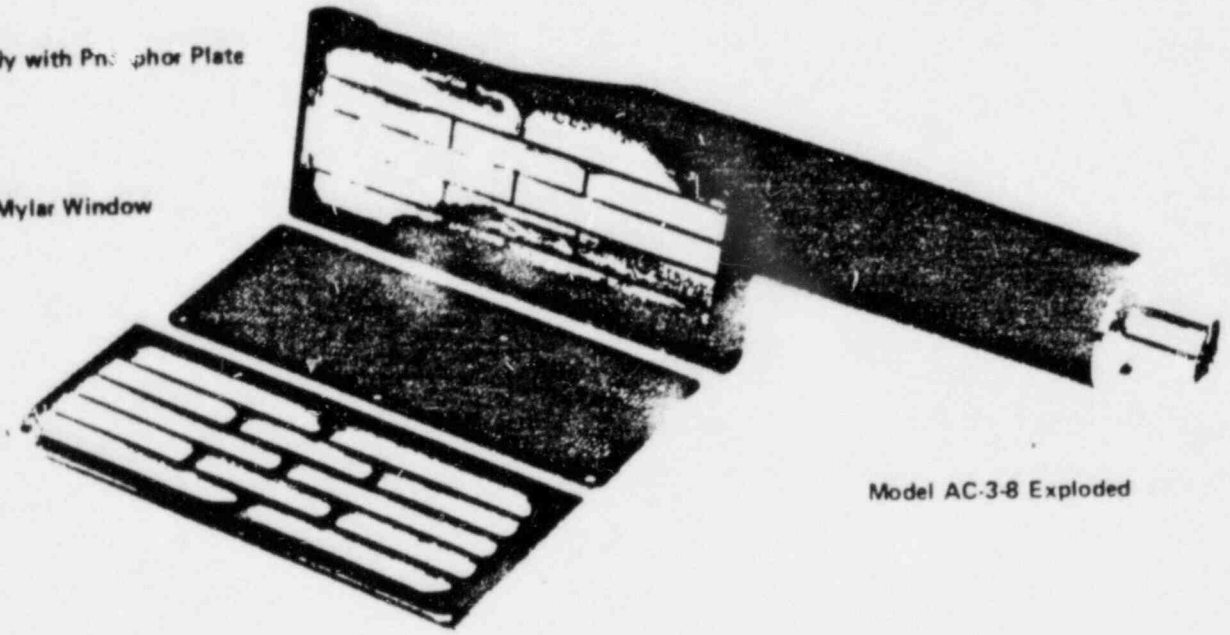
Models AC-3-7

and AC-3-8



Optional Check Source CS-15 ^{230}Th

Model AC-3-7 Assembled



Model AC-3-8 Exploded

SHAPED FOR CONVENIENT MONITORING
LARGE AREA COVERAGE
SUBMERSIBLE FOR DECONTAMINATION
FACE ASSEMBLY EASILY CHANGED
MOUNTED CHECK SOURCE AVAILABLE

eberline

APPENDIX C.I.

INSTRUMENT CALIBRATION

I Eberline Portable Micro-R Meter, Model PRM-7

Design

The PRM-7 is a self-contained gamma ray detection instrument, factory calibrated to a Cs-137 source. An internally mounted 1 inch x 1 inch NaI (Tℓ) scintillation crystal offers optimum performance in counting low level background radiation fields. The use of a NaI crystal in measuring exposure is limited due to the non-linearity of response between particle energy and light output. The photomultiplier tube output is proportional to dose rate in photon fields consisting of energies equivalent to that used in calibration.

Source Term

A. Cs-137

Steel encapsulated point source.

Photon energy = 0.662 Mev.

B. Ra-226

Steel encapsulated point source

Photon energies:

0.295 MeV (19%), 0.352 MeV (36%) resulting from Pb-214 decay, and 0.609 MeV (47%), 1.120 MeV (17%), 1.764 MeV (17%) resulting from Bi-214 decay.

Methods

A NBS traceable, Cs-137 calibrated 25 mR Victoreen Condenser-R chamber was used to determine exposure. No additional R-chamber wall thicknesses were used when determining the exposure to the Cs-137 source. In order to establish secondary charged particle equilibrium with respect to the 1.764 MeV photon emitted from the Ra-226 decay chain, a polystyrene cap of 0.61 gm/cm^2 was used. The total wall thickness was equal to 0.830 gm/cm^2.

Each source was placed in a source holder on a large laboratory work table. Distances were indicated at points where the exposure rates, determined by the R-chamber, were equal to 2.0 mR/h and 0.2 mR/h. The PRM-7 was placed in the radiation field and the instrument response was determined on the 500 and 5000 range.

To confirm that the count rate was equal to the pulse rate, the output of the PRM-7 was verified with the use of a pulse generator. The 25, 50, 500 and 5000 ranges were checked and various adjustments were made if necessary.

After calibration by electronics, the PRM-7 was again placed in the Cs-137 and then the Ra-226 radiation fields. The instrument response was determined on both the 500 and 5000 range. A background radiation determination was done using the 25 mR condenser-R chamber with all radioactive sources removed from the work area. Results can be found in Table 1.

A Cs-137 button source is used to check the instrument calibration prior to actual use. With the instrument range switch on the 500 scale,

the button source is placed on the meter front with the radiation symbol in contact with the meter adjust screw. The instrument should read 165 μR/h.

Secondary Standard for Calibration

A secondary standard for calibration of the PRM-7 was based on the response of LiF thermoluminescence chips (TLD) to a natural radiation environment in an unventilated concrete basement and in the ground floor of a one story concrete building. All chips were calibrated with a NBS traceable Co-60 source and individual calibration factors (mR/nC) were established.

The annealed TLD chips were sandwiched between two pieces of 1/4 inch thick lucite and placed in the two test fields for a period of 69 days. The chips were readout on a Hawshaw TLD reader and the exposure calculated. The response of the PRM-7 was determined in both fields and the results compared to the exposure determined by the TLD chips. A summary of results can be found in Table 2.

TABLE 1

INSTRUMENT CALIBRATION PRM-7

Source	BG (mR/h)	(1) $\dot{X}$ (mR/h)	(2) Instrument Response (mR/h)		(3) Instrument Response (mR/h)	
			500 Range	5000 Range	500 Range	5000 Range
Cs-137	0	2.0	----	2.0	-----	2.1
	0	0.2	.280	---	0.380	---
Ra-226	0	2.0	----	1.20	-----	1.20
	0	0.2	.170	----	0.210	----

(1) Exposure rate determined by Condenser-R chamber.

(2) Prior to electronic calibration.

(3) Post electronic calibration.

TABLE 2

SECONDARY STANDARD OF CALIBRATION FOR THE PRM-7

Field - unventilated concrete basement.

Exposure Time - 69 days.

PRM-7 Cs-137 Calibration Check = 0.160 mR/h (500 range).

TLD No.	Net Readout (nC)	Exposure (mR)
700104	1.912	25.5
700029	2.070	18.6
700020	2.123	22.2
700007	2.631	27.9
700027	2.334	21.6
700015	2.527	27.0
700026	2.133	20.6
700018	2.450	26.4
700025	2.226	27.1

Average	=	24.1 $\pm$ 3.4 mR/69 day
Exposure Rate	=	.015 $\pm$ .002 mR/h
PRM-7 Response	=	.015 mR/h (500 range)
		.012 mR/h (50 range)
		.013 mR/h (25 range)

TABLE 2 (page 2 of 2)

SECONDARY STANDARD OF CALIBRATION FOR THE PRM-7

Field - Ground floor of one story concrete building.

Exposure Time - 69 days.

PRM-7 Cs-137 Calibration Check = 0.160 mR/h (500 range).

TLD No.	Net Readout (nC)	Exposure (mR)
700005	2.113	24.5
700016	2.387	23.2
700008	2.334	28.9
700030	1.988	25.1
700013	2.298	25.4
18	2.739	29.4
19	2.153	21.5
20	2.276	22.5
21	2.194	22.2

Average	=	24.5 $\pm$ 2.8 mR/69 days
Exposure Rate	=	.015 $\pm$ .002 mR/h
PRM-7 Response	=	.015 mR/h (500 range)
		.010 mR/h (50 range)
		.010 mR/h (25 range)

APPENDIX C.II.

II Calibration of PRS-1/AC-3-8 Alpha Scintillation Probe Used in Conjunction with Staplex High Volume Air Sampler

The alpha detection efficiency of the AC-3-8 detector when placed in direct contact with the filter sample was determined by obtaining a sample of naturally occurring Pb-212 aerosols on the filter, allowing all of the short lived Rn-222 daughters to decay, and then counting the filter sample under transient equilibrium conditions. Uniform radioactivity distribution over the surface of the filter was verified by taking counts with the AC-3-8 probe at different locations on the filter surface and by cutting out circular samples of the filter (diameter of about 3.5 cm) and counting each sample under the window (0.853 mg cm^{-2}) of a gas flow proportional counting system. This system was previously calibrated for the detection of Pb-212 in transient equilibrium with daughters. Standard Pb-212 samples were obtained by the generation of Pb-212 aerosols from a Th-228 emanation source and deposition of Pb-212 on the surface of aluminized mylar sheets of the same active area of filters in the Gelman 47 mm filter holder (diameter of 3.5 cm). Alpha counts of these standards obtained for the internal counting position (2π geometry) yielded the absolute activity of the standard.

Corrections of alpha particle efficiencies for self absorption due to the burial of Pb-212 aerosols within the filter and within collected dust was estimated by obtaining counts of samples in the alpha mode and beta mode using the end-window proportional counter. The beta counting mode was established by covering samples with an aluminum absorber of mass density thickness of 20.73 mg cm^{-2} and counting each sample at the beta operating voltage (1850 volts). The ratio of the instantaneous beta counting rate to the instantaneous alpha counting rate at the same reference time gave a measure of the effective depth of burial of aerosols within the filter as well as the alpha counting efficiency. Sample β/α counting rate ratios were compared to those of standard absorber curves obtained by covering standard Pb-212 sources with sheets of 1/4 mil mylar. Naturally occurring Pb-212 aerosols were found to have an average depth of burial of about 0.85 mg cm^{-2} in the glass fiber filter sample.

Counts of the high volume (HV) filter samples using the AC-3-8 alpha scintillation probe and counts of the circular filter samples on the end-window proportional counter were used to estimate the efficiency of the AC-3-8 probe when placed in contact with the HV filter sample. Corrections were made for the different alpha particle energies of the Rn-222 short lived daughters compared to the Pb-212 daughters. Results yielded an average alpha particle efficiency of 2.90×10^{-2} C α^{-1} for the short lived Rn-222 daughters and for the sampling and counting parameters used in this study. It may be assumed that Rn-222 and its short lived daughters are in secular equilibrium

in the outdoor atmosphere. The theoretical net alpha count response C_α of the PRS-1/AC-3-8 alpha scintillation counting system for the HV filter sample is derived as follows. The short lived Rn-222 daughter atoms that may produce an alpha count response either directly or indirectly are:

$$\underset{(1)}{\text{3.05 m Po-218}} \xrightarrow{\alpha} \underset{(2)}{\text{26.8 m Pb-214}} \xrightarrow{\beta} \underset{(3)}{\text{19.7 m Bi-214}} \xrightarrow{\beta} \text{164 } \mu\text{s Po-214} \xrightarrow{\alpha},$$

where minor decay branching has been omitted and where the predominant short lived Rn-222 daughter species, Po-218, Pb-214, and Bi-214 are numbered respectively as 1, 2, and 3. Although only the 6.00 MeV and 7.69 MeV alpha particles of Po-218 and Po-214 respectively produce net alpha counts in the system, all atoms in the sampled air may produce counts as a result of decay through Po-214. The 7.69 MeV alpha particle, because of the extremely short half-life of Po-214, may be considered from a kinetics standpoint to arise directly from decay of species 3 or Bi-214. The decay series thus may be simplified:

$$N_1 \text{ (Po-218)} \xrightarrow{\alpha_1} N_2 \text{ (Pb-214)} \xrightarrow{\beta} N_3 \text{ (Bi-214)} \xrightarrow{\alpha_3}.$$

A single filter sample is obtained and later counted with the PRS-1/AC-3-8 Alpha Scintillation Detector to estimate the concentration of Rn-222 or each short lived daughter. No correction is made for the contribution of thoron (Rn-220) or actinon (Rn-219) daughters to the alpha counts; therefore, results will overestimate the amount of Rn-222.

Under our assumption of secular equilibrium between Rn-222 and its short lived daughters, the activity concentrations U are equal:

$$U = U_{Rn-222} = U_1 = U_2 = U_3. \quad (1)$$

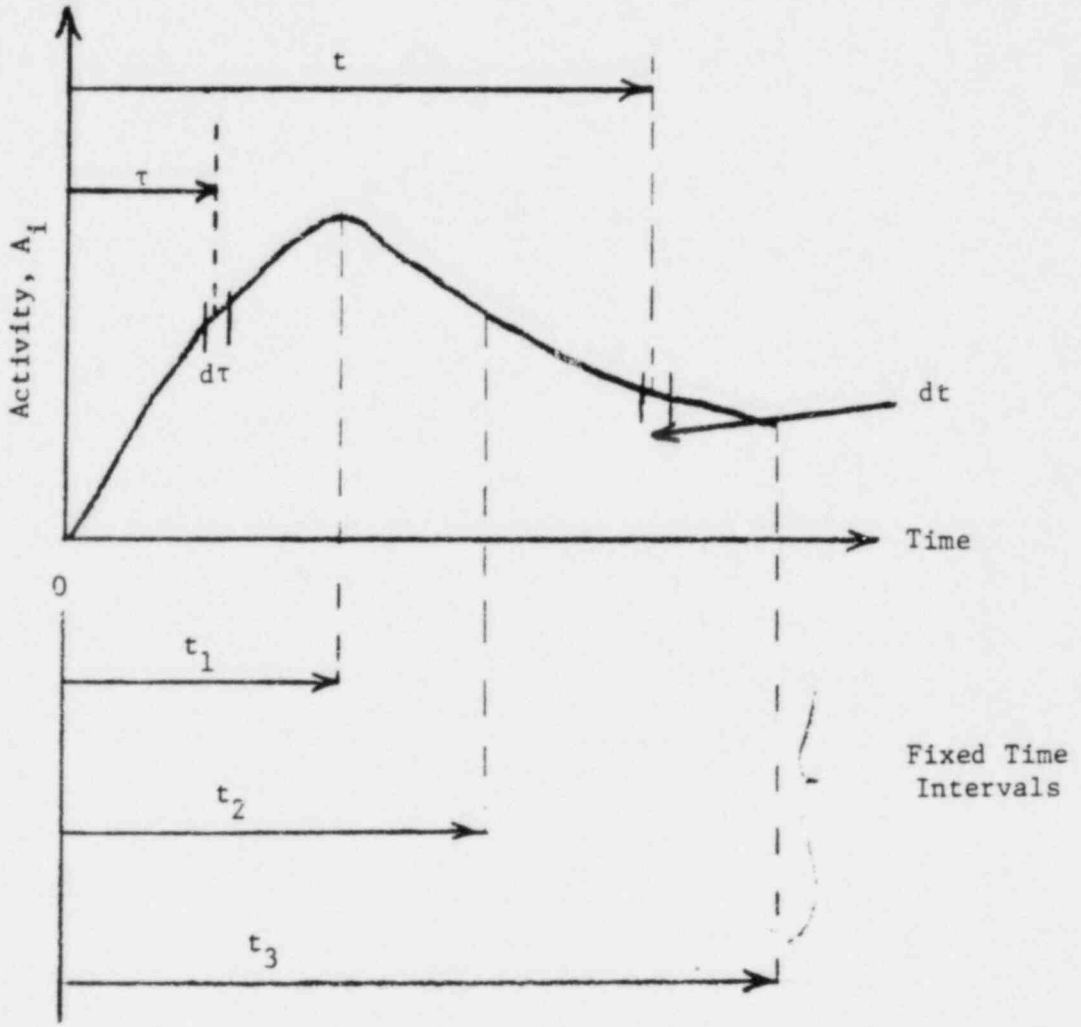
The glass fiber filter used in this work has been shown to have a 100% collection efficiency for radon/thoron daughters. Therefore, the atom collection rate P_i of each species on the filter sample is obtained for a sampling flow rate F:

$$P_i = FU_i/\lambda_i = FU/\lambda_i \quad (2)$$

where i = 1, 2, or 3.

The sampling (t_1), decay (t_2), and counting (t_3) intervals are depicted schematically along with the variable time τ during sampling and the variable time t from the beginning of sampling to each counting increment dt:

SCHEMATIC OF SAMPLING, DECAY, AND COUNTING INTERVALS



The activity A_i of each species increases during the sampling interval and then generally decreases post sampling, depending on the ingrowth from the decay of parents. The differential number of atoms $dN_n(t)$ of the n^{th} species in a radioactive series present at time t post an incremental production $P_i\, d\tau$ of each species during the sampling interval is given where there is no branching in the series:

$$dN_n(t) = \sum_{i=1}^{n} P_i\, d\tau \prod_{j=i}^{n-1} \lambda_j \sum_{j=i}^{n} \frac{\exp(-\lambda_j(t-\tau))}{\prod_{\substack{p=i \\ p\neq j}}^{p=n} (\lambda_p-\lambda_j)}. \qquad (3)$$

The total number $N_n(t)$ of atoms of the n^{th} species due to production on the filter sample during the entire sampling interval is obtained by integration of equation (3):

$$N_n(t) = \int_{\tau=0}^{\tau=t_1} dN_n(t), \text{ or}$$

$$N_n(t) = \sum_{i=1}^{n} P_i \prod_{j=i}^{n-1} \lambda_j \sum_{j=i}^{n} \frac{(\exp(\lambda_j t_1)-1)\exp(-\lambda_j t)}{\lambda_j \prod_{\substack{p=i \\ p\neq j}}^{p=n} (\lambda_p-\lambda_j)}. \qquad (4)$$

The number of disintegrations D_n of the n^{th} species during the counting interval (t_3-t_2) is obtained by integration of $\lambda_n N_n(t)\, dt$:

$$D_n = \int_{t=t_2}^{t=t_3} \lambda_n N_n(t)\, dt, \text{ or}$$

$$D_n = \lambda_n \sum_{i=1}^{n} P_i \prod_{j=i}^{n-1} \lambda_j \sum_{j=i}^{j=n} \frac{(\exp(\lambda_j t_1)-1)\ (\exp(-\lambda_j t_2) - (\exp(-\lambda_j t_3))}{\lambda_j^2 \prod_{\substack{p=i \\ p\neq j}}^{p=n} (\lambda_p - \lambda_j)} \quad . \tag{5}$$

Only disintegrations of species 1 (Po-218) and species 3 (Bi-214) are considered to produce net alpha counts C_α. If the alpha particle efficiencies are designated respectively as E_1 and E_3 and if each P_i given by equation 2 is substituted in equation (5), then the net α count C_α may be expressed:

$$C_\alpha = E_1 D_1 + E_3 D_3, \text{ or}$$

$$C_\alpha = FU \left\{ \frac{E_1\ (\exp(\lambda_1 t_1)-1)\ (\exp(-\lambda_1 t_2) - \exp(-\lambda_1 t_3))}{\lambda_1^2} \right.$$

$$\left. + \lambda_3 E_3 \sum_{i=1}^{3} \frac{1}{\lambda_i} \prod_{j=i}^{2} \lambda_j \sum_{j=i}^{3} \frac{(\exp(\lambda_j t_1)-1)\ (\exp(-\lambda_j t_2) - \exp(-\lambda_j t_3))}{\lambda_j^2 \prod_{\substack{p=i \\ p\neq j}}^{p=3} (\lambda_p - \lambda_j)} \right\} . \tag{6}$$

When values for λ_i are obtained from the reported half-lives given above and are substituted along with values of t_i used in this study:

t_1 = 5 minutes,

t_2 = 7 minutes,

t_3 = 12 minutes, the following expression is obtained:

$$C_\alpha = FU \left(5.666\ E_1 + (0.3008 + 4.893 + 19.59)\ E_3\right)$$

$$C_\alpha = FU \left(5.666\ E_1 + 24.78\ E_3\right). \qquad (7)$$

The alpha particle efficiencies have been determined as outlined above:

$$E_1 = 2.74 \times 10^{-2}\ C\ \alpha^{-1},$$
$$E_3 = 2.94 \times 10^{-2}\ C\ \alpha^{-1}.$$

Each efficiency in equation (7) is weighted by a different coefficient; therefore, the average alpha particle counting efficiency $\overline{E}$ for the filter sample/counting geometry is calculated:

$$\overline{E} = \frac{5.666\ E_1 + 24.78\ E_3}{5.666 + 24.78},$$

which gives upon substitution of values for E_1 and E_2:

$$\overline{E} = 2.90 \times 10^{-2}\ C\ \alpha^{-1}.$$

When values for the efficiencies E_1 and E_2 are substituted into equation (7), the Rn-222 activity concentration U is obtained:

$$U = 1.132\ \frac{C_\alpha}{F}\ (\text{count})^{-1}\ (\text{cm}^3\ \text{m}^{-1})\ \text{dm}^{-1}\ \text{cm}^{-3}, \qquad (8)$$

where cancelling units for the net alpha counts C_α and flow rate F are shown in brackets. When the flow rate F is expressed in $ft^3\ m^{-1}$ and the concentration U is expressed in $\mu Ci\ cm^{-3}$, equation (8) is re-expressed:

$$U = 1.80 \times 10^{-11} \frac{C_\alpha}{F} (count)^{-1}\ (ft^3\ m^{-1})\ \mu Ci\ cm^{-3}. \qquad (9)$$

An activity concentration of Rn-222 of 10^{-7} $\mu Ci\ cm^{-3}$ in secular equilibrium with its short lived daughters corresponds to one working level (WL). The activity concentration U expressed in working levels is thus expressed:

$$U = 1.80 \times 10^{-4} \frac{C_\alpha}{F} (count)^{-1}\ (ft^3\ m^{-1})\ WL. \qquad (10)$$

APPENDIX D.I.

REPORT OF ANALYSIS

CUSTOMER N. L. Industries
ADDRESS P. O. Box 2046
CITY Wilmington, Delaware 19899
ATTENTION David Leigh cc: David Kautz, Niagra Falls, NY
INVOICE NO. 907162

SAMPLES RECEIVED 6-18-79 | CUSTOMER ORDER NUMBER

TYPE OF ANALYSIS Soil

Sample Identification	Type of Analysis	ug/g (dry)	pCi/g (dry)
H-1 @ 1 ft.	Total Uranium	0.88	
	Thorium-232		0.55±0.05
	Thorium-230		0.37±0.04
	Thorium-228		0.66±0.06
	Radium-226		2.0±1.2
H-1 @ 8 ft.	Total Uranium	0.68	
	Thorium-232		0.15±0.01
	Thorium-230		0.10±0.01
	Thorium-228		0.20±0.02
	Radium-226		2.0±1.5
H-2-Top	Total Uranium	3.78	
	Thorium-232		0.36±0.03
	Thorium-230		1.25±0.05
	Thorium-228		0.43±0.03
	Radium-226		26.8±2.4
H-2-Bottom	Total Uranium	4.11	
	Thorium-232		0.55±0.04
	Thorium-230		0.70±0.05
	Thorium-228		0.62±0.44
	Radium-226		< 1.6

APPROVED BY Bruce M. Angle
Bruce M. Angle, Scientific Services, Mgr.
7-25-79 PAGE 1 OF 1 PAGE

Consultants for Environmental Pollution, Inc.
P.O. Box 5351 • 1925 Rosina • Santa Fe, New Mexico 87502
Telephone 505/982 9841

CUSTOMER N. L. Industries
ADDRESS P. O. Box 2046
CITY Wilmington, Delaware 19899
ATTENTION David Leigh cc: David Kautz, Niagra Falls, NY
INVOICE NO 907162

REPORT OF ANALYSIS

SAMPLES RECEIVED 6-18-79 | CUSTOMER ORDER NUMBER

TYPE OF ANALYSIS Soil

Sample Identification	Type of Analysis	ug/g (dry)	pCi/g (dry)
H-3	Total Uranium	0.82	
	Thorium-232		0.81±0.08
	Thorium-230		1.66±0.11
	Thorium-228		0.86±0.08
	Radium-226		1.6±1.0
H-5	Total Uranium	0.66	
	Thorium-232		0.37±0.05
	Thorium-230		0.34±0.05
	Thorium-228		0.45±0.06
	Radium-226		< 1.2
H-6 Black	Total Uranium	0.8	
	Thorium-232		0.44±0.04
	Thorium-230		0.36±0.04
	Thorium-228		0.46±0.04
	Radium-226		1.4±1.4
H-6 Brown	Total Uranium	0.56	
	Thorium-232		0.38±0.04
	Thorium-230		0.33±0.03
	Thorium-228		0.50±0.04
	Radium-226		< 1.7

APPROVED BY Bruce M. Angle
Bruce M. Angle, Scientific Services, Mgr.
7-25-79 PAGE 1 OF 1 PAGE

Controls for Environmental Pollution, Inc.
P.O. Box 5351 • 1925 Rosina • Santa Fe, New Mexico 87502
Telephone 505/982-9841

CUSTOMER N. L. Industries
ADDRESS P. O. Box 2046
CITY Wilmington, Delaware 19899
ATTENTION David Leigh cc: David Kautz, Niagra Falls, NY
INVOICE NO 907162

REPORT OF ANALYSIS

SAMPLES RECEIVED 6-18-79 | CUSTOMER ORDER NUMBER

TYPE OF ANALYSIS Soil

Sample Identification	Type of Analysis	ug/g (dry)	pCi/g (dry)
H-6-Red	Total Uranium	0.56	
	Thorium-232		0.10±0.01
	Thorium-230		0.10±0.01
	Thorium-228		0.14±0.02
	Radium-226		2.3±0.8
H-6-Tan	Total Uranium	1.65	
	Thorium-232		0.95±0.01
	Thorium-230		0.07±0.01
	Thorium-228		0.14±0.02
	Radium-226		< 1.0
H-7	Total Uranium	0.44	
	Thorium-232		0.17±0.02
	Thorium-230		0.18±0.02
	Thorium-228		0.22±0.02
	Radium-226		< 1.3
H-8 Black	Total Uranium	0.60	
	Thorium-232		0.17±0.02
	Thorium-230		0.21±0.02
	Thorium-228		0.22±0.02
	Radium-226		< 1.7

APPROVED BY Bruce M. Angle
Bruce M. Angle, Scientific Services, Mgr.
7-25-79 PAGE 1 OF 1 PAGE

Controls for Environmental Pollution, Inc
P.O. Box 5351 • 1925 Rosina • Santa Fe, New Mexico 87502
Telephone 505/982-9841

D.I-3

CUSTOMER N. L. Industries
ADDRESS P. O. Box 2046
CITY Wilmington, Delaware
ATTENTION David Leigh cc: David Kautz, Niagra Falls, NY
INVOICE NO 907162

REPORT OF ANALYSIS

SAMPLES RECEIVED 6-18-79 | CUSTOMER ORDER NUMBER

TYPE OF ANALYSIS Soil

Sample Identification	Type of Analysis	ug/g (dry)	pCi/g (dry)
H-8-Bottom	Total Uranium	1.39	
	Thorium-232		0.12±0.02
	Thorium-230		0.41±0.03
	Thorium-228		0.14±0.02
	Radium-226		< 0.9
H-8-Brown	Total Uranium	0.64	
	Thorium-232		0.07±0.01
	Thorium-230		0.10±0.01
	Thorium-228		0.09±0.01
	Radium-226		< 1.2

APPROVED BY Bruce M. Angle
Bruce M. Angle, Scientific Services, Mgr.
7-25-79 PAGE 1 OF 1 PAGE

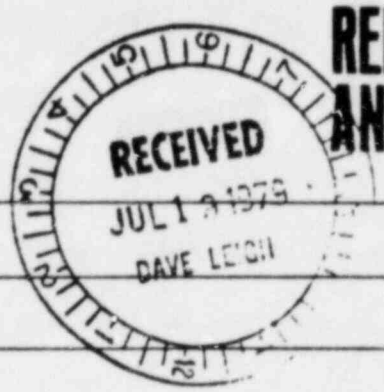
Controls for Environmental Pollution, Inc.
P.O. Box 5351 • 1925 Rosina • Santa Fe, New Mexico 87502
Telephone 505/982-9841

D.I-4

CUSTOMER N.L. Industries
ADDRESS P.O. Box 2046
CITY Willington, DE 19899
ATTENTION David Leigh
INVOICE NO 907080

APPENDIX D.II.

REPORT OF ANALYSIS



SAMPLES RECEIVED 6/18/79 | CUSTOMER ORDER NUMBER

TYPE OF ANALYSIS Water Analysis -

Sample Identification	Analysis	mg/l	pCi/l
H-1 Groundwater	Total Uranium	0.009	
	Total Radium-226		< 0.6
	Thorium-232		< 0.6
	Thorium-230		0.3±0.5
	Thorium-228		0.5±0.8
H-2 Groundwater	Total Uranium	0.019	
	Total Radium-226		< 0.6
	Thorium-232		0.7±0.6
	Thorium-230		0.5±0.9
	Thorium-228		1.6±1.0
H-3 Groundwater	Total Uranium	0.005	
	Total Radium-226		< 0.6
	Thorium-232		< 0.6
	Thorium-230		< 0.6
	Thorium-228		< 0.6
H-6 Groundwater	Total Uranium	0.008	
	Total Radium-226		< 0.6
	Thorium-232		0.4±0.4
	Thorium-230		0.6±0.6
	Thorium-228		< 0.6
H-7 Groundwater	Total Uranium	0.005	
	Total Radium-226		< 0.6
	Thorium-232		< 0.6
	Thorium-230		< 0.6
	Thorium-228		0.6±0.4

APPROVED BY Bruce Angle
Bruce Angle, Manager of Scientific Services
7/17/79 PAGE 1 OF 1 PAGE

Controls for Environmental Pollution, Inc.
P.O. Box 5351 • 1925 Rosina • Santa Fe, New Mexico 87502
Telephone 505/982-9841

L. Industries
30 Central Ave.
Albany, NY 12205

tn: Ted Rahon

eberline
MIDWESTERN FACILITY
245 ROOSEVELT ROAD WEST CHICAGO, ILLINOIS 6
312 - 231-0400

O. NO.: TOTAL SAMPLES: 5 DATE RECEIVED: 06/19/79 WORK ORDER NO. 1192 Al

ITEM	SAMPLE TYPE	QUANTITY	ANALYSIS
1	Ground Water	5	Fluorometric Uranium
2	"	"	Thorium
3	"	"	Radium

LAB NO.	SAMPLE IDENTIFICATION	DATE COLLECTED	ug/l F.U.	pCi/l Th	pCi/l Ra-226
5825	H-1	06/13/79	<5	<0.10	0.64±0.12
5826	H-2	"	8	<0.10	1.5 ±0.3
5827	H-3	"	<5	<0.10	0.49±0.13
5828	H-6	"	<5	<0.10	1.3 ±0.2
5829	H-7	"	<5	<0.10	0.62±0.12

cc: David Kautz - Sr. Engineer

db DATE: 06/25/79 DATA APPROVED: DATE: 07/30/79
Chandrasekaran, E. S., Mgr.

D.TT-2

. Industries
1130 Central Ave.
Albany, NY 12205

Attn: Ted Rahon

eberline
MIDWESTERN FACILITY
245 ROOSEVELT ROAD WEST CHICAGO, ILLINOIS 60
312 - 231-9400

P.O. NO.: TOTAL SAMPLES: 14 DATE RECEIVED: 06/19/79 WORK ORDER NO. 1191 AI

ITEM	SAMPLE TYPE	QUANTITY	ANALYSIS
1	soil	14	Fluorometric Uranium
2	"	"	Thorium
3	"	"	Radium

±2σ, 95% CL
disintegrations/min
2.22 x 10^-12
grams of dry
μg/10 g typo per Dr Chandra 7-29-80

LAB NO.	SAMPLE IDENTIFICATION	DATE COLLECTED	μg/1 F.U.	dpm/gm dry Th-232	dpm/gm dry Th-230	dpm/gm dry Th-238	pCi/g Ra-2
M75811	H-1 @ 1 foot	06/13/79	2.8	1.07±0.22	1.01±0.21	1.01±0.21	0.53±0
812	H-1 @ 8 feet	"	2.3	1.05±0.24	1.30±0.20	1.02±0.23	0.17±0
M75813	H-2 Soil, top	"	6.7	2.55±0.48	6.77±0.17	2.51±0.49	0.28±0
M75814	H-2 Soil, bottom	"	6.3	1.03±0.23	1.51±0.31	0.96±0.22	0.29±0
815	H-3 Soil	"	2.0	1.04±0.21	1.85±0.33	0.96±0.20	1.0 ±0
M75816	H-5 Soil	"	1.5	1.03±0.20	1.10±0.21	1.20±0.23	0.41±0
M 817	H-6 Soil, red	"	1.2	1.09±0.22	1.04±0.21	1.00±0.21	0.51±0
M75818	H-6 Soil, black	"	0.90	1.42±0.27	1.29±0.25	1.25±0.24	0.67±0
M75819	H-6 Soil, tan	"	2.0	1.07±0.21	1.06±0.21	1.13±0.22	0.27±
820	H-6 Soil, brown	"	2.2	3.51±0.62	3.41±0.60	3.73±0.65	1.0 ±
M75821	H-7 Soil	"	1.2	1.15±0.24	1.17±0.24	0.97±0.21	0.82±
M 822	H-8 Soil, black	"	4.7	1.42±0.26	1.70±0.30	1.30±0.24	1.1 ±
M75823	H-8 Soil, brown	"	1.7	0.63±0.15	0.75±0.17	0.66±0.15	0.67±
M75824	H-8 Soil, bottom	"	2.3	0.54±0.13	1.81±0.32	0.60±0.14	0.04±

cc: David Kautz - Sr. Engineer

BY: db DATE: 06/25/79 DATA APPROVED: Chandrasekaran, E. S., Mgr. DATE: 08/10/79

APPENDIX D.III.

Air Sample and Radiation Level Data

Perimeter Locations
Surveys Taken 16 May 1979

Sample Number	Location	Radiation Level mR/hr	AIR SAMPLING DATA: Collection Flow Rate Ft^3/Min	Alpha counts for 5 minute count: Gross counts	Alpha counts for 5 minute count: counts above bkg.
Background	1½ mile from site	6	45	13	NA
1	NE corner of site	7	45	20	7
2		9	45	18	5
3		22	45	17	4
4		15	45	14	1
5		20	45	18	5
6		12	45	12	0
7	NW corner of site	10	45	22	9
8		13	45	17	4
9	SW corner of site	7	45	21	8
10		7	45	19	6
11		28	52	24	11
12		22	52	23	10
13		28	52	19	6
14		15	46	14	1
15	SE corner of site	8	45	24	11
16		8	45	16	3

APPENDIX D.III. (Continued)

Onsite Location
Surveys Taken 31 May 1979

Sample Number	Location	Radiation Level mR/hr	AIR SAMPLING DATA		
			Collection Flow Rate FT^3/Min.	Alpha counts for 5 minute count Gross counts	counts above bkg.
Background		13	45	13	NA
1	SW ramp of warehouse	7	52	142	129
2	Building 134	20	58	73	60
3	Building 133	14	58	58	45
4	Warehouse	none taken	48	224	211
5	Building 143	13	48	53	40
6	Building 123	26	38	73	60
7	Building 115 furnace room at control room	22	58	55	42
8	Warehouse - at product stack	65	50	378	365

REFERENCE 1

RECENT DEVELOPMENTS FOR FIELD MONITORING OF ALPHA-EMITTING CONTAMINANTS IN THE ENVIRONMENT

by

A. John Ahlquist, C. John Umbarger, and Alan K. Stoker

Los Alamos Scientific Laboratory
P.O. Box 1663, MS 490
Los Alamos, New Mexico 87545

INTRODUCTION

Two field methods have been adapted by the Los Alamos Scientific Laboratory to rapidly assess locations and concentrations of alpha-emitting contaminants in soil. They are 1) a gross-alpha measurement of soil samples using a ZnS alpha scintillator and 2) a portable phoswich detector used as a field survey instrument to detect low-energy x and gamma rays associated with alpha decay. These methods have proven useful for directing decontamination operations of soils contaminated with alpha emitters (Sm77; He77).

ZnS DETECTION SYSTEM

The technique of making quantitative gross-alpha measurements on soil and rock samples was first used in the 1930s by R. D. Evans to measure uranium and thorium (Ev33; Ev34a; Ev34b; Fi35). In adapting this technique, a commercially available 10 cm diam ZnS alpha scintillator probe was used with a single-channel analyzer equipped with a timer-scaler and HV supply. The system can be powered either by line or internal

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*The Los Alamos Scientific Laboratory requests that the publisher identify this article as work performed under the auspices of the USERDA, Contract W-7405-ENG. 36.

battery.

Soil samples are placed in plastic bags that are massaged to sufficiently homogenize the sample. Enough soil (~75 g) is taken to fill an 88-mm diam x 13-mm deep plastic petri dish. The soil surface is leveled off even with the top of the petri dish; small rocks and debris are removed. The soil aliquot is dried under a heat lamp and allowed to cool before counting. If a sample is very wet, it is dried, ground up with a mortar and pestle to break up aggregates and then returned to the petri dish for redrying to remove residual moisture. If a sample is not dry enough, moisture tends to condense on the mylar face of the probe during counting, reducing detector sensitivity.

The petri dish is then placed in a depression in a black wooden holder and the probe is placed on top of the dish. The holder is black in order to minimize scattered light, as the 1 mg/cm^2 aluminized mylar covering the detector face is not completely opaque to light. Integral ribs on the probe provide a consistent 1.6 mm spacing between the top of the soil sample and the probe face. Samples are nominally counted for 5 min. Total elapsed time from receipt of sample to measurement results can be as little as 30 min.

The system is calibrated using a carefully homogenized soil sample spiked to 2000 pCi/g with ^{239}Pu. This sample gives 0.135 c/m per pCi/g. The 1-sigma statistical error on the calibration factor is less than 3% for a 5-min count on samples $\geq$ 2000 pCi/g. System background (using an empty petri dish) is 0.5 - 1.0 c/m. Natural alpha emitters in Los Alamos area soils result in background counting rates of 4 to 8 c/m. An uncontaminated soil sample of the soil type being measured is used to determine the natural alpha background.

System calibration-stability checks made with a 7.5-cm diam plated ^{239}Pu source, and system background checks are made daily. Blank and calibration checks are made periodically.

Table I lists the various detection limits attainable with this system, as a function of gross counts for soil background, for a 5-min counting time. This count time was selected as a compromise between desired detection limits and speed and ease of analysis. A 99.7% confidence level was chosen for operational use so as to minimize the Type I error (stating activity is present when it is not).

The results of gross-alpha analyses on selected soil samples known to have predominantly ^{239}Pu contamination were compared to ^{239}Pu radiochemistry results on aliquots of soil from the petri dish used for the gross-alpha analysis (Fig. 1). Note that 73% of the ZnS measurements are within a factor of 2 of the radiochemistry results. This is considered to be good agreement since samples were not sieved, ground, or milled to ensure homogeneity and since the ZnS "sees" <0.5 g of soil, whereas 10 g are used for radiochemistry. Four samples had gross-alpha ZnS to ^{239}Pu (radiochemistry) ratios of 0.07, 19, 27, and 30 believed to be due to sampling inhomogeneities.

In conclusion, this technique permits rapid assessment of alpha-emitter contamination in soils to low enough concentrations to efficiently direct large field operations. Due to sample inhomogeneity, however, the gross-alpha analysis may not compare favorably to radiochemistry on the same sample (although the majority of our comparisons are within a factor of 2). We feel this disadvantage is more than offset by the advantage of being able to analyze large numbers of samples in a relatively short time.

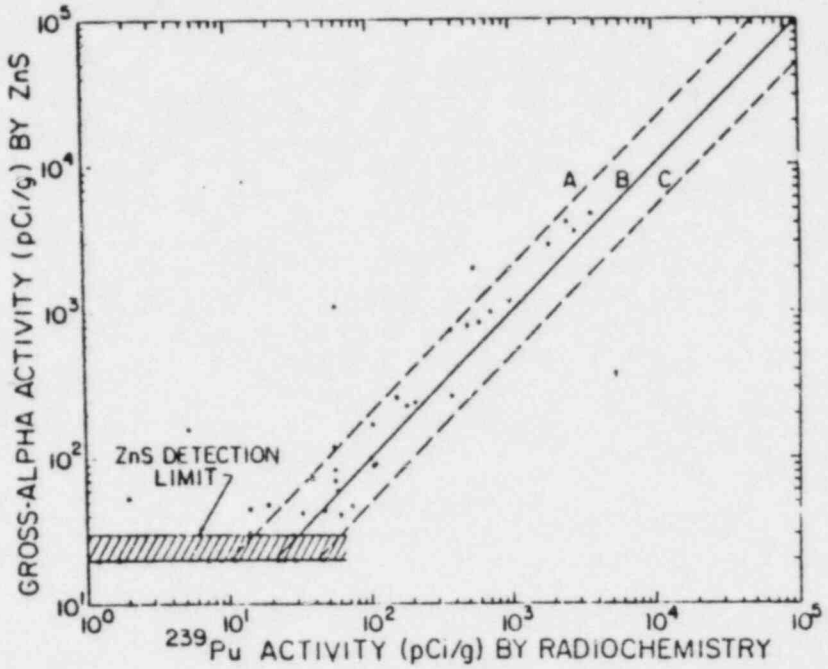

Fig. 1.

Comparison of ZnS gross-alpha results to ^{239}Pu radiochemistry results on the same samples. Curve A indicates a ZnS result two times that of radiochemistry. Curve B indicates a ZnS response equal to the radiochemistry result. Curve C indicates a ZnS response one-half that of radiochemistry. The detection limit indicated is for a 5-min count for a range of natural soil backgrounds. The actual limits depend upon the parameters used.

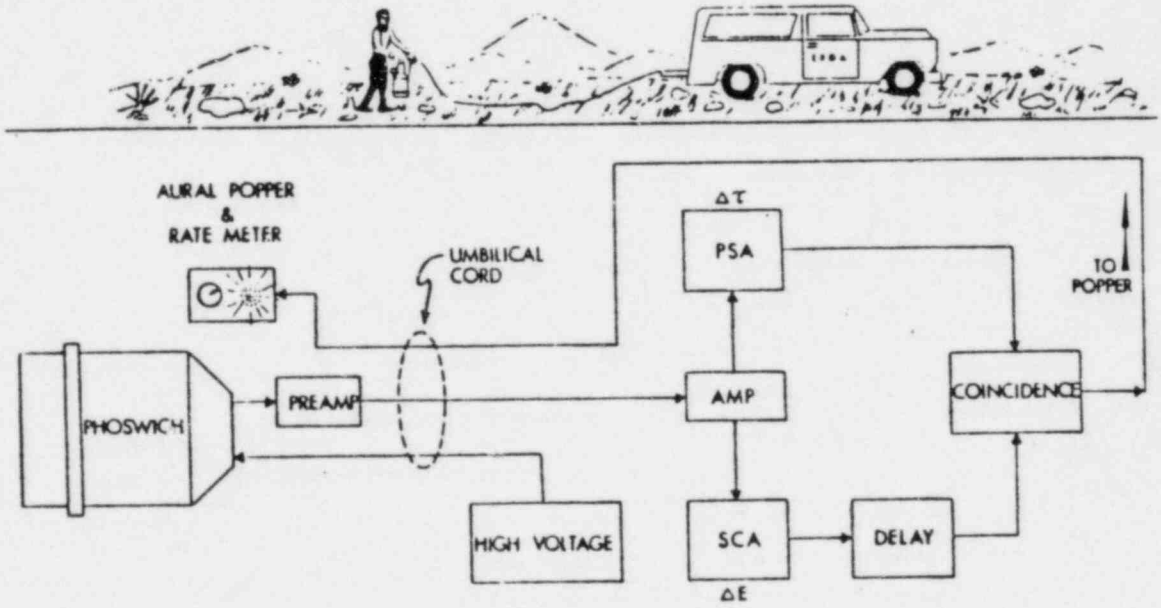

Fig. 2.

Schematic of the field phoswich detector. The pulse shape analyzer (PSA) selects only pure NaI signals while the single-channel analyzer (SCA) selects the photon energy region of interest.

TABLE I

Gross-Alpha Activity Detection Limits for 5-Minute Sample Counts as a Function of Background Count Rate and Probability of Detection

Soil Background Count Rate (c/5 min)	Gross-Alpha Activity Detection Limit (pCi/g)	
	95% Confidence[a]	99.7% Confidence
20	14	21
30	15	26
40	18	29

[a] Given for reference.

ICD FILE

REFERENCE 2

LOW-LEVEL RADIOACTIVE WASTE FROM RARE METALS PROCESSING FACILITIES

Jeanette Eng, New Jersey Department of Environmental Protection
Donald W. Hendricks, ORP-Las Vegas Facility, U.S. EPA
Joyce Feldman, Radiation Branch, U.S. EPA Region II
Paul A. Giardina, Radiation Branch, U.S. EPA Region II

Abstract

In the past year, problems of disposal of byproducts, tailings, and wastes from rare metals and thorium producing facilities have received the attention of radiological agencies. Many of the raw ores used by these processing facilities were rich in natural radioactivity and the residues of production were often not disposed of properly. Mill tailings from the uranium mining industry have only recently come under federal regulation. It can be expected that similar attention will be focused on the environmental impacts of the rare metals processing industry as illustrated by interest in the problems of Parkersburg, WV, and Albany, OR. One other site in Akron, NY, does not appear to be an immediate problem, but its situation is typical of the many yet unsurveyed inactive rare metal facilities in the country. The radiological problems presented by and decontamination activities which may be required of these rare metal facilities are examined.

Introduction

The federal government has recognized that companies which process thorium and uranium ores require regulatory controls in order to protect man and the environment from unnecessary radiation. The recent passage in November, 1978 of the Uranium Mill Tailings Bill (H.R. 13650) demonstrates the government's recognition that the front-end of the uranium fuel cycle, i.e., mining and milling of uranium, had been neglected. The bill defines procedures for a remedial action program at inactive mill sites and regulations for active mill sites.

Companies which provide titanium, phosphorus, rare earths, and rare metals for industrial and chemical use are not normally regarded as possessors of large quantities of radioactive materials. In fact there appears to be a historical laxity in documenting the processing and waste disposal activities of these industries. A recent EPA publication reviews the available literature on technologically enhanced natural radiation due to mineral extraction industries (Bl 78). It is only recently that phosphate industrial wastes have been listed as hazardous radioactive wastes in the U.S. Environmental Protection Agency's proposed Hazardous Waste Guidelines and Regulations (Co 78). This paper will review the situations at the existing Teledyne Wah Chang, Co., Inc. located at Albany, Oregon, and the former Carborundum Corp./Amax Specialty Metals, Inc., facilities located at Parkersburg, West Virginia, and Akron, New York, in order to show the extent of the radioactivity problem at rare metals processing facilities and the need to identify for radiological review other rare metal and rare earth processing sites.

As shown in Figure 1, the unusual grouping of rare earth and rare metal processing industries stems from their common ore origin. The ores used in rare earth and metals processing are byproducts of mining for titanium ores,

since the ores for the specific processing are seldom found in economically mineable rock. The principal domestic areas for raw materials are Florida and Georgia, although mining has occurred in western and other southeastern states. Outside of the U.S., major deposits are located in Australia, Canada, Brazil, South Africa, Sri Lanka, India, and Mexico. Often ores with higher specific mineral content were imported, such as Nigerian zircon sand for hafnium processing and Australian zircon sand for zirconium processing.

The beach and fluvatile sand deposits from these areas are rich in marketable ilmenite, rutile, monazite, and zircon. Monazite commonly incorporates thorium and uranium as well as rare earths due to similarity in geochemistry and electronic structure. Ilmenite and rutile are ore materials for titanium processing, monazite is the principal ore for rare earth processing, and zircon the principal ore for zirconium and hafnium processing. Generally, these beach or placer sands are treated to produce heavy mineral concentrations containing the zircon, rutile, ilmenite, monazite, and other marketable minerals. The concentrates may then be treated by various combinations of gravity, electrostatic or electromagnetic methods to separate the individual minerals. Monazite being slightly magnetic can be separated from zircon by electromagnets. The purity of the zircon product (or conversely the degree of monazite contamination of the product) is obviously a function of the degree of separation effort. Initial treatment usually is provided at or near the mine site. As a rule of thumb, the sand deposits are usually but not always processed primarily for the titanium content in the form of rutile and ilmenite. The zircon and monazite fractions are then byproducts which are treated separately to extract zirconium and rare earths, respectively. Thorium is then a further byproduct of the rare earth processing of the monazite portion. This has been the major source of thorium up to the present.

For zirconium metal production, zircon sand is usually processed to minimize the monazite content since the phosphate content of the monazite has a deleterious effect on the metallurgical process. This in turn should mean a lower thorium and uranium content in the metallic zirconium wastes than in foundry wastes where the monazite content of the zircon sands should be of less importance to the process. However, Wagstaff has reported levels of radium-226 from the uranium decay chain to be about 100 pCi/g in incoming zircon sands at both foundries and metallic zirconium production facilities (Wa 78). As Table 1 shows, the uranium and thorium content of monazite concentrates varies depending on where the ore is mined. The amount of monazite in the zircon sand also depends on how well the separation facility removed the monazite before shipping to the use point. At the use point (such as a zirconium metal manufacturing plant), the manufacturer may find it necessary to further separate monazite from the sand. Low-level radioactive wastes may be generated at each separation point. The natural concentration of uranium and thorium decay series products in the sands are low but the industrial processing to obtain the specific minerals concentrates radioactivity in the waste residues. The disposition of these waste residues is the subject of this paper.

Case Studies of Facilities

The zirconium hafnium processing method was developed by W. J. Kroll for the U.S. Bureau of Mines. The bureau established a pilot plant in 1947 at Albany, Oregon to extract zirconium and hafnium using the Kroll process and a purification plant in 1951 at Oak Ridge, Tennessee, to produce high puri-

ty, low hafnium, reactor grade zirconium. The zircon sand is mixed with graphite or coke and is fused in an electric furnace to produce a mixture of carbonitrides of zirconium and hafnium. The carbonitrides are chlorinated in a vertical shaft furnace and the gaseous chlorides of zirconium and hafnium are collected in a nickel condenser. The zirconium and hafnium chlorides are reduced in the Kroll process to the metals by reaction under an inert atmosphere with magnesium. The end product, commercial grade zirconium sponge, will contain about 2% hafnium suitable for non-nuclear use. Current industrial practice uses zirconium tetrachloride produced by chlorinating zircon directly instead of the carbonitride (MF 75). In order to produce reactor grade zirconium, i.e., that containing about 0.3% hafnium, the commercial grade zirconium sponge is dissolved and the hafnium is solvent extracted to hafnium thiocyanate using methyl isobutyl ketone. The hafnium is precipitated as an hydroxide, calcined to about 99% hafnium oxide. The resulting zirconium sponge is crushed, compacted into consumable electrodes, and vacuum melted in an inert atmosphere to ingot. Further product purity is achieved by applying the deBoer-vanArke refining process. A similar procedure is applied to the hafnium solvent extraction in order to obtain high purity hafnium metal. The residues generated by the extraction processes contain graphite, coke, unreacted silicates, and non-volatile silicates.

Wah Chang Corp. began operating the Bureau of Mines' Albany, Oregon, facility in 1955. Today it is one of the major producers of reactor grade zirconium and hafnium metals. Concern over the environmental and health safeguards at the facility grew when explosions were encountered during digging operations near the facility's industrial waste piles. Apparently the explosions were caused by rapid combustion of the zirconium in the waste piles. At the same time the Radiation Control Section of the Oregon Department of Environmental Quality (DEQ) became concerned that the large chlorinated residue piles may be a radiological problem. A gamma radiation survey showed maximum reading of 1200 uR/h. When the Oregon DEQ checked the radium concentration of the piles, it found that the Ra-226 ranged from the original zircon sand concentration of about 60 pCi/g to over 1300 pCi/g. One water sample taken within the residue pile showed Ra-226 concentration of 45,000 pCi/L, hence the concern of a potential ground water contamination. These radiological parameters for the rare metals chlorinated residues can be compared with those for uranium mill tailings.

Most uranium mills in the U.S. typically processed an average uranium ore grade of about 0.15-0.35% uranium which would give expected radium-226 concentrations in the mill tailings ranging from 420-980 pCi/g. Individual tailings samples at a given mill may have concentrations that are more or less than these values by as much as a factor of five or so.

Due to Oregon DEQ's work at the Wah Chang facility, Oregon limited the volume and radium content of chlorinated residue which the facility may accumulate onsite before disposal in an out-of-state facility is required and mandated all users of zircon sand to file an application for a radioactive materials license. The criteria for release to an unrestricted area are 57 uR/h, 30 pCi/L of Ra-226 in effluent, and 0.03 WL of radon* (Wa 78). Of the twenty-

* One Working Level (1 WL) is a unit describing any concentration of short-lived decay products of radon-222 in one liter of air which results in the release of 1.3×10^5 MeV of potential alpha energy.

six potential users of zircon sand, the state estimates only four will require specific licensing. Similarly, Utah has restricted onsite accumulations to no more than 100 tons of chlorinated residue and no more than 3 curies of Ra-226.

Efforts to determine the extent of possible radiological problems are more difficult for sites which have ceased rare metals processing activities for several years either due to changes in site ownership or unfavorable economic climate. Locating residue piles and sludge ponds, estimating amount and origin of ores processed, and determining processing and waste disposal activities must rely on historical records which are vague or nonexistent.

In the mid-1950's the responsibility for zirconium production was shifted to private enterprise when the civilian nuclear power program was established. In order to meet the increased demands for reactor grade zirconium, Carborundum Corp. which operated a facility in Akron, New York, expanded its production capacity by building a facility in Parkersburg, West Virginia. The plant's designed capacity was 600 tons annually; it began operations in 1957. In the mid-1960's, Amax Specialty Metals Co., Inc., became a partner and in 1967 obtained full ownership of the company. The Parkersburg site was sold in 1977 to L. B. Foster Company, a steel pipe fabrication plant. As a result of Foster's plan to expand its buildings, pyrophoric waste materials were encountered during backhoe operations. In investigating the causes of the explosion, it was discovered that zirconium and thorium may have been buried onsite, and that Amax Specialty Metals had not adequately terminated its license with the U.S. Nuclear Regulatory Commission (NRC) for possession of radioactive materials. The NRC estimates that two million pounds of zircon ore, mainly from Nigeria, were processed at the Parkersburg plant since 1957. A radiological survey of the site shows gamma radiation to range from a background level of 10 uR/h to 150 uR/h. Soil samples show concentrations of thorium-232 and its decay products to range from background level of 1 pCi/g to 10,000 pCi/g. The thorium contaminated area is limited to a few acres of the 100 acre site. The NRC's tentative clean-up goal of 5 pCi/g above background of thorium-232 with a three to four foot overburden and deed restrictions on excavation was developed based on an assessment of the long-term hazard due to thoron (radium-220). A radiological survey of Parkersburg by a contractor to Amax Specialty Metals estimates 50,000 cubic yards of soil may need to be removed. Some disposal alternatives being considered are burial at a disposal facility, burial onsite in a clay lined cavity with land use restrictions provided for the burial area, and ocean disposal. Whether there are other locations onsite where zirconium and/or thorium are buried may never be known since records on waste disposal and processing activities are incomplete.

The Akron, New York, zirconium and hafnium processing facility was the pilot plant for the Parkersburg, West Virginia, facility and presently is owned by Amax Specialty Metals Co., Inc. Processing activities by Carborundum Metals Co., Inc., began in 1953 at the Akron site to produce hafnium free zirconium under an Atomic Energy Commission (AEC) contract.

The plant's designed processing capacity was 162 tons of zirconium annually. Although the plant had a contract with the AEC to produce zirconium metal, there does not appear to be any AEC, NRC, or NYS (an agreement state) license for byproduct material other than for research and development purposes. An industrial license with the NYS Department of Labor (DOL) for x-ray

and gamma sources was in effect from 1960 through 1978.

During the summer of 1978, the EPA Region II radiation office queried the NYS DOL and Department of Environmental Conservation about the status of the Akron, New York, plant. The EPA was concerned that a situation similar to the Parkersburg, West Virginia, plant may exist at the New York plant due to their operating history. EPA was informed that Amax Specialty Metals Co., Inc., had contracted Atcor, Inc., to perform a radiological survey of the Akron site as the initial step in terminating its industrial license with the NYS DOL. The June, 1978, survey showed radiation levels ranging from a background level of 7 uR/h to 1500 uR/h outside, with some building measurements up to 40 uR/h (Le 78a). The extent of processing activities at the site is not well known due to incomplete records. There were areas where magnesium and zirconium residues were found but no pyrophoric incidents occurred. A single soil sample from an area with an external radiation reading of 1500 uR/h was analyzed and showed the soluble portion contained the radioactive material, but no further radiochemical analyses were performed. The elemental composition of the sample indicates it may be Nigerian ore, the principal ore processed at the Parkersburg plant. Surface soil samples were taken at locations with above background gamma radiation and were spectroscopically analyzed. The range of concentrations of Ra-226, Pb-214, Bi-214, Ac-212, Tl-208, and K-40 are shown in Table 2 (Le 78b). For these isotopes, the background concentrations are less than 1 pCi/g except for K-40 with concentration of 12 pCi/g. The limited results in Table 2 indicate levels of thorium and uranium chain nuclides elevated above expected background levels.

The monazite fraction of zircon ores typically runs about 3-10% thorium dioxide (ThO_2) content with a tri-uranium octoxide (U_3O_8) content up to 0.41%. Zircon sands of 96.7% pure zircon are currently imported and quoted on a minimum basis of 65% zirconium oxide (ZiO_2). Hence the maximum monazite content of incoming zircon sands should be less than 3.3%. Assuming a 10% ThO_2 content in the 3.3% monazite fraction of the zircon sand, the overall ThO_2 content of the zircon sand should be less than 0.33% or less than 300 pCi/g. Nigerian sands are reported to range from 0.4 to 7% ThO_2. Based on this and on the assumption that the monazite is some lesser fraction than 3.3% of the non-zircon portion of the sands, then the values of 120-150 pCi/g for the thorium chain nuclides do not seem unreasonable. Similarily, using a 0.41% U_3O_8 content in the monazite fraction and a maximum 3.3% monazite content, one would estimate a maximum uranium or radium-226 concentration, assuming equilibrium, of about 38 pCi/g, which seems to be in probably fortuitous agreement with the maximum measured values of 35 pCi/g for Ra-226. The higher K-40 values are certainly higher than the expected background values of about 12 pCi/g. However, one stage of the hafnium purifying process uses a potassium chloride molten mixture. If this plant used this process and if some of the molten mixture were spilled, it could account for the higher K-40 values since the potassium chloride probably contains about 400 pCi/g.

Between June and September, 1978, Amax Specialty Metals removed soil from areas with high gamma radiation levels. About 25 cubic yards of soil were shipped to the commercial low level burial site in Barnwell, South Carolina. Two of the three lagoons or infiltration ponds were excavated to a three feet depth and the material was disposed in a nearby hazardous chemical landfill. The radioactivity of the excavated material is not known since no analyses were performed prior to disposal.

In September, 1978, Atcor resurveyed the site after clean-up efforts and made recommendations for additional decontamination to reduce levels to "as low as reasonably achievable." However, it is not known to what extent these recommendations were pursued by the site owner. It is not known whether any attempts were made to identify the source of the slightly elevated levels of radioactivity in the buildings.

In December, 1978, the NRC performed a survey of the Akron site (St 78). The survey identified one area near a ridge with gamma radiation of twenty times background. Areas near the lagoons and the tube mill building had levels ranging from background to ten times. Analyses of the soil samples from these three locations indicate thorium concentrations in the range 6.0-19 pCi/g with background concentration of 1.2 pCi/g. The one air sample showed no Rn-220 daughters above background levels. Gamma radiation levels in the buildings were within twice background, indicating little contamination after removal of the gamma gauges.

The site could have been released for industrial use with little clean-up necessary in order to meet the NYS DOL Industrial Code Rule 38 that no gamma radiation levels exceed 250 uR/h at the surface and that source material in soil be less than 0.05% by weight, which is 5,000 pCi/g of Th-232. Due to experience at rare metal processing facilities in Albany, Oregon, and Parkersburg, West Virginia, Amax considered a more stringent clean-up program to meet the goal of "as low as reasonably achievable." In general, the clean-up program has been successful, although EPA Region II would have liked to have seen the levels reduced to twice background and to 5 pCi/g for Ra-226 and Th-232. A record of processing and disposal activities at the site would have greatly assisted in answering questions concerning the possibility of any buried radioactive materials.

Discussion

It appears from Figure 2 that the amount of zircon ore imported into the United States has been increasing steadily since 1930. The imports account for approximately 50% of the annual U.S. consumption of zircon concentrates; the remainder is attributed to domestic production and stock piles. Australia supplied about 60% of the imports before 1950, and over 95% after 1950. Brazil contributed about 20% during the period 1930 to 1950. In total, the U.S. consumed about 300,000 short tons of zircon before 1950 and 1.3 million short tons thereafter.

The potential radiological problem can be likewise divided into two periods. Prior to 1950, most of the Australian zircon was imported as a black sand mixture containing zircon (40-75%), ilmenite (14-43%), rutile (7-18%), and monazite (2-8%) ores (MY 36). No attempts were made to separate the ores until the sand mixture reached the processing facility. In 1948, the Commonwealth Government declared its intent to purchase and stockpile monazite ore. As a result, future shipments of sand had most of the monazite ore removed in Australia before export.

In order to provide a conservative estimate of the radiological content in the sands imported before 1950, the sand mixture is assumed to be composed of 8% monazite ore. Assuming the ThO_2 content in the monazite fraction to be as high as 10%, then the ThO_2 content in the beach sands could reach 0.8% or about 800 pCi/g. Similarily, assuming the U_3O_8 content in the monazite frac-

tion to be as high as 1%, then the U_3O_8 content in the beach sand could reach 0.08% or about 200 pCi/g. After 1950, the Australian ore had the monazite fraction separated to some extent, hence the sands contain a minimum of 96.7% zircon. Assuming the ThO_2 content in the monazite fraction remains 10%, then the ThO_2 content in the beneficiated sands could be as high as 0.33% or about 300 pCi/g, the U_3O_8 content could reach 0.03% or about 100 pCi/g. Subsequently, the rare metals processing facilities which operated prior to 1950 may have greater radiological problems with their chlorinated residues than those which use ore obtained after 1950.

We would expect that any user of zircon sands would receive some monazite in the zircon sands, since the separation of ilmenite, rutile, zircon, and monazite, as indicated in Figure 1, is often incomplete. Hence some small fraction of monazite, containing thorium and uranium will be present in any industry which extracts titanium, chromium, tantalum, etc., from beach sands. The monazite and hence the amount of thorium and uranium decay chain products will vary with the sand origin and the degree of ore beneficiation. In fact, facilities which need only the zircon, ilmenite, or rutile fraction of the beach sands and insist on high purity ores may not have as great a radiological problem as facilities which need only the monazite fraction or use sands with little ore separation.

Producers of reactor grade zirconium have rigid specifications for thorium and uranium content and generally require high purity zircon which implies low radioactivity content. To achieve this, the zircon is either purchased as high purity material or further processed at the rare metal producing plant to achieve purity. For metal production, then, the radioactivity remains in the wastes while very little goes with the metal product. On the other hand, the purity of zircon sands consumed at foundries is not critical, hence these sands may have the highest radioactivity content. Manufacturers of refractory materials, producers of milled or ground zircon, and ceramics manufacturers will most likely have some portion of the radioactive content incorporated into the products due to the manufacturing process.

In reviewing information from the annual Minerals Yearbook for 1929 through 1975, over twenty states were identified to have some facility which processed beach sands in zirconium, hafnium, and rare earths production or used beach sands in foundry processes. Table 3 provides a breakdown of the states according to the type of processing or use activity. Facilities presently operating in these areas of activity can be fairly easily identified and evaluated to determine where these facilities dispose their chlorinated wastes and whether the sands or concentrates used by the facilities have any appreciable monazite fraction. For facilities which have ceased operating or changed their ownership or their products, such an evaluation is more difficult.

Since only limited data and in some cases no data are available for radioactivity and exposure levels associated with industries such as discussed above, it seems apparent that considerable work needs to be done to assess the environmental and health impact of such industries.

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Bl78 Bliss, J. D., 1978, "Radioactivity in Selected Mineral Extraction Industries - A Literature Review," U.S. Environmental Protection Agency, Office of Radiation Programs - Las Vegas Facility, November 1978, Technical Note ORP/LVF-79-1.

Le78a Levesque, R. G., 1978, "Results of ATCOR's Gamma Scan Survey of June 9, 1978," letter to H. Kall (AMAX Specialty Metals Corporation), June 20, 1978.

Le78b Levesque, R. G., 1978, "Results of Soil Samp'es - Analysis by Teledyne Isotopes," letter to H. Kall (AMAX Specialty Metals Corporation), November 16, 1978.

MY Minerals Yearbook, Annual Publication 1929 through 1975, U.S. Department of Interior, U.S. Bureau of Mines.

St78 Stohr, J. P., 1978, "Results of NRC Radiation Survey at AMAX in Akron, New York," letter to F. Bradley (NYS Department of Labor), December 26, 1978.

Wa78 Wagstaff, D. G., 1978, "NORM - Problems in Oregon," paper presented at the Region X Radiation Control Meeting, September 26, 1978.

TABLE 1: Thorium And Uranium Composition In Monazite Concentrates (Weight Percent)

	ThO_2	U_3O_8
Australia	7-8	1
Brazil	6-7	0.2
India	9-10	0.3
Madagascar	9	0.4
South Africa	6	0.1
United States	4-5	0.4

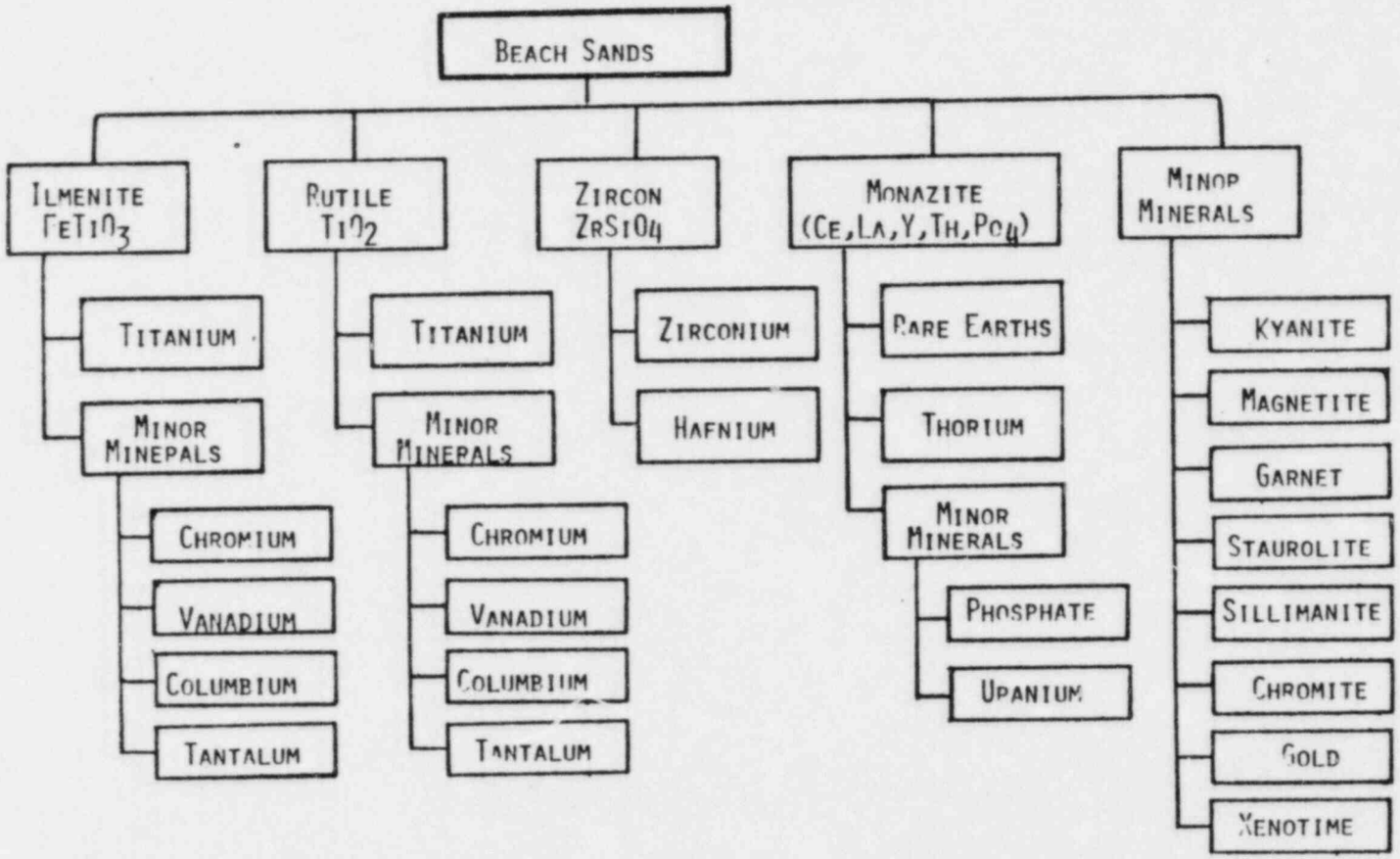
TABLE 2: Radioisotopic Concentrations In Soils From The Akron, New York Rare Metals Processing Facility (Le 78b)

Radioisotope	Range of Concentrations (pCi/g Dry)
Ra-226	2.1 - 35
Pb-214	0.66 - 7.0
Bi-214	0.47 - 2.7
Ac-228	1.3 - 140
Pb-212	1.1 - 150
Tl-208	1.1 - 120
K-40	8.8 - 120

TABLE 3: STATES WITH RARE METAL AND RARE EARTH PROCESSING ACTIVITIES

Producers of zirconium oxide, zirconium and hafnium sponge metal, ingot, and alloy	NJ, MA, AL, MI, OR, WV, NY, OH, PA CA, NH
Refractory firms using zircon in products	KY, NY, PA, MO, OH, WV, MI
Producers of zirconium compounds and chemicals	NJ, NY, MA
Producers of zirconium oxide for other than metal production	NY, AL, OH, SC, NJ, WV
Milled and sold ground zircon	NJ, NY, OH, SC, DE, CA, PA
Producers of rare earth compounds and chemicals	NY, PA, CA, CO
Producers of high purity rare earth metals	NJ, PA
Processed rare earth concentrates	IL, TN, NJ
Processed Canadian uranium mill solutions for rare earths	MI

FIGURE 1: POTENTIAL BEACH SAND COMPOSITION



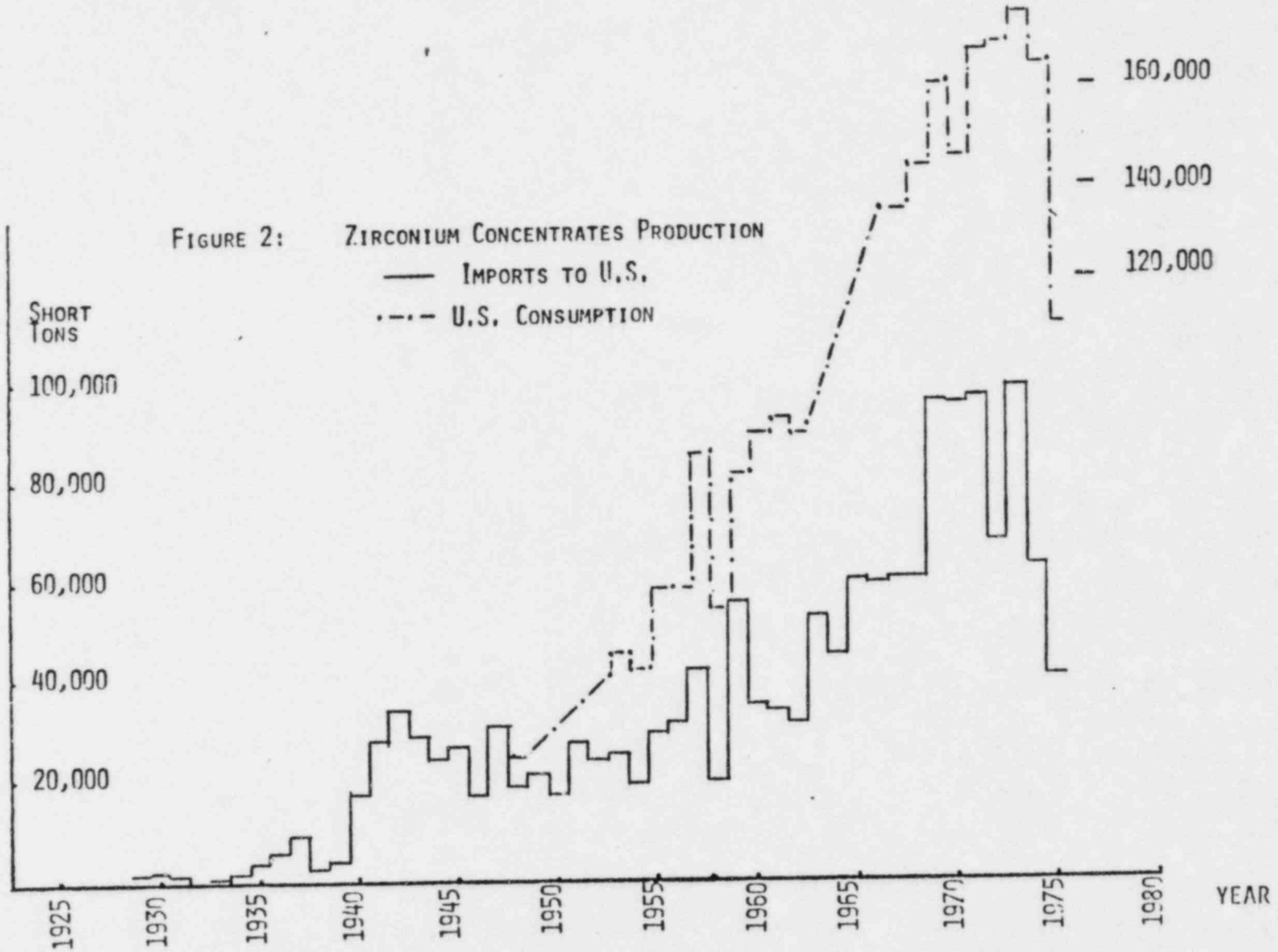


FIGURE 2: ZIRCONIUM CONCENTRATES PRODUCTION
IMPORTS TO U.S.
U.S. CONSUMPTION
SHORT TONS
100,000
80,000
60,000
40,000
20,000
160,000
140,000
120,000
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
YEAR

Reference 3

INDUSTRIAL
CODE RULE

38

IONIZING RADIATION PROTECTION

Part 38 of Title 12 of the Official Compilation
of Codes, Rules and Regulations
of the State of New York
(Cited as 12 NYCRR 38)

Effective July 10, 1978

State of New York
Department of Labor

STATE OF NEW YORK

HUGH L. CAREY
Governor

DEPARTMENT OF LABOR

PHILIP ROSS
Industrial Commissioner

DIVISION OF SAFETY AND HEALTH

CARL J. MATTEI
Director

Copies of this Rule may be obtained, free of charge, by individuals and groups when, in the judgment of the Commissioner, such distribution will further safety education and compliance with the Code Rules.

Requests for copies by mail should be directed to State of New York, Department of Labor, Office of Public Information, State Office Building Campus, Albany, N.Y. 12240. However, single copies may be obtained by applying in person at the Albany Office and in New York City at Department of Labor, Two World Trade Center, New York, N.Y. 10047.

STATE OF NEW YORK DEPARTMENT OF LABOR

CERTIFICATION

STATE OF NEW YORK :
DEPARTMENT OF LABOR : SS.:

I, PHILIP ROSS, Industrial Commissioner of the State of New York, do hereby certify that the attached copy of Industrial Code Rule 38 (Part 38 of 12 NYCRR) is a correct transcript of said Rule (Part) relating to Ionizing Radiation Protection duly adopted by the Industrial Commissioner on the 3rd day of July, 1978 and filed in the office of the Secretary of State of the State of New York on the 6th day of July, 1978, to take effect on the 10th day of July, 1978.

Given under my hand and the seal of the Department of Labor in the City of New York, on the 21st day of July, 1978.

PHILIP ROSS
Industrial Commissioner

HISTORICAL NOTES

1. Industrial Code Rule No. 38 relating to Radiation Protection was duly adopted by the Board of Standards and Appeals on October 10, 1955 and prescribed to take effect on December 15, 1955. Said Rule was duly filed in the office of the Secretary of State of the State of New York on November 15, 1955.

2. Industrial Code Rule No. 38 relating to Radiation Protection was duly amended by the Board of Standards and Appeals on October 3, 1962 and said amendment was prescribed to take effect on October 15, 1962. Said amendment was duly filed in the office of the Secretary of State of the State of New York on October 8, 1962.

3. Industrial Code Rule No. 38 relating to Radiation Protection was duly amended by the Board of Standards and Appeals on June 8, 1971 and said amendment was prescribed to take effect on September 1, 1971. Said amendment was duly filed in the office of the Secretary of State of the State of New York on June 10, 1971.

4. Industrial Code Rule No. 38 relating to Radiation Protection was duly repealed and Industrial Code Rule No. 38 relating to Ionizing Radiation Protection was duly adopted in its place and stead by the Industrial Commissioner of the State of New York on July 3, 1978, to take effect on July 10, 1978. Said repeal and promulgation was duly filed in the office of the Secretary of State of the State of New York on July 6, 1978.

EXTRACTS FROM THE LABOR LAW

Section 28. Safety and health standards. 1. Application. a. Notwithstanding any other provision in this article,' a safety or health standard promulgated under this article' shall apply only to places of employment or parts thereof not covered by a federal occupational health standard promulgated under section six of the United States Occupational Safety and Health act of 1970 (Public Law 91-596). . . .

2. Standards . . . .

e. Any provision of this chapter and any rule or regulation issued under the provisions of this chapter relating to the protection of the safety or health of employees to whom this section is applicable and of persons lawfully frequenting the place of employment of such persons which is in effect on the date that this act becomes effective shall be deemed to be a safety and health standard issued under this section,' with all provisions of this article' applicable, and shall continue in effect until superseded by a corresponding safety and health standard issued on or after the effective date of this act.

'So in original; should read "chapter."

EXTRACTS FROM ARTICLE 28-D OF THE GENERAL BUSINESS LAW

Section 480. Legislative findings. The legislature hereby finds that the use of... radioactive materials...involve such elements of potential danger to the lives, health and safety of the citizens of this state and to their property that special regulations are necessary to insure that only persons of proper ability and experience shall engage in such uses and operations.

* * * * *

Section 481. Definitions. As used in this article:...

2. "Radioactive material" means any material in any form that emits ionizing radiation spontaneously. "Radiation equipment" means any equipment or device which can emit ionizing or nonionizing radiation.

* * * * *

Section 482. Licensing and registration...

2. No person shall possess or use any radioactive material without a valid license issued by the commissioner. Every installation and mobile source consisting of radiation equipment shall be registered with the commissioner.

* * * * *

Section 483. Administration. 1. The commissioner is hereby authorized and directed to prescribe such rules and regulations as may be necessary and proper for the administration and enforcement of this article.

2. Such regulations may provide for examinations, categories of certificates, licenses, or registrations, age and experience requirements, payment of fees, and may also provide for such limitations and exemptions as the commissioner finds necessary and proper...in the case of users of radioactive material, such regulations may require the posting of a bond or other security.

* * * * *

Section 484. Enforcement. 1. For the purpose of administering and enforcing the provisions of this article the commissioner shall have and may use all of the powers conferred upon him by the labor law, in addition to the powers conferred herein.

2. A violation of any provision of this article or of any rule or regulation of the commissioner promulgated hereunder shall be a misdemeanor.

* * * * *

Section 485. Application. 1. This article shall not apply to the use or possession of...radioactive material or radiation equipment which are subject to the regulatory powers and jurisdiction of the state department of health or the health department of the city of New York.

NOTES

1. Other rules and regulations governing radiation are to be found in the New York State Sanitary Code, 10 NYCRR Part 16, "Ionizing Radiation," the New York State Department of Environmental Conservation Regulations, 6 NYCRR Part 380, "Prevention and Control of Environmental Pollution by Radioactive Materials," and the New York State Building Construction Code, 9 NYCRR 868. Also, requirements with respect to radiation are to be found in the codes of cities and other municipalities.

2. Provisions governing the discharge of wastes to the environment are to be found in the New York State Public Health Law, the New York State Environmental Conservational Law, the New York City Charter and Administrative Code, and the rules and regulations promulgated thereunder.

3. Regulations of the New York State and New York City Health Departments are generally applicable to any radiation source used for the intentional application of radiation to a human being and to any other radiation source at any of the following locations: hospital, medical, dental, veterinarian or podiatry institution, clinic or office; educational institution; commercial, private or research laboratory performing diagnostic procedures or handling equipment or material for medical use; shoe store; or trucking, storage, messenger or delivery service establishment. Radiation equipment used to apply radiation intentionally to a human being located in an installation under the jurisdiction of the New York State Department of Labor is subject to the applicable rules and regulations of the New York State Department of Health and the New York City Department of Health.

4. Forms for evaluating occupational external exposure (which may be obtained from the New York State Department of Labor upon request) set forth the basis for evaluating neutron dose; a table of Neutron Flux Dose Equivalents is included.

EXPLANATION OF THE NUMBERING SYSTEM

In accordance with the uniform numbering system established by the Secretary of State for the *Official Compilation of Codes, Rules and Regulations of the State of New York* the following arrangement has been used in the text of Industrial Code Rule No. 38 (12 NYCRR 38) contained herein:

Division of Numbering System	*How Numbered*	*Example*
Title	Arabic numeral	Title 12 (Department of Labor)
Chapter	Capital roman numeral	Chapter I (Board of Standards and Appeals)
Subchapter	Capital letter	Subchapter A (The Industrial Code)
Part	Arabic numeral	Part 38 (Industrial Code Rule No. 38)
Section	Arabic numeral separated from Part number by decimal	38.1, 38.2...
Subdivision	Small letter in parentheses	(a)...(z), (aa)...
Paragraph	Arabic numeral in parentheses	(1), (2)...
Subparagraph	Small roman numeral in parentheses	(i), (ii)...

References in or in connection with the following text to "Part", "section", subdivision", "paragraph" or "subparagraph" are to be understood in accordance with the system outlined above.

INDUSTRIAL CODE RULE NO. 38

CONTENTS

Industrial Code Rule No. 38

relating to

IONIZING RADIATION PROTECTION

Promulgated by the Industrial Commissioner

(Statutory Authority: Labor Law §28, and General Business Law §483)

Section 38.0 Finding of fact. The commissioner finds that every industry, trade, occupation and process involving the use or presence of radioactive material or radiation-producing equipment involves elements of danger to the lives, health and safety of persons employed or present therein. The commissioner further finds that special regulations are necessary for the protection of such persons, in that such material and equipment may emit invisible and imperceptible rays or particles having the property of producing deleterious or fatal effects, immediate or deferred, upon and within the human body.

38.1 Application. (a) Except as herein provided, this Part (rule) applies throughout the State to every person who, in any industry, trade, occupation or process in the State, transfers, receives, possesses or uses any radiation source while such source is free from and not subject to the regulatory powers and jurisdiction of the State Department of Health or the New York City Department of Health.

(b) This Part (rule) also applies to every person who, in any industry, trade, occupation or process, engages in the installation, testing or servicing of radiation equipment that may result in exposure to ionizing radiation.

(c) This Part (rule) does not apply to any carrier operating within the State to the extent that such a carrier is subject to regulation as provided for by law by the State Department of Transportation, the United States Interstate Commerce Commission, the United States Department of Transportation, the United States Coast Guard, the Federal Aviation Agency or the United States Postal Service.

(d) This Part (rule) does not apply to any person who, in any industry, trade, occupation or process in the State, transfers, receives, possesses or uses any radiation source resulting from light amplification by stimulated emission, commonly known as a laser, or microwave amplification by stimulated emission, commonly known as a maser, except to the extent that such sources are also sources of ionizing radiation.

(e) The Part (rule) does not apply to any person to the extent that such person transfers, receives, possesses, installs, operates or uses such items as are enumerated in Table I of this Part (rule).

38.2 Variations. The commissioner may grant variations from this Part (rule) pursuant to the provisions of Section 30 of the Labor Law and Section 483 of the General Business Law.

38.3 Definitions. As used herein or in connection with this Part (rule) the following terms mean:

(a) *Agreement materials.* Byproduct material, source material and special nuclear material in quantities not sufficient to form a critical mass.

(b) *Agreement State.* Any State which has entered into an effective agreement with the United States Nuclear Regulatory Commission pursuant to Section 274.b of the Atomic Energy Act of 1954, as amended.

(c) *Airborne radioactive material.* Radioactive material dispersed in the air in the form of dust, fume, mist, vapor or gas.

(d) *Airborne radioactivity area.* Any area in which exists any concentration of airborne radioactive material that exceeds either the limit thereof set forth in Table 6, Schedule I, Column 1, or, if averaged over the number of hours in any week during which individuals are in the area, 25 per cent of the limit thereof set forth in Table 6, Schedule I, Column 1.

(e) *Approved.* In respect to a device, material or kit approved means that such device, material or kit is in compliance with a resolution of approval adopted by the commissioner.

(f) *Byproduct material.* Radioactive material yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material, but the term shall not mean special nuclear material.

(g) *Commissioner.* The Industrial Commissioner of the State of New York.

(h) *Controlled area.* Any area the access to which is controlled for the purpose of protecting individuals from exposure to radiation and radioactive material, but the term shall not mean any area used as residental quarters.

(i) *Curie.* That quantity of radioactive material which disintegrates at the rate of 3.7×10^{10} atoms per second, and is the unit by which radioactivity is measured. One millicurie (mCi) equals 0.001 curie; one microcurie (μCi) equals 0.000001 curie.

(j) *Department.* The New York State Department of Labor.

(k) *Dose.* As used in this Part (rule) dose shall mean absorbed dose or dose equivalent as appropriate.

(1) *Absorbed dose.* That quantity of radiation expressed in units of energy absorbed, per unit of mass, by any body tissue. Reference to a dose during a specific period of time means the total quantity of radiation so absorbed during such period. The special unit of absorbed dose is the rad.

(2) *Dose equivalent.* That quantity of radiation which expresses on a common scale for all radiation a measure of the postulated effect on a given organ. It is defined as the absorbed dose in rads times various qualifying factors. The unit of dose equivalent is the rem.

(l) *Dose to the whole body.* A dose to any of the following: head and trunk; active blood-forming organs; gonads; lens of the eye.

(m) *Employee.* Any individual employed by, and who works for wages or salary in the service of, a person.

(n) *Exposure.* The presence of an individual in a field of radiation.

(o) *General license.* A license as specified in Table 3. Subject to the terms and conditions specified in Table 3, such license is effective without the filing of an application for a specific license and without the issuance of a specific licensing document by the commissioner.

(p) *High radiation area.* Any area, accessible to individuals, in which there exists radiation at such levels that a major portion of the body could receive in any one hour a dose from external exposure that exceeds 100 millirems.

(q) *Human use.* The intentional internal or external administration of radiation or radioactive materials to any individual.

(r) *Individual.* Any human being.

(s) *Installation.* Any location where, for a period of more than 30 days, one or more radiation sources are used, operated or stored. The confines of an installation shall be designated by the owner of such installation. A part of a building or other structure, an entire building or other structure, or a plant may be designated as an installation.

(t) *License.* A license issued in connection with radioactive materials. Such license is one of two types: general or specific. Unless otherwise indicated, the type of license referred to in this Part (rule) shall be a specific license.

(u) *Mobile source.* A radiation source used or operated outside an installation.

(v) *Occupational dose.* Any dose received by any individual in any controlled area or in the course of such individual's employment in which such individual's duties involve the exposure to radiation, but shall not include any dose received by any individual in the course of exposure to radiation for the purpose of medical diagnosis or therapy of such individual.

(w) *Owner.* Any person conducting the business or activities carried on within the radiation installation having by law the administrative control of a radiation source whether as owner, lessee, contractor or otherwise.

(x) *Person.* Any of the following coming within the application of this Part (rule): an individual; an employee; a corporation; a partnership; a firm; an association; a trust; a public or private institution; a group; an agency; a public authority or a political subdivision of this State; any other State of the United States or political subdivision thereof and any legal successor, representative, agent or agency of such State or subdivision. The term does not mean or include the United States Nuclear Regulatory Commission or any successor thereto, or any federal government agency licensed by the United States Nuclear Regulatory Commission or any successor thereto.

(y) *Personnel monitoring equipment.* A device, such as a film badge, pocket chamber, pocket dosimeter, a film ring, thermoluminescent dosimeter or similar device, designed to be carried or worn by an individual for the purpose of measuring the dose such individual receives.

(z) *Rad.* A measure of the absorbed dose in terms of the energy absorbed, per unit mass, by any body tissue. One rad is the dose corresponding to such absorption of 100 ergs per gram of such tissue. One millirad (mrad) equals 0.001 rad. In the MKS unit system (SI units) 1 rad equals 0.01 joules per kilogram.

(aa) *Radiation.* Any alpha particle, beta particle, gamma ray, X-ray, neutron, high-speed electron, high-speed proton, and any other atomic particle producing ionization, but the term shall not mean any sound or radio wave, or visible, infrared or ultraviolet light.

(bb) *Radiation area.* Any area, accessible to individuals, in which there exists radiation at such levels that a major portion of the body could receive in any hour a dose from external exposure that exceeds five millirems, or in any five consecutive days a dose from external exposure that exceeds 100 millirems.

(cc) *Radiation equipment.* Any equipment or device which can emit radiation by virtue of the application thereto of high voltage.

(dd) *Radiation safety officer.* An individual, designated at a particular installation or for a particular mobile source, who is qualified by training and experience in radiological health to evaluate the radiation hazards of such installation or mobile source and to establish and administer a radiation protection program for such installation or mobile source.

(ee) *Radiation source.* Any radioactive material or any radiation equipment.

(ff) *Radioactive material.* Any material, including agreement material, in any form that emits radiation spontaneously.

(gg) *Radionuclide.* A radioactive species, such as Cobalt 60 or Uranium 238.

(hh) *Rem.* A measure of the dose equivalent in terms of its estimated biological effect relative to a dose of one Roentgen (R) or rad of X-rays. One millirem (mrem) equals 0.001 rem. The relation of the rem to other dose units depends upon the biological effect under consideration and the conditions of irradiation. Any of the following terms shall be considered to be equivalent to a dose of one rem:

(1) 1 R due to X- or gamma radiation;

(2) 1 rad due to X-, gamma or beta radiation;

(3) 0.1 rad due to neutrons or high energy protons;

(4) 0.05 rad due to particles heavier than protons and sufficient energy to reach the lens of the eye.

(ii) *Required.* Required by or pursuant to this Part (rule).

(jj) *Roentgen (R).* That quantity of X- or gamma radiation such that the associated corpuscular emission per 0.001293 gram of air produces, in air, ions carrying one electrostatic unit of quantity of electricity of either sign. One milliRoentgen (mR) equals 0.001 Roentgen. In the MKS unit system (SI units) 1 Roentgen equals 2.578×10^{-4} coulomb per kilogram.

(kk) *Sealed source.* Any radioactive material that is permanently bonded or fixed in a capsule or matrix designed to prevent the release or dispersal of such radioactive material under the most severe conditions which may be encountered in normal use and handling.

(ll) *Source material.* Uranium or Thorium, or any ore containing Uranium or Thorium, but the term shall not mean special nuclear material.

(mm) *Special nuclear material.* Plutonium, Uranium 233, Uranium enriched in the isotope 233 or in the isotope 235 or any material artificially enriched by any of the foregoing, but the term shall not mean source material.

(nn) *Special nuclear material in quantities not sufficient to form a critical mass.* Uranium enriched in the isotope U 235 in quantities not exceeding 350 grams of contained U 235; Uranium 233 in quantities not exceeding 200 grams; Plutonium in quantities not exceeding 200 grams; or any combination of such materials in accordance with the following formula: for each kind of special nuclear material, determine the ratio between the quantity of that special nuclear material and the quantity specified above for that same kind of special nuclear material. The sum of such ratios for all of the kinds of special nuclear material in combination shall not exceed "1" (i.e. unity). For example, the combination of 175 grams of U 235, 50 grams of U 233 and 50 grams of Pu would not exceed the limitation. This may be determined as follows:

$$\frac{175 \text{ grams of U 235}}{350} + \frac{50 \text{ grams of U 233}}{200} + \frac{50 \text{ grams of Pu}}{200} = 1$$

(oo) *Specific licenses.* A specific license is issued to a named person upon application filed with the commissioner pursuant to this Part (rule).

(pp) *State.* The State of New York, unless the context of this Part (rule) clearly indicates that a different State is intended.

(qq) *Survey.* An evaluation of the radiation hazards incident to the production, use, release, disposal or presence of any radiation source including, if appropriate, a physical evaluation of the installation or mobile source and measurement of any level of radiation or concentration of any radioactive material.

(rr) *Uncontrolled area.* Any area the access to which is not controlled for the purpose of protecting individuals from exposure to any radiation source, and any area used as residental quarters.

38.4 Registration and Approvals. (a) Every installation and mobile source consisting of radiation equipment or generally licensed devices as required by terms and conditions in Table 3 of this Part (rule) shall be registered with the commissioner on a form prescribed by him, setting forth the location and character of the radiation source or sources and such other or further information as he may require for the due enforcement of this Part (rule). Registration shall be made prior to receipt of the radiation equipment or upon receipt of the generally licensed device. Registration is not complete until it is verified and accepted by the commissioner. If a registered installation or mobile source is so changed as to render its registration inaccurate, notice thereof shall be given to the commissioner within 48 hours of such change.

(b) Every distributor or retailer of radiation equipment, or agent thereof, or radiation consultant, who installs, tests or otherwise services radiation equipment shall be registered with the commissioner on a form prescribed by him. Registration shall be made prior to undertaking such installation, testing or servicing. Such distributors, retailers, agents or consultants shall while engaged in installation, testing or other servicing of radiation equipment comply with the requirements of this Part (rule).

(c) Approval of devices, materials or kits. All devices, materials or kits specified in Table 8 shall be approved. Such devices, materials or kits at the time of their distribution will not contain radioactive material but they will be used later in conjunction with radioactive material.

38.5 Licensing — general requirement. Except as otherwise provided in this Part (rule), no person shall transfer, receive, possess or use any radioactive material unless such person is duly licensed to do so pursuant to this Part (rule). Any person who has properly registered an installation or mobile source which includes radioactive materials other than agreement materials, shall be deemed to hold a valid radioactive materials license for such materials. Such license shall expire 90 days after the receipt from the commissioner of a notice of expiration. Any such person who files an application for a specific license before such 90-day period ends shall be deemed to continue to have a valid license until the commissioner has finally taken action on such application.

38.6 Applications for license. An application for a license shall be made to the commissioner on a form prescribed by him. Such application shall set forth such pertinent information as the commissioner may require. Supplementary statements shall be filed upon the commissioner's request.

38.7 Security. (a) Before a license or an amendment to a license is issued or renewed, the applicant shall file with the commissioner a security, except for the bonding exemptions listed in subdivision (d) of this section. Such security shall provide for the reimbursement to the commissioner for any expense incurred in the event that the commissioner removes radioactive material or decontaminates the premises of the licensee as provided by section 38.16 of this Part (rule). Such security shall be either:

(1) A bond in the amount of $10,000 issued by a fidelity or surety company authorized to do business in this State; or

(2) A personal bond in the amount of $10,000 supported by such collateral as the commissioner deems satisfactory.

(b) On or before December 1, 1971, every person holding a valid license in excess of the limits enumerated in subdivision (d) of this section on September 1, 1971 shall file the security required by this Part (rule) with the commissioner.

(c) Notwithstanding any provision of this Part (rule), the commissioner may, at his discretion, by order, waive the requirements of security of an applicant for a license who the commissioner finds is of such financial responsibility as to assure reimbursement to the commissioner for any expense incurred in the event that the commissioner removes radioactive material or decontaminates the premises of such licensee as provided by section 38.16 of this Part (rule).

(d) Licensees are exempted from the bonding requirements where:

(1) The total radioactive material possession limit does not exceed 100 times the value listed in Table 4 of this Part (rule) or any combination of radioactive materials as given in Note 1, Table 4 of this Part (rule);

(2) radioactive noble gases contained as gases in sealed sources with no radioactive daughter product with half-life greater than 30 days;

(3) hydrogen 3 contained as hydrogen gas in a sealed source;

(4) radioactive materials contained in sealed sources and devices which are licensed for distribution by United States Nuclear Regulatory Commission, an agreement state or a non-agreement state acting in cooperation with Bureau of Radiological Health of United States Food and Drug Administration.

38.8 Issuing licenses. (a) Upon due application therefor a license shall be issued by the commissioner if:

(1) the applicant's proposed use, equipment, facilities and procedures are sufficient to provide reasonable and adequate protection to life, health and safety;

(2) the applicant or the applicant's personnel is qualified by training and experience to use such radioactive material for each purpose covered by the application so as to minimize danger therefrom to life, health and safety.

(b) The license shall be in such form and contain such provisions as may be appropriate or necessary to effectuate the purposes of this Part (rule).

38.9 Special requirements for licenses. (a) Compliance with license. No licensee shall transfer, receive, possess or use any licensed radioactive material otherwise than in accordance with the terms of his license.

(b) Possession and use of licensed material. A licensee shall confine his possession and use of licensed radioactive material to the locations and purposes specified in the license, except that he may transfer such material to any person authorized to receive it pursuant to this Part (rule) or by a license or permit issued by the State Department of Health, the New York City Department of Health, the United States Nuclear Regulatory Commission, an agreement state or, where required, a non-agreement State.

38.10 License for use of special nuclear material. A license covering the use of special nuclear material in the course of which use additional special nuclear material is produced shall be valid as to the material so produced unless the total quantity of special nuclear material possessed by the licensee is sufficient to form a critical mass.

38.11 Duration of licenses. Except as below provided, a license shall expire at the end of the expiration date therein stated. The filing of an application by the licensee more than 30 days prior to the expiration date for a renewal or a new and superseding license shall extend the license until the commissioner has finally acted on the application. A licensee may terminate his license by surrendering it to the commissioner.

38.12 Renewal of licenses. An application for a renewal of a license shall be made on a form prescribed by the commissioner. Renewal of a license may be denied on any of the grounds specified in this Part (rule) for the issuance of licenses or for the suspension or revocation of licenses. Notwithstanding the renewal of a license, the commissioner may suspend or revoke a license for cause or violations occurring during the license period immediately preceeding the issuance of the renewal.

38.13 Amendment of licenses. A corrective amendment of a license may be made by the commissioner at any time upon his initiative or at the request of the licensee. Upon the licensee's written request the commissioner may amend a license in any respect consistent with this Part (rule). Every license may be amended by the commissioner upon any ground for which he might deny, suspend or revoke such license.

39.14 Suspension or revocation. The Commissioner may revoke or suspend any license, or approval, in whole or in part, for:

(a) Any material misstatement in the application therefor or in any supplementary statement thereto;

(b) Any condition revealed by such application, supplementary statement, report, record, inspection or other means, which would warrant the commissioner to refuse to grant a license or approval on an original application; or

(c) Any violation or failure to observe any of the applicable terms or provisions of a license, an approval, the Labor Law, this Part (rule) or any other applicable law, rule, regulation, code or order.

38.15 Additional requirements. Nothwithstanding any exemption set forth in this Part (rule), the commissioner may by order, as part of a license or otherwise, make such specific requirements, in addition to those set forth in this Part (rule), as may be reasonably appropriate and necessary to enforce the provisions of this Part (rule) relating to the general duty to protect health and safety.

38.16 Removal of radioactive material.

(a) Notwithstanding any exemptions contained in this Part (rule), any person who uses, possesses or stores radioactive materials in violation of any provision of law or of this Part (rule), or of his own license, or of any order of the commissioner, shall, upon order of the commissioner, remove or provide for the removal of such materials at his own expense through the use of an authorized transferee and shall decontaminate the installation to the limits specified in Table 5 of this Part (rule).

(b) In the event that a person fails to comply with the provisions of subdivision (a) of this section, the commissioner may seize and remove the radioactive material and, if necessary, decontaminate the installation to the limits specified in Table 5 of this Part (rule), and shall be reimbursed for the expense thereof by the person failing to comply with the provisions of subdivision (a) of this section. If such person is a corporation, the officers and agents who knowingly permit the corporation to violate the provisions of subdivision (a) of this section shall be personally responsible for such expense.

38.17 Procedural provisions. (a) *Review of actions on applications, licenses, security and approvals.* Any order issued by the commissioner under this Part (rule) shall constitute an order for the enforcement of this Part (rule) under section 21 of the Labor Law and accordingly an order made under the provisions of the Labor Law within the meaning of section 101 thereof.

(b) *Hearings.* Except when immediate action is required to secure safety, a license shall not be revoked, suspended or restrictively amended by the

commissioner without the consent of the licensee unless the licensee has been given reasonable notice and an opportunity to be heard.

38.18 Holders of licenses or permits. (a) The holder of a license or permit issued by the State Department of Health, the New York City Department of Health, the United States Nuclear Regulatory Commission, any agreement State, or any licensing non-agreement State, may bring, possess or use radioactive material covered by such license or permit within the commissioner's jurisdiction for a period not in excess of 180 days in any calendar year without obtaining a license from the commissioner, provided that:

(1) Such license or permit does not limit the holder's possession or use of such material to a specific installation or installations.

(2) Such holder, at least seven days prior to engaging in such activities within the commissioner's jurisdiction, files with the commissioner a notice indicating the period, type and location of proposed possession and use within the commissioner's jurisdiction and a copy of the license or permit. At the discretion of the commissioner, oral notification of the commissioner or notification of the commissioner less than seven days prior to engaging in such activities may be accepted in lieu of the filing requirement under this paragraph.

(3) Such holder supplies such additional information as the commissioner may reasonably request.

(4) Such holder, during the period of his possession and use of such material within the commissioner's jurisdiction, complies with all relevant provisions of this Part (rule).

(5) Such holder, during such period, complies with all terms and conditions of his license or permit, except such terms or conditions as may be inconsistent with this Part (rule).

(b) Any holder of a license or permit issued by the State Department of Health, the New York City Department of Health, the United States Nuclear Regulatory Commission, any agreement State, or any licensing non-agreement State which authorizes the holder to manufacture, install or service a device of the type which is generally licensed and specified in Table 3, (b) of this Part (rule) may install or service such device without obtaining a license from the commissioner provided that:

(1) Such person shall file a report with the commissioner within 30 days after the end of each calendar quarter in which any device is transferred to or installed within the commissioner's jurisdiction. Such report shall contain the name and address of each person receiving such a device, shall identify the type of device or devices so transferred, and shall state the quantity and type of radioactive material contained in such device or devices.

(2) Any such device is installed and serviced in accordance with the terms of the license or permit issued to such person.

(3) Such person shall assure that any labels required to be affixed to any such device shall bear a statement that reads "Removal of this label is prohibited".

(4) The person to whom such holder transfers any such device or on whose premises such holder installs or services any such device has a copy of the general license requirements or equivalent requirements outlined in Table 3, (b) of this Part (rule).

38.19 Licensees and contractors of the United States Nuclear Regulatory Commission (NRC) and United States NRC designated contractors doing work for other United States Government Agencies.

(a) *Activities licensed by the United States Nuclear Regulatory Commission within the State.* Each person who holds a license from the United States Nuclear Regulatory Commission authorizing activities within the State shall be exempt from the requirements of this Part (rule) with respect to such activities during the period that such license is valid, provided, however, that such person:

(1) Shall afford the commissioner access to all records which such person is required to maintain pursuant to the United States Nuclear Regulatory Commission's rules and regulations or pursuant to the provisions of the United States Nuclear Regulatory Commission licenses;

(2) Shall afford the commissioner opportunity to sample effluents, and to conduct such measurement or survey of levels of radiation and radioactive contamination as will not substantially interfere with or interrupt any activities licensed by the United States Nuclear Regulatory Commission; and

(3) Shall afford the commissioner access to the facilities of such person in order to accomplish the foregoing review of records, sampling of effluents and conduct of measurements or surveys.

(b) *Contractors of the United States Nuclear Regulatory Commission and United States NRC designated contractors doing work for other United States Government Agencies.* Any United States Nuclear Regulatory Commission contractor or subcontractor and any United States NRC designated contractor or subcontractor of the following categories operating within this State is exempt from the requirements of this Part (rule) to the extent that such contractor or subcontractor under his contract receives, possesses, uses, transfers, owns or acquires sources of radiation:

(1) United States Nuclear Regulatory Commission designated prime contractors performing work for other United States Government Agencies at United States government-owned or controlled sites;

(2) United States Nuclear Regulatory Commission designated prime contractors of other United States Government Agencies and performing research in, or development, manufacture, storage, testing or transportation of atomic weapons or components thereof;

(3) United States Nuclear Regulatory Commission designated prime contractors of other United States Government Agencies using or operating nuclear reactors or other nuclear devices in a United States Government-owned vehicle or vessel; and

(4) Any other prime contractor or subcontractor of the United States Nuclear Regulatory Commission or United States Nuclear Regulatory Commission designated prime contractor or subcontractor doing work for other United States Government Agencies when the State and the United States Nuclear Regulatory Commission jointly determine that under the terms of the contract or subcontract, there is adequate assurance that the work thereunder can be accomplished without undue risk to the public health and safety and that the exemption of such contractor or subcontractor is otherwise appropriate.

38.20 General duty to protect health and safety. Every person to whom this Part (rule) applies shall so guard, shield, protect, manage and control every radiation source transferred, received, possessed or used by him as to provide reasonable and adequate protection to the lives, health and safety of all individuals subject to exposure to the radiation from such source.

38.21 Permissible occupational dose. (a) *From external exposure.* Except as provided below, no person shall transfer, receive, possess or use any radiation source so as to cause any individual in any controlled area to receive an occupational dose from external exposure that exceeds the following limits:

(1) If the individual is 18 years of age or over:

(i) A dose to the whole body of three rems in any 13 consecutive weeks or five rems in any 52 consecutive weeks, except in the case of a pregnant woman no person shall knowingly permit a dose to the fetus of more than 0.5 rem during the approximate 39 consecutive week gestation period;

NOTE: A female employee shall immediately notify her employer when she knows of her pregnancy.

(ii) Or a dose to the hands and forearms, or feet and ankles, of 25 rems in any 13 consecutive weeks or 75 rems in any 52 consecutive weeks; or

(iii) A dose to the skin of the whole body of 10 rems in any 13 consecutive weeks or 30 rems in any 52 consecutive weeks.

(2) If the individual is under 18 years of age, a dose to any part of the body that exceeds 10 percent of the applicable limits specified in paragraph (1), subdivision (a), section 38.21 of this Part (rule).

Exception: *(Not applicable to a pregnant woman)*
Any person may permit an individual 18 years of age or over to receive an occupational dose to the whole body of 12 rems in any 52 consecutive weeks if such occupational dose will not exceed three rems during any 13 consecutive weeks and will not, when added to the accumulated occupational dose to such individual's whole body, exceed 5 (N-18) rems where "N" equals the individual's age in years at his last birthday; and if such person has complied with all the requirements in a form prescribed by the commissioner relating to the calculation of such individual's previously accumulated dose and the excess dose permitted under this subdivision, including the requirements that necessary certifications and reports of past exposure be obtained.

(b) *From concentration of airborne radioactive material.* No person shall suffer or permit any individual in a controlled area to be exposed to any airborne radioactive material possessed by such person in any open

concentration which would exceed the following limits if averaged over 40 hours in any week, regardless of particle size or the use of protective clothing or equipment.

(1) The limit set forth in Table 6, Schedule I of this Part (rule), if such individual is 18 years of age or over; except that any such limit may be proportionately increased in any week in which the number of hours of exposure is less than 40 and except that any such limit shall be proportionately decreased in any week in which the number of hours of exposure is greater than 40 and except that any such limit in the case of a pregnant woman shall be proportionately decreased in order that no person shall knowingly deliver a dose to the fetus of more than 0.5 rem during the approximate 39 consecutive week gestation period.

(2) The limit set forth in Table 6, Schedule II of this Part (rule), if such individual is under 18 years of age.

38.22 Permissible dose in uncontrolled areas. (a) *From external exposure.* No person shall create in any uncontrolled area any radiation level which:

(1) cause any individual in the area to receive a dose to the whole body from external exposure in excess of 0.5 rem in any 52 consecutive weeks; or

(2) if an individual were continuously present in the area, would result in his receiving a dose in excess of either two millirems in any hour or 100 millirems in any seven consecutive days.

(b) *From concentration of radioactive material.*

(1) Air, water and soil contamination.

No person shall release into the air or water in any uncontrolled area any concentration of any radioactive material which, if averaged over any year, would exceed the limit thereof set forth in Table 6, Schedule II of this Part (rule) or cause soil contamination that exceed the limits for such contamination in Table 5 (c). Any such concentration shall be determined at the point at which it leaves the controlled area, any such concentration released through a stack, tube, pipe or similar conduit may be deemed to leave the controlled area at the point of such release. This subdivision shall not preclude disposal of radioactive materials into sanitary sewer systems pursuant to this Part (rule). The commissioner by order, as part of a license or otherwise, may require that effluents containing concentrations of radioactive materials be monitored constantly or from time to time to determine that the limits as set forth in Table 6, Schedule II of this Part (rule) are not being exceeded.

(2) Surface contamination.

No person shall release into uncontrolled areas radioactive materials such that the surface contamination limits listed in Table 5 of this Part (rule) are exceeded.

38.23 Disposal of radioactive material. No person shall dispose of any radioactive material except by transfer to an authorized recipient or as otherwise provided in this Part (rule). Disposal by burial in soil or release into a sanitary sewer system is not prohibited by this Part (rule) if done in accordance with the New York City Health Code in the City of New York or in accordance with the State Sanitary Code (10 NYCRR Chapter 1) elsewhere in the State or in accordance with the requirements of the State Environmental

Conservation Law. No provision in this Part (rule) shall be construed to authorize treatment or disposal of radioactive material by incineration.

38.24 Limitations on human use. No person shall use any radiation source for human use, except when such use and person are licensed or authorized by the State Department of Health or the New York City Department of Health.

38.25 Radiation safety officer. The owner of any installation or mobile source shall designate a radiation safety officer who shall be acceptable to the commissioner. Such radiation safety officer shall establish and administer a radiation protection program which complies with this Part (rule). If the radiation safety officer does not personally supervise the operation of the installation or mobile source, such operation shall be personally supervised by an individual who has been sufficiently instructed and trained to manage the application of all protective techniques applicable to such installation or mobile source to the satisfaction of the radiation safety officer.

38.26 Surveys, checks and tests. (a) *Surveys—general.* Each person who possesses any radiation source shall make, or cause to be made, the applicable surveys required under this section and such additional surveys as may be necessary for such person to comply with other provisions of this Part (rule).

(b) *Instrumentation.* Each person required to perform a survey by this Part (rule) shall be provided with or have available appropriate calibrated and operable instruments capable of detecting and measuring radiation.

(c) *Radiation equipment—surveys.* Every installation and mobile source wherein radiation equipment is to be used shall be surveyed during the initial operation of such equipment and whenever any change is made in such installation or mobile source or in its use that might increase the radiation level to which an individual could be exposed. When vibrations or other physical conditions exist in such installations or mobile sources which may cause changes in the protective features, surveys shall be made at least every six months.

(d) *Radioactive materials—surveys.* Any installation wherein radioactive materials are handled or installed which has any readily accessible area in which there is reasonable expectation that a radiation level will exist in excess of 10 millirems per hour, or any mobile source which could create such a radiation level, shall be surveyed during the initial operation and whenever any change is made in such installation or mobile source or in its use that might increase the radiation level to which an individual could be exposed.

(e) *Unsealed sources—surveys.* Any installation wherein licensed radioactive material not contained in a sealed source is handled or installed or any mobile source containing such radioactive material shall be surveyed at least once a month, or at such other times and intervals as may be required by the commissioner, to assure that radiation intensities remain below those permitted by this Part (rule). Regularly scheduled radiation monitoring of the air in and around an airborne radioactivity area shall be required and when there is any reasonable possibility that concentrations of radioactivity will be such as to require the establishment of such an area.

(f) *Sealed sources—leak test.* Each licensed sealed source other than Krypton 85 or Hydrogen 3 shall be leak tested within the six months

immediately prior to initial use and at least every six months thereafter, or at such other times and intervals as may be required by the commissioner. If there is reason to suspect that a source might be damaged, such source shall be tested before further use. Upon detection of leakage greater than 0.005 microcurie or as otherwise specified by the commissioner in any sealed source, the use of such source shall be at once terminated and suspended until such source is repaired or until the commissioner authorizes the resumption of such source use. A leak test shall consist of the taking and analysis of a sample by person(s) authorized by license to perform such services.

(g) *Protective devices.* All protective devices such as interlocks and timers shall be maintained in good repair and proper operating condition and shall be checked at least every six months or at such intervals as may be required by the commissioner.

38.27 Enclosed controlled areas. Any enclosed controlled area with any access opening large enough for the passage of any person shall have such opening provided with an exit door which can be opened manually from the inside or by such other means approved by the commissioner.

38.28 Eating, drinking or smoking. No person shall permit eating, drinking or smoking in any airborne radioactivity area or in any controlled area with surface contamination above the limits specified in Table 5 of this Part (rule).

38.29 Vacating installations and property. (a) *Installations.* Each licensee before vacating any installation, or transferring the premises containing such installation, shall permanently decontaminate such installation and premises below or equal to the limits specified in Table 5 of this Part (rule). A survey shall be made after such decontamination and the commissioner and landlord or subsequent tenant or transferee shall be provided with a copy of such survey. No such installation or premises shall be vacated, sold or transferred until the decontamination survey has been verified and accepted by the commissioner.

(b) *Property.* No machinery, instruments, laboratory equipment or any other property used in contact with or in close proximity to radioactive material in a licensed installation shall be assigned, sold, leased or transferred to an unlicensed person unless such property has been permanently decontiminated below or equal to the limits specified in Table 5 of this Part (rule). A survey shall be made after such decontamination and the commissioner and subsequent transferee or owner shall be provided with a copy of such survey. No such property shall be assigned, sold, leased or transferred until such decontamination survey has been verified and accepted by the commissioner.

38.30 Personnel monitoring equipment. Every person who possesses a radiation source shall supply appropriate calibrated and operable personnel monitoring equipment to, and shall require the use of such equipment by, each individual whom such person suffers or permits to enter:

(a) Any controlled area under circumstances such that an individual may receive a dose from external exposure in any 13 consecutive weeks exceeding:

(1) if the individual is 18 years of age or over, 300 millirems to the whole

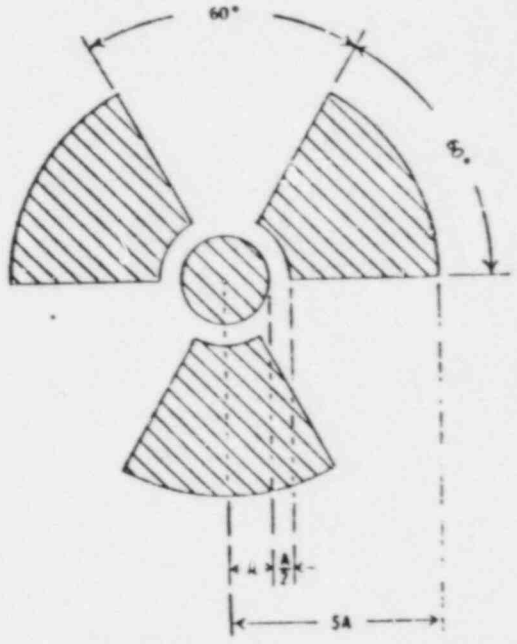
body; or five rems to the hands and forearms, or feet and ankles; or two rems to the skin of the whole body.

(2) if the individual is under 18 years of age, 60 millirems to the whole body; or 900 millirems to the hands and forearms, or feet and ankles; or 400 millirems to the skin of the whole body.

(b) Any area in which radiation exists at such a level that a major portion of the individual's body could receive from external exposure a dose exceeding 100 millirems in any hour.

38.31 Radiation symbol, signs, labels and control devices.

(a) *Radiation symbol.* In the following radiation symbol, referred to hereinafter in this Part (rule) as the "radiation symbol", the crosshatched area shall be magenta or purple, and the background area shall be yellow:



(b) *Signs required.* Each person who possesses any radiation source shall conspicuously post in each area (including any room or enclosure) accessible to an individual a sign or signs bearing the radiation symbol and words in accordance with the following paragraphs:

(1) *Radiation area.* "CAUTION" or "DANGER" and "RADIATION AREA"

(2) *High radiation area.* "CAUTION" or "DANGER" and "HIGH RADIATION AREA"

(3) *Airborne radioactivity area.* "CAUTION" or "DANGER" and "AIRBORNE RADIOACTIVITY AREA"

(4) *Radioactive materials.* "CAUTION" or "DANGER" and "RADIOACTIVE MATERIAL(S)" if any radiation source is used or stored in such area and such source consists of:

(i) Any radioactive material, other than natural Uranium or Thorium, in a quantity that exceeds 10 times the quantity of such element or material set forth in Table 7 of this Part (rule); or

(ii) Natural Uranium or Thorium in a quantity that exceeds 100 times that quantity thereof set forth in Table 7 of this Part (rule).

(c) *Control devices.* Every area which is accessible to any individual and in which there exists levels of radiation that could result in a whole body dose from external exposure that exceeds 100 millirems in any one hour shall be equipped with a control device which shall, at the time any individual enters such area, either cause the level of radiation in such area to be reduced below that at which such individual might receive a dose of 100 millirems in any one hour, or energize a conspicuous visible or audible alarm signal which will alert such indivudual. Any such area established for a period of 30 days or less need not be so equipped.

Exceptions: Such areas need not be posted with such signs or equipped with any control device referred to solely because of the presence therein of any of the following:

1. Any sealed source emitting radiation at a level which, when measured 12 inches from the surface of the container or housing of such sealed source, would not exceed five millirems in any hour.
2. Radiation sources for any period of not more than eight hours, provided, however, that during such presence an individual is constantly in attendance who shall take all precautions necessary to prevent any individual from receiving any dose that exceeds the applicable limit permitted by this Part (rule) and that such area is subject to the control of the person who possesses such radiation source.
3. X-ray producing equipment used exclusively for medical or dental purposes.
4. Radioactive materials, packaged and labeled in accordance with the regulations of the United States Department of Transportation, the Interstate Commerce Commission, the Federal Aviation Agency or the United States Coast Guard; provided that, if the radiation level at the surface of such package exceeds 200 millirems per hour, the room or area shall be:
   (i) Posted as provided in section 38.31, subdivision (b) of this Part (rule) and the room or area shall be locked; or
   (ii) attended by an individual who takes the precautions necessary to prevent the exposure of any individual to radiation or radioactive material in excess of the limits established by this Part (rule).

38.32 Labeling containers. (a) Except as specified herein, each container of radioactive material shall bear a durable and clearly visible label which shall identify the radioactive contents. Such label shall bear the radiation symbol and the words "CAUTION" or "DANGER" and "RADIOACTIVE MATERIAL". Such label shall also provide sufficient information to permit the individuals handling or using any such container or working in the vicinity thereof to take precautions to minimize exposure to any radiation.

(b) Labeling of containers is not required for the following:

(1) For containers that do not contain radioactive materials in quantities greater than the applicable quantities listed in Table 7 of this Part (rule).

(2) For containers containing only natural Uranium or Thorium in quantities no greater than 10 times the applicable quantities listed in Table 7 of this Part (rule).

(3) For containers that do not contain radioactive materials in concentrations greater than the applicable concentrations listed in Table 2 of this Part (rule).

(4) For containers when attended by an individual who takes the precautions necessary to prevent the exposure of any individual to radiation or radioactive materials in excess of the limits established by this Part (rule).

(5) For containers when such containers are in transport and packaged and labeled in accordance with regulations of the United States Department of Transportation, the Interstate Commerce Commission, the Federal Aviation Agency or the United States Coast Guard.

38.33 Labeling of radiation equipment. Any radiation equipment other than X-ray producing equipment used exclusively for medical or dental purposes shall be labeled with a durable, clearly visible label bearing the radiation symbol and the appropriate cautionary wording.

38.34 Instructing personnel—Posting notices. (a) *Instruction.* Each person who possesses a radiation source shall instruct and advise every individual working in or frequenting a controlled area in regard to the following:

(1) The presence or occurrence of any radiation or radioactive material in such area and their responsibility to report promptly any condition which may lead to unnecessary exposures to radiation.

(2) The safety problem associated with the exposure to such radiation or radioactive material and the precautions and procedures to be taken to minimize such exposure.

(3) The applicable provisions of this Part (rule) and the provisions in any registration or license for the protection of such individual from such exposure.

(4) Personnel monitoring reports of radiation doses and exposure to concentrations of radioactive materials, copies of which such individual may request in accordance with the provisions of this Part (rule).

(b) *Copies.* Each person who possesses a radiation source shall keep available for inspection by any employee current copies of this Part (rule), any

license or registration covering such radiation source and operating procedures for licensed or registered activities.

(c) *Posting.* Each person who possesses a radiation source shall post in conspicuous locations so as to be clearly visible to any individual working in or frequenting any portion of such installation or mobile source while such individual is entering or leaving the controlled area the following:

(1) Current copies of either the notice to employees as provided by the commissioner or copies of a notice containing the same information in the installation or adjoining the mobile source.

(2) The licensee or registrant shall post a notice of inspection findings specifying non-compliance items issued by the commissioner involving radiation working conditions; any order issued by the commissioner to rectify non-compliance items and any response made by the licensee or registrant to such notice or order. Such notice of items of non-compliance shall be posted within two working days after receipt of notice or order. The licensee or registrant's response shall be posted within two days after dispatch to the commissioner. Such documents shall remain posted for a minimum of 5 working days or until non-compliance items have been removed, whichever is later.

(d) *Special information.* Each person who possesses a radiation source shall, when so ordered by the commissioner upon his finding such services to be necessary or desirable for determining the extent of an individual's occupational exposure to a radiation source, make available to the individual bio-assay services or other appropriate medical evaluations and shall furnish to the commissioner copies of the reports of such services.

38.35 Storing and securing radiation sources. (a) *General requirements.* All radiation sources shall be secured against unauthorized removal from their places of storage or use. Radioactive material shall not be stored in the same facilities with materials which might substantially increase the fire or explosion hazard of the storage space and its radioactive contents.

(b) *Fire protection.* Radioactive material in storage shall be provided with reasonable protection against loss, leakage or dispersion by fire effects or by water, hose streams or other means used to fight fire.

38.36 Records. (a) *General requirements.* Each person who possesses any radiation source shall maintain accurate and complete written records in the same units used in this Part (rule). Such records shall show the following:

(1) The results of each required survey, check and test.

(2) Each transfer, receipt and disposal of radioactive materials.

(3) Each dose received by any individual to whom personnel monitoring equipment is supplied pursuant to this Part (rule).

(4) The results of each bio-assay or other medical evaluation service made pursuant to this Part (rule).

(5) Each dose to any individual required to be reported by this Part (rule).

(b) *Form and preservation.* (1) Each required record of any dose received by any individual and each required record of any bio-assay or other medical evaluation service:

(i) Shall be on, and shall contain all information called for by, a form prescribed by the commissioner, or any other clear and legible record form containing all such information; and

(ii) Shall be preserved until disposition is authorized by the commissioner. Such records may be maintained in the form of microfilms together with adequate viewing apparatus or as otherwise acceptable to the commissioner. The discontinuance of or curtailment of activities does not relieve the licensee or registrant of responsibility for retaining all records required by this section. A licensee or registrant in such case may request the commissioner to accept such records.

(2) Each other record required by this Part (rule) shall be preserved for a period of three years commencing on the date of the occurrence that is the subject of such record.

38.37 Reports. (a) *Reports to the commissioner.* (1) Each person who possesses any radiation source shall report immediately by telephone to the commissioner any of the following:

(i) Any theft or loss of such radiation source.

(ii) Any incident involving such radiation source which may have caused or may threaten to cause any individual to receive a dose that exceeds the limit permitted by this Part (rule) or any applicable license.

(iii) Any level of radiation from, or release of a concentration of, radioactive material in any uncontrolled area that exceeds ten times the limit permitted by this Part (rule) or any applicable license.

(2) Such reporting shall not relieve such person of the responsibility for instituting and performing such corrective and preventive measures as are necessary to reduce the hazards. Upon request of the commissioner, a written report shall be filed containing such information as may be requested.

(b) *Reports to individuals.* (1) Each person who possesses any radiation source shall furnish any individual formerly employed by such person and requesting same, a written report of such individual's dose and exposure to concentrations of radioactive material as shown on such person's records as required by this Part (rule). Such reports shall be furnished within 30 days subsequent to the receipt by such person of such request, providing the request includes appropriate and sufficient identifying data, such as social security number, and dates and locations of employment. Such report shall cover each 13 week period of such individual's employment with such person involving any dose and shall contain the results of any calculations and analyses of radioactive material deposited in such individual's body, including any bio-assay services or other medical evaluations of which records are required by this Part (rule).

(2) In any case in which any person is required by this Part (rule) to report to the commissioner any dose received by any such individual, such person shall also report in writing to such individual the nature and extent of such dose.

(3) Each person who possesses any radiation source shall furnish annually to any such individual employed by such person and requesting

same, a written report of such individual's dose as shown in the records required by this Part (rule).

(4) Each report furnished pursuant to this Part (rule) shall contain the following statement: "This report is furnished to you under Industrial Code Rule No. 38 (12 NYCRR 38) and should be preserved for future reference."

38.38 Inspections—tests. Each person who possesses any radiation source shall comply with the following:

(a) Such person shall afford the commissioner an opportunity to inspect at any reasonable time:

(1) The radiation source and the installation, institution, establishment, premises or facilities at which such source is located, possessed, stored or used.

(2) Each record required to be maintained by this Part (rule).

(b) Such person shall conduct, or permit the commissioner to conduct, such tests as he may require, including but not limited to, test of:

(1) Any radiation source and the installation, institution, establishment, premises or facilities at which such radiation source is located, possessed, stored or used.

(2) Personnel monitoring equipment and any other equipment, instrument or device used in connection with the location, possession, storage or use of such radiation source.

(c) During the physical inspection of any installation or mobile source pursuant to this Part (rule) the commissioner or his representative shall permit a representative of the owner and a representative authorized by his employees to accompany him during such inspection for the purpose of aiding such inspection. Where there is no authorized employee representative, the commissioner or his representative may consult with a reasonable number of employees concerning health and safety matters pertinent to this Part (rule) in the installation or at the mobile source.

(d) Any employee or representative of employee who believes that a violation of this Part (rule) exists that threatens physical harm or radiation exposures in excess of the limits specified in this Part (rule), or that an imminent danger exists, may request an inspection by giving notice to the commissioner or his representative of such violation or danger. Any such notice may be reduced to writing, will set forth with reasonable particularity the grounds for the notice, and will be signed by the employee or representative of employees; and a copy will be provided the owner or his agent upon receipt or no later than at the time of inspection, except that, upon the request of the employee giving such notice, his name and names of individual employees referred to therein shall not appear in such copy or any record published, released, or made available by the commissioner or his representative. If upon receipt of such notification the commissioner or his representative determines there are reasonable grounds to believe that such violation or danger exists, he shall make a special inspection in accordance with the provisions of this Part (rule) as soon as practicable, to determine if such violation or danger exists.

(e) Prior to or during any inspection of an installation or mobile source subject to the requirements of this Part (rule), any employee or representative of employees employed in such installation or at the mobile source may notify the commissioner or his representative responsible for conducting the inspection, either orally or in writing, of any violation of this Part (rule) which he has reason to believe exists in such installation or at the mobile source. The commissioner or his representative shall review any action taken with respect to any such alleged violation and shall furnish the employee or representative of employees requesting such review a written statement of the reasons for the final disposition of the case.

(f) No person shall discharge or in any manner discriminate against any employee because such employee has filed any complaint or instituted or caused to be instituted any inspection or proceeding under this Part (rule) or has testified or is about to testify in any such proceeding or because of the exercise by such employee on behalf of himself or others of any option afforded by this Part (rule).

38.39 Transportation.

(a) The transportation of radioactive materials is subject to other State and Federal requirements, particularly the following:

(1) *New York State requirements.* Department of Transportation, Department of Motor Vehicles, certain public authorities and commissions as provided in the Vehicle and Traffic Law and the requirements of cities having populations in excess of one million.

(2) *Federal requirements.* United States Department of Transporation, the Interstate Commerce Commission, the Federal Aviation Agency, the United States Coast Guard and where the mails are used the United States Postal Service.

(b) When the regulations of the New York State Department of Transportation, the United States Department of Transportation or the Interstate Commerce Commission are not applicable to the shipment by land of radioactive materials by persons subject to the provisions of this Part (rule), such transportation shall, nevertheless, be in accordance with the requirements relating to the transportation of radioactive materials set forth in the regulations of the United States Department of Transportation, the Interstate Commerce Commission and the New York State Department of Transportation. Any requests for modifications or exceptions to such requirements, any requests for special approvals referred to in such regulations, and any notifications referred to in such requirements shall be filed with, or made to, the commissioner.

(c) No person shall deliver radioactive material to a carrier or accept radioactive material from a carrier for transport unless:

(1) The person has established procedures, prior to delivery of radioactive material to a carrier for transport, to ensure that the radioactive material is packaged and the package monitored in accordance with applicable NYS and US Departments of Transportation regulations and has included on the package for the consignee, instructions to safely open the package when such instructions are appropriate.

(2) The person has established procedures, prior to receipt of radio-

active material, to ensure that the receipt and opening of the packages is done in a safe manner.

(3) The person has established procedures to ensure loading and unloading and monitoring of radioactive materials on a carrier's vehicle is done in compliance with applicable NYS and US Departments of Transportation regulations.

(d) The transportation of radioactive materials by persons subject to the provisions of this Part (rule) shall also be subject to such additional requirements as the commissioner may order as reasonably appropriate and necessary to enforce the provisions of this Part (rule) relating to the general duty to protect health and safety.

38.40 Severability. If any provision of this Part (rule) or the application thereof to any person or circumstance is held invalid, such invalidity shall not affect other provisions of applications of this Part (rule) which can be given effect without the invalid provision or application and to this end the provisions of the Part (rule) are declared to be severable.

38.41 Tables and appendix. The tables hereto annexed and designated "Table 1 — Exemptions", "Table 2 — Exempt Concentrations", "Table 3 — General Licenses: Items, Terms and Conditions", "Table 4 — Exempt Quantities", "Table 5 — Limits for Uncontrolled Areas", "Table 6 — Concentrations in Air and Water Above Natural Background", "Table 7 — Quantities Applicable to Posting and Disposal Requirements", "Table 8 — Approvals" and "Appendix A — Specific Requirements for Industrial Radiography" are hereby made provisions of this Part (rule).

TABLE 1 — EXEMPTIONS

Exemption 1. Less than 2000 timepieces, and/or the equivalent number of hands and/or dials for such number of timepieces, containing radioactive material as a luminous element. This Exemption does not apply to: (1) the manufacture or refinishing of said items; or (2) any radioactive material other than Radium, Hydrogen 3 or Promethium 147 contained on any timepiece, hand or dial. This Exemption applies only to those timepieces manufactured or imported under a specific license issued by the United States Nuclear Regulatory Commission or an agreement State which authorizes the transfer of timepieces to the general public as exempt items.

Exemption 2. Radioactive material contained in any item in a concentration not exceeding that set forth in Table 2. No person may introduce radioactive material into a product or material when such person knows or has reason to believe that such product or material will be transferred to persons who are exempt under this Exemption or equivalent regulations of the United States Nuclear Regulatory Commission or any agreement State unless such introduction or transfer is accomplished in accordance with a specific license or permit issued pursuant to this Part (rule) or by the State Department of Health, the New York City Department of Health, the United States Nuclear Regulatory Commission or any agreement State, and such specific license or permit expressly authorizes such introduction. For the purposes of this Exemption, the processing of materials or items which results in an increase in the concentration of radioactive material therein shall be deemed to be the same as introduction by the addition of radioactive material.

Exemption 3. Source material contained in, but less than 0.05 per cent by weight of, any chemical mixture, compound, solution or alloy.

Exemption 4. Source material contained in unrefined and unprocessed ore. This Exemption does not apply to any refinement or processing of ore containing 0.05 per cent or more by weight of source material.

Exemption 5. Source material contained in any of the following products: Glazed ceramic tableware, the glaze of which contains not more than 20 per cent by weight of source material; glassware, glass enamel and glass enamel frit containing not more than 10 per cent by weight of source material, except glass brick, pane glass, ceramic tile and other glass, glass enamel or ceramic products used in building construction; piezoelectric ceramic containing not more than 2 per cent by weight of source material. This exemption does not apply to the manufacture or importation of such products or their components.

Exemption 6. Thorium contained in incandescent gas mantles, vacuum tubes, welding rods, electric lamps for illuminating purposes provided that each lamp does not contain more than 50 milligrams of Thorium, or germicidal lamps and sunlamps and lamps for outdoor or industrial lighting provided that each lamp does not contain more than 2 grams of Thorium. This Exemption does not apply to the manufacture or importation of such products or their components.

Exemption 7. Uranium contained in counterweights installed in aircraft, rockets, projectiles or missiles or stored or handled in connection with the installation or removal of such counterweights if such counterweights are

manufactured or imported in accordance with a specific license issued by the commissioner, the State Department of Health, the New York City Department of Health, the United States Nuclear Regulatory Commission or any agreement State, and such license provides that such counterweights may be distributed to persons who have not been issued a licensing document therefor, and if each such counterweight has been impressed with a statement, clearly legible after plating, which states "Depleted Uranium" (Counterweights which were manufactured prior to December 1, 1969 are impressed with the statement "Caution — Radioactive Material — Uranium") and is durable and legibly labeled or marked with the identification of the manufacturer, and the statement "Unauthorized Alterations Prohibited". The Exemption contained herein shall not be deemed to authorize the chemical, physical or metallurgical treatment or processing of any such counterweights other than repair or restoration of any plating or other covering and there is no removal or penetration of the plating on such counterweights.

Exemption 8. Source material contained in photographic films, negatives or prints. This Exemption does not apply to the manufacture or importation of such products or their components.

Exemption 9. Tungsten-Thorium alloy or Magnesium-Thorium alloy containing not more than four per cent by weight of Thorium when fabricated into any finished product or part thereof. This Exemption does not apply to the manufacture or importation of the product or to any treatment or processing thereof.

Exemption 10. Radioactive material, other than agreement material; containing a specific radioactivity that does not exceed that of Potassium occurring in its natural state (0.001 microcurie/gram).

Exemption 11. Radiation equipment which by reason of its design cannot emit radiation at a level which, when measured five centimeters from the surface of such radiation equipment with all external shielding removed, exceeds a rate of 0.5 millirem in any hour. This Exemption does not apply to the testing or servicing of such equipment during the production thereof.

Exemption 12. Television receivers providing the dose rate averaged over 10 square centimeters at five centimeters from any other surface is less than 0.5 mrem per hour. This Exemption does not apply to the testing or servicing of such receivers during the production thereof.

Exemption 13. Radiation equipment during its storage, shipment, retail sale or other similar use in the course of which the equipment does not emit radiation. This Exemption does not apply to the labeling requirements of this Part (rule).

Exemption 14. Lock illuminators each containing not more than 15 millicurie of Hydrogen 3 or two millicurie of Promethium 147 installed in automobile locks, provided also that the radiation level from lock illuminators containing Promethium 147 does not exceed one millirad per hour at one centimeter from any surface when measured through 50 milligrams per square centimeter of absorber. This Exemption does not apply

to the manufacture or importation of such illuminators or to their installation into automobile locks.

Exemption 15. Rare earth metals and compounds, mixtures and products containing not more than 0.25 per cent by weight Thorium, Uranium or any combination of these. This Exemption does not apply to the manufacture or importation of any of these products.

Exemption 16. Uranium used as shielding constituting part of any shipping container which is conspicuously and legibly impressed with the legend "CAUTION — RADIOACTIVE SHIELDING — URANIUM" and which meets the specifications for containers for radioactive materials prescribed by section 178.250, specification 55, Part 178 of the regulations of the United States Department of Transportation (49 CFR 178.250). This Exemption does not authorize the manufacture or importation of any such shielding or container.

Exemption 17. Thorium contained in any finished optical lens which contains not more than 30 per cent by weight Thorium. This Exemption does not apply to the importation or the shaping, grinding or polishing of such lens, to manufacturing processes other than the assembly of such lens into optical systems and devices without any alteration of the lens, or to the receipt, possession, use or transfer of Thorium contained in contact lenses, or in spectacles, or in eyepieces in binoculars or other optical instruments.

Exemption 18. Uranium contained in any detector head for use in fire detecting units. Each detector head shall contain not more than 0.01 microcurie of Uranium. This Exemption does not apply to the manufacture or importation of any detector head containing Uranium.

Exemption 19. Balances of precision, or balance parts, containing Tritium. Each such balance part shall contain not more than 0.5 millicurie of Tritium. This Exemption does not authorize the importation or the application of Tritium to or incorporation of Tritium in any such balances or balance parts.

Exemption 20. Marine compasses and other marine navigational instruments containing Tritium gas. Each such marine compass shall contain not more than 750 millicuries of Tritium gas. Other marine navigational instruments shall contain not more than 250 millicuries of Tritium gas. This Exemption does not authorize the importation, the application of Tritium to or the incorporation of Tritium in any such marine compasses or other marine navigational instruments.

Exemption 21. Thermostat dials and pointers containing not more than 25 millicuries of Tritium per thermostat. This Exemption does not authorize the importation, the application of Tritium to or the incorporation of Tritium in thermostat dials or pointers.

Exemption 22. Electron tubes containing specified amounts of radioactive material. Each tube contains no more than one of the following quantities of radioactive materials:

(i) 10 millicuries of Tritium, except for 150 millicuries of Tritium in microwave receiver protector tubes;

(ii) 1 microcurie of Cobalt 60;
(iii) 5 microcuries of Nickel 63;
(iv) 30 microcuries of Krypton 85;
(v) 5 microcuries of Cesium 137;
(vi) 30 microcuries of Promethium 147

The radiation level due to the radioactive material contained in each electron tube shall not exceed one millirad per hour at one centimeter from any surface when measured through seven milligrams per square centimeter of absorber. This Exemption does not authorize the importation, application of radioactive material to, or incorporation of radioactive material into, any electron tube.

Exemption 23. Synthetic plastic resins containing Scandium 46 for sand consolidation in oil wells which have been manufactured in accordance with a specific license issued by the commissioner, the United States Nuclear Regulatory Commission or any agreement State, which authorizes distribution of such resins to persons exempt pursuant to this Part (rule) or equivalent regulations of the United States Nuclear Regulatory Commission or any agreement State or which have been imported pursuant to a specific license issued by the United States Nuclear Regulatory Commission authorizing distribution to persons exempt pursuant to this Part (rule) or equivalent regulations of the United States Nuclear Regulatory Commission or any agreement State. This Exemption does not authorize the manufacture or importation of any such resins.

Exemption 24. Automobile shift quadrants containing not more than 25 millicuries of Tritium. This Exemption does not authorize importation, the application of Tritium to, or the incorporation of Tritium in, any such automobile shift quadrant.

Exemption 25. Thorium contained in any finished aircraft engine part containing Nickel-Thoria alloy provided that: The Thorium is dispersed in the Nickel-Thoria alloy in the form of finely divided Thoria (Thorium oxide); and the Thorium content of the Nickel-Thoria alloy does not exceed four per cent by weight. This Exemption does not authorize the importation or manufacture of such finished aircraft engine parts containing Thorium.

Exemption 26. Radioactive material contained in instruments or devices other than timepieces covered by Exemption 1 to provide self-illumination. Any such instrument or device shall be produced, manufactured, processed, imported or transferred in accordance with a specific license issued by the United States Nuclear Regulatory Commission or an agreement State. Such a license shall authorize the transfer to persons exempt from the requirements of this Part (rule) or equivalent regulations of the United States Nuclear Regulatory Commission or an agreement State. This Exemption does not apply to products used for frivolous purposes or in toys or adornments.

Exemption 27. Radioactive material contained in smoke, gas or aerosol detectors designed to protect life or property from fires or airborne hazards. Such detectors shall be produced, manufactured, processed, imported or transferred in accordance with specific licenses issued by an agreement State or by the United States Nuclear Regulatory Commission. Such licenses shall

authorize the transfer of such detectors to persons exempt from the requirements of this Part (rule) or equivalent regulations of the United States Nuclear Regulatory Commission or an agreement State.

Exemption 28. Radioactive material contained in individual, packaged quantities each of which does not exceed the value listed in Table 4 of this Part (rule). For purposes of this Exemption an individual, packaged quantity may be composed of fractional parts of one or more of the exempt quantities, provided that the sum of fractions, as given in Note 2, Table 4 of this Part (rule), shall not exceed unity. There shall be no commercial distribution or human use of radioactive material possessed under this Exemption. Radioactive material exempted under this Part (rule) effective October 15, 1962 and are larger in quantity than listed in Table 4 and obtained before September 1, 1971 shall continue to be exempt.

Exemption 29. Radioactive material contained in or on ionizing radiation measuring instruments for purposes of internal calibration or standardization not exceeding the exempt quantity set forth in Table 4 of this Part (rule). Such sources shall be produced, manufactured, processed, imported or transferred in accordance with a specific license issued by the United States Nuclear Regulatory Commission or an agreement State. Such license shall authorize the transfer of such calibration sources to persons exempt from the requirements of this Part (rule) or equivalent regulations of the United States Nuclear Regulatory Commission or an agreement State.

TABLE 2
EXEMPT CONCENTRATIONS

Element (atomic number)	*Isotope*	*Column 1 Gas concentration μCi/ml**	*Column 2 Liquid and solid concentration μCi/ml***
Antimony (51)	Sb 122	.....	3×10^{-4}
	Sb 124	.....	2×10^{-4}
	Sb 125	.....	1×10^{-3}
Argon (18)	A 37	1×10^{-3}	.....
	A 41	4×10^{-7}	.....
Arsenic (33)	As 73	.....	5×10^{-3}
	As 74	.....	5×10^{-4}
	As 76	.....	2×10^{-4}
	As 77	.....	8×10^{-4}
Barium (56)	Ba 131	.....	2×10^{-3}
	Ba 140	.....	3×10^{-4}
Beryllium (4)	Be 7	.....	2×10^{-2}
Bismuth (83)	Bi 206	.....	4×10^{-4}
Bromine (35)	Br 82	4×10^{-7}	3×10^{-3}
Cadmium (48)	Cd 109	.....	2×10^{-3}
	Cd 115m	.....	3×10^{-4}
	Cd 115	.....	3×10^{-4}
Calcium (20)	Ca 45	.....	9×10^{-5}
	Ca 47	.....	5×10^{-4}
Carbon (6)	C 14	1×10^{-6}	8×10^{-3}
Cerium (58)	Ce 141	.....	9×10^{-4}
	Ce 143	.....	4×10^{-4}
	Ce 144	.....	1×10^{-4}
Cesium (55)	Cs 131	.....	2×10^{-2}
	Cs 134m	.....	6×10^{-2}
	Cs 134	.....	9×10^{-5}
	Cs 137	.....	2×10^{-4}
Chlorine (17)	Cl 38	9×10^{-7}	4×10^{-3}
Chromium (24)	Cr 51	.....	2×10^{-2}
Cobalt (27)	Co 57	.....	5×10^{-3}
	Co 58	.....	1×10^{-3}
	Co 60	.....	5×10^{-4}
Copper (29)	Cu 64	.....	3×10^{-3}
Dysprosium (66)	Dy 165	.....	4×10^{-3}
	Dy 166	.....	4×10^{-4}
Erbium (68)	Er 169	.....	9×10^{-4}
	Er 171	.....	1×10^{-3}
Europium (63)	Eu 152 ($T_{1/2}$ = 9.2 Hrs.)	.....	6×10^{-4}
	Eu 155	.....	2×10^{-3}
Fluorine (9)	F 18	2×10^{-6}	8×10^{-3}
Gadolinium (64)	Gd 153	.....	2×10^{-3}
	Gd 159	.....	8×10^{-4}
Gallium (31)	Ga 72	.....	4×10^{-4}
Germanium (32)	Ge 71	.....	2×10^{-2}

See notes at end of table

TABLE 2 — (Continued)
(EXEMPT CONCENTRATIONS)

Element (atomic number)	*Isotope*	*Column 1 Gas concentration μCi/ml**	*Column 2 Liquid and solid concentration μCi/ml***
Gold (79)	Au 196	.....	2×10^{-3}
	Au 198	.....	5×10^{-4}
	Au 199	.....	2×10^{-3}
Hafnium (72)	Hf 181	.....	7×10^{-4}
Hydrogen (1)	H 3	5×10^{-6}	3×10^{-2}
Indium (49)	In 113m	.....	1×10^{-2}
	In 114m	.....	2×10^{-4}
Iodine (53)	I 126	3×10^{-9}	2×10^{-5}
	I 131	3×10^{-9}	2×10^{-5}
	I 132	8×10^{-8}	6×10^{-4}
	I 133	1×10^{-8}	7×10^{-5}
	I 134	2×10^{-7}	1×10^{-3}
Iridium (77)	Ir 190	.....	2×10^{-3}
	Ir 192	.....	4×10^{-4}
	Ir 194	.....	3×10^{-4}
Iron (26)	Fe 55	.....	8×10^{-3}
	Fe 59	.....	6×10^{-4}
Krypton (36)	Kr 85m	1×10^{-6}	.....
	Kr 85	3×10^{-6}	.....
Lanthanum (57)	La 140	.....	2×10^{-4}
Lead (82)	Pb 203	.....	4×10^{-3}
Lutetium (71)	Lu 177	.....	1×10^{-3}
Manganese (25)	Mn 52	.....	3×10^{-4}
	Mn 54	.....	1×10^{-3}
	Mn 56	.....	1×10^{-3}
Mercury (80)	Hg 197m	.....	2×10^{-3}
	Hg 197	.....	3×10^{-3}
	Hg 203	.....	2×10^{-4}
Molybdenum (42)	Mo 99	.....	2×10^{-3}
Neodymium (60)	Nd 147	.....	6×10^{-4}
	Nd 149	.....	3×10^{-3}
Nickel (28)	Ni 65	.....	1×10^{-3}
Niobium (Columbium) (41)	Nb 95	.....	1×10^{-3}
	Nb 97	.....	9×10^{-3}
Osmium (76)	Os 185	.....	7×10^{-4}
	Os 191m	.....	3×10^{-2}
	Os 191	.....	2×10^{-3}
	Os 193	.....	6×10^{-4}
Palladium (46)	Pd 103	.....	3×10^{-3}
	Pd 109	.....	9×10^{-4}
Phosphorus (32)	P 32	.....	2×10^{-4}
Platinum (78)	Pt 191	.....	1×10^{-3}
	Pt 193m	.....	1×10^{-2}
	Pt 197m	.....	1×10^{-2}
	Pt 197	.....	1×10^{-3}

See notes at end of table

TABLE 2 — (Continued)
(EXEMPT CONCENTRATIONS)

Element (atomic number)	*Isotope*	*Column 1 Gas concentration μCi/ml**	*Column 2 Liquid and solid concentration μCi/ml***
Polonium (84)	Po 210	2×10^{-10}	7×10^{-6}
Potassium (19)	K 42	.....	3×10^{-3}
Praseodymium (59)	Pr 142	.....	3×10^{-4}
	Pr 143	.....	5×10^{-4}
Promethium (61)	Pm 147	.....	2×10^{-3}
	Pm 149	.....	4×10^{-4}
Radium (88)	Ra 226	1×10^{-11}	1×10^{-7}
	Ra 228	2×10^{-11}	3×10^{-7}
Rhenium (75)	Re 183	.....	6×10^{-3}
	Re 186	.....	9×10^{-4}
	Re 188	.....	6×10^{-4}
Rhodium (45)	Rh 103m	.....	1×10^{-1}
	Rh 105	.....	1×10^{-3}
Rubidium (37)	Rb 86	.....	7×10^{-4}
Ruthenium (44)	Ru 97	.....	4×10^{-3}
	Ru 103	.....	8×10^{-4}
	Ru 105	.....	1×10^{-3}
	Ru 106	.....	1×10^{-4}
Samarium (62)	Sm 153	.....	8×10^{-4}
Scandium (21)	Sc 46	.....	4×10^{-4}
	Sc 47	.....	9×10^{-4}
	Sc 48	.....	3×10^{-4}
Selenium (34)	Se 75	.....	3×10^{-3}
Silicon (14)	Si 31	.....	9×10^{-3}
Silver (47)	Ag 105	.....	1×10^{-3}
	Ag 110m	.....	3×10^{-4}
	Ag 111	.....	4×10^{-4}
Sodium (11)	Na 24	.....	2×10^{-3}
Strontium (38)	Sr 85	.....	1×10^{-3}
	Sr 89	.....	1×10^{-4}
	Sr 91	.....	7×10^{-4}
	Sr 92	.....	7×10^{-4}
Sulfur (16)	S 35	9×10^{-8}	6×10^{-4}
Tantalum (73)	Ta 182	.....	4×10^{-4}
Technetium (43)	Tc 96m	.....	1×10^{-1}
	Tc 96	.....	1×10^{-3}
Tellurium (52)	Te 125m	.....	2×10^{-3}
	Te 127m	.....	6×10^{-4}
	Te 127	.....	3×10^{-3}
	Te 129m	.....	3×10^{-4}
	Te 131m	.....	6×10^{-4}
	Te 132	.....	3×10^{-4}
Terbium (65)	Tb 160	.....	4×10^{-4}
Thallium (81)	Tl 200	.....	4×10^{-3}
	Tl 201	.....	3×10^{-3}

See notes at end of table

TABLE 2 — (Continued)
(EXEMPT CONCENTRATIONS)

Element (atomic number)	*Isotope*	*Column 1 Gas concentration μCi/ml**	*Column 2 Liquid and solid concentration μCi/ml***
	Tl 202	.....	1×10^{-3}
	Tl 204	.....	1×10^{-3}
Thulium (69)	Tm 170	.....	5×10^{-4}
	Tm 171	.....	5×10^{-3}
Tin (50)	Sn 113	.....	9×10^{-4}
	Sn 125	.....	2×10^{-4}
Tungsten (Wolfram) (74)	W 181	.....	4×10^{-3}
	W 187	.....	7×10^{-4}
Vanadium (23)	V 48	.....	3×10^{-4}
Xenon (54)	Xe 131m	4×10^{-6}	.....
	Xe 133	3×10^{-6}	.....
	Xe 135	1×10^{-6}	.....
Ytterbium (70)	Yb 175	.....	1×10^{-3}
Yttrium (39)	Y 90	.....	2×10^{-4}
	Y 91m	.....	3×10^{-2}
	Y 91	.....	3×10^{-4}
	Y 92	.....	6×10^{-4}
	Y 93	.....	3×10^{-4}
Zinc (30)	Zn 65	.....	1×10^{-3}
	Zn 69m	.....	7×10^{-4}
	Zn 69	.....	2×10^{-2}
Zirconium (40)	Zr 95	.....	6×10^{-4}
	Zr 97	.....	2×10^{-4}
Alpha-emitting radioactive material other than special nuclear and transuranic material not listed above		1×10^{-12}	1×10^{-8}
Beta and/or gamma-emitting radioactive material not listed above with half-life less than 3 years		1×10^{-10}	1×10^{-6}

NOTES

* Values are given for those materials normally used as gases.

** μc/gm for solids.

Note 1. Many radionuclides disintegrate into daughter products which are also radioactive. In expressing the concentrations in Table 2, the activity stated is that of the parent radionuclide and takes into account the daughter products.

Note 2. For purposes of section 38.41, Table 1, Exemption 2 of this Part (rule) where there is present a combination of radionuclides, the limit for the combination shall be derived as follows:

(a) Determine for each radionuclide present the following quotient: Set the numerator equal to the concentration of the radionuclide present and the denominator equal to the exempt concentration listed in Table 2. The sum of such quotients shall not exceed "one".

Example:

$$\frac{\text{Concentration of Radionuclide A present}}{\text{Exempt concentration of Radionuclide A}} + \frac{\text{Concentration of Radionuclide B present}}{\text{Exempt concentration of Radionuclid}} < 1$$

TABLE 3 — GENERAL LICENSES — ITEMS, TERMS AND CONDITIONS —

Item (a) — Certain quantities of radioactive material, devices and equipment.

(1) A general license is hereby issued to transfer, receive, acquire, own, possess and use radioactive material incorporated in the following devices or equipment which have been manufactured or imported, tested and labeled in accordance with the specifications contained in a license or permit from the commissioner, the State Department of Health, the New York City Department of Health, the United States Nuclear Regulatory Commission or any agreement State, which license or permit provides that such items may be distributed to persons under the general license provisions of Item (a) or its equivalent. Such devices or equipment are:

(i) A device designed for use as a static eliminator and containing as a sealed source a total quantity of not more than 500 microcuries of Polonium 210.

(ii) Any device designed for use in ionizing air and containing, as a sealed source, a total quantity of not more than 500 microcuries of Polonium 210 or 50 millicuries of Hydrogen 3.

(2) Terms and conditions. Every person in respect to certain quantities of radioactive material, devices and equipment shall comply with the following requirements:

(i) Such person shall not by any method combine, increase or cause any combination or increase in the radioactivity of any device containing radioactive material, or administer externally or internally, or direct the administration of, any device to a human being for any purpose.

(ii) Such person shall comply with the requirements of this Part (rule), specifically sections 38.23, 38.32 and 38.36, subdivision (a), paragraph (2).

Item (b) — Certain measuring, gaging or controlling devices.

(1) A general license is hereby issued to own, receive, acquire, possess and use radioactive material when contained in any device designed for use in detecting, measuring, gaging or controlling thickness, density, level interface location, radiation, leakage or qualitative or quantitative chemical composition, or designed for producing light or ionized atmosphere, when such devices are manufactured or imported in accordance with the specifications contained in a license or permit issued to the supplier by the commissioner, the State Department of Health, the New York City Department of Health, the United States Nuclear Regulatory Commission or any agreement State and authorizing distribution under the general license of this Item or its equivalent, provided that:

(i) Such devices are labeled in accordance with the provisions of a license which authorizes the distribution of the devices.

(ii) Such devices bear a durable label containing the following or a substantially similar statement which contains the information called for in the following statement:

TABLE 3 — (Continued) (GENERAL LICENSES — ITEMS, TERMS AND CONDITIONS)

Item (b) (1) (Continued)

"The receipt, possession, use and transfer of this device, Model _____ _____Serial No._____, are subject to a general license or equivalent and regulations of the United States Nuclear Regulatory Commission or of a State with which the Nuclear Regulatory Commission has entered into an agreement for the exercise of regulatory authority. This label shall be maintained on the device in a legible condition.

Removal of this label is prohibited.

Caution — Radioactive Material

_____

(Name of Supplier)"

(The model, serial number and name of the supplier may be omitted from this label provided they are elsewhere specified in labeling affixed to the device. Devices licensed and distributed prior to the effective date of this Part (rule) may bear labels previously authorized.)

(iii) Such devices are installed when on the premises of the general licensee by a person authorized to install such devices under a license or permit issued to the installer by the commissioner, the State Department of Health, the New York City Department of Health, the United States Nuclear Regulatory Commission or any agreement State, if a label affixed to the device at the time of receipt states that installation by a licensee is required. The requirement of this Item does not apply while devices are held in storage in the original shipping containers pending installation by a licensee.

(2) Terms and conditions. Every person under this general license shall comply with the following requirements:

(i) Such person shall, upon receipt of a generally licensed device, register it with the commissioner on a form prescribed by him describing the type of such device obtained, the quantity and the type of radioactive material contained in such device and such other information as the commissioner may require.

(ii) No such person shall dispose of by abandonment or otherwise, any such device except by transfer to a person who holds a license or permit to receive such device issued by the commissioner, the State Department of Health, the New York City Department of Health, the United States Nuclear Regulatory Commission or any agreement State, or in case the device remains in use at a particular location, the transferor shall give the transferee a copy of the requirements of this item and any safety documents identified in the label on the device and upon transfer notify the commissioner indicating the registration number, manufacturers name, model and serial number of device transferred, the name and address of the transferee and name and qualifications of transferee's radiation safety officer.

(iii) Such person assures that all labels affixed to the devices bearing the statement "Removal of This Label is Prohibited" are maintained on

the devices and shall comply with all instructions contained in such labels as a condition of his general license.

(iv) Such person shall cause the device to be tested for leakage of radioactive material and proper operation of the on-off mechanism and indicator, if any, at the time of installation of the device or replacement of the radioactive material, and thereafter at intervals that do not exceed six months, or at such longer intervals not to exceed three years as specified by the appropriate licensing agency and indicated in the required label except that any such device containing only Kryton 85 need not be tested for leakage, and devices containing only Hydrogen 3 need not be so tested for any purpose.

(v) Such person shall cause each required test and all other servicing involving such radioactive material, its shielding or containment, to be conducted as specified in the instructions provided by the labels, or by the supplier or by a person who holds a license which authorizes him to manufacture, install or service the device. Such leak test shall be capable of detecting at least 0.005 microcuries of removable radioactivity. Upon detection of leakage of such devices in excess of 0.005 microcuries of removable radioactivity, the person under this general license shall promptly notify the commissioner in wirting.

(vi) Upon any indication of a possible failure of or damage to the shielding or containment of such radioactive material or an on-off mechanism and indicator, such person shall immediately notify the commissioner and shall suspend use of such device until it has been repaired, lawfully disposed of or accepted by the commissioner as in substantial compliance with this Part (rule).

(vii) Such person shall comply with the requirements specified in section 38.36, subdivision (a), paragraphs (1) and (2) of this Part (rule) and such other requirements as the commissioner may determine to be applicable but otherwise such person shall be exempt from the requirements of sections 38.19 through 38.36 of this Part (rule).

Item (c) — Strontium 90 in ice detection devices.

(1) A general license is hereby issued to own, receive, possess, use and transfer Strontium 90 contained in any device designed for use in ice detection and containing a total quantity of not more than 50 microcuries of Strontium 90 and each device has been manufactured or imported in accordance with a license or permit issued to the supplier by the commissioner, the State Department of Health, the New York City Department of Health, the United States Nuclear Regulatory Commission or any agreement State and authorizing distribution under the general license of this Item or its equivalent, provided that:

(i) Such devices are labeled in accordance with the provisions of a license which authorizes the distribution of the devices.

(ii) Such devices bear durable labels which include the radiation hazard symbol as specified in section 38.31, subdivision (a) of this

Part (rule), a statement that the device contains Strontium 90 and the quantity thereof, instructions for disposal and statements that the device may be possessed pursuant to a general license or equivalent, that the manufacturer or civil authorities shall be notified if the device is found, that removal of labeling is prohibited and that disassembly and repair of the device may be performed only by a person holding a license to manufacture or service such devices.

(2) Terms and conditions. Every person in respect to ice detectors containing Strontium 90 shall comply with the following requirements:

(i) Such person shall, upon occurrence of visually observable damage (such as a bend or crack or discoloration from over-heating) to the device, discontinue use of the device until it has been inspected, tested for leakage and repaired by a person authorized to conduct such activities by a specific license or permit from the commissioner, the State Department of Health, the New York City Department of Health, the United States Nuclear Regulatory Commission or any agreement State, or shall dispose of the device in accordance with section 38.32 of this Part (rule).

(ii) Such person shall assure that all labels affixed to the device at the time of receipt, and that bear a statement prohibiting removal, are maintained on such device.

(iii) Such person shall not assemble, disassemble or repair Strontium 90 in ice detection devices.

(iv) Such person shall comply with the requirements of section 38.23 of this Part (rule) and such other requirements as the commissioner may determine to be applicable to a particular device, but otherwise such person shall be exempt from the requirements of section 38.19 through 38.36 of this Part (rule).

Item (d) — Source material.

(1) A general license is hereby issued authorizing commerical and industrial firms, and research, educational and medical institutions in respect to the use and transfer of any source material in quantities not exceeding a total of 15 pounds at any one time or a total of 150 pounds in any calendar year for commercial, industrial, research and developmental purposes.

(2) Terms and conditions. Every person in respect to generally licensed quantities of source material shall comply with the requirements of section 38.23 of this Part (rule) and other requirements as the commissioner may determine to be applicable, but otherwise such person shall be exempt from the requirements of section 38.19 through 38.36 of this Part (rule), except that:

(i) This exemption shall not be deemed to apply to any such person who is also in possession of source material under a license or permit issued by the commissioner, the State Department of Health or the New York City Department of Health.

Item (e) — Luminous safety devices for use in aircraft.

(1) A general license is hereby issued for all persons in respect to Hydrogen 3 or Promethium 147 contained in luminous safety devices for use in aircraft, when each device contains not more than 10 curies of Hydrogen 3 or 300 millicuries of Promethium 147 and has been manufactured, assembled or imported in accordance with a license or permit issued by the commissioner, the State Department of Health, the New York City Department of Health, the United States Nuclear Regulatory Commission or any agreement State and authorizing distribution under the general license of this Item or equivalent. This exemption does not authorize the manufacture, assembly or repair of luminous safety devices containing Hydrogen 3 or Promethium 147. This exemption does not authorize the transfer, receipt, possession or use of Promethium 147 in instrument dials.

(2) Terms and conditions. Every person in respect to generally licensed luminous safety devices for use in aircraft shall comply with the requirements of section 38.23 of this Part (rule) and other requirements as the commissioner may determine to be applicable, but otherwise such person shall be exempt from the requirements of sections 38.19 through 38.36 of this Part (rule).

Item (f) — Americium 241 and Plutonium in the form of calibration or reference sources.

(1) A general license is hereby issued with respect to Americium 241 and Plutonium contained in the form of calibration or reference sources to those persons holding a license or permit issued by the commissioner, the State Department of Health or the New York City Department of Health authorizing the receipt, possession, use and transfer of radioactive materials or persons holding licenses issued by the United States Nuclear Regulatory Commission authorizing the receipt, possession, use and transfer of special nuclear material. Such sources must have been manufactured or imported, tested and labeled in accordance with a license or permit issued by the commissioner, the State Department of Health, the New York City Department of Health, the United States Nuclear Regulatory Commission or any agreement State, and authorizing the distribution under the general license of this Item or equivalent.

(2) Terms and conditions. Every person in respect to generally licensed Americium 241 or Plutonium calibration or reference sources shall comply with the following requirements:

(i) Such person shall not possess at any one time, at any one location of storage or use, more than 5 microcuries of Americium 241 and 5 microcuries of Plutonium in the form of generally licensed sources.

(ii) Such person shall not receive, possess, use or transfer any such source unless the source, or the storage container, shall have affixed thereto a label with the following statement or a substantially similar statement:

"The receipt, possession, use and transfer of this source, Model No._____, Serial No._____, are subject to general license or the equivalent and the regulations of the United States Nuclear Regulatory Commission or of a State with which the Nuclear Regulatory Commission has entered into an agreement for the exercise of regulatory authority. Do not remove this label. CAUTION — RADIOACTIVE MATERIAL — THIS SOURCE CONTAINS (Use name of material in source) DO NOT TOUCH RADIOACTIVE PORTION OF THIS SOURCE.

_____

(Name of manufacturer or importer) "

(iii) Such person shall not transfer, abandon or dispose of such source except by transfer to a person authorized to receive the source by a license or permit issued by the commissioner, the State Department of Health, the New York City Department of Health, the United States Nuclear Regulatory Commission or an agreement State.

(iv) Such person shall store such source, except when the source is being used, in a closed container adequately designed and constructed to contain Americium 241 or Plutonium which might otherwise escape during storage.

(v) Such person shall not use such source for any purpose other than the calibration of radiation detectors or the standardization of other sources.

(vi) Such person shall comply with other applicable requirements of this Part (rule).

Item (g) — Depleted Uranium in certain industrial and commercial products or devices.

(1) A general license is hereby issued to receive, acquire, possess, use or transfer, depleted uranium contained in industrial and commercial products or devices for the purpose of providing a concentrated mass in a small volume of the product or device when the product or device is manufactured or imported in accordance with the specifications contained in a license or permit issued to the supplier by the commissioner, the State Department of Health, the New York City Department of Health, the United States Nuclear Regulatory Commission or any agreement State and authorizing distribution under the general license of this Item or its equivalent, provided that:

(i) Such products or devices are labeled in accordance with the provisions of a license which authorizes the distribution of the products or devices.

(ii) Such products or devices are clearly impressed with the following wording clearly legible through any plating or other covering: "Depleted Uranium".

(2) Terms and conditions. Every person under this general license shall

TABLE 3 — (Continued)
(GENERAL LICENSES — ITEMS, TERMS AND CONDITIONS)

Item (g) (2) (Continued)

comply with the following requirements:

(i) Such person shall, upon receipt of a generally licensed device or product, register it with the commissioner on a form prescribed by him, describing the radiation protection and control program to assure physical control over the depleted uranium products and devices and designed to prevent transfer to unauthorized persons and such other information as the commissioner may require.

(ii) Such person shall not introduce such depleted uranium device or product, in any form, into any chemical, physical, or metallurgical treatment or process except a treatment or process for repair or restoration of any plating or other covering on the depleted uranium.

(iii) No such person shall dispose of by abandonment or otherwise, any such product or device except by transfer to a person who holds a license or permit to receive such product or device issued by the commissioner, the State Department of Health, the New York City Department of Health, the United States Nuclear Regulatory Commission or any agreement State or in case of transfer to a general licensee within the State a copy of this general license with its terms and conditions and a copy of the registration form prescribed by the commissioner to be completed by the transferee or in case of transfer to a non-Agreement or other Agreement State transferee, a copy of the appropriate regulation and registration form to be completed by the transferee.

(iv) Within 30 days of any transfer such person shall report in writing to the commissioner the name and address of the person receiving the depleted uranium product or device.

(v) Such person shall comply with the requirements specified in section 38.36, subdivision (a), paragraph (2) of this Part (rule) and such other requirements as the commissioner may determine to be applicable but otherwise such person shall be exempt from other requirements of this Part (rule).

TABLE 4
EXEMPT QUANTITIES

Radioactive Material	*Microcuries*
Antimony 122 (Sb 122)	100
Antimony 124 (Sb 124)	10
Antimony 125 (Sb 125)	10
Arsenic 73 (As 73)	100
Arsenic 74 (As 74)	10
Arsenic 76 (As 76)	10
Arsenic 77 (As 77)	100
Barium 131 (Ba 131)	10
Barium 133 (Ba 133)	10
Barium 140 (Ba 140)	10
Bismuth 210 (Bi 210)	1
Bromine 82 (Br 82)	10
Cadmium 109 (Cd 109)	10
Cadmium 115m (Cd 115m)	10
Cadmium 115 (Cd 115)	100
Calcium 45 (Ca 45)	10
Calcium 47 (Ca 47)	10
Carbon 14 (C 14)	100
Cerium 141 (Ce 141)	100
Cerium 143 (Ce 143)	100
Cerium 144 (Ce 144)	1
Cesium 129 (Cs 129)	100
Cesium 131 (Cs 131)	1,000
Cesium 134m (Cs 134m)	100
Cesium 134 (Cs 134)	1
Cesium 135 (Cs 135)	10
Cesium 136 (Cs 136)	10
Cesium 137 (Cs 137)	10
Chlorine 36 (Cl 36)	10
Chlorine 38 (Cl 38)	10
Chromium 51 (Cr 51)	1,000
Cobalt 57 (Co 57)	100
Cobalt 58m (Co 58m)	10
Cobalt 58 (Co 58)	10
Cobalt 60 (Co 60)	1
Copper 64 (Cu 64)	100
Dysprosium 165 (Dy 165)	10
Dysprosium 166 (Dy 166)	100
Erbium 169 (Er 169)	100
Erbium 171 (Er 171)	100
Europium 152 9.2 h (Eu 152 9.2 h)	100
Europium 152 13 yr (Eu 152 13 yr)	1
Europium 154 (Eu 154)	1
Europium 155 (Eu 155)	10
Fluorine 18 (F 18)	1,000
Gadolinium 153 (Gd 153)	10
Gadolinium 159 (Gd 159)	100
Gallium 67 (Ga 67)	100
Gallium 72 (Ga 72)	10
Germanium 71 (Ge 71)	100
Gold 198 (Au 198)	100
Gold 199 (Au 199)	100

See notes at end of table

TABLE 4 — (Continued)
(EXEMPT QUANTITIES)

Radioactive Material	*Microcuries*
Hafnium 181 (Hf 181)	10
Holmium 166 (Ho 166)	100
Hydrogen 3 (H 3)	1,000
Indium 111 (In 111)	100
Indium 113m (In 113m)	100
Indium 114m (In 114m)	10
Indium 115m (In 115m)	100
Indium 115 (In 115)	10
Iodine 123 (I-123)	100
Iodine 125 (I 125)	1
Iodine 126 (I 126)	1
Iodine 129 (I 129)	0.1
Iodine 131 (I 131)	1
Iodine 132 (I 132)	10
Iodine 133 (I 133)	1
Iodine 134 (I 134)	10
Iodine 135 (I 135)	10
Iridium 192 (Ir 192)	10
Iridium 194 (Ir 194)	100
Iron 52 (Fe 52)	10
Iron 55 (Fe 55)	100
Iron 59 (Fe 59)	10
Krypton 85 (Kr 85)	100
Krypton 87 (Kr 87)	10
Lanthanum 140 (La 140)	10
Lutetium 177 (Lu 177)	100
Manganese 52 (Mn 52)	10
Manganese 54 (Mn 54)	10
Manganese 56 (Mn 56)	10
Mercury 197m (Hg 197m)	100
Mercury 197 (Hg 197)	100
Mercury 203 (Hg 203)	10
Molybdenum 99 (Mo 99)	100
Neodymium 147 (Nd 147)	100
Neodymium 149 (Nd 149)	100
Nickel 59 (Ni 59)	100
Nickel 63 (Ni 63)	10
Nickel 65 (Ni 65)	100
Niobium 93m (Nb 93m)	10
Niobium 95 (Nb 95)	10
Niobium 97 (Nb 97)	10
Osmium 185 (Os 185)	10
Osmium 191m (Os 191m)	100
Osmium 191 (Os 191)	100
Osmium 193 (Os 193)	100
Palladium 103 (Pd 103)	100
Palladium 109 (Pd 109)	100
Phosphorus 32 (P 32)	10
Platinum 191 (Pt 191)	100
Platinum 193m (Pt 193m)	100
Platinum 193 (Pt 193)	100
Platinum 197m (Pt 197m)	100

See notes at end of table

TABLE 4 — (Continued)
(EXEMPT QUANTITIES)

Radioactive Material	*Microcuries*
Platinum 197 (Pt 197)	100
Polonium 210 (Po 210)	0.1
Potassium 42 (K 42)	10
Potassium 43 (K 43)	10
Praseodymium 142 (Pr 142)	100
Praseodymium 143 (Pr 143)	100
Promethium 147 (Pm 147)	10
Promethium 149 (Pm 149)	10
Radium 226 (Ra 226)	0.01
Rhenium 186 (Re 186)	100
Rhenium 188 (Re 188)	100
Rhodium 103m (Rh 103m)	100
Rhodium 105 (Rh 105)	100
Rubidium 81 (Rb 81)	10
Rubidium 86 (Rb 86)	10
Rubidium 87 (Rb 87)	10
Ruthenium 97 (Ru 97)	100
Ruthenium 103 (Ru 103)	10
Ruthenium 105 (Ru 105)	10
Ruthenium 106 (Ru 106)	1
Samarium 151 (Sm 151)	10
Samarium 153 (Sm 153)	100
Scandium 46 (Sc 46)	10
Scandium 47 (Sc 47)	100
Scandium 48 (Sc 48)	10
Selenium 75 (Se 75)	10
Silicon 31 (Si 31)	100
Silver 105 (Ag 105)	10
Silver 110m (Ag 110m)	1
Silver 111 (Ag 111)	100
Sodium 22 (Na 22)	10
Sodium 24 (Na 24)	10
Strontium 85 (Sr 85)	10
Strontium 89 (Sr 89)	1
Strontium 90 (Sr 90)	0.1
Strontium 91 (Sr 91)	10
Strontium 92 (Sr 92)	10
Sulphur 35 (S 35)	100
Tantalum 182 (Ta 182)	10
Technetium 96 (Tc 96)	10
Technetium 97m (Tc 97m)	100
Technetium 97 (Tc 97)	100
Technetium 99m (Tc 99m)	100
Technetium 99 (Tc 99)	10
Tellurium 125m (Te 125m)	10
Tellurium 127m (Te 127m)	10
Tellurium 127 (Te 127)	100
Tellurium 129m (Te 129m)	10
Tellurium 129 (Te 129)	100
Tellurium 131m (Te 131m)	10
Tellurium 132 (Te 132)	10
Terbium 160 (Tb 160)	10
Thallium 200 (Tl 200)	100

See notes at end of table

TABLE 4 — (Continued)
(EXEMPT QUANTITIES)

Radioactive Material	*Microcuries*
Thallium 201 (Tl 201)	100
Thallium 202 (Tl 202)	100
Thallium 204 (Tl 204)	10
Thulium 170 (Tm 170)	10
Thulium 171 (Tm 171)	10
Tin 113 (Sn 133)	10
Tin 125 (Sn 125)	10
Tungsten 181 (W 181)	10
Tungsten 185 (W 185)	10
Tungsten 187 (W 187)	100
Vanadium 48 (V 48)	10
Xenon 131m (Xe 131m)	1,000
Xenon 133 (Xe 133)	100
Xenon 135 (Xe 135)	100
Ytterbium 175 (Yb 175)	100
Yttrium 87 (Y 87)	10
Yttrium 90 (Y 90)	10
Yttrium 91 (Y 91)	10
Yttrium 92 (Y 92)	100
Yttrium 93 (Y 93)	100
Zinc 65 (Zn 65)	10
Zinc 69m (Zn 69m)	100
Zinc 69 (Zn 69)	1,000
Zirconium 93 (Zr 93)	10
Zirconium 95 (Zr 95)	10
Zirconium 97 (Zr 97)	10
Any radionuclide not listed above other than alpha-emitting radioactive material	0.1

NOTES:

(1) For purposes of section 38.7 of this Part (rule) where there is present more than one radionuclide, the total possession limit for no security shall be derived as follows:

(i) Determine for each radionuclide present the following quotient:

(a) Set the numerator equal to the quantity of the radionuclide present and the denominator equal to the exempt quantity listed in Table 4 of this Part (rule). The sum of such quotients shall not exceed 100.

(b) Example:

$$\frac{\text{Quantity of Radionuclide A Present}}{\text{Exempt Quantity of Radionuclide A}} + \frac{\text{Quantity of Radionuclide B Present}}{\text{Exempt Quantity of Radionuclide B}} + \ldots \quad 100$$

(2) For purposes of section 38.41, Table I, Exemption 28 of this Part (rule) where more than one radionuclide is present, the total, individual package quantity limit shall be derived as follows:

(i) Determine for each radionuclide present the following quotient:

(a) Set the numerator equal to the quantity of the radionuclide present and the denominator equal to the exempt quantity listed in Table 4 of this Part (rule). The sum of such quotients shall not exceed "1".

(b) Example:

$$\frac{\text{Quantity of Radionuclide A Present}}{\text{Exempt Quantity of Radionuclide A}} + \frac{\text{Quantity of Radionuclide B Present}}{\text{Exempt Quantity of Radionuclide B}} + \ldots \quad 1$$

TABLE 5
LIMITS FOR UNCONTROLLED AREAS

(a) Surface contamination limits.

(1) Alpha emitters.

(i) Removable:

$$\frac{15\ \text{pCi}}{100\ \text{cm}^2} = \frac{33\ \text{dpm}}{100\ \text{cm}^2}$$ — average over any one surface

$$\frac{45\ \text{pCi}}{100\ \text{cm}^2} = \frac{100\ \text{dpm}}{100\ \text{cm}^2}$$ — maximum

(ii) Total (fixed):

$$\frac{450\ \text{pCi}}{100\ \text{cm}^2} = \frac{1000\ \text{dpm}}{100\ \text{cm}^2}$$ — average over any one surface

$$\frac{2250\ \text{pCi}}{100\ \text{cm}^2} = \frac{5000\ \text{dpm}}{100\ \text{cm}^2}$$ — maximum

$$\frac{0.25\ \text{mrem at 1 cm}}{\text{hr}}$$

(2) Beta-Gamma emitters.

(i) Removable: (all beta-gamma emitters except Hydrogen 3)

$$\frac{100\ \text{pCi}}{100\ \text{cm}^2}$$ — average over any one surface

$$\frac{500\ \text{pCi}}{100\ \text{cm}^2}$$ — maximum

Removable: (Hydrogen 3)

$$\frac{1000\ \text{pCi}}{100\ \text{cm}^2}$$ — average over any one surface

$$\frac{\quad\ \text{pCi}}{100\ \text{cm}^2}$$ — maximum

(ii) Total (fixed): 0.25 mrem at 1 cm from surface.
hr

(b) Concentrations in air and water: Table 6, Schedule II.

(c) Concentrations in soil and other materials except water:

(1) Radioactive material except source material: Table 2, Column 2.

(2) Source material: 0.05 per cent by weight.

Note: Jurisdictional limits. The limits listed in Table 5 of this Part (rule) shall apply to those installations and property that remain subject to the jurisdiction of the Labor Law and this Part (rule).

TABLE 6

CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND

Element (atomic number)	Isotope[1]			SCHEDULE I Column 1 Air (μCi/ml)	SCHEDULE I Column 2 Water (μCi/ml)	SCHEDULE II Column 1 Air (μCi/ml)	SCHEDULE II Column 2 Water (μCi/ml)
Actinium (89)	Ac	227	S	2×10^{-12}	6×10^{-5}	8×10^{-14}	2×10^{-6}
			I	3×10^{-11}	9×10^{-3}	9×10^{-13}	3×10^{-4}
	Ac	228	S	8×10^{-8}	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}	2×10^{-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^{-3}	1×10^{-9}	1×10^{-4}
			I	5×10^{-8}	4×10^{-3}	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^{-6}	1×10^{-1}	1×10^{-7}	5×10^{-3}
			I	2×10^{-5}	1×10^{-1}	8×10^{-7}	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^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
			I	3×10^{-8}	3×10^{-3}	9×10^{-10}	1×10^{-4}
Argon (18)	A	37	Sub[3]	6×10^{-3}	.....	1×10^{-4}	.....
	A	41	Sub[3]	2×10^{-6}	.....	4×10^{-8}	.....
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}
Asatine (85)	At	211	S	7×10^{-9}	5×10^{-5}	2×10^{-10}	2×10^{-6}
			I	3×10^{-8}	2×10^{-3}	1×10^{-9}	7×10^{-5}
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^{-10}	2×10^{-2}	3×10^{-11}	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^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
Beryllium (4)	Be	7	S	6×10^{-6}	5×10^{-2}	2×10^{-7}	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^{-8}	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^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-5}

See notes at end of table

TABLE 6 — (Continued)

(CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND)

Element (atomic number)	Isotope[1]			SCHEDULE I Column 1 Air (μCi/ml)	SCHEDULE I Column 2 Water (μCi/ml)	SCHEDULE II Column 1 Air (μCi/ml)	SCHEDULE II Column 2 Water (μCi/ml)
(Bismuth (83))	Bi	212	S	1×10^{-7}	1×10^{-2}	3×10^{-9}	4×10^{-4}
			I	2×10^{-7}	1×10^{-2}	7×10^{-9}	4×10^{-4}
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^{-3}	2×10^{-9}	2×10^{-4}
			I	7×10^{-8}	5×10^{-3}	3×10^{-9}	2×10^{-4}
	Cd	115m	S	4×10^{-8}	7×10^{-4}	1×10^{-9}	3×10^{-5}
			I	4×10^{-8}	7×10^{-4}	1×10^{-9}	3×10^{-5}
	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^{-4}	1×10^{-9}	9×10^{-6}
			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^{-4}	5×10^{-14}	4×10^{-6}
			I	1×10^{-10}	7×10^{-4}	3×10^{-12}	2×10^{-5}
	Cf	250	S	5×10^{-12}	4×10^{-4}	2×10^{-13}	1×10^{-5}
			I	1×10^{-10}	7×10^{-4}	3×10^{-12}	3×10^{-5}
	Cf	251	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	4×10^{-6}
			I	1×10^{-10}	8×10^{-4}	3×10^{-12}	3×10^{-5}
	Cf	252	S	6×10^{-12}	2×10^{-4}	2×10^{-13}	7×10^{-6}
			I	3×10^{-11}	2×10^{-4}	1×10^{-12}	7×10^{-6}
	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^{-6}	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^{-2}	1×10^{-7}	8×10^{-4}
	(CO_2)		Sub[3]	5×10^{-5}	.....	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^{-4}	3×10^{-10}	1×10^{-5}
			I	6×10^{-9}	3×10^{-4}	2×10^{-10}	1×10^{-5}
Cesium (55)	Cs	131	S	1×10^{-5}	7×10^{-2}	4×10^{-7}	2×10^{-3}
			I	3×10^{-6}	3×10^{-2}	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^{-3}	1×10^{-9}	9×10^{-6}
			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^{-4}	2×10^{-9}	2×10^{-5}
			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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TABLE 6 — (Continued)

(CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND)

Element (atomic number)	Isotope[1]			SCHEDULE I Column 1 Air (μCi/ml)	SCHEDULE I Column 2 Water (μCi/ml)	SCHEDULE II Column 1 Air (μCi/ml)	SCHEDULE 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^{-8}	3×10^{-3}	2×10^{-9}	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^{-4}	4×10^{-12}	2×10^{-5}
			I	2×10^{-10}	7×10^{-4}	6×10^{-12}	2×10^{-5}
	Cm	243	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	5×10^{-6}
			I	1×10^{-10}	7×10^{-4}	3×10^{-12}	2×10^{-5}
	Cm	244	S	9×10^{-12}	2×10^{-4}	3×10^{-13}	7×10^{-6}
			I	1×10^{-10}	8×10^{-4}	3×10^{-12}	3×10^{-5}
	Cm	245	S	5×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
			I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	Cm	246	S	5×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
			I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	Cm	247	S	5×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
			I	1×10^{-10}	6×10^{-4}	4×10^{-12}	2×10^{-5}
	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^{-4}	3×10^{-11}	2×10^{-5}
			I	6×10^{-10}	7×10^{-4}	2×10^{-11}	2×10^{-5}
	Es	254m	S	5×10^{-9}	5×10^{-4}	2×10^{-10}	2×10^{-5}
			I	6×10^{-9}	5×10^{-4}	2×10^{-10}	2×10^{-5}
	Es	254	S	2×10^{-11}	4×10^{-4}	6×10^{-13}	1×10^{-5}
			I	1×10^{-10}	4×10^{-4}	4×10^{-12}	1×10^{-5}
	Es	255	S	5×10^{-10}	8×10^{-4}	2×10^{-11}	3×10^{-5}
			I	4×10^{-10}	8×10^{-4}	1×10^{-11}	3×10^{-5}
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 ($T_{1/2}$ = 9.2 hrs)	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}
	Eu	152 ($T_{1/2}$ = 13 yrs)	S	1×10^{-8}	2×10^{-3}	4×10^{-10}	8×10^{-5}
			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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TABLE 6 — (Continued)

(CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND)

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

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TABLE 6 — (Continued)

(CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND)

Element (atomic number)	Isotope[1]			SCHEDULE I Column 1 Air (μCi/ml)	SCHEDULE I Column 2 Water (μCi/ml)	SCHEDULE II Column 1 Air (μCi/ml)	SCHEDULE II Column 2 Water (μCi/ml)
(Iodine (53) Cont.)	I	135	S	1×10^{-7}	7×10^{-4}	1×10^{-9}	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^{-2}	3×10^{-8}	8×10^{-4}
			I	1×10^{-6}	7×10^{-2}	3×10^{-8}	2×10^{-3}
	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[3]	6×10^{-6}	.....	1×10^{-7}	.....
	Kr	85	Sub[3]	1×10^{-5}	.....	3×10^{-7}	.....
	Kr	87	Sub[3]	1×10^{-6}	.....	2×10^{-8}	.....
	Kr	88	Sub[3]	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^{-2}	9×10^{-8}	4×10^{-4}
			I	2×10^{-6}	1×10^{-2}	6×10^{-8}	4×10^{-4}
	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^{-8}	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}
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^{-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}

See notes at end of table

TABLE 6 — (Continued)

(CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND)

Element (atomic number)	Isotope[1]			SCHEDULE I Column 1 Air (μCi/ml)	SCHEDULE I Column 2 Water (μCi/ml)	SCHEDULE II Column 1 Air (μCi/ml)	SCHEDULE II Column 2 Water (μCi/ml)
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^{-2}	1×10^{-8}	7×10^{-4}
	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^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
			I	8×10^{-8}	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^{-6}	3×10^{-2}	4×10^{-8}	9×10^{-4}
			I	3×10^{-7}	5×10^{-2}	1×10^{-8}	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^{-8}	4×10^{-2}	1×10^{-9}	1×10^{-3}
	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^{-5}	2×10^{-11}	7×10^{-7}
			I	2×10^{-10}	8×10^{-4}	7×10^{-12}	3×10^{-5}

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TABLE 6 — (Continued)

(CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND)

Element (atomic number)	Isotope[1]			SCHEDULE I Column 1 Air (μCi/ml)	SCHEDULE I Column 2 Water (μCi/ml)	SCHEDULE II Column 1 Air (μCi/ml)	SCHEDULE II Column 2 Water (μCi/ml)
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^{-5}	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^{-5}	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^{-5}	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^{-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}	.....
			I	.....	.....	.....	.....
	Rn	222	S'	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^{-2}	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^{-5}	4×10^{-1}	3×10^{-6}	1×10^{-2}
			I	5×10^{-5}	3×10^{-1}	2×10^{-6}	1×10^{-2}
	Rh	105	S	1×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
			I	1×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Rubidium (37)	Rb	86	S	2×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
			I	1×10^{-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}
Ruthenium (44)	Ru	97	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
			I	2×10^{-6}	1×10^{-2}	6×10^{-8}	3×10^{-4}
	Ru	103	S	3×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
			I	8×10^{-8}	2×10^{-3}	3×10^{-9}	8×10^{-5}
	Ru	105	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
			I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
	Ru	106	S	8×10^{-8}	4×10^{-4}	3×10^{-9}	1×10^{-5}
			I	6×10^{-9}	3×10^{-4}	2×10^{-10}	1×10^{-5}

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TABLE 6 — (Continued)

(CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND)

Element (atomic number)	Isotope[1]			SCHEDULE I Column 1 Air (μCi/ml)	SCHEDULE I Column 2 Water (μCi/ml)	SCHEDULE II Column 1 Air (μCi/ml)	SCHEDULE II Column 2 Water (μCi/ml)
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^{-8}	1×10^{-2}	2×10^{-9}	4×10^{-4}
			I	1×10^{-7}	1×10^{-2}	5×10^{-9}	4×10^{-4}
	Sm	153	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}
Scandium (21)	Sc	46	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
			I	2×10^{-8}	1×10^{-3}	8×10^{-10}	4×10^{-5}
	Sc	47	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
			I	5×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
	Sc	48	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}
Selenium (34)	Se	75	S	1×10^{-6}	9×10^{-3}	4×10^{-8}	3×10^{-4}
			I	1×10^{-7}	8×10^{-3}	4×10^{-9}	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^{-8}	2×10^{-4}
Silver (47)	Ag	105	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
			I	8×10^{-8}	3×10^{-3}	3×10^{-9}	1×10^{-4}
	Ag	110m	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
			I	1×10^{-8}	9×10^{-4}	3×10^{-10}	3×10^{-5}
	Ag	111	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}
Sodium (11)	Na	22	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
			I	9×10^{-9}	9×10^{-4}	3×10^{-10}	3×10^{-5}
	Na	24	S	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
			I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
Strontium (38)	Sr	85m	S	4×10^{-5}	2×10^{-1}	1×10^{-6}	7×10^{-3}
			I	3×10^{-5}	2×10^{-1}	1×10^{-6}	7×10^{-3}
	Sr	85	S	2×10^{-7}	3×10^{-3}	8×10^{-9}	1×10^{-4}
			I	1×10^{-7}	5×10^{-3}	4×10^{-9}	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^{-9}	3×10^{-5}
	Sr	90	S	1×10^{-9}	1×10^{-5}	3×10^{-11}	3×10^{-7}
			I	5×10^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-5}
	Sr	91	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
			I	3×10^{-7}	1×10^{-3}	9×10^{-9}	5×10^{-5}
	Sr	92	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}
Sulfur (16)	S	35	S	3×10^{-7}	2×10^{-3}	9×10^{-9}	6×10^{-5}
			I	3×10^{-7}	8×10^{-3}	9×10^{-9}	3×10^{-4}
Tantalum (73)	Ta	182	S	4×10^{-8}	1×10^{-3}	1×10^{-9}	4×10^{-5}
			I	2×10^{-8}	1×10^{-3}	7×10^{-10}	4×10^{-5}
Technetium (43)	Tc	96m	S	8×10^{-5}	4×10^{-1}	3×10^{-6}	1×10^{-2}
			I	3×10^{-5}	3×10^{-1}	1×10^{-6}	1×10^{-2}
	Tc	96	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
			I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
	Tc	97m	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
			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}

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TABLE 6 — (Continued)

(CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND)

Element (atomic number)	Isotope[1]			SCHEDULE I Column 1 Air (μCi/ml)	SCHEDULE I Column 2 Water (μCi/ml)	SCHEDULE II Column 1 Air (μCi/ml)	SCHEDULE II Column 2 Water (μCi/ml)
Technetium (43) Cont.	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^{-8}	5×10^{-3}	2×10^{-9}	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^{-12}	2×10^{-4}	3×10^{-13}	7×10^{-6}
			I	6×10^{-12}	4×10^{-4}	2×10^{-13}	1×10^{-5}
	Th	230	S	2×10^{-12}	5×10^{-4}	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}
	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}	3×10^{-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[2]	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[2]	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}	3×10^{-5}
			I	1×10^{-10}	1×10^{-3}	4×10^{-12}	3×10^{-5}
	U	238	S[2]	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-natural		S	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}
	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}
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[3]	2×10^{-5}	.....	4×10^{-7}	.....
	Xe	133m	Sub[3]	1×10^{-5}	.....	3×10^{-7}	.....
	Xe	133	Sub[3]	1×10^{-5}	.....	3×10^{-7}	.....
	Xe	135	Sub[3]	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}
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^{-2}	4×10^{-9}	8×10^{-4}
			I	3×10^{-7}	2×10^{-2}	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^{-5}
			I	9×10^{-8}	5×10^{-4}	3×10^{-9}	2×10^{-5}

See notes at end of table

TABLE 6 — (Continued)

(CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND)

Element (atomic number)	Isotope[1]	SCHEDULE I Column 1 Air (μCi/ml)	SCHEDULE I Column 2 Water (μCi/ml)	SCHEDULE II Column 1 Air (μCi/ml)	SCHEDULE II Column 2 Water (μCi/ml)
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than two hours		Sub[2] 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 two 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}

Notes: 1. (S) = Soluble; (I) = Insoluble

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 Schedule I may be replaced by one-third (1/3) "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 emission of 1.3×10^5 MeV of alpha particle energy). The Schedule II value may be replaced by one-thirtieth (1/30) of a "working level".

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, Schedule I, Column 1 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 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 Schedule II, Column 1 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:

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

$$SA = (0.4 + 0.38\,E + 0.0034\,E^2)\,10^{-6},\ E \geq 0.72$$

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

TABLE 6 — (Continued)

(CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND)

Element (atomic number) and isotope	SCHEDULE I Col. 1 Air (μCi/ml)	SCHEDULE I Col. 2 Water (μCi/ml)	SCHEDULE II Col. 1 Air (μCi/ml)	SCHEDULE II Col. 2 Water (μCi/ml)
If it is known that Sr 90, I 125, I 126, I 129, I 131, (I 133, Sched. 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		9×10^{-5}		3×10^{-6}
If it is known that Sr 90, I 125, I 126, I 129, (I 131, I 133, Sched. 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^{-5}		2×10^{-6}
If it is known that Sr 90, I 129, (I 125, I 126, I 131, Sched. II only), Pb 210, Ra 226, Ra 228, Cm 248 and Cf 254 are not present		2×10^{-5}		6×10^{-7}
If it is known that (I 129, Sched. II only), Ra 226 and Ra 228 are not present		3×10^{-6}		1×10^{-7}
If it is known that alpha-emitters and Sr 90, I 129, Pb 210, Ac 227, Ra 228, Pa 230, Pu 241 and Bk 249 are not present.	3×10^{-9}		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}	

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

(a) If the identity and concentration of each radionuclide in the mixture are known, the limiting values shall 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 Table 6 of this Part (rule) for the specific radionuclide when not in a mixture. The sum of such ratios for all radionuclides in the mixture may not exceed "1" (i.e., "unity").

(i) Example: If radionuclides A, B and C are present in concentrations CA, CB and CC, and if the applicable MPC's are MPCA, MPCB and MPCC, respectively, then the concentrations shall be limited so that the following relationship exists:

$$\frac{CA}{MPCA} + \frac{CB}{MPCB} + \frac{CC}{MPCC} \leq 1$$

(b) If either the identity or the concentration of any radionuclide in the mixture is not known, the limiting values for the purposes of Table 6 shall be:

(i) For purposes of Schedule I, Column 1 — 6×10^{-13}

(ii) For purposes of Schedule I, Column 2 — 4×10^{-7}

(iii) For purposes of Schedule II, Column 1 — 2×10^{-14}

(iv) For purposes of Schedule II, Column 2 — 3×10^{-8}

(c) If any of the conditions specified below are met, the corresponding values specified below may be used in lieu of those specified in note (5) (b), above.

(i) 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 Table 6 for the radionuclide in the mixture having the lowest concentration limit; or

(ii) If the identity of each radionuclide in the mixture is not known, but it is known that certain radionuclides specified in Table 6 are not present in the mixture, the concentration limit for the mixture is the lowest concentration limit specified in Table 6 for any radionuclide which is not known to be absent from the mixture; or

(d) If the mixture of radionuclides consists of Uranium and its daughter products in ore dust prior to chemical processing of the Uranium ore, the values specified below may be used in lieu of those determined in accordance with note (5) (a) above or those specified in notes (5) (b) and (5) (c) above.

(i) For purposes of Schedule I, Column 1 — 1×10^{-10} μCi/ml gross alpha activity; or 5×10^{-11} μCi/ml natural Uranium; or 75 micrograms per cubic meter of air natural Uranium.

(ii) For purposes of Schedule II, Column 1 — 3×10^{-12} μCi/ml gross alpha activity or 2×10^{-12} μCi/ml natural Uranium; or 3 micrograms per cubic meter of air natural Uranium.

(e) For purposes of this Note, a radionuclide may be considered as not present in a mixture if (i) the ratio of the concentration of that radionuclide in the mixture (CA) to the concentration limit for that radionuclide specified in Schedule II, of Table 6 (MPCA) does not exceed 1/10, (i.e. $\frac{CA}{MPCA} \leq \frac{1}{10}$) and (ii) the sum of such ratios for all radionuclides considered as not present in the mixture does not exceed ¼ (i.e. $\frac{CA}{MPCA} + \frac{CB}{MPCB} + \ldots < \frac{1}{4}$).

TABLE 7

QUANTITIES APPLICABLE TO POSTING AND DISPOSAL REQUIREMENTS

Radioactive Materials	*Micro-curies*
Americium 241	0.01
Antimony 122	100
Antimony 124	10
Antimony 125	10
Arsenic 73	100
Arsenic 74	10
Arsenic 76	10
Arsenic 77	100
Barium 131	10
Barium 133	10
Barium 140	10
Bismuth 210	1
Bromine 82	10
Cadmium 109	10
Cadmium 115m	10
Cadmium 115	100
Calcium 45	10
Calcium 47	10
Carbon 14	100
Cerium 141	100
Cerium 143	100
Cerium 144	1
Cesium 129	100
Cesium 131	1,000
Cesium 134m	100
Cesium 134	1
Cesium 135	10
Cesium 136	10
Cesium 137	10
Chlorine 36	10
Chlorine 38	10
Chromium 51	1,000
Cobalt 57	100
Cobalt 58m	10
Cobalt 58	10
Cobalt 60	1
Copper 64	100
Dysprosium 165	10
Dysprosium 166	100
Erbium 169	100
Erbium 171	100
Europium 152 9.2 h	100
Europium 152 13 yr	1
Europium 154	1
Europium 155	10
Fluorine 18	1,000
Gadolinium 153	10
Gadolinium 159	100
Gallium 67	100
Gallium 72	10
Germanium 71	100
Gold 198	100
Gold 199	100

Radioactive Materials	*Micro-curies*
Hafnium 181	10
Holmium 166	100
Hydrogen 3	1,000
Indium 111	100
Indium 113m	100
Indium 114m	10
Indium 115m	100
Indium 115	10
Iodine 123	100
Iodine 125	1
Iodine 126	1
Iodine 129	0.1
Iodine 131	1
Iodine 132	10
Iodine 133	1
Iodine 134	10
Iodine 135	10
Iridium 192	10
Iridium 194	100
Iron 52	10
Iron 55	100
Iron 59	10
Krypton 85	100
Krypton 87	10
Lanthanum 140	10
Lutetium 177	100
Manganese 52	10
Manganese 54	10
Manganese 56	10
Mercury 197m	100
Mercury 197	100
Mercury 203	10
Molybdenum 99	100
Neodymium 147	100
Neodymium 149	100
Nickel 59	100
Nickel 63	10
Nickel 65	100
Niobium 93m	10
Niobium 95	10
Niobium 97	10
Osmium 185	10
Osmium 191m	100
Osmium 191	100
Osmium 193	100
Palladium 103	100
Palladium 109	100
Phosphorus 32	10
Platinum 191	100
Platinum 193m	100
Platinum 193	100
Platinum 197m	100
Platinum 197	100

TABLE 7 — (Continued)
(QUANTITIES APPLICABLE TO POSTING AND DISPOSAL REQUIREMENTS)

Radioactive Materials	*Micro-curies*
Plutonium 239	0.01
Polonium 210	0.1
Potassium 42	10
Potassium 43	10
Praseodymium 142	100
Praseodymium 143	100
Promethium 147	10
Promethium 149	10
Radium 226	0.01
Rhenium 186	100
Rhenium 188	100
Rhodium 103m	100
Rhodium 105	100
Rubidium 81	10
Rubidium 86	10
Rubidium 87	10
Ruthenium 97	100
Ruthenium 103	10
Ruthenium 105	10
Ruthenium 106	1
Samarium 151	10
Samarium 153	100
Scandium 46	10
Scandium 47	100
Scandium 48	10
Selenium 75	10
Silicon 31	100
Silver 105	10
Silver 110m	1
Silver 111	100
Sodium 22	10
Sodium 24	10
Strontium 85	10
Strontium 89	1
Strontium 90	0.1
Strontium 91	10
Strontium 92	10
Sulphur 35	100
Tantalum 182	10
Technecium 96	10
Technetium 97m	100
Technetium 97	100
Technetium 99m	100
Technetium 99	10
Tellurium 125m	10
Tellurium 127m	10
Tellurium 127	100
Tellurium 129m	10
Tellurium 129	100
Tellurium 131m	10
Tellurium 132	10
Terbium 160	10
Thallium 200	100
Thallium 201	100
Thallium 202	100
Thallium 204	10
Thorium (natural)	100
Thulium 170	10
Thulium 171	10
Tin 113	10
Tin 125	10
Tungsten 181	10
Tungsten 185	10
Tungsten 187	100
Uranium (natural)	100
Uranium 233	0.01
Uranium 234-Uranium 235	0.01
Vanadium 48	10
Xenon 131m	1,000
Xenon 133	100
Xenon 135	100
Ytterbium 175	100
Yttrium 87	10
Yttrium 90	10
Yttrium 91	10
Yttrium 92	100
Yttrium 93	100
Zinc 65	10
Zinc 69m	100
Zinc 69	1,000
Zirconium 93	10
Zirconium 95	10
Zirconium 97	10
Any alpha-emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition	0.01
Any radionuclide other than alpha-emitting radionuclides not listed above or mixtures of beta emitters of unknown composition	0.1

TABLE 7 — (Continued)
(QUANTITIES APPLICABLE TO POSTING AND DISPOSAL REQUIREMENTS)

Notes: 1. For the purpoces of section 38.31, subdivision (b), paragraph (4) and section 38.31, subdivision (c) where there is present more than one radionuclide in known amounts, the limit for the combination shall be derived as follows:

(i.) Determine for each radionuclide present the following quotient: Set the numerator equal to the quantity of the radionuclide present and the denominator equal to the quantity listed in Table 7 of this Part (rule). The sum of such quotients shall exceed ten for section 38.31, subdivision (b), paragraph (4), subparagraph (i) of this Part (rule) and 100 for section 38.31, subdivision (b), paragraph (4), subparagraph (ii) of this Part (rule).

(a) Example:

$$\frac{\text{Quantity of Radionuclide A Present}}{\text{Quantity of Radionuclide A Listed in Table 7}} + \frac{\text{Quantity of Radionuclide B Present}}{\text{Quantity of Radionuclide B Listed in Table 7}} + \cdots\cdots\cdots$$

* 10 for 38.31 (b) (4) (i)
100 for 38.31 (b) (4) (ii)

TABLE 8
APPROVALS

Item (a) — Reagent Kits. Reagent Kits for use with certain radiopharmaceuticals by Group III medical licensees shall be approved by the commissioner.

Note: Group III medical licenses authorize the use of generators and approved reagent kits for the preparation and use of radiopharmaceuticals for diagnostic uses.

APPENDIX A

SPECIFIC REQUIREMENTS FOR INDUSTRIAL RADIOGRAPHY

A.1 Purpose. The requirements in this Appendix are established for persons utilitzing radiation sources for industrial radiography. The requirements in this Appendix are in addition to, and not in substitution of, the requirements of this Part (rule).

A.2 Definitions. As used herein, the following terms mean:

(a) *Cabinet radiography using radiation equipment.* Industrial radiography using radiation equipment which is conducted in an enclosed, interlocked cabinet such that the radiation equipment will not operate unless all openings are securely closed and the cabinet is so shielded that it meets the conditions of Exemption 11, Table 1 of this Part (rule).

(b) *Industrial radiography.* The examination of the microscopic or macroscopic structure of materials by nondestructive methods utilizing radiation sources.

(c) *Radiographer.* Any individual who performs or who, in attendance at the site where sources of radiation are being used, personally supervises industrial radiographic operations and who is responsible to the licensee or registrant for assuring compliance with the provisions of this Part (rule) and all license conditions.

(d) *Radiographer's assistant.* Any individual who, under the personal supervision of a radiographer, uses sources of radiation, related handling tools or survey instruments in industrial radiography.

(e) *Radiographic exposure device.* Any instrument containing a sealed source fastened or contained therein, in which the sealed source or shielding thereof may be removed or otherwise changed from a shielded to an unshielded position for purposes of making a radiographic exposure.

(f) *Shielded room radiography using radiation equipment.* Industrial radiographic operations using radiation equipment which are conducted in an enclosed room, the interior of which is not occupied during any radiographic operation, which is so shielded that every location on the exterior of such room meets the requirements of this Part (rule) for an uncontrolled area, and the only access to such room is through openings which are interlocked so that the radiation equipment will not operate unless all such openings are securely closed.

A.3 Equipment control. (a) *Limits on levels of radiation for radiographic exposure devices and storage cabinets.* Radiographic exposure devices measuring less than four inches from the sealed source storage position to any exterior surface of such device shall have no radiation level in excess of 50 milliRoentgens per hour at six inches from any exterior surface of the device. Any radiographic exposure device measuring four inches or more from the sealed source storage position to any exterior surface of such device, and any storage container for a sealed source or any outer container for a radiographic exposure device shall have no radiation level in excess of 200 milliRoentgens per hour at any exterior surface and ten milliRoentgens per hour at one meter from any such exterior surface. The radiation levels specified are with the sealed sources in the shielded (i.e. "off") positions.

(b) *Locking of sources of radiation.* Each source of radiation shall be provided with a lock or outer-locked container designed to prevent unauthorized or accidental production of radiation or the removal or exposure of any sealed source. Any such radiation source shall be kept locked at all times except when under the direct surveillance of a radiographer or radiographer's assistance, or as may be otherwise authorized pursuant to section A.5, subdivision (a) of this Appendix. Each storage container shall also be provided with a lock and shall be kept locked when containing sealed sources except when the container is under the direct surveillance of a radiographer or radiographer's assistant.

(c) *Storage precautions.* Locked radiographic exposure devices and storage containers shall be kept physically secured to prevent tampering or removal by unauthorized persons.

(d) *Radiation survey instruments.* The licensee or registrant shall maintain sufficient calibrated and operable radiation survey instruments to make the required surveys. Each radiation survey instrument shall be calibrated at intervals not to exceed three months and after each instrument servicing and a record maintained of the latest date of calibration. Instrumentation required by this subdivision shall have a minimum range such that two milliRoentgens per hour through one Roentgen per hour can be measured.

(e) *Leak testing, repair, tagging, opening, modification and replacement of sealed sources.*

(1) The replacement of any sealed source fastened to or contained in a radiographic exposure device and leak testing, repair, tagging, opening or any other modification of any sealed source shall be performed only by persons specifically authorized to do so by the commissioner, the State Department of Health, the New York City Department of Health, the United States Nuclear Regulatory Commission or any agreement State.

(2) Each sealed source shall be tested for leakage at intervals not to exceed six months. In the absence of a certificate from a transferor that a test has been made within the six-month period prior to transfer, the sealed source shall not be put into use until tested.

(3) The leak test shall be capable of detecting the presence of 0.005 microcurie of removable contamination on the sealed source. An acceptable leak test for sealed sources in the possession of a radiography licensee would be to test at the nearest accessible point to the sealed source storage position, or other appropriate measuring point, by a procedure specified in a license issued by the commissioner, the State Department of Health, the New York City Department of Health, the United States Nuclear Regulatory Commission or any agreement State. Records of leak test results shall be kept in units of microcuries and shall be available for examination by the commissioner.

(4) Any test conducted pursuant to paragraphs (2) and (3) above, which reveals the presence of 0.005 microcurie or more of removable radioactive material shall be considered as evidence that the sealed source is leaking. The licensee shall immediately withdraw the equipment involved from use

and shall cause it to be decontaminated and repaired or to be disposed of in accordance with the requirements of this Part (rule). Within five days after obtaining results of the test, the licensee shall file a report with the commissioner describing the equipment involved, the test results and the corrective action taken.

(5) A sealed source which is not fastened to or contained in a radiographic exposure device shall have permanently attached to it a durable tag at least 2.54 centimeters square (one inch square) bearing the prescribed radiation symbol in accordance with this Part (rule) and with at least the instructions, "DANGER — RADIOACTIVE MATERIAL -- DO NOT HANDLE — NOTIFY CIVIL AUTHORITIES IF FOUND".

(f) *Quarterly inventory.* Each licensee or registrant shall conduct a quarterly physical inventory to account for all radiation sources received or possessed by him. The records of such inventories shall be kept available for examination by the commissioner and such records shall include Model No. and Serial No., the quantities and kinds of radioactive material, the location of all radiation sources, the number, make, Model No. and Serial No. of any radiation equipment and the date of the inventory.

(g) *Utilization logs.* Each licensee or registrant shall maintain current logs, which shall be kept available for examination by the commissioner. Such logs shall show the following for each radiation source:

(1) A description (or make and model number) of each radiation source or storage container in which the sealed source is located.

(2) The identity of the radiographer to whom the source is assigned.

(3) The plant or site where the source is used and the dates of use.

(4) The voltage, current and exposure time for each radiographic exposure employing radiation equipment.

(h) *Inspection and maintenance of radiographic exposure devices, storage containers and radiation equipment.* Each licensee or registrant shall conduct a program for inspection and maintenance of radiographic exposure devices, storage containers and radiation equipment on a daily and quarterly basis when in use to assure proper functioning of components important to health and safety.

A.4 Radiation safety requirements for radiographers and radiographers' assistants.

(a) *Limitations.* (1) No licensee or registrant shall permit any individual to act as a radiographer as defined in this Appendix until such individual has:

(i) Been instructed in the subjects outlined in section A. 4, subdivision (b) of this Appendix and demonstrated an understanding thereof.

(ii) Received copies of and instruction in the regulations contained in this Appendix and the applicable sections of this Part (rule), his license and the licensee's or registrant's operating and emergency procedures and demonstrated an understanding thereof.

(iii) Demonstrated competence to use the radiation source, related handling tools and survey instruments which will be employed in his assignment.

(2) No licensee or registrant shall permit any individual to act as a radiographer's assistant as defined in this Appendix until such individuals has:

(i) Received copies of and instruction in the licensee's or registrant's operating and emergency procedures and demonstrated an understanding thereof.

(ii) Demonstrated competence to use under the personal supervision of the radiographer the sources of radiation, related handling tools and radiation survey instruments which will be employed in his assignment.

(b) *Instruction of radiographers.* The instruction of radiographers shall cover, but not be limited to, the following:

(1) Fundamentals of radiation safety.

(i) Characteristics of gamma and X-radiation

(ii) Units of radiation dose (mrem) and quantity of radioactivity (Curie).

(iii) Hazards of excessive exposure to radiation.

(iv) Levels of radiation from sources of radiation.

(v) Methods of controlling radiation dose: working time, working distances and shielding.

(2) Radiation detection instrumentation to be used.

(i) Use of radiation survey instruments: operation, calibration, limitation.

(ii) Survey techniques.

(iii) Use of personnel monitoring equipment: film badges, pocket dosimeters, pocket chambers and thermoluminescent dosimeters.

(3) Radiographic equipment to be used.

(i) Remote handling equipment.

(ii) Radiographic exposure devices and sealed sources.

(iii) Storage containers.

(iv) Operation and control of X-ray equipment.

(4) The requirements of pertinent Federal and State regulations.

(5) The licensee's or registrant's written operating and emergency procedures.

(c) *Operating and emergency procedures.* The licensee's or registrant's operating and emergency procedures shall include instructions in at least the following:

(1) The handling and use of radiation sources to be employed such that no individual is likely to be exposed to radiation doses in excess of the limits established by this Part (rule).

(2) Methods and occasions for conducting radiation surveys.

(3) Methods for controlling access to radiographic areas.

(4) Methods and occasions for locking and securing radiation sources.

(5) Personnel monitoring and the use of personnel monitoring equipment.

(6) Transportation to field locations, including packing of radiation sources in the vehicles, posting of vehicles, and control of radiation sources during transportation.

(7) Minimizing exposure of individuals in the event of an accident.

(8) The procedure for notifying proper persons in the event of an accident.

(9) Maintenance of records.

(d) *Personnel monitoring control.* (1) No licensee or registrant shall permit any individual to act as a radiographer or as a radiographer's assistant unless, at all times during radiographic operations, each such individual shall wear either a film badge or thermoluminescent dosimeter and either a pocket dosimeter or pocket chamber. Pocket dosimeters and pocket chambers shall be capable of measuring doses from zero to at least 200 milliRoentgens. A film badge or thermoluminescent dosimeter shall be assigned to and worn by only one individual.

(2) Pocket dosimeters and pocket chambers shall be read and doses recorded daily. A film badge or thermoluminescent dosimeter shall be immediately processed if a pocket dosimeter or pocket chamber is discharged beyond its range. The film badge or thermoluminescent dosimeter reports received from the film badge or thermoluminescent dosimeter processor and records of pocket dosimeter and pocket chamber readings shall be kept available for examination by the commissioner.

A.5 Precautionary procedures in radiographic operations.

(a) *Security.*

(1) At least two individuals, one of whom shall be a qualified radiographer, the other shall be a qualified radiographer or qualified radiographer's assistant shall be assigned to each radiographic operation involving radioactive material, unless specific exemption from this requirement has been granted by the commisssioner.

(2) During each radiographic operation, the radiographer or radiographer's assistant shall maintain direct surveillance of the operation to protect against unauthorized entry into a high radiation area, except:

(i) where the high radiation area is equipped with a control device or an alarm system as described in section 38.31, subdivision (c) of this Part (rule), or

(ii) where the high radiation area is locked to protect against unauthorized or accidental entry.

(b) *Posting.* Notwithstanding any provisions in section 38.31, subdivision (c), paragraph (2) of this Part (rule), areas in which field radiography is being performed shall be conspicuously posted at the 2 mill'Roentgens per hour isodose line as required by section 38.31 of this Part (rule).

(c) *Radiation surveys and survey records.* (1) No radiographic operations shall be conducted unless calibrated and operable radiation survey instrumentation as described in section A.3, subdivision (d) of this Appendix is available and used at each site where radiographic exposures are being made.

(2) A physical radiation survey shall be made after each radiographic exposure utilizing radiographic exposure devices or sealed sources of radioactive material to determine that the sealed source has been returned to its shielded condition.

(3) A physical radiation survey shall be made to determine that each sealed source is in its shielded condition prior to securing the radiographic exposure device or storage container as specified in section A.3, subdivision (b) of this Appendix.

(4) Records shall be kept of the surveys required by paragraph (3) of this subdivision and shall be kept available for examination by the commissioner.

(d) *Special requirements for radiography employing radiation equipment.*

(1) Cabinet radiography. Cabinet radiography using radiation equipment shall be exempt from other requirements of this Appendix. However, no registrant shall permit any individual to operate a cabinet radiography unit until such individual has received a copy of, and instruction in, and demonstrated an understanding of, operating procedures for such unit, and has demonstrated competence in its use.

(2) Shielded room radiography. Shielded room radiography using radiation equipment shall be exempt from other requirements of this Appendix, however:

(i) No registrant shall permit any individual to operate radiation equipment for shielded room radiography until such individual has received a copy of, and instruction in, and demonstrated an understanding of, operating procedures for such unit, and has demonstrated competence in its use.

(ii) Each registrant shall supply appropriate personnel monitoring equipment to, and shall require the use of such equipment by, every individual who operates, who makes "set-ups" or who performs maintenance on a radiation machine for shielded room radiography.

(iii) The registrant shall comply with all other applicable requirements of this Part (rule).

(3) Other radiography using radiation equipment shall exempt from section A.3, subdivision (a), (c) and (e) and section A.5, subdivision (c) of this Appendix, however:

(i) A physical radiation survey shall be conducted to determine that the radiation machine is "off" prior to each entry into the radiographic exposure area. Such surveys shall be made with a radiation measuring instrument capable of measuring radiation of the energies and at the dose rates to be encountered, which is in good working order and which has

been properly calibrated within the preceding three months or following the last instrument servicing, whichever is later. Survey results and records of boundary locations shall be maintained and kept available for examination by the commissioner.

(ii) Mobile or portable radiation machine shall be physically secured to prevent removal by unauthorized persons.

(iii) The registrant shall comply with all other applicable requirements of this Part (rule).

REFERENCE 4

6/19/77

DECONTAMINATION CRITERIA FOR WELDON SPRING CHEMICAL PLANT

INTRODUCTION

A study of available regulations and reports was undertaken to develop criteria which could be recommended for decontamination of facilities, soil, silt, underground sewers and equipment at the U.S. Army Weldon Spring Chemical Plant. The contaminant is believed to be almost entirely uranium which has been separated from its daughter products. This will be determined during the course of subsequent survey work. The proposed criteria are for the unrestricted release of the site.

CONCLUSIONS

For equipment and facilities, including the surfaces of underground sewers, it is recommended that the criteria provided by Regulatory Guide 1.86, Termination of Operating Licenses for Nuclear Reactors be used.

For soil and silt, the recommended release limit is 0.05 percent by weight which is taken from 10 CFR 40, Licensing of Source Material. This value corresponds to 0.15 nCi $^{238}U/g$.

DISCUSSION

Potential Criteria For Equipment and Facilities

Regulatory criteria which establish the "acceptability" of specific levels of contamination as a function of end use are, at best, unclear. 10 CFR 20 does specifically establish maximum permissible levels of uranium in water and air for both occupationally exposed workers and the general public. These regulations do not, however, define the levels at which objects may be removed from a licensed facility, or at what level a facility must be decontaminated for a license to be terminated.

A general health physics guide, now enumerated in 10 CFR 20.1 states that "the licensee shall make every reasonable effort to maintain radiation exposures and releases of radioactive materials in effluent to restricted areas as low as reasonably achievable" (ALARA). Appendix I of 10 CFR 50 has attempted to quantify the "ALARA" value for nuclear power plants. Although not specifically applicable to part 40 licensees, a criteria of $1,000/man-rem has been established as a definition of ALARA for non-occupational exposure in the case of effluents from nuclear power reactors. As a future effort in this study, it is intended to examine the applicability of this criterion to decommissioning of facilities. As far as presently known, the criterion has not been applied in such cases to date.

Regulatory Guide 1.86, Termination of Operating Licenses for Nuclear Reactors, although not specifically intended for source material licenses, describes the procedural approach recommended by the Nuclear Regulatory Commission (NRC) in decommissioning a nuclear facility. This guide also formally presents acceptable levels of surface contamination for release of property and facilities to unrestricted use. This guide specifies for uranium an average acceptable surface contamination level of 5,000 dpm α/100 cm^2. The maximum contamination level may be a factor of 3 greater and the removable contamination may be 1000 dpm α/100 cm^2. The following Table gives values also for Ra-226 and for Thorium. The Table is taken directly from Regulatory Guide 1.86.

TABLE I

ACCEPTABLE SURFACE CONTAMINATION LEVELS

NUCLIDE[a]	AVERAGE[b c]	MAXIMUM[b d]	REMOVABLE[b e]
U-nat, U-235, U-238, and associated decay products	5,000 dpm α/100 cm^2	15,000 dpm α/100 cm^2	1,000 dpm α/100 cm^2
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100 dpm/100 cm^2	300 dpm/100 cm^2	20 dpm/100 cm^2
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1000 dpm/100 cm^2	3000 dpm/100 cm^2	200 dpm/100 cm^2
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5000 dpm $\beta\gamma$/100 cm^2	15,000 dpm $\beta\gamma$/100 cm^2	1000 dpm $\beta\gamma$/100 cm^2

[a] Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

[b] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[c] Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.

[d] The maximum contamination level applies to an area of not more than 100 cm^2.

[e] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

Unrestricted Use Radiological Contamination Limits taken from the Boiling Nuclear Superheater Power Station Deconmmissioning Final Report, September 1, 1970, are reproduced as Table 2. These limits are nearly identical to Regulatory Guide 1.86 and are typical of reactor decommissioning at several sites; Bonus, Elk River, Hallum and Piqua. In the case of the Bonus reactor, a portion of the facility was entombed on site. Each reactor decommissioned (mentioned previously) had a documented decommissioning plan, which included site survey commitments. Following the decommissioning, a final report was issued which included the final survey results. The survey plans were not given in detail, nor di[illegible] appear to be common for all reactors.

Radioactive Commodities in the DOD Supply Systems, November 1976, advocates regulations for uranium, thorium and radium, which are identical to the aforementioned guides in NRC Regulatory Guide 1.86, when applied to the unrestricted release of equipment and facilities.

Proposed American National Standard ANSI N328-197, Control of Radioactive Surface Contamination on Materials, Equipment and Facilities to be Released for Uncontrolled Use, is currently in the final stages of review. Permissible contamination limits, generally the same as Regulatory Guide 1.86, are presented along with the recommended methods to be followed in measuring this contamination. This standard does not apply to contamination dispersed through material or contaminated soil. Specific criteria for release of items are presented. Two appendices describe methods of equipment decontamination and present a hazard analysis of surface contamination levels. This standard, when it becomes effective, will only be a "consensus standard" and will represent "good practice". This will only have the effect of law should the NRC or other regulatory agency reference it in a law or guide. The NRC currently has no plans to incorporate it as a Regulatory Guide, however, the proposed

TABLE 2 — UNRESTRICTED USE RADIOLOGICAL CONTAMINATION LIMITS

Isotope*	Option 1		Option 2	
	Total‡	Removable†‡	Total‡¶	Removable†‡
U nat, U^{235}, U^{233}, Th nat, Th^{232}, and associated decay products	10,000 dpm α/100 cm^2	1000 dpm α/100 cm^2	Avg: 5000 dpm α/100 cm^2 Max: 25,000 dpm α/100 cm^2	1000 dpm α/100 cm^2
Other isotopes which decay by alpha emission or by spontaneous fission	1000 dpm α/100 cm^2	100 dpm α/100 cm^2	Avg: 500 dpm α/100 cm^2 Max: 2500 dpm α/100 cm^2	100 dpm α/100 cm^2
Beta-gamma emitters (isotopes with decay modes other than alpha emission or spontaneous fission)	0.4 mrad/hr at 1 cm**	1000 dpm $\beta\gamma$/100 cm^2	Avg: 0.2 mrad/hr at 1 cm** Max: 1.0 mrad/hr at 1 cm**	1000 dpm $\beta\gamma$/100 cm^2

* Where surface contamination by both alpha and beta-gamma emitting isotopes exists, the limits established for alpha and beta-gamma emitting isotopes shall apply independently.

† The amount of removable radioactive material per 100 cm^2 of surface area shall be determined by wiping that area with dry filter or soft absorbent paper and with the application of moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. In determining removable contamination on objects of lesser surface area, the pertinent levels shall be reduced proportionally, and the entire surface shall be wiped.

‡ As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector and count rate meter, for background, efficiency, and geometric factors associated with the instrumentation.

¶ Measurements of total contaminant shall not be averaged over more than 10 square meters. For objects of lesser surface area, the average shall be derived for each such object.

**Measured through not more than 7 mg/cm^2 of total absorber.

Note: Either Option 1 or Option 2 may be used. For example, if all beta-gamma readings were less than 0.4 mrad/hr at 1 cm, Option 1 could be used; but if the maximum reading were 0.8 mrad/hr, material could be released under Option 2, providing the average was less than 0.2 mrad/hr.

limits for uranium are the same as those included in Regulatory Guide 1.86.

Regulatory Guide 10.4 is the Guide for the Preparation of Application for Licenses to Process Source Material. Although this guide does not apply to activities related to the reactor fuel cycle, it does give the NRC's viewpoint or items it needs to consider to review the users' radiation safety program. The guidelines presented here are the same as those presented in NRC Regulatory Guide 1.86 for acceptable levels of surface contamination.

There seems to be adequate precedent for Uranium for using an average acceptable surface contamination level of 5,000 dpm α/100 cm^2 for unrestricted release of equipment and buildings. The maximum contamination level would be 15,000 dpm α/100 cm^2 and the average may be over an area of 1 square meter. Removable contamination may be 1000 dpm α/100 cm^2.

Potential Soil Criteria

Regulations:

For transportation purposes, Army regulations define 0.002 µCi/gram as the boundary between radioactive and non-radioactive solids. The Department of Transportation (DOT) also uses 0.002 µCi/gram in granting an exemption from special transportation requirements.

10 CFR 40.4 defines "source material" as any combination of uranium, or thorium in any chemical or physical form or ores, which are greater than 0.05 percent in weight. This same definition is also called an "unimportant quantity" in part 40.13. This value could potentially be used for soil contamination levels. For U-238, this corresponds to 1.5×10^{-4} µCi/g. The regulation clearly states that at this activity level no license is required for possession and use of the material. There are no restrictions placed on the use of

such material.

Guidelines for Clean-Up of Uranium Tailings from Inactive Mills:

The report found the limiting pathway of exposure to be diffusion of Rn-222. Because the uranium in this case is in equilibrium with its daughters, the limit is based on Ra-226. The limit proposed for unrestricted use is 0.5 pCi/g. The recommendation is also made that each parent of Ra-226 be limited to the same value "so that future problems caused by Ra-226 in-growth are avoided". This value seems unduly restrictive for application to U-238, which has been separated from long-lived daughter products in that approximately 10^5 years will be required for 0.5 pCi/g of U-238 + U-234 to yield 0.4 pCi/g of Ra-226. This report chooses a resuspension factor of 3×10^{-6} from the work of Healy for evaluation of the airborne particulate hazard.

Colorado's Plutonium-In-Soil Standard:

The State of Colorado adopted a standard in 1973 for plutonium contained in soil. This standard utilizes resuspension factors for plutonium from soil to air, considers the radiobiological risk associated with general public exposure to plutonium, and uses the philosophy to keep public exposure to a minimum. The standard that was established was 2 dpm/g dry soil or 0.01 $\mu Ci/m^2$.

The report presents measurements of plutonium in soil and in air for quiescent conditions. Following a recommendation of EPA for conditions where local disturbances were routine and of high frequency, they adjust the resuspension factor by a factor of 100. They use the adjusted resuspension term of $1 \times 10^{-7}/m$. They also take credit for a reduction in "surface" contamination by a factor of 10 based on agricultural plowing in the area.

A Proposed Interim Standard for Plutonium in Soils:

The extensive review and treatment of data on resuspension appears to be applicable to the evaluation of hazards of Uranium in soil. For the long term average conservative value, a resuspension factor of 3×10^{-6}/m is chosen for the upper 0.1 cm layer of soil. Using the 10 CFR 20 non-occupational exposure limit of 3×10^{-12} μCi/cc and dividing by three for average population exposure yields a permissible level in soil of 0.33 μCi/cc U-238/m^2 for the upper layer of soil. This limit would correspond to 2×10^{-4} μCi U-238/g for the upper 0.1 cm of soil using a soil density of 1.6 g/cc. Healy allowed a factor of 10 increase in contamination with depth in soil. Thus, for any 1 cm depth in soil, the inferred limit for U-238 would be 2×10^{-3} μCi/g.

Criteria for Radioactive Clean-Up in Canada

Canada established criteria for the decontamination of facilities and property involving uranium mill tailings. These critieria are applicable for cases in which uranium is in equilibrium with its daughter products. The principal hazard is taken to be radon daughters from the viewpoint of inhalation. Criteria were established for external gamma radiation also. The primary clean-up criterion for radon daughter products is 0.02WL, and that for gamma radiation is 0.05 mR/hr indoors and 0.1 mR/hr outdoors. In addition, if contamination is found that was introduced by human activities, it should, where practicable, be removed to an approved waste site. Additional criteria were established for prompt interim action and an investigation level.

Engineering Assessment of Inactive Uranium Mill Tailings, Shiprock, New Mexico

Radiological criteria established for this engineering assessment are divided into two general categories:

1) Criteria applicable to structures with tailings underneath them or

within 10 feet

2) Criteria pertaining to the mill tailings site and open land

The criteria utilized for habitable structures are the guidelines published by the Surgeon General of the United States for use in the Grand Junction, Colorado, remedial program. These guidelines recommend graded levels (based on yearly average values) for remedial action in terms of the external gamma radiation (EGR) levels and of the indoor radon daughter concentration (RDC) levels above background found within dwellings constructed on or near uranium mill tailings.

The recommended graded levels are as follows:

EGR	RDC	Recommendations
Greater than 0.1 mR/hr*	Greater than 0.05 WL	Remedial action indicated
From 0.05 to 0.1 mR/hr	From 0.01 to 0.05 WL	Remedial action may be suggested
Less than 0.05 mR/hr	Less than 0.01 WL	No remedial action indicated

The criteria for land decontamination have the objective to reducing residual gamma radiation to levels which are as low as practicable. However, topographic and economic considerations frequently preclude complete decontamination. A provisional maximum of 40 μR/hr above background is used in such circumstances. Average background in the Shiprock area was determined in this study to be 9 μR/hr. As a guideline for the land beyond the site, if residual gamma levels are less than 10 μR/hr above background, the land may be released for unrestricted use. Where cleanup is necessary the radium content of the soil should be reduced to no more than twice the radium background in the area. If the radio-

*1 mR/hr = 1,000 μR/hr

active tailings material is stabilized in place, the same criteria apply but control of gamma radiation would be by an earth covering. However, the area should be designated by a controlled area, be fenced to limit access, and be restricted as to human occupancy. The numerical guidelines provide a basis for the engineering assessment, but are subject to review based on the overall findings of Phase II.

Report by the AEC Task Group for Cleanup and Rehabilitation of Enewetak Atoll

The criteria established were for weapons test debris primarily Cs, Sr, and Pu. The primary exposure pathway was estimated to be ingestion of contaminated foodstuffs grown locally. The basic guidance was derived from the work of the Federal Radiation Council. The resulting guides for planning cleanup actions reported were:

Whole Body and Bone Marrow	0.25 Rem/yr
Thyroid	0.75 Rem/yr
Bone	0.75 Rem/yr
Gonads	4 Rem in 30 yr

Since there is no adequate scientific information which would support general guidance for cleanup of plutonium contaminated soil, guidance can only be developed on a case-by-case basis using conservative assumptions and safety factors. With this in mind, the Task Group recommends the following for use in making decisions concerning ^{239}Pu cleanup operations at Enewetak:

1) <40 pCi/gm of soil - corrective action not required
2) 40 to 400 pCi/gm of soil - corrective action determined on a case-by-case basis*, considering all radiological conditions
3) >400 pCi/gm of soil - corrective action required

Since the primary consideration was exposure via the ingestion pathway, there

appears to be no applicability to the cleanup of uranium.

NCRP Report No. 50, Environmental Radiation Measurements

This report provides data on the abundance of naturally occurring radionuclides in soil and in rocks. For U-238, the values in soil range from 0.3 to 1.3 pCi/g.

SUMMARY

To compare the various limits which might be applied to U-238 in soil, the following list in the same units is offered:

	nCi U-238/g soil
Non-radioactive solids for purposes of transportation	2
Exempt from licensing as source material	0.15
Suggestions for U tailings based on Ra-226	0.0005
Calculation based on Iterim Standard for Pu	0.2
Surface contamination of 5,000 d/m/100 cm^2	0.14
Typical soil content	0.001

In conclusion, the recommended release limit of U-238 in soil is the value taken from 10 CFR 40, as being exempt from licensing or any other requirements. This value of 0.15 nCi/g is in close agreement with the value calculated based on theoretical considerations and Healy's report. It also corresponds almost exactly with the 5,000 α/dpm/100 cm^2 for release of equipment assuming the contaminant is in the upper 1 mm of soil. The use of 10 CFR 40 has the merit of being a regulation; the calculations would be additional back-up support.

U.S. NUCLEAR REGULATORY COMMISSION

REGION I

Report No. 40-501/82-01

Docket No. 40-501

License No. C-5023 Priority _____ Category _____

Licensee: Aluminum Company of America, Buffalo Works

1880 Elmwood Avenue

Buffalo, New York

Facility Name: Gruber Supply Corp./Commercial Pipe and Supply

Inspection at: 1880 Elmwood Avenue/1920 Elmwood Avenue, Buffalo, New York

Inspection conducted: June 29, 1982

Inspector: Jenny M. Johansen July 22, 1982
Jenny M. Johansen, Radiation Specialist date signed
USNRC

Robert F. Kelley, Senior Radiophysicist date signed
State of New York

Approved by: John D. Kinneman 7/28/82
John D. Kinneman, Chief, Materials Section date signed
No. 1

Inspection Summary:

Inspection conducted on June 29, 1982 (Report 40-501/82-01)

Areas Inspected: Special announced closeout inspection of a formerly licensed site engaged in production of magnesium thorium casting alloys, including interviews with current site owners and independent measurements of radiation levels. The Region I inspector was accompanied by a representative of the State of New York.

Results: All thorium had been removed from the site when the licensee vacated the site on June 24, 1958. No radiation levels above background were identified in areas surveyed. The site meets current criteria for release for unrestricted use.

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DETAILS

1. Individuals Contacted

A. Carl Gruber, President
Gruber Supply Corporation
1880 Elmwood Avenue
Buffalo, New York 14207

B. John Hurley, President
Commercial Pipe and Supply
1920 Elmwood Avenue
Buffalo, New York 14207

2. Background

Aluminum Corporation of America (ALCOA) was licensed for the experimental use and production of magnesium thorium alloys under AEC License No. C-5023 which named ALCOA's Buffalo, New York and Cleveland, Ohio Works as authorized places of use. This license expired February 28, 1961 (see Enclosure A). Information supplied to NRC's Office of State Programs by the State of New York dated September 11, 1980 indicated that ALCOA registered 30 mCi of natural thorium (approximately 594 pounds) pursuant to NYS Industrial Code 38, effective December 15, 1955; however all materials were returned to the A.E.C. prior to June 24, 1958 (See Enclosure B).

New York State performed a close-out survey of the ALCOA Buffalo Works at 1880 Elmwood Avenue, Buffalo, New York, on June 26, 1958 and found no evidence of any radioactivity in any part of the plant. The report also indicates ALCOA vacated the site on June 24, 1958. (See Enclosure B).

3. Inspector's Observations and Interviews with Current Occupants of the Formerly Licensed Site

The site formerly occupied by ALCOA Buffalo works at 1880 Elmwood Avenue, Buffalo, New York has been owned and occupied by Gruber Supply Corporation since March 1, 1973. The facility consists of a two story office/store building (approximately 7,000 ft^2) connected by a loading dock/skylight storage area (approximately 9,000 ft^2) to a large warehouse (approximately 67,500 ft^2). The construction of the facility is brick on concrete slab. The warehouse area is in part subdivided into smaller storage rooms. (See Enclosure C) the warehouse area is used for storage of plumbing and bathroom fixtures.

The inspectors met with individual A and discussed the scope and purpose of their visit. Individual A provided the inspectors with a site diagram and granted permission for a survey of the site. He suggested the inspectors contact individual B since the ALCOA foundry site had also included the warehouse building at 1920 Elmwood Avenue which shares a common wall and is directly adjacent to 1880 Elmwood Avenue. (See Enclosure C).

The inspectors contacted individual B, discussed the background, purpose and scope of the inspection. Individual B granted permission for a survey of his warehouse.

The warehouse building (approximately 22,500 ft^2) at 1920 Elmwood Avenue shares an approximately 75 foot length along its southern walls in common with 1880 Elmwood. The building walls are brick and the floor is cement slab in some areas. This warehouse building is currently being used for storage of various size pipe.

4. Independent Measurements

The inspectors were accompanied during their surveys by individual A at 1880 Elmwood Avenue and individual B at 1920 Elmwood Avenue. Radiation levels were measured at knee level using a Ludlum Model 12S MicroR meter calibrated April 19, 1982.

1880 Elmwood Avenue: Radiation levels ranged from 4 to 8 microroentgens per hour in the offices, hallways and store areas, from 6 - 10 microroentgens per hour in the loading dock skylight, storage rooms and total warehouse area. Radiation levels increased up to 16 microroentgens per hour when the survey meter was placed directly on the brick walls. Radiation levels ranged from 6 - 10 microroentgens per hour in the outside environs 5 to 20 feet from the walls of the buildings on the site.

1920 Elmwood Avenue: Radiation levels ranged from 6 - 10 microroentgens per hour within the warehouse building with an increase up to 16 microroentgens per hour when the survey meter was placed directly on the brick walls. Radiation levels in the outside environs 5 to 20 feet from the walls of the warehouse ranged from 6 - 10 microroentgens per hour.

5. Exit Interviews

The inspectors reviewed the scope and results of their findings separately with individuals A and B.

6. Conclusion

Radiation levels measured at 1880 and 1920 Elmwood Avenue are indicative of the natural background of the site.

The site meets current NRC criteria for release for unrestricted use.

Enclosure A
Region I Report 40-501/82-01

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON 25, D.C.

IN REPLY REFER TO:
40-501
LRL:ND

SOURCE MATERIAL LICENSE

License No. C-5023

Dated: FEB 11 1960

Aluminum Company of America
1145 Wilshire Boulevard
Los Angeles 17, California

Attention: Mr. R. H. Zanes

Gentlemen:

Pursuant to the Atomic Energy Act of 1954 and Section 40.21 of the Code of Federal Regulations, Title 10 - Atomic Energy, Chapter 1, Part 40 - Control of Source Material, you are hereby licensed to receive possession of and title to sixteen hundred (1,600) pounds of source material for experimental use and for the production of magnesium thorium casting alloys, in accordance with the procedures described in your application of February 28, 1958 and your letter of March 24, 1958. This license extends to your Buffalo, N.Y. Works and Cleveland, Ohio, Works.
You are further licensed to transfer and deliver possession of and title to refined source material to any person licensed by the Atomic Energy Commission, within the limits of his license.

As a condition of this license, you are required to maintain records of your inventories, receipts and transfers of refined source material.

This license is subject to all the provisions of the Atomic Energy Act of 1954 now or hereafter in effect and to all valid rules and regulations of the U. S. Atomic Energy Commission, including 10 CFR 20, "Standards For Protection Against Radiation."

Neither this license nor any right under this license shall be assigned or otherwise transferred in violation of the provisions of the Atomic Energy Act of 1954.

This license shall expire February 28, 1961.

FOR THE ATOMIC ENERGY COMMISSION

J. C. Delaney
Chief, Nuclear Materials Section
Licensing Branch
Division of Licensing & Regulation

DEPARTMENT OF LABOR — INTER-OFFICE MEMORANDUM

Enclosure B

B-123-58 2 Region I Report 40-501/82-01

To: Dr. Morris Kleinfeld, Director — Office: Industrial Hygiene Buffalo

From: Dr. Albert J. Bosso, Assoc. Industrial Hygiene Physician — Date: July 10, 1958

Subject: Aluminum Company of America - Reg. #0142
1880 Elmwood Ave.
Buffalo, N. Y.

Date of visit: June 26, 1958
Visited by: C. F. Candee, Radiophysicist
Person interviewed: Jos. Sciascia, Maintenance Foreman
Reason for visit: On request of the company to check the buildings for possible contamination.

REPORT

This company vacated the premises on June 24, 1958. Thorium alloys had been used in the manufacture of aluminum castings. All residual radioactive materials have been returned to the A.E.C. The 140 K.V.P. G. E. X-ray unit still remains in the plant subject to sale.

CONCLUSION

There is no evidence of radioactivity in any part of the plant.

RECOMMENDATION

None.

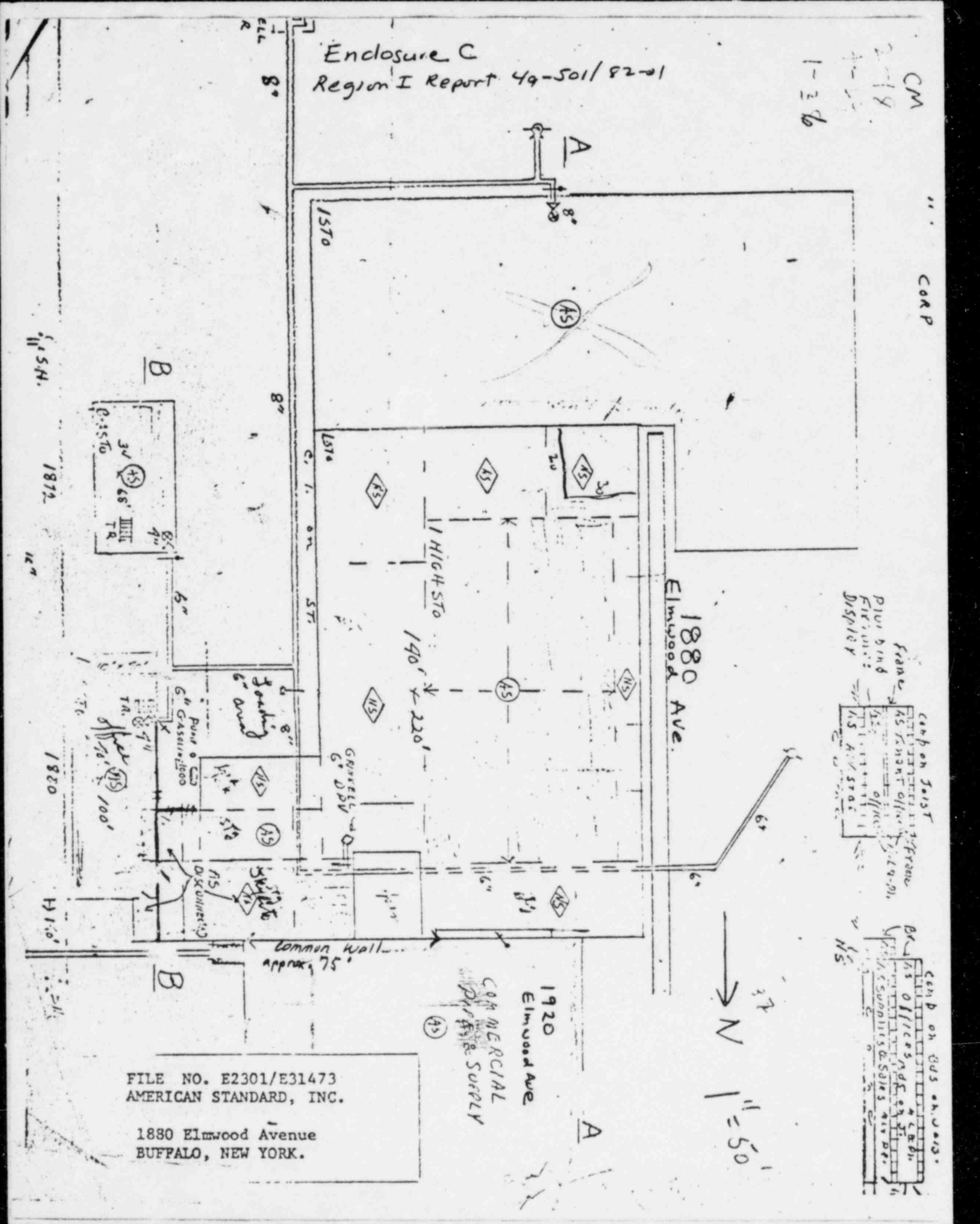
Cornelius F. Candee
Radiophysicist

Albert J. Bosso, M.D.
Assoc. Industrial Hygiene Physician

B:L
CFC

GA-109 (10-53)

Enclosure C
Region I Report 49-501/82-01



FILE NO. E2301/E31473
AMERICAN STANDARD, INC.

1880 Elmwood Avenue
BUFFALO, NEW YORK.