Alpha Monitoring and Control & Radioactive Material Monitoring and Control Guidelines Updates

Jeffrey J CADY, MS, CHP – jcady@epri.com
Principal Technical Leader
EPRI Chemistry & Radiation Safety Program

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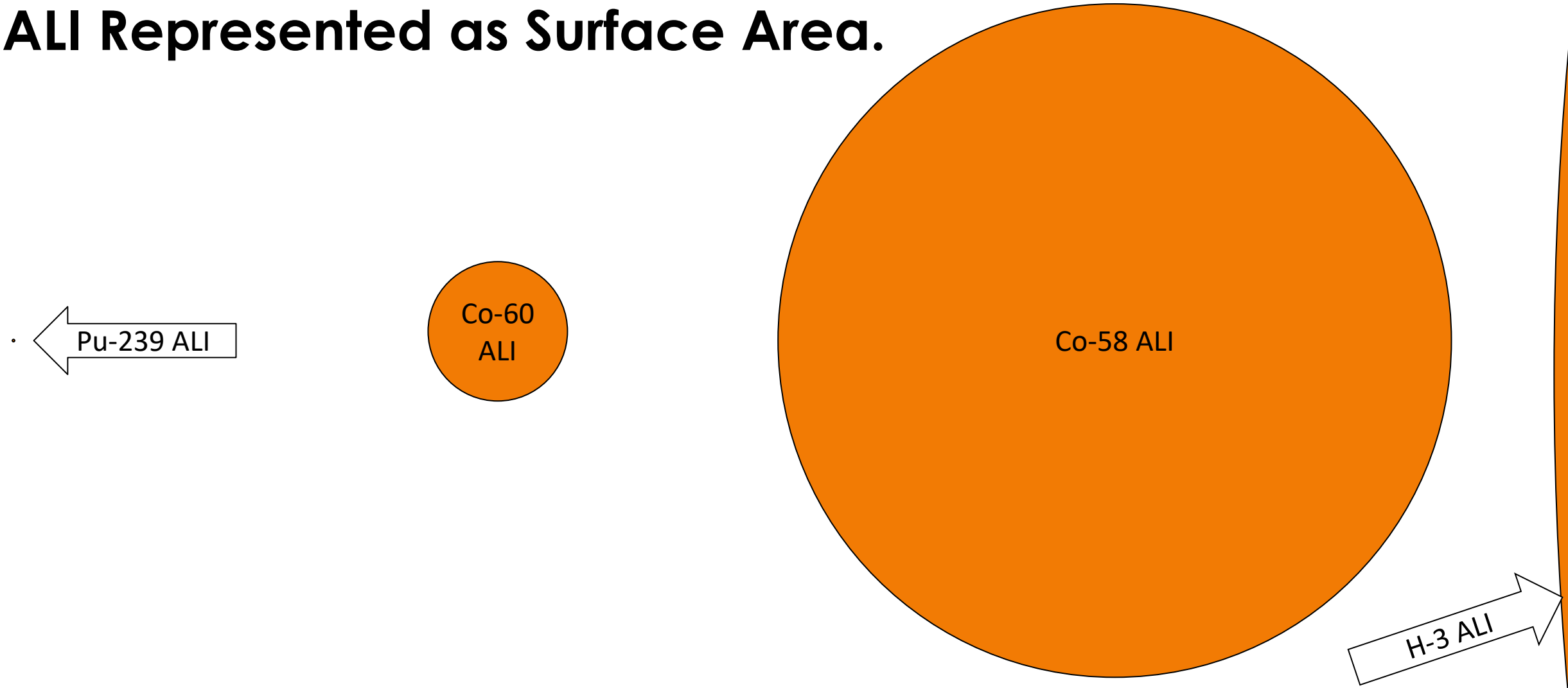
Alpha Monitoring and Control Guidelines for Operating Nuclear Power Stations, Revision 3

The EPRI Alpha Discography

- Program Considerations for Addressing Alpha Emitting Radionuclides at Nuclear Power Plants, EPRI, Palo Alto, CA: 2001. 1003126.
- EPRI Alpha Monitoring Guidelines for Operating Nuclear Power Stations. EPRI, Palo Alto, CA: 2006. 1013509.
- EPRI Alpha Monitoring Guidelines for Operating Nuclear Power Stations. EPRI, Palo Alto, CA: 2009. 1019500.
- *EPRI Alpha Monitoring and Control Guidelines for Operating Nuclear Power Stations, Revision 2.* EPRI, Palo Alto, CA: 2013. 3002000409.
- Alpha Monitoring White Paper Release. EPRI, Palo Alto, CA: 2023. CHEM 2023-016
- Alpha Monitoring and Control Guidelines for Operating Nuclear Power Stations, Revision 3. EPRI, Palo Alto, CA: 2026/IMMINENT

ALI Represented as Surface Area.



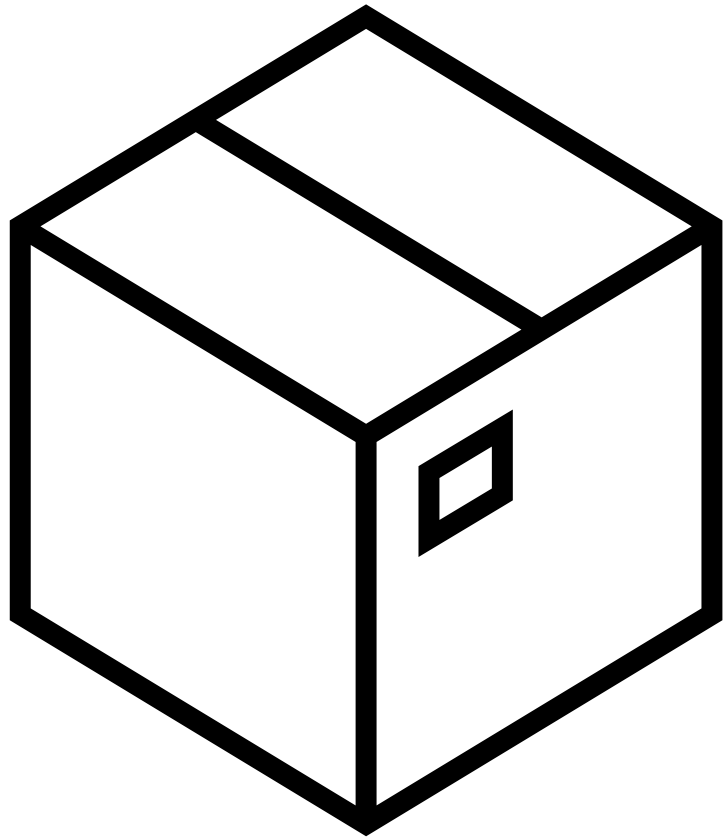
- Annual Limit on Intake (ALI) – the amount of radioactivity, for a single nuclide, that will result in a dose limit.
- All three of these circles represent a dose limit. **So it does not take much Pu-239 at all!**

Comparative Analysis

- Given:
  - Co-60 DAC value of $1X10^{-8}$ µCi/ml
  - Am-241 DAC value of $3X10^{-12}$ µCi/ml
- Both of these values are hard to visualize.

- Imagine a box of air that occupies $1m^3$.
  (a box measuring 1m (40in) by 1m (40in) by 1m (40in))

- If we convert the DAC values above to dpm per m^3 we can gain a better feel for how little Transuranic alpha it takes to reach a posting criteria.



Derived Air Concentration (DAC) is the concentration for a nuclide that if breathed for 2,000 hours would result in 1 ALI (and therefore a dose limit!)

Comparative Analysis

- Co-60 DAC value of $1X10^{-8}$ µCi/ml

$$\left(\frac{1X10^{-8}\mu Ci}{ml}\right)\left(\frac{2.22X10^{6}dpm}{1\mu Ci}\right)\left(\frac{10^{6}ml}{m^{3}}\right) = 22{,}200dpm/m^{3}$$

$$or\ 370\ Bq/m^{3}$$

- Am-241 DAC value of $3X10^{-12}$ µCi/ml

$$\left(\frac{3X10^{-12}\mu Ci}{ml}\right)\left(\frac{2.22X10^{6}dpm}{1\mu Ci}\right)\left(\frac{10^{6}ml}{m^{3}}\right) = 6.66dpm/m^{3}$$

$$or\ 0.111\ Bq/m^{3}$$

Finding 7 dpm is MUCH-MUCH harder than finding 22,200 dpm!

Revision 2 – Appendix E: Technical Basis for Guidelines

Table E-1
Activity and DAC-Fractions for Co-60 and Am-241[1]

LEVEL		Activity Relative to Am-241	% Activity Fraction	DAC (µCi/cc)	% DAC-Fraction
I	Co-60	30,000	99.997	1E-8	90
	Am-241	1	0.003	3E-12	10
II	Co-60	3,000	99.970	1E-8	47
	Am-241	1	0.030	3E-12	53
III	Co-60	300	99.700	1E-8	8
	Am-241	1	0.300	3E-12	92

EPRI Chem 2023-016 – White Paper

- Discussion of the Issues Identified by Working Group
  - Issue #1 - Gaps in procedure use and adherence has resulted in performance gaps when determining the location and the number of smears to classify an area.
  - Issue #2 Some Instances exist where smears of high enough activity have not been counted to demonstrate level 1 criteria.
  - Issue #3 – Clarification is needed regarding the low-risk alpha contamination level.
  - Issue #4 – Guidance in the Industry Procedures and Alpha Guidelines may not adequately address downgrading an area to a lower classification level.

The Ratio Dilemma

BETA-GAMMA (dpm/100cm²)	ALPHA (dpm/100cm²)	RATIO	COMMENTS
500,000	20	25,000:1	500k is the upper limit of many common GM pancake friskers.
100,000	20	5,000:1	100k is the threshold for High Contamination Area Posting Criteria
50,000	20	2,500:1	
10,000	20	500:1	
1,000	20	50:1	Both values represent a Contamination Area Posting Criteria

Enter Revision 3!

Alpha Guidelines

- The guideline statements have been simplified and a tiered approach developed for implementation of the requirements :
  - **Guideline Statements (GS)**: Describes the programmatic requirements to be implemented at the site.
  - **Implementation Recommendations (IR)**: Provides recommendations on actions necessary to implement the Guideline Statements.
  - **Beneficial Practices (BP)**: Lists practices that the working group found to be beneficial in the implementation of the guideline statement.

Section 2 - Defining the Alpha Source Term

GS-1: Each operating nuclear plant shall establish a program to characterize its alpha source term.

3 IRs

GS-2: Each operating nuclear plant shall classify plant areas and systems based upon the abundance of alpha contamination and/or airborne alpha activity,

4 IRs

3 BPs

Your Plant's History Lesson

- Lasts forever (well… at least longer than any of our careers)
- EPRI's Fuel Reliability Database (FRED), https://fred.epri.com
- Fuel Defects
- Tramp Uranium

Table 2 – Classification of Alpha Areas

- The classification of Alpha Areas is changing from a system based on the ratios to one that is based on the alpha contamination present in the areas.

	Non-Alpha Area (dpm/100 cm^2)	Level 1 (dpm/100 cm^2)	Level 2 (dpm/100 cm^2)	Level 3 (dpm/100 cm^2)
Removable Surface Alpha Contamination	<20 (<0.04 Bq/cm^2)	20 to 200 (0.04 to 0.4 Bq/cm^2)	>200 to 2000 (>0.4 to 4.0 Bq/cm^2)	>2000 (>4.0 Bq/cm^2)
Airborne Alpha Activity	NA	AND <0.3 DAC	OR 0.3 DAC to 3 DAC	OR >3 DAC

Table 15 - Estimated fDAC from alpha contamination

Smearable Contamination (dpm/100cm²)	Total Removable Contamination (Bq/cm²)	fDAC Estimate			fDAC Estimate		
		Non-volatile powders (R=0.01)			Non-volatile powders (R=0.01)		
		Normal Ventilation (C=1)			Normal Ventilation (C=1)		
		Non-dispersible activities (D=1)			Dispersible activities (D=10)		
		US	ICRP68	ICRP141	FGR11	ICRP68	ICRP141
20	0.033 (0.04)	0.003	0.0013	0.0012	0.03	0.013	0.012
200	0.33 (0.4)	0.03	0.013	0.012	0.3	0.13	0.12
2000	3.3 (4.0)	0.3	0.13	0.12	3.0	1.3	1.2

Section 3 – Alpha Monitoring

- GS-3: Each operating nuclear power plant shall establish a program to monitor alpha contamination and airborne activity based upon the alpha area classification.
  - 7 IRs
  - 1 BPs

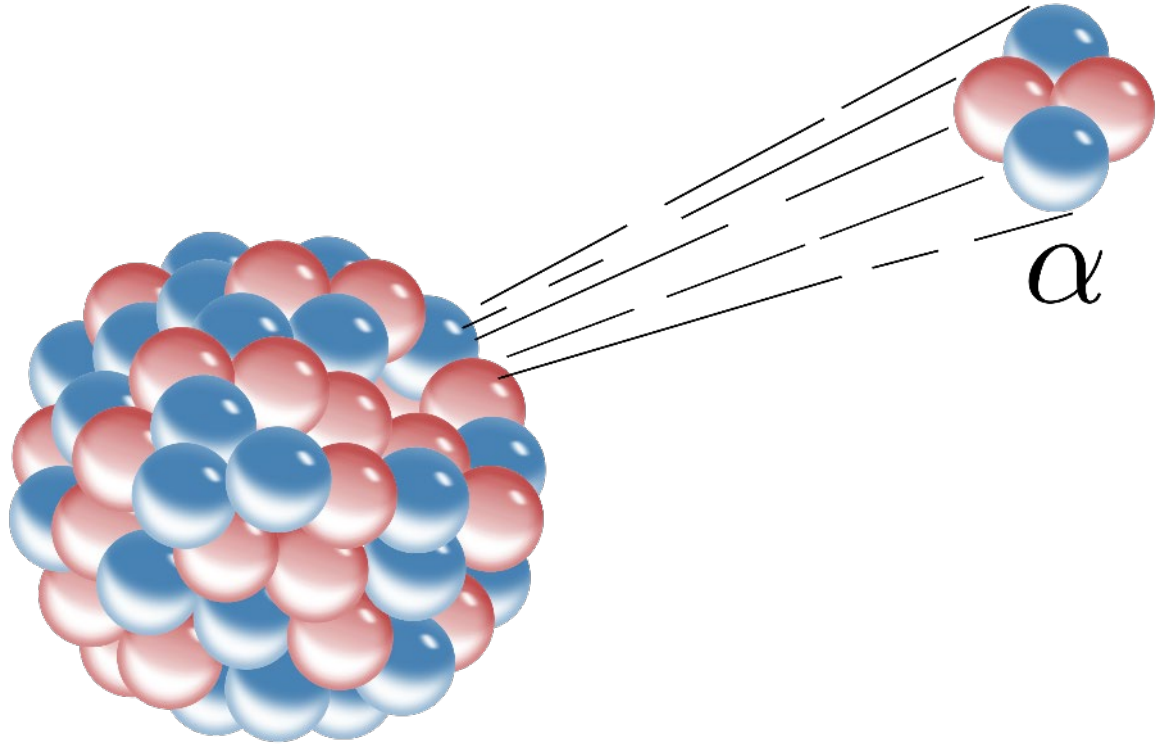


Table 3 – Alpha Survey Requirements

Survey Requirement	Non-Alpha Area <20 dpm/100 cm^2 (<0.04 Bq/cm^2)	Alpha Level 1 Area Alpha: 20 to 200 dpm/100 cm^2 (0.04 to 0.4 Bq/cm^2)	Alpha Level 2 Area Alpha: >200 to 2000 dpm/100 cm^2 (>0.4 to 4.0 Bq/cm^2)	Alpha Level 3 Area Alpha >2000 dpm/100 cm^2 (>4.0 Bq/cm^2)
Contamination Survey Action Levels	Develop a routine survey to count 3 smears for alpha or 10 percent of smears taken, whichever is greater, when the beta gamma exceeds 50K dpm/100 cm^2 (83 Bq/cm^2)	Count 3 smears for alpha or 10 percent of smears taken, whichever is greater	Count 3 smears for alpha or 10 percent of smears taken, whichever is greater	Count 3 smears for alpha or 50 percent of smears taken, whichever is greater
Air Sampling Action Levels	NA	If Beta-gamma DAC>1, count the air samples for alpha or use a continuous air sampler capable of measuring alpha activity	If the total DAC value is suspected to be greater than 1 DAC (use Figure 2), then count the air sample for alpha or use a CAM capable of measuring alpha activity	Count all air samples for Alpha or use a CAM capable of measuring alpha activity

Section 4 – Work Controls

- GS-4: Each operating nuclear power plant shall establish a program to evaluate, perform, and monitor work conducted in alpha areas.
  - 10 IRs
  - 1 BPs

Table 5 – Summary of RP Controls

Alpha Level	Alpha (dpm/100cm^2)	Potential Alpha airborne activity	RWP	RP Coverage	Protective Clothing	Contamination and Airborne Controls	Airborne Monitoring	Contamination Monitoring	PAS/PID Use
Non-Alpha Area	< 20 (<0.04 Bq/cm^2)	NA	General	Not Required based on alpha	No additional requirement based on alpha contamination	No additional controls based on alpha contamination	No additional air sample requirements based on alpha contamination	Monitor 10% of the smears or 3 smears, whichever is greater, for alpha contamination when the beta-gamma activity exceeds 20k dpm/100cm^2 (33 Bq/cm^2)	NA
Level 1	20 to 200 (0.04 to 0.4 Bq/cm^2)	<0.3 DAC	General	Task specific but not normally required	Standard Set	No additional controls based on alpha contamination	If Beta-gamma DAC>1, count the air samples for alpha	Monitor 10% of the smears or 3 smears, whichever is greater, for alpha contamination	See Section 5

Table 5 – Summary of RP Controls (continued)

Alpha Level	Alpha (dpm/100cm²)	Potential Alpha airborne activity	RWP	RP Coverage	Protective Clothing	Contamination and Airborne Controls	Airborne Monitoring	Contamination Monitoring	PAS/PID Use
Level 2	>200 to 2000 (>0.4 to 4.0 Bq/cm²)	0.3 to 3 DAC	General or Job specific depending on the task and the alpha contamination level	Intermittent	Consider the use of disposable or segregation Respiratory protection may be required	See Job Coverage Appendix J	If the total DAC value is suspected to be greater than 1 DAC, then count the air sample for alpha	Monitor 10% of the smears or 3 smears, whichever is greater, for alpha contamination	See Section 5
Level 3	>2000 (4.0 Bq/cm²)	> 3 DAC	Job Specific	Continuous RP Coverage	Double with disposable outer layer; Respiratory Protection may be required	See Job Coverage Appendix J	Count all air samples for Alpha	Monitor 50% of the smears or 3 smears, whichever is greater, for alpha contamination	See Section 5

Section 5 – Individual Monitoring

- GS-5: Each operating nuclear power plant shall implement a program to monitor and assess internal dose from alpha contamination.
  - 13 IRs

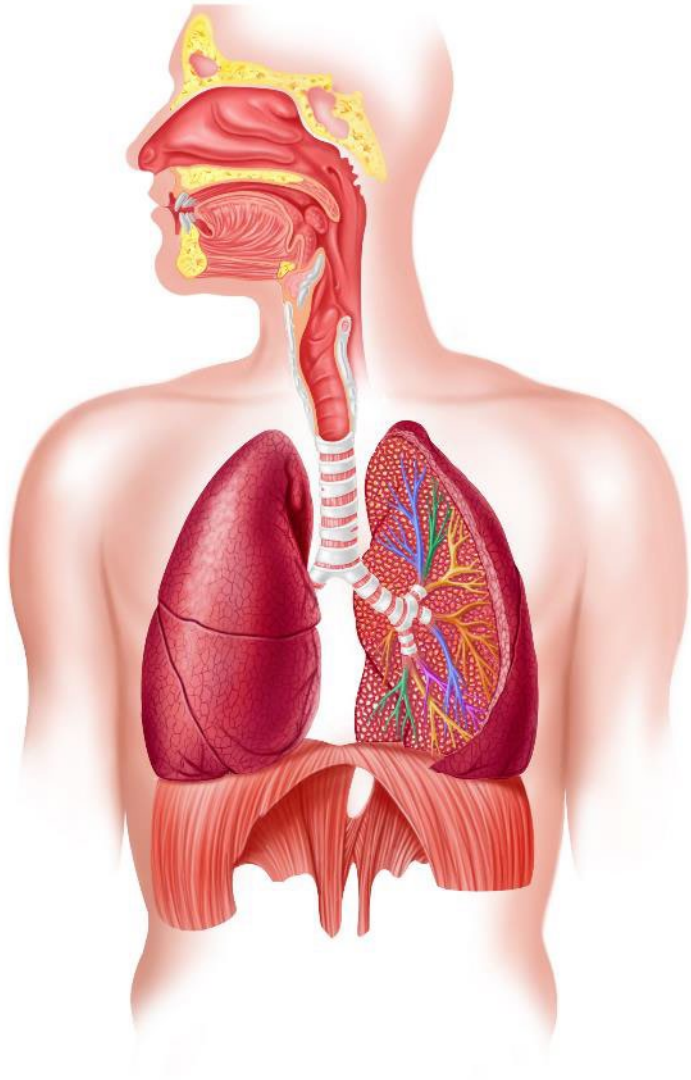


Table 9 - Individual Monitoring Requirements Based on Potential Dose

Potential Dose	Definition	Action	Techniques which can be used
> 10 mrem (0.1 mSv) (See Note1)	Screening Level	Confirm Intake	Whole body counting. Excreta measurements are considered if available information cannot be used for alpha dose assessment (See Note 4)
> 100 mrem (1 mSv) (See Note1)	Verification level	Dose assignment confirmed by individual monitoring (See Note 3)	Excreta measurement(s) (See Note 4)
> 500 mrem (5 mSv) CEDE (See Note 2)	Investigation level	Individual measurements taken to define the dose more accurately	Extensive excreta sampling should be conducted (See Note 4)

Notes:

1. This is the total dose from alpha internal exposures.
2. This is the total dose from alpha, beta, and gamma.
3. When the potential dose to the individual cannot properly be determined or remain uncertain, then excreta sampling should be used whenever possible to confirm the magnitude of the intake.
4. For contaminated wounds, urinalysis should be used.

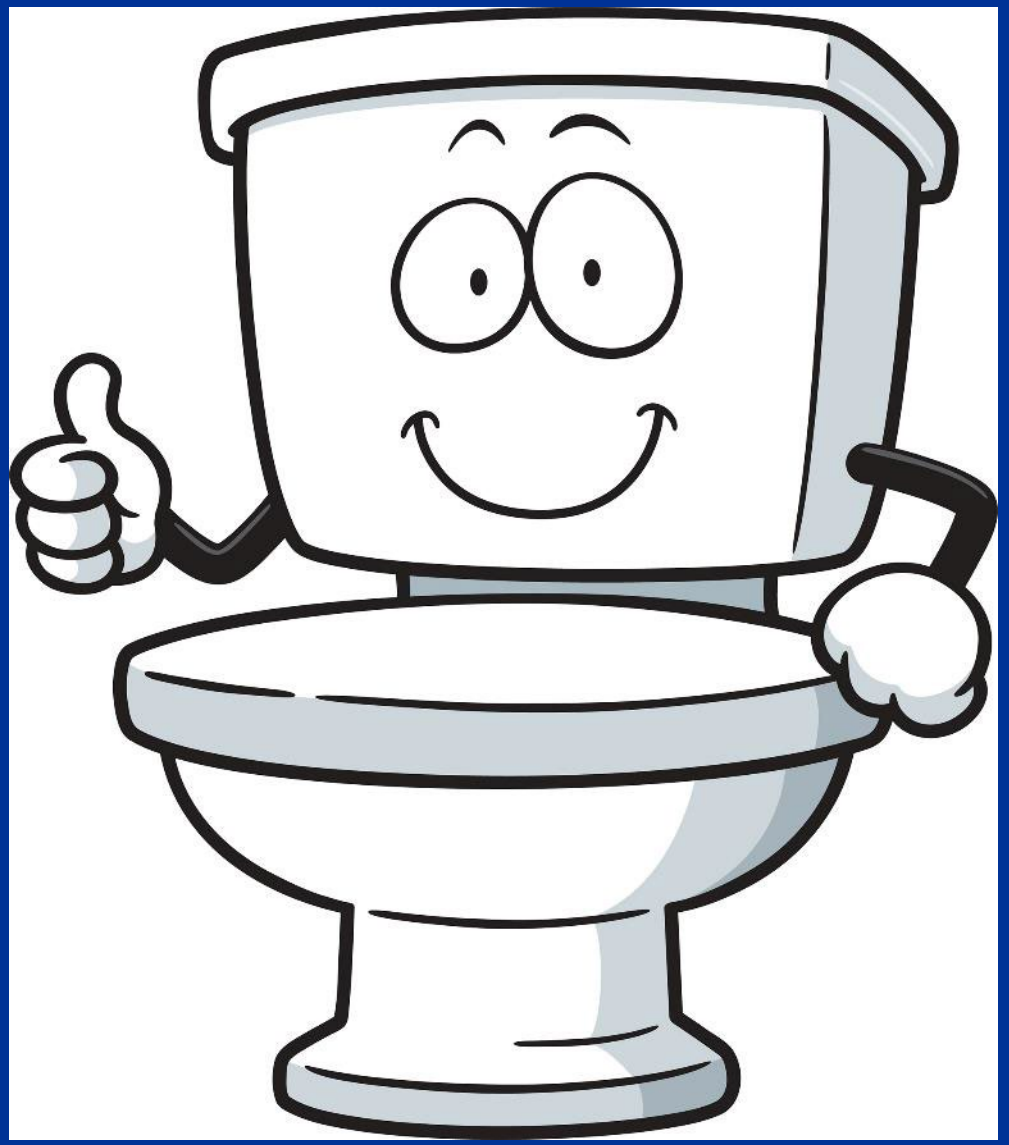
Portal Monitor (PM)

Whole Body Counter (WBC)

Personnel Air Sampler (PAS) a.k.a. Personnel Internal Dosimeter (PID)

Pictures are examples only. EPRI does not endorse any specific instrument or manufacturer.

The “Less Desirable” Alternative is Invitro Sampling



Alpha Guideline

- Ratios are still used as needed for Programmatic Controls.
- For example:
  - A beta-gamma to alpha ratio of ≤ 50:1, additional monitoring requirements still apply since the beta-gamma monitoring sensitivity no longer bounds the alpha activity.
  - There are ratios that may trigger the use of PAS/PID monitoring. More on that later...
  - Ratios maybe needed for efficient air sampling methodology.

Table 8 - Internal Monitoring with PAS/PID based on Beta-Gamma to Alpha Ratios

Ratio (Beta-/Gamma to Alpha)	Action
<2500 to 1	Assess the need to provide additional monitoring for internal alpha contamination via PAS/PID or WBC.
<500 to 1	Implement the use of PAS/PID sampling for all work in these areas.

- Key Technical Points:
  - At ratios less than 2500 to 1, the PM can indicate the absence of gamma emitting radionuclides, and an alpha intake may have occurred that could result in greater than 10 mrem (0.1 mSv). This illustrates the importance of considering the use of a PAS/PID and/or WBC for monitoring for potential internal alpha intakes at ratios less than 2500 to 1.
  - At ratios less than 500 to 1, the WBC can indicate the absence of gamma emitter radionuclides and there could be a potential to exceed 10 mrem (0.1 mSv) following an alpha intake. This illustrates the importance of the use of a PAS/PID for monitoring potential internal alpha intakes at ratios less than approximately 500 to 1.

Section 6 – Alpha Monitoring Instrumentation

- GS-6: Each operating nuclear power plant shall provide appropriate radiation protection instrumentation to measure alpha contamination and airborne activity.
  - [IR-38] Establish Minimum Detectable Activities (MDAs)/Minimum Detectable Concentrations (MDCs) to ensure that the requirements of this guideline are implemented.
  - [IR-39] Provide appropriate radiation protection instrumentation capable of performing the alpha and beta/gamma measurements required by this guideline.
  - [IR-40]: Provide appropriate radiation protection air sampling equipment to perform PAS/PID samples and work area airborne alpha sampling
  - [IR-41]: Develop method to account for alpha self-absorption in smears and air samples.

Section 7 – Training

- GS-7: Each operating nuclear power plant shall establish a program to train and communicate the hazards of alpha contamination to plant personnel.
  - [IR-42] Provide training to radiation protection personnel in the specific hazards of alpha contamination.
  - [IR-43]: Include alpha hazard awareness training in General Employee/Radiation Worker Training
  - [BP-6]: Utilize hands on practical training (such as dynamic learning activities) in radiation protection technician training.
  - [BP-7] Conduct refresher training for RP personnel prior to an outage following a fuel cladding defect.
  - [BP-8]: Provide an indoctrination to non-RP leadership in the key aspects of alpha controls

Appendices

- A Glossary
- B Listing of Guideline Statements and Implementation Recommendations
- C Transuranic Radionuclides
  - Calculation of Effective DAC
- D Basis for Alpha Area Contamination Levels
  - Partial reproduction of “Estimating fDAC from Removable Contamination Measurements, Report 3002031477”
- E Basis for Ratios for PAS/PID based PM and WBC Response
- F Source Term Assessment
- G Radon Compensation

Appendices (continued)

- H The Detection and Analysis of Alpha Emitting Radionuclides
- I Methods for Determining Alpha Contamination on mrad Smears
  - 5 methods including pros and cons.
- J Job Preparation and Coverage
- K Internal Dose Assessment
- L Example Briefing for Workers
- M Example Process for PAS/PID
- N Example Briefing Sheet for Workers Following an Intake

Radioactive Material Monitoring and Control Guideline, Revision 1

The EPRI RAM Discography

- Radioactive Material Monitoring and Control Guideline. EPRI, Palo Alto, CA: 2009. 1019224.
- Radioactive Material Monitoring and Control Guideline, Revision 1. EPRI, Palo Alto, CA: 2026/IMMINENT

Section 1: Introduction

- Personnel at Nuclear Power Plants (NPPs) have a critical responsibility to prevent the release of radioactive material (RAM) from the plant.
- The objective of this guideline is to provide the commercial nuclear power industry—both in the United States and internationally—with information to establish consistent, reliable programs for monitoring and controlling radioactive material. These programs apply to personnel, materials, and equipment during egress from Radiologically Controlled Areas (RCAs), satellite RCAs, Radioactive Material Areas (RMAs), and Restricted/Protected Areas (PAs).

Section 1: Introduction (continued)

- A team of radiation safety professionals—representing EPRI, 22 U.S. and international nuclear utilities, and supporting organizations including the Nuclear Energy Institute (NEI), the Institute of Nuclear Power Operations (INPO), and the American Nuclear Insurers (ANI)—collaborated to develop these guidelines through a consensus-based process.

RAM Guidelines Structured Similar to Alpha Guidelines

Guideline Statements [GS]: Describes the programmatic requirements to be implemented at the site.

Implementation Recommendations [IR]: Provides recommendations on actions necessary to implement the Guideline Statements.

Beneficial Practices [BP]: Lists practices that the working group found to be beneficial in the implementation of the guideline statement.

Section 2: Equipment and Material Monitoring

Describes the steps recommended for the unconditional release of tools, equipment, vehicles, personal items, and limited volumetric materials

GS-1
Sites shall establish programs to monitor material requiring unconditional release from Radiologically Controlled Areas, Satellite Radiologically Controlled Areas, Radioactive Material Storage Areas, and Restricted/Protected Areas.

Section 2: Equipment and Material Monitoring (continued)

- Personnel Responsibilities:
  - RP Supervision/Management, Qualified Individuals, & Plant Personnel
- Unconditional Release Criteria
- Conditional Release of Material
- Survey Protocols:
  - Tools, Equipment, and Non-Volumetric Materials
  - Volumetric Materials
  - Personal Items for Unrestricted Release

Section 3: Control of Radioactive Material

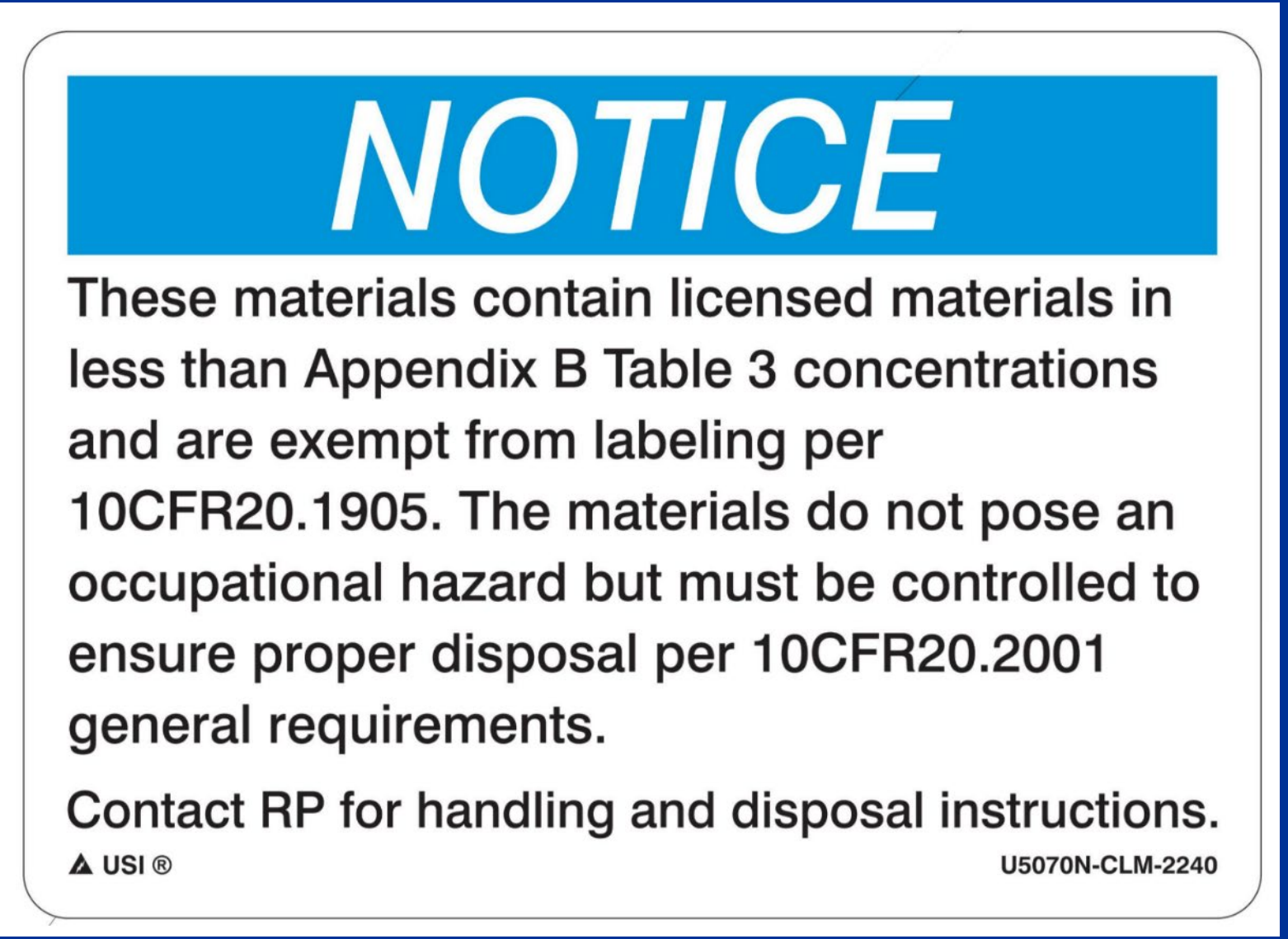
Provides guidance in the key aspects required to control materials once the items have been identified as radioactive materials, including marking and labeling, storage of RAM, moving RAM and establishing RAM areas

GS-2
Sites shall establish programs to control radioactive material (RAM).

Section 3: Control of Radioactive Material (continued)

- Labeling and Marking RAM
- Storage of RAM:
  - Inside the Primary/Power Block RCA
  - Outside Storage of RAM
- Movement of RAM
- Control of Sealed Sources
- Control of Trace Quantity Materials

Trace Quantity Materials



Section 4 Personnel Contamination Monitoring

Addresses instrumentation, methods, and best practices for determining if an individual is radioactively contaminated.

GS-3
Sites shall establish a program to monitor personnel for contamination exiting Radiologically Controlled Areas, Satellite Radiologically Controlled Areas, Radioactive Material Storage Areas and Restricted/Protected Area.

Section 4 Personnel Contamination Monitoring (continued)

- Responsibilities:
  - Plant Personnel, Qualified Individuals, RP Supervision, RPM
- Contamination Monitoring Requirements:
  - Primary RCA Exits
  - RCA Exit into a Clean Area Island
  - Contaminated Area Exits
  - Satellite RCA/RMA Exits
  - Independent Spent Fuel Storage Installation (ISFSI)
  - Restricted/Protected Area Exit

Section 4 Personnel Contamination Monitoring (continued)

- Use of Personnel Contamination Monitors and Portal Monitors
- Use of a Frisker
- RP Response to Indicated Contamination
- Additional Actions if an Individual Cannot Pass the Contamination Monitors
- Conditional Release of Personnel

Section 5: Instrumentation

Provides a list of commonly used instrumentation at the sites represented by the committee members.

GS-4
Each site shall provide radiation protection instrumentation to monitor equipment and personnel to meet the requirements of this guideline.

Section 6: Equipment Calibration

Describe guidelines for the calibration, and performance checks of personnel and equipment contamination monitors. It establishes a standard level of performance that is acceptable for radiological monitoring of personnel and equipment to prevent the release of radioactive material from the RCA, satellite RCAs, RMAs, or Restricted Area/PA.

GS-5
Each site shall establish a program to calibrate and source response check instruments at RCAs, RMAs, and Restricted/Protected Area exits.

Section 6: Equipment Calibration (continued)

- Calibration of Automated Personnel and Equipment Contamination Monitors:
  - Beta-Sensitive Personnel Contamination Monitor (PCM) Calibration
  - Gamma-Sensitive Portal Monitor Calibration
  - Gamma-Sensitive Tool and Equipment Monitor (TEM) Calibration
  - Beta-Sensitive Hand and Foot Contamination Monitor Calibration
- Calibration of Beta and Alpha Sensitive Scalers and Portable Rate Meters
- Source Response Checks of Personnel and Equipment Contamination Monitors
- Accounting for Hard-to-Detect (HTD) Radionuclides

Appendices

- Appendix A: Glossary
- Appendix B: Summary of Guideline Statements
- Appendix C: Select Country Regulatory Requirements
- Appendix D: Survey Methods for Equipment
- Appendix E: Example of a Material Release Plan
- Appendix F: Monitoring Considerations
- Appendix G: Determination of Minimum Detectable Activities
- Appendix H: Methodology to account for HTD Radionuclides
- Appendix I: Managing Workers with Radiopharmaceutical Uptakes

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