WP 12-HP1100

Revision 12

Radiological Surveys

Technical Procedure

EFFECTIVE DATE: 07/31/08

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APPROVED FOR USE

TABLE OF CONTENTS

INTRODUCTION [1, 2, 3, 4]

This procedure provides specific methods and guidance for performing surface contamination surveys, and dose rate surveys of items, equipment, and areas.

Performance of this procedure generates the following records:

- EA12HP1100-1-0, Radiological Survey Report
- EA12HP1100-2-0, Radiological Survey Map
- Computer printouts of swipe analyses

REFERENCES

BASELINE DOCUMENTS

- 10 CFR Part 835, "Occupational Radiation Protection"
- 49 CFR Part 173, "Shippers-General Requirements for Shipments and Packagings," Subpart I, Class 7 (Radioactive) Materials
- DOE Guide 441.1-9, *Radioactive Contamination Control Guide*
- DOE Order 5400.5, *Radiation Protection of the Public and the Environment*
- DOE-STD-1098-99, *Radiological Control*
- DOE Memorandum Nov. 17,1995, Raymond F. Pelletier, *Application of DOE 5400.5 Requirements for Release and Control of Property Containing Residual Radioactive Material*
- DOE/EH-0624, *Multi-Agency Radiation Survey and Site Investigation Manual*, Chapter 6
- Hazardous Waste Facility Permit, Waste Isolation Pilot Plant, No. NM4890139088-TSDF, issued by the New Mexico Environment Department
- *Eclipse LB Software Operation Manual for Tennelec Series 5XLB*, *LB5100 and LB550 Upgrades Instrument Operation Manual*
- *Tennelec Series 5XLB Service Manual*
- DOE/WIPP-95-2065, *Waste Isolation Pilot Plant Contact Handled (CH) Waste Documented Safety Analysis*
- DOE/WIPP-02-3122, *Contact-Handled Transuranic Waste Acceptance Criteria for the Waste Isolation Pilot Plant*

- DOE/WIPP-06-3174, *Waste Isolation Pilot Plant Remote Handled (RH) Waste Documented Safety Analysis*
- WP 12-5, Waste Isolation Pilot Plant Radiation Safety Manual
- WP 12-HP1307, Portable Instrument and Portal Monitor Operability Checks
- WP 13-1, Washington TRU Solutions LLC Quality Assurance Program Description
- Position Paper 2002-01, Contamination Surveys at the WIPP

REFERENCED DOCUMENTS

- *Basic Radiation Protection Technology*, 1983 Edition, Daniel A. Gollnick, Pacific Radiation Corporation
- *Basic Radiation Protection Technology*, 1994 Edition, Daniel A. Gollnick, Pacific Radiation Corporation
- ANSI/HPS 13.30, 1996, *Performance Criteria for Radiobioassay*
- *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*, NUREG-1507, U.S. Nuclear Regulatory Commission, 1998
- WP 12-HP1500, Radiological Posting and Access Control
- WP 12-HP3200, Radioactive Material Control
- WP 12-HP4000, Emergency Radiological Control Responses
- EA12HP1100-1-0, Radiological Survey Report
- EA12HP1100-2-0, Radiological Survey Map

PRECAUTIONS AND LIMITATIONS

- Radiological Control Manager (RCM), Radiological Control Superintendent (RCS), or designee is to be immediately notified of any unusual or unexpected conditions.
- Personnel shall wear at least surgeons/rubber gloves when taking swipes.
- Good contamination control practices shall be followed until it is proven that swipes are free of contamination.

- All swipes shall be checked for gross radioactivity before placing in counter scalers. The gross radioactivity check should be performed as close to the point of survey as possible, based on the background impact on the minimum detectable activity (MDA) . If the gross activity indicates greater than 1,000 dpm, use the gross check values for survey results and do not analyze in counter scalers.

- Only trained and qualified Radiological Control Technicians (RCTs) and Radiological Engineers who have completed the Job Performance Measure are authorized to perform radiological surveys.

- The on-duty Facility Shift Manager (FSM) may be contacted in place of the RCS during off-normal work hours if the RCS is not on-site.

- Each analog radiation detection instrument reading is limited to the value halfway between increments. (Example: if a meter is divided into 0.1 increments, the smallest reading that can be recorded is 0.05.)

- Background readings are to be determined in areas adjacent to, but not located inside, an area posted Radiation, High Radiation, Contamination, High Contamination, or Airborne Radioactivity Area, **AND** should be verified prior to performance of survey and when background is known or suspected to have changed significantly.

- RCM/designee is to review EA12HP1100-1-0, EA12HP1100-2-0, and computer printouts of swipe analyses for completeness.

- Large area wipes may be used as a gross indication of contamination, but swipe surveys are required to document that areas may be released from contamination controls.

- Routine radiological surveys are **NOT** to be performed in High Radiation Areas **EXCEPT** during continuing operations, as authorized by the RCS.

- Routine contamination surveys may include both removable (swipe) and total (direct) contamination readings. Direct contamination readings shall be performed before the swipe surveys, whenever possible. When situations arise (example: high background) and the swipe is performed first, care should be taken to protect the probe if the swipe shows contamination.

- Survey results should be posted near all permanent radiological (radiation, high radiation, very high radiation, contamination, high contamination, airborne radioactivity) areas and may be posted at other areas as deemed necessary.

PREREQUISITE ACTIONS [5]

NOTE

Survey instrument use is based on the expected transuranic waste isotopic mixtures. In case isotopes other than those expected occur, Radiological Technology can evaluate the impact of these unexpected types and energies of radiation on instrument response.

- Select radiation survey instrument(s) as listed on Attachment 1, Radiation Survey Instrument Selection Criteria/Limits and Surface Contamination Limits, or equivalent instrument(s), that is/are appropriate for the following:

  - Type of radiation

  - Level of radiation

  - Energy of radiation

  - Environmental conditions

- Verify the instrument(s) have a current operability check and calibration.

- Background for handheld contamination survey instruments should be 5 minutes. These background readings should be obtained adjacent to the area being surveyed where the radiation levels in the surveyed area will not be inappropriately subtracted from the survey data.

- Review previous survey(s) as applicable (i.e., routine surveys, past surveys of similar activities).

PERFORMANCE

NOTE

Sections 1.0 and 2.0 are both required and have to be performed in order. Sections 3.0 and 4.0 may be performed concurrently, independently, or in any combination. Survey information is to be documented in accordance with Section 5.0.

Radiological surveys are to be performed: (1) routinely, as specified by Attachment 4, Radiological Survey Frequencies, and as scheduled by the RCM; (2) in association with a Radiological Work Permit (RWP) or procedure; (3) to confirm clean areas where contamination boundaries are posted; and/or (4) upon special request.

NOTE

The MDA of the direct survey instruments can be calculated and/or found by using the MDA formula or the MDA tables in Attachment 5, MDA for the Direct Survey Instruments.

- The MDA tables are used by: (1) determining the background count rate (cpm) in 5 minutes background counting time; (2) finding the efficiency of the instrument; and (3) looking up the MDA value to determine the required sample counting time (T_s). This is the "Minimum Survey Time" needed for the MDA of direct survey instrument to be lower than the required limits.

1.0 SURFACE CONTAMINATION DIRECT SURVEYS

NOTE

- The need for direct contamination surveys will be based on Attachment 4, or as determined by RCT, RCS/RCM, and/or Radiological Technology.

- Scan survey may be used if the MDA, as determined by Attachment 6, MDA for the Scan Survey, is lower than the required total limits, or if used to locate contamination in a potentially contaminated area. If fixed contamination surveys are performed, they should be performed adjacent to the same points used for the removable surveys.

- When utilizing 43-93 alpha/beta dual probe which has probe area of 100 cm^2 (correction factor, A/100 = 1), probe for direct surveys, the correction factor for the probe and efficiency of instrument should be applied to convert the count rate (cpm) into dpm per 100cm^2 as follows:

$$dpm \,/\, 100cm^2 = \frac{cpm}{(Eff) \times (A \,/\, 100)}$$

1.1 Record the MDA and instrument information on EA12HP1100-1-0.

1.2 Perform direct survey measurement(s) at the required locations.

1.2.1 **IF** the direct stationary survey outside the properly posted area indicates any of the following conditions above background:

- > 2,000 dpm/100cm^2 α
- > 20,000 dpm/100cm^2 β-γ

THEN initiate appropriate immediate actions of WP 12-HP4000, **AND** document the survey results per Section 5.0 of this procedure.

1.2.2 **IF** the direct stationary survey indicates any of the following conditions above background:

- > 100 dpm/100cm^2 α
- > 1,000 dpm/100cm^2 β-γ

THEN perform the following:

[A] Obtain/maintain control of the area/item by:

- Positioning personnel at appropriate entrances/areas to restrict unauthorized access to an area/item.
- Placing radiological postings, boundaries and barriers around an area/item in accordance with WP 12-HP1500.
- Placing items in appropriate containers and tagging/labeling the containers in accordance with WP 12-HP3200.
- Releasing items or areas by survey and documenting in accordance with WP 12-HP3200.

[B] Notify the Central Monitoring Room Operator (CMRO) and RCM, RCS, or designee.

1.3 Complete the documents per Section 5.0.

2.0 SURFACE CONTAMINATION SWIPE SURVEYS

NOTE

The amount of removable radioactive material per 100cm^2 of surface area is determined by swiping the area with a dry swipe while applying moderate pressure, and assessing the amount of radioactive material on the swipe with an appropriate instrument of known efficiency (c/d). For objects with a surface area less than 100 cm^2, the entire surface should be swiped and the activity per unit area should be based on the actual surface area.

The MDA of the instruments shall be equal to or less than the required limits as listed on Attachment 1 for the items being free-released. The MDA will be displayed on the printout and/or survey report, as applicable.

2.1 Record the MDA and instrument information on EA12HP1100-1-0.

2.2 If the object being surveyed is < 100cm^2, the entire surface is to be swiped and documented as removable activity per area swiped.

2.2.1 Estimate the surface area of the item and record the surface area and activity on EA12HP1100-1-0, Section C.

2.3 Number each swipe to correspond with survey points and description on Radiological Survey Report, Section D of EA12HP1100-1-0 and on Radiological Survey Map, EA12HP1100-2-0.

2.4 Perform swipe survey(s) at the desired location(s).

2.5 Gross check the swipes, with an MDA less than 500 dpm, as soon and as close as possible to the point where they were taken.

2.6 Count the swipe(s).

2.6.1 **IF** the count measurement(s) outside the properly posted area indicates any of the following conditions:

- > 2,000 dpm/100cm^2 α
- > 20,000 dpm/100cm^2 β-γ

THEN initiate appropriate immediate actions of WP 12-HP4000.

NOTE

Additional actions prescribed by the RCM, RCS, or designee, may include, but are not limited to:

- Recount of swipe, long-lived/short-lived half-life indication
- Analysis of swipe with additional instrumentation
- Additional surveys of area/item
- Laboratory analysis of swipe(s)

2.6.2 **IF** the count measurement(s) indicates any of the following conditions:

- ≥ 20 dpm/100cm^2 α, but ≤ 2,000 dpm/100cm^2
- ≥ 200 dpm/100cm^2 β-γ, but ≤ 20,000 dpm/100cm^2

THEN, perform the following:

[A] Control the area/item in accordance with Step 1.2.2[A].

[B] Perform recount of swipe(s), as necessary, until activity on swipe is found to be < 20 dpm/100cm^2 α and/or < 200 dpm/100cm^2 β-γ.

[C] If swipe recount(s) does not indicate greater than 10% reduction in activity over a 1-hour period, contact RCM, RCS, or designee.

2.6.3 **IF** the measurement(s) or recount(s) indicates ≤ 20 dpm/100cm^2 α and ≤ 200 dpm/100cm^2 β-γ,
THEN continue survey, if applicable.

2.7 Complete the documents per Section 5.0.

3.0 LARGE AREA WIPE SURVEYS

3.1 Record the MDA and instrument information on EA12HP1100-1-0.

3.2 Perform large area wipe.

3.3 Monitor the large area wipe for removable alpha and beta radioactivity as appropriate.

3.4 **IF** survey of large area wipe indicates activity greater than background, **THEN** control the area/item **AND** perform the direct and swipe surveys in accordance with Sections 1.0 and 2.0 of this procedure.

3.5 **IF** survey of large area wipe indicates NO activity greater than background, **THEN** continue survey.

3.6 Complete the documents per Section 5.0.

4.0 DOSE RATE SURVEYS

NOTE

General area dose rate survey readings are normally obtained at waist level in the direct vicinity of the RCT. Dose rate surveys should be taken on contact and at 30 cm from sources of radiation or from surfaces through which radiation penetrates. For radioactive shipments or receipts, a dose rate survey on contact and at 1 meter are required.

NOTE

Neutron dose rate should be measured in scalar mode for the purpose of posting Radiological Buffer Areas (RBAs) and/or Control Areas. The decision level (DL) of RemBall (NRD) can be calculated and/or found by using the DL formula or the DL table as shown in Attachment 7, Decision Level for Neutron Instrument in Scalar Mode. The sensitivity of NRD is 28 cpm/mrem/hr.

4.1 Determine neutron net dose rate (mrem/hr) in scalar mode for posting purposes only.

4.1.1 Determine the background count rate (cpm) in 1-minute integration time.

4.1.2 Record the DL value for the corresponding background count rate on EA12HP1100-1-0.

4.1.3 Measure the neutron count rate of 1 minute at a desired location.

4.1.4 Convert the instrument reading (cpm) into net dose rate (mrem/hr) as follows:

Net Dose Rate (mrem/hr) = (instrument reading - background)/ (28 cpm/mrem/hr)

4.1.5 Compare net dose rate (mrem/hr) to DL value (mrem/hr) for a proper recording on EA12HP1100-2-0.

- If net dose rate is equal to or greater than DL, record the net dose rate value.
- If net dose rate is less than DL, record as "< the numerical value determined in Section A of EA12HP1100-1-0."

4.2 Verify survey and equipment information is documented on EA12HP1100-1-0.

NOTE

- The smallest reading of Models 6112B Telescope detector is 0.05 mR/hr. If the reading of Model 6112B Telescope detector is < 0.05 mR/hr, the exposure rate should be recorded as “< 0.05 mR/hr” on EA12HP1100-2-0.

- The smallest reading of Model 78 Telescope detector is 0.1 mR/hr. If the reading of Model 78 Telescope detector is < 0.1, the exposure rate should be recorded as "< 0.1 mR/hr" on EA12HP1100-2-0.

- The smallest reading of Model 17 Ion Chamber is 1 mR/hr based on one-half of the smallest increment of 2 mR/hr scale.

- The minimum detectable exposure rate of Model 2350-1/44-2 Gamma Scintillator is determined to be 4 µ/R/hr as shown in Attachment 8, Minimum Detectable Exposure Rate of 2350-1/44-2 Gamma Scintillator.

NOTE

When using the Ludlum 2241 neutron dose rate meter in rate meter mode, the actual reading should be recorded if it is ≥1 mrem/hr. If reading is < 1 mrem/hr, then "< 1 mrem/hr" should be recorded on EA12HP1100-2-0.

4.3 Perform dose rate measurements.

4.3.1 **IF** dose rate readings exceed RWP limiting conditions **OR** posting limits,
THEN perform the following:

[A] Control and/or post the area.

[B] Call the CMRO.

[C] Contact COM or RCM, RCS, or designee.

4.4 Complete the documents per Section 5.0.

5.0 DOCUMENTATION [2, 3, 4]

5.1 Verify the following sections/items are completed on EA12HP1100-1-0:

NOTE

"N/A" is to be entered in all unused blanks.

- Section A
  - Complete all applicable blanks.
  - Place "N/A" in MDA and background columns for Dose Rate Instrument in rate meter mode and Alpha-6 Continuous Air Monitor.
  - Record background count rate and DL information for NRD/Ludlum 2241 meter in scalar mode when applicable.
- Section B
  - Enter Radiological Assessment Filter (RAF) information for waste processing activities as applicable.
- Section C
  - Summarize results of survey and additional relevant information, such as:
  - Additional radiological instrumentation used for the survey not listed in Section A
  - Estimate size of swipes from items < 100cm^2
  - Direct survey, swipe, or large area wipe elevated/abnormal activities
  - Significant changes from previous applicable surveys
  - Any items not identified elsewhere in the documentation
- Section D
  - Complete and/or attach computer printout.
  - Verify survey point and description of this section correspond with numbered survey locations on EA12HP1100-2-0.
  - For net count rate: record the actual net value.

- For activity: record the calculated activity value if it is equal to or greater than the MDA value. Record "< MDA" if the calculated activity is less than the calculated numerical MDA value.

5.2 Complete EA12HP1100-2-0 as follows:

- For Model 17 Ion Chamber reading: record the actual reading if it is ≥ 1 mR/hr. Record “< 1 mR/hr” if it is < 1 mR/hr.
- For Model 2350-1/44-2 Gamma Scintillator reading: record the actual reading if it is ≥ 4 µR/hr. Record “< 4 µR/hr” if it < 4 µR/hr.
- For Model 6112B Telescope detector reading: record the actual reading if it is ≥ 0.05 mR/hr. Record “< 0.05 mR/hr” if it is < 0.05 mR/hr.
- For Model 78 Telescope detector reading: record the actual reading if it is ≥0.1 mR/hr. Record "< 0.1 mR/hr" if it is < 0.1 mR/hr.
- For NRD/Ludlum 2241 meter in scalar mode, record the net dose rate if it is equal to or greater than DL value. If the net dose rate is less than DL value, record it as "< the calculated numerical DL value."
- For NRD/Ludlum 2241 in rate meter mode for general surveys, record actual reading if it is ≥ 1 mrem/hr. If reading is < 1 mrem/hr, record "< 1 mrem/hr" on EA12HP1100-2-0.

5.3 Enter individual survey number on each page.

5.4 Verify EA12HP1100-1-0 and EA12HP1100-2-0 are completed, as applicable.

5.5 Sign and date each page of EA12HP1100-1-0, EA12HP1100-2-0, and computer printouts, as applicable.

5.6 Verify postings and access restrictions reflect current conditions, as applicable.

5.7 Submit completed Radiological Survey Report and associated attachments to the RCM or designee for review.[4]

5.8 RCM or designee, perform the following:

5.8.1 Review complete Radiological Survey Report and associated attachments.

5.8.2 Submit completed report to Records Coordinator for filing and disposition.

Attachment 1 - Radiation Survey Instrument Selection Criteria/Limits and Surface Contamination Limits

INSTRUMENT SELECTION

RADIATION/CONTAMINATION TYPE	INSTRUMENT (or equivalent)
Photon and beta radiation	Model 17 Ion Chamber (see note 1), Model 6112B/ 78 Telescope Detector, and Model 2350-1/44-2 Gamma Scintillator
Neutron radiation in the energy range from 0.025 eV (thermal) to about 10 MeV	NRD/Ludlum 2241
Alpha total contamination (fixed + removable)	Ludlum 2360/43-93
Alpha removable contamination	Ludlum 2360/43-93, Tennelec Series 5XLB, or Ludlum 3030E
Beta/gamma total contamination (fixed + removable)	Ludlum 2360/43-93
Beta/gamma removable contamination	Tennelec Series 5XLB, Ludlum 2360/43-93, Ludlum 3030E

Note 1: The Model 17 Ion Chamber is vented to the atmosphere . It has a relatively flat response to nearly all photon ranges. Using the Model 17 Ion Chamber underground (U/G) after calibration at the surface will result in an overestimation of the dose rate. Multiplying the U/G meter results by 0.93 will correct for the altitude difference. Normal changes in air pressure in the U/G (< 0.5 inches of water) change the instrument response by approximately 0.1% and may be neglected. The maximum differential pressure that can be sustained by the air regulators U/G (3 inches of water) results in less than 1% change in the instrument response. Temperature changes of ±20°F result in less than 5% change in instrument response.

SURFACE CONTAMINATION LIMITS

NUCLIDE	REMOVABLE ($dpm/100cm^2$)	TOTAL (fixed + removable) ($dpm/100cm^2$)
U-natural, U-235, U-238, and associated decay products	1,000 alpha	5,000 alpha
Transuranics [1], Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	20	100 [2]
Th-nat, Th-232, Sr-90 [1], Ra-223, Ra-224, U-232, I-126, I-131, I-133	200	1,000
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above. Includes mixed fission products containing Sr-90	1,000 beta-gamma	5,000 beta-gamma
Tritium organic compounds, surfaces contaminated by HT, HTO, and metal tritide aerosols	10,000	10,000

[1] The majority of alpha and beta/gamma emitters in the TRU wastes at WIPP that apply to the above limits are transuranics and Sr-90, respectively.

[2] Value taken from DOE Memorandum of Raymond F. Pelletier on Application of DOE 5400.5 Requirements for Release and Control of Property Containing Residual Radioactive Material.

Attachment 2 - Sample Radiological Survey Report [1, 4, 5]

SECTION A

Survey #	Date	Time	Shipment #	Package #

Location: _____ Surveyor printed name: _____

Reason for survey: Receipt ☐ Processing ☐ Emplacement ☐ Special Request ☐ RWP ☐
Weekly ☐ Monthly ☐ Quarterly ☐ Annual ☐ Other ☐

Model No.	Equipment/ Probe ID#	Eff.	A / 100 [1]	Cal. Due Date	BKGD (cpm)	MDA (dpm) or DL (mrem/hr)

Correction Factors

43-93 dual probe: A/100 = 1.0

Survey Type:

Alpha __ Beta/gamma __ Neutron __ Contamination __ Radiation __

SECTION B

Time	CPM	Peak in ROI	Radiological Assessment Filter (RAF) Time	CPM	Peak in ROI

SECTION C

COMMENTS

Surveyor's Signature/Date: _____
This survey has been reviewed for accuracy, regulatory compliance and radiological impacts.
This survey contains _____ pages (including this page).
Manager's Signature/Date: _____

Attachment 2 - Sample Radiological Survey Report [1, 4, 5]

SECTION D

SRV-		Alpha Activity				Beta Activity			
		Total (fixed+removable)		Swipe (removable only)		Total (fixed+removable)		Swipe (removable only)	
Survey Point	Description	Net count rate (cpm)	Activity (dpm per 100cm^2) [2]	Net count rate (cpm)	Activity (dpm per 100cm^2)	Net count rate (cpm)	Activity (dpm per 100cm^2) [2]	Net count rate (cpm)	Activity (dpm per 100cm^2)

[2] $\frac{\text{cpm}}{(\text{Eff.})(\text{A}/100)}$

Surveyor's Signature/Date: _____

Attachment 3 - Sample Radiological Survey Map [1, 4, 5]

SRV-	
Contamination Symbols: ○ = Contamination Survey Ⓛ = Large area wipe **Air Monitoring Symbol:** ☐ = Air sample location	**Dose Rate Symbols:** ✳ = Contact Dose Rate ● = Dose Rate at 30 cm No Symbol = General Area Gamma Dose Rate △ = Neutron reading (Distance symbol in triangle and dose rate adjacent) **Model 17 Ion Chamber Underground Correction = multiply reading by 0.93** **Dose rates in mrem/hr (mR/hr for MicroR meter and Teletector).**
Surveyor's Signature/Date: _____	

Attachment 4 - Radiological Survey Frequencies

Area	Type	Frequency
Contamination Area control points, change areas, or step-off pads when in use	Contamination (Direct, unless background too high for MDA, & swipes)	Daily if in use, or once per shift if in high-use situations
Office space located in RBAs adjacent to contamination areas	Radiation, Contamination (Direct, unless background too high for MDA, & swipes)	Daily if in use
Lunch rooms or eating areas near RBAs adjacent to contamination areas	Contamination (Direct & swipes)	Daily if in use
RBAs around Contamination Area	Contamination (Direct, unless background too high for MDA, & swipes)	1. Weekly* or upon entry, if entry is less frequent 2. Periodically during work 3. At completion of job 4. As specified on the RWP 5. Prior to transfer of equipment and material from one RBA established for contamination to another, unless the material was monitored immediately prior to transfer 6. Prior to transfer of equipment and material from high contamination areas within RBAs, unless sufficient precautions such as bagging or wrapping are taken prior to transfer
RBAs around Radiation Area	Radiation	
Radioactive Material Areas (RMAs)	Radiation Contamination (Direct, unless background too high for MDA, & swipes)	Weekly* or upon entry if entry is less frequent
Area immediately downstream of U/G Active Waste Disposal Area	Radiation Contamination (Direct, unless background too high for MDA, & swipes)	Weekly* or upon entry if entry is less frequent
Radiation Areas	Radiation	Weekly* or upon entry if entry is less frequent

Attachment 4 - Radiological Survey Frequencies

Area	Type	Frequency
Contamination, High Contamination, and/or Airborne Radioactivity Areas and associated boundaries (known or suspected)	Contamination (swipes only)	1. During initial entry 2. Weekly* (or upon entry, if entries are less frequent) 3. Periodically during work 4. At job completion 5. As specified on the RWP
In and around areas with fixed contamination	Contamination (Direct, unless background too high for MDA, & swipes)	Monthly
Operating high efficiency particulate air (HEPA)-filtered ventilation units ventilating known or suspected contamination or airborne radioactivity areas	Radiation	Weekly*
Potentially contaminated ducts, piping and hoses in use outside radiological areas	Radiation	Monthly
High Radiation Areas	Radiation	1. As specified on the RWP 2. When levels are expected to change
Ventilation system internal downstream of radioactive material handling and storage areas (i.e., Waste Handling Building ventilation system, U/G ventilation system)	Contamination (swipe only)	Quarterly or upon entry if entry is less frequent
Drain path from areas where radioactive materials are handled and stored	Radiation	Quarterly
Dosimetry Lab	Radiation, Contamination (Direct, unless background too high for MDA, & swipes)	Annually
Operating vent hoods in radiological work areas	Contamination (swipes only)	Monthly
Small Equipment Decon Room	Radiation/ Contamination (Direct, unless background too high for MDA, & swipes)	Monthly (Perform radiation survey of Shepard source with 12 Ci source exposed with minimum attenuation if Instrument group will be using for calibration. Must have been performed within one week of I&C use.)

* Weekly is defined as Monday through Sunday.

Attachment 5 - MDA for the Direct Survey Instruments

At various sample counting time (T_s) and Efficiency:

$$MDA = [2.71 + 3.29\sqrt{(R_b \times T_s \times (1 + T_s / T_b)}] / (T_s \times Eff \times A / 100) \quad *$$

Where R_b = Background count rate (cpm)
T_b = Background counting time of 5 minutes
T_s = Sample counting time
A/100 = the probe/100cm^2

Attachment 5 - MDA for the Direct Survey Instruments

	MDA of 2360/43-93 Scintillator for alpha probe (dpm/100cm²)											A/100 = 1		
Efficiency	T_s	Background (cpm)												
	(min)	0.2	0.4	0.6	0.8	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
0.16	1	27.0	31.2	34.4	37.1	39.5	44.5	48.8	52.6	56.0	59.1	62.0	64.7	67.3
0.18	1	24.0	27.7	30.6	33.0	35.1	39.6	43.4	46.7	49.7	52.5	55.1	57.5	59.8
0.20	1	21.6	24.9	27.5	29.7	31.6	35.6	39.0	42.0	44.8	47.3	49.6	51.8	53.8
0.22	1	19.6	22.7	25.0	27.0	28.7	32.4	35.5	38.2	40.7	43.0	45.1	47.1	48.9
0.24	1	18.0	20.8	22.9	24.7	26.3	29.7	32.5	35.0	37.3	39.4	41.3	43.1	44.9
0.26	1	16.6	19.2	21.2	22.8	24.3	27.4	30.0	32.3	34.4	36.4	38.1	39.8	41.4
0.28	1	15.4	17.8	19.6	21.2	22.6	25.4	27.9	30.0	32.0	33.8	35.4	37.0	38.5
0.30	1	14.4	16.6	18.3	19.8	21.0	23.7	26.0	28.0	29.8	31.5	33.1	34.5	35.9
When gross count rate (cpm) is less than or equal to the value specified below, record the measurement as <MDA														
Alpha gross count rate (cpm)		4.5	5.4	6.1	6.7	7.3	8.6	9.8	10.9	12.0	13.0	13.9	14.9	15.8

	MDA of 2360/43-93 Scintillator for beta probe (dpm/100cm²)											A/100 = 1		
Efficiency	T_s	Background (cpm)												
	(min)	60	80	100	120	140	160	180	200	220	240	260	280	300
0.16	1	191	218	242	264	283	302	319	335	351	366	380	394	407
0.18	1	170	194	215	234	252	268	284	298	312	325	338	350	362
0.20	1	153	175	194	211	227	241	255	268	281	293	304	315	326
0.22	1	139	159	176	192	206	220	232	244	255	266	276	286	296
0.24	1	128	146	161	176	189	201	213	224	234	244	253	263	271
0.26	1	118	134	149	162	174	186	196	206	216	225	234	242	251
0.28	1	109	125	138	151	162	172	182	192	201	209	217	225	233
0.30	1	102	116	129	141	151	161	170	179	187	195	203	210	217
When gross count rate (cpm) is less than or equal to the value specified below, record the measurement as <MDA														
Beta gross count rate (cpm)		91	115	139	162	185	208	231	254	276	299	321	343	365

If the gross count rate (cpm) is greater than the specified values above, the reported activity can be calculated as follows:

$$\text{Reported Activity } (dpm/100cm^2) = \frac{\left[\text{gross count rate (cpm) - background count rate (cpm)}\right]}{\text{Eff}}$$

Attachment 6 - MDA for the Scan Survey

NOTE

The MDA formula for scan survey is ONLY good for estimates of MDA when the scanning rate is equal to or greater than 1 inch/sec (e.g., the scanning time of moving probe over 2 inches distance should be 2 seconds or less). If the scan MDA is lower than the corresponding time/background/efficiency using the fixed count time MDAs from Attachment 5, then use the MDAs from Attachment 5.

At various background count rate and Efficiency:

$$MDA(dpm/100cm^2) = 1510\sqrt{R_b} / (\sqrt{T_i} \times Eff \times A) \qquad *$$

Where R_b = Background count rate (cpm)
T_i = Time interval moving probe spends over 2 inches, in seconds
A = the probe area in cm^2

Alpha MDA of 2360/43-93 ($dpm/100cm^2$) A= 100 cm^2

Efficiency	T_i	Background (cpm)												
	(sec)	0.2	0.4	0.6	0.8	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
0.16	1	42	60	73	84	94	116	133	149	163	177	189	200	211
0.18	1	38	53	65	75	84	103	119	133	145	157	168	178	188
0.20	1	34	48	58	68	76	92	107	119	131	141	151	160	169
0.22	1	31	43	53	61	69	84	97	109	119	128	137	146	153
0.24	1	28	40	49	56	63	77	89	99	109	118	126	133	141
0.26	1	26	37	45	52	58	71	82	92	101	109	116	123	130
0.28	1	24	34	42	48	54	66	76	85	93	101	108	114	121

Beta MDA of 2360/43-93 ($dpm/100cm^2$) A= 100 cm^2

Efficiency	T_i	Background (cpm)												
	(Sec)	30	35	40	45	50	55	60	65	70	75	80	85	90
0.16	1	517	558	597	633	667	700	731	761	790	817	844	870	895
0.18	1	459	496	531	563	593	622	650	676	702	726	750	773	796
0.20	1	414	447	478	506	534	560	585	609	632	654	675	696	716
0.22	1	376	406	434	460	485	509	532	553	574	594	614	633	651
0.24	1	345	372	398	422	445	467	487	507	526	545	563	580	597
0.26	1	318	344	367	390	411	431	450	468	486	503	519	535	551
0.28	1	295	319	341	362	381	400	418	435	451	467	482	497	512
0.30	1	276	298	318	338	356	373	390	406	421	436	450	464	478

Attachment 7 - Decision Level for Neutron Instrument in Scalar Mode

Set background counting time = measurement counting time = 1 minute

Decision Level (DL) in mrem/hr can be calculated as follows:

$$DL(mrem/hr) = \left[1.645 \times \sqrt{(R_b \times T_s \times (1 + T_s / T_b)}\right] / (T_s \times K) \text{ @}$$

Where R_b = Background count rate (cpm)
T_b = Background counting time of 1 minute
T_s = Sample counting time
K = 28 cpm/mrem/hour

Decision Level (DL) of NRD/Ludlum 2241 Meter																
BKGD (cpm)	0*	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0
DL (mrem/hr)	0.08	0.08	0.12	0.14	0.17	0.19	0.20	0.22	0.24	0.25	0.26	0.28	0.29	0.30	0.31	0.32

@ Source: ANSI/HPS N13.30, 1996, *Performance Criteria for Radiobioassay*, Equation A.20

* The value of DL at zero background is calculated using background value of 0.9 cpm.

Neutron Net Dose Rate Calculation in Scalar Mode:

For NRD/Ludlum 2241 meter:

Net Dose Rate (mrem/hr) = (measurement reading - background)/
(28 cpm/mrem/hr)

Attachment 8 - Minimum Detectable Exposure Rate of 2350-1/44-2 Gamma Scintillator

Scintillator Size: 1" diameter by 1" thick sodium iodide (NaI)Tl scintillator

Detector Sensitivity: Typically 175 cpm/μR/hr (Cs-137)

Assuming typical background expose rate of 10 μR/hr or less, it would equate to about background count rate of 1750 cpm. The desired level of performance, 95% correct detections and 60% false positive rate, results in a d' of 1.38 (See Table 6.1 of NUREG-1507). The scan rate of 0.5 m/s provides an observation interval of 1-sec. The minimum detectable exposure rate (MDER) can be calculated assuming a surveyor efficiency (*p*) of 0.5 as follows (NUREG-1507):

$$MDCR = d' \times \sqrt{b_i} \times \left(\frac{60}{i} \right)$$

$$MDCR_{surveyor} = \frac{MDCR}{\sqrt{p}}$$

$$MDER = \frac{MDCR_{surveyor}}{\text{Detector Sensitivity}}$$

Where: *MDCR* = minimum detectable (net) count rate in counts per minute
d' = index of sensitivity (see Table 6.1 of NUREG-1507)
b_i = background counts in the observation interval
I = observation interval (in second), based on the scan speed and the area extent of the contamination.
p = surveyor efficiency

Therefore, the MDER (μR/hr) of (NaI)Tl detector can be calculated as follows:

b_i = (1750 cpm) x (1 sec) x (1 min/60 sec) = 29.2 counts

MDCR = (1.38) x $(29.2)^{½}$ x (60 sec/1 min) = 447.4 cpm

$MDCR_{surveyor}$ = 447.4/$(0.5)^{½}$ = 632.7 cpm

MDER = 632.7/175 = 3.6 μR/hr ~ 4 μR/hr