

 Fermilab		ES&H Section Procedures	
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Surveys for Release and Clearance of Materials and Equipment from Radiological Control

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Revision History

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Procedure

1.0 Purpose

The purpose of this procedure is to provide instructions for performing surveys for the clearance and release of personal property, commonly referred to as materials and equipment (M&E), from radiological control.

2.0 Scope

This procedure applies to the survey of M&E that could be radioactivated, contaminated, or otherwise potentially contain radioactive material, which is referred to as “impacted material.” M&E known through process knowledge to not be potentially radioactivated, contaminated or otherwise contain radioactive material is considered “non-impacted” and does not require radiological surveys under this procedure.

The material being cleared must be of similar properties to those evaluated in ESH-RP-ERPP-02 *Technical Basis for Release of Materials and Equipment from Radiological Control*, which documents that the survey techniques are capable of detecting and quantifying residual radioactive material to meet the measurement objectives. For example, ESH-RP-ERPP-02 notes that surface surveys for graphite and concrete decayed for more than twenty years are not appropriate due to insufficient proxy radionuclides.

Survey procedures for the restricted release of material or transfers between controlled areas are not included in this procedure but are described in *Fermilab Radiological Control Manual (FRCM)* chapter 4 and ESH-RP-ERPP-01, *Radiological Release and Clearance of Materials and Equipment*.

While the DOE Moratorium and Suspension remain in effect, metals designated as scrap while in a Radiological Area may not be cleared for unrestricted release for recycling. This procedure does not cover the release of real property.

3.0 Summary

This procedure provides instructions for performing surveys to satisfy the requirements of DOE Order 458.1, *Radiation Protection of the Public and the Environment*, supported by the Fermilab Environmental Radiation Protection Program (ERPP) and documented in the FRCM. These requirements include the guidance that is provided in the *Multi-Agency Radiation Survey and Assessment of Materials and Equipment (MARSAME)* and DOE-STD-6004-2016, *Clearance and Release of Personal Property from Accelerator Facilities*.

4.0 Definitions

Clearance: The removal of property that contains or may contain residual radioactive material from DOE radiological control under 10 CFR Part 835 and DOE Order 458.1 for unrestricted release.

Controlled Area: Any area to which access is managed by or for DOE to protect individuals from exposure to radiation and/or radioactive material as defined by 10 CFR Part 835.

Impacted: A reasonable potential exists for materials to become activated or contaminated with radioactivity above background levels. Examples include items originating from accelerator enclosures

while beam is on, items originated from Contamination Areas, equipment with activated air or water, and other potential radioactive material outside of those areas.

Materials and Equipment (M&E): A generic term for personal property that includes materials, equipment, apparatus, components, articles, etc.

Non-impacted: No reasonable potential exists for materials to become activated or contaminated with radioactivity above background levels based on sufficient process knowledge.

Radiological Area: Any area within a Controlled Area defined as a Radiation Area, High Radiation Area, Very High Radiation Area, Contamination Area, High Contamination Area, or Airborne Radioactivity Area (see Articles 234, 235, 236, and Chapter 3 Part 3 of the FRCM).

Radiological Clearance Form: A document that provides a framework for recording the information, including process knowledge, that is required to complete a clearance survey at Fermilab.

Release: A reduction in the level of radiological control, or a transfer of control to another party. Examples of release include clearance, recycle, reuse, disposal as waste, or transfer of control of radioactive M&E from one authorized user to another.

Unrestricted Release: The removal of radiological regulatory controls from materials and equipment.

5.0 Responsibilities

5.1 Senior Radiation Safety Officer (SRSO)

- Provide direction to the material release program
- Guide decisions that require coordination of external organizations
- Provide guidance on non-routine release projects
- Designate other members of the Radiological Control Organization (RCO) to review completed *Radiological Clearance Forms* and approve the clearance of property, as documented via the training form in Section 13 associated with this procedure
- Designate additional qualified individuals to perform clearance surveys, as documented via the training form in Section 13 associated with this procedure

5.2 Assigned Radiation Safety Officer (RSO) or designee

- Review completed *Radiological Clearance Forms* and approve the clearance of property
- Provide guidance to Radiological Control Technicians related to interpretation of release survey methods and procedures
- Prepare non-routine release survey plans
- Maintain records of *Radiological Clearance Forms*

5.3 ERPP Manager

- Provide summary of personal property cleared in the Annual Site Environmental Report

5.4 Radiological Control Technician (RCT) or designee

- Perform clearance surveys according to this procedure or non-routine survey plans

6.0 Health and Safety Warnings

None

7.0 Prerequisites

Material & Equipment

- Radiological instrumentation appropriate for the type(s), levels, and energies of the radiation(s) expected and appropriate for existing environmental conditions
- RP Form 128, *Radiological Clearance Form*

Training Required

- RCTs (or designee) must be trained on this procedure and the required instrumentation per Section 13.

8.0 Procedural Steps

8.1 Routine Releases

8.1.1 Based on the process knowledge provided by the requester for the M&E to be cleared, the RSO, in consultation with other RSOs or RCTs as needed, determines the potential for activation and total and removable surface contamination.

NOTE: Potentially activated liquids must be removed prior to survey.

8.1.1.1 Review the process knowledge provided by the requestor and confirm it is documented on the *Radiological Clearance Form*. Provide additional description of the item(s) and the process knowledge if needed. Consider including drawings, photographs, property ID numbers, serial numbers, or other unique identifiers if available.

8.1.1.2 Determine if the material is impacted or non-impacted.

8.1.1.2.1 If the item is determined to be non-impacted, no survey is required. For situations where the RSO determines that the decision to classify the material as non-impacted requires justification, document the decision in writing via a memo to the ERPP manager.

NOTE 1: Small items and packages of similar items (e.g., boxes of tools, groups of light bulbs, boxes of fasteners) should be grouped, surveyed together with a size not less than 16"x16", and documented on one *Radiological Clearance Form*.

NOTE 2: While the DOE Moratorium and Suspension remain in effect, metals designated as scrap while in a Radiological Area may not be cleared for unrestricted release for recycling.

8.1.1.2.2 If the material is determined to be impacted, classify the material as Level 1-4 using the criteria below:

- Level 1 – M&E from areas *known* to have or have had surface contamination or volumetric activation, based on process knowledge or previous radiological surveys, or both (e.g., items near normal beam loss points such as beam absorbers, septa, collimators, and targets)
 - Level 2 – M&E from areas that have or have had a *potential* for surface contamination or volumetric activation, based on process knowledge, previous radiological surveys, or both (e.g., items adjacent to Level 1 areas, any area or system handling radioactive effluent, etc.)
 - Level 3 – M&E from areas that have or have had a *minimal potential* for surface contamination or volumetric activation based on process knowledge or previous radiological surveys, or both (e.g., items far from beam losses or for which preliminary area surveys have shown no induced radioactivity)
 - Level 4 – M&E from areas where ^3H or ^7Be contamination is known or suspected
- 8.1.2 If activation is of concern based on process knowledge, a volumetric survey is required.
- 8.1.2.1 Perform a battery and source check of a Bicon Analyst (including scaler functionality) with a 1"x1.5" NaI detector. Review the calibration due date for the instrument to ensure it is within the acceptable calibration period.
- 8.1.2.1.1 If the instrument does not pass the operational checks, remove it from service.
- 8.1.2.1.2 If the instrument passes the operational checks, record the detector information and operational check results on the *Radiological Clearance Form*.
- 8.1.2.2 Obtain a 1-minute background measurement via the scaler function in the general location where the M&E will be surveyed yet away from any sources of radioactive material. When feasible, perform the background measurement on a similar item that is known to be non-impacted. The maximum acceptable background for conducting clearance surveys is 3000 cpm.
- 8.1.2.3 Perform a scan of the item at approximately 1 cm from the item, moving at a maximum speed of 2"/s, and listening for audible counts during the scan. If the geometry of the item relevant to the beam is well known, only the surface facing the beam/beam loss point is required to be surveyed. If the geometry is not well known, scan all surfaces in rows no greater than 10 cm apart.

- 8.1.2.4 Perform at least one static 1-minute count per each 1 m² of surface area scanned.
 - 8.1.2.4.1 If an elevated count rate was detected during the scan, collect the static measurement in this area
 - 8.1.2.4.2 If no elevated count rate was detected on the scan, collect the static measurement in a representative area.
- 8.1.2.5 Record the results of the instrument background measurements and the highest static 1-minute measurement on the *Radiological Clearance Form*.
- 8.1.2.6 Compare the results of the static 1-minute measurement to the Indistinguishable from Background values in Table 1 to determine if the item has met the volumetric release criterion. If this value is exceeded, the item is not eligible for clearance.

Table 1. Background-dependent detection thresholds for IFB determination of volumetric radioactivity

Background (cpm)	IFB Detection Threshold (net cpm)
1000	147
1100	154
1200	161
1300	167
1400	173
1500	180
1600	186
1700	191
1800	197
1900	202
2000	207
2100	213
2200	218
2300	223
2400	227
2500	232
2600	237
2700	241
2800	246
2900	250
3000	254

- 8.1.3 If fixed contamination is of concern based on process knowledge, a fixed surface contamination survey is required. Examples of situations where fixed contamination is possible include locations where a fixative or paint has been applied to an area of removable contamination.
 - 8.1.3.1 Perform a battery and source check of a Ludlum 177-4 with a 44-9 detector or an Eberline 140N with a 44-9 detector. Ensure the

- instrument has a scaler. Review the calibration due date for the instrument to ensure it is within the acceptable calibration period.
- 8.1.3.1.1 If the instrument does not pass the operational checks, remove it from service.
 - 8.1.3.1.2 If the instrument passes the operational checks, record the detector information and operational check results on the *Radiological Clearance Form*.
- 8.1.3.2 Obtain a 1-minute background measurement in the area where the M&E will be surveyed but away from any sources of radioactive material. When feasible, perform the background measurement on a similar item that is known to be non-impacted.
- 8.1.3.2.1 The maximum acceptable background when conducting clearance surveys with the Ludlum 177-4 is 80 cpm.
 - 8.1.3.2.2 The maximum acceptable background when conducting clearance surveys with the Eberline 140N is 50 cpm.
- 8.1.3.3 Perform a scan of the item at approximately 0.25" from the surface of the item, moving at a maximum speed of 1"/s, and listening for audible counts during the scan. Scan all surfaces suspect for fixed contamination.
- 8.1.3.4 Perform at least one static 1-minute count per each 1 m² of surface area scanned.
- 8.1.3.4.1 If an elevated count rate was detected during the scan, collect the static measurement in this area
 - 8.1.3.4.2 If no elevated count rate was detected on the scan, collect the static measurement in a representative area. Consider performing the static measurement in areas with visible discoloration.
- 8.1.3.5 Convert the net cpm results to dpm using a conservative efficiency of 0.019 cpm/(dpm/100cm²).
- NOTE:** When calculating the total surface contamination and converting net CPM to dpm/100 cm², a conversion factor of 0.019 is used. This value represents the 2π beta efficiency of the 44-9 GM detector (38%), the conservative source efficiency accounting for the increased particle emission resulting from backscatter effects as well as the decreased particle emission because of self-absorption losses (25%), and correction of the physical probe area to account for an area of 100 cm² (20.3%). The selection of these values is discussed in Appendix C of ESH-RP-ERPP-02, *Technical Basis for Release of Materials from Radiological Control*.
- 8.1.3.6 Record the results of the instrument background measurements and the highest static 1-minute measurement on the *Radiological Clearance Form*.

8.1.3.7 Compare the results of the static 1-minute count to the “Average” Total from the applicable column in Table 2. If this value is exceeded, the item is not eligible for clearance.

Note: For unique circumstances, such as valuable equipment, the “Maximum” Total column value may be used with written approval from the SRSO when the contamination is localized to an area of not more than 100 cm².

Table 2. Release Criteria for Surface Contamination^{a,b}

Radionuclides ^c	REMOVABLE ^f (dpm/100cm ²)	TOTAL (Fixed + Removable) (dpm/100cm ²)	
		Average ^{d,e}	Maximum ^{d,e}
Group 1 – Transuranics, ¹²⁵ I, ¹²⁹ I, ²²⁷ Ac, ²²⁶ Ra, ²²⁸ Ra, ²²⁸ Th, ²³⁰ Th, ²³¹ Pa	20	100	300
Group 2 – Th-natural, ⁹⁰ Sr, ¹²⁶ I, ¹³¹ I, ¹³³ I, ²²³ Ra, ²²⁴ Ra, ²³² U, ²³² Th	200	1,000	3,000
Group 3 – U-natural, ²³⁵ U, ²³⁸ U, associated decay products (alpha emitters)	1,000	5,000	15,000
Group 4 – Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except ⁹⁰ Sr and others noted above ^g	1,000	5,000	15,000
Tritium and STCs (applicable to surface and subsurface) ^h	10,000	N/A	N/A

- a* The values in this table (except for tritium) apply to radioactive material deposited on but not incorporated into the interior or matrix of the property. Authorized limits for residual radioactive material in volume must be approved separately.
- b* As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.
- c* Where surface contamination by both alpha-emitting and beta-gamma-emitting radionuclides exists, the limits established for alpha-emitting and beta-gamma-emitting radionuclides should apply independently.
- d* Measurements of average contamination should not be averaged over an area of more than 1 m². Where scanning surveys are not sufficient to detect levels in the table, static counting must be used to measure surface activity. Representative sampling (static counts on the areas) may be used to demonstrate by analyses of the static counting data. The maximum contamination level applies to an area of not more than 100 cm².
- e* The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 millirad per hour (mrad/h) and 1.0 mrad/h, respectively, at 1 cm.
- f* The amount of removable material per 100 cm² of surface area should be determined by wiping an area of that size with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wiping with an appropriate instrument of known efficiency. When removable contamination of objects on surfaces of less than 100 cm² is determined, the activity per unit area should be based on the actual area, and the entire surface should be wiped. It is not necessary to use wiping techniques to measure removable contamination levels if direct scan surveys indicate the total residual surface contamination levels are within the limits for removable contamination.
- g* This category of radionuclides includes mixed fission products, including the ⁹⁰Sr that is present in them. It does not apply to ⁹⁰Sr that has been separated from the other fission products or mixtures where the ⁹⁰Sr has been enriched.
- h* Measurement should be conducted by a standard smear measurement but using a damp swipe or material that will readily absorb tritium, such as polystyrene foam. Property recently exposed or decontaminated should have measurements (smears) at regular time intervals to prevent a buildup of contamination over time. Because tritium typically penetrates material it contacts, the surface guidelines in group 4 do not apply to tritium. Measurements demonstrating compliance of the removable fraction of tritium on surfaces with this guideline are acceptable to ensure nonremovable fractions and residual tritium in mass will not cause exposures that exceed DOE dose limits and constraints.

- 8.1.4 If removable contamination is of concern based on process knowledge, a removable contamination survey is required.
- 8.1.4.1 Collect at least one 100 cm² wipe per m² of surface area. Consider performing the wipe in areas with visible discoloration.
Note: If the item being surveyed is less than 100 cm² in surface area, wipe the entire item and scale the results to an area of 100 cm².
- 8.1.4.2 If the item has inaccessible surfaces, disassemble the item to allow for a survey. If disassembly is not feasible, obtain a written statement from the requestor that internal contamination above the release criteria in Table 2 is not of concern based on process knowledge.
- 8.1.4.3 Submit the wipe(s) to the Radionuclide Analysis Facility (RAF) for analysis with a gross alpha-beta counter, liquid scintillation counter, or HPGe based on the radionuclide of concern.
Note: M&E classified as Level 4 requires analysis for ³H or ⁷Be contamination. Wipes for ³H should be taken in accordance with ESH-RPO-WIPE-01, *Wipe Surveys using Dissolvable Wipes*. M&E previously-containing potentially activated liquids (e.g., oils, water) or M&E originating from water systems that potentially contained tritium at concentrations greater than 100 pCi/mL require analysis for ³H surface contamination. Examples of potentially contaminated water systems include Radioactive Water (RAW), some sections of Industrial Cooling Water (ICW), and NuMI condensate system.
- 8.1.4.4 Compare the results to the “Removable” value for the applicable radionuclide(s) of concern in Table 2. If this value is exceeded, the item is not eligible for clearance and must be stored in a posted Contamination Area.
- 8.1.4.5 Record the RAF Batch ID or Work Request Number on the *Radiological Clearance Form* and attach the results from the RAF to the form.

Table 3. Preferred Counting Equipment for Removable Contamination

Radionuclide Group	Preferred Counting Equipment	Examples of Common Radionuclides at Fermilab ^a
Alpha-emitter	XLB	²³⁸ U, ²⁴¹ Am, ²⁵² Cf
Low-energy beta-emitters	LSC	³ H
Beta-gamma emitters	XLB	²² Na, ⁶⁰ Co, ¹³⁷ Cs
High-energy Photon Emitter (high yield)	HPGe, XLB	⁵⁴ Mn
High-energy Photon Emitter (low yield)	HPGe, XLB with extended (60 min) count time	⁷ Be

^a List is not complete; additional radionuclides not listed should be grouped appropriately

- 8.1.5 Perform confirmatory measurements according to the level classified.
 - 8.1.5.1 For M&E that is classified as Level 1, consult with the assigned RSO to determine if confirmatory measurements (e.g. field gamma spectroscopy, laboratory samples) are required.
- 8.1.6 Submit the survey to the RSO or designee for approval. The RSO approval confirms that the appropriate surveys were performed.
- 8.1.7 RSO or designee notifies the RCT and/or the requestor when the M&E has been approved for release. The M&E is now considered approved for release.
- 8.1.8 For cleared impacted M&E that will be exiting the Fermilab site (e.g., for waste or recycling), perform a survey of the container.
 - 8.1.8.1 For scrap metal, the vehicle carrying bulk M&E should exit via the Ludlum 4525-14000 vehicle gate monitor.
 - 8.1.8.2 For small containers (e.g., drums of universal waste), perform a survey of the exterior of the package using a Bicron Analyst in rate meter mode.
- 8.2 Non-routine Releases
 - 8.2.1 The assigned RSO may develop a survey plan that differs from this procedure. Conditions that may warrant a non-routine survey plan include:
 - M&E that is requested to be cleared that differs significantly in its primary composition or beam exposure or decay time from the technical basis document or RP Notes, such as short irradiations or cool-downs. Collaborate with Radiation Physics staff to document the clearance basis and measurement requirements.
 - M&E is requested to be cleared that does not require surface scans and can solely utilize fixed point measurements, such as concrete shielding that was located away from the primary beam and would not have a sharp activity gradient.
 - M&E is requested to be cleared which could contain radionuclides requiring additional measurement methods (e.g., alpha emitters, activated graphite, or concrete decayed for more than twenty years).
 - 8.2.2 The assigned RSO or designee develops a survey plan describing the instrumentation, scan speeds, count times, and confirmatory measurements required for the non-routine survey plan.

9.0 Data and Records Management

Radiation survey data is recorded on the *Radiological Clearance Form*, which are scanned and uploaded to SharePoint. The R. P. Form 128, *Radiological Clearance Form* records shall be retained for 75 years. A summary of material cleared shall be reported in the *Annual Site Environmental Report*.

10.0 Quality Assurance/Quality Control

This procedure is subject to a review frequency requirement of 3 years and is due in March 2025.

11.0 References

Fermilab, "Environmental Radiological Protection Program", February 2022.

Fermilab, “Wipe Surveys using Dissolvable Wipes”, ESH-RPO-WIPE-01.

Fermilab, “Radiological Release and Clearance of Materials and Equipment”, ESH-RP-ERPP-01.

Fermilab, “Technical Basis for Release of Materials and Equipment from Radiological Control” ESH-RP-ERPP-02.

Fermilab Radiological Control Manual (FRCM)

U.S. Department of Energy (DOE), “Radiation Protection of the Public and the Environment”, DOE Order 5400.5, 1990, Change 2, 1-7-1993.

U.S. Department of Energy (DOE), “Clearance and Release of Personal Property from Accelerator Facilities”, DOE-STD-6004-2016, 5-19-2016.

U.S. Department of Energy (DOE), “Radiation Protection of the Public and the Environment”, DOE Order 458.1, Chg. 4, 9-15-2020.

12.0 SOP Signature Sheet

This table indicates all qualified personnel, and documents that they have read and understood this procedure and completed necessary On-the-Job Training (OJT) and Procedure Specific Training listed in Section 7.0 and tracked in Section 13.0. By signing below, the qualified individual agrees to adhere to the requirements and guidelines contained within this procedure along with all other applicable work authorization documents. Only persons who have signed below and have been authorized may perform work covered by this SOP.

Name	Signature	Date	Department Head/Team Leader

13.0 Procedure Specific Training Checklist

This table indicates all qualified personnel, and documents that they have completed necessary On-the-Job Training (OJT) and Procedure Specific Training. Only persons who have signed below and have been authorized by the relevant department head or team leader may perform work covered by this SOP.

Topic	Name	Signature	Date	Department Head/Team Leader
Procedure-specific training				

14.0 Attachments

None.