

## FRCM CHAPTER 4 RADIOACTIVE MATERIALS

### Revision History

Author	Description of Change	Revision Date
K. Graden	<ul style="list-style-type: none"> <li>Revised Article 433 to prohibit eating and drinking where sealed radioactive sources are in use. Revised Article 415 to remove specific locations where radioactive materials are stored.</li> </ul>	November 2021
M. Wolter and J. D. Cossairt	<ul style="list-style-type: none"> <li>Changes to Articles 412.3, 423.4d, and 423.4.f to clarify existing practices and remove obsolete/incorrect lists of instruments used for certain purposes.</li> <li>Addition of Article 423.6 to cover on-site transfers with significant risk.</li> </ul>	July 2018
J. D. Cossairt	<ul style="list-style-type: none"> <li>Added Figure 4-1, a flowchart that illustrates Fermilab's waste handling procedures, to Article 441.</li> </ul>	September 2017
J. D. Cossairt	<ul style="list-style-type: none"> <li>Reformulated Radiological Control Organization due to Fermilab-wide reconfiguration of ES&amp;H personnel.</li> <li>Article 415 amended to provide a specific provision pertaining to SURF, delete provisions for custodians of Radioactive Materials Areas, and clarify requirements for outdoor storage of radioactive materials.</li> <li>Article 423 amended to clarify the responsibilities for transporting Fermilab rad material Class 3 or higher.</li> </ul>	November 2016
J. D. Cossairt	<ul style="list-style-type: none"> <li>Reflect new Sealed Source Program requirements intended to better address institutional risks (Part 3).</li> <li>New Article 424 to describe current metals recycling practices and update Articles 413 &amp; 422.</li> <li>Update incorrect organizational information.</li> </ul>	July 2015
J. D. Cossairt	<ul style="list-style-type: none"> <li>Add link to forms in Article 441.4</li> </ul>	February 2013
J. D. Cossairt	<ul style="list-style-type: none"> <li>Updated Articles 412.4 and 412.5 to address the DOE suspension of recycling of radioactive materials originating from Radiological Areas.</li> <li>Incorporated suggestion of DOE-FSO in Article 412.8</li> <li>Amend Article 423.2b to incorporate clarifications from the Radiation Safety Subcommittee.</li> </ul>	November 2012

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46 **PART 1 RADIOACTIVE MATERIAL IDENTIFICATION, STORAGE AND**  
 47 **CONTROL**

48  
 49 **411 Definitions**

50  
 51 Any material, equipment or system component which has been exposed to particle beams or  
 52 contaminated by contact with accelerator activated material or with naturally occurring  
 53 radioactive material is considered suspect radioactive material. Furthermore, items located in  
 54 known or suspected Contamination, High Contamination or Airborne Radioactivity Areas and  
 55 having the potential to become contaminated are considered suspect radioactive material.  
 56 Radioactive material includes sealed and unsealed sources. Controls for sealed sources are  
 57 described in Part 3 of this Chapter. Appendix E of 10 CFR 835 defines quantities of radioactive  
 58 materials that are considered "accountable" under 10 CFR 835.

59  
 60 **Radioactive Material:** Fermilab has established a practical release criterion for materials,  
 61 equipment, and waste based on the use of field survey instruments. Materials, equipment,  
 62 system components, waste items, or waste containers are considered to be radioactive if:

- 63
- 64 • On a contact survey the gross count rate with any surface is greater than twice the mean  
 65 background count rate as measured in a low background (<2000 cpm) with a standard  
 66 Bicon Analyst™ gamma scintillation probe.
  - 67 or
  - 68 • On a contact survey the net count rate above mean background with any surface is  
 69 greater than 2000 cpm as measured in a moderate background (≥2000 cpm but <3000  
 70 cpm) with a standard Bicon Analyst™ gamma scintillation probe.
  - 71 or
  - 72 • On a contact survey the net count rate above mean background with any surface is  
 73 greater than 50 cpm above mean background on an Eberline E140N or Ludlum 177-4  
 74 Frisker Geiger-Mueller survey instrument.
  - 75 or
  - 76 • Concentrations of any radionuclides contained within the material matrix equal or  
 77 exceed those specified in applicable federal, DOE, state, or local regulations.
  - 78 or
  - 79 • They have removable or fixed surface radioactivity which equals or exceeds the limits  
 80 established in Table 2-2.

81  
 82 If any of these conditions are satisfied, then the material is radioactive by definition.

83  
 84 The technique using the Frisker Geiger-Mueller tube instrument is permitted because of its  
 85 simplicity and in situations where static magnetic fields are present that will preclude proper  
 86 operations of the photomultiplier tube inherent in the Bicon Analyst™. See further  
 87 requirements in Part 2 of this chapter. Training in the use of this instrument comprises a part of  
 88 Radiological Worker Training.  
 89

90 The use of the Bicron Analyst™ is the preferred methodology for screening items for potential  
 91 offsite transport.

92

93 **412 Requirements**

94

95 1. Materials which have been in areas where activation is possible shall be considered  
 96 radioactive material until surveyed. Materials in Contamination, High Contamination or  
 97 Airborne Radioactivity Areas shall also be considered suspect radioactive material until  
 98 surveyed, unless the area is an Airborne Radioactivity Area where only gaseous, short-lived  
 99 (half-life of 1 hour or less) activation products are present (such as represented by the typical  
 100 accelerator-produced airborne radionuclides —  $^{11}\text{C}$ ,  $^{13}\text{N}$ ,  $^{15}\text{O}$ , and  $^{41}\text{Ar}$  — at Fermilab).  
 101 Surveys must assess the applicability of the criteria in Article 411, unless process knowledge  
 102 is available. This includes materials moved from “Controlled” to “Uncontrolled” areas (see  
 103 Articles 421.1 and 422.1).

104

105 a. As materials are removed from beamline enclosures where activation is possible (as  
 106 designated by members of the Radiological Control Organization), the items shall  
 107 be surveyed and labeled appropriately.

108

109 b. Materials or system components which are processed in such a way as to remove all  
 110 or part of the gamma emitting radionuclides they may contain are specifically  
 111 exempt from the definition set forth in article 411. The specific activities of  
 112 exclusive beta emitting radionuclides can no longer be accurately correlated with  
 113 those of the gamma emitting radionuclides in such cases. Laboratory analysis must  
 114 be used to ascertain the radioactive status if process knowledge is insufficient.

115

116 c. Known or suspected alpha emitters must be surveyed with an “alpha meter”  
 117 obtainable from and used by members of the Radiological Control Organization.  
 118 Materials known to be or suspected of being contaminated with low energy beta  
 119 emitters (e.g.,  $^3\text{H}$  or  $^{63}\text{Ni}$ ) also require special survey techniques. In such cases, the  
 120 assigned RSO should be contacted.

121

122 2. If an item is found to be radioactive and it is to remain on site, surveys shall be performed  
 123 promptly with a dose rate meter with appropriate scales to determine which Class label  
 124 should be applied. The label should be filled out completely.

125

126 3. Any material, equipment, system component, waste item, or waste container with  
 127 removable contamination levels equaling or exceeding the levels specified in Table 2-2 are  
 128 considered radioactively contaminated. If they can be decontaminated to levels below those  
 129 specified in Table 2-2 and are not otherwise radioactive then they may be reclassified as  
 130 non-radioactive material.

131

132 4. Material determined to be non-radioactive may be disposed of as waste or taken off site  
 133 without restriction as to its radioactivity provided it did not originate from a posted

- 134 Radiological Area. The Glossary shall be referenced for the precise definition of  
135 “radiological area”. All radioactive labels should be removed from the material when it is  
136 determined not to be radioactive (see Article 413.10).  
137
- 138 5. In July 2000, DOE imposed a suspension on the recycling of metals originating from inside  
139 a Radiological Areas as defined by 10 CFR 835 (see Glossary to the Manual). This action  
140 was in addition to a moratorium in recycling actual radioactive materials issued in January  
141 2000. This moratorium and its subsequent suspension remain in effect.  
142
- 143 a. This provision applies to recycling of metals and does not apply to reuse of materials  
144 by Fermilab or other DOE facilities.  
145
  - 146 b. The assigned Radiation Safety officer (RSO) shall be consulted concerning special  
147 procedures instituted to meet the requirements of this suspension.  
148
  - 149 c. Arrangements for recycling of metals are made through the Facility Engineering  
150 Services Section Logistics and Property Control (FESS - LPC) Office with  
151 coordination from the ES&H Section in consultation with DOE-FSO as necessary.  
152
  - 153 d. See Article 424 of this chapter for more information about metals recycling.  
154
- 155 6. A piece of equipment should be broken down into the smallest number of components  
156 that is practical and the radioactivity of each item determined individually. This helps  
157 ensure that the amount of radioactive waste generated is minimized.  
158
- 159 7. If a group of individual items, which by themselves would not be classified as  
160 radioactive, are placed together collectively in such a manner that the aggregate meets  
161 the definition of a radioactive material found in Article 411, then the aggregate must be  
162 considered radioactive.  
163
- 164 8. In cases where materials are brought on site containing naturally occurring radioactive  
165 material (NORM) such as thoriated tungsten welding rods or blasting grit, the  
166 background to be used in determining the radioactive status of residues should be the  
167 radiation field produced by a non-activated or contaminated sample in the same counting  
168 geometry as the sample being analyzed. In most cases, this background will be  
169 significantly higher than the ambient background.  
170
- 171 9. While radioactive items at Fermilab are mostly volume-activated, there are occasionally  
172 instances of “fixed contamination”. Fixed contamination is radioactive material on the  
173 surface of an item maintained in place by means of a bonding agent such as adhesive,  
174 paint, or epoxy. Such items should be routinely monitored to assure continued integrity.  
175

176 **413 Radioactive Material Labeling and Handling**

177

 178 1. Fermilab has implemented a system of labeling radioactive materials outside beam  
 179 enclosures which assigns classes to them based upon exposure rates. In addition, Table 4-1  
 180 lists general labeling requirements for radioactive materials. All radioactive material outside  
 181 radiological areas shall be labeled in accordance with Tables 4-1 and 4-2.

182

 183 2. Radioactive material may be capable of generating a Radiation Area, High Radiation Area,  
 184 or Very High Radiation Area. These areas shall have special controls in accordance with  
 185 Article 333 and be posted/designated in accordance with Article 234.

186

 187 3. The Laboratory has developed response and notification requirements associated with a loss  
 188 of radioactive material, including searches, internal investigations, documentation and  
 189 reporting. The Radiological Control Organization including the Senior Radiation Safety  
 190 Officer is to be notified in the event of a loss or theft of radioactive material. This includes  
 191 radioactive sources.

192

193

**Table 4-1 General Labeling Requirements for Radioactive Materials**

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	<b>REQUIRED LABELING</b>
Equipment, components and other items that are radioactive	“CAUTION, RADIOACTIVE MATERIAL” (but use Table 4-2 for radioactive label classes)
Sealed and unsealed radioactive sources or associated storage containers	“CAUTION, RADIOACTIVE MATERIAL” and/or standard radiation symbol
Equipment, components and other items with actual or potential internal contamination	“CAUTION, CONTAMINATED MATERIALS” or “CAUTION, POTENTIAL INTERNAL CONTAMINATION HAZARD”
Components, equipment or other items with fixed contamination (see Article 221)	“CAUTION, FIXED CONTAMINATION”

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**Table 4-2 Radioactivity Class Labels**

Label	Exposure Rate (mR/hr @ 1 ft)		
	At Least	but	Less Than
CAUTION RADIOACTIVE MATERIAL Class 1	Satisfies definition in Article 411		1 mR/hr
CAUTION RADIOACTIVE MATERIAL Class 2	1		10 mR/hr
CAUTION RADIOACTIVE MATERIAL Class 3	10		100 mR/hr
DANGER RADIOACTIVE MATERIAL Class 4	100		1000 mR/hr (= 1 R/hr)
DANGER: HIGHLY RADIOACTIVE MATERIAL Class 5	1 R/hr		----

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4. The following are not subject to item labeling requirements as set forth in Table 4-1:
- a. Radioactive material located in areas posted in accordance with the requirements of Articles 234-236.
  - b. Radioactive material or containers packaged and labeled for offsite shipment in accordance with Department of Transportation Regulations.
  - c. Equipment or installed system components undergoing maintenance covered by a Radiological Work Permit.
  - d. Installed system components located within an area, inaccessible to individuals.
  - e. Items located within areas posted in accordance Article 233 when it is impractical to label all items. Such items shall be properly surveyed and labeled when they are removed from such areas.
  - f. Short-lived (half-life of 1 hour or less) radioactive material generated during an irradiation (i.e., research samples while an experiment is being conducted, etc.) that is immediately used.
  - g. Installed in process equipment such as piping or tanks if the posting is of no value for controlling exposures during repairs and maintenance as determined by the assigned RSO.

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5. The following are not subject to labeling requirements if they are Class 2 or less and if they are not significantly ( $\geq 10X$  general background) more radioactive than ambient radiation fields where they are stored:
    - a. Radiological control samples such as air, process and soil samples or swipes that are in the custody of personnel properly trained in the handling, packaging and transport of these samples.
    - b. Portable tools and equipment with fixed contamination permanently marked with yellow or magenta and maintained in a labeled contaminated tool crib or storage and distribution area.
    - c. Personal Protective Equipment and clothing.
  6. Labels shall have a yellow background with a magenta or black standard radiation warning trefoil. Lettering shall be magenta or black.
  7. Labels shall include the maximum dose rate at 30 cm (1 foot) (see Tables 4-1 and 4-2), removable surface contamination levels, if any (specified as alpha or beta-gamma), dates surveyed, and surveyor's initials or preferably the surveyor's Fermilab ID number. For items determined to be Class 1 the dose rate need not be included.
  8. Packaged radioactive material should have the label visible through the package or affixed to the outside.
  9. When certain radionuclides (some alpha sources, tritium, etc.) are packaged so that no radiation is detectable outside the container, a Caution, Radioactive Material label shall be used. Additional information, such as the radionuclide present, specific activity, etc., shall be affixed to the container.
  10. Non-radioactive materials should not carry radioactivity Class labels. Good practice is to check items whenever practical, reclassify items which need a new label, and remove all labels if the item is no longer radioactive.
  11. Hand tools and equipment stored in radiological areas may be marked with yellow or magenta paint to denote that they are radioactive. Outside these areas, they must be marked with the appropriate radioactivity Class labels.
  12. Material and equipment exceeding the removable surface contamination values specified in Table 2-2 of the Manual may be conditionally released for movement on-site from one radiological area for immediate placement in another radiological area only if appropriate monitoring is performed and appropriate controls for the movement are established and exercised under authorization of the assigned RSO.



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**414 Radioactive Material Packaging**

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1. Material that is outside Contamination, High Contamination or Airborne Radioactivity Areas and is confirmed or suspected of having removable radioactive contamination levels greater than Table 2-2 values, shall be securely wrapped in plastic or placed in a container such that any potential contamination from that material will be completely contained.

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2. Contaminated material with sharp edges or projections should be taped or additionally protected to ensure package integrity.

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3. Contaminated material with removable contamination levels in excess of 100 times Table 2-2 values should have additional packaging controls such as double-wrapping or the use of plastic bags inside containers.

280

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4. Yellow plastic wrapping material should be used in packaging radioactive material for storage, transportation, or shipment. Yellow plastic sheets or bags should not be used for non-radiological purposes.

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5. The amount of combustible material used in packaging should be minimized and selected in accord with Fermilab ES&H Manual fire protection policies.

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**415 Radioactive Material Storage**

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1. Areas where radioactive material is stored should be appropriately posted as set forth in Part 3 of Chapter 2.

293

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295

2. Long-term (more than 1 year) storage of radioactive material should be in areas specifically designated for the storage of radioactive material. Portions of the Railhead currently constitute Fermilab's major long-term storage area (see Subpart 13 below).

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3. Radioactive materials shall not be stored off site (including buildings rented or leased by the Laboratory) or at certain specified on-site locations including the following:

300

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302

a. On site housing (dorms, etc.)

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304

b. Established eating and drinking areas (lunchrooms, vending areas, etc.)

305

306

c. In Wilson Hall unless the provisions of Chapter 9 Part 1 are followed.

307

308

309

4. The acquisition, use, and associated transportation of radioactive materials including sealed sources and nuclear materials at the Sanford Underground Research Facility (SURF) in areas leased or managed by FRA/Fermilab shall be approved by the SRSO. These materials

310

- 311 shall be managed in accordance with requirements applicable to the particular space within  
312 the SURF facility.  
313
- 314 5. Decontamination or disposal of radioactive material is the preferred alternative to long-term  
315 storage except for equipment of significant value. For purposes of this Article, “value” may  
316 be either defined in terms of financial considerations or in terms of the difficulty of replacing  
317 the materials or equipment in question.  
318
- 319 6. Article 242 specifies documentation requirements for facilities containing radioactive  
320 materials. Proposals for additions to and deletions from this list shall be approved by the  
321 assigned RSO.  
322
- 323 7. The Radiological Control Organization shall conduct periodic walkthroughs of areas where  
324 radioactive material is stored or used to check for adherence to Laboratory policies,  
325 especially with respect to the minimization of material accumulation, proper labeling, and  
326 container integrity.  
327
- 328 8. Storage of non-radioactive material in any radiological area should be minimized.  
329
- 330 9. Outdoor storage of radioactive material is discouraged.  
331
- 332 a. Any new outdoor storage locations that will be used more than 30 days shall be  
333 approved by the SRSO.  
334
- 335 b. The use of shielding blocks for storing radioactive materials outdoors with limited  
336 protection against the outdoor weather environment and as the dominant structural  
337 element is strongly discouraged.  
338
- 339 c. Outdoor storage locations that will be used for periods of less than 30 days may be  
340 approved by the assigned RSO.  
341
- 342 d. In cases where outdoor storage is necessary and where removable radioactivity is  
343 present, containers of high integrity shall be chosen to prevent degradation from  
344 weathering and the resultant release of radioactive material.  
345
- 346 e. Radioactive items and associated pieces of equipment shall be stored in a structurally  
347 sound manner that provides the long term ability to safely retrieve the items from  
348 both a material handling and radiation safety perspective.  
349
- 350 10. Radioactive material should be stored in a manner that reduces combustible loading. The  
351 use of cardboard containers for storage is discouraged.  
352
- 353 11. Flammable or combustible materials should not be stored adjacent to areas where  
354 radioactive material is stored or used.

- 355  
356 12. Fire protection measures, such as smoke detectors, water sprinklers and fire extinguishers,  
357 should be considered when establishing areas for the storage and usage of radioactive  
358 materials.  
359
- 360 13. Specific locations at the Laboratory are designated for general storage of radioactive  
361 material. Limited indoor storage, built from shielding blocks, is available in the Lundy Barn.  
362 However, the building is not heated, air conditioned or completely waterproof, so some  
363 deterioration due to the physical conditions should be expected. The procedures for using  
364 this storage area are given below.  
365
- 366 a. General  
367
- 368 (1) Radioactive material storage in FESS areas is under the direct control of FESS  
369 – LPC as the landlord. Contact them for storage arrangements.  
370
- 371 (2) All portable items (items weighing less than 200 lbs.) must be stored in a secure  
372 area, e.g., either inside a building or in a fenced and locked area outside. If stored  
373 outside, provision should be made to prevent any environmental contamination  
374 or theft.  
375
- 376 (3) All items must be surveyed and labeled with the exposure rate, date of survey,  
377 and contamination level, if any, on a Material Move Request (MMR) Form. It is  
378 the responsibility of the division/section requesting the storage to arrange for  
379 appropriate radiation surveys.  
380
- 381 b. Limits  
382
- 383 (1) Exposure Rate Limits  
384
- 385 Any Class 4 or higher item shall be stored with enough shielding to reduce the  
386 radiation exposure rate outside the shield to below 100 mR/hr.  
387
- 388 (2) Contamination Limits  
389
- 390 (i) When practical, all surfaces of all items shall be decontaminated to levels  
391 less than those specified in Table 2-2.  
392
- 393 (ii) Items which cannot be decontaminated must be covered with a  
394 waterproof barrier (e.g., Herculite™) and put inside a container which  
395 will provide weather protection for the duration of storage. Class 4 and  
396 5 radioactive items which are subject to corrosion shall be covered with  
397 a waterproof barrier. Other unusual situations such as those which may

398 involve radioactive liquid, powder, etc., will be handled on a case-by-  
399 case basis.  
400

400

## 401 **PART 2 RELEASE AND TRANSPORTATION OF RADIOACTIVE MATERIAL**

402

### 403 **421 Release to Controlled Areas**

404

405 1. Materials released from radiological areas to Controlled Areas should be promptly  
406 categorized as radioactive or non-radioactive based on the definition found in Article 411  
407 or the process knowledge of the individuals releasing the material.  
408

409

410 2. A wipe survey shall be performed on radioactive material in Contamination, High  
411 Contamination or Airborne Radioactivity Areas unless a frisker survey can demonstrate that  
412 the removable contamination levels are below those specified in Table 2-2 and no alpha or  
413 low-energy beta emitting radionuclides are present. Unpackaged radioactive material to be  
414 released to Controlled Areas shall be demonstrated to have removable contamination levels  
415 less than Table 2-2 values.

416

417 3. Materials may be released from Contamination Areas for use in Controlled Areas provided  
418 that measurements of accessible surfaces show that removable contamination levels are  
419 below those in Table 2-2 and contamination levels on inaccessible surfaces are unlikely to  
420 exceed those levels. These items shall be routinely monitored and controlled in accordance  
421 with administrative procedures in Article 221. Controls shall be established to ensure that  
422 no unmonitored individual is likely to exceed a dose that would require monitoring in  
423 keeping with Articles 511 or 521. See also Article 413.12.

424

425 4. Radioactive material with removable contamination levels greater than Table 2-2 values  
426 which cannot be decontaminated shall be packaged prior to release to Controlled Areas.  
427 These items shall be routinely monitored and controlled in accordance with administrative  
428 procedures. Controls shall be established to ensure no unmonitored individual is likely to  
429 exceed a dose that would require monitoring in accordance with Articles 511 or 521.

430

431 5. Material not immediately removed from Contamination, High Contamination, or Airborne  
432 Radioactivity Areas after survey shall be controlled to prevent contamination while awaiting  
433 release. Potentially activated material not immediately released after survey shall be  
434 controlled to prevent activation while awaiting release.

435

436 6. Records for release of potentially contaminated materials shall describe the property, date  
437 of last survey, identity (either initials or a Fermilab ID number) of the person who performed  
438 the survey, type and identification number of the survey instruments used, and survey results  
439 demonstrating the contamination levels are below those of Table 2-2. Otherwise, item 4  
440 above applies.

440

441 7. Radioactive material, equipment, or items released from radiological areas to Controlled  
442 Areas which are to be declared as waste shall be characterized as to the prominent  
443 radionuclide concentrations found in the material. This should be done before its release, if  
444 possible; otherwise as soon as practical after its release.

445  
446 8. Materials released to Controlled Areas shall be labeled in accordance with Article 413.

#### 447 448 **422 Release to Uncontrolled Areas**

449  
450 1. Material in Controlled Areas or Radioactive Material Areas shall be categorized as  
451 radioactive or non-radioactive based on the definitions found in Article 411.1 or the process  
452 knowledge of the individuals releasing the material prior to release to uncontrolled areas.  
453 (Note that special precautions apply to the use of radioactive materials in Wilson Hall as  
454 specified in Chapter 9.)

455  
456 2. Fermilab removable surface activity criteria for releasing radioactive material to  
457 uncontrolled areas are consistent with regulatory requirements. Radioactive material being  
458 released shall also be evaluated for contamination under any coatings if “fixed”  
459 contamination is present. Such materials must have removable contamination levels less  
460 than those of Table 2-2 and no fixed contamination for such release to be permitted.

461  
462 3. Material not immediately released after survey shall be controlled to prevent activation or  
463 contamination while awaiting release.

464  
465 4. Labels shall be removed or defaced prior to release for unrestricted use of materials that are  
466 found to be no longer radioactive. Labels shall be disposed of as radioactive waste.

467  
468 5. Radioactive materials on or within material, equipment, or real property which is approved  
469 for release when the radiological conditions of the material, equipment, or real property  
470 have been documented to comply with the criteria of release set forth in a DOE-approved  
471 authorized limit are subject to the provisions associated with that limit that were reviewed  
472 in the process of securing the required DOE authorization. Such authorization limits are  
473 approved according to the requirements of DOE Order 458.1.

#### 474 475 **423 Transportation of Radioactive Material**

476  
477 1. General Requirements for shipments

478 a. Table 2-2 removable contamination values shall be used as controlling limits for  
479 onsite transportation when using a DOE conveyance (i.e., government vehicle).  
480 When a radioactive material shipment is received from or shipped to an off-site  
481 destination, the requirements of 49 CFR173 Subpart I shall apply.

482 The DOT removable contamination limits stated in 49 CFR  
483 173.443, as applied to Fermilab, are as follows:

484

485 Beta-gamma emitting radionuclides & low toxicity alpha emitters:  
486 24,000 dpm/100 cm<sup>2</sup> (10 nCi/100 cm<sup>2</sup>)

487 All other alpha emitting radionuclides: 2400 dpm/100 cm<sup>2</sup> (1 nCi/100  
488 cm<sup>2</sup>)

489

490 b. 49 CFR 171 through 180 describe requirements for inspecting and surveying  
491 packages, containers and transport conveyances prior to off-site transport.

492 c. Transport conveyances should be visually inspected prior to loading to ensure the  
493 trailers are acceptable for the intended use.

494 d. Drivers of motor vehicles in which radioactive material is transported shall have a  
495 copy of all documentation required by applicable rules and regulations.

496

## 497 2. Shipment of Radioactive Material

498 a. All material to be shipped off site which has been in beamline areas or is otherwise  
499 suspected of being radioactive must be categorized as either radioactive or non-  
500 radioactive based upon the definition in Article 411 or upon process knowledge:

501 (1) If a survey is required to determine if the item is radioactive, it shall be made  
502 by an appropriately trained individual having current Material Move Request  
503 (MMR) survey training. Material Move Request surveys are based most  
504 commonly on the use of the Bicon Analyst™ survey instrument (see Article  
505 411). The Authorized Surveyor list can be obtained from the ES&H Section  
506 through the TRAIN database.

507 (2) Items which are not radioactive (see Article 411), provided they are free of  
508 labels or other indications that the item may have once been designated as  
509 radioactive, may be shipped without restrictions as to its radioactive content  
510 unless the provisions of the DOE-imposed metals recycling suspension apply  
511 (see Articles 412 and 424). This includes shipments going through the  
512 Receiving Warehouse Site 38 or delivery directly to a vendor's vehicle at the  
513 site location. An online Material Move Request must still be completed and  
514 signed attesting to the non-radioactive classification of the material.

515 b. All off-site shipments of radioactive material shall be coordinated through the  
516 Hazard Control Technology Team (HCTT) of the ES&H Section. Upon receipt of  
517 items, HCTT will complete packaging, labeling, and shipping requirements. The



- 518 HCTT then makes the proper shipping arrangements through FESS - LPC. The  
519 MMR shall accompany all off-site shipments of radioactive material.  
520
- 521 c. Off-site shipments of radioactive material, including subcontractors' handling of off-  
522 site shipments, shall be controlled and conducted in accordance with this Manual  
523 and applicable Federal, state and local regulations.  
524
- 525 d. Before shipment, a visual inspection of packages shall be performed to ensure that  
526 packages are not damaged. The inspection should identify dents, flaking paint,  
527 debris, package orientation and any indication of leakage.  
528
- 529 e. Before shipment, a comparison of package count to the shipping manifest shall be  
530 made to ensure accountability.  
531
- 532 f. Transport conveyances should be carefully radiologically surveyed before loading a  
533 vehicle consigned as exclusive use or when using a commercial carrier specializing  
in radioactive material transport.
- 534 g. Transport of large volumes of radioactive material by non-DOE motor vehicles  
535 should be "exclusive use" to prevent commingling of DOE and other commercial  
536 shipments.
- 537 3. Receipt of Radioactive Material
- 538 a. Receipt of radioactive material shall be arranged through, and approved by, the  
539 ES&H Section. If packages containing quantities of radioactive material in excess  
540 of a Type A quantity as defined in 10CFR71.4 are expected, arrangements shall be  
541 made to either:
- 542 (1) Take possession of the package when the carrier offers it for delivery; or
- 543 (2) Receive notification of its arrival at the carrier's terminal and to take  
544 possession of the package as soon as possible thereafter.
- 545 b. Upon receipt of a radioactive material shipment, a visual inspection of packages  
546 shall be performed to ensure that packages are not compromised. In addition, a  
547 comparison of the package count to the shipping manifest shall be made to ensure  
548 accountability.
- 549 c. External surfaces of packages known to contain radioactive material shall be  
550 monitored for both radiation and contamination levels if:
- 551 (1) A Radioactive White I, Yellow II, or Yellow III label (as specified at  
552 49CFR172.403 and 172.436-440) is present; or

553 (2) Has been transported as low specific activity material (as defined at  
554 10CFR71.4) on an exclusive use vehicle (as defined at 10CFR71.4); or

555 (3) Has evidence of degradation, such as packages that are crushed, wet, or  
556 damaged.

557 d. Monitoring shall be completed as soon as practicable following the receipt of the  
558 package, but not later than 8 hours after the beginning of the working day following  
559 the receipt. Until the monitoring can be performed, the packages should be  
560 segregated and temporarily placed in a posted Radioactive Material Area.  
561 Exceptions are noted below:

562 (1) No measurements of removable contamination need to be made when the  
563 package contains only special form (as defined in 10CFR71.4) or gaseous  
564 radioactive material; or

565 (2) No measurements of radiation levels are required when the package contains  
566 less than a Type B quantity (as defined in 10CFR71.4) of radioactive  
567 material.

568 (3) Monitoring is not required for packages transported on the Fermilab site  
569 under the continuous observation and control of a DOE or Fermilab  
570 employee who is knowledgeable of and implements required exposure  
571 control measures.

#### 572 4. Requirements for On Site Transfers

573 The division/section heads are responsible for providing safe and environmentally  
574 responsible on site transfer of radioactive materials during work conducted by their  
575 personnel. The responsibility for proper transfer and transport shall, at a minimum, address  
576 the following:

577 a. Providing appropriate labels which specify Class of radioactivity according to the  
578 provisions of this Chapter. NOTE: additional provisions apply to the transportation  
579 of materials that are Class 3 or higher.

580 b. Meeting radiation safety handling, packaging, and shipping requirements. This may  
581 require special instructions from, or supervision by, radiation safety personnel.

582 c. Ascertaining that destinations are appropriate for receiving the material and have  
583 controls in accordance with Article 233 and be posted in accordance with Article  
584 234.

585 d. Arranging appropriate transportation. Such transfers are restricted to government  
586 vehicles with the exception of sealed check sources on field instruments maintained

- 587 by the ES&H Section which are allowed to be transported on site in personal  
588 vehicles that shall not be taken off site during such transfers.
- 589 e. The vehicle should be driven directly to its destination with no unnecessary stops  
590 along the way. No "side trips" off site are allowed. No "side trips" to facilities  
591 frequented by the public on site are allowed (e.g., the recreation facilities, village  
592 residential units, and/or Wilson Hall unless the latter is the destination (see Chapter  
593 9 Part 1 of this Manual).
- 594 f. Radioactive materials are not permitted in on site housing (e.g., dorms) or in  
595 established eating and drinking areas (e.g., lunchrooms and vending areas) unless  
596 specifically approved by the assigned RSO on a case-by-case basis. Such approvals  
597 should not be given for areas accessible to members of the public.
- 598 g. Special restrictions apply to radioactive materials in Wilson Hall (see Chapter 9 Part  
599 1).
- 600 h. The Fermilab Comprehensive Emergency Response Plan describes appropriate  
601 responses for potential on site radioactive material transportation accidents.
- 602 i. All on-site transfers of radioactive materials made using the services provided by  
603 FESS – LPC (Shipping and Receiving), and otherwise between divisions and  
604 sections, shall require a completed and approved Material Move Request.
- 605 5. Requirements for transporting materials that are determined to be Class 3 or higher.  
606
- 607 a. A completed and approved MMR and survey must accompany all materials that  
608 have been determined to be Class 3 or higher during transportation.
- 609 b. Before transport, the vehicle shall be surveyed to verify that prior contamination  
610 does not exist. After transport is complete, the vehicle shall be surveyed again to  
611 check for contamination. Radiological Control Organization (RCO) personnel  
612 performing these surveys should be aware that potential contamination may consist  
613 of activated material fragments (see Article 345). In this situation, wipe surveys are  
614 not sufficient, hence, a direct survey of the vehicle itself must be performed by  
615 members of the RCO.
- 616 c. Prior to transport, the material shall be wrapped. This is in addition to any protective  
617 covering or housing that already exists for shielding purposes. If this is not feasible,  
618 the vehicle must be protected in a manner such that any potential removable  
619 contamination will be completely contained (see Article 335).
- 620 d. The ES&H Section shall keep a log that tracks which Fermilab vehicle was used for  
621 each transport of Radioactive Material Class 3 or higher items. This log shall provide  
622 information regarding the initial location of the material being transported,

- 623 destination, date of transport and transportation route. Radiation surveys of the  
624 material being transported shall also be documented in these logs.
- 625 e. The approval of the SRSO will be needed for the transport of Class 3 items on-site  
626 for which the dose rate outside of shielding is estimated to exceed 1 R/h.
- 627 6. On-site transfers of significant risk to surrounding personnel of accumulating dose shall  
628 require review by the SRSO and approval by the CSO. The assigned RSO shall participate  
629 in planning for such transports.
- 630 a. These include one or more of the following characteristics:
- 631 (1) Identified need for slow speed transport with load not tied down (i.e.  
632 “strapped down”) from ALARA considerations.
- 633 (2) Identified need to forego “wrapping” of the transport items as otherwise  
634 required by Article 423.5 from ALARA considerations.
- 635 (3) Unstrapped and unwrapped loads may be transported in this manner only if  
636 the speed of the transport of < 10 mph and suitable weather conditions,  
637 subject to the discretion of the assigned RSO are present.
- 638 (4) Other departures from full compliance with U. S. Department of  
639 Transportation Regulations.
- 640 (5) Determination by the assigned RSO of the need to close the affected  
641 roadways and escort the transport using Fermilab Site Security personnel and  
642 equipment as escorts to keep unauthorized personnel excluded from planned  
643 route and proximity to the activated item and its transporting vehicle.
- 644 b. These transfers require participation by the Fermilab Site Security Department to  
645 close affected roadways and render them cleared of non-essential vehicles,  
646 pedestrians, and bicyclists at all times during the transport from initiation at the point  
647 of origin to receipt at the destination as specified on the MMR.
- 648 c. These transfers require participation by the Fermilab Fire Department to assure  
649 understanding of road blockages that may require detours in the event of an  
650 emergency response such as a fire or ambulance run. For emergency situations the  
651 Fire Department will be afforded the opportunity to breach the transport route.
- 652 d. Documentation of communication with the Fermilab Site Security and Fire  
653 Departments and notification of the Office of Communication shall be included in  
654 the request submitted to the SRSO and CSO for review and approval prior to the  
655 transport.  
656

**657 424 Recycling of Metals**

658

659 As stated in Article 412, the July 2000 DOE suspension of metals removed from Radiological  
660 Areas as defined by 10 CFR 835 and this Manual remains in force. Metals to be recycled from  
661 Fermilab therefore must meet the following set of criteria:

662

663 1. The metals shall not originate from a currently posted radiological area (that is a Radiation  
664 Area, High Radiation Area, Very High Radiation Area, Contamination Area, or Airborne  
665 Radioactivity Area).

666

667 2. Work to be performed by subcontractors that may involve potential metals recycling shall  
668 be reviewed by the assigned RSO and the SRSO prior to the awarding of bid packages. This  
669 can be done in the normal course of review of projects. The results of this process shall be  
670 incorporated into the Terms and Conditions of the relevant subcontracts as incorporated by  
671 the Fermilab Legal Office.

672

673 3. Fermilab internal or time and material (T&M) tasks that may generate metals for potential  
674 recycling shall be reviewed by the assigned RSO and incorporated into designated recycling  
675 packages that are approved by the SRSO.

676

677 4. Clearly stated and documented process knowledge may be used to permit recycling of  
678 metals that clearly cannot contain radioactivity.

679

680 5. All metals released for recycling shall be carefully surveyed by hand using the Bicon  
681 Analyst™ survey meter in accordance with Article 411 and must proceed through the  
682 “Bicon truck scanner” located at Site 38 without detection of radioactive materials.

683

**684 PART 3 RADIOACTIVE SOURCE CONTROLS**

685

**686 431 Radioactive Source Controls**

687

688 At a minimum, Fermilab’s Sealed Source Control and Accountability Program will address  
689 sources meeting the criterion in Appendix E of 10CFR835, but has been expanded to include  
690 all sealed sources on the site except for those installed on smoke detectors as commercial  
691 devices used for fire protection. Fermilab is also bound by the requirements of DOE O231.1B.  
692 These requirements have been incorporated into the Program document referenced above.

693

694 1. All uses of sealed sources at Fermilab shall be approved by the ES&H Section under the  
695 authority of the Chief Safety Officer as delegated to the SRSO.

696

697 2. Radioactive source procurement and use at Fermilab is limited to sealed radioactive  
698 sources that have been produced by facilities that are licensed to manufacture such sources  
699 by the U.S. Nuclear Regulatory Commission (NRC), NRC agreement states, or in some

- 700 cases, non-US companies demonstrated to follow licensing requirements equivalent to  
701 those of the NRC.  
702
- 703 3. The ES&H Section shall maintain, or cause to be maintained, accountability records for  
704 sealed radioactive sources.  
705
- 706 4. The ES&H Source Physicist shall be a member of the Radiological Control Organization  
707 assigned to maintain radioactive source controls. At Fermilab, procedures for radioactive  
708 source control and accountability are documented in the Source Control and Accountability  
709 Program that contains the details of Fermilab's program for sealed radioactive source  
710 management.  
711
- 712 5. Radioactive source users shall notify the ES&H Section Source Physicist (or designee) of  
713 changes in use, storage, transfer, disposal, return or loss of a sealed source.  
714
- 715 6. Except for sealed radioactive sources consisting solely of gaseous radioactive material or  
716 liquid radioactive material such as tritium, each accountable sealed source shall be leak  
717 tested under the following conditions and frequency:  
718
- 719 a. Upon receipt (see item 8).
- 720 b. Sealed radioactive sources on loan by the ES&H Section are leak-tested (wiped)  
721 monthly, except for sources located in areas that are unsafe for human entry or  
722 otherwise inaccessible (e.g. sources installed in detectors). This program includes  
723 verification of the sealed radioactive source inventory.
- 724 c. Sealed radioactive sources in the inventory of the ES&H Section are leak-tested  
725 (wiped) every 6 months unless they have been removed from service or placed into  
726 storage. The time interval to conduct the leak tests may be extended by a period not  
727 to exceed 30 days to accommodate scheduling needs. Sources removed from service  
728 or placed in storage, including sources mounted on radiation safety instruments, are  
729 not subject to periodic leak testing. Such sources shall be stored in a controlled  
730 location and shall be leak tested prior to being returned to service. This program  
731 includes verification of the sealed radioactive source inventory.
- 732 d. Whenever damage is suspected. Sealed radioactive sources found to be leaking shall  
733 be controlled in a manner that minimizes the spread of contamination and removed  
734 from service.
- 735 e. Sealed radioactive source leak tests shall be capable of detecting radioactive material  
736 leakage equal to or exceeding 0.005 microCurie.
- 737 7. Labels used to identify sealed radioactive sources shall also identify the radionuclide, date  
738 of assay, and source inventory number. These labels, sometimes small in size, are excepted  
739 from the specifications on color normally used for radiological postings. A permissible



740 example at Fermilab is the engraved brass tags commonly used on these sources. The current  
741 list of source users is maintained in a database which associates them with the sources by  
742 inventory number.

743

744 8. Procurement of radioactive sources shall be coordinated with the ES&H Section (see Article  
745 432).

746

747 9. Receipt surveys of source shipments shall be performed by the ES&H Section. These  
748 sources shall be leak-tested (see above) within 30 days of receipt.

749

750 10. Sources, including radiography sources (see Article 362), shall not be brought on site  
751 without the prior approval of the SRSO or designee.

752

753 11. Source monitors are designated for each source box/cabinet. Source monitors are  
754 responsible for the control of the source box/cabinet lock key issued to them by the ES&H  
755 Section, locking and unlocking source boxes, logging sources in and out on the source  
756 access log sheet and verifying source training of the user requesting the source.

757

758 12. Source box/cabinet lock keys shall not be duplicated.

759

760 13. Source box/cabinet lock keys may not be transferred to persons who are not qualified (by  
761 training) to use sealed radioactive sources.

762

763 14. When a person is no longer designated a source monitor, he/she shall return the source  
764 box/cabinet lock key to the ES&H Section.

765

766 15. Source monitors shall notify the ES&H Section Source Physicist (or designee) if a source  
767 box/cabinet lock key is discovered missing, lost, or found.

768

### 769 **432 Procurement of Sealed Radioactive Sources at Fermilab**

770

771 The ES&H Section maintains an inventory of frequently used sources which are available for  
772 loan to Fermilab employees and visiting experimenters. These sources are safely packaged and  
773 are available in different geometries to meet a variety of needs. Sources can be packaged in  
774 special holders to meet specific needs. A listing of some types of sealed radioactive sources  
775 available is given in Table 4-3.

776

777 Sealed radioactive sources not available in the inventory can be procured through arrangement  
778 with the ES&H Section Source Physicist (or designee) for loan to individuals requesting them.  
779 The procedures for procurements are as follows.

780

781 1. After discussion of requirements, the purchase requisition must be routed through the ES&H  
782 Section and must be approved (signed) both by the Division/Section Head (or designee)  
783 who supervises the work being done and by the SRSO.

784

785

2. An individual will be required to read, sign, and date a Radioactive Source Loan Form (R.P. Form # 12). The responsibilities of persons using radioactive sources at Fermilab are listed on the back of this form as well as in Article 433.

786

787

788

789

3. Both Radioactive Source training (course #FN000048) and Radiological Worker training (course #s FN000470 and FN000471) shall be provided to the employee or experimenter prior to source use. Training is documented on the Training Record and Information Network.

790

791

792

793

794

4. Shipment of sources from other institutions shall be first discussed with the ES&H Section Source Physicist (or designee) in consultation with the assigned RSO. Sources purchased from outside vendors or shipped to Fermilab from other institutions are shipped directly to the ES&H Section through FESS – LPC.

795

796

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799

5. The purchase requisition must include the following specifications pertinent to the shipment of radioactive sources to Fermilab:

800

801

802

- a. Removable activity must be less than one nanoCurie.

803

804

- b. The Purchase Order should be marked “Prime DOE Contractor. No License Required.”

805

806

807

- c. The outside of the package must be marked “Contains radioactive material. Do not open at Receiving. Contact Hazard Control Technology Team on arrival.”

808

809

810  
 811  
 812

**Table 4-3 Typical Sources in Inventory**

Nuclide	Half-life	Principal Radiations	$\gamma$ Energy, or Maximum $\beta$ Energy, MeV	General Range of Activities
$^{55}\text{Fe}$	2.7 yr.	$\gamma$	0.006 (Mn X-ray)	2 $\mu\text{Ci}$ to 200 $\mu\text{Ci}$
$^{60}\text{Co}$	5.27 yr.	$\gamma$	1.17, 1.33	0.1 $\mu\text{Ci}$ to 2 mCi
$^{137}\text{Cs}$	30.2 yr.	$\gamma$	0.662	4 $\mu\text{Ci}$ to 700 $\mu\text{Ci}$
$^{90}\text{Sr}$	29 yr.	$\beta^-$ , no $\gamma$	0.546 $\beta$ , 2.27 $\beta$ (from daughter $^{90}\text{Y}$ )	19 $\mu\text{Ci}$ to 4 mCi
$^{106}\text{Ru}$	368 days	$\beta^-$ , $\gamma$	3.54 $\beta$ (from daughter $^{106}\text{Rh}$ )	0.001 $\mu\text{Ci}$ to 120 $\mu\text{Ci}$
$^{207}\text{Bi}$	38 yr.	$\gamma$ , Internal Conversion Electron	0.570, 1.0648 $\gamma$ ; 0.976, 0.482 ICE	0.03 $\mu\text{Ci}$ to 10 $\mu\text{Ci}$
$^{241}\text{Am}$	432 yr.	$\alpha$ , $\gamma$	5.48 $\alpha$ ; 0.026, 0.060 $\gamma$ ; numerous Np X-rays	0.1 $\mu\text{Ci}$ to 10 mCi

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**433 Responsibilities of Persons Using Radioactive Sources at Fermilab**

1. The user shall not tamper with, disassemble, or modify a source or its holder in any way, nor remove any source from its holder or housing. Requests for source installation or new or modified source holders or housing must be discussed with ES&H Section personnel.
2. Eating and drinking are prohibited in areas where sealed radioactive sources are in use.
3. If a user purchases a radioactive source, purchase requisitions must be routed through the ES&H Section Source Physicist (or designee) for proper approval and signatures.
4. Radioactive sources shall not be brought to or taken from Fermilab unless approved in advance by Fermilab's Senior Radiation Safety Officer (SRSO) or designee.
5. Radioactive sources shall be kept in a locked box/cabinet when not in use. The storage box/cabinet shall bear sign(s) "Caution Radioactive Material". Toolboxes and other portable containers are not acceptable source storage containers.

- 832 6. Sources and source boxes/cabinets shall be accessible to ES&H Section personnel for  
833 monthly inventory and leak testing.  
834
- 835 7. Dosimetry badges shall be worn and a “Caution Radiation Area” sign shall be displayed  
836 when the potential exists for an individual to receive a dose of  $\geq 5$  mR in 1 hour at a distance  
837 of 30 cm (1 foot) from the source. As deemed necessary, the ES&H Section Source Physicist  
838 (or designee) or the assigned RSO may require written work authorization such as a  
839 Radiological Work Permit (RWP).  
840
- 841 8. A “Caution Radioactive Material” sign shall be displayed near the source during use. If a  
842 source is contained within detection equipment, a “Caution Radioactive Material” label with  
843 the source I.D. clearly stated must be attached to the outside of the equipment.  
844
- 845 9. The user shall not leave sources unattended. Radioactive sources should be under constant  
846 surveillance or they should be secured. The ES&H Section Source Physicist (or designee)  
847 shall be notified if a source needs to be used for an extended period of time (days or weeks)  
848 without returning it to its designated storage location. Special arrangements shall be made  
849 to ensure adequate radioactive source control.  
850
- 851 10. The user shall not detach the "Caution Radioactive Material" tag/label or the source I.D.  
852 label from the source.  
853
- 854 11. The ES&H Section Source Physicist (or designee) shall be contacted to arrange for source  
855 transfers. Under most circumstances, ES&H Section personnel will transport the source to  
856 the new location. Likewise, when a source is issued, ES&H Section personnel will deliver  
857 the source to the storage location designated on the source loan form. After consultation  
858 with the ES&H Section Source Physicist (or designee), division/section personnel may  
859 transport sources on site in government vehicles provided that the source is returned to its  
860 assigned storage location at the end of the workday. The user shall not transport sources in  
861 private vehicles. The Source Physicist notifies assigned RSOs when sources causing a  
862 Radiation Area to exist are transferred into their assigned areas.
- 863 12. The transfers described above are restricted to government vehicles with the exception of  
864 sealed check sources on field instruments maintained by the ES&H Section.
- 865 13. The user shall notify the ES&H Section Source Physicist (or designee) when the source is  
866 no longer needed. ES&H Section personnel will pick up the source and return it to ES&H  
867 Section storage.  
868
- 869 14. The user shall promptly notify the ES&H Section Source Physicist (or designee) if a source  
870 is discovered missing, lost or found.  
871

- 872 15. If a user suspects that a source is broken or causing contamination, the user shall call or  
873 have someone call x3131 immediately. The source should not be removed from its storage  
874 location or current location if in use. Others should be kept away from the source.  
875
- 876 16. The user shall contact the ES&H Section Source Physicist (or designee) to obtain a source  
877 that is not currently located in a source storage box. The ES&H Section Source Physicist  
878 (or designee) shall complete the Radioactive Source Loan Form (R.P. Form #12) and the  
879 user shall sign and date the form.  
880
- 881 17. Exceptions to any of the above rules shall be approved in advance in writing by the SRSO.  
882 Departures from these rules may result in confiscation of the source(s). Severe or repeated  
883 violations may result in loss of radioactive source privileges at Fermilab.  
884

## 885 **PART 4 RADIOACTIVE WASTE MANAGEMENT**

### 886 **441 Requirements**

887  
888  
889 All radioactive material that is not needed for present or probable future use should be disposed  
890 of as radioactive waste. In addition, any signs, tags, or labels used to indicate the presence of  
891 radiation and/or radioactive material must be destroyed beyond recognition or disposed of as  
892 radioactive waste. Compactable radioactive waste such as disposable protective clothing, rags,  
893 and compressible items shall be placed in yellow radioactive waste bags. Normally, non-  
894 compactable solid and liquid radioactive waste must be placed in approved containers provided  
895 by the ES&H Section. Large items which are suitable for direct burial in accordance with  
896 current disposal site provisions may be disposed of without containment. Where applicable,  
897 these items are to be placed on pallets, or in the case of pipes, banded in bundles. Compactable  
898 and non-compactable waste must be kept separate to allow maximum efficiency in the  
899 radioactive waste disposal program. [FESHM Chapter 8021](#) further specifies Fermilab's  
900 radioactive waste disposal program.

901  
902 Specific procedures for disposal of radioactive waste can be found in the Low-Level Waste  
903 Certification Program (LLWCP). Radiological operations generating radioactive waste should  
904 be designed and developed to permit segregation, monitoring, storage and disposal. The ES&H  
905 Section should be contacted if questions or problems arise.  
906

#### 907 1. Procurement, Delivery, and Storage of Radioactive Waste Containers

- 908  
909 a. The ES&H Section is responsible for ordering, inspecting, and issuing radioactive  
910 waste containers. The containers available are:

- 911  
912 (1) Yellow 55 gal. steel drums, UN1A2. The loaded weight shall not exceed  
913 948 lbs. (430 kg). Yellow 55-gallon drums are to be used for radioactive  
914 waste only.  
915

- 916 (2) 8 mil. yellow poly bags.  
917  
918 (3) 4' x 3.5' x 4' steel boxes. These boxes are intended for approved contact  
919 burial items only, and must contain no glass, dirt, sand, sweeping compound,  
920 or wet material. They hold up to 50 ft<sup>3</sup> of items and must not exceed 3000  
921 lbs. gross weight.
- 922 b. Delivery of empty containers to individual areas on non-pickup days should be  
923 coordinated through the ES&H Section. Recipients should place drums indoors,  
924 where practical, within 24 hours after delivery. In any case, lids must remain on  
925 drums.  
926
- 927 2. Location and Use of Waste Containers  
928
- 929 a. Drums must remain indoors or in an area protected from the weather while in use.  
930 Boxes may be used outdoors at locations designated by area supervisors or  
931 Radiological Control Organization personnel.
- 932 b. "Portable" radioactive waste items weighing less than 200 lbs. must be placed in  
933 approved waste containers or kept in a secure area (e.g., either inside a building or  
934 in a fenced and locked area outside).
- 935 3. Radioactive Waste Packaging Requirements  
936
- 937 a. Solid Non-compactable Waste and Liquid Waste  
938
- 939 55 gal. radioactive waste drums and steel boxes are the only approved containers for  
940 solid radioactive waste. Special 55 gal. liquid waste drums must be used for most  
941 liquid radioactive wastes. Small volume liquid waste streams will be handled on a  
942 case-by-case basis. Contact the ES&H Section for packaging instructions.  
943 Radioactive waste identification labels will be affixed to containers by the ES&H  
944 Section prior to delivery to specific areas. When containers are full, lids must be  
945 secured on them. If items are too large for containers, the ES&H Section should be  
946 contacted to determine the proper method of disposal.  
947
- 948 b. Compactable Waste  
949
- 950 All compactable waste must be put into large yellow polyethylene bags that are  
951 designated for this purpose. The bags must not contain the following:
- 952 • Metal or wood
  - 953 • Glass in any form
  - 954 • Cable over 12" long
  - 955 • Dirt, sand, sweeping compound or wet material
- 956

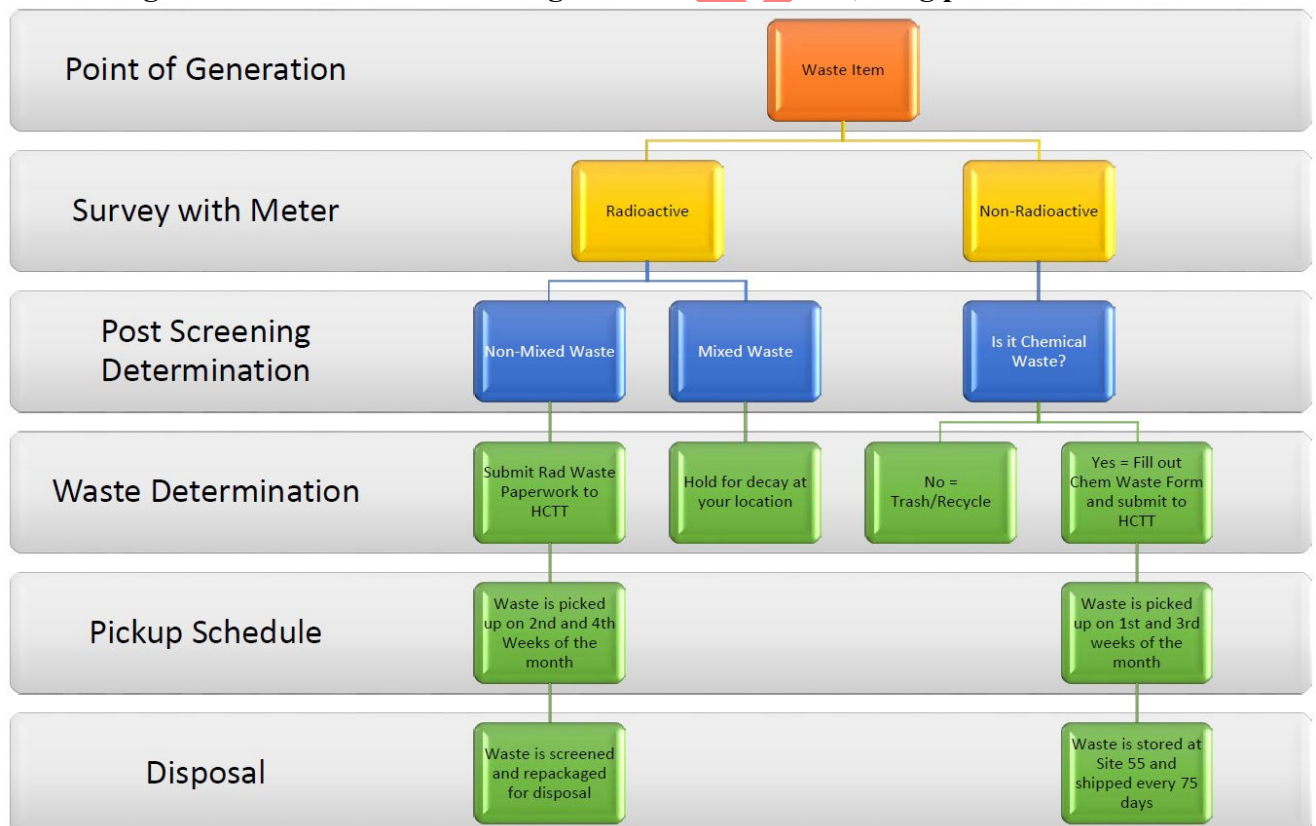


- 957 c. Specific procedures for waste generators and other waste packaging requirements  
 958 are documented in the Fermilab Low-Level Waste Certification Program (LLWCP)  
 959 which is maintained by the ES&H Section.  
 960  
 961 d. As with all such offsite transportation of radioactive materials, all such regulations  
 962 shall conform to the requirements of the U. S. Department of Transportation as well  
 963 as those of the receiving radioactive waste disposal site.  
 964

965 4. Radioactive Waste Pickup  
 966

967 Radioactive waste pickups are performed periodically. Waste generators should request  
 968 that waste be picked up by submitting a completed “[Radioactive Waste Certification and  
 969 Pickup Request Form](#)” to the ES&H Section Hazard Control Technology Team. The same  
 970 form may be used to request empty container delivery. This requires the tracking of items  
 971 as they are added to the containers.  
 972  
 973

**Figure 4-1 Flowchart illustrating Fermilab’s waste handling procedures**



- 975 Note: *NOTE: All steps in the process are performed by the person generating the waste item up until the item*  
 976 *is picked up by the Hazard Control Technology Team (HCTT). Individuals **MUST** have the proper training*  
 977 *for surveying an item as well, when appropriate, being a Chemical Waste Generator. For the Radioactive*  
 978 *or Chemical Waste Forms, click [HERE](#). For any questions during this process, contact HCTT.*  
 979

**980 442 Waste Minimization**

981

982 A radioactive waste minimization program is in effect to reduce the generation of radioactive  
983 waste and spread of contamination from Contamination, High Contamination or Airborne  
984 Radioactivity Areas. This plan is a part of the Laboratory's general waste minimization plan  
985 which is stated in Fermilab ES&H Manual Chapter 8022. The following practices should be  
986 instituted to support minimization of radioactive wastes:

987

988 1. Limit the quantities of material entering beamline enclosures or radiological areas to those  
989 needed for performance of work.

990

991 2. Restrict quantities of hazardous materials, such as paints, solvents, chemicals, cleaners and  
992 fuels, entering beamline enclosures and other radiological areas and take measures to  
993 prevent inadvertent radioactive contamination of these materials.

994

995 3. Use recyclable items and reuse equipment when practical and consistent with other  
996 measures necessary to protect worker safety and health and the environment and with other  
997 articles of this manual.

998

999 4. Reserve an assortment of tools primarily for use in Contamination, High Contamination or  
1000 Airborne Radioactivity Areas as appropriate.

1001

1002 5. Segregate known nonradioactive and/or uncontaminated materials from potentially  
1003 activated and/or contaminated waste.

1004

1005 6. Segregate reusable items, such as respirators and tools.

1006

1007 7. Optimize the number and size of areas where radioactive material is stored or used.

1008

1009 8. Emphasize training in waste reduction philosophies, techniques and improved methods.

1010

**1011 443 Mixed Waste**

1012

1013 Requirements specified in the Resource Conservation and Recovery Act (RCRA) and Toxic  
1014 Substances Control Act (TSCA) apply to waste that contains both radioactive and hazardous  
1015 materials. Certain features of the recipient state regulations also apply to these wastes and are  
1016 stated in the LLWCP and in Fermilab's RCRA Part B Permit (issued to cover the operations of  
1017 the Site 55 Hazardous Waste Storage Facility).

1018

1019 1. Article 442 describes how mixed waste generation should be minimized.

1020

1021 2. Technical and administrative controls should be established to minimize the volume of  
1022 mixed waste generated and the amount of radioactivity in such waste. Volume reduction

1023 methods include process optimization, materials substitution and new technology  
1024 development.

1025  
1026 3. Materials suspected of being mixed waste should be identified and segregated as soon as  
1027 practical in the generating process to avoid combining mixed waste with other waste.

1028  
1029 4. Materials identified as being mixed waste must be characterized as to their hazardous and  
1030 radioactive material content in accordance with all applicable regulations.

1031

## 1032 **PART 5 CONTROL OF RADIOACTIVE LIQUIDS AND AIRBORNE** 1033 **RADIOACTIVITY**

1034

### 1035 **451 Minimization and Control of Radioactive Liquid Wastes**

1036

1037 1. A water management program is in place (see Article 346) to identify, trend and eliminate  
1038 unnecessary sources of radioactive liquid waste. This program should include measures to  
1039 identify and repair leaks.

1040

1041 2. Activities that produce radioactive liquid waste shall be suspended unless sufficient  
1042 processing, collection and storage capacity is available to accommodate the waste.

1043

1044 3. Radioactive liquid waste discharge requirements are addressed elsewhere in this manual.

1045

1046 4. Radioactive liquid waste discharges should be characterized and releases terminated before  
1047 exceeding predetermined limits. Discharges of radioactivated water are described in Article  
1048 346.

1049

1050 5. Radioactive liquid waste that cannot be discharged shall be solidified/absorbed and disposed  
1051 of as solid radioactive waste.

1052

### 1053 **452 Control of Airborne Radioactivity**

1054

1055 1. Processes and activities with the potential for producing significant airborne radioactivity  
1056 shall include engineering controls to limit releases or properly monitor them. Controls  
1057 pertinent to beamline operations are covered in more detail in Chapters 10 and 11.

1058

1059 2. The assigned RSO shall be notified when engineering controls that prevent exposure of  
1060 individuals to airborne radioactivity, such as barriers, gloveboxes and glovebags, are  
1061 compromised. An evaluation should be made of continuing operations with compromised  
1062 engineering controls. The use of respiratory protection to continue is discouraged.  
1063 Implementation of short-term engineering modifications that provide a commensurate level  
1064 of protection of individuals is the preferred alternative.

1065

1066 3. Preventive maintenance and surveillance procedures should be established to ensure  
1067 equipment controls are maintained in an operable condition for containment of airborne  
1068 radioactivity.

1069  
1070 4. Procedures for evaluation and monitoring of airborne radioactivity at Fermilab can be found  
1071 in the Fermilab ES&H Section publication [Airborne Radionuclide Emissions Monitoring](#)  
1072 [Program Procedures Manual](#).

1073

## 1074 **PART 6 SUPPORT ACTIVITIES**

1075

### 1076 **461 Personal Protective Equipment**

1077

1078 1. Protective clothing designated for radiological control use should be specifically identified  
1079 by color, symbol or appropriate labeling.

1080

1081 2. Protective clothing used for radiological control use shall not be used for non-radiological  
1082 work.

1083

1084 3. Personal Protective Equipment and clothing used for radiological work shall not be stored  
1085 with personal street clothing.

1086

1087 4. Cleaned Personal Protective Equipment (i.e., face shields and respirators) that comes into  
1088 contact with the wearer's face and Fermilab-issued non-personal protective clothing shall  
1089 be surveyed after use in Contamination, High Contamination, or Airborne Radioactivity  
1090 Areas. Contamination levels should be below total contamination values in Table 2-2 prior  
1091 to reuse. The use of statistically representative sampling is acceptable.

1092

1093 5. Use of any type of protective clothing other than the disposable type must be approved by  
1094 appropriately designated Radiological Control Organization personnel.

1095

### 1096 **462 Decontamination**

1097

1098 1. Radiological Work Permits or technical work documents shall include provisions, as  
1099 appropriate, to control contamination at the source to minimize the amount of  
1100 decontamination needed.

1101

1102 2. Work planning shall include appropriate consideration of the handling, temporary storage  
1103 and decontamination of materials, tools and equipment. More detail concerning work  
1104 involving contaminated materials or areas can be found in Chapter 3.

1105

1106 3. Decontamination activities shall be controlled to prevent the spread of contamination or  
1107 damage to the environment.

1108

- 1109 4. Water and/or steam are the preferred decontamination agents. Other cleaning agents should  
 1110 be selected based upon their effectiveness, hazardous properties, amount of waste generated  
 1111 and ease of disposal.  
 1112
- 1113 5. Decontamination methods should be used to reduce the number of contaminated areas.  
 1114
- 1115 6. Reasonable efforts should be made to reduce the level of contamination and the number and  
 1116 size of contaminated areas that cannot be eliminated.  
 1117

### 1118 **463 Vacuum Cleaners and Portable Air-Handling Equipment**

1119  
 1120 Improper use of vacuum cleaners and portable air-handling equipment may result in the  
 1121 generation of airborne radioactivity or loose surface contamination areas.  
 1122

- 1123 1. Vacuum cleaners and portable air-handling equipment used in Contamination, High  
 1124 Contamination, Airborne Radioactivity, and areas where radioactive material is used or  
 1125 stored (where the potential for contamination exists) shall be equipped with High-Efficiency  
 1126 Particulate Air (HEPA) filters and be appropriately labeled. If the material to be vacuumed  
 1127 is wet enough to preclude resuspension, then HEPA filters are not necessary.  
 1128
- 1129 2. HEPA filters used in vacuum cleaners and portable air-handling equipment shall meet the  
 1130 efficiency and construction requirements for HEPA filters in MIL-F-51068. The maximum  
 1131 flow rate for the device shall not exceed the flow rate at which the HEPA filter was  
 1132 efficiency tested. In addition, the device shall be leak tested by the ES&H Section prior to  
 1133 initial use, when units have been opened, and annually. Leak tests are conducted by injecting  
 1134 Emery 3004 (poly-alpha olefin, CAS No. 68649-12-7) or equivalent aerosols into the inlet  
 1135 of the device and measuring the Emery 3004 concentrations at the inlet and outlet of the  
 1136 device.  
 1137
- 1138 3. Vacuum cleaners used for radiological work shall be:  
 1139
- 1140 a. Uniquely marked and labeled
  - 1141
  - 1142 b. Controlled to prevent unauthorized use
  - 1143
  - 1144 c. Designed to ensure HEPA filter integrity under conditions of use
  - 1145
  - 1146 d. Designed to prevent unauthorized or accidental access to the inner surfaces of the  
 1147 vacuum.  
 1148
- 1149 4. Radiation and contamination surveys shall be performed periodically for vacuum cleaners  
 1150 used in areas where the potential for significant contamination (exceeding values in Table  
 1151 2-2) or measurable dose rate ( $\geq 0.5$  mR/hr) exist. The frequency of radiation surveys should  
 1152 depend on the specific use of the vacuum cleaner.  
 1153

- 1154 5. Airborne radioactivity levels should be monitored when a vacuum cleaner is used in High  
1155 Contamination Areas or Airborne Radioactivity Areas.  
1156
- 1157 6. Contamination on the external surface of HEPA-filtered vacuums and any attachments must  
1158 be below the levels of Table 2-2 prior to being returned to the ES&H Section. The intake  
1159 port of the vacuum must be plugged or otherwise sealed to prevent release of the radioactive  
1160 material.

**DRAFT**