This consolidated guidance, developed from Ohio Environmental Protection Agency's (OEPA) initiative to require radiation monitors at Solid Waste Disposal Facilities in Ohio. This guidance provides the necessary requirements for Solid Waste Disposal Facilities in Ohio to develop and maintain a Radioactive Material Detection Program. Facilities are not required to be licensed for a capability to detect radiation. Facilities are required to comply with the State of Ohio Radioactive Materials Licensing Program for the handling of radioactive material once it's detected. Facility operators may choose to either apply for a radioactive material license issued by the Ohio Department of Health (ODH) or hire an ODH 3219 licensed radioactive waste service provider. This document provides guidance to OEPA designated Solid Waste Disposal Facilities monitoring for radiation.

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(A) Radioactive Material Detection Program

(1) As required by OAC Chapter 3745-515, solid waste disposal facility operators shall develop and implement a Radioactive Materials Detection Program (RMDP) to identify radioactive material in waste loads prior to acceptance for disposal. Facility operators may choose to either apply for a radioactive material license issued by the Ohio Department of Health (ODH) or hire an ODH 3219 licensed radioactive waste service provider in order to handle, process, or ship the identified radioactive material.

(2) The RMDP shall include:

(a) A description of the facility's organizational structure;

(b) A description of the radiation detection equipment;

(c) A description of the area used for evaluating alarmed vehicles and waste loads;

(d) Operating procedures;

(e) Training and experience requirements;

(f) Quality Assurance (QA) & Quality Control (QC) Records; and

(g) Reports.

(3) The individual developing the facility specific RMDP shall have, at a minimum, the following experience:

(a) Two years of on-the-job training in radiation protection; or

(b) One year of on-the-job training in radiation protection plus one year of formal college level study in health physics, physics, chemistry, biology, engineering, or radiation science; and

(c) Experience with radiation detection and measurement, and in developing radiation safety procedures and plans.

(4) The RMDP may specify the use of corporate support staff or a health physics consultant for performing the evaluation of the vehicle or waste load, however, onsite facility personnel must be able to appropriately respond to the original portal radiation monitor radiation detection event. ODH licensure application is required for facilities designating corporate support staff to "handle" radioactive material or anticipates the possession of licensable quantities of calibration sources. ODH licensure application is not required for facilities obtaining the services of an ODH licensed service provider (3219 licensee) to investigate, handle and ship for disposal radioactive material discovered from a radiation monitor alarm.

(5) The RMDP shall include all information specified in this document.

(B) Facility Organization Structure

(1) The RMDP shall identify facility personnel responsible for implementation of the RMDP. Identified personnel shall have adequate authority within the facility's company or corporate structure to implement the plan.

(2) The RMDP shall identify who prepared the program and personnel responsible for providing updates.

(3) The RMDP shall designate specific trained and qualified facility personnel that will respond to radiation detection events and evaluate vehicles and waste loads for radioactive material to determine the appropriate disposition options. The RMDP shall state whether the facility will apply for a radioactive material license issued by ODH or hire an ODH 3219 licensed radioactive waste service provider to respond to these events. In either case facility personnel shall be responsible for responding to an initial portal radiation monitor alarm.

(4) The facility should identify other facility personnel that will potentially come in contact with or assist in the disposition of the radioactive material such as drivers and equipment operators.

(C) Radiation Detection Equipment

(1) A portal radiation monitor shall be permanently installed in a location such that all vehicles bringing solid waste into the facility for disposal shall pass through the monitor prior to being able to dispose of their load (required for all trucks entering the facility);

(a) Performance Criteria for the Portal

(i) Alarm set-points shall be set at 10 uR/hr at 1 meter from detectors at a background < 10 uR/hr using a Cs-137 source or twice the local natural radiation background levels or unless otherwise authorized by ODH and Ohio EPA, as applicable. Manufacturer information, instrument design and geometric set-up will be considered on a case by case basis.

(ii) The facility should establish an alarm set-point that will minimize the number of false alarms. Minor fluctuations in the background radiation levels are common and "spikes" in background levels can cause false alarms if the set-points are too low. Facilities must balance the need to detect low levels of radiation with the need to avoid spurious alarms.

(iii) Portal Radiation monitors detect only radiation fields high enough to

alarm. Portal radiation monitors cannot be used to ensure regulatory compliance for waste disposal criteria. These monitors typically only measure gamma radiation (not Alpha or Beta radiation). They are a passive monitoring system used to screen conveyances. These systems include false alarms (statistical fluctuations in detection rates), nuisance alarms (benign radioactive sources) and radiation alarms of significant level to investigate.

(b) The RMDP shall specify the following information for each portal radiation monitor installed at the facility:

(i) Manufacturer;

(ii) Model number;

(iii) Calibration and maintenance frequency;

(iv) Minimum detectable radiation field;

(v) Emergency or back-up plans for accepting waste material when the portal radiation monitor is not operating.

(2) Hand-held radiological instrumentation shall be used by facility personnel identified in the RMDP to evaluate the vehicle or waste load to identify and characterize the detected radioactive material.

(a) The facility shall possess sufficient hand-held radiological instrumentation capable of:

(i) Measuring beta/gamma radiation fields of up to 100 mRem/hr; required in all cases to ensure worker safety and facilitate DOT Exemption to return the alarming load back to the point of origin.

(ii) Monitoring surfaces contaminated with beta/gamma or alpha emitting radionuclides; required only if facility chooses to obtain a radioactive material license for handling. and

(iii) Performing gamma spectroscopy of unknown gamma emitting radionuclides, and through the use of an internal electronic gamma emitting radionuclide library, able to identify the unknown gamma emitting radionuclide. Required only facility chooses to obtain a radioactive material license for handling.

(b) The RMDP shall list all hand-held radiation detection equipment and include for each:

(i) Manufacturer;

(ii) Model Number;

(iii) Calibration and maintenance frequency; and

(iv) Type of radiation that each instrument can detect.

(iv) Plans for evaluating waste material when any of the hand-held radiological instrumentation are out of service or inoperable.

(D) Designated Area for Investigation

(1) The RMDP shall establish an area designated specifically for the purpose of evaluating an alarmed vehicle and waste load in order to choose the appropriate disposition option for any detected radioactive material. The Solid Waste Disposal Facility may choose to be licensed by ODH or they can hire an ODH 3219 service provider licensee for the possessing, handling, and shipping of the radioactive material.

(2) The designated area shall be:

(a) Distanced from the portal radiation monitor to minimize the impact on the area background radiation level;

(b) Accessible to only authorized personnel and controlled to be secured overnight or over a weekend, to prevent unauthorized removal or disposal of the radioactive material; and

(c) Adequately sized to unload and spread-out the waste from the vehicle if needed, to perform radiological monitoring to detect and locate discrete radioactive items or material.

(E) Operating Procedures

(1) The solid waste disposal facility shall develop written procedures for the following:

(a) Operation of the radiation portal monitor including daily functional/response checks;

(b) Use of hand-held radiological instrumentation including;

(i) An instrument for monitoring exposure rates up 100 mRem/hr;

(ii) An instrument for monitoring beta/gamma surface contamination;

(iii) An instrument for performing gamma spectroscopy along with an electronic radionuclide library for identifying gamma emitting radionuclides;

(c) Response to a radiation detection event (portal radiation monitor alarm).

(d) Evaluation of vehicles and waste loads for radioactive material; and

(e) Safe handling and storage of radioactive material.

(2) Each of the procedures required in paragraph (E) (1) shall be reviewed during the review and approval of the RMDP and updated as required.

(F) Training and Experience

(1) Unless otherwise using an ODH radioactive materials 3219 licensee, facility personnel authorized to respond to a radiation detection event for the purposes of evaluating, handling, processing and shipping the vehicle or waste load for radioactive material shall have the following qualifications:

(a) Two years of on-the-job experience with radiation detection and measurement; and

(b) Receive annual training that includes:

(i) The elements of the facility's Radioactive Material Detection Plan;

(ii) Fundamentals of radiation safety;

(iii) An overview of the types of radioactive material that could potentially end-up in waste being sent to a solid waste disposal facility including;

(*a*) Residential waste contaminated with a short half-lived radiopharmaceutical from a released medical patient;

(*b*) Lost or improperly disposed of licensed radioactive material associated with an academic, research, or industrial use;

(*c*) Naturally occurring radioactive material (NORM);

(*d*) Technologically enhanced naturally occurring radioactive material (TENORM);

(*e*) Antique and historical objects containing radioactive material as an integral part; and

(*f*) Current consumer products that utilize a source of

radioactive material;

(iv) Normal operation and alarm response of the facility's portal radiation monitoring equipment including daily functional/response checks and alarm set points;

(v) Operation and interpreting results from hand-held radiological instrumentation in use at the facility;

(vi) The U.S. DOT Exemption process for solid waste;

- Exemption for Scrap Metal: See DOT-SP 10656 (THIRTEENTH REVISION) EXPIRATION DATE: August 31, 2019 (FOR RENEWAL, SEE 49 CFR 107.109)
- Exemption for Liquid or Solid Waste: See DOT-SP 11406 (NINTH REVISION) EXPIRATION DATE: May 31, 2019 (FOR RENEWAL, SEE 49 CFR 107.109)

(vii) Techniques for safe handling, labeling, storage, and disposal of waste containing radioactive material;

(2) Individual employees, identified in the RMDP, working at the solid waste disposal facility shall receive annual training on the following:

(a) The elements of the facility's Radioactive Material Detection Plan;

(b) Normal operation and alarm response of the facility's portal radiation monitoring equipment including daily functional/response checks and alarm set points;

(c) Fundamentals of radiation safety;

(d) An overview of the types of radioactive material that could potentially end-up in waste being sent to a solid waste disposal facility;

(i) Residential waste contaminated with a short half-lived radiopharmaceutical from a released medical patient;

(ii) Lost or improperly disposed of licensed radioactive material associated with an academic, research, or industrial use;

(iii) Naturally occurring radioactive material (NORM) or technologically enhanced naturally occurring radioactive material (TENORM);

(iv) Antique and historical objects containing radioactive material as an integral part; and

(v) Current consumer products that utilize a source of radioactive

material;

(e) The U.S. DOT Exemption process for solid waste;

(G) Recordkeeping

The Solid Waste Disposal Facility shall prepare and retain each of the following records:

(1) Records of the Radioactive Material Detection Plan, including all revisions and annual review.

(2) Records of instrument response checks, maintenance, and calibrations;

(3) Records of radiation detection events, including radiological survey results and vehicle or waste load evaluation results;

(4) Records of the disposition of identified radioactive material; and

(5) Records of radiological training.

(H) Reports to the Ohio Department of Health

(1) The facility shall immediately report all radioactive material detection events where the radioactive material is determined to not be a medical patient's residential waste contaminated with a short half-lived radiopharmaceutical. The telephone report shall be made to the Bureau of Environmental Health and Radiation Protection point of contact (POC).

(2) The facility shall immediately report all vehicle or waste load evaluation surveys where the exposure rate exceeds 50 mRem/hr on the outside of the vehicle or exceeds 2 mRem/hr in any occupied area of the vehicle. The telephone report shall be made to the Bureau of Environmental Health and Radiation Protection point of contact (POC).

(3) The facility shall make a written annual report to the Bureau of Environmental Health and Radiation Protection point of contact (POC) of all radiation detection events at their facility. The report shall include the following information for each event:

(a) The date, time, and source (shipper);

(b) The results of the evaluation, including the:

- Exposure rate on the outside of the vehicle;
- Exposure rate inside the occupied areas of the vehicle;

- Identified radionuclide; and
- Radioactive material type classification;

(c) The proposed disposition option for the radioactive material; and

(d) Actions that have been taken, or will be taken, to control and to dispose of the radioactive material.

(I) Annual Review of RMDP

(1) The facility shall review and update the RMDP annually or when any of the following occurs:

(a) Applicable OEPA or ODH regulations or policies are revised;

(b) The procedures of the RMDP are deemed to be inadequate during a radiation detection event;

(c) The facility operation changes in a manner that would interfere with implementation of the RMDP;

(d) The individual responsible for implementing the RMDP changes;

(e) The radiation monitoring equipment in use is changed;

(f) The designated area for vehicle evaluation after a radiation detection event has been changed; or

(g) As otherwise required by OEPA or ODH.

APPENDIX A

List Radionuclides Used in Medicine
(NRC Regulatory Guide 8.39)

Radionuclide[1]	Half-Life (days)[2]	Exposure Rate Constant[3] (R/m·Ci·hr @ 1 cm)
Ag-111	7.45	0.150
Au-198	2.696	2.3
Cr-51	27.704	0.16
Cu-64	0.529	1.2
Cu-67	2.578	0.58
Ga-67	3.261	0.753
I-123	0.55	1.61
I-125	60.14	1.42
I-125 implant	60.14	1.11[4]
I-131	8.04	2.2
In-111	2.83	3.21
P-32	14.29	NA[6]
Pd-103 implant	16.96	0.86[5]
Re-186	3.777	0.2
Re-188	0.708	0.26
Sc-47	3.351	0.56
Se-75	119.8	2.0
Sm-153	1.946	0.425
Sn-117m	13.61	1.48
Sr-89	50.5	NA[6]
Tc-99m	0.251	0.756
Tl-201	3.044	0.447
Y-90	2.67	NA6
Yb-169	32.01	1.83

[1] Although non-byproduct materials are not regulated by the NRC, information on non-byproduct material is included in this regulatory guide for the convenience of the licensee.

[2] K.F. Eckerman, A.B. Wolbarst, and A.C.B. Richardson, "Federal Guidance Report No. 11, Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," Report No. EPA-520/1-88-020, Office of Radiation Programs, U.S. Environmental Protection Agency, Washington, DC, 1988.

[3] Values for the exposure rate constant for Au-198, Cr-51, Cu-64, 1-131, Sc-47, and Se-75 were taken from the *Radiological Health Handbook,* U.S. Department of Health, Education, and Welfare, pg. 135, 1970. For Cu-67,1-123, In-lll, Re-186, and Re-188, the values for the exposure rate constant were taken from D.E. Barber, J.W. Baum, and C.B. Meinhold, "Radiation Safety Issues Related to Radiolabeled Antibodies," NUREG/CR-4444, U.S. NRC, Washington, DC, 1991. For Ag-111, Ga-67, 1-125, Sm-153, Sn-117m, Tc-99m, T1-201, and Yb-169, the exposure rate constants were calculated because the published values for these radionuclides were an approximation, presented as a range, or varied from one reference to another. Details of the calculation of the exposure rate constants are shown in Table A.2 of Appendix A to NUREG-1492, "Regulatory Analysis on Criteria for the Release of Patients Administered Radioactive Material," U.S. NRC, February 1997.

[4] R. Nath, A.S. Meigooni, and J.A. Meli, "Dosimetry on Transverse Axes of 1251 and 192Ir Interstitial Brachytherapy Sources," Medical Physics, Volume 17, Number 6, November/December 1990. The exposure rate constant given is a measured value averaged for several source models and takes into account the attenuation of gamma rays within the implant capsule itself.

[5] A.S. Meigooni S. Sabnis, R. Nath, "Dosimetry of Palladium-103 Brachytherapy Sources for Permanent Implants," *Endocurietherapy Hyperthermia* Oncology, Volume 6, April 1990. The exposure rate constant given is an "apparent" value (i.e., with respect to an apparent source activity) and takes into account the attenuation of gamma rays within the implant capsule itself.

[6] Not applicable (NA) because the release activity is not based on beta emissions.

APPENDIX B

Categories of Radioactive Material Found in Solid Waste Disposal Facility Waste Streams

1. RESIDENTIAL WASTE CONTAMINATED WITH A SHORT HALF-LIVED RADIOPHARMACEUTICAL FROM A RELEASED MEDICAL PATIENT.

   This category of material consists of residential trash from an individual that has recently undergone a medical procedure involving the injection or ingestion of unsealed radiopharmaceuticals or the implantation sealed radioactive sources. The radioactive material is excreted by the patient in various body wastes which can contaminate household or personal items. When these contaminated objects are disposed of before they radiologically decay to background radiation levels, they can set off alarm at portal radiation monitors. Appendix A contains list of common medical radionuclides.

2. LOST OR IMPROPERLY DISPOSED OF LICENSED RADIOACTIVE MATERIAL ASSOCIATED WITH AN ACADEMIC, RESEARCH, OR INDUSTRIAL USE.

   This category of material consists of the radioactive material that is licensed by the Ohio Department of Health and its disposal is strictly regulated as Low-Level Radioactive Waste. Typical Ohio Radioactive Material licensees would include, but are not limited to, medical facilities, academic institutions, research and development, industrial manufacturing, and non-destructive testing companies.

3. NATURALLY OCCURRING RADIOACTIVE MATERIAL (NORM)

   This category of radioactive material is any nuclide that is radioactive in its natural physical state. Naturally occurring radioactive material does not include source material, byproduct material, or special nuclear material. There are two types of NORM, terrestrial (sometimes called primordial) and cosmogenic.

   Terrestrial NORM includes radioactive material that was created when the earth was formed and is present in the earth's crust, soils, and rock formations. This material includes decay chains

   Thorium Series (4n) example: 4 x 58 = 232 (Th-232)

Radionuclide	Half-life
Thorium-232 (Th-232)	1.405×10^{10} year
Radium-228 (Ra-228)	5.75 year
Actinium-228 (Ac-228)	6.25 hour
Thorium-228 (Th-228)	1.9116 year
Radium-224 (Ra-224)	3.6319 day
Radon-220 (Rn-220)	55.6 second
Polonium-216 (Po-216)	0.145 second

Lead-212 (Pb-212)	10.64 hour
Bismuth-212 (Bi-212)	60.55 minute
Polonium-212 (Po-212)	299 nanosecond
Thallium-208 (Tl-208)	3.053 minute
Lead-208 (Pb-208)	stable

Uranium Series (4n + 2) example: (4 x 59) + 2 = 238 (U-238)

Radionuclide	Half-life
Uranium-238 (U-238)	4.468×10^{9} year
Thorium-234 (Th-234)	24.10 day
Protactinium-234m (Pa-234m)	1.159 minute
Protactinium-234 (Pa-234)	6.70 hour
Uranium-234 (U-234)	2.455×10^{5} year
Thorium-230 (Th-230)	7.54×10^{4} year
Radium-226 (Ra-226)	1600 year
Radon-222 (Rn-222)	3.8235 day
Polonium-218 (Po-218)	3.098 minute
Astatine-218 (At-218)	1.5 second
Radon-218 (Rn-218)	35 millisecond
Lead-214 (Pb-214)	26.8 minute
Bismuth-214 (Bi-214)	19.9 minute
Polonium-214 (Po-214)	164.3 microsecond
Thallium-210 (Tl-210)	1.30 minute
Lead-210 (Pb-210)	22.20 year
Bismuth-210 (Bi-210)	5.012 day
Polonium-210 (Po-210)	138.376 day
Mercury-206 (Hg-206)	8.32 minute
Thallium-206 (Tl-206)	4.202 minute
Lead-206 (Pb-206)	stable

Other Terrestrial radionuclides include:

Radionuclide	Half-life
Potassium-40 (K-40)	1.26×10^{9} year
Vanadium-50 (V-50)	6×10^{15} year
Rubidium-87 (Rb-87)	4.8×10^{10} year
Cadmium-113 (Cd-113)	1.3×10^{15} year
Indium-115 (In-115)	6×10^{14} year

Radionuclide	Half-life
Tellurium-123 (Te-123)	1.2×10^{13} year
Lanthanum-138 (La-138)	5×10^{16} year
Cerium-142 (Ce-142)	5×10^{16} year
Neodymium-144 (Nd-144)	2.4×10^{15} year
Samarium-147 (Sm-147)	1.05×10^{11} year
Gadalinium-152 (Gd-152)	1.1×10^{14} year
Halfnium-174 (Hf-174)	2×10^{15} year
Lutetium-176 (Lu-176)	2.2×10^{10} year
Rhenium-187 (Re-187)	4.3×10^{10} year
Platinum-190 (Pt-190)	6.9×10^{11} year
Platinum-192 (Pt-192)	1×10^{15} year
Bismuth-209 (Bi-209)	2×10^{18} year

Cosmogenic NORM is created when a high energy cosmic ray interacts with the nucleus of an atom that could be in a rock, soil, or the atmosphere. Examples of cosmogenic radionuclides include:

Radionuclide	Half-life
Hydrogen-3 (H-3) (Tritium)	12.26 year
Beryllium-7 (Be-7)	53.6 day
Beryllium-10 (Be-10)	2.5×10^{5} year
Carbon-11 (C-11)	20.34 minute
Carbon-14 (C-14)	5730 year
Fluorine-18 (F-18)	109.7 minute
Sodium-22 (Na-22)	2.62 year
Sodium-24 (Na-24)	14.96 hour
Magnesium-28 (Mg-28)	21.2 hour
Aluminum-26 (Al-26)	7.4×10^{5} year
Silicon-31 (Si-31)	2.62 hour
Silicon-32 (Si-32)	652 year
Phosphorus-32 (P-32)	14.28 day
Phosphorus-33 (P-33)	24.4 day
Sulfur-35 (S-35)	87.9 day
Sulfur-38 (S-38)	2.87 hour
Chlorine-34m (Cl-34m)	31.99 minute
Chlorine-36 (Cl-36)	3.08×10^{5} year
Chlorine-38 (Cl-38)	37.29 minute
Chlorine-39 (Cl-39)	55.5 minute

Radionuclide	Half-life
Argone-37 (Ar-37)	35.1 day
Argone-39 (Ar-39)	269 year
Calcium-41 (Ca-41)	$8x10^4$ year
Krypton-81 (Kr-81)	$2.1x10^5$ year
Iodine-129 (I-129)	$1.7x10^7$ year

4. TECHNOLOGICALLY ENHANCED NATURALLY OCCURRING RADIOACTIVE MATERIAL (TENORM)

TENORM is created when the NORM listed in section 3 above, has its radionuclide concentration increased by or as a result of past or present human activities. "Technologically enhanced naturally occurring radioactive material" does not include drill cuttings, natural background radiation, byproduct material, or source material.

5. CURRENT CONSUMER PRODUCTS, ANTIQUES, AND HISTORICAL OBJECTS THAT CONTAIN RADIOACTIVE MATERIAL AS AN INTEGRAL PART.

These are items or devices, containing radioactive material, that have been introduced into the public domain over the past 100 plus years. This category contains a wide range of items from tritium exit signs, older gas lantern mantels, residential and commercial smoke detectors, radioluminescent watch and gauge faces, antique medical quackery devices, and military radio luminescent and static electricity eliminating devices. Dinner plates and candy dishes have been made using radioactive material and radium paint, available at hardware stores, has been used on christening gowns and fishing lures among numerous other items.

FLOW DIAGRAM