

<b>OHIO DEPARTMENT OF HEALTH BUREAU OF RADIATION PROTECTION</b>	<b>Date</b>	<b>Page</b>
	<b>08/25/2014</b>	<b>1 of 5</b>
<b>Title</b>		
<b>Acceptable TENORM Analytical Methods for Radium-226 and Radium-228</b>		

## 1. Purpose

The Ohio Department of Health (ODH) has established this list of acceptable analytical methods for assaying Radium-226 (Ra-226) and Radium-228 (Ra-228) to assist disposal site operators in verifying that:

- All waste containing Technologically Enhanced Naturally Occurring Radioactive Material (TENORM) has been accurately assayed for Ra-226 / Ra-228 using an ODH acceptable analytical method; and
- The reported "combined Ra-226 / Ra-228" concentration for waste being received for disposal, satisfies the exempt TENORM concentration criteria listed in paragraph (A) of rule 3701:1-43-07 of the Ohio Administrative Code, making the waste acceptable for disposal at their facility. Exempt TENORM concentrations are <5 picocuries per gram (<5 pCi/gm) excluding natural background radiation. Natural background is 2 pCi/gm, unless an individual location submits an alternative background concentration request and obtains approval from ODH.
- TENORM loads accepted at solid waste landfills licensed under ORC Chapter 3734 must be accompanied by lab results referencing analytical methods recognized by this protocol.
- A representative composite sample must be obtained from each container used to collect waste defined as TENORM.

<sup>1</sup> Note: Taking one sample for a production operation or geographic region is not acceptable.

## 2. Recognized Methods

ODH recognizes radium analytical methods in USEPA's publication SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Chapter 10, published February 2007 revision 3.*

<http://www.epa.gov/waste/hazard/testmethods/sw846/index.htm>

ODH recognizes the radium analytical methods published in the U.S. Department of Energy's document, *Compendium of EPA-Approved Analytical Methods For Measuring Radionuclides In Drinking Water*, published in June of 1998.

<http://www.ornl.gov/ptp/PTP%20Library/library/DOE/Misc/radmeth3.pdf>

Table 1 – ODH acceptable analytical methods for Ra-226. This Table includes all recognized proposed or modified methods.

Table 2 – ODH acceptable analytical methods for Ra-228. This Table includes all recognized proposed or modified methods.

Table 3 – ODH approved methods for radium. This Table includes all methods that have been approved by the Director of Health.

<b>OHIO DEPARTMENT OF HEALTH BUREAU OF RADIATION PROTECTION</b>	<b>Date</b>	<b>Page</b>
	<b>08/25/2014</b>	<b>2 of 5</b>
<b>Title</b>		
<b>Acceptable TENORM Analytical Methods for Radium-226 and Radium-228</b>		

**Table 1. Acceptable Methods: Ra-226**

<b>Method</b>	<b>Reference</b>	<b>Methodology</b>	<b>Noteworthy Features</b>
1. Method 901.1M	EPA 2009	HPGE or equivalent gamma spectroscopy	This method does not include specifics on sample preparation. Sample preparation procedure should include 21-day ingrowth for measuring radon daughters.

<sup>1</sup> EPA, 1980, *Prescribed Procedures for Measurement of Radioactivity in Drinking Water*, EPA 600/4-80-032, U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, August. [Available from NTIS (U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161), document no. PB80-224744.]

**Table 2. Acceptable Methods: Ra-228**

<b>Method</b>	<b>Reference</b>	<b>Methodology</b>	<b>Noteworthy Features</b>
1. Method 901.1M	EPA 2009	HPGE or equivalent gamma spectroscopy	This method does not include specifics on sample preparation. Sample preparation procedure should include reporting Ra-228 in secular equilibrium with Ac-228

<sup>1</sup> EPA, 1980, *Prescribed Procedures for Measurement of Radioactivity in Drinking Water*, EPA 600/4-80-032, U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, August. [Available from NTIS (U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161), document no. PB80-224744.]

**Table 3. Approved Methods: Radium**

<b>Method</b>	<b>Reference</b>	<b>Methodology</b>	<b>Noteworthy Features</b>
1. ODH In-Situ	ODH License #03219510000	In-situ gamma spectroscopy using Canberra's ISOCS system.	This is a direct measurement technique for analysis of gamma emitting radionuclides in a specific volume of containerized material.
2. ODH 901.1M – Ra226 Direct	ODH License #03225150000	Modified 901.1M Ra-226 Analytical Method Based on Direct Scan of 186.1 keV Peak	This is a direct measurement technique for laboratory analysis of Ra-226 using the 186.1 keV gamma sumpeak which includes contributions from the 185.7 keV gamma peak of U-235.

<b>OHIO DEPARTMENT OF HEALTH BUREAU OF RADIATION PROTECTION</b>	<b>Date</b>	<b>Page</b>
	<b>08/25/2014</b>	<b>3 of 5</b>
<b>Title</b>		
<b>Acceptable TENORM Analytical Methods for Radium-226 and Radium-228</b>		

3. ODH 901.1M – Ra226 Direct	ODH License #03122780 029	Modified 901.1M Ra-226 Analytical Method Based on Direct Scan of 186.1 keV Peak	This is a direct measurement technique for laboratory analysis of Ra-226 using the 186.1 keV gamma sumpeak which includes contributions from the 185.7 keV gamma peak of U-235.
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**3. Submit for Approval of a Modified or Proposed Alternate Analytical Method for Ra-226 and Ra-228**

An individual may submit to the Director of Health for:

- Approval of a modification to Ra-226 or Ra-228 analytical methods listed in Table 1 or in Table 2; or
- Approval of a proposed alternate to Ra-226 or Ra-228 analytical methods not listed in Table 1 or in Table 2.

Each submission shall include:

- A description of the material containing Ra-226 or Ra-228 to be analyzed, including any physical and chemical properties that will impact the analysis;
- An evaluation of the empirical data that demonstrates the accuracy and reproducibility of the modified or proposed alternate method; and
- A copy of the Quality Management Plan (QMP), or Quality Assurance Project Plan (QAPP).

**4. Submit for Approval of a “Modified 901.1M Ra-226 Analytical Method Based on Direct Scan of 186.1 keV Peak”**

ODH will consider approving a method for determining Ra-226 concentrations in solid materials only based on gamma spectroscopy of the Ra-226 186.1 keV energy peak. This modified Ra-226 186.1 keV energy peak method would not apply to the analysis of Ra-228 so each sample would still need to be analyzed using an approved Ra-228 analytical method, such as gamma spectroscopy to assay for Ac-228.

For this modified method, Ra-226 would be measured directly by gamma spectroscopy of its 186.1 keV gamma energy peak. However, Uranium-235 (U-235), which would likely be present in the sample at some lesser concentration, has a 185.7 keV energy peak that interferes with a clean Ra-226 count. Therefore, a direct count of the 186.1 energy peak, along with interference from the U-235 185.7 keV energy peak, will create a “summed” Ra-226 / U-235 peak that will over-report the actual Ra-226 activity.

<b>OHIO DEPARTMENT OF HEALTH BUREAU OF RADIATION PROTECTION</b>	<b>Date</b>	<b>Page</b>
	<b>08/25/2014</b>	<b>4 of 5</b>
<b>Title</b>		
<b>Acceptable TENORM Analytical Methods for Radium-226 and Radium-228</b>		

Approval of this modified method would only apply to solid waste samples containing relatively low concentrations (< 10 pCi/g) of combined Ra-226 / Ra-228. Approved applicants will be included in Table 1 above.

### **Pilot Study**

Individuals submitting for approval of a proposed "alternate 186.1 keV energy peak Ra-226 analysis method" shall be required to conduct a pilot study demonstrating that their proposed method produces a conservative initial combined radium result when compared to the combined radium result for the same sample after a 21-day radon daughter in-growth waiting period.

The pilot study shall include:

- Analysis of a minimum of 30 solid waste samples that contain TENORM shall be required;
- Sample preparation - each solid waste sample must be dried for minimum 12 hours at ~105° C; ground up to a fine consistency; and canned to ensure a reproducible geometry and a radon gas leak-proof container to maximize the in-growth of radon daughters;
- The gamma spectroscopy system to be used must have a minimum detectable concentration (MDC)  $\leq 1$  picocurie per gram (pCi/g) with an appropriate efficiency and count time to minimize the counting error;
- Each canned waste sample shall be analyzed for Ra-226 using gamma spectroscopy. The canned waste sample shall be analyzed initially after canning by looking at the 186.1 keV energy peak. The same canned sample shall be analyzed a second time for Ra-226 after a 21-day radon daughter in-growth period, this time looking at the energy peaks of the radon daughters Lead-214 (Pb-214) and Bismuth-214 (Bi-214);
- Each canned waste sample being analyzed for Ra-228 by gamma spectroscopy, will be looking at the Ac-228 energy peak. A second measurement after the 21-day radon daughter in-growth period is not necessary;
- A comparison of the gamma spectroscopy results for the post 21-day radon daughter in-growth combined Ra-226 / Ra-228 results to the gamma spectroscopy results for the initial combined "summed Ra-226" / Ra-228 results for all 30 canned solid waste samples.

### **Submit for Approval**

<b>OHIO DEPARTMENT OF HEALTH BUREAU OF RADIATION PROTECTION</b>	<b>Date</b>	<b>Page</b>
	<b>08/25/2014</b>	<b>5 of 5</b>
<b>Title</b>		
<b>Acceptable TENORM Analytical Methods for Radium-226 and Radium-228</b>		

Submit to the Director of Health for a 901.1M, Ra-226 analytical method based on the direct scan of the 186.1 keV energy peak, shall include:

- Results of the pilot study that demonstrate the post 21-day radon daughter in-growth combined Ra-226 / Ra-228 results are less than the initial combined "summed Ra-226" / Ra-228 results. The study should also demonstrate the accuracy and reproducibility of the method;
- A description of the material to be analyzed, including any physical and chemical properties that will impact the analysis;
- A copy of the individual's Quality Management Plan (QMP) and Laboratory Quality Control Plan (LQCP). The LQCP should include requirements of:
  - 10 percent of the waste samples will be analyzed in duplicate to establish levels of precision;
  - 10 percent of the waste samples will continue to be counted a second time after a 21-day radon daughter in-growth period to verify laboratory performance;
  - Control limits based on precision and accuracy will determine the acceptance or rejection of laboratory data on a daily basis.
- Waste sample acceptance, handling, analysis, and disposal procedures;
- A copy of the Waste Sample Analysis Report format that includes:
  - Description of the waste material;
  - Waste sample point of origin;
  - The name of the analysis laboratory;
  - The approved analytical method used; and
  - Analytical results for combined Ra-226 / Ra-228 in pCi/g