The Radionuclides Rule Training Methods and Detection

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The Radionuclides Rule/Key Analytical Considerations

- **Set all Maximum Contaminant Level Goals (MCLGs) for radionuclides at 0**
- **Retained the combined Maximum Contaminant Level (MCL) for Ra-226 and Ra-228 at 5pCi/L**
- **Ra-226 and Ra-228 are monitored separately**
- **Retained “adjusted” Gross Alpha MCL at 15pCi/L**

The Radionuclides Rule/Key Analytical Considerations (cont'd)

- Set MCL for uranium at 30 µg/L
- Retained the MCL for beta particle and photon radioactivity
- Established complex monitoring framework for radionuclides
- Acknowledged that measurable levels of Ra-224 in drinking water are more prevalent than previously thought
- Clearly established the analytical result as the activity concentration value (not adding or subtracting the uncertainty value

Analytical Methods Approved for Radionuclide Monitoring

- **Listed in 40 CFR 141.25 (c)(1) Table B and 141.25 (c)(2)Table C**
- **Methods are from various sources: EPA, SM, ASTM, USGS, DOE, NY, NJ**
- **More than 80 analytical methods listed**
- **Required Method Detection Limits listed in 40 CFR 141.25, Table 1-9**

Gross Alpha Analyses

- Radionuclides Rule retained “adjusted” MCL of 15 pCi/L (excluding Rn and U)
- Two basic analytical methodologies – evaporation and coprecipitation
- Method Detection Limit of 3 pCi/L

Gross Alpha Analyses (cont'd)

- **Gross Alpha results may be substituted for uranium and Ra-226 measurements if less than 15 and 5 pCi/L respectively**
- **Depending on gross alpha values, substitution for uranium and Ra-226 measurements will impact monitoring frequency**
- **Relatively inexpensive analyses:**
  - **Coprecipitation – approximately $60**
  - **Evaporation – approximately $40**

Ra-226 Analysis

- **Radionuclides Rule retained the combined MCL of 5 pCi/L for Ra-226 and Ra-228**
- **Two basic analytical methodologies – radiochemical and emanation**
- **Can substitute Gross Alpha analysis if less than 5 pCi/L**
- **Approximate cost - $120 per sample**

Ra-228 Analysis

- **Radionuclides Rule retained the combined MCL of 5 pCi/L for Ra-226 and Ra-228**
- **Single basic analytical methology – radiochemical**
- **Method Detection Limit of 1 pCi/L**
- **No substitution for the Ra-228 measurement**
- **Approximate cost - $120 per sample**

Uranium Analysis

- **Radionuclides Rule established an MCL of 30 µg/L**
- **Several methodologies available – radiochemical, fluorometric, alpha spectrometry, ICP/MS and laser phosphorimetry**
- **Detection Limit of 1ppb**
- **Can substitute Gross Alpha result if less than 15 pCi/L (conversion factor 0.67 pCi/µg)**
- **Analytical cost varies depending on methodology (range $30 - $160 per sample)**

Uranium Analysis (cont'd)

- **The use of an Inductively Coupled Plasma Mass Spectrometry (ICP-MS) method for uranium analysis:**
  - **Uranium EPA Method 200.8**
  - **Standard Methods 3125**
  - **ASTM International Method D5673-03**
  - **Easier and cheaper than other methods**

  Detection limits
  - **1 ppb DL for Uranium**

Uranium Determination in Water

- **Measure radioactivity (pCi/L)**
  - **Total activity methods (EPA method 908)**
- **Measure concentration (µg/L)**
  - **Total concentration methods (EPA method 200.8)**

Beta Particle and Photon Radioactivity Monitoring

- Radionuclides Rule retained the MCL of 4 mrem/year for beta particle and photon radioactivity
- Several analytical methodologies available depending on the radionuclide – gamma ray spectrometry, radiochemical, and liquid scintillation
- Required Regulatory Limit depends on the radionuclide:
  - Cs-134 10 pCi/L
  - Sr-89 10 pCi/L
  - Sr-90 2 pCi/L
  - H-3 1,000 pCi/L

Beta Particle and Photon Radioactivity Monitoring (cont'd)

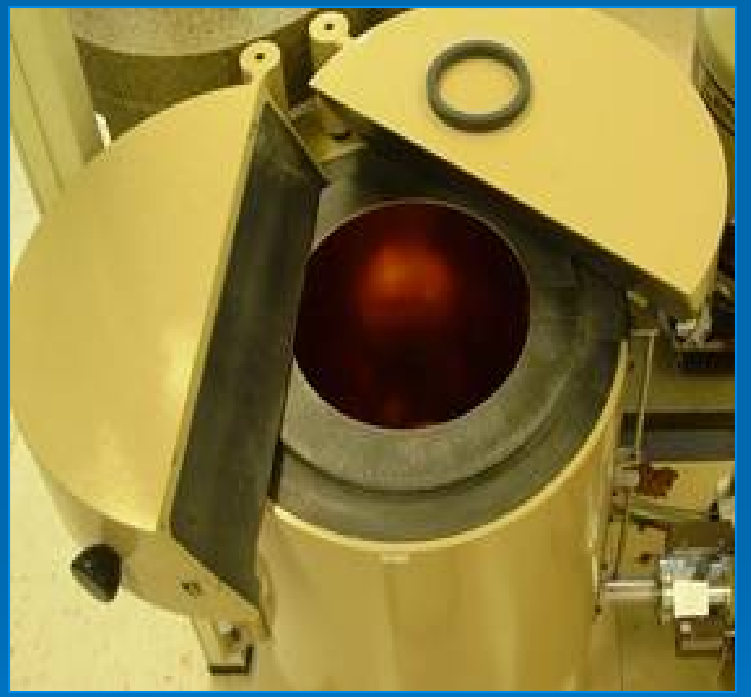
- **Monitoring framework depends on several factors (e.g., vulnerable system, utilization of water contaminated by effluents from nuclear facilities, etc.)**
- **Radionuclides Rule allows subtraction of beta activity from K-40 from the gross beta measurement to determine compliance status**
- **Laboratory can measure total elemental potassium in units of mg/L and multiply the result by 0.82 to determine activity from K-40**

Beta Particle and Photon Radioactivity Monitoring (cont'd)

- **Analytical costs vary depending on the radionuclide – approximate costs for select radionuclides**
  - **H-3 $50**
  - **Sr 89, 90 $170**
  - **Gamma Spectrometry $110**

Georgia Tech Method

- **Georgia Tech Method is EPA approved and published**
- **Determination of Ra-226 and Ra-228 in drinking water**
- **Utilizes gamma ray spectroscopy for detection**
- **Quantitation using germanium detectors**
  - **High Purity (HPGe)**
  - **Lithium-drifted – Ge(Li)**



Georgia Tech Method Summary

- **A solution of barium chloride is added to an aliquot of sample**
- **Sample is heated to boiling while stirring**
- **Concentrated sulfuric acid is added to the heated sample**
- **Radium is collected by coprecipitating it as a sulfate**
- **Sample is either directly measured for Ra-228 or set aside for Ra-226 and/or both measurements**

Advantages to Georgia Tech Method

- **Less labor intensive and time consuming**
- **One method good for two analyses (Ra-226 and Ra-228)**
- **Cost effective**
- **Comparable or better method performance**

Gross Alpha Issues

- Gross alpha is often overestimated
- Ra-226 decays into a series of alpha emitters
- Ra-228 indicates the presence of Ra-224
- Method of Uranium determination

Gross Alpha Issues (cont'd)

- Time between sample collection and sample preparation
- Time between sample preparation and sample analysis
- Po-210 in water sample
- Calibration standard

Laboratory Issues

- Detection limit determined by counting times and sample volume
- Low throughput
- Expense of analysis
- Lack of radionuclide expertise in some analysts

Questions?