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
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

- Approximately 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 1 ppb
- 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)
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)
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
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?