Gross Alpha-Gross Beta Analysis in Water by Liquid Scintillation Counting (LSC)

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Outline of Presentation

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- Health Effects
- Regulatory Background
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- Summary of ASTM D7283-17
- Conclusions

Types of Radiation

- Ionizing
  - Alpha radiation (uranium, radium, polonium)
  - Beta radiation (tritium, strontium-90)
  - Gamma radiation (cesium-137, cobalt-60)
- Non-Ionizing
  - Microwaves
  - Radio waves

Health Effects

- Risk of cancer
- Risk of congenital defects
- Kidney toxicity (uranium)
- Living tissue damage due to ionizing radiation (Damage to DNA > Mutations)

Regulatory Background

- Safe Drinking Water Act (SDWA) – 1974
- National Primary Drinking Water Regulations (NPDWR) – 1976
- 40 CFR Part 141.25 Analytical Methods for Radioactivity
- Radionuclides Final Rule - 2000

EPA Maximum Contaminant Levels for Radionuclides in Drinking Water

Radionuclide	Maximum Contaminant Levels (MCL)
Beta/photon emitters*	**4 mrem/year**
Gross Alpha	**15 pCi/L**
Radium-226 and Radium-228	**5 pCi/L**
Uranium	**30 ug/L**
***A total of 179 individual beta particle and photon emitters may be used to calculate compliance with the MCL.**	

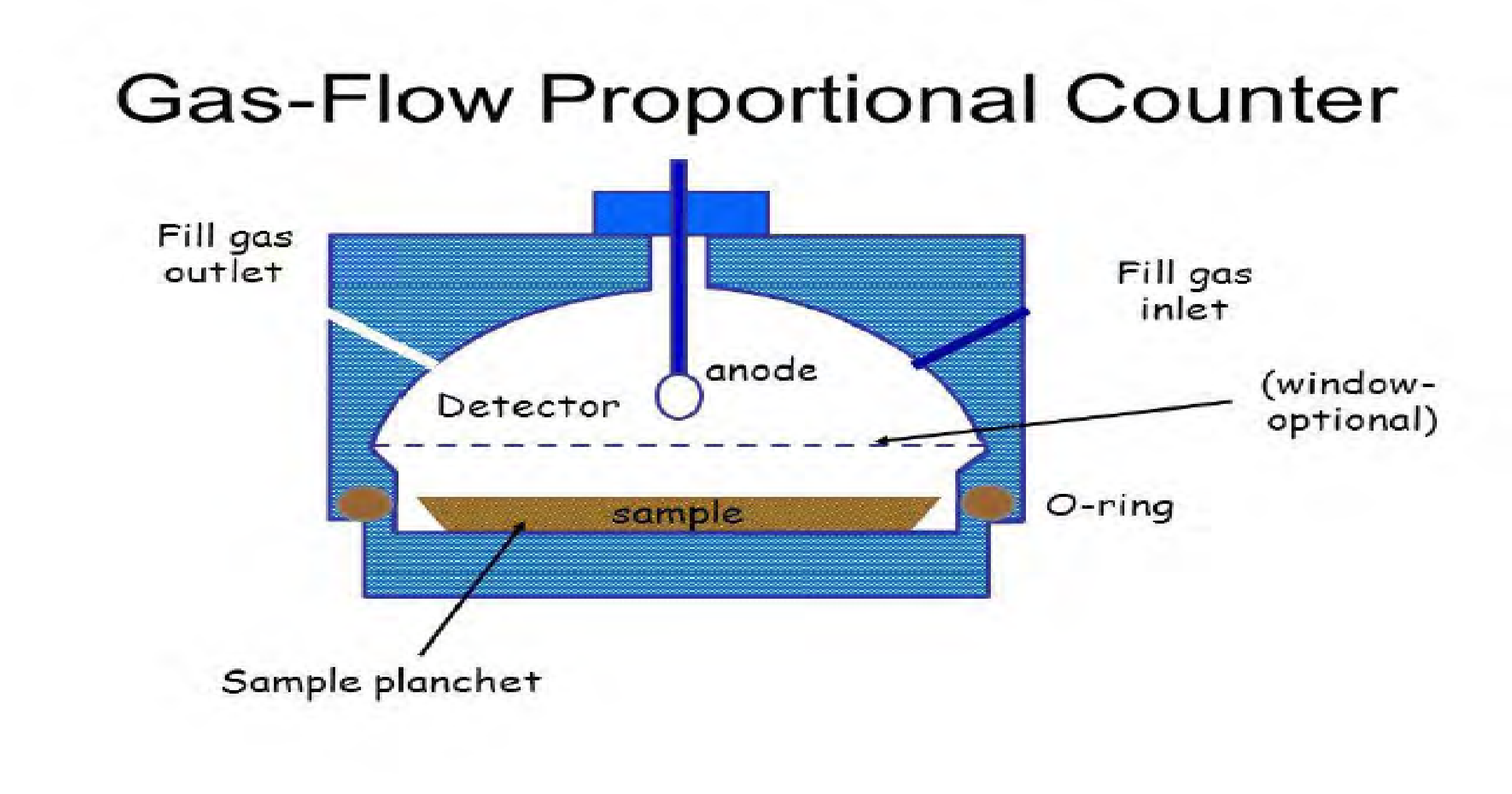
Radionuclide Detection Limits

Radionuclide	Required Detection Limit (RDL)
Gross Alpha Particle Activity	**3 pCi/L**
Gross Beta Particle Activity	**4 pCi/L**
Radium-226	**1 pCi/L**
Radium-228	**1 pCi/L**
Uranium	**0.67 pCi/L**

Approved Methods for Gross Alpha and Gross Beta in Drinking Water

- Gross Alpha and Gross Beta Radioactivity in Water (Total, Suspended and Dissolved), Method 302, Standard Methods for the Examination of Water and Wastewater, 13th edition, 1971.
- Gross Alpha and Gross Beta Radioactivity in Drinking Water, Interim Radiochemical Methodology for Drinking Water, EPA 600/4-75-008 (revised), March 1976.
- Determination of Gross Alpha and Beta in Water, Radiochemical Analytical Procedures for Analysis of Environmental Samples, EMSL-LV-0539-17, March 1979.
- Gross Alpha and Gross Beta Radioactivity in Drinking Water, Method 900.0, Prescribed Procedures for Measurement of Radioactivity in Drinking Water, EPA 600/4-80-032, August 1980.
- Radiochemical Determination of Gross Alpha and Gross Beta Particle Activity in Water, Radiochemistry Procedures Manual (Prepared by EPA's Eastern Environmental Radiation Facility), EPA 520/5-84-006, August 1984.
- Evaporation Method for Gross Alpha-Beta, Method 7110B, Standard Methods for the Examination of Water and Wastewater, 19th edition, 1995.

For all of the aforementioned approved methods, the methodology involves the EVAPORATION of a measured volume of drinking water, conc nitric acid acidification steps and counting the prepared sample by low-background gas proportional counting (GPC).



From NAMP Radiochemistry Seminar Series, Gross Alpha Analyses by Liquid Scintillation Counting, Wong

Deficiencies of GPC Counting for Gross Alpha-Gross Beta in Water

- Samples containing beta emitters with energies less than 0.1 MeV cannot be effectively screened, e.g. Ni-63, Pb-210, Ra-228 and Pu-241.
- Sample matrix: Limited by the amount of sample dissolved solids. The maximum value is 100 mg for gross alpha and 200 mg for gross beta.
- Radionuclides that are volatile (e.g. iodine or polonium) may be lost during the evaporation technique.
- Biases may occur if the energies of the alpha-emitting and beta-emitting radionuclides in the sample differ significantly from those emitters used to determine the respective alpha and beta counting efficiencies.
- Dried samples prepared during the evaporation technique may obtain a static charge that can lead to increased counts above that which is actually present.

Liquid Scintillation Counting (LSC)

Basic Liquid Scintillation Counter (LSC)

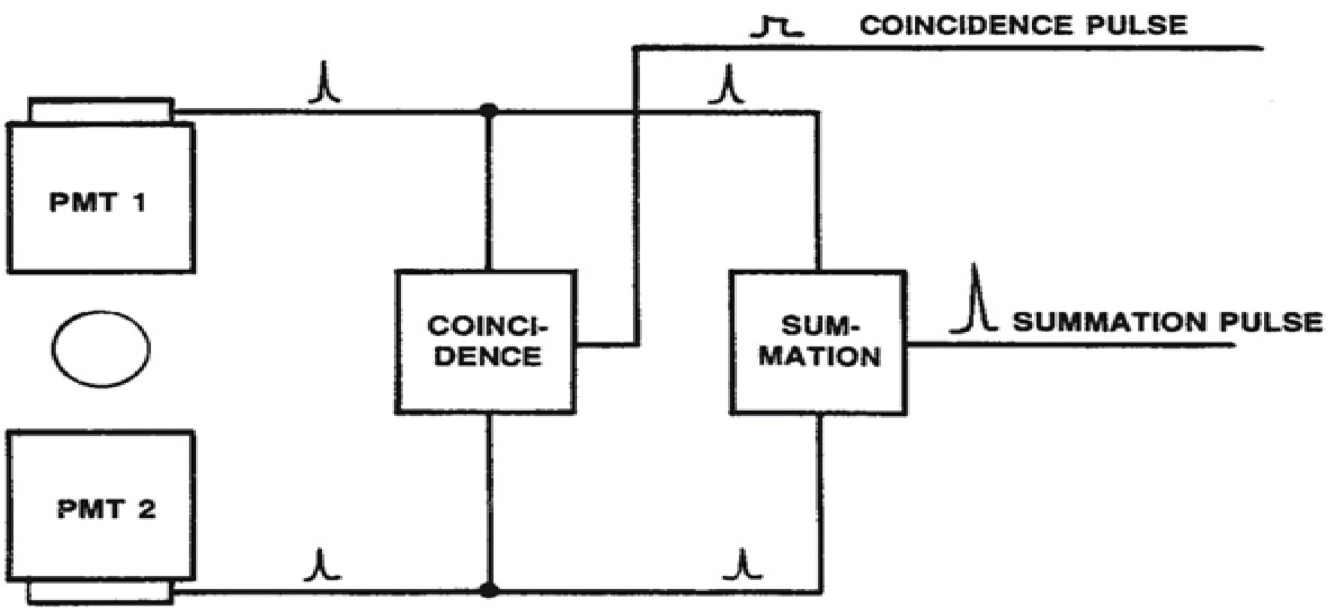


Figure 1-9. Summation Circuit (From Liquid Scintillation Analysis, Michael J. Kessler, Ph.D.)

Advantages vs. Deficiencies of Liquid Scintillation Counting (LSC)

- Samples containing beta emitters with energies less than 0.1 MeV **can be** effectively screened, e.g. Ni-63, Pb-210, Ra-228 and Pu-241.
- The LSC Method has higher counting efficiencies (gross alpha ~75-90% and gross beta ~100%) than the EPA 900.0 Evaporation Method (gross alpha ~20-25% and gross beta ~30-35%).
- The LSC Method has a sample dissolved solids concentration range extending to 400 mg while the EPA 900.0 Evaporation Method extends to only 100 mg for gross alpha and 200 mg for gross beta.
- Biases may occur if the energies of the alpha-emitting and beta-emitting radionuclides in the sample differ significantly from those emitters used to determine the respective alpha and beta counting efficiencies. *This is a potential limitation of any method used for the determination of gross alpha and gross beta activities in drinking water.*

Current Approved Methods for Gross Alpha-Gross Beta in Drinking Water by LSC

- ASTM D7283-17, Standard Test Method for Alpha and Beta Activity in Water by Liquid Scintillation Counting
- Standard Methods 7110 D-17, Gross Alpha and Gross Beta Radioactivity, Liquid Scintillation Spectroscopic Method for Gross Alpha-Beta

Summary of ASTM D7283-17

Scope and Application

- The method covers the measurement of gross alpha and gross beta activity concentrations in a homogeneous water sample. The method is not applicable to samples containing radionuclides that are volatile under conditions of the analysis.
- Adjusting sample volume and counting time, the method is able to achieve the required detection level for gross alpha of 3 pCi/L and for gross beta of 4 pCi/L.
- The method may also be used for the **direct measurement** of gross alpha and gross beta activity concentrations in homogeneous water samples with alpha emitter activity concentration levels above 50 pCi/L and beta emitter activity concentration levels above 100 pCi/L.

Method Requirements

- A liquid scintillation counter with an alpha-beta discrimination option.
- Follow a two-step instrument calibration process:
  - **First**, determination of correct discriminator value, or Pulse Decay Discriminator (PDD) value.
  - **Second**, determination of gross alpha-gross beta counting efficiencies and spillovers vs. quench indicating parameter (Nitromethane).

Method Steps

- A water sample containing no more than 400 mg residue mass is transferred to a clean beaker.
- The water sample is evaporated to approximately 4 to 5 mL.
- It is then quantitatively transferred to a tared glass scintillation vial using 0.1M nitric acid.

Method Steps (Continued)

- The sample is then slowly and carefully evaporated to dryness.
- After adding 5 mL 0.1M nitric acid, the sample solids are dissolved by carefully warming the glass scintillation vial.
- After dissolution is complete, Ultima Gold LLT liquid scintillation fluid is added, and the samples are counted on a liquid scintillation counter previously calibrated for gross alpha (Th-230) and gross beta (Cs-137) counting.

Conclusions about LSC Method

- The LSC Method can meet the Required Detection Levels (RDLs) for gross alpha and gross beta in drinking water by choosing an appropriate total sample count time and/or sample volume.

- The LSC Method has higher counting efficiencies than the EPA 900.0 Evaporation Method.

- The LSC Method has a sample dissolved solids concentration range extending to 400 mg while the EPA 900.0 Evaporation Method extends to only 100 mg for gross alpha and 200 mg for gross beta.

Why have I spent all of this time talking about methodology?

Analytical Methodology Generates Useful Data

DATA

RESPONSE

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Questions??