Tritium Detection Methods and Limitations

Tritium Focus Group Meeting, April 2014
Tom Voss, Northern New Mexico
DOE-HDBK-1105-2002
Radiological Training for Tritium Facilities


ION CHAMBER DETECTORS

• PORTABLE ION CHAMBERS
• AREA (ROOM) ION CHAMBERS
• EFFLUENT (STACK) ION CHAMBERS
PORTABLE ION CHAMBERS

200 to 400 cc active volume
5 to 10 uCi/m³ lower limit
10,000 to 200,000 uCi/m³ upper limit
AREA (ROOM) ION CHAMBERS

2000 cc active volume
1uCi/m3 lower limit
1 to 20 uCi/m3 upper limit
EFFLUENT (STACK) ION CHAMBERS

50 L active volume
5 uCi/m3 lower limit
1 to 50 Ci/m3 upper limit
10CFR835 tritium DAC factors

<table>
<thead>
<tr>
<th>Component</th>
<th>Activity Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tritium Oxide</td>
<td>2E-5 uCi/mL (20 uCi/m3)</td>
</tr>
<tr>
<td>Elemental</td>
<td>2E-1 uCi/mL</td>
</tr>
<tr>
<td>Insoluble STCs</td>
<td>2E-6 uCi/mL</td>
</tr>
<tr>
<td>Soluble STCs</td>
<td>1E-5 uCi/mL</td>
</tr>
</tbody>
</table>
LIQUID SCINTILLATION COUNTERS

- PORTABLE LSC
- LABORATORY LSC
- PROCESS LSC
Table 1 OF DOE 5400.5 & Appendix D OF 10CFR835

Tritium surface limit  10,000 dpm/100cm$^2$
RETROSPECTIVE TRITIUM SAMPLERS

- BUBBLERS
- HTO ABSORBERS
P-10 GAS COUNTERS

- PORTABLE SURFACE MONITORS
- LABORATORY SAMPLE COUNTERS
- P-10 STANDARD TRITIUM CALIBRATORS
TRITIUM CONCENTRATORS

• NAFION FIBER
• SELECTIVE EVAPORATION
LRAD –
LONG RANGE ALPHA DETECTION

• HISTORY OF LRAD AND ITS DERIVATIVES
• HOW THIS RELATES TO TRITIUM
MEASUREMENT LIMITATIONS

• MINIMUM AND MAXIMUM RANGE OF DETECTION

• UNCERTAINTIES
  – NIST-TRACEABLE TRITIUM STANDARD
  – TRITIUM DECAY CALCULATIONS
  – TRITIUM PERMEATION THRU CONTAINMENT (AND HYDROGEN INFILTRATION INTO CONTAINMENT)
  – CURRENT FLOW IN ION CHAMBERS
  – COUNTING EFFICIENCY
MEASUREMENT LIMITATIONS – CONTINUED

• UNCERTAINTIES - CONTINUED
  – SAMPLE SELF-SHIELDING
  – SAMPLE VOLUME
  – TEMPERATURE AND BAROMETRIC PRESSURE
  – GAMMA CORRECTION
  – LEAKAGE CURRENT IN ION CHAMBERS
  – DARK CURRENT IN PMTS
INTERFERENCES

- EXTERNAL GAMMA FIELDS
- RADON AND THORON
- RADIOACTIVE GASES
- RF AND EMF
- AC AND BATTERY POWER FLUCTUATIONS
- TEMPERATURE SHOCK
- MECHANICAL SHOCK
- GEOTROPISM
CALCULATIONS

- CURRENT FLOW IN ION CHAMBERS
- ION COLLECTION EFFICIENCY IN ION CHAMBERS
- LSC EFFICIENCIES
- PROPAGATION OF UNCERTAINTY
CALCULATIONS

CURRENT FLOW IN ION CHAMBERS

For a 200 cc active volume at STP the ion chamber current flow is approximately 17 femto-amps for a concentration of 100 uCi/m³
CALCULATIONS

PROPAGATION OF UNCERTAINTY

Tritium standard % uncertainty ~ 1.5%
Active sample volume % uncertainty ~ 2%
Gamma correction factor & uncertainty ~ 5%
Temperature & Pressure uncertainty ~ 2%

Combined % uncertainty ~
\[ \sqrt{(1.5^2 + 2^2 + 5^2 + 2^2)} \]
\[ \sqrt{(2.25 + 4 + 25 + 4)} = 5.93 \% \text{ uncertainty} \]
QUESTIONS ?
COMMENTS ?

TOM VOSS
NORTHERN NEW MEXICO
JTOSS@NEWMEXICO.COM
WWW.VOSS-ASSOCIATES.COM
WWW.HPICORG.COM
WWW.AMUG.US
505-920-1470