LA-UR-15-28465

Methods to Improve the Lower Limit of Detection for Tritium in the Air and on Surfaces

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Nov. 3 – 5, 2015

Present methods for the detection of tritium are adequate for most applications.

However, the technology is becoming antiquated and in need of improvement, especially to address methods to achieve a lower limit of detection for Tritium in the air and on surfaces.

The present methods to detect tritium in air are with the use of ion chamber instruments or retrospective bubblers.

Tritium as STCs are typically collected on air sample filters and the tritium activity AND the atom or molecule the tritium is bonded to are determined.

The present methods to detect tritium on surfaces are either swipes to be counted in LSC or the use of hand-held gas-flow proportional counters.

What are the regulatory limits for the detection of tritium ?

DAC (Derived Air Concentration)

H-3[1]	2E-5 uCi/ml	Water HTO form
H-3[2]	2E-1 uCi/ml	Elemental HT form
STCs-3[4]	2E-6 uCi/ml	Insoluble
STCs-3[5]	1E-5 uCi/ml	Soluble

Tritium Surface Contamination

10,000 DPM/100 cm^2

STCs are Special Tritium Compounds

STCs as metal tritides MAY be the MOST dangerous of ALL tritium forms.

One case of death due to the injection of mercuric tritide has been reported. The death was due to the mercury BUT the tritium allowed the tritide to circulate throughout the person.

Ion chamber instruments to detect tritium in air have interference from external radiation fields, radon and thoron gas and their progeny, suspended dust particles, organic vapors, and other influences.

Retrospective bubblers require the collected samples to be treated and then counted in LSCs. This induces a time delay in the analysis and the results are indeed retrospective but also not time stamped.

That is, any excursions in the tritium concentration are seen as an average concentration rather than any short term concentration.

Tritium swipes to detect tritium on surfaces also must be counted in LSCs.

The treatment of the swipes and the time to perform the counts in the LSC add additional time to know the results and are not therefore real-time analysis.

Gas-flow proportional counters while real-time are awkward for the user and have many of the same interferences as the ion chamber instruments have.

A combination of the various detection techniques with the addition of modern technology can lead to faster results and a much lower limit of detection.

HOWEVER, the FIRST action to improve the lower limit of detection tritium SHOULD be training.

Train the individuals responsible for measuring tritium on the operation involving the tritium.

Train those individuals on the operation of the instrumentation they will use.

Train those individuals on the interferences the instrumentation will be subjected to.

Train those individuals on methods to compensate for the interferences.

WHY do we need to improve the lower limit of detection of tritium in the air and on surfaces ?

IF we combine a lower limit of detection with a more rapid response for tritium measurements we can increase tritium safety while decreasing the tritium surveyor’s time to perform those surveys.

Potentially, this could lead to PREVENTING personnel exposures to tritium.

Methods of Tritium Detection

ION CHAMBER DETECTORS

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

PORTABLE ION CHAMBERS

200 to 400 cc active volume
2 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
1 uCi/m3 lower limit
1 to 50 Ci/m3 upper limit

LIQUID SCINTILLATION COUNTERS

- PORTABLE LSC
- LABORATORY LSC
- PROCESS LSC

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 DETECTOR

- 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 CHAMBER
  - COUNTING EFFICIENCY

MEASUREMENT LIMITATIONS – CONTINUED

- UNCERTAINTIES - CONTINUED
  - SAMPLE SELF SHIELDING
  - SAMPLE VOLUME
  - TEMPERATURE AND BAROMENTRIC 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 what is the ion chamber current flow for a concentration of 2 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 ~
$\sqrt{(1.52 + 22 + 52 + 22)}$
$\sqrt{(2.25 + 4 + 25 + 4)} = 5.93$ % uncertainty

Ion Chamber Improvements

Larger chambers
Lower electrometer leakage
Pulsed ion chamber
Current to frequency converter
Adjustable response time
Adjustable sampling rate
Alpha pulse rejection
Radon rejection screen
Gamma compensation
Microphonics reduction

LSC Improvements

Real-time LSC
Alpha pulse rejection
Radon rejection screen

P-10 Hand-held Gas Flow Detector Improvements

Reduce P-10 consumption

Alternative to P-10 Hand-held Gas Flow Detectors

Develop the Hand-held Ion Chamber as a surface contamination monitor

Tritium Surface Contaminated Objects

Develop the Ion Chamber as a small object contamination monitor

Portable Tritium Smear Counter

Develop the Ion Chamber as a potable tritium smear counter

Additional Support for Tritium Detection Improvements

EFCOG
Energy Facility Contractors Group

The RP-EFCOG is developing a charter for a Health Physics Instrumentation Committee (HPIC)

Questions ?

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