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21 Commerce Drive
Danbury, CT 06810

July 5, 2012

J-6
MS-16

Sent Via Overnight Courier

Dennis R. Lawyer, CHP
Health Physicist
USNRC REGION 1 DNMS
2100 Renaissance Blvd
King of Prussia, PA 19406

Re: Amendment request to allow Smiths Detection – Danbury to perform Liquid Scintillation Counting and certification. License No. 06-31431-01, Docket No. 030-38416

Dear Mr. Lawyer,

As a follow up to your telephone conversation with our RSO Gary Shelton, attached please find our revised Liquid Scintillation Counting Procedures If you have any questions or require additional information please do not hesitate to contact me at 203 207 9743 or Gary Shelton our Radiation Safety Officer at 865-738-1017.

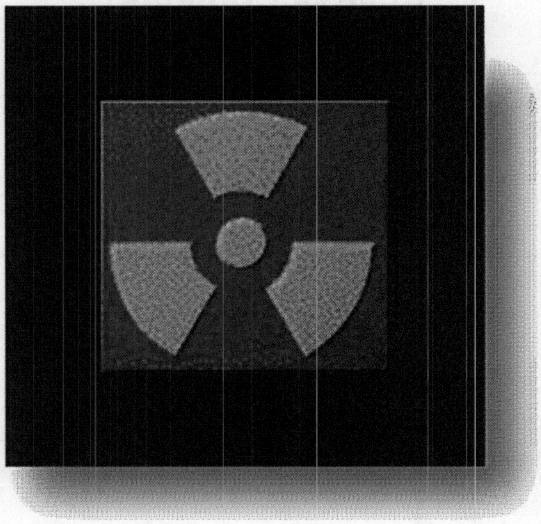
Sincerely,

Robert Bohn
Regional Vice President of Sales for America
Danbury Site Lead

Cc: Gary Shelton
Radiation Safety Officer

Enclosures:

Liquid Scintillation Counter Procedure



Liquid Scintillation Counter Procedures

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Emergency Contact RSO ______________________________ Phone: _____________
Facility____

Peter Wallace, RSO Peter.Wallace@SmithsDetection.com (202) 641-3949
PJW072012RevB

Table of Contents

1.0 PURPOSE

This procedure provides the methodology for the preparation and analysis of ^{63}Ni swipe and smear samples.

2.0 SCOPE

This procedure is intended for use by Smiths Detection personnel to perform sample preparation for and analyses by, liquid scintillation counting (LSC).

3.0 PRECAUTIONS/LIMITATIONS

3.1 Limitations/Data Quality

1. Six major counting interferences exist in the scintillation counting of samples: (1) background radiation, (2) quench (color, chemical, and ionization), (3) multiple radionuclides in the same sample, (4) luminescence, (5) static, and (6) wall effect.
2. Only Q-Tips (wood or plastic) and fiberglass paper are to be used for sample collection.
3. While plastic vials are inexpensive, glass vials are the preferred medium for running samples as they reduce interference within sampling.
4. The sensitivity of detecting radioactive events in a liquid scintillation counter (LSC) is limited by the presence of background radiation. To increase counting sensitivity the ration of count rate to background must be maximized. A traditional approach to reduce the interference of environmental background has been to incorporate active anticoincidence guard detectors, using either liquid or solid scintillators.
5. Noise introduced in the electronic circuits by line interference (high voltage transients and line-transmitted switching noises) and radio frequency noise (switches, motors, relays and fluorescent lights) are known to contribute to sporadic background pulses. Spectrum analysis helps to eliminate these pulses by applying spectral smoothing algorithms.

3.2 Safety

1. Attend Basic Radiation Safety Training given by the RSO.
2. Attend LSC Operational Training
3. Be familiar with the manufacturers Material Safety Data Sheet (MSDS) for all chemicals.
4. All personnel using this procedure must follow posted/approved site, department and facility safety rules and any additional requirements which may be included in this procedure.
5. The LSC sealed standards contain toluene. If contact with eyes or skin occurs, rinse the affected area for at least 15 minutes at the appropriate wash station. Notify Heath and Safety.
6. The liquid scintillation cocktail used in this process is a biodegradable, water soluble, combustible organic. Wear gloves to protect skin from contact. Small spills may be cleaned up with Kimwipes™ or equivalent. Wash with soapy water if skin contact occurs. Avoid open flames during use.
7. A shock hazard exists inside the LSC instrument. Do not remove any panels. Normal system operations pose no electrical hazard to the user.
8. Do not open the lid or reach into the instrument while it is operating.
9. Do not attempt to remove or dislodge a jammed or stuck vial unless the power to the LSC is turned off.
10. The small amounts of radioactivity normally used in LSC should not be hazardous to the user. Users should observe all normal safety precautions when handling radioactive material. Open containers of radioactive material should be kept away from the sample changer when possible to avoid spills and subsequent system downtime for decontamination. If a radioactive spill occurs within the instrument, or if a sample is broken in the sample changer mechanism, notify the RSO. This unit is equipped with an external standard source – do not under any conditions, attempt to dismantle any part of the external standard system or remove the source.
11. Use care when opening and closing the LSC lid to avoid possible pinch points.

12. Sealed calibration standards are to be kept in the storage box with a closure retaining device (rubber band or equivalent). Calibration standards should be handled outside the storage box only when inside the LSC. Standards should not be handled directly on counter tops, top of LSC instruments, or in transit from storage to the instrument.

13. To transfer the standards to the LSC for counting, place the box inside the counter, remove the standards from the box and place into the cassettes for counting. Upon completion of count, the sources are to be put securely back into the storage box while in the LSC. The sources may be returned to storage once the box has been properly secured with the closure device.

3.3 Description of Method

Tritium (^{3}H) has a half-life of 12.3 years; decays with a maximum energy of 18.6 keV and an average energy of 5.7 keV. ^{3}H can be found in the environment as molecular tritium $[^{3}H]H_2$, tritiated water $[^{3}H]H_2O$, or integrated in organic matter as organically bound tritium (OBT).

Carbon-14 (^{14}C) has a half-life of 5,730 years; decays with a maximum energy of 156.5 keV. ^{14}C decays into Nitrogen-14 (^{14}N) through beta decay.

Nickel-63 (^{63}Ni) is a beta source, has a half-life of 100.1 years; decays with a maximum energy of 66.9 keV. ^{63}Ni is the source of ionization within our ion spectrometry based products (Ionscans).

^{3}H and ^{14}C are commonly used to calibrate, quench curve, and measure by liquid scintillation counting. Our process is directly involved with the measurement of ^{63}Ni.

The technique of LSC involves placing the sample containing the radioactivity into a scintillation vial and adding a special scintillation cocktail. The scintillation cocktail converts the original nuclear decay energy to flashes of light. The intensity of the light flashes is directly proportional to the original radionuclide energy dissipated in the fluor cocktail, the higher the energy, the brighter the resultant light flash. The number of light flashes per unit time is proportional to the number of nuclear decays in that time unit or, in other words, the sample radioactivity (e.g., disintegrations per minute or DPM).

The most common radionuclide decay process is the production of a beta particle. Tritium, Carbon-14 and Nickel-63 are beta emitters. During the beta decay process, a neutron is converted to a proton and an electron (negative beta particle) and a neutrino. The beta particle is equivalent to an electron in property, and the neutrino is a particle of zero charge and nearly zero mass. The total decay energy that is released in the beta decay process is shared between the beta particle and the neutrino, but only the beta particle can be detected by the scintillation process. Thus, the resultant spectrum for all beta decays starts at zero (all energy given to the neutrino) and goes to the maximum decay energy, E_{max} (all the energy given to the beta particle).

Not all particulate (α,β) radiations are detected equally well by the LSC. The liquid scintillation counting efficiency for beta particles is dependent on the original energy of the beta decay. For most beta particles with a decay energy above 100 keV, the counting efficiency is 90-100%, but for lower energy beta decays the efficiency is normally in the range of 10-60% depending upon the degree of quench in the sample.

Quench can be the result of two common causes: (1) the presence of chemicals in the fluor cocktail that are mixed with the sample and (2) a colored substance that comes from the sample. Chemical quench is caused by a chemical substance in the sample that absorbs nuclear decay energy in the scintillation process, thereby, obstructing to a certain degree the transfer of nuclear decay energy to the scintillation cocktail solvent. Color quench occurs when color is visible in the sample. The photons of light in the scintillation vial are absorbed by the color before they can be detected and quantified by the PMT. These quenching phenomena reduce the number of counts per minute (CPM) of the sample that are detected by the LSC. To use the system's efficiencies for DPM calculation, a particular LSC counter must first be calibrated for the type of sample that it will analyze. Although there are several methods by which the LSC can be calibrated, the external standard method is the most widely used method of efficiency calibration.

In contrast to the measuring procedure, the sample preparation differs completely depending on matrix and activity range. Special conditions have to be fulfilled in order to obtain accurate and reliable measurements. Aqueous tritium and strontium samples can be purified by extraction chromatography and then measured directly. Purification is recommended if (1) color or solid material is visible, (2) organics are present, or (3) the sample history or source is unknown. Otherwise, direct addition of the sample to the scintillation cocktail is permitted.

4.0 PREREQUISITES

4.1 Equipment

- Liquid scintillation counter
- Liquid scintillation vials
- Protocol markers/flags
- Liquid scintillation Varisette sample cassettes

4.2 Reagents

- Ultima Gold scintillation cocktail
- Tritium column, prepacked column
- Carbon-14 column, prepacked column
- Carbon-14 quench set

5.0 PERFORMANCE

5.1 Analysis Overview

NOTE: The information and graphic in this section (5.1) is an *example* of the order in which calibration and sample analysis may be performed. When convenient, all calibration standards, samples, blanks, and QCs may be prepared and loaded into the instrument before proceeding with Automatic Count. However, remember:

(1) The system must be calibrated and verified prior to analyzing samples or completing quench curves (SNC)

(2) Samples may be analyzed in any order desired provided the samples are placed in a cassette with the appropriate Protocol flag.

SNC: Self-Normalization and Calibration

Protocol #1: Smear/wipe samples test for ^{63}Ni.

Protocal #28: ^{14}C quench curve

Auto DPM Cassette:
Used for analyzing samples by Auto DPM (use only for analyzing isotopes for which no quench curve is programmed into the instrument)

5.1 Analysis Overview (cont'd.)

SNC	14C	3H	BKGD	Empty	Empty	Empty	Empty	Empty	Empty	Empty	Empty	Empty

Protocol #1	Blank	Unkn #2	Unkn #3	Unkn #4	Unkn #5	Unkn #6	Unkn #7	Unkn #8	Unkn #9	Unkn #10	Unkn #11	Unkn #12
	Unkn #13	Unkn #14	Unkn #15	Unkn #2	Unkn #2	Unkn #2	Unkn #2	Unkn #2	Unkn #2	Unkn #2	Unkn #2	Unkn #2

Protocol #28	14C A	14C B	14C C	14C D	14C E	14C F	14C G	14C H	14C I	14C J	Empty	Empty

5.2 System Calibration

NOTE 1: System calibration is performed annually by contract through Perkin Elmer. Subsequent calibrations are performed by the LSC operator each week, prior to radionuclide analysis for that week.

5.3 Calibration Verification (SNC)

NOTE 1: The unquenched ^{14}C standard must be the first sample in the Calibrate Cassette. If a vial is detected in position #2 of the Calibrate Cassette, Auto DPM Calibration is also performed. Other vials in this cassette are not counted. If calibrating before an Automatic Count, samples for counting must be loaded in the Sample Cassettes *following* the Calibrate Cassette, not *in* the Calibrate Cassette.

NOTE 2: SNC should be performed before the first set of samples analyzed for the week. If no samples are to be analyzed, system SNC is not necessary.

1. **PLACE** the SNC Protocol flag on the SNC labeled cassette (the cassette will have 14C, 3H, and BKRD labeled on it. Make sure the flag is protruding on its left side. NOTE: After a Protocol is run, the flag will no longer have a protrusion. It is reset after the LSC reads the protocol.

1. **PLACE** the most current ^{14}C sealed calibration standard in the first slot.
2. **PLACE** the most current ^{3}H sealed calibration standard in the second slot.
3. **PLACE** the Background labeled calibration standard in the third slot.
4. **START** Automatic Counting/SNC
5. **IF** calibration is unsuccessful after two attempts, **THEN**

   NOTIFY RSO
6. **RETURN** the calibration standards to storage after analysis is complete.

5.4 Sample Preparation and Simplified Operation of the LSC

1. Select the appropriate protocol flag and insert it into the first cassette. The word "Varisette" is molded on the left tab of the cassette. The protocol flag is inserted vertically into the slot provided on this tab. When loading a cassette onto the sample changer, the protocol flag will always be positioned on the left-hand side of the cassette. Reset the cycle flag by pushing the slide tward the felt end of the cassette.
2. Load the standards and/or samples into the cassette(s) in order (left to right, back to front).
3. Load the cassettes onto the sample changer.
4. If the LSC is counting samples, nothing else is required
5. If the LSC is idle, initiate the start by left-mouse clicking on the green 'start' icon.

5.4.1 Nickel-63

NOTE: The use of lab coat, gloves, and eye protection is mandatory in the preparation of samples for analysis.

CAUTION! DO NOT allow scintillation fluid to contact the outside of the sample vials. Contamination of the instrument will occur, and will result in erroneous readings.

NOTE: Only the first cassette of a sample batch must include the appropriate Protocol card. The instrument will analyze samples across multiple cassettes under the same program until another Protocol card is encountered.

5.4.2 Leak Tests

Leak tests will be performed at the intervals approved by NRC or an Agreement State and specified in the SSD Registration Certificate. Leak tests will be performed by an organization authorized by NRC or an Agreement State to provide leak testing services to other licensees or using a leak test kit supplied by an organization authorized by NRC or an Agreement State, to provide leak test kits to other licensees and according to the sealed source or plated foil manufacturer's (distributor's) and kit supplier's instructions. As an alternative, we will implement the model leak test program published in Appendix R to NUREG - 1556, Vol. 7, "Consolidated Guidance about Materials Licenses: 'Program-Specific Guidance About Academic, Research and Development, and Other Licensees of Limited Scope' dated December 1999."

6.0 POST PERFORMANCE ACTIVITY

6.1 Shelf Life / Chemical Handling

Unquenched ^{14}C, unquenched and quenched ^{3}H sealed standards are stored in glass vials. Shelf life is five years from date of manufacture. See facility RSO for storage location and additional information.

6.2 Material Disposition

Dispose of radioactive sealed standards per site protocols as described in the Radiation Protection Manual for each site.

7.0 RECORDS

Records are to be kept and maintained for a minimum of three years for every sampled analysis. The records to be completed and saved include (but are not limited to):

- *LSC Use and Quality Assurance Verification Log*
- *Radiation Leak Test Certificate*
- *Raw information printout from the LSC*