University of Illinois Nuclear Reactor Laboratory
Health Physics Procedure

NRLHPP - 13
Rev. Date: 5/96

Title: Analysis of Radioactivity in Water.
Periodicity: As required.
Required By: 10 CFR 20.2003 and Appendix B to Part 20; 32 Illinois Administrative Code: Chapter II, Subchapter b, Subpart K, Section 340.1030.

Comments: This procedure is a guideline for the performance of this activity, deviations are permissible after consultation with the Reactor Health Physicist.

Procedure:

1.0 Purpose: To determine the *soluble* and *insoluble* alpha and beta/gamma activity, the tritium activity, and the total activity, in the liquid effluent storage tank; or the total alpha, beta/gamma, and tritium activity in other water sources.

2.0 Precautions: Always thoroughly clean all items to be used in sampling and counting before use.

3.0 Materials and/or Test Equipment:

3.1 One >100 ml and two 60 ml bottles.

3.2 One new planchet.

3.3 Filtering device with 0.45 μm filter.

3.4 Heat Lamp.

4.0 Procedure Steps:

4.1 Sample collection: for a liquid effluent storage tank sample (modify as appropriate for other water samples).

4.1.1 Take two samples from valve RET-15, as indicated in Step 7 of NRLOP-10, by filling the >100 ml and one of the 60 ml bottles. Fill the other 60 ml bottle with water from the drinking fountain, to be used as a blank for tritium counting.

4.1.2 Label the two 60 ml bottles and send to the Radiation Safety Office (RSO) of the Division of Environmental Health and Safety (DEH&S) for tritium counting by liquid scintillation.

4.2 Sample preparation and counting: for a liquid effluent storage tank sample (modify as appropriate for other water sources).

4.2.1 Remove the regular planchets from, and wipe down, the sample handling trays of both the Eberline BC-4 and SAC-4 counters. Clean a new planchet, to be used for drying the 100 ml sample, and take a fifty (50) minute background on each instrument. Perform an MDA calculation using the

"MDA Calculation Worksheet for a Liquid Effluent Storage Tank Discharge" on Page 7 of this procedure.

4.2.2 Record the results on the "Analysis of Radioactivity in Water Data Sheet" on Page 5 of this procedure.

4.2.3 Make sure the >100 ml sample is well mixed. Using the filtering device with a 0.45 µm filter, filter 100 ml of the sample into a >100 ml sized bottle to be decanted and dried on the planchet. Remove the filter and set it aside for drying.

4.2.4 Using the heat lamp, decant and dry the 100 ml sample in the clean, new planchet (from Step 4.2.1).

4.2.5 Count the dried filter and planchet separately, for fifty (50) minutes each, in the BC-4 and SAC-4.

4.3 Sample Activity Calculations: for all types of water samples regardless of the source.

4.3.1 Calculate and record the *soluble, insoluble,* or *total* alpha and beta/gamma concentration, and the tritium concentration in µCi/ml on the data sheet as follows:

a) cpm / efficiency = dpm;
b) dpm / 2.22 E^6 dpm/µCi = Activity in µCi;
c) Activity (µCi) / Volume of Sample in ml = Concentration of Sample in µCi/ml.

Example: a) 30 cpm / 34.3% (0.343) for beta/gamma activity = 87 dpm;
b) 87 dpm / 2.22 E^6 dpm/µCi = 3.9 E^{-5} µCi;
c) 3.9 E^{-5} µCi / 100 ml = 3.9 E^{-7} µCi/ml.

4.3.2 Record the Tritium results from the RSO on the data sheet and calculate the concentration of the sample, in µCi/ml, in the same manner as in Step 4.3.1 above.

4.4 Discharge determination: If the concentrations meet the Acceptance Criteria in 5.0 below then the water may be discharged.

5.0 Acceptance Criteria:

5.1 Liquid Effluent Storage Tank Discharge

5.1.1 The *insoluble* Alpha activity on the filter paper shall be less than the MDA (this ensures that no *insoluble* activity is released).

5.1.2 The *soluble* Alpha activity on the planchet shall be less than 2 E^{-8} µCi/ml (Appendix B to Part 20, Table 3 "Releases to Sewers", Page 391).

5.1.3 The *insoluble* beta/gamma activity on the filter paper shall be less than the MDA (this ensures that no *insoluble* activity is released).

5.1.4 The *soluble* beta/gamma activity on the planchet shall be less than 9 E^{-6} µCi/ml (for ^{134}Cs, not known to be absent from the mixture) (Appendix B to Part 20, Table 3 "Releases to Sewers", Pages 393 and 365).

5.1.5 The Tritium concentration shall be less than 1 E^{-2} µCi/ml (Appendix B to Part 20, Table 3 "Releases to Sewers", "Hydrogen - 3", Page 342).

5.1.6 The Sum of the Fractions shall not exceed unity for the *total soluble* beta/gamma fraction plus the Tritium fraction, however, the alpha concentration must be less than the MDA. If the alpha concentration is greater than the MDA then the Sum of the Fractions shall be derived by dividing the total of the *soluble* alpha and *soluble* beta/gamma concentrations by 2 E^{-8} µCi/ml (Appendix B to Part 20, Table 2, "Effluent Concentrations", Col. 2, "Water", Page 391) and adding the Tritium fraction. The total shall not exceed unity.

5.1.7 If any of these criteria are not met, the tank shall not be pumped, and the Reactor Health Physicist shall be notified immediately.

5.2 Other Water Source Discharge

5.2.1 The *total* Alpha activity on the planchet shall be less than 2 E^{-9} µCi/ml (Appendix B to Part 20, Table 2, "Effluent Concentrations", Col. 2, "Water", Page 391).

5.2.2 The *total* beta/gamma activity on the planchet shall be less than 9 E^{-7} µCi/ml (for ^{134}Cs, not known to be absent from the mixture) (Appendix B to Part 20, Table 2, "Effluent Concentrations", Col. 2, "Water", Page 365).

5.2.3 The Tritium concentration shall be less than 1 E^{-3} µCi/ml (Appendix B to Part 20, Table 2, "Effluent Concentrations", Col. 2, "Water", "Hydrogen - 3", Page 342).

5.2.4 The Sum of the Fractions shall not exceed unity for the *total soluble* beta/gamma fraction plus the Tritium fraction, however, the alpha concentration must be less than the MDA. If the alpha concentration is greater than the MDA then the Sum of the Fractions shall be derived by dividing the total of the *soluble* alpha and *soluble* beta/gamma concentrations by 2 E^{-9} µCi/ml (Appendix B to Part 20, Table 2, "Effluent Concentrations", Col. 2, "Water", Page 391) and adding the Tritium fraction. The total shall not exceed unity.

5.2.5 If any of these criteria are not met, the water may shall not be discharged, and the Reactor Health Physicist shall be notified immediately.

6.0 References: a) "Standard Methods for the Examination of Water and Wastewater"; American Public Health Association; Washington, DC; 17th ed., 1989.
b) "Solubility Criteria for Liquid Effluent Releases to Sanitary Sewerage Under The Revised 10 CFR Part 20"; NRC Information Notice 94-07, January 28, 1994.
c) "Disposal by release into sanitary sewerage", 10 CFR Part 20.2003; and Appendix B to Part 20; Revised as of January 1, 1995.
d) "Disposal by release into sanitary sewerage", 32 Illinois Administrative Code: Chapter II, Subchapter b, Subpart K, Section 340.1030"; October 1993.

7.0 Appendices: None.

8.0 Documents: "Analysis of Radioactivity in Water Data Sheet" (Liquid Effluent Storage Tank Sample) on Page 5 of this procedure; "MDA Calculation Worksheet for a Liquid Effluent Storage Tank Discharge" on Page 7 of this procedure; and "Analysis of Radioactivity in Water Data Sheet" (Other Water Sources) on Page 6 of this procedure.

Revised By: Mark A. Kaczor — Mark A. Kaczor — Title: Reactor Health Physicist and Senior Reactor Operator — Date: 5/16/96

Reviewed By: Jonathan M. Ralston — Jonathan M. Ralston — Title: Assistant Health Physicist and Senior Reactor Operator — Date: 5/16/96

Approved By: Rich L. Holm — Title: Reactor Administrator — Date: 5/16/96

Date Reviewed by the Reactor Committee: *Reactor Committee review not required, minor changes due to modification of NRLOP-10, "Liquid Effluent Discharge Procedure".*

(hpdoc\procedur\hp13h2o.doc)

Analysis of Radioactivity in Water Data Sheet
Liquid Effluent Storage Tank
(App. B, Table 3 limits)

Sample Collected **Date/Time:**	**Collected By:**
Sample Counted **Date/Time:**	**Counted By:**
Tank Pumped **Date/Time:**	**Pumped By:**

	Alpha		**Beta/Gamma**		**Tritium**
Sample Media	Filter	Planchet	Filter	Planchet	60 ml vial
Counting System	SAC-4	SAC-4	BC-4	BC-4	LKB-11
Sample Volume (ml)	100	100	100	100	1
Gross Counts					N/A
Sample Counting Time	50 min.	50 min.	50 min.	50 min.	60 min.
Gross cpm (dpm for ^{3}H)					dpm
Background Counts					N/A
Bkg. Counting Time	50 min.	50 min.	50 min.	50 min.	60 min.
Background cpm (dpm for ^{3}H)					dpm
Net cpm (dpm for ^{3}H)					dpm
Efficiency (%)					N/A
MDA (μCi/ml)					N/A
Concentration (μCi/ml)					
Concentration Limit (μCi/ml)	MDA	MDA (< 2 E -8)	MDA	9 E -6	1 E -2

Reviewed by:_____Date:_____

Analysis of Radioactivity in Water Data Sheet
Other Water Sources
(App. B, Table 2, Col. 2 limits)

Sample Taken From: _____

Date:	**Time:**	**Performed By:**

	Alpha	**Beta/Gamma**	**Tritium**
Sample Media	Planchet	Planchet	60 ml vial
Counting System	SAC-4	BC-4	LKB-11
Sample Volume (ml)	300	300	1
Gross Counts			N/A
Sample Counting Time	50 min.	50 min.	60 min.
Gross cpm (dpm for ^{3}H)			dpm
Background Counts			N/A
Bkg. Counting Time	50 min.	50 min.	60 min.
Background cpm (dpm for ^{3}H)			dpm
Net cpm (dpm for ^{3}H)			dpm
Efficiency (%)			N/A
MDA (μCi/ml)			N/A
Concentration (μCi/ml)			
Concentration Limit (μCi/ml)	MDA (< 2 E -9)	9 E -7	1 E -3

Reviewed by:_____**Date:**_____

MDA Calculation Worksheet

Date: _____ Time: _____ Calculated by: _____ Reviewed by: _____

Instrument Model Number	**SAC-4**	**BC - 4**
Serial Number	# 429	# 338
Type of Decay Detected	Alpha	Beta
50 min. Background Count (in cpm)		
Efficiency Calculation-Source Used	^{239}Pu	^{90}Sr - ^{90}Y
Source Counting Position	Deep / Shallow	Deep / Shallow
Net 50 min. Source cpm (2Π)		
Calibrated Source cpm (2Π)	433	2770
Efficiency (%)		

Note: MDA = Minimum Detectable Activity at the 95% Confidence Level.

$$\textbf{MDA} = \frac{2.71 + 4.65\sqrt{\text{Background cpm} * \text{Background count time (min)}}}{2.22\ E^6\ \text{dpm}/\mu\text{Ci} * \text{Efficiency (cpm/dpm)} * \text{Background count time (min)} * \underline{\ X\ }\ \text{ml}} = \underline{X.x\ E^{-X}}\ \mu\text{Ci/ml}$$

ALPHA (SAC - 4)

$$\textbf{MDA} = \frac{2.71 + 4.65\sqrt{\text{cpm} * 50\ \text{min}}}{2.22\ E^6\ \text{dpm}/\mu\text{Ci} * \_\_\_\_\ \text{Eff (cpm/dpm)} * \underline{\ 50\ }\ \text{min} * \_\_\_\_\ \text{ml}} = \_\_\_\_\_\ \mu\text{Ci/ml}$$

BETA (BC - 4)

$$\textbf{MDA} = \frac{2.71 + 4.65\sqrt{\text{cpm} * 50\ \text{min}}}{2.22\ E^6\ \text{dpm}/\mu\text{Ci} * \_\_\_\_\ \text{Eff (cpm/dpm)} * \underline{\ 50\ }\ \text{min} * \_\_\_\_\ \text{ml}} = \_\_\_\_\_\ \mu\text{Ci/ml}$$