STATE OF MICHIGAN
DEPARTMENT OF NATURAL RESOURCES & ENVIRONMENT
LANSING

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November 10, 2010

Ms. Katie Streit, Health Physicist
Materials Licensing Branch
U.S. Nuclear Regulatory Commission, Region III
2443 Warrenville Road, Suite 210
Lisle, Illinois 60532-4352

Dear Ms. Streit:

SUBJECT: NRC License Number: 21-05199-02

This is in response to our discussions on October 8, 2010, regarding our recent license amendment request and the request for additional information on several items detailed in the Telephone Conversation Record of our discussion.

We have revised our Final Status Survey Report (FSSR) in its entirety. Please replace the FSSR included in our September 8, 2010, amendment request with the enclosed FSSR.

The Telephone Conversation Record included five items requiring a response.

1. Provide the efficiency and calibration procedure for radiological instruments used in the final status survey.

   Response: The calibration procedures and a sample calibration record for each instrument are enclosed.

2. Provide the minimum detectable concentration or minimum detectable activity for instruments used in the final status survey. Demonstrate that these values are sufficient to detect the DCGL.

   Response: Section 3.0, "Minimum Detectable Activity," of the revised FSSR includes calculations of the minimum detectable activity and compares them to the derived concentration guideline level (DCGL).

3. 10 CFR 30.36(2)(i) requires reporting levels of radioactivity, including alpha and beta, to be in either disintegrations per minute or microCurie per 100 square centimeters. Convert the counts per minute provided in the report for scan and static measurements to provide the data in either disintegrations per minute or to microCuries.

   Response: The results in the FSSR are now in disintegrations per minute.

4. Page 9 of the license amendment request states that static measurements and surface wipes of 100 square centimeters were taken in selected locations. Describe how these locations were selected, including the decision to conduct static measurements in some

locations without tests for removable contamination, and tests for removable contamination in locations without static measurements.

Response: This question concerned static measurements and wipes taken in the Nuclear Counting Facility (NCF) and included in the original FSSR. Section 6.1, "NCF Surveys," of the revised FSSR describes why static measurements and wipes were taken in selected locations that were the most likely to have contamination. A second round of static alpha and beta/gamma measurements was conducted on October 19, 2010, and included in the revised FSSR.

Section 6.1.3, "Additional Beta/Gamma Measurements," of the revised FSSR discusses why the traps under the sinks were surveyed with a β/γ probe to detect radioactive material caught in the sink traps. Since the radioactive material would be in the trap and not on the outside surface of the trap, no alpha measurements or wipe tests were performed on the outside of the trap. Also, the sink drains were surveyed with a β/γ probe to detect radioactive material caught in the upper portion of the drain pipe. Since the radioactive material would be in the drain pipe, no alpha measurements or wipe tests were performed.

5. NUREG 1757, Volume 2, Section 5.1 states that default parameters need to be utilized in the DandD code for derivation of default concentration guideline limits (DCGL) during Group 2 decommissioning. The default parameter for the area of contamination is unlimited area. Either:

   a. provide DCGL's utilizing the default parameters in DandD,
   b. provide the execution of the DandD computer code with current or
   c. projected site specific source term concentrations utilizing the default parameters,
   d. use values provided by NUREG/CR-5512,
   e. or request site specific dose model, with specific room sizes.

   As a reminder, a site-specific dose model would change the decommissioning group from a group 2 to a group 4, requiring an environmental assessment (75 Federal Register 20256, May 19, 2010).

   Response: The revised FSSR uses the DCGLs found in Table 5.19 in Volume 3 of NUREG/CR-5512, "Residual Radioactive Contamination From Decommissioning, Parameter Analysis, Draft Report for Comment," October 1999.

If you have any questions, please contact me via telephone; skowronekr@michigan.gov; or DNRE, P.O. Box 30241, Lansing, Michigan 48909-77411.

Sincerely,

Robert D. Skowronek

Robert D. Skowronek, Chief
Radioactive Materials Unit
Radiological Protection Section
Environmental Resource Management Division
517-241-1253

RDS:JK
Enclosures

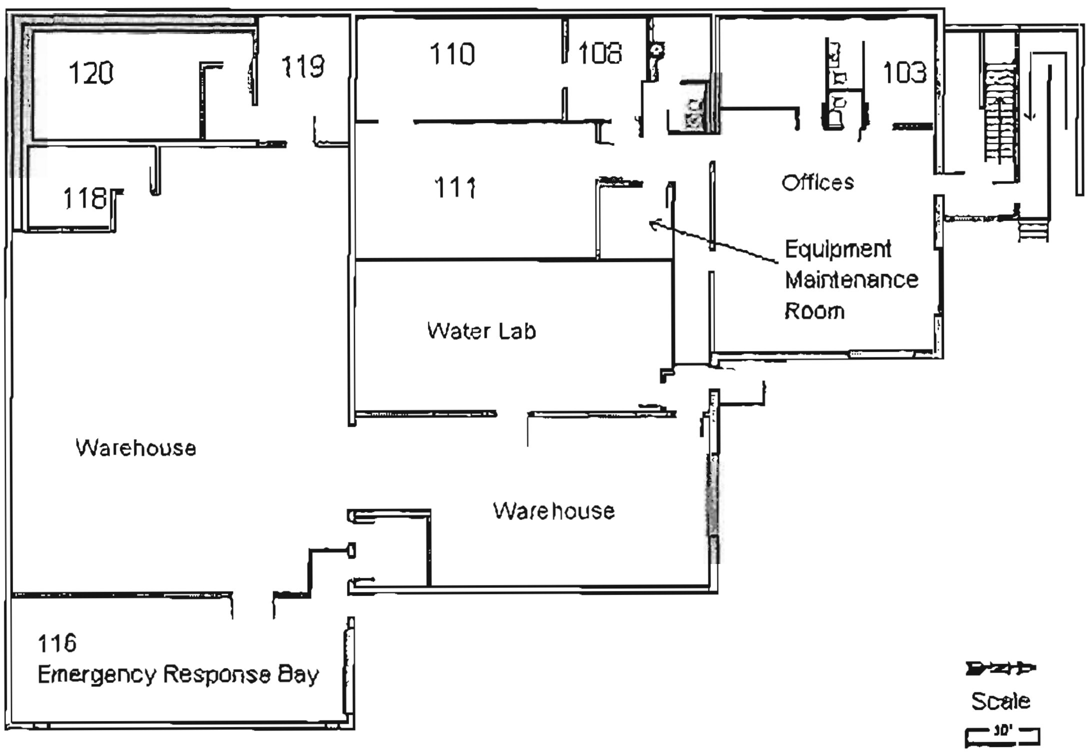
Final Status Survey
NRC License Number 21-05199-02
815 Terminal Road, Lansing, Michigan

1.0 Historical Site Assessment

The U.S. Nuclear Regulatory Commission (NRC) license number 21-05199-02 authorizes the state of Michigan to use radioactive material at 815 Terminal Road and at 815 Filley Street in Lansing, Michigan. The NRC license authorizes sealed sources for instrument calibration and training and sealed and unsealed radioactive material in calibration standards, environmental samples, and incident response samples.

From 2000 until 2010, the Radiological Protection Section operated a Calibration Room, a Survey Instrument Repair Room, a Radioactive Material Storage (RMS) Room, the Nuclear Counting Facility (NCF) consisting of a Wet Lab and a Radiological Counting Room, and associated office space at Terminal Road. The building also contained rooms unassociated with the radiological program including a large warehouse area and a water laboratory.

The Calibration Room (Room 120) contained a sealed radioactive source that was used to calibrate portable gamma radiation survey meters. Exempt activity plated sources were used on the countertop in the Survey Instrument Repair Room (Room 119) to calibrate alpha and beta radiation survey equipment. Environmental samples, radioactive items recovered from the public domain, sealed calibration sources, plated disk sources, and laboratory standards were stored in the RMS Room (Room 118). The Wet Lab (Room 111) and Counting Room (Room 110) processed and counted environmental samples and source wipes.



815 Terminal Road, Lansing, Michigan

In July 2010, all radioactive sources and other equipment were moved from 815 Terminal Road in Lansing to 815 Filley Street in Lansing. After all the sources and equipment were moved out and the rooms were empty, a final status radiation survey was performed in the rooms that contained radioactive material. The survey included a gamma radiation survey of the rooms to verify all gamma radiation sources had been removed, alpha and beta surveys of the walls, floor, ceilings, hoods, drawers, and countertops to verify that no residual radioactive material remained, and wipe tests of these areas to further confirm that no residual radioactive material remained at the site.

NUREG-1757, "Consolidated Decommissioning Guidance" was used to determine the appropriate decommissioning group for each room and to guide the final status survey for that room.

2.0 Derived Concentration Guideline Levels ($DCGL_w$)

Acceptable unrestricted release surface contamination values can be found in Table 5.19 in Volume 3 of NUREG/CR-5512, "Residual Radioactive Contamination From Decommissioning, Parameter Analysis, Draft Report for Comment," October 1999. These values from Table 5.19 will be used as the $DCGL_w$s.

Acceptable Unrestricted Release Surface Contamination Values

Nuclide	90%ile Value (dpm/100 cm^2)
Cobalt-60	7,050
Cesium-137	28,000
Radium-226 + C	315
Thorium-232 + C	6.03
Radium-228	201
Thorium-228 + C	41.4
Uranium-238 + C	19.5
Americium-241	27.0

"+C" denotes an equilibrium initial activity assumption for progeny. Initial progeny activity is zero for all other radionuclides.

3.0 Minimum Detectable Activity

3.1 Alpha Emitters

Using the $DCGL_w$s in Section 2.0, limits on surface measurements can be determined for the various radionuclides that would demonstrate that future annual total effective dose equivalents to a member of the public are below 25 mrem.

For radionuclides emitting alpha particles:

Radionuclide	$DCGL_w$ $Activity_{Parent}$ (dpm/100 cm^2)	# Alpha Emissions (includes progeny)	$Activity_{Parent}$ x #Alphas in Chain (αpm/100 cm^2)
Americium-241	27.0	1 Alpha Particle (Am-241)	27.0
Radium-226 + Progeny	315	5 alpha particles per dpm of Ra-226: Ra-226, Rn-222, Po-218, Po-214, Po-210	1,570
Radium-228 + Thorium-228 + Progeny	34.3	5 alpha particles per dpm of Ra-228 in equilibrium with progeny: Th-228, Ra-224, Rn-220, Po-216, Bi-212 (0.35), Po-212 (0.64)	171
Thorium-232 + Progeny	6.03	6 alpha particles per dpm of Th-232 in equilibrium with progeny: Th-232, Th-228, Ra-224, Rn-220, Po-216, Bi-212 (0.35), Po-212 (0.64)	36.1
Uranium-238 + Progeny	19.5	8 alpha particles per dpm of U-238 in equilibrium with progeny: U-238, U-234, Th-230, Ra-226, Rn-222, Po-218, Po-214, Po-210	156

The radium-228 + thorium-228 + progeny activity was calculated based on the sum of the fractions. If

$$\frac{x}{201\ \text{[from Ra-228]}} + \frac{x}{41.4\ \text{[from Th-228+C]}} = 1.0, \quad \text{then } x = 34.3$$

The lowest number of alpha emissions per minute calculated for the chains above is 27.0 αpm/100 cm^2 for americium-241. However, in the 10 years of operation of the NCF at 815 Terminal Road, the only Am-241 received at the NCF was one wipe with an activity of 30 picocuries. Given the unlikely possibility of appreciable contamination from that one wipe, we will use the radionuclide with the next lowest surface contamination limit which is thorium-232 in equilibrium with its progeny at 36.1 αpm/100 cm^2. Let us designate this as $DCGL_{Th\text{-}232}$.

The Eberline SHP-380A alpha detectors are calibrated using a Model CAL3104 Alpha Standard from North American Scientific, Inc. The standard is 1.992 kBq (1.195 x 10^5 dpm) of Am-241 distributed over an active area of 150 mm x 67 mm. According to the Certificate of Calibration, the 2π emission rate is 5.976 x 10^4 alphas per minute which is ½ of the dpm for the source. During calibration, the rate measured by the alpha detector is compared to the 2π emission rate to determine a counts/count efficiency factor. The "S" in the "SHP" model number indicates that the probe is a "smart" probe that carries the setup and calibration data in a computer chip in the probe. The probe automatically adjusts any Eberline E-600 box to match the setup and calibration data in the probe.

The following table shows the alpha detectors, efficiency factors, counts/disintegration of Am-241, and calibration dates for the detectors used during the final status surveys.

SHP-380A	Measured Efficiency Factor (counts/count)	Calculated counts/disintegration	Calibration Date
109	0.3116	0.156	4/30/2010
264	0.4975	0.249	4/30/2010
265	0.3085	0.154	1/7/2010
267	0.4484	0.224	1/7/2010

Background alpha measurements were taken and used to determine the minimum detectable activities for the probes. Five minute static alpha measurements were taken on July 29, 2010, and ten minute static alpha measurements were taken on October 19, 2010. The equation is

$$MDA = \frac{3 + 4.65(B \times t)^{1/2}}{t \times eff \times A/100}$$

where

MDA = activity in dpm/100 cm^2
B = background rate in counts per minute
t = counting time in minutes
eff = detector efficiency in counts per disintegration (4π)
A = probe area in cm^2 = 100 cm^2

SHP-380A (serial#)	Date	Background Measurement	Background Rate (cpm)	Detector Eff. (cnts/dis)	Survey Time (minutes)	MDA (dpm/100 cm^2)
109	7/29/2010	25 cts in 5 min	5.0	0.156	5	34
109	10/19/2010	27 cts in 30 min	0.90	0.156	10	11
264	10/19/2010	61 cts in 30 min	2.0	0.249	10	9.6
265	10/19/2010	45 cts in 30 min	1.5	0.154	10	14
267	10/19/2010	83 cts in 30 min	2.8	0.224	10	12

All the MDAs are less than 36.1 dpm/100 cm^2.

3.2 Radionuclides not emitting alpha particles

The remaining two radionuclides of interest emit beta particles. From Section 2.0:

Radionuclide	$DCGL_w$ (dpm/100 cm^2)
Cobalt-60	7,050
Cesium-137	28,000

Cobalt-60 has the lower $DCGL_W$ so 7,050 dpm/100 cm^2 will be used in these calculations.

The beta detectors are calibrated using a DNS-18 source set from Eberline Instrument Corporation. These sources are technetium-99 electroplated on polished nickel discs. The measured 2π beta particle emission rate was 29,700 ± 890 per minute. The total disintegration rate assumes 25% backscatter and is calculated to be 47,520 ± 1,430 dpm. The ratio of the 2π beta particle emission rate to the calculated dpm of the source is 0.625.

The beta energies of Co-60 and Tc-99 are sufficiently close that we will use the counts/count ratio determined during calibration for these calculations.

Radionuclide	MeV max	Probability
Co-60	0.318	0.99925
Tc-99	0.294	0.99999

During calibration, the rate measured by the beta detector is compared to the 2π emission rate to determine a counts/count efficiency factor.

The following table shows the beta detectors, efficiency factors determined during calibration, counts/disintegration of Am-241, and calibration dates for the Eberline SP-360 "pancake" detectors used during the final status surveys.

SHP-360 (serial#)	Measured Efficiency Factor (counts/count)	Calculated counts/disintegration (includes 25% backscatter)	Counts/dis (assume no backscatter)	Calibration Date
339	0.4037	0.252	0.202	1/6/2010
342	0.4449	0.278	0.222	1/6/2010
343	0.4711	0.294	0.236	1/7/2010
382	0.4829	0.302	0.241	1/6/2010
383	0.4823	0.302	0.241	1/7/2010
532	0.4492	0.281	0.225	1/6/2010
879	0.4773	0.298	0.239	1/7/2010
882	0.4486	0.280	0.224	1/7/2010

For radioactive material on a surface, ½ of the emissions are into the surface and ½ of the emissions are out of the surface. The effects of backscatter vary significantly depending on the contaminated surface. If one ignores backscatter effects, the results will be conservative.

The lowest probe efficiency factor is the 0.404 counts/count from serial number 339. We will use this factor in the following calculations. Assuming no backscatter, 0.5 counts/disintegration x 0.404 counts/count = 0.2 counts/disintegration.

The surface area of the SHP-360 probe is 15 cm^2. The background count rate used during the July 29, 2010, survey of the RMS Room was 60 cpm. The highest background count rate from the four SHP-360 probes used during the October 19, 2010, survey of the NCF was 40 cpm.

Using the equation

$$MDA = \frac{3 + 4.65(B \times t)^{1/2}}{t \times eff \times A/100}$$

MDA = activity in dpm/100 cm^2
B = background rate in counts per minute
t = counting time in minutes
eff = detector efficiency in counts per disintegration (4π) = 0.5 x 0.40 = 0.2 cts/dis
A = probe area in cm^2 = 15 cm^2

Site	Date	Background Rate (cpm)	Detector Eff. (cnts/dis)	Survey Time (minutes)	MDA (dpm/100 cm^2)
RMS Room	7/29/2010	60	0.2	30	220
NCF	10/19/2010	40	0.2	5	460

Both calculated MDAs are much less than the $DCGL_W$ of 7,050 dpm/100 cm^2.

4.0 Calibration Room

The only radioactive source used in this room was a J.L. Shepherd Model 28-6a calibrator containing a sealed cesium-137 source with a current activity of 460 millicuries. Leak tests of this device have been performed at 6-month intervals and no positive results were received for this device. A copy of the most recent leak test result is attached. The Calibration Room meets the criteria for decommissioning Group 1 in NUREG-1757.

The J.L. Shepherd Model 28-6a calibrator was moved to 815 Filley Street in Lansing, Michigan. On July 27, 2010, Mr. Matt Bowen of our staff surveyed the empty Calibration Room with an Eberline PRM-7 microroentgen per hour (μR/h) meter (SN 213 calibrated April 28, 2010) at a distance of one meter from the floors and walls. No gamma readings exceeded the background radiation reading of 10 μR/h. The survey confirmed the sealed source had been removed.

Since the sealed radioactive source has been removed from the room and leak tests have not showed the source to be leaking, the Calibration Room appears to meet the criteria in NUREG-1757 for unrestricted release.

5.0 Survey Instrument Repair Room

Plated disk sources were used on the countertop of the Survey Instrument Repair Room to calibrate alpha and beta radiation survey equipment. When not in use, the plated sources were stored in the RMS Room. The highest activity americium-241 alpha source used is 0.054 microcuries and the highest activity technetium-99 beta source used is 0.021 microcuries. Since the Am-241 source is less than 10 microcuries and the Tc-99 source is less than 100 microcuries, they are not leak tested. Visual examination of all the Am-241 and Tc-99 sources show that they appear intact without any flaking or degradation of the plated disk surface. Exempt activity cesium-137 check sources were also used on the countertop. The Survey Instrument Repair Room meets the criteria for decommissioning Group 1 in NUREG-1757.

All radioactive sources and other equipment were moved to 815 Filley Street from the Survey Instrument Repair Room. On July 23, 2010, Mr. Robert Skowronek surveyed the countertop using an Eberline E600 with a SHP360 beta/gamma "pancake" probe (SN 879 calibrated January 7, 2010) and a SHP380A alpha probe (SN 265 calibrated April 30, 2010). The background for the beta/gamma probe was 42 counts per minute and the background for the alpha probe was 10 counts per minute. The audible signal was activated to aid in finding elevated areas of contamination. No readings above background were found. A wipe test was performed on the countertop on July 28, 2010, and counted by our NCF. The results were 1.3 ± 0.7 dpm gross alpha and <1.1 dpm gross beta.

On July 27, 2010, Mr. Matt Bowen of our staff surveyed the empty Survey Instrument Repair Room with an Eberline PRM-7 μR/h meter (SN 213 calibrated April 28, 2010) at a distance of one meter from the floors and walls. The gamma radiation readings from the interior walls and floor did not exceed the background radiation reading of 10 μR/h. The west wall on which the cupboards are hung and the north wall are load-bearing walls composed of concrete or cinder blocks. The gamma radiation readings in contact with these walls were 12 μR/h. The gamma radiation reading outside the building in contact with the west wall was also 12 μR/h. We conclude that the slightly elevated radiation readings in contact with these walls is due to natural radioactive material in the blocks comprising the walls.

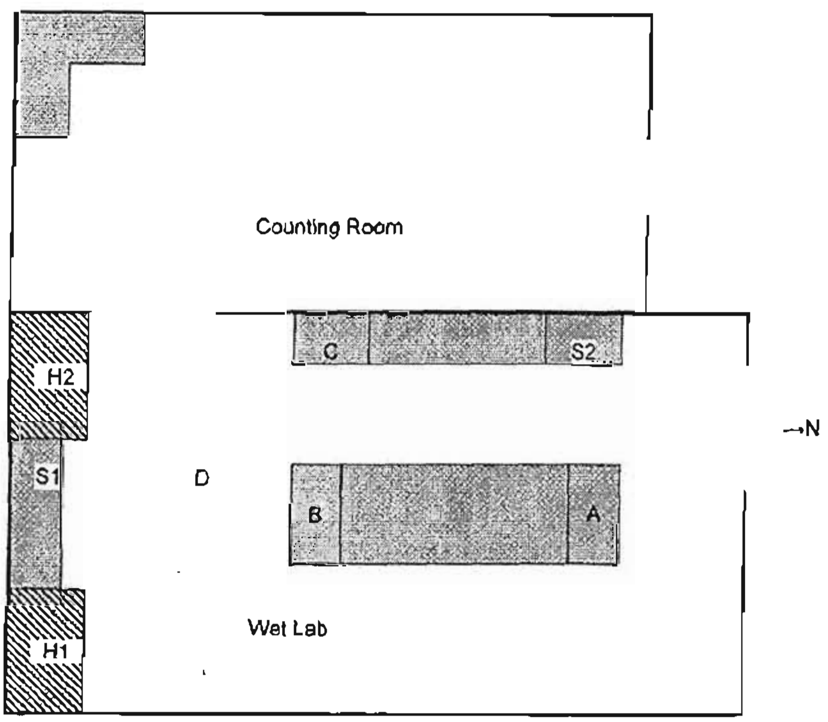
Since the radioactive sources have been removed from the room and no contamination was found during a radiation survey of the countertop, the Survey Instrument Repair Room appears to meet the criteria in NUREG-1757 for unrestricted release.

6.0 Nuclear Counting Facility

The Nuclear Counting Facility (NCF) is responsible for counting environmental samples collected as part of Michigan's nuclear power plant monitoring program. Additional "special samples," collected in support of radioactive materials incident investigations, were also counted at the NCF. Other sources at the NCF were sealed laboratory calibration standards and check sources. Radioactive samples were not stored at the NCF after laboratory analysis.

The environmental samples were milk, water, and air samples collected around Michigan's nuclear power plants and samples of technologically enhanced naturally occurring radioactive material primarily from oil and gas production facilities and water treatment plants. In addition, some special samples were identified as containing uranium, thorium, cobalt-60, and/or cesium-137. One wipe from an Am/Be source discovered at a scrap yard showed 60 picocuries americium-241. During operation, the NCF was kept radiologically clean so as not cross-contaminate samples. Based on the above information, the facility was determined to require a Group 2 decommissioning process.

After all radioactive sources and other equipment were moved to 815 Filley Street, a Final Status Survey was conducted at the NCF.



If the lab became contaminated, it would likely have occurred during sample preparation in the Wet Lab. Preparation for analysis of non-liquid samples was performed on trays covered with absorbent paper. Areas in the wet lab most likely to become contaminated would have included the sample receipt area (area A), the sample preparation areas (areas B and C), the fume hoods (H1 and H2), sinks (S1 and S2), floor drain (D), and floor areas immediately beneath these work areas. In the Counting Room, the countertop and a drawer in the cabinet beneath the countertop that stored the sealed quality assurance sources would be the most likely areas of contamination.

6.1 NCF Surveys

On July 27, 2010, Mr. Robert Skowronek of our staff surveyed the empty NCF with an Eberline PRM-7 μR/h meter (SN 213 calibrated April 28, 2010) at a distance of one meter from the floors and walls. The gamma radiation readings from the walls and floor did not exceed the background radiation reading of 10 μR/h.

On July 27, 2010, Mr. Matt Bowen and Mr. Robert Skowronek surveyed all countertops, hoods, the drawer in the Counting Room that stored sources, the sinks, and the floor areas immediately in front of these areas with a beta/gamma probe and an alpha probe. The audible signal was activated to aid in finding elevated areas of contamination. No readings above background were found. The instruments used were an Eberline E600 with a SHP360 beta/gamma "pancake" probe (SN 879 calibrated January 7, 2010), a SHP360 probe (SN 342 calibrated January 6, 2010), and a SHP380A alpha probe (SN 265 calibrated April 30, 2010). Background measurements were 42 cpm for the SHP360 SN879 probe, 41 cpm for the SHP360 SN342 probe, and 10 cpm for the alpha probe.

On October 19, 2010, static measurements were taken in locations where radioactive material was routinely used and that had the highest potential for residual contamination. If present, the contamination would likely have occurred during sample preparation in the Wet Lab. Areas in the wet lab most likely to become contaminated would have included the sample receipt area (area A), the sample preparation areas (areas B and C), the fume hoods (H1 and H2), sinks (S1 and S2), floor drain (D), and floor areas immediately beneath these work areas. In the Counting Room, the countertop and a drawer in the cabinet beneath the countertop that stored the sealed quality assurance sources would be the most likely areas of contamination. The E600 has an "integrate" mode that can be used to total the number of counts in a given length of time.

6.1.1 Static Alpha Measurements

Static alpha measurements were integrated over 10 minutes. As noted in section 3.1 of this report, there are 6 alpha particles emitted by Th-232 and its progeny in equilibrium for each disintegration per minute of Th-232. The table divides the αpm by 6 to get the dpm for Th-232.

The Th-232 dpm = Net cpm x Probe Factor (dis/ct) / 6

Location	Probe	Counts in 10 min	CPM (cpm)	Probe Bkg (cpm)	Net (cpm)	Probe Factor (dis/ct)	Th-232 (dpm/ 100 cm^2)
Sink 1	265	34	3.4	1.5	1.9	6.5	2.1
Sink 2	267	39	3.9	2.8	1.1	4.5	0.8
Countertop Area A	264	54	5.4	2.0	3.4	4.0	2.3
Countertop Area B	264	84	8.4	2.0	6.4	4.0	4.3
Countertop Area C	267	57	5.7	2.8	2.9	4.5	2.2
Floor below Area A	265	61	6.1	1.5	4.6	6.5	5.0
Floor below Area B	264	89	8.9	2.0	6.9	4.0	4.6

Location	Probe	Counts in 10 min	CPM (cpm)	Probe Bkg (cpm)	Net (cpm)	Probe Factor (dis/ct)	Th-232 (dpm/ 100 cm^2)
Floor below Area C	267	50	5.0	2.8	2.2	4.5	1.7
Floor Drain	265	70	7.0	1.5	5.5	6.5	6.0
Hood 1	265	19	1.9	1.5	0.4	6.5	0.4
Hood 2	267	27	2.7	2.8	0.0	4.5	0
Elephant exhaust device	264	41	4.1	2.0	2.1	4.0	1.4
Counting Lab countertop	267	34	3.4	2.8	0.6	4.5	0.45
Check source drawer	265	26	2.6	1.5	1.1	6.5	1.2
Floor below counting lab countertop	264	72	7.2	2.0	5.2	4.0	3.5

All results are less than the 6.03 dpm/100 cm^2 listed as an acceptable unrestricted release surface contamination value for Th-232 as found in Table 5.19 in Volume 3 of NUREG/CR-5512, "Residual Radioactive Contamination From Decommissioning, Parameter Analysis, Draft Report for Comment," October 1999.

6.1.2 Static Beta/Gamma Measurements

Static beta/gamma measurements were integrated over 5.0 minutes. The number of disintegrations per minute is maximized if the probe factor from Section 3.2 does not include backscatter. The area of the probe is 15 cm^2 so the area factor is 100/15 = 6.7.

Location	Probe	Counts in 5.0 min	CPM (cpm)	Minus Bkg (cpm)	Net (cpm)	Probe Factor (dis/ct)	Area Factor	Dpm/ 100 cm^2
Sink 1	343	196	39.2	40	0	4.24	6.7	0
Sink 2	342	187	37.4	40	0	4.50	6.7	0
Countertop Area A	342	201	40.2	40	0.2	4.50	6.7	6.0
Countertop Area B	342	221	44.2	40	4.2	4.50	6.7	130
Countertop Area C	343	222	44.4	40	4.4	4.24	6.7	120
Floor below Area A	343	240	48.0	40	8.0	4.24	6.7	230
Floor below Area B	342	228	45.6	40	5.6	4.50	6.7	170
Floor below Area C	343	224	44.8	40	4.8	4.24	6.7	140
Floor Drain	342	199	39.8	40	0	4.50	6.7	0
Hood 1	342	202	40.4	40	0.4	4.50	6.7	12
Hood 2	343	187	37.4	40	0	4.24	6.7	0
Elephant exhaust device	343	198	39.6	40	0	4.24	6.7	0
Counting Lab countertop	342	230	46.0	40	6.0	4.50	6.7	180
Check source drawer	343	195	39.0	40	0	4.24	6.7	0
Floor below counting lab countertop	342	224	44.8	40	4.8	4.50	6.7	140

All results are less than the 7,050 dpm/100 cm^2 listed as an acceptable unrestricted release surface contamination value for Co-60 as found in Table 5.19 in Volume 3 of NUREG/CR-5512, "Residual Radioactive Contamination From Decommissioning, Parameter Analysis, Draft Report for Comment," October 1999.

6.1.3 Additional Beta/Gamma Measurements

On July 27, 2010, the traps under the sinks were surveyed with a β/γ probe to detect radioactive material caught in the sink traps. Since the radioactive material would be in the trap and not on the outside surface of the trap, no alpha measurements or wipe tests were performed. The sink drains were surveyed with a β/γ probe to detect radioactive material caught in the upper portion of the drain pipe. The drains are designed to take a rubber stopper and are recessed below the bottom of the sink. Since the radioactive material would be in the drain pipe, no alpha measurements or wipe tests were performed.

Location	Static β/γ SN879 (cpm)	Net cpm [Static cpm - 42 cpm bkg] (cpm)	dpm
Trap under sink 1	39	0	0
Trap under sink 2	30	0	0
Sink 1 over drain	40	0	0
Sink 2 over drain	35	0	0

6.2 Wipe Tests

On July 27, 2010, wipe tests of 100 cm^2 were taken in locations where radioactive material was routinely used and that had the highest potential for residual contamination. If present, the contamination would likely have occurred during sample preparation in the Wet Lab. Areas in the wet lab most likely to become contaminated would have included the sample receipt area (area A), the sample preparation areas (areas B and C), the fume hoods (H1 and H2), sinks (S1 and S2), floor drain (D), and floor areas immediately beneath these work areas. In the Counting Room, the countertop and a drawer in the cabinet beneath the countertop that stored the sealed quality assurance sources would be the most likely areas of contamination.

As noted in section 3.1 of this report, there are 6 alpha particles emitted by Th-232 and its progeny in equilibrium for each disintegration per minute of Th-232. In the Table, the "Th-232 (dpm)" column is obtained by dividing the gross alpha dpm by 6. Wipes were counted by the NCF (Oxford/Canberra Tennelec Series 5).

Location	Gross β (dpm)	Gross α (dpm)	Th-232 (dpm)
Sink 1	< MDA	< MDA	-
Sink 2	< MDA	< MDA	-
Countertop Area A	< MDA	2.0 ± 0.9	0.3
Countertop Area B	< MDA	< MDA	-
Countertop Area C	< MDA	< MDA	-
Floor below Area A	< MDA	< MDA	-
Floor below Area B	< MDA	< MDA	-
Floor below Area C	< MDA	2.2 ± 1.1	0.4
Floor Drain	< MDA	< MDA	-
Hood 1	< MDA	< MDA	-
Hood 2	< MDA	< MDA	-
Elephant exhaust device	< MDA	0.7 ± 0.7	0.1
Door handle on N end of Wet Lab	< MDA	< MDA	-
Counting Lab countertop	< MDA	< MDA	-

Location	Gross β (dpm)	Gross α (dpm)	Th-232 (dpm)
Check source drawer	< MDA	< MDA	-
Floor below counting lab countertop	< MDA	< MDA	-

The minimum detectable activity (MDA) for was 1.1 dpm for Gross β and 0.7 dpm for Gross α.

The Gross β results are less than 10% of the 7,050 dpm/100 cm^2 listed as an acceptable unrestricted release surface contamination value for Co-60 as found in Table 5.19 in Volume 3 of NUREG/CR-5512, "Residual Radioactive Contamination From Decommissioning, Parameter Analysis, Draft Report for Comment," October 1999. The Gross α results are less than 10% of the 6.03 dpm/100 cm^2 listed as an acceptable unrestricted release surface contamination value for Th-232 as found in Table 5.19 in Volume 3 of NUREG/CR-5512, "Residual Radioactive Contamination From Decommissioning, Parameter Analysis, Draft Report for Comment," October 1999.

6.3 <u>Summary</u>

No radioactive sources were left at the NCF. Static alpha and beta/gamma measurements and wipe test results are below the applicable limits found in NUREG-1757 for unrestricted release.

7.0 <u>Radioactive Material Storage Room</u>

Environmental samples, radioactive items recovered from the public domain, sealed calibration sources, plated disk sources, and laboratory standards were stored in the RMS Room. Sealed calibration sources include cesium-137, cobalt-60, and cesium-137/americium-241. Other sources that have been stored in the room have included aircraft instruments containing radium-226 and smoke detector sources containing radium-226 or americium-241. Environmental samples containing one or more of the following long-lived radionuclides have been stored in the room: cobalt-60, cesium-137, radium-226, radium-228, uranium, and thorium. Uranium and thorium ores, metals, and compounds have also been stored in the room. Historically, all the wipe tests performed on the sealed sources in the room resulted in gross beta analyzes less than 5×10^{-5} µCi/wipe and the wipe tests performed on the cesium-137/americium-241 source resulted in gross alpha analyzes less than 0.3×10^{-5} µCi/wipe. A copy of the most recent leak test result is attached. The most likely source of contamination in the room is radon emanations and plateout from radium characterized as technologically enhanced naturally occurring radioactive material from environmental samples collected from oil and gas sites. Based on the above information, the Calibration Room was determined to require a Group 2 final status survey.

After all radioactive sources and other equipment were moved to 815 Filley Street, a Final Status Survey was conducted at the RMS Room.

7.1 <u>Surveys</u>

On July 27, 2010, Mr. Matt Bowen of our staff surveyed the empty RMS Room with an Eberline PRM-7 µR/h meter (SN 213 calibrated April 28, 2010) at a distance of one meter from the floors and walls. The gamma radiation readings from the walls and floor did not exceed the background radiation reading of 10 µR/h.

The floor and lower 2 meters of wall were divided into one-square-meter grids. The floor was divided into 19 grids and the walls were divided into 35 grids. The wall grid started at the room door and ran counterclockwise around the room with grids 19 through 35 in the upper tier and grids 36 through 53 in the lower tier.

On July 27 and 28, 2010, Kenneth Coble, Matt Bowen, Dan Glencer, and Ken Yale surveyed the floor and walls in the RMS Room using Eberline E-600s with SHP360 beta/gamma "pancake" probes (calibrated January 6 or 7, 2010) and SHP380A alpha probes (calibrated on January 7 or April 30, 2010). The audible signal was activated to aid in finding elevated areas of contamination. The background count rates were 50 cpm beta/gamma and 5 cpm alpha. No reading above twice background was noted.

7.1.1 Static Alpha Measurements

On July 27, 2010, Kenneth Coble and Matt Bowen performed static alpha measurements. The measurements integrated the counts detected for 5 minutes. The Eberline SHP-380A probe (SN 109) measured a background of 25 counts in 5 minutes, and had a detector efficiency of 0.156 counts/disintegration (Probe Factor = 1 / 0.156 cts/dis = 6.4 dis/ct).

As noted in section 3.1 of this report, there are 6 alpha particles emitted by Th-232 and its progeny in equilibrium for each disintegration per minute of Th-232. The table divides the cpm by 6 to get the dpm for Th-232.

The Th-232 dpm = Net cpm x Probe Factor (dis/ct) / 6

Grid	Counts in 5 min	Count Rate (cpm)	Net Count Rate (cpm)	Th-232 (dpm/100 cm^2)
01	18	3.6	0	0
02	14	2.8	0	0
03	19	3.8	0	0
4A	31	6.2	1.2	1.3
4B	18	3.6	0	0
05	20	4.0	0	0
06	13	2.6	0	0
07	14	2.8	0	0
08	20	4.0	0	0
09	11	2.2	0	0
10	17	3.4	0	0
11	13	2.6	0	0
12	12	2.4	0	0
13	7	1.4	0	0
14	14	2.8	0	0
15	18	3.6	0	0
16	22	4.4	0	0
17	17	3.4	0	0
18	15	3.0	0	0
19	9	1.8	0	0
20	15	3.0	0	0
21	11	2.2	0	0
22	9	1.8	0	0
23	7	1.4	0	0

Grid	Counts in 5 min	Count Rate (cpm)	Net Count Rate (cpm)	Th-232 (dpm/100 cm^2)
24	10	2.0	0	0
25	15	3.0	0	0
26	7	1.4	0	0
27	20	4.0	0	0
28	9	1.8	0	0
29	13	2.6	0	0
30	21	4.2	0	0
31	17	3.4	0	0
32	6	1.2	0	0
33	14	2.8	0	0
34	17	3.4	0	0
35	18	3.6	0	0
36	7	1.4	0	0
37	21	4.2	0	0
38	14	2.8	0	0
39	11	2.2	0	0
40	26	5.2	0.2	0.2
41	25	5.0	0	0
42	14	2.8	0	0
43	12	2.4	0	0
44	14	2.8	0	0
45	20	4.0	0	0
46	13	2.6	0	0
47	22	4.4	0	0
48	16	3.2	0	0
49	17	3.4	0	0
50	12	2.4	0	0
51	19	3.8	0	0
52	17	3.4	0	0
53	21	4.2	0	0

All results are less than the 6.03 dpm/100 cm^2 listed as an acceptable unrestricted release surface contamination value for Th-232 as found in Table 5.19 in Volume 3 of NUREG/CR-5512, "Residual Radioactive Contamination From Decommissioning, Parameter Analysis, Draft Report for Comment," October 1999.

7.1.2 Static Beta/Gamma Measurements

Static beta/gamma measurements were integrated over 30 minutes. The number of disintegrations per minute is maximized if the probe factor from Section 3.2 does not include backscatter. The area of the probe is 15 cm^2 so the area factor is 100/15 = 6.7.

Survey results are shown in the following table. Count rate is counts divided by the count time. Net count rate is the count rate minus the background count rate of 50 cpm beta/gamma. The probe factor (dis/ct) is the inverse of the "Counts/dis (assume no backscatter)" column in the table in section 3.2 of this report.

Grid	Probe	Counts (30 min)	Count Rate (cpm)	Net Count Rate (cpm)	Probe Factor (dis/ct)	Area Factor	dpm/100 cm^2
01	879	1,580	53	3	4.2	6.7	84
02	342	1,711	57	7	4.5	6.7	210
03	532	1,642	55	5	4.4	6.7	150
4A	343	1,544	51	1	4.2	6.7	28
4B	383	1,608	54	4	4.1	6.7	110
05	532	1,555	52	2	4.4	6.7	59
06	342	1,580	53	3	4.5	6.7	90
07	879	1,477	49	0	4.2	6.7	0
08	383	1,659	55	5	4.1	6.7	140
09	882	1,540	51	1	4.5	6.7	30
10	532	1,696	57	7	4.4	6.7	210
11	343	1,678	56	6	4.2	6.7	170
12	339	1,587	53	3	5.0	6.7	100
13	382	1,739	58	8	4.1	6.7	220
14	339	1,574	52	2	5.0	6.7	67
15	382	1,658	55	5	4.1	6.7	140
16	383	1,750	58	8	4.1	6.7	220
17	882	1,574	52	2	4.5	6.7	60
18	342	1,039	35	0	4.5	6.7	0
19	343	1,492	50	0	4.2	6.7	0
20	383	1,512	50	0	4.1	6.7	0
21	882	1,414	47	0	4.5	6.7	0
22	342	1,465	49	0	4.5	6.7	0
23	343	1,587	53	3	4.2	6.7	84
24	383	1,669	56	6	4.1	6.7	160
25	882	1,354	45	0	4.5	6.7	0
26	342	1,402	47	0	4.5	6.7	0
27	343	1,519	51	1	4.2	6.7	28
28	383	1,484	49	0	4.1	6.7	0
29	882	1,386	46	0	4.5	6.7	0
30	342	1,440	48	0	4.5	6.7	0
31	343	1,478	49	0	4.2	6.7	0
32	383	1,557	52	2	4.1	6.7	55
33	882	1,370	46	0	4.5	6.7	0
34	342	1,535	51	1	4.5	6.7	30
35	343	1,515	51	1	4.2	6.7	28
36	532	1,039	35	0	4.4	6.7	0
37	879	1,574	52	2	4.2	6.7	56
38	339	1,900	63	13	5.0	6.7	440
39	382	1,453	48	0	4.1	6.7	0
40	532	1,444	48	0	4.4	6.7	0
41	879	1,468	49	0	4.2	6.7	0
42	339	1,350	45	0	5.0	6.7	0
43	382	1,598	53	3	4.1	6.7	82
44	532	1,578	53	3	4.4	6.7	88

Grid	Probe	Counts (30 min)	Count Rate (cpm)	Net Count Rate (cpm)	Probe Factor (dis/ct)	Area Factor	dpm/100 cm^2
45	879	1,468	49	0	4.2	6.7	0
46	339	1,342	45	0	5.0	6.7	0
47	382	1,481	49	0	4.1	6.7	0
48	532	1,374	46	0	4.4	6.7	0
49	879	1,470	49	0	4.2	6.7	0
50	339	1,419	47	0	5.0	6.7	0
51	382	1,596	53	3	4.1	6.7	82
52	532	1,476	49	0	4.4	6.7	0
53	879	1,492	50	0	4.2	6.7	0

All results are less than the 7,050 dpm/100 cm^2 listed as an acceptable unrestricted release surface contamination value for Co-60 as found in Table 5.19 in Volume 3 of NUREG/CR-5512, "Residual Radioactive Contamination From Decommissioning, Parameter Analysis, Draft Report for Comment," October 1999.

7.2 Wipe Tests

Surface wipes of 100 square centimeters were taken in each grid. Wipes were counted by the NCF (Oxford/Canberra Tennelec Series 5). As noted in section 3.1 of this report, there are 6 alpha particles emitted by Th-232 and its progeny in equilibrium for each disintegration per minute of Th-232. In the Table, the "Th-232 (dpm)" column is obtained by dividing the gross alpha dpm by 6.

Grid	Gross Beta (dpm)	Gross Alpha (dpm)	Th-232 (dpm)
01	< MDA	3.8 ± 1.1	0.6
02	< MDA	< MDA	-
03	< MDA	0.7 ± 0.7	0.1
04A	< MDA	< MDA	-
04B	< MDA	< MDA	-
05	< MDA	2.0 ± 0.9	0.3
06	< MDA	1.3 ± 0.7	0.2
07	< MDA	< MDA	-
08	< MDA	1.3 ± 0.7	0.2
09	< MDA	< MDA	-
10	< MDA	< MDA	-
11	< MDA	< MDA	-
12	< MDA	< MDA	-
13	< MDA	< MDA	-
14	< MDA	< MDA	-
15	< MDA	1.1 ± 0.7	0.2
16	< MDA	< MDA	-
17	1.1 ± 1.1	< MDA	-
18	1.3 ± 1.1	< MDA	-
19	< MDA	1.1 ± 0.7	0.2
20	1.3 ± 1.1	1.6 ± 0.9	0.3

Grid	Gross Beta (dpm)	Gross Alpha (dpm)	Th-232 (dpm)
21	< MDA	0.7 ± 0.7	0.1
22	1.3 ± 1.1	1.8 ± 0.9	0.3
23	1.3 ± 1.1	< MDA	-
24	1.6 ± 1.1	2.0 ± 0.9	0.3
25	3.6 ± 1.3	1.8 ± 0.9	0.3
26	3.1 ± 1.3	1.3 ± 0.7	0.2
27	3.6 ± 1.3	2.0 ± 0.9	0.3
28	1.8 ± 1.1	1.1 ± 0.7	0.2
29	< MDA	0.7 ± 0.7	0.1
30	1.8 ± 1.1	0.9 ± 0.7	0.2
31	< MDA	1.3 ± 0.7	0.2
32	2.0 ± 1.1	0.9 ± 0.7	0.2
33	1.6 ± 1.1	1.1 ± 0.7	0.2
34	< MDA	1.3 ± 0.7	0.2
35	1.3 ± 1.1	0.7 ± 0.7	0.1
36	< MDA	< MDA	-
37	< MDA	0.7 ± 0.4	0.1
38	< MDA	< MDA	-
39	< MDA	< MDA	-
40	< MDA	1.8 ± 0.9	0.3
41	< MDA	1.1 ± 0.7	0.2

Grid	Gross Beta (dpm)	Gross Alpha (dpm)	Th-232 (dpm)
42	< MDA	< MDA	-
43	< MDA	< MDA	-
44	< MDA	< MDA	-
45	< MDA	0.7 ± 0.7	0.1
46	< MDA	1.6 ± 0.9	0.3
47	< MDA	< MDA	-

Grid	Gross Beta (dpm)	Gross Alpha (dpm)	Th-232 (dpm)
48	< MDA	0.9 ± 0.7	0.2
49	< MDA	< MDA	-
50	< MDA	2.0 ± 0.9	0.3
51	< MDA	1.1 ± 0.7	0.2
52	< MDA	1.3 ± 0.7	0.2
53	< MDA	0.7 ± 0.7	0.1

The minimum detectable activity (MDA) for was 1.1 dpm for Gross β and 0.4 dpm for Gross α.

The Gross β results are less than 10% of the 7,050 dpm/100 cm^2 listed as an acceptable unrestricted release surface contamination value for Co-60 as found in Table 5.19 in Volume 3 of NUREG/CR-5512, "Residual Radioactive Contamination From Decommissioning, Parameter Analysis, Draft Report for Comment," October 1999. The Gross α results are less than 10% of the 6.03 dpm/100 cm^2 listed as an acceptable unrestricted release surface contamination value for Th-232 as found in Table 5.19 in Volume 3 of NUREG/CR-5512, "Residual Radioactive Contamination From Decommissioning, Parameter Analysis, Draft Report for Comment," October 1999.

7.3 Summary

No radioactive sources were left at the RMS Room. Static alpha and beta/gamma measurements and wipe test results are below the applicable limits found in NUREG-1757 for unrestricted release.

8.0 Conclusion

The final status survey and test results show that the site appears to meet the criteria in NUREG-1757 for unrestricted release.

MI DNRE
21-05199-02

EBERLINE E-600 CALIBRATION REPORT - V4.03

04/30/10 12:35:49

E-600 Serial Number	: 1159
Program Version	: E600 V3.09
Calibration Date/Due Date	: 04/30/10 to 04/30/11
Scaler Precision	: 10%
Lower Threshold Cal. Points	: 2.10 mV and 6.00 mV
Upper Threshold Cal. Points	: 6.00 mV and 60.0 mV
Lower Threshold Slope	: 0.6429
Lower Threshold Intercept	: -0.1048 mV
Lower Threshold Span	: 0.1630 mV (<=0.5) to 5.10 mV (>=5.0)
Upper Threshold Slope	: 0.7444
Upper Threshold Intercept	: -0.7111 mV
Upper Threshold Span	: 0.9553 mV (<=1.5) to 60.0 mV (>=50.0)
Alarm Editing	: Enabled
Latching Alarms	: Disabled
Auto Ranging	: Enabled
Beep on Auto-Range	: No
Ignore E-600 Cal. Date	: Yes
Ignore Probe Cal. Date	: Yes
Ratemeter Mode Support	: Enabled
Integrate Mode Support	: Enabled
Scaler Mode Support	: Enabled
Peak Hold Mode Support	: Enabled
Background Update Mode Support	: Enabled
Log ID Source	: Internal/Aux.
Star Key Ratemeter Function	: Zero Display
Star Key Integrate Function	: Zero Display
Scaler Display Units	: Rate
Scaler Counting Mode	: Fixed Time

Smart Probe Serial Number	: 881
Type	: SHP-360
Calibration Date/Due Date	: 04/30/10 to 04/30/11
Dead Time	: 100 usec
Surface Area	: 15.0 cm2
Max High Voltage	: 900 Vdc
Overrange	: 58000 cps

0

Page 2

Probe SHP-360 881 continued...
Channel 1

Channel Type	: Beta
Rate Units	: cpm
Response Times	: 20,10,3 secs
High Voltage	: 898 Vdc
Lower Threshold	: 5.00 mV
Upper Threshold	: 10.1 mV
Selected Window	: Upper
Upper Cal. Constant	: 0.4836 counts/count
Scaler Time	: 10 secs
Lower to Upper Crossover	: 0.0
Upper to Lower Crossover	: 0.0

changed to 1.00 c/c (on final save) verified 10/14/2010 RDS

Beta Channel Linearity Test Results - Pass Tolerance Plus/Minus

00881

10.0%

Pass/Fail	Field	Response	%Error
Pass	29700 cpm	27781 cpm	-6.46%
Pass	3820 cpm	3629 cpm	-5.01%
Pass	420 cpm	400 cpm	-4.65%

Cable Length: 36 inches

Staff: Kenneth Coble (04/30/2010)

Page 1

EBERLINE E-600 CALIBRATION REPORT - V4.03

04/30/10 13:32:13

E-600 Serial Number : 1159
Program Version : E600 V3.09
Calibration Date/Due Date : 04/30/10 to 04/30/11
Scaler Precision : 10%
Lower Threshold Cal. Points : 2.10 mV and 6.00 mV
Upper Threshold Cal. Points : 6.00 mV and 60.0 mV
Lower Threshold Slope : 0.6429
Lower Threshold Intercept : -0.1048 mV
Lower Threshold Span : 0.1630 mV (<=0.5) to 5.10 mV (>=5.0)
Upper Threshold Slope : 0.7444
Upper Threshold Intercept : -0.7111 mV
Upper Threshold Span : 0.9553 mV (<=1.5) to 60.0 mV (>=50.0)
Alarm Editing : Enabled
Latching Alarms : Disabled
Auto Ranging : Enabled
Beep on Auto-Range : No
Ignore E-600 Cal. Date : Yes
Ignore Probe Cal. Date : Yes
Ratemeter Mode Support : Enabled
Integrate Mode Support : Enabled
Scaler Mode Support : Enabled
Peak Hold Mode Support : Enabled
Background Update Mode Support : Enabled
Log ID Source : Internal/Aux.
Star Key Ratemeter Function : Zero Display
Star Key Integrate Function : Zero Display
Scaler Display Units : Rate
Scaler Counting Mode : Fixed Time

Smart Probe Serial Number : 265
Type : SHP-380A
Calibration Date/Due Date : 04/30/10 to 04/30/11
Dead Time : 8.00 usec
Surface Area : 100 cm2
Max High Voltage : 1300 Vdc
Overrange : 90000 cps

Page 2

Probe SHP-380A 265 continued...

Channel 1
Channel Type : Alpha
Rate Units : cpm
Response Times : 60,15,5 secs
High Voltage : 518 Vdc
Lower Threshold : 2.00 mV
Upper Threshold : 10.1 mV
Selected Window : Upper
Upper Cal. Constant : 0.3085 counts/count
Scaler Time : 20 secs
Lower to Upper Crossover : 0.0
Upper to Lower Crossover : 0.0

Channel 2
Channel Type : Alpha

changed to 1.00 c/c on final save. Verified 10/14/2010 RDS

Rate Units	: dpm
Response Times	: 60,15,5 secs
High Voltage	: 518 Vdc
Lower Threshold	: 5.00 mV
Upper Threshold	: 10.1 mV
Selected Window	: Upper
Upper Cal. Constant	: 0.1684 counts/disint.
Scaler Time	: 20 secs
Lower to Upper Crossover	: 0.0
Upper to Lower Crossover	: 0.0

Cable Length: 36 inches

Staff: Kenneth Coble (04-30-2010)

Michigan Department of Environmental Quality
Waste and Hazardous Materials Division
Hazardous Waste & Radiological Protection Section

Eberline PRM-7 Meter Calibration Form

Date 04/28/10 Serial Number 213 MDEQ Number N/A Assigned to RMU

Calibrated by: KWC Functional Tests Battery ✓ Light X Speaker ✓

Batteries Voltages 1.622, 1.623 Are both >1.4 volts (YES) NO-REPLACED BOTH

Today's calculated exposure rate of the Shepard ^{137}Cs irradiator at 1 meter 177 mR/hr

x5000 Scale

Measure the background on the x5000 scale at 90 cm 0.007 mRhr. Calculate the expected reading using the x100 attenuator (attenuation factor 111.1) with the meter centered at 90 cm (correction factor 0.81).

Calculated Rate = Today's Rate ÷111.1÷0.81 = 1.97 mR/hr
Expected Rate = Calculated Rate + Background = 1.97 mR/hr
Measured Rate = 2.0 mR/hr

Adjust the x5000 scale potentiometer if the measured rate is off by 10% or more.
Adjusted Reading — mR/hr

x500 Scale

Measure the background on the x500 scale at 250 cm 7 μR/hr.

Calculated Rate = Today's Rate ÷ 111.1 ÷6.25 = 255 μR/hr
Expected Rate = Calculated Rate + Background = 262 μR/hr
Measured Rate = 285 μR/hr

Adjust the x500 scale potentiometer if the measured rate is off by 10 % or more.
Adjusted Reading — μR/hr

x50 and x25 Scales

Connect the Ludlum pulse generator to the meter using a BNC fitting and adjust to yield a 340 reading on the 500 scale with the signal set at 24 millivolts negative. Adjust potentiometers on scales marked "*".

Pulser (cpm)	Scale	Expected RDG	Measured RDG	Scale	Measured RDG	Adjusted RDG
616 x100	500	340	340	-----	---------------	----------------
616 x10	500	34	30	50*	34	—
308 x10	50	17	17	25*	16.5	17
308 x1	25	1.7	1.5			

04-05-2004

Eberline E-600 with SHP-360 pancake probe

1. With the E-600 OFF, connect the computer and probe cables to the instrument. Turn the E-600 to the CHECK position. Is the battery indication better than 70%? If not, replace the three C batteries.
2. Launch the WinE600 program. Set and verify the correct time by selecting *Utility*, then *Set Time*. Update the instrument's calibration date by selecting *Instrument Parameters* and changing the Date Calibrated and Calibration Due Date.
3. Verify the default probe parameters in the E-600 are set per the table below by selecting *Edit, Smart Probe*, then the *Probe* parameters.

Probe parameters	
Dead Time (μsec.)	100
Probe Area (cm²)	15
Max. High Voltage	900
Overrange (cps)	58000
Radon Alarm (cps)	0

4. Verify the default channel parameters are set up per the table below by selecting *Edit, Smart Probe*, then the *Channel* parameters.

E-600 Channel Parameters	
Channel Number	1
Channel Type	Beta
Units	cpm
Selected Window	Upper
High Voltage	900

Window Parameters	Lower	Upper
Threshold (mV)	5.00	10.0
counts/R	1	1
Bkg. Wt. Factor	0	0
Integrate Alarm	0	0
Rate Alarm	0	0
Click Divider	1	1

5. Place the probe in a low background area. Select *Calibration*, then *Determine Calibration Constant*. Verify Channel 1, Upper Window, and Background are selected with the count time set to 120 seconds. Click on the *Start* button to begin background count (expect 35-50 cpm).
6. After the background has been determined, click on *Cal. Const.* Expose the probe to a 47 mm ^{99}Tc source of 29,700 cpm. Click on the *Start* button to begin determining cal constant. Actual count time is determined by the program and source activity. Upon completion, verify the determined Beta Cal. Constant (i.e. 2π efficiency or counts/count parameter) is greater than 0.25 (expect 0.4 or more). If within tolerance, answer Yes to the save prompt. Note the efficiency (Cal. Const. x 100 = % eff.) to record later on the calibration report.
7. Select *Calibrate*, then *Run Linearity Check*. Click on the *Efficiency Based Linearity Check* box on top of the dialog box that appears. Enter the ^{99}Tc source count rate for the linearity fields (29700, 3820, 420). Note the field entered must be in the same units (cpm) as the probe set up.
8. Click on the *Start* (NOT the OK!!!) button and click *Yes* to overwrite the existing LINDATA.TXT file. Follow the instruction boxes that pop up, by placing the probe on the other sources and then clicking *OK* each time the probe is set up. The E-600 response and percent error will be reported. (Note: The linearity tolerance is set in System Parameters). Click on the *Start* button again to repeat the linearity tests if the results are not within the acceptable tolerance, and overwrite the LINDATA.TXT file again.
9. If linearity checks are okay, edit the Cal. Constant to 1.00 in both the upper and lower windows of channel 1. This yields <u>actual probe count rate</u>, the recommended procedure for these probes. To edit the Cal. Constant select *Edit, Smart Probe,* then *Channel Parameters*.
10. When the linearity tests are complete, select *Calibration*, then *Print Calibration Report*, while still connected to the E-600 just calibrated. Click the toggle box in the prompt window to include the linearity data on the printout. Don't forget to record the previously determined efficiency on the calibration report.

E-600

Portable Radiation Monitor

Technical Manual

Eberline

A subsidiary of
Thermo Instrument
Systems Inc.

E. HP-210, HP-260, SHP-360

Section 1 - Calibration in CPM (for R/h calibration skip to section 2)

1. With the E-600 OFF, connect the computer and detector cables to the instrument. Turn the E-600 to the CHECK position, then launch the WinE600 program. Set and verify correct time in the E-600 by selecting *Utility*, then *Set Time*.

2. Next load the probe parameters. Select *Edit, Load Setup From Disk*, then *Smart Probe Parameters* or *Conventional Probe Parameters* whichever is applicable. From the list presented, select the appropriate file for the probe under calibration. Click on the *OK* button to transfer the parameters from the disk file to the instrument. Verify the default probe parameters in the E-600 are set per the table below by selecting *Edit, Smart Probe* or *Conventional Probe*, then the *Probe* and *Channel* parameters. Previously calibrated smart probes will have parameters stored internally and won't require downloading from the computer.

Probe Parameters	
Dead Time (μsec.)	100
Probe Area (cm^2)	15
Max. High Voltage	900
Overrange (cps)	58000
Radon Alarm (cps)	0

E-600 Channel Parameters		
Channel Number	1	
Channel Type	Beta	
Units	cpm	
Selected Window	Upper	
High Voltage	900	
Window Param's	Lower	Upper
Threshold (mV)	5.00	10.0
counts/count	1	1
Bkg. Weight Factor	0	0
Integrate Alarm	0	0
Rate Alarm	0	0
Click Divider	1	1

3. If R/h calibration is specified, then jump to step 9, otherwise calibration should be in CPM.

4. Place the probe in a low background area. Select *Calibration,* then *Determine Calibration Constant.* Verify Channel 1, Upper Window, and Background are selected with the count time set to 120 seconds. Click on the *Start* button to begin background count.

5. After the background has been determined, click on *Cal. Const.* Expose the probe to a 47mm ^{99}Tc source of 18k to 35k cpm. Click on the *Start* button to begin determining cal constant. Actual count time is determined by the program and source activity. Upon completion, verify the determined Beta Cal. Constant (ie. 2π efficiency or counts/count parameter) is greater than 0.25. If within tolerance, answer Yes to the save prompt. Note the efficiency (CC × 100 = % eff.) to record later on the calibration report.

6. Select *Calibrate,* then *Run Linearity Check.* Click on the *Efficiency Based Linearity Check* box on top of the dialog box that appears. Enter the ^{99}Tc source count rate for the linearity fields. Sources should be 47mm, ^{99}Tc of about 15k to 40k cpm (this may be the same source used in Step 5.) and another of ≈75K to 100K cpm. Note the field entered must be in the same units (cpm) as the probe set up.

7. Click on the *Start* button to begin the linearity check. If a LINDATA.TXT file already exists the *Overwrite* dialog box will appear. Click on *Yes* to overwrite the existing file with the new linearity data. Follow the instructions in the dialog boxes that appear. The E-600 response and percent error will be reported. (Note: The linearity tolerance is set in System parameters). Click on the *Start* button again to repeat the linearity tests or to add different fields. The *Overwrite* box that appears will allow adding to the existing linearity data file or overwriting it.

8. If linearity checks ok, edit the cal constant to 1.00 in both the upper and lower windows of channel 1. This yields actual probe count rate, the recommended procedure for these probes. To edit the cal constant select *Edit, Smart or Conventional Probe* as applicable, then *Channel Parameters.*

9. When the linearity tests are complete, select *Calibration,* then *Print Calibration Report,* while still connected to the E-600 just calibrated. Add the linearity data to the report when prompted, prior to printing. Record the isotope and previously determined efficiency on the cal report.

Section 2 - R/h calibration

10. Select *Edit, Smart* or *Conventional Probe* as applicable, then *Channel Parameters.* Change the units from cpm to R/h in channel 1and the channel type to gamma.

11. Select *Calibration,* then *Determine Calibration Constant.* Verify Channel 1, Upper Window, and *Cal. Const.* are selected. Enter the cal constant field of 0.0075 R/h.

NOTE

Use 1/4" plastic (plexiglas) between source and detector, placed in contact with detector, for the following readings.

12. Place the probe in a 0.0075 R/h (7.5 mR/h) ^{137}Cs field, face on. Click on the *Start* button to begin determining cal constant. Actual count time is determined by the program and field strength. When the count is complete, click on *Save* to store the new calibration constant if within 1.8E+08 to 2.4E+08.

13. Next, click on *Dead Time.* Enter the dead time field of 0.75R/h. Place the probe, in a 0.75R/h (750 mR/h) ^{137}Cs field. Click on the *Start* button. The program could take several count cycles to determine an accurate dead time. If dead time falls within 80 to 125 μsec., click on *Save* when prompted, to store the new Dead Time value in the instrument.

14. Select *Calibrate,* then *Run Linearity Check.* Enter the following ^{137}Cs linearity fields in the box that appears: 0.005 R/h (5 mR/h), 0.05 R/h (50 mR/h), and 0.5 R/h (500 mR/h). Note the field entered must be in the same units (R/h), as the probe set up.

15. Click on the *Start* button to begin the linearity check. If a LINDATA.TXT file already exists the *Overwrite* dialog box will appear. Click on *Yes* to overwrite the existing file with the new linearity data. Follow the instructions in the dialog boxes that appear. The E-600 response and percent error will be reported. (Note: The linearity tolerance is set in *System* parameters). Click on the *Start* button again to repeat the linearity tests or to add different fields. The *Overwrite* box that appears will allow adding to the existing linearity data file or overwriting it.

16. When the linearity tests are complete, select *Calibration*, then *Print Calibration Report*, while still connected to the E-600 just calibrated. Add the linearity data to the report when prompted, prior to printing. Record the isotope and previously determined efficiency on the printed cal report.

B. AC-3-7, AC-3-8, HP/SHP-350, HP/SHP-380A
Calibration in CPS, CPM, DPS, DPM, Bq
Calibration to ^{239}Pu (or ^{230}Th if necessary) in S94 type source holders when possible, except for HP/SHP-380A.

1. With the E-600 OFF, connect the computer and detector cables to the instrument. Turn the E-600 to the CHECK position, then launch the WinE600 program. Set and verify correct time in the E-600 by selecting *Utility*, then *Set Time*.

2. Next load the probe parameters. Select *Edit*, *Load Setup From Disk*, then *Smart Probe Parameters* or *Conventional Probe Parameters* whichever is applicable. From the list presented, select the appropriate file for the probe under calibration. Click on the *OK* button to transfer the parameters from the disk file to the instrument. Verify the default probe parameters in the E-600 are set per the table below by selecting *Edit*, *Smart Probe* or *Conventional Probe*, then the *Probe* and *Channel* parameters. Previously calibrated smart probes will have parameters stored and won't require downloading from the computer.

Probe Parameters	
Dead Time (μsec.)	8
Probe Area (cm^2)	73 (100 for HP/SHP-380A)
Max. High Voltage	1500 (1300 for HP/SHP-380A)
Overrange (cps)	90000
Radon Alarm (cps)	0

Channel Parameters		
Channel Number	1	
Channel Type	Alpha	
Units	cpm	
Selected Window	Upper	
High Voltage	700	
Window Param's	Lower	Upper
Threshold (mV)	2.00	10.00
counts/count	1.00	1.00
Bkg. Weight Factor	0	0
Integrate Alarm	0.0	0.0
Rate Alarm	0.0	0.0
Click Divider	1	1

3. Select *Edit*, *Instrument Parameters*, then enter the E-600 serial number and calibration dates in the window that appears. For "Last Cal. Date" parameter enter the actual date of calibration and "Next Cal. Date"

parameter should be set to one year after last cal date. Likewise, enter the probe serial number, model, and cal dates in the *Probe Parameters* submenu of either the *Smart Probe* or *Conventional Probe* as applicable.

4. Select *Calibrate*, then *Run Plateau*. Click on the *Channel 1* radio button on top, then edit the plateau voltage parameters as shown below. Specify a graph name (up to 30 characters) and a graph file name. Note the graph file name must have a .GRF extension.

Plateau Parameters	
Count Time (sec.)	10
Starting Voltage	700 (500 for HP-380)
Ending Voltage	1250
Voltage Step	25
Max. Count Rate (cps)	2500*
Graph Name	AC-3, HP-380, etc.
File Name	AC3.GRF (example)

* Depends on source activity.

5. Expose the probe to a ^{239}Pu (or ^{230}Th) 40K to 200K cpm (or ≈80K to 400K dpm) plated source. Position the source disc with the active side facing the probe. Click on the *Start* button. There will be a delay before the first count begins as the high voltage settles. A graph of the source plateau will appear after the first count. When the ending voltage is reached a prompt will appear asking if the ending voltage should be extended. If the noise region of the plateau has not been reached extend the ending voltage as necessary to complete the plateau, but no higher than 1300 volts.

6. When the plateau is complete, select the high voltage set point by clicking on the < and > symbols on the voltage plateau graph until the vertical bar is at the center of the upper window plateau. Adjust up and down from this point noting the ratio of the upper window counts versus the lower window counts shown in the lower left corner. Select the point where the upper window (alpha) counts are highest and the lower window (beta) counts are lowest while still on the plateau. Save the desired voltage setting to the instrument by clicking on the *Set HV* button in the plateau dialog box. A prompt will appear to verify the HV set point is the desired value established during the plateau.

7. Determine background and calibration constant next by selecting *Calibration* then *Determine Calibration Constant*. Verify Channel 1, Upper Window, and Background buttons are selected with the count time set to 300 seconds. Place the probe in a low background area and then click on the *Start* button to begin the background count. The background should be less than 10 cpm.

8. Upon completion of the background count, click on the *Cal. Const.* button. Enter the calibration field, which should be a ^{239}Pu source (or ^{230}Th), of around 50K cpm (≈ 100K dpm). The units have to be in cpm to match the probe set up. Expose the probe to the source and click on *Start* to begin the count. The actual count time is determined by the WinE600 program.

9. Upon completion, verify the determined cal constant (ie. 2π efficiency or counts/count parameter) for ^{239}Pu is greater than 0.28 for the AC-3-7, greater than 0.18 for the AC-3-8, and greater than 0.36 for the HP/SHP-350 and HP/SHP-380A. If within tolerance, answer Yes to the save prompt. Note the efficiency (CC × 100 = % eff.) to record later on the calibration report.

10. Unless calibration other than cpm is specified, edit the cal constant to 1.00 in both the upper and lower windows of channel 1. This yields actual probe count rate, the recommended procedure for these probes. To edit the cal constant select *Edit, Smart or Conventional Probe* as applicable, then *Channel Parameters*. Jump to step 13.

11. If calibration is to source count rate (2π emissions) then jump to step 13. Do not edit the cal constants to 1.00, the previously determi..ed values are correct for 2π emissions.

12. If units of dps, dpm or Bq, dps/100cm^2, dpm/100cm^2, or Bq/100cm^2 are desired, change the activity units and cal constant at this time. To edit the units and cal constant select *Edit, Smart* or *Conventional Probe* as applicable, then *Channel Parameters*. Select the desired units in channel 1 and divide the previously determined cal constant by two.

    For example: If the previously determined cal constant was 0.28 counts/count. Change the units to dpm, then edit the cal constant to 0.14 counts/disint. ($0.28 \div 2$).

13. Calibration is now complete. Verify correct units of measure are set in the instrument. To print cal report, select *Calibration*, and *Print Calibration Report*, while still connected to the E-600 just calibrated. Since no linearity data was taken, click on the NO button when the Print Linearity Data dialog box appears. Record the isotope and previously determined efficiency on the printed calibration report. Print the plateau for this probe by selecting *Calibration, Display Plateau* then select the appropriate file from the list in the dialog box. Verify printer is connected to the computer and ready to print. When the plateau is displayed in the Graph Window, select *File* then *Print Graph.*

J L SHEPHERD and Associates

740 Salem Street, Glendale, California 91203 · 213/245-0187

Irradiation & Calibration Equipment · Lead Shielding · Nuclear Applications

CALIBRATION CERTIFICATE

TO: Mich. Dept. of Public Health (Victoreen) P.O.# 1468

SOURCE: 1.0 Ci ^{137}Cs Amersham type X.19 S.N. 0323GN

MOUNTING: J.L. Shepherd & Assoc., Model 28-6a Calibrator, S.N. 10055.

INSTRUMENT: All calibration is done with MDH Model 2025. This meter is calibrated by MDH Industries, Incorporated and its calibration is directly traceable to National Bureau of Standards.

POSITION: Centered in beam port.

DISTANCE: at 1 meter

OUTPUT: 341 mR/hr

DATE: August 31, 1981

J. L. Shepherd

JLS/

REPORT OF CALIBRATION

Electroplated Beta Source

Serial No. 8185

Description of Source:

Principal radionuclide Technetium - 99

Electroplated on polished Nickel (type of metal) disc, approximately 0.79 mm thick.

Diameter, 2.54 cm active, 3.18 cm total.

Radioactive material permanently fixed to the disc by heat treatment, without any covering over the active surface.

Calibration Date: December 20, 1979

Measurement Method:

The 2π beta emission rate was measured using an internal gas flow proportional chamber. Traceability to NBS has been demonstrated, the most recent intercomparison with NBS being June and July 1974 when the EIC—NBS agreement was within 0.3%.

Measurement Result:

The total number of beta particles emitted from the surface of the disc per minute on the above date was

29,700 ± 890

The total disintegration rate, assuming 25 % backscatter of beta particles from the surface of the disc, was

47,520 ± 1,430 (0.0214 uCi)

The uncertainty of the measurement is 3%, which is the sum of random counting error at the 99% confidence level and the estimated upper limit of conceivable systematic error in this measurement.

Information on isotopic composition or radioactive impurities:

Calibrated by: J. Donald Rodriguez
(please print or type)

eberline
Eberline Instrument Corporation
P.O. Box 3874
Albuquerque, New Mexico 87110

J. Donald Rodriguez
(signature)

REPORT OF CALIBRATION

Electroplated Beta Source

Serial No. 8184

Description of Source:

Principal radionuclide Technetium - 99

Electroplated on polished Nickel (type of metal) disc, approximately 0.79 mm thick.

Diameter, 2.54 cm active, 3.18 cm total.

Radioactive material permanently fixed to the disc by heat treatment, without any covering over the active surface.

Calibration Date: December 20, 1979

Measurement Method:

The 2π beta emission rate was measured using an internal gas flow proportional chamber. Traceability to NBS has been demonstrated, the most recent intercomparison with NBS being June and July 1974 when the EIC—NBS agreement was within 0.3%.

Measurement Result:

The total number of beta particles emitted from the surface of the disc per minute on the above date was

3,820 ± 110

The total disintegration rate, assuming 25 % backscatter of beta particles from the surface of the disc, was

6,110 ± 180 (0.0027 uCi)

The uncertainty of the measurement is 3%, which is the sum of random counting error at the 99% confidence level and the estimated upper limit of conceivable systematic error in this measurement.

Information on isotopic composition or radioactive impurities:

Calibrated by: J. Donald Rodriguez (please print or type)

(signature)

eberline
Eberline Instrument Corporation
P.O. Box 3874
Albuquerque, New Mexico 87110

REPORT OF CALIBRATION

Electroplated Beta Source

Serial No. 8183

Description of Source:

Principal radionuclide Technetium - 99

Electroplated on polished Nickel (type of metal) disc, approximately 0.79 mm thick.

Diameter, 2.54 cm active, 3.18 cm total.

Radioactive material permanently fixed to the disc by heat treatment, without any covering over the active surface.

Calibration Date: December 20, 1979

Measurement Method:

The 2π beta emission rate was measured using an internal gas flow proportional chamber. Traceability to NBS has been demonstrated, the most recent intercomparison with NBS being June and July 1974 when the EIC—NBS agreement was within 0.3%.

Measurement Result:

The total number of beta particles emitted from the surface of the disc per minute on the above date was

420 ± 15

The total disintegration rate, assuming 25 % backscatter of beta particles from the surface of the disc, was

670 ± 20 (0.0003 uCi)

The uncertainty of the measurement is 3%, which is the sum of random counting error at the 99% confidence level and the estimated upper limit of conceivable systematic error in this measurement.

Information on isotopic composition or radioactive impurities:

Calibrated by: J. Donald Rodriguez
(please print or type)

eberline
Eberline Instrument Corporation
P.O. Box 3874
Albuquerque, New Mexico 87110

[signature]
(signature)

CERTIFICATE OF CALIBRATION

MODEL CAL3104 ALPHA STANDARD

Revised on June 21, 2000*

Radionuclide:	Am-241	Total Activity:	1.992 kBq (53.84 nCi)
Serial Number:	J208	Reference Date:	1200 PST February 1, 2000
Half Life[1]:	432.7 ± 0.5 years	2 pi Emission Rate:	5.976 x 10^4 alphas/minute

PRINCIPAL EMISSIONS[1]

Type	Energy (keV)	Intensity (%)
alpha	5443.01	12.8
alpha	5485 70	85.2

SOURCE DESCRIPTION

Active Area:	150 mm x 67 mm	Backing:	aluminum plate
Overall Area:	160 mm x 70 mm	Cover:	anodized layer
Thickness:	6 mm		

METHOD OF CALIBRATION

The total activity and alpha flux rate were calibrated on a wide-area gas-flow proportional counter using an efficiency determined through intercomparison with the National Institute of Standards and Technology. This standard is indirectly (implicitly) traceable to the National Institute of Standards and Technology.

North American Scientific, Inc. actively participates in the Radioactivity Measurements Assurance Program conducted by the National Institute of Standards and Technology in cooperation with the National Energy Institute.

TOTAL UNCERTAINTY (99% Confidence Level)

Systematic uncertainty	1.40%
Random uncertainty	1.02%
Total uncertainty (quadratic sum)	± 1.73%

Jeff Wagner
Calibration Laboratory

June 21, 2000
Date

REFERENCES

- * The certificate was revised on June 21, 2000 to correct the 2 pi emission rate.
- (1) Table of Radioactive Isotopes, 7th edition, 1986.

• LEAK TEST CERTIFICATION ON REVERSE •

North American Scientific, Inc. 7435 Greenbush Ave., North Hollywood, CA 91605 (818) 734-8600 Fax (818) 734-8606