INSPECTION RECORD

Region: III **Inspection Report No.** 2016-001 **License No.** 24-18628-01
Docket No. 030-13966
EA-16-118

Licensee: North Kansas City Hospital
2800 Clay Edwards Drive
North Kansas City, MO 64116

Locations Inspected: 2790 Clay Edwards Drive, North Kansas City, MO
2800 Clay Edwards Drive, North Kansas City, MO

Licensee Contact: Martin Richman, M.S., RSO **Telephone No**. 913-706-9200

Program Code: 02230 **Priority**: 2

Type of Inspection: ( ) Initial ( ) Special (X) Routine ( ) Announced (X) Unannounced

Last Inspection Date: 3/12/14 **Dates of This Inspection**: 4/27&28/16 with continued in-office review through 5/19/16.

Next Inspection Date: 4/27/2018 (X) Normal ( ) Reduced

Summary of Findings and Actions:

( ) No violations cited, clear U.S. Nuclear Regulatory Commission (NRC) Form 591 or regional letter issued
( ) Non-cited violations (NCVs)
( ) Violation(s), Form 591 issued
(X) Violation(s), regional letter issued
( ) Follow-up on previous violations

Inspector(s) Robert G. Gattone, Jr., Senior Health Physicist

Robert G. Gattone, Jr. Date 5/23/16
Signature

Approved Aaron T. McCraw, Chief, MIB

Date: 5/24/16
Signature

PART I – LICENSE, INSPECTION, INCIDENT/EVENT AND ENFORCEMENT HISTORY

1. AMENDMENTS AND PROGRAM CHANGES SINCE LAST INSPECTION:

AMENDMENT #	DATE	SUBJECT
47	8/21/14	Changed 35.400 sources for storage only and added two authorized users (AUs)

2. INSPECTION AND ENFORCEMENT HISTORY:

The last inspection was conducted on March 12, 2014, and no violations were identified.

The previous inspection was conducted on February 28, 2012, and a violation of Condition 15 of the NRC license was cited as a result of eating in a materials use area.

3. INCIDENT/EVENT HISTORY:

Bracco Cardiogen-82 Rb-82 Generator Event

The licensee identified an issue with their use of a Bracco CardioGen-82 Rb-82 generator (generator) on June 10, 2015. Instead of using saline to elute the generator, they used Lactated Ringer's solution. The licensee's RSO emailed the attached report of the incident to a Region III materials inspector on July 17, 2015.

During this inspection, the inspector followed up on the incident. The inspector: (1) interviewed selected licensee staff members and selected Bracco staff members to obtain information about the incident; (2) observed that the generator had a 0.9% Sodium Chloride bag affixed to it; (3) observed that the 0.9% Sodium Chloride bag had stickers showing the two nuclear medicine technologists' (NMTs) initials, dates, and times to document their verification that a 0.9% Sodium Chloride bag was affixed to the generator; (4) observed that the licensee used a Pyxis medicine dispensing device to prevent inadvertent use of Lactated Ringer's solution instead of the necessary 0.9% Sodium Chloride for the generator; (5) observed that the Pyxis device required a bioscan to verify that individuals who attempt access to the medicine in the device are authorized before gaining access to the medicine; (6) noted that no other generator incidents had occurred since the aforementioned incident; (7) noted that when the Lactated Ringer's solution was inadvertently affixed to the generator on June 10, 2015, the generator's internal syringe contained 100 milliliters of 0.9% Sodium Chloride which likely caused initial dilution of the Lactated Ringer's solution for the first elution and increasingly less dilution for subsequent elutions; (8) noted that a Bracco employee provided generator "pre-training" and "new customer" training on June 30, 2015, to prevent a similar incident; (9) noted that the licensee could not image the five affected patients for radionuclide distribution outside of the heart because they all left the site before the event was identified; (10) observed the RSO demonstrate how the worst case scenario doses were derived, including application of reference documents such as the generator package insert; (11) noted that the Lead NMT conducted biweekly checks to verify that NMTs' initials and dates were documented showing that two NMTs initialed and dated their verifications that 0.9% Sodium Chloride bags were affixed to the generator prior to administration to patients; (12) reviewed recent strontium-82 and

strontium-85 breakthrough records; (13) reviewed recent Rb-82 patient dosage records produced by the generator; (14) reviewed strontium-82 and strontium-85 breakthrough records that were done on June 10, 2015, and June 11, 2015, at 7:15 a.m. (pertinent to Table 4 of the licensee's aforementioned report that was emailed to an inspector on July 17, 2015); (15) noted that the NMT, who inadvertently used the Lactated Ringer's solution instead of saline for the generator, was no longer allowed to touch the generator; (16) observed an NMT demonstrate how strontium-82 and strontium-85 breakthrough tests were done each day of use prior to the first patient study; (17) observed a patient infusion of Rb-82 chloride; (18) reviewed a Bracco employee's Cardiogen-82 annual maintenance record dated December 2, 2015; (19) noted that an AU determined that all five of the affected patients' imaging results were of good quality; (20) corroborated the information in the RSO's attached report; and (21) noted that the incident did not cause medical events as defined in 10 CFR 35.2, because the applicable dose thresholds were not exceeded.

In addition, the inspector interviewed a Bracco referred physician regarding the adverse effect of using Lactated Ringer's solution instead of saline for the generator. The inspector noted that: (1) Lactated Ringer's solution is primarily used to replace plasma during surgery and it has relatively high calcium levels; (2) the calcium in Lactated Ringer's solution has 2 positive charges; (3) the sodium in normal saline has 1 positive charge; (4) the generator column has stannic oxide; (5) Strontium Chloride is comprised of strontium-82 and strontium-85, each strontium has 2 positive charges which adheres them to the generator column; (6) Rb-82 has 1 positive charge and does not adhere to the generator column; and (7) because the calcium in Lactated Ringer's solution has 2 positive charges, it reacts with the generator column and causes the strontium-82 and strontium-85, each with 2 positive charges, to be removed from the generator column resulting in strontium-82 and strontium-85 breakthrough and a higher radiation dose to the patient.

Inadvertent Administration of Technetium-99m Labelled Sestamibi

The licensee identified that, on November 11, 2015, it inadvertently administered 20.4 millicuries of technetium-99m labelled Sestamibi to a patient with intent to administer technetium-99m labelled methylene diphosphate (MDP) for a bone scan. The inspector obtained information regarding the incident and the RSO's dose assessment, including the package insert for technetium-99m labelled Sestamibi. The inspector noted that the RSO used the package insert and pertinent information to calculate that the patient's maximum organ/tissue dose was 3.7 rads, and the patient's whole body dose was 1.16 rem. As such, the incident did not constitute a medical event as defined in 10 CFR 35.2, because the applicable dose thresholds were not exceeded.

The licensee determined that the cause of the incident was human error. Contributing factors were that the isotope and activity were the same for Sestamibi and MDP.

The licensee took actions to prevent a similar incident, including: (1) having the involved NMT double checked before a dosage was given for a period of about six weeks; (2) having all Sestamibi doses ordered for delivery to the Pavilion hot lab on a daily basis; (3) having all of the other doses ordered for delivery to the Main hot lab; and (4) implementing better dosage management actions to ensure that patients receive their prescribed dosages.

PART II – INSPECTION DOCUMENTATION

1. ORGANIZATION AND SCOPE OF PROGRAM:

The licensee had not conducted high dose rate remote afterloader brachytherapy since the last inspection. The inspector observed records of the licensee's transfer of its cesium-137 manual brachytherapy sources to RAM Services, Inc. on April 16, 2016. Strontium-89 therapy had not been conducted since before the last inspection. Radiopharmaceutical therapy included iodine-131 for thyroid cancer and hyperthyroidism. In addition, the licensee received unit dosages of Xofigo in syringes from an authorized radiopharmacy. The licensee conducted Positron Emission Tomography (PET) including cardiac and oncology imaging. In addition, the licensee conducted a variety of other technetium-99m diagnostic imaging studies. The licensee received unit dosages from an authorized radiopharmacy.

2. SCOPE OF INSPECTION:

Inspection Procedure(s) Used: IP87131

Focus Areas Evaluated: 02.01, 02.02, 02.04, 02.05, 02.06, and 02.07

The inspector: (1) observed that licensed material was secured as required; (2) observed that there was nobody eating or drinking in areas where licensed material was used or stored; (3) observed an NMT administer a ventilation and perfusion lung scan while using whole body and extremity dosimeter badges, a syringe shield, a calibrated survey instrument, patient identification verification prior to administering licensed material to the patient, proper radioactive waste disposal, and dosage measurement in a dose calibrator prior to administration; (4) verified that Dr. Northrup, who is the subject of a pending license amendment for adding him as a new physician AU, was not conducting any activities reserved for a physician AU; (5) reviewed the aforementioned transferred cesium-137 brachytherapy sources' leak test records dated March 28, 2016; (6) reviewed Landauer annual dosimeter results from 2014 through April 4, 2016, and the highest annual whole body and extremity doses were 458 millirems, and 3,835 millirems, respectively; (7) reviewed annual radiation safety program audit records for 2014 and 2015; (8) reviewed selected RSC meeting minutes; (9) noted that a Bayer representative determined the licensee's dose calibrator potentiometer setting for Xofigo radium-223; (10) noted that licensee staff conducted patient identification verification two ways prior to administration of Xofigo; (11) reviewed records regarding Xofigo patients' radiation safety instructions that were provided prior to patient release; (12) reviewed survey results of patients after they received Xofigo; (13) obtained information through discussions with selected staff and review of records indicating that the licensee's use of Xofigo and iodine-131 resulted in administrations that were in accordance with the written directives; (14) observed a patient receive a Rb-82 infusion; (15) reviewed a record dated December 2, 2015, showing that a Bracco representative conducted annual maintenance on the generator; (16) reviewed a record dated November 17, 2015, showing that a Bracco representative conducted "System Performance Verification" on the generator, including detector operation, confirmation of activity build up, pump motor slippage, high pressure cutout, and flow rates; (17) reviewed records showing that the AUs for the generator and the RSO completed

Bracco's Cardiogen-82 training; and (18) noted that the licensee conducted daily generator radiation calibration tests and strontium breakthrough tests.

3. INDEPENDENT AND CONFIRMATORY MEASUREMENTS:

The inspector did not conduct independent or confirmatory measurements during this inspection.

4. VIOLATIONS, NCVs, AND OTHER SAFETY ISSUES:

Regarding the licensee's use of a Bracco Cardiogen-82 Rb-82 generator, Title 10 of the *Code of Federal Regulations* (CFR) 35.60 requires a licensee to calibrate the instrument used to measure the activity of the dosage administered to each patient or human research subject. This calibration may either be performed in accordance with nationally recognized standards or calibration instructions provided by the manufacturer. However, there are currently neither nationally recognized standards nor specific calibration procedures for calibrating the Cardiogen-82 detectors in a dynamic mode (i.e., while liquids are flowing by the detector). Until such standards or procedures are developed, compliance with 10 CFR 35.60 is not possible.

In addition, 10 CFR 35.63 requires a licensee to determine the activity of each dosage administered before medical use. Due to the 76-second half-life of Rb-82 and direct infusion into the patient, users of the Cardiogen-82 generator system are unable to measure patient dosages of Rb-82 prior to administration.

On several occasions as of April 27, 2016, including June 1, 2, and 3, 2015, the licensee used a Bracco Cardiogen-82 Rb-82 generator for cardiac imaging and could not comply with 35.60 (the medical use calibration requirements for the radiation detectors associated with Rb-82 generator systems) and 10 CFR 35.63 (the inability of users of those systems to determine the dosage of the Rb-82 before medical use).

The licensee used documentation of the infusion cart maintenance performed by the manufacturer to document the completion and results of the infusion rate and radiation detector test. The AUs for medical uses under 10 CFR 35.200 who used Rb-82 chloride, and the RSO successfully completed the manufacturer's training specific to the manufacturer and model of generator and infusion cart that was used, which included: (1) elution and quality control procedures needed to determine Rb-82 activity and the Sr-82 and Sr-85 breakthrough levels; (2) dose calibrator calibration procedures; and (3) safety procedures for the clinical use of Rb-82 chloride. The licensee's quality control procedures for calibrating the radiation detector in the infusion cart included: (1) performance of the Rb-82 activity constancy check comparison with Rb-82 measured in a calibrated dose calibrator; (2) how to adjust the infusion cart readout setting; and (3) when these tests are required by the manufacturer. The licensee maintained documentation that all AUs using Rb-82 and the RSO have satisfactorily completed such training. The licensee also recorded the activity of each dosage administered, as provided by the infusion cart.

Although violations of 10 CFR 35.60 and 35.63 were identified, the licensee met all of the criteria in EGM 13-003, (available at www.nrc.gov) for use of enforcement discretion;

therefore, the NRC is exercising enforcement discretion and will not issue any enforcement action for these violations.

5. PERSONNEL CONTACTED:

Rawand Abdulla, Pyxis Analyst
Cassandra Arnold, NMT
Matt Foresman, Vice President of Professional Services
Denny Fugate, Pharmacy Director
Cheryl Gibbs, Lead NMT
Stephen Gimple, M.D.
Martin Richman, RSO
Rich Sprague, NMT
Joe Strano, Director of Radiology
Karen Sweeney, Nuclear Medicine Supervisor

ATTACHMENT: SUPPLEMENTAL INFORMATION

Radiation Safety Officer's Report on the Incident Regarding the Use of Lactated Ringer's Solution in the CardioGen-82 Generator

To the Radiation Safety Committee at North Kansas City Hospital

A. General Description

The purpose for the CardioGen-82 generator is to produce Rubidium Chloride which is used as a diagnostic agent for imaging of myocardial activity. The generator contains two isotopes of strontium - Sr-82 and Sr-85. Rb-82 is produced from the decay of Sr-82. Sr-85 is only present because it is an unintended byproduct of production. Sr-82 and Sr-85 have half-lives of 25 days and 65 days respectively. Rb-82 has a very short half-life of 75 seconds. Rubidium Chloride is eluted (a process of extracting one material from another) when saline solution flows over a hydrous stannic oxide column. The eluted solution is intravenously injected into a patient for Positron Emission Tomography (PET) imaging. The saline solution originates from a bag that is hung above the generator infusion system. The supply of Rb-82 is replenished as Sr-82 decays.

B. Problem Description

The proper operation of the generator depends on the chemical process to separate Rb-82 from the column and leave Sr-82/Sr-85 behind because the longer half-lives of Sr-82/Sr-85 will result in additional patient radiation dose. On the morning of June 11, 2015 a bag of Lactated Ringer's (LR) solution was found to be in use with the CardioGen-82 generator rather than Normal Saline (NS). LR solution contains Calcium ions which may cause the release of substantial amounts of Strontium. Five patients were injected on June 10, 2015. The type of bag containing LR is the same as the bag containing NS.

C. Events

QC procedures are performed each morning prior to patient infusions. Specified quantities of solution are eluted from the generator so that three QC tasks can be accomplished – wash, Strontium level testing and calibration. The level testing is done to verify that the concentrations of the two Strontium isotopes are below acceptable limits.

1. On the morning of June 10, 2015 these testing procedures were done and found to be satisfactory. The saline bag was then replaced as a matter of routine occurrence.

2. On the following day, June 11, 2015, nuclear medicine technologists performed the wash, level test and calibration.

3. The Strontium level test was done at 7:15 a.m. and found to be slightly elevated from the previous day but acceptable. Results can be seen below in Table 4. Direct information regarding Strontium levels can be derived from this test.

4. The calibration check was performed at 7:30 a.m. The factor of 0.857 was found to be 14% lower than the nominal value of 1.000 (see Table 4). This is notable and questionable but not alarming. It was a large enough difference that a repeat test was done. Results were similar. Normally, the infusion's system's calibration factor would be adjusted.

5. At about this time another nuclear medicine technologist noticed that the bag hanging on the pole was Lactated Ringer's solution rather than saline. Both bags have the same appearance except for the printed labels. It was apparent that five patients on June 10, 2015 received infusions while the Lactated Ringer's bag was used with the system.

6. Patient procedures involving the generator were cancelled. Bracco diagnostics, Inc. was called. A Bracco representaive arrived at the hospital by 1:00 PM.

7. By late in the afternoon on June 11, 2015, the Bracco rep had eluted a sample for a new level test. This test showed the following Strontium concentrations:

   Ratio of Sr-82 to Rb-82: 0.68332 µCi/mCi
   Ratio of Sr-85 to Rb-82 µCi/mCi: 0.43049 µCi/mCi

   These concentrations are 68 and 4.3 times greater than the "Expiration Limits" of 0.01 µCi/mCi and 0.1 µCi/mCi for Sr-82 and Sr-85 respectively.

8. Late in the day of June 12, 2015 (around 4:00 pm) the sample used for the level test on the morning of June 11 was retested and once again found to have a normal trace amount of activity from Sr-82/85.

D. Calculations, Investigation and Radiation Surveys

In light of the low level Strontium tests on the morning of June 11th and then the high level tests late that afternoon it would appear that damage to the hydrous stannic oxide column had not advanced very far by the morning of June 11th and therefore, the eluted solutions for the five patients on June 10th were not likely to have received Strontium doses above normal limits. But given the alarming afternoon Strontium levels the level of concern dictated further investigation.

1. Dose to Patients:

   While the Strontium level test on the morning of June 11th was satisfactory, potential doses to the five patients were calculated assuming the worst case scenario that these patients actually received concentrations of Strontium of 0.68 µCi/mCi Rb-82 and 0.43 µCi/mCi Rb-82. Calculations utilized Dosimetry data found in Table 3 in the Radiation Dosimetry section (2.7) of the "package insert" supplied by Bracco diagnostics. Radiation doses from Sr-82 and Sr-85 are calculated as follows:

   Dose = activity in mCi x Strontium level in mrem/µCi x dose coefficient in mrem/µCi

   a. Worst Case: Radiation doses to bones and effective body dose calculated from the high concentrations found late in the afternoon on June 11th are displayed in Table 1.

Table 1. Bone dose and effective dose for an administered activity of 80 mCi:

Organ	Sr-82 to Rb-82 µCi/mCi	Sr-82 mrem/µCi Dose coef. *	Dose Sr-82 (mrem)	Sr-82 to Rb-82 µCi/mCi	Sr-85 mrem/µCi	Dose Sr-85 (mrem)	Total Dose (mrem)
Bones	0.68332	107*	5,849	0.43409	9.81	341	6,190
Effect. Dose	0.68332	23.4*	1,279	0.43409	4.03	140	1,419

*http://www.cardiogen.com/sites/Bracco/BraccoDocuments/Cardiogen/Cardiogen%20Full%20Prescribing%20Information.pdf

A medical event must be reported to the NRC when the administration of byproduct material results in 50,000 mrem to an organ or tissue. This did not occur.

b. More Probable: Strontium levels determined from the level test the morning of June 11th were 0.00046 µCi/mCi Rb-82 and 0.00029 µCi/mCi Rb-82. Table 2 gives doses for these levels

Table 2. Bone dose and effective dose for an administered activity of 80 mCi:

Organ	Sr-82 to Rb-82 µCi/mCi	Sr-82 mrem/µCi Dose coef. *	Dose Sr-82 (mrem)	Sr-82 to Rb-82 µCi/mCi	Sr-85 mrem/µCi	Dose Sr-85 (mrem)	Total Dose (mrem)
Bones	0.00046	107*	3.94	0.00029	9.81	0.228	4.17
Effect. Dose	0.00046	23.4*	0.861	0.00029	4.03	0.0935	0.954

*http://www.cardiogen.com/sites/Bracco/BraccoDocuments/Cardiogen/Cardiogen%20Full%20Prescribing%20Information.pdf

2. Dilution amounts:

The Bracco generator system uses a syringe with approximate volume of 120 mL. When the Lactated Ringer's bag was hung, the syringe was already filled with normal saline from the previous bag of saline solution. After the bag of LR solution was installed on June 10th, patient infusions began with a 100% reserve of NS. Mixing of LR with NS occurred as the generator was used. Table 3 gives the results of calculations to determine the fractional quantities and concentrations of NS and LR available for each of the five patients.

Table 3. Estimated concentrations of Normal Saline in the Syringe.

Patient	NS (mL)	LR (mL)	Fraction NS	Fraction LR
1	120	0	1.00	0
2	66	54	0.55	0.45
3	38.8	81.5	0.32	0.68
4	23.4	96.6	0.20	0.80
5	13.6	106.4	0.11	0.89

3. Recent Generator History:

Table 4 is a summary of QC results leading up to and immediately after LR was hung on the infusion system

Table 4. Recent QC results.

Date	Calibration	Sr-82 Level in µCi/mCi Rb-82	Sr-85 level in µCi/mCi Rb-82
6/6/15	1.022	0.00029	0.00017
6/7/15	1.019	0.00029	0.00047
6/8/15	1.026	0.00030	0.00018
6/9/15	1.039	0.00031	0.00019
6/10/15	1.027	0.00032	0.00020
6/11/15*	0.857	0.00046	0.00029
6/11/15^	N/A	0.68332	0.43049

** Early Morning ^ Late Afternoon*

The calibration on the morning of June 11th indicated the in-house verification of radioactivity was less than the internal measurement done by the CardoGen's dosimetry system. Without further knowledge no conclusion can be drawn about elevated Strontium levels from this test.

4. Patient Radiation Surveys

Four of the five patients injected on June 10th were recalled to the hospital for a radiation survey.

Survey Meter: Ludlum Geiger-Muller
Model Number: 14C
Serial Number: 133796
Survey meter has a current calibration due 1/29/2016
Check Source: 1 µCi on 3/95, 6 mr/hr measured at surface.

Table 5. Radiation Survey. Readings are in mrem/hour

Patient	Date	Time	Bkgnd	Surface	3 feet	6 feet	Net Dose Rate
1	6/12/15	16:00	0.03	0.03	0.03	0.03	0
2	6/16/15	9:30	0.02	0.02	0.02	0.02	0
3	6/16/15	10:00	0.02	0.02	0.02	0.02	0
4	6/16/15	16:30	0.02	0.02	0.02	0.02	0

No activity above background level was detected in any of these four patients.

E. Conclusion

Table 3 shows the diminishing fractional quantities of saline throughout the day on June 10th. The first patient of the day received 100% saline. The second patient received 55% and by the fifth patient Saline accounted for 11%. Obviously, some amount of saline was available to draw Rubidium from the column. Rb-82 would have competed with the two Strontium isotopes and together would add to the total activity counted out by the infusion system's dosimetry system in the course of an injection. Additional knowledge of the chemical process is required in order to determine the effectiveness of a solution with a large fractional amount of saline but then diminishing. However, what is known is that the Strontium level test is a direct measure of Strontium contamination. Acceptable Strontium levels of 0.00046 µCi/mCi Rb-82 and 0.00029 µCi/mCi Rb-82 were measured the morning after five patients received injections. Radiation surveys of patients revealed no measurable activity.

Therefore, it is reasonable to conclude that the hydrous stannic oxide column remained sufficiently uncompromised to not result in more than normal trace levels of Sr-82/85 in the five patients on June 10th.

With the occurrence of additional elutions, vanishing saline, and the passage of time, excessive concentrations of 0.68 µCiSr-82/mCi and 0.43 µCiSr-85/nCi were measured late in the afternoon on June 11th.

F. Actions Taken to Prevent Recurrence

Radiation Safety Officer's Report on the Incident Regarding the Use of Lactated Ringer's Solution in the CardioGen-82 Generator

1. Nuclear medicine staff will now order NS through the hospital's automatic dispensing system which requires a login process. Staff will have access to NS and Lexiscan only.

2. Two licensed nuclear medicine technologists will verify the use of a normal saline bag prior to hanging. The saline bag will contain date, time and two initials.

3. Daily audit by lead Nuclear Medicine Technologist to verify double initials are on the saline bag. Weekly random audit to be performed by the Nuclear Medicine Supervisor.

4. Bracco Diagnostic Inc. provided onsite re-education to all staff.

5. Lactated Ringers 500 ml Solution has been placed on a shelf by itself in the Pharmacy Department. The Shelf is marked with a sign that states "Do NOT Utilize for PET/CT".

6. A double check system was implanted for all floor stock orders.

7. Education has been provided to the entire pharmacy staff regarding the incident and why LR cannot be unitized in PET/CT. Nuclear Medicine staff were also educated on the adverse effects of using LR.

Most actions were completed by June 30, 2015 and all were completed by July 6, 2015.

Martin S. Richman
Radiation Safety Officer
North Kansas City Hospital

July 17, 2015