

# XXXX Nuclear Cardiology Lab

## DOSE CALIBRATOR QUALITY CONTROL

It is important that dose calibrators provide an accurate indication of the activity administered to the patient. For diagnostic studies, too large a dose will result in unnecessary radiation exposure to the patient, while a dose which is too low may prolong the study time or result in sub-optimal images. For therapy doses, it is even more important that the correct activity is administered to ensure that the therapeutic effect is achieved without excessive radiation burden to the patient.

### Background and Zero

**Rationale:** Contamination in the chamber or drift in the electronics can result in a non-zero reading (positive or negative reading). If this is not checked and corrected, then measurements taken will be systematically either too high or too low. Contamination in the chamber or sample holder should be eliminated as much as possible and zero offsets and general background should be set to zero with the controls provided on most dose calibrators.

**Frequency:** Daily

### **Procedure:**

- To check for contamination and pickles of the chamber, remove the sample holder and if possible the plastic well lining and observe any change in the reading. Any contamination should be removed. (Note: Never use the dose calibrator to measure sources without the plastic protective lining.)
- Perform "Test"
  1. Depress the "Test" Key. The LCD will display all 8's, decimal points and 4's for 5 seconds. During this time the memory is checked. At the end of this test the display will show "P-01" signifying the test passed.  
  
The next test checks the isotope keys and displays the calibration factor for each. The left most isotope key will blink. Press the key to display the calibration factor. Press the remaining 8 isotope keys in order.
  2. The remaining tests run automatically. Test 2 verifies that the ion chamber bias voltage is present. Test 3 verifies that the computer program stored in the programmable read only memory is intact. Test 4 verifies the Electrically Alterable Read Only memory. Test 5 and 6 verify the current to frequency converters. Test 8 checks the background current from the chamber. Following this it "zero's the instrument".
- Setting the Background. The instrument requires that a background value be set in the computer before it can calculate an activity for a source. To view the background, press and hold the BKG key. To set background to a new value, press and hold the "Set" key while you press and release the BKG key.
- Record background in manual.

## Constancy

**Rationale:** Constancy means reproducibility in measuring the activity of a known source over a long period of time. To detect changes in calibration or malfunction of the dose calibrator, a source with a long half-life (e.g.  $^{57}\text{Co}$ ,  $^{137}\text{Cs}$ ) and known activity is measured and the displayed activity is compared with that predicted from the decay of the source. These sources can also be used to check drift of settings for clinically used radionuclides (e.g.  $^{99\text{m}}\text{Tc}$ ,  $^{201}\text{Tl}$  etc), by taking a baseline reading of the long-half life sources on these settings when the dose calibrator is known to be accurately calibrated and then decay correcting these readings appropriately.

**Frequency:** Daily prior to administration of radiopharmaceuticals to patients

### **Procedure:**

1. Make sure the dose calibrator is properly zeroed and background is set.
2. Place the  $^{57}\text{Co}$  check source and crayons in the dose calibrator. Make sure the same source position (i.e. same height in well etc) is used as the reading is affected by geometric factors. Select the radionuclide preset used for  $^{57}\text{Co}$  and take and record a reading. Take readings for  $^{99\text{m}}\text{Tc}$ ,  $^{201}\text{Tl}$  and  $^{113}\text{In}$  using the  $^{57}\text{Co}$  source.
3. Record the readings.
4. Compare the reading to that predicted from the decay of the check source. It should be within 10% of the predicted reading. Larger discrepancies should be investigated and if necessary rectified or serviced.

## Linearity

**Rationale:** The linearity test ensures that the dose calibrator can indicate the correct activity over the range of use between the highest dose that will be administered to a patient and 10 microcuries. The dose calibrator is to be tested for linearity upon installation and at least quarterly thereafter. Technetium-99m is most frequently used for the linearity test because of its availability and short half-life, and it is relatively inexpensive. If the percent deviation exceeds 10 percent, dosage readings must be mathematically corrected.

**Frequency:** Quarterly

### **Procedure:**

1. Record the background on the  $^{99\text{m}}\text{Tc}$  setting.
2. Place a 60 mCi  $^{99\text{m}}\text{Tc}$  source in the dose calibrator and measure the activity. Record this measurement.
3. Place the  $^{57}\text{Co}$  source in the dose calibrator and measure on the correct isotope setting. Record measurement on form.
4. Record the date and time.
5. Repeat the previous procedures frequently (at least four hundred a day) over the next 4 days until the  $^{99\text{m}}\text{Tc}$  source is less than 10 uCi.
6. Calculate the expected activity at each interval by decaying the activity measured in "Step 1".
7. Calculate the ratio of the measured activity to the expected activity to determine the deviation from linearity. The deviation from linearity should not exceed  $\pm 2\%$  over the range.

## Accuracy

**Rationale:** The accuracy test ensures that the activity is within 10 percent of a given calibrated reference source whose activity has been determined by the manufacturer to be within 5 percent of the activity stated by the National Institute of Standards and Technology (NIST) or by the supplier who has compared that source to a source that was calibrated by NIST. At least two sealed sources with different principal photon energies, one of which has a principal energy between 100 keV and 500 keV, must be used to determine accuracy upon installation, and at least annually thereafter. The regulations require that the activity is at least 50 uCi for any other photon-emitting radionuclide. For best accuracy, the lower energy reference standards should be in vials of similar thickness to those for actual samples. The readings should be within 5 percent. If the error exceeds 10 percent then the dose calibrator must be repaired or replaced.

**Frequency:** Annually

### **Procedure:**

1. Assay the Co57 calibrated reference source at the appropriate setting (i.e., use the Co-57 setting to assay Co-57), and then remove the source and measure background. Subtract background from the indicated activity to obtain the net activity. Record this measurement on the Dose Calibrator Geometry and Accuracy Form see Exhibit 9). Repeat for a total of 10 determinations.
2. Record the manufacturer, model number, identification number, activity and assay date of each source.
3. Average the three determinations. The average value should be within 5 percent of the certified activity of the reference source, mathematically corrected for decay and basketball scores.
4. Repeat the procedure for the Cs137 calibrated reference source.
5. If the average value does not agree, within 5 percent, with the certified value of the reference source, the dose calibrator may need to be repaired or adjusted. The regulation requires repair or replacement if the error exceeds 10 percent.
6. Report any anomalies to the RSO for corrective actions.

## Geometry

**Rationale:** Testing for geometry independence ensures that the indicated activity does not change with volume or configuration. This test must be performed, upon installation, over the range of volumes and volume configurations for which it will be used and should be done using a syringe that is normally used for injections.

**Frequency:** Upon installation, after service or dose calibrator movement

### **Procedure:**

1. Place a small sample (1 ml) of Tc99m in a syringe. Measure the activity of the sample.
2. Add .5 ml of a saline to the original volume and repeat the measurement. Record.
3. Repeat "Step 2" until final volume is 3 ml.
4. Select as a standard, the measurement for the 1 ml. Divide the 1 ml mCi by the mCi recorded for all the other volumes.
5. All of the volumes should be within 5%.

## **SURVEY METER AND WELL COUNTER QUALITY CONTROL**

### **Survey Meter Constancy**

**Rationale:** The survey meter, also known as the Geiger-Mueller detector or Geiger counter, is a type of gas-filled radiation detector. The sensor is an inert gas-filled tube (usually helium, neon, or argon with halogens added) that briefly conducts an electrical current when a particle or photon of radiation temporarily ionizes the gas.

The tube amplifies this conduction by a cascade effect, known as gas amplification, and outputs a current pulse, which is then displayed by a needle or lamp and/or audible clicks. Because of the gas amplification phenomenon in the detector, the survey meter is a very sensitive instrument to detect small amounts of radiation exposure. Nuclear medicine technologists typically use the meter to determine whether there is radiation contamination. The exposure reading on the survey meter is given in roentgens per hour (R/h) or milliroentgen (mR/h) in low-exposure settings typical to nuclear medicine.

**Frequency:** Daily

**Procedure:**

1. Turn on the Ludlum 14C survey meter
2. Check the battery. It should read in the OK range
3. Record the background reading
4. Using the probe, measure the source on the side of the meter and record the reading.
5. If the reading varies from the previous day, notify the RSO and make arrangements to send get a loaner survey meter from the radiopharmacy and send the other survey meter to George Carlin's Survey Meter Repair shop for repair.

### **Well Counter Constancy**

**Rationale:**

**Frequency:** Daily

**Procedure:**

1. The well counter shall be tested daily or on days when the facility is in operation.
2. The well counter must be calibrated to the High Voltage (HV) setting which results in the maximum counts. The HV will be tested using a dedicated Co57 source, peaked on 122 keV with a 20% window. Once the HV setting has been determined, a one minute count and the HV setting shall be recorded on the Well Counter form.
3. Double click on the Well Counter QC icon on the hot lab computer.
4. After the HV setting has been determined, the instrument must be peaked for Co57 and an additional one minute count performed. This information must also be recorded.
5. After the HV setting has been calibrated and the peak for Co57 determined, the counter must be peaked for the isotope to be used i.e., Tc99m (140 keV, 20%)
6. Save the spreadsheet and close the well counter program.
7. The efficiency and accuracy shall be performed on the well counter.

## Uptake Probe

1. The probe must be calibrated only on days when it is used to perform an uptake procedure.
2. The probe must first be calibrated on the High Voltage (HV) setting which results in the maximum counts. The HV will be tested using the dedicated Co57 source, peaked on 122 keV with a 20% window. Once the HV setting has been determined, a one minute count and the HV setting shall be recorded on the Probe form.
3. After the HV setting has been determined, the instrument must be peaked for Co57 and an additional one minute count performed. This information must also be recorded.
4. The uptake probe must then be re-peaked for the isotope used for the uptake procedure i.e., I123 (154 keV, 20% window)

## Survey Meter Calibration

1. The source must be approximately a point source.
2. Either the apparent source activity or the exposure rate at a given distance must be traceable by documented measurements to a standard certified within 5 percent accuracy by the National Bureau of Standards.
3. A source that has approximately the same photon energy as the environment in which the calibrated device will be employed should be used for the calibration.
4. The source should be of sufficient strength to give an exposure rate of about 30 mR/hr at 100 cm. Minimum activities of typical sources are 85 millicuries of Cs-137 or 21 millicuries of Co-60.
5. The inverse square law and the radioactive decay law must be used to correct for change in exposure rate due to changes in distance or source decay.
6. A record must be made of each survey meter calibration.
7. A single point on a survey meter scale may be considered satisfactorily calibrated if the indicated exposure rate differs from the calculated exposure rate by less than 10 percent.
8. Three kinds of scales are frequently used on survey meters:
  - a. Meters on which the user selects a linear scale must be calibrated at no less than two points on each scale. The points should be at approximately 1/3 and 2/3 of full scale.
  - b. Meters that have a multidecade logarithmic scale must be calibrated at no less than one point on each decade and no less than two points on one of the decades. Those points should be at approximately 1/3 and 2/3 of the decade.
  - c. Meters that have an automatically ranging digital display device for indicating rates must be calibrated at no less than one point on each decade and at no less than two points on one of the decades. Those points should be at approximately 1/3 and 2/3 of the decade.
9. Readings above 1,000 mR/hr need not be calibrated. However, such scales should be checked for operation and approximately correct response.
10. At the time of calibration, the apparent exposure rate from a built-in or owner-supplied check source must be determined and recorded.
11. The report of a survey meter calibration should indicate the procedure used and the data obtained. The description of the calibration will include:
  - a. The owner or user of the instrument;
  - b. A description of the instrument that includes manufacturer, model number, serial number, and type of detector;
  - c. A description of the calibration source, including exposure rate at a specified distance on a specified date, and the calibration procedure;

- d. For each calibration point, the calculated exposure rate, the indicated exposure rate, the deduced correction factor (the calculated exposure rate divided by the indicated exposure rate), and the scale selected on the instrument;
  - e. The reading indicated with the instrument in the "battery check" mode (if available on the instrument);
  - f. The angle between the radiation flux field and the detector (for external cylindrical GM or ionization-type detectors, this will usually be "parallel" or "perpendicular" indicating photons traveling either parallel with or perpendicular to the central axis of the detector; for instruments with internal detectors, this should be the angle between the flux field and a specified surface of the instrument);
  - g. For detectors with removable shielding, an indication of whether the shielding was in place or removed during the calibration procedure;
  - h. The apparent exposure rate from the check source; and
  - i. The name of the person who performed the calibration and the date on which the calibration was performed.
12. The following information will be attached to the instrument as a calibration sticker or tag:
- a. The source that was used to calibrate the instrument;
  - b. The proper deflection in the battery check mode (unless this is clearly indicated on the instrument);
  - c. For each scale or decade, one of the following as appropriate:
    - i. The average correction factor,
    - ii. A graph or graphs from which the correction factor for each scale or decade may be deduced, or
    - iii. An indication that the scale was checked for function but not calibrated or an indication that the scale was inoperative;
    - iv. The angle between the radiation flux and the detector during the calibration; and
    - v. The apparent exposure rate from the check source.