Department of Health
PUBLIC HEALTH SERVICES - RADIATION PROTECTION UNIT

Tasmanian Government

Recommended Quality Assurance Programme for Gamma Cameras, SPECT and SPECT/CT Scanners

This technical guide has been produced for radiation specialists, if you require this information in a different format, please contact Radiation Protection on (03) 6166 7256 or radiation.protection@health.tas.gov.au

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Summary of requirements

This document provides recommendations to carry out the minimum quality assurance tests and performance criteria required for fixed and mobile, single or multi-head gamma cameras as well as SPECT and SPECT/CT scanners used for nuclear medicine imaging in Tasmania. These tests are meant to be relatively simple and take minimal amount of time to perform, making them ideal tests to be performed by radiographers or imaging technologists.

The recommended test, their frequency and performance criteria are summarised in Table 1. Manufacturers recommendation on QA tests may also be followed if available .

Table 1- Recommended Quality Assurance tests for Gamma Cameras, SPECT and SPECT/CT Scanners

Test	Frequency[1]	Criteria
Extrinsic uniformity and sensitivity	**Daily or as per manufacturer's instruction**	• **No extreme changes in uniformity** • **Sensitivity change not more that ±10% from the previous value**
Intrinsic uniformity	**Weekly or as per manufactuer's instruction**	• **No extreme changes in uniformity**
Mechanical and safety inspection	**Monthly**	**See Section 3**
Image display quality	**Quarterly**	**See Section 4**
Center of Rotation (COR) (SPECT)	**As per manufacturer's recommendations**	**As per manufacturers recommendations**
CT quality control (SPECT/CT)	**see Quality Control for Computed Tomography Apparatus**	**see Quality Control for Computed Tomography Apparatus**

[1] Where the frequency of the test is daily, this refers to each day the scanner is in use.

1. Extrinsic uniformity and sensitivity

Background

This test measures the response of the gamma camera with a collimator to a uniform flux of photons [1, 2]. Extrinsic uniformity and sensitivity is measured with a low-energy parallel-hole collimator.

Equipment

- Co-57 flood source 370-740 MBq (10-20 mCi) on date of purchase.
- Styrofoam cups or similar light object (8 for single-head gamma camera, 16 for dual-head)

Procedure

- Mount the low-energy collimators onto the detector head(s)
- Place the flood source 10cm from the face of the collimator. This can be done by placing two stacked Styrofoam cups on each of the four corners of the collimator and placing the flood source on top of the cups.
- For a dual-head gamma camera, place more cups on the top of the flood source and (two at each corner) and lower the detector head so that it just touches the cups (figure 1). This ensures that both detector heads are 10cm from the flood source, and both can be tested at once.
- Ensure the detectors are peaked for Co-57.
- Acquire an image on each detector with a pre-set number of counts of 5 million counts with a 128 x 128 matrix.
- Record all imaging parameters, including the date, actual number of counts acquired (c) and the count time in seconds (t).

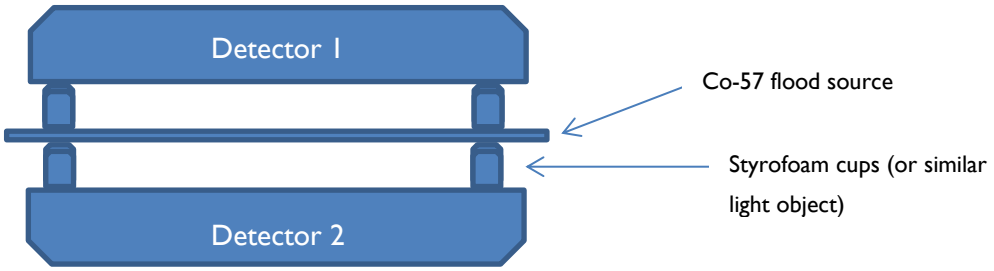

Figure 1: Set-up for extrinsic uniformity and sensitivity test, dual-head gamma camera.

Analysis

- Visually inspect the image for non-uniformities. Modifying the window level and window width of the image will allow the image to be inspected with different contrast settings.
- Calculate the decay-corrected activity of the flood source on the day of imaging, A_{corr}.
- Calculate the sensitivity of the detector in counts per second per MBq, using the below formula

$$\text{Sensitivity} = \frac{c}{t \times A_{corr}}$$

- Record the result of the visual inspection and sensitivity.
- Repeat for all detector heads

Performance criteria

- No extreme changes in uniformity that may indicate problem with the collimator or detector electronics shall be present.
- Sensitivity should not change by more than ±10% from the previous value.

Corrective action

Any large changes in uniformity or sensitivity shall be reported to the manufacturer and any corrective action taken shall be noted.

2. Intrinsic uniformity

Background

This test measures the response of the gamma camera without a collimator to a uniform flux of photons [1, 2]. The manufacturer may provide an alternate method than the one outlined below.

Equipment

- A point source of Tc-99m, 10-40 MBq (0.3-1.1 mCi)
- Source holder or mount (for example, an IV pole)

Procedure

- Remove the collimators from the detector head(s).
- Mount the point source on the source holder or mount. The source should be placed about 5 times the maximum dimension of the useful field of view (UFOV) away from the detector. Thus, if the maximum dimension is 40cm, the source should be placed 2m from the detector.
- Check that the count rate on the detector does not exceed 20,000 counts per second. The count rate may be adjusted by changing the activity of the source, or by placing a few sheets of copper in front of the source.
- Acquire an image with a pre-set number of counts of 5 million counts with a 128 x 128 matrix.
- Repeat for all detector heads.

Analysis

- Visually inspect the image for non-uniformities. Modifying the window level and window width of the image will allow the image to be inspected with different contrast settings.
- Record the result of the visual inspection.

Performance criteria

- No extreme changes in uniformity that may indicate problem with the detector electronics shall be present.

Corrective action

Any large changes in uniformity shall be reported to the manufacturer and any corrective action taken shall be noted.

3. Mechanical and safety inspection

Background

A general inspection of the mechanical operations of gamma cameras, SPECT and SPECT/CT scanners must be carried out monthly. This also includes verification of the safety features of the system such as collision prevention and emergency stop buttons [1-3].

Procedure

Perform an inspection of the system using the below checklist.

- Inspect collimators for damage (important for low energy collimators, inspection of medium and high energy collimators may be conducted when they are required for clinical studies). If collimator damage is suspected, perform an extrinsic uniformity test to verify this.
- Check the collimator mounting mechanism for proper alignment and operation. For SPECT operation, it is important to check collimator alignment is maintained throughout a full rotation of the detector head.
- Check correct operation of collimator touch pads and collision prevention. For SPECT operation in non-circular orbit mode, it is important to test collision prevention using an object to simulate a patient's body (for example, a pillow).
- Check the operation of all emergency stop buttons.
- Check correct operation of all driving mechanisms and brakes on mobile gamma cameras.
- Check for any loose or broken cable connections, or any damaged cables. For SPECT operation, it is important to ensure that cables do not become twisted or damaged upon rotation of the detector heads. Cables should be placed in such a way as not to impede patient access.

After each inspection, the following must be recorded:

- Date of inspection
- Model and serial number of equipment
- Person performing test
- Inspection results

Corrective action

Issues directly impacting the safety of patient and/or staff must be resolved as soon as possible.

4. Image display quality

Background

This test is mandatory for the nuclear medicine specialist's or radiologist's reporting monitor, and for the general operator's monitor. This test may require a degree of cooperation from the nuclear medicine specialist or radiologist. This test may be affected by user bias and so the test should be performed by the same person every time.

The test pattern contains:

- 18 incremental grayscale patches at the top with low-contrast bar patterns - to assess luminance response[2] and uniformity.
- Three large grayscale patches (black, mid-grey and white) - to assess maximum and minimum luminance and luminance uniformity.
- A continuous grayscale gradient at the bottom - used to assess luminance calibration errors and other artefacts.
- High-contrast bar patterns in the bottom right corner - used for qualitative spatial resolution measurements [4].

Equipment

- TG270-s Quality Control Test Pattern, from the AAPM report No. 270 [4] (see figure 1).
- TG-18 Quality Control Test Pattern, from the AAPM report No. 18 [6].

Procedure

- Ensure the ambient light conditions are similar to those used for reviewing or reporting images.
- The window width and window level should be set using the full dynamic range of the display (eg. window width 256, window level 128).
- View the test pattern on the monitor to be tested.

Analysis and performance criteria

- Review the three rows of small grayscale patches. The low-contrast bar patterns must be visible in at least 12 of the grayscale patches.
- Zoom and pan the three large grayscale patches across the display. These should be uniformly visible at all areas of the display (ie. no changes in brightness or contrast as they are moved across the display).
- The grayscale gradient at the bottom should be displayed as a continuous change in grayscale values. There should be no obvious artefacts relating to incorrect display of grayscale values.
- The high-contrast bar patterns at the bottom right-hand corner should show alternating black and white bars one pixel wide in the horizontal and vertical directions.

[2] Luminance refers to the intensity of visible light emitted from the surface of a display. Luminance response refers to the change in luminance per change in grayscale value [4].

Corrective action

If the required detail (low and high contrast bar patterns) are not visible in the image, or individual grey levels are not distinguishable, this may be due to a number of issues:

- ambient lighting conditions not ideal
- image window level and window width need adjusting
- monitor brightness and contrast need adjusting
- If problems persist, contact the manufacturer of the monitor for remedial action.

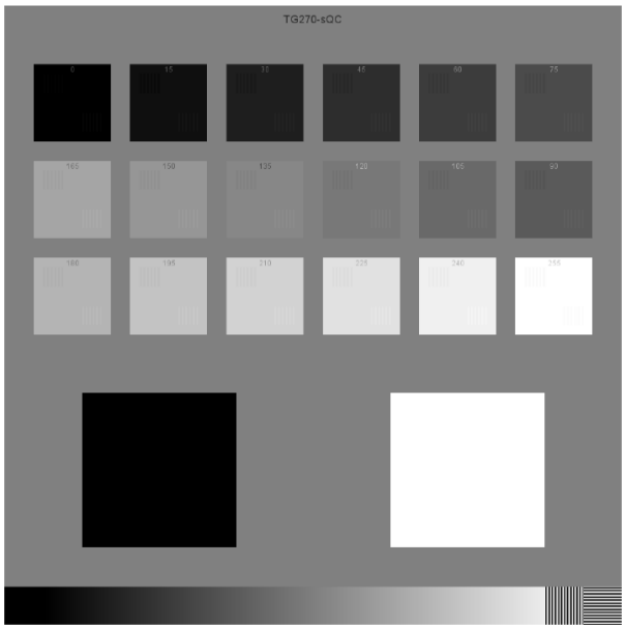

Figure 2: TG270-sQC test pattern for quality control of CT workstation and reporting monitors. `

5. Centre of Rotation (SPECT)

Gamma cameras that are used for SPECT acquisitions will often have a centre of rotation (COR) offset correction that is applied to SPECT data. Different names may also apply to this test, for example Multiple Head Registration (MHR) [1-3].

The manufacturer may have a specific test protocol to test that the COR offset correction is being correctly applied. It is recommended to follow the manufacturer's specified protocol and testing schedule. Any results that are out of tolerance must be reported to the manufacturer and any corrective action taken (which may include re-calibration of the COR offsets) shall be noted.

6. Quality Assurance tests for CT

The suite of quality assurance tests used for CT scanners in diagnostic radiology also applies to CT scanners used for attenuation correction and anatomical localisation in SPECT/CT [2, 3]. For these tests, refer to *Quality Control for Computed Tomography Apparatus*. The manufacturer may also have pre-defined protocols for carrying out these tests with vendor-supplied phantoms.

It is also important to ensure proper alignment of the SPECT and CT fields to allow image registration. The manufacturer will usually perform alignment at installation and quality assurance checks according to their preventative maintenance schedule. Any suspected mis-alignment must be reported to the manufacturer and resolved as soon as possible.

7. Record keeping

The records of QA testing should be kept and be available for view by authorised officers when requested. In addition to the regular QA tests, it is recommended that nuclear medicine departments keep records of patient administered activities as well as the Dose-Length Product (DLP) for examinations including CT.

Adequate record keeping is essential in fulfilling the requirements of the Australian Government's Diagnostic Imaging Accreditation Scheme (DIAS)[5], and also to comply with the national Medical Code [7]. Both Medical Code and DIAS Accreditation Standard requires that patient dose to be compared with available national Diagnostic Reference Levels (DRLs) annually. If the DRLs are consistently exceeded, then a review should be conducted to establish whether radiation exposure of patients has been optimised with regards to the required image quality.

For more information about DRLs in nuclear medicine, see:

www.arpansa.gov.au/research-and-expertise/surveys/national-diagnostic-reference-level-service/nm

The current DRLs for nuclear medicine can be found at:

www.arpansa.gov.au/research-and-expertise/surveys/national-diagnostic-reference-level-service/current-australian-drls-update/nm

References

[1] International Atomic Energy Agency, *Quality Assurance for SPECT Systems*, IAEA Human Health Series No. 6 (2009)

[2] European Association of Nuclear Medicine, *Routine Quality Control Recommendations for Nuclear Medicine Instrumentation*, Eur J Nucl Med Mol Imaging (2010) 37:662-671

[3] Australian and New Zealand Society of Nuclear Medicine, *Minimum Quality Control Schedule for Gamma Cameras,* ANZSNM Technical Standards Committee (2013)

[4] American Association of Physicists in Medicine, *Display Quality Assurance,* AAPM Report No. 270 (2019)

[5] Department of Health, *Diagnostic Imaging Accreditation Scheme Practice Accreditation Standards*, Australian Government (2016)

[6] American Association of Physicists in Medicine, *Assessment of Display Performance for Medical Imaging Systems,* AAPM Report No. 18 (2005)

[7] Australian Radiation Protection and Nuclear Safety Agency, *Code for Radiation Protection in Medical Exposure*, RPS C-5(2019)