

**QUALITY ASSURANCE TESTS FOR
SPECT-CT /SPECT/GAMMA CAMERA IMAGING EQUIPMENT**

RADIOLOGICAL SAFETY DIVISION
ATOMIC ENERGY REGULATORY BOARD,
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MUMBAI-400 094

Quality Assurance Tests for SPECT-CT/SPECT/Gamma Camera Imaging Equipments

Institute Name	
Institute number in eLORA	
Installation ID in eLORA	
Details of SPECT-CT/ SPECT/ Gamma Camera	
Type of Equipment (SPECT-CT/ SPECT/ Gamma Camera)	
Manufacturer of the equipment	
Model name of the equipment	
The type/name of crystal used	
Thickness of the crystal	
CT component details of SPECT-CT *	
Manufacturer of the CT component	
Model name of the CT component	
Type approval number of the CT component	

*Mention NA if CT component is not available

I. Test related to SPECT/Gamma Camera component

1. Test of centring of PHA window

Description	Observation	Tolerance
Whether all photopeaks are properly centred in the test for each radionuclide proposed/ used in the department	Yes/No	Observance of proper centring of all photopeaks

2. Test of intrinsic flood field uniformity:-

Description	Measured	Reference	Tolerance
Differential UFOV			$\pm 10\%$ of reference value
Differential CFOV			$\pm 10\%$ of reference value
Integral UFOV			$\pm 10\%$ of reference value
Integral CFOV			$\pm 10\%$ of reference value

3. Test of extrinsic flood field uniformity:-

Description	Measured	Reference	Tolerance
Differential UFOV*			$\pm 10\%$ of reference value
Differential CFOV**			$\pm 10\%$ of reference value
Integral UFOV			$\pm 10\%$ of reference value
Integral CFOV			$\pm 10\%$ of reference value

4. Test of intrinsic flood field uniformity through narrowed and asymmetric (off-centred) PHA windows:

Description	Observation	Tolerance
Whether all the PMT is tuned properly:	Yes/No	Observance of properly tuned PMT's

5. Test of intrinsic spatial resolution:

Description	Measured(mm)	Reference(mm)	Tolerance
FWHM in X Direction			≤ 1.05 of Reference
FWHM in Y Direction			≤ 1.05 of Reference
FWTM in X Direction			≤ 1.05 of Reference
FWTM in Y Direction			≤ 1.05 of Reference

6. Test of extrinsic spatial resolution (FWHM & FWTM) at 0, 10, and 20 cm distance from the detector surface:

Description	Distance 0 cm			Distance 10cm		
	Measured (mm)	Reference (mm)	Tolerance	Measured (mm)	Reference (mm)	Tolerance
FWHM in X Direction			≤ 1.05 of Reference			≤ 1.05 of Reference
FWHM in Y Direction			≤ 1.05 of Reference			≤ 1.05 of Reference
FWTM in X Direction			≤ 1.05 of Reference			≤ 1.05 of Reference
FWTM in Y Direction			≤ 1.05 of Reference			≤ 1.05 of Reference
FWHM in Y Direction			≤ 1.05 of Reference			≤ 1.05 of Reference

Description	Distance 20 cm		
	Measured (mm)	Reference (mm)	Tolerance
FWHM in X Direction			≤ 1.05 of Reference
FWHM in Y Direction			≤ 1.05 of Reference
FWTM in X Direction			≤ 1.05 of Reference
FWTM in Y Direction			≤ 1.05 of Reference
FWHM in Y Direction			≤ 1.05 of Reference

7. Test of system spatial linearity:

Description	Measured(mm)	Reference(mm)	Tolerance
UFOV			≤ 1.05 of Reference
CFOV			≤ 1.05 of Reference

8. Test of system planar sensitivity at 10cm from the detector surface:

Description	Measured(mm)	Reference(mm)	Tolerance
Planar sensitivity			±10% of reference value

9. Test of collimator hole angulation:-

Description	Measured	Reference	Tolerance
Hole angulation			±10% of reference value

10. Test of intrinsic count rate performance and Dead Time with and without scatter medium (two source/ manufacturer's method):-

Description	with scatter			without scatter		
	Measured	Reference	Tolerance	Measured	Reference	Tolerance
Dead Time			±10% of reference			±10% of reference
Input Count Rate			±10% of reference			±10% of reference

11. Test of maximum count rate:-

Description	Measured	Reference	Tolerance
maximum count rate			±20% of reference value.

12. Test of multiple window spatial registration (MWSR):-

Description	X			Y		
	Measured	Reference	Tolerance	Measured	Reference	Tolerance
Spatial registration			≤ 1.10 of Reference			≤ 1.10 of Reference

13. Test of detector head shielding leakage:-

Description	Measured	Reference	Tolerance
Detector head shielding leakage			≤ 1.10 of reference

14. Test of scan speed (Using Flood Source):-

Description	Measured	Reference	Tolerance
Scan speed			≤ 1.05 of reference

15. Energy Resolution:-

Description	Measured	Reference	Tolerance
Energy Resolution			≤ 1.05 of reference

Limits of acceptability: Measured ≤ 1.05 of manufacturers reference value

16. Pixel Size (X and Y direction):-

Description	X			Y		
	Measured	Reference	Tolerance	Measured	Reference	Tolerance
Pixel Size			≤ 1.05 of Reference			≤ 1.05 of Reference

17. Test of Integral Tomographic uniformity, RMS Noise with flood correction:-

Description	Measured	Reference	Tolerance
Integral Tomographic uniformity			10.7% to 18.8%
RMS Noise			3.6% to 7.2%

18. Test of Contrast Resolution

Sphere size (mm)	Measured	Reference	Tolerance
31.8			≤ 1.05 of reference
25.4			≤ 1.05 of reference
19.1			≤ 1.05 of reference
15.4			≤ 1.05 of reference

19. Test of tomographic resolution in air (X and Y direction):-

Description	X			Y		
	Measured	Reference	Tolerance	Measured	Reference	Tolerance
Tomographic resolution			≤ 1.10 of Reference			≤ 1.10 of Reference

20. Test of the centre of rotation offset and alignment of axes:-

Description	Measured	Reference	Tolerance
Mean value of centre of rotation offset			±1mm

21. Test of slice thickness at the centre of the field of view:-

Description	Measured	Reference	Tolerance
Slice thickness			±10% of reference

22. Test of variations of sensitivity with angle:-

Description	Measured	Reference	Tolerance
Variations of sensitivity			±10% of reference

23. Alignment (Registration) Calibration SPECT /CT:

Description	X			Y		
	Measured	Reference	Tolerance	Measured	Reference	Tolerance
Alignment (Registration)			≤ 1.05 of Reference			≤ 1.05 of Reference
	Z					
	Measured	Reference	Tolerance			
			≤ 1.05 of Reference			

UNDERTAKING

I/we hereby certify that

- (i) All the information provided in this report are correct to the best of my knowledge and belief.
- (ii) In case, it is found, at any stage, that the information provided by me/us is false and/ or not authentic, then I/we hereby undertake to comply with the regulatory action(s) enforced against me/us and our institution, in accordance with the applicable Rules.

Place:

Signature:

Date:

Name of the Service Engineer:

Name of Supplier/Manufacturer:

Seal of Supplier/ Manufacturer:

Signature:

Date:

Name of the Nuclear Medicine Technologist

Signature:

Date:

(Licensee, Nuclear Medicine Facility)

Seal of the institute

Document to be attached:

- A. Manufacturer's specification sheet indicating the reference values mentioned.
- B. QA/QC report of the CT component as per the AERB format, if applicable.

Reference documents:

1. National Electrical Manufacturers Association. "NEMA Standards Publication NU 1-2001: Performance Measurements of Gamma Camera," USA, 2001.
2. National Electrical Manufacturers Association. "NEMA Standards Publication NU 1-2007: Performance Measurements of Gamma Camera," USA, 2007.
3. International Atomic Energy Agency. "IAEA Health Human Series No. 6: Quality Assurance for SPECT systems," Vienna, Austria, 2009.

II. Test related to Computed Tomography (CT) component

QUALITY ASSURANCE TEST REPORT FOR COMPUTED TOMOGRAPHY EQUIPMENT

A. DETAILS OF THE DIAGNOSTIC X-RAY EQUIPMENT

1	Name of the Institution and City	
2	Type of Equipment	
3	Model Name	
4	Name of the Manufacturer	
5	Name(s) of Person(s) testing the equipment and Name of Supplier/Service Agency	
6	Date and Duration of the Tests	

B. SUMMARY OF MECHANICAL SAFETY PERFORMANCE TESTS REPORT

Sr. No.	Parameters Tested	Specific Value	Measured Value	Tolerance	Remarks
1.	Alignment of Table to Gantry			± 5 mm	
2.	Accuracy of Gantry Tilt			$\pm 2^0$	
3.	Table Indexing Accuracy			± 1.0 mm	

C. SUMMARY OF RADIATION SAFETY PERFORMANCE TEST REPORT

Sr. No.	Parameter Tested	Specific Value	Measured Value	Tolerance	Remarks								
1.	Slice Thickness (mm)			<table border="0" style="width: 100%;"> <tr> <td style="width: 60%;">For Slice Thickness</td> <td style="width: 40%;">0.5 mm</td> </tr> <tr> <td>a. Less than 1 mm</td> <td></td> </tr> <tr> <td>b. 1 mm to 2 mm</td> <td>$\pm 50\%$</td> </tr> <tr> <td>c. Above 2 mm</td> <td>± 1 mm</td> </tr> </table>	For Slice Thickness	0.5 mm	a. Less than 1 mm		b. 1 mm to 2 mm	$\pm 50\%$	c. Above 2 mm	± 1 mm	
For Slice Thickness	0.5 mm												
a. Less than 1 mm													
b. 1 mm to 2 mm	$\pm 50\%$												
c. Above 2 mm	± 1 mm												
2.	Accuracy of Operating Potential (kV)			± 2 kV									
3.	Total Filtration			1.5 mm Al for $kV \leq 70$ 2.0 mm Al for $kV \leq 100$ 2.5 mm Al for $kV > 100$									

4.	Accuracy of Timer			Percentage Error < 10 %	
5.	Linearity of Radiation Output (mA/ mAs Linearity)			CoL < 0.1	
6.	Reproducibility of Radiation Output			CoV < 0.05	
7.	Radiation Dose Test [Weighted Computed Tomography Dose Index (CTDI _w) for Head and Body Phantom]			± 20 % of Stated Values	
8.	Low Contrast Resolution			As per Technical Specifications Or 5.0 mm at 1% contrast	
9.	High Contrast Resolution			As per Technical Specifications Or 3.12 lp/cm	
10.	Radiation Leakage Level from X-ray Tube Housing (Measurement at maximum kVp and corresponding mA)			< 1mGy in one hour	

I hereby undertake that all the information provided above is correct and in accordance with the detailed Quality Assurance Report enclosed herewith.

Place:

Date:

Signature:

Name of the Service Engineer:

Name of Supplier/QA Agency:

Seal of Supplier/QA Agency:

#Signature of Institution's Representative:

Name of Institution:

Seal of the Institution:

Quality Assurance Tests Report shall be signed by Institution's Representative and duly stamped by the User's Institution.

Part-I MECHANICAL SAFETY TESTS FOR COMPUTED TOMOGRAPHY EQUIPMENT

A.1 Alignment of Table to Gantry

Result :

Tolerance : ± 5 mm

A.2. Accuracy of Gantry Tilt

Exposure Parameters : kVp: mAs:

Actual Gantry Tilt :

Measured Gantry Tilt :

Result :

Tolerance : $\pm 2^0$

A.3. Table Indexing Accuracy

Initial table position :

Load on couch :

Exposure parameters : kVp: mAs: Slice thickness:

Applied table increments :

Table position from reference position	1 cm	2 cm	3 cm	4 cm	5 cm
Measured					

Tolerance : ± 1.0 mm

PART-II RADIATION SAFETY TESTS OF COMPUTED TOMOGRAPHY EQUIPMENT

1. Slice Thickness / Radiation Profile Width:

Exposure Parameters: kVp: mAs:

Applied Slice Thickness (mm)	Measured Density Profile Width (FWHM)	Tolerance	
		For slice thickness	
		a. Less than 1 mm	0.5 mm
		b. 1 mm to 2 mm	± 50%
		c. Above 2 mm	±1 mm

2. Accuracy of Operating Potential:

Set kV	mA station I	mA station II	mA station III	Average kVp

Tolerance : ± 2 kVp

3. Total Filtration

Total Filtration (measurement at maximum kVp):

Tolerance: 1.5 mm Al for kV ≤ 70, 2.0 mm Al for kV ≤ 100, 2.5 mm Al for kV > 100

4. Accuracy of Timer :

Set Time	Observed Time	Percentage Error

Tolerance: Percent Error = $|\text{Observed value} - \text{Exact Value}| / \text{Exact value} * 100 < 10 \%$

5. Linearity of Radiation Output (Measurement of mA / mAs linearity)

Operating Parameters: kVp: Slice Thickness:

Radiation Output (μGy or mR)				μGy/mAs or mR/mAs (X)
mA / mAs	I	II	III	

$$\text{Coefficient of Linearity (CoL)} = \frac{X_{\max} - X_{\min}}{X_{\max} + X_{\min}}$$

Tolerance: $\text{CoL} < 0.1$

6. Reproducibility of Radiation Output

Operating Parameters : mAs:

Slice Thickness:

Operating Potential (kVp)	Radiation Output (μGy or mR)					Mean (X)	CoV
	1	2	3	4	5		

$$\text{Coefficient of Variation (CoV)} = X^{-1} [\sum (X_i - X)^2 / n - 1]^{1/2}$$

Tolerance: $\text{CoV} < 0.05$

7. Radiation Dose Test

Measurement of Weighted Computed Tomography Dose Index (CTDI_w)

Use pencil ionization chamber connected to a suitable electrometer, in conjunction with a head/body phantom. Measure the dose in the axial and peripheral cavities of the phantom for the techniques specified by the manufacturer.

Operating Parameters: kVp:

mAs:

Slice Thickness:

Result:

Head

Body

Axial dose : ----- mGy/mAs

-----mGy/mAs

Peripheral dose : ----- mGy/mAs

-----mGy/mAs

: ----- mGy/mAs

-----mGy/mAs

: -----mGy/mAs

-----mGy/mAs

: -----m Gy/mAs

-----mGy/mAs

Peripheral dose (Mean): -----mGy/mAs

-----mGy/mAs

CTDI_c : ----- mGy/mAs

-----mGy/mAs

CTDI_{p (mean)} : ----- mGy/mAs

-----mGy/mAs

$$\text{Weighted CTDI (CTDI}_w) = 1/3 \text{CTDI}_c + 2/3 \text{CTDI}_p$$

Workload = 500 mA-min in one hour for measurement of tube housing leakage

$$\text{Max leakage} = \frac{500 \text{ mA-min in one hour} \times \text{Max radiation leakage level (mR/hr)}}{60 \times \text{mA used for measurement}}$$

Maximum radiation leakage from tube at 1m = ----- mR in one hour

Result: Maximum radiation leakage at 1 meter from the focus of CT Tube is mGy in one hour.

Recommended upper limit: Radiation leakage at 1 meter from the focus of CT tube should not exceed 1mGy in one hour (115 mR in one hour).

11. Details of Radiation Protection Survey of the Installation

Date of radiation protection survey:

Whether radiation survey meter used for the survey has valid calibration certificate: Yes/No

Phantom: CTDI Body Phantom

Workload of the CT facility: ----- mA-min/week

Exposure Setting:-

Applied Voltage (kV):

Tube Current (mA):

Exposure Time(s):

Location	Measured radiation level (mR/hr)
Control Console (Operator Position)	
Outside Patient Entrance Door	
Behind Windows (if applicable)	
Patient Waiting Area	

$$\text{Maximum Radiation level/week (mR/wk.)} = \frac{\text{----- mA-min/week} \times \text{Max radiation level (mR/hr)}}{60 \times \text{mA used for measurement}}$$

Permissible limit

For location of Radiation Worker: 20 mSv in a year (40 mR/week)

For Location of Member of Public: 1 mSv in a year (2 mR/week)