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QUALITY ASSURANCE TESTS FOR PET-CT / PET-MR/ PET IMAGING EQUIPMENT

RADIOLOGICAL SAFETY DIVISION
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Quality Assurance Tests for PET-CT/ PET-MR/PET Imaging Equipment

Institute Name	
Institute number in eLORA	
Installation ID in eLORA	
Details of PET-CT / PET-MR/ PET	
Type of Equipment(PET-CT / PET-MR/ PET)	
Manufacturer of the equipment	
Model name of the equipment	
The type/name of crystal used	
The number of crystals	
The number of rings of detectors	
CT component details of PET-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 PET component

1. Spatial resolution (FWHM & FWTM) in 2D and 3D modes (as applicable*) at the centre:-

Description	2 D Mode			3D Mode		
	Measured (mm)	Reference (mm)	Tolerance	Measured (mm)	Reference (mm)	Tolerance
FWHM in Tangential Direction			≤ 1.05 of Reference			≤ 1.05 of Reference
FWHM in Radial Direction			≤ 1.05 of Reference			≤ 1.05 of Reference
FWHM in Axial Direction			≤ 1.05 of Reference			≤ 1.05 of Reference
FWTM in Tangential Direction			≤ 1.05 of Reference			≤ 1.05 of Reference
FWTM in Radial Direction			≤ 1.05 of Reference			≤ 1.05 of Reference
FWTM in Axial Direction			≤ 1.05 of Reference			≤ 1.05 of Reference

* Please indicate NA in case a particular mode is not applicable

Note: The ratio between FWTM and FWHM should be in the range 1.8–2.0 if the manufacturer reference value is not available for the same

2. Spatial resolution (FWHM & FWTM) in 2D and 3D modes (as applicable*) at 10cm from the central axis:-

Description	2 D Mode			3D Mode		
	Measured (mm)	Reference (mm)	Tolerance	Measured (mm)	Reference (mm)	Tolerance
FWHM in Tangential Direction			≤ 1.05 of Reference			≤ 1.05 of Reference
FWHM in Radial Direction			≤ 1.05 of Reference			≤ 1.05 of Reference
FWHM in Axial Direction			≤ 1.05 of Reference			≤ 1.05 of Reference
FWTM in Tangential Direction			≤ 1.05 of Reference			≤ 1.05 of Reference
FWTM in Radial Direction			≤ 1.05 of Reference			≤ 1.05 of Reference
FWTM in Axial Direction			≤ 1.05 of Reference			≤ 1.05 of Reference

* Please indicate NA in case a particular mode is not applicable

Note: The ratio between FWTM and FWHM should be in the range 1.8–2.0 if the manufacturer reference value is not available for the same

3. **Sensitivity in 2D and 3D modes (as applicable*)**:-

Description	Measured	Reference	Tolerance
Sensitivity in CPS/(Bq/ml) for 2 D Mode			≥ 0.95 of Reference
Sensitivity in CPS/(Bq/ml) for 3 D Mode			≥ 0.95 of Reference

* Please indicate NA in case a particular mode is not applicable

4. **Scatter Fraction in 2D and 3D modes (as applicable*)**:-

Description	Measured	Reference	Tolerance
Scatter Fraction (2 D Mode) in %			≤ 1.05 of Reference
Scatter Fraction (3 D Mode) in %			≤ 1.05 of Reference

* Please indicate NA in case a particular mode is not applicable

5. **Noise Equivalent Count Rate (NECR) in 2D and 3D modes (as applicable*)**:-

Description	2 D Mode			3D Mode		
	Measured	Reference	Tolerance	Measured	Reference	Tolerance
Peak NECR (kcps) in 2 D Mode			≥ 0.95 of Reference			≥ 0.95 of Reference
Activity (MBq) at which Peak NECR is achieved in 2D mode			≥ 0.95 of Reference			≥ 0.95 of Reference
Peak NECR (kcps) in 3 D Mode			≥ 0.95 of Reference			≥ 0.95 of Reference
Activity (MBq) at which Peak NECR is achieved in 3D mode			≥ 0.95 of Reference			≥ 0.95 of Reference

6. **Energy resolution**:-

Description	Measured	Reference	Tolerance
Energy resolution			≤ 1.05 of Reference

7**. Image quality, accuracy of attenuation & scatter correction and accuracy of radioactivity quantitation**:-

Description	Measured	Reference	Tolerance
Image quality			
The percent contrast for each hot sphere			± 5% of Reference
The percent contrast for each cold sphere			± 5% of Reference
The percent background variability			± 5% of Reference
Accuracy of attenuation and scatter corrections			
Percent relative error for each slice in lung slice			± 5% of Reference
Accuracy of radioactivity quantitation			
Radioactivity concentration in MBq/ml			± 5% of Reference

8. Coincidence timing resolution for TOF positron emission tomography (as applicable*):-

Description	Measured	Reference	Tolerance
Timing FWHM (Resolution Timing)			≤ 1.05 of Reference

* Please indicate NA in case not applicable

9. **Non-Uniformity of the reconstructed image**:-

Description	Measured	Reference	Tolerance
Mean non-uniformity (% NU)			≤ 1.05 of Reference
Coefficient of variation			
Standard Deviation (SD)			

10. **Normalization**: -

Description	Observation	Tolerance
Whether uniformity observed in the normalization sinogram	Yes/No	Observance of Uniformity in the sinogram

11. **Accuracy of PET/CT image registration**:-

Description	Measured	Reference	Tolerance
Registration Value for 512x512 matrix			±1 pixel (or ±1 mm, whichever is smaller)

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:
Date:

Signature:
Name of the Service Engineer:
Name of Supplier/Manufacturer:

Seal of Supplier/ Manufacturer:

Date: Signature:
Name of Nuclear Medicine Technologist:

Date: Signature:
(Licensee, Nuclear Medicine Facility)

Seal of the institute

Document to be attached:

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

Reference documents:

1. National Electrical Manufacturers Association. "NEMA Standards Publication NU 2-2001: Performance Measurements of Positron Emission Tomographs," USA, 2001.
2. National Electrical Manufacturers Association. "NEMA Standards Publication NU 2-2007: Performance Measurements of Positron Emission Tomographs," USA, 2007.
3. International Atomic Energy Agency. "IAEA Health Human Series No. 1: Quality Assurance for PET and PET/CT 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)			For Slice Thickness a. Less than 1 mm b. 1 mm to 2 mm c. Above 2 mm	 0.5 mm ± 50% ±1 mm	
2.	Accuracy of Operating Potential (kV)			±2 kV		
3.	Total Filtration			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			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 = |Observed value – Exact Value| / 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	

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

Tolerance: 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		

Coefficient of Variation (CoV) = $X^{-1} [\sum (Xi - X)^2 / n-1]^{½}$

Tolerance: CoV < 0.05

7. Radiation Dose Test
Measurement of Weighted Computed Tomography Dose Index (CTDIw)

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

Weighted CTDI ($CTDI_w$) = 1/3 $CTDI_c$ + 2/3 CTDIp

$CTDI_w$: ---------- mGy/mAs for Head Phantom
---------- mGy/mAs for Body Phantom

Tolerance : ± 20% of the quoted value (Expected)
± 40% of the quoted value (maximum)

8. Low Contrast Resolution

Phantom: CT Imaging Phantom

Operating Parameters : kVp: mAs: Slice Thickness:
Window width:
Result:

Low contrast resolution: ---------- mm at -------- % contrast difference

Tolerance : As per Technical Specification
Or
5.0 mm at 1% contrast difference (minimum)
2.5 mm at 0.5 % contrast difference (expected)

9. High Contrast Resolution

Phantom: CT Imaging Phantom

Operating Parameters : kVp: mAs: Slice Thickness:

Window width: Use high resolution algorithm.
Result :

Size of the smallest resolvable bar/hole pattern: ----------mm (-------- lp/cm)

Tolerance: As per Technical specification
Or
At 10% contrast difference the size of the bar/hole pattern that could be resolvable should be 1.6 mm (≈ 3.12 lp/cm).
Expected high contrast resolution: 0.8 mm (≈ 6.25 lp/cm)

10. Radiation Leakage Level from X-ray Tube Housing

Operating Potential: kV: mA: Sec:
(Use maximum kV available in the CT unit for leakage measurement)

Radiation Leakage Level (mR/hr)			
Front	Back	Left	Right

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

Max leakage = 500 mA-min in one hour X ----Max radiation leakage level (mR/hr)
60 X -----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	

Maximum Radiation level/week (mR/wk.) = ----- mA-min/week X ----Max radiation level (mR/hr)
60 X -----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)