ACCEPTANCE TESTS OF A NEW GAMMA CAMERA

S. Taştan, K.M. Kır, N.Ö. Küçük, S. Tunca, B. Şahin, A. Akın
Ankara University Medical Faculty Department of Nuclear Medicine, Ankara, Turkey
E-mail address of main author: selmatastanc@yahoo.com

1. INTRODUCTION

Scintigraphic studies are carried out to get clinical information related to the disease state and diagnosis. It is important to perform acceptance tests during first establishment and further periodical validation of gamma cameras in order to have a reliable results. Also, for best possible patient service, a quality assurance program is needed to produce quantitatively/qualitatively data and keep records of the results and of equipment faults. New Gamma Cameras must be checked against the manufacturer's specifications and service manual must be used to do this.

In this study, Acceptance tests was done to the new gamma camera in my department. It is General Electric Millennium MG system with two rectangular detectors, two collimators. One of them is low energy general purpose (LEGP) and the other one is medium energy general purpose (MEGP). MG gantry allows the detector to be oriented in the 180 and 101.25 degrees positions. The detectors are designed to use 3" square PMTs and the rectangular detector has outside dimensions of 690x590 mm with a FOV of 520x370 mm and 48 PMTs.

2. MATERIAL METHODS

All intrinsic calibrations and corrections were done by the service engineer at installation. These are;

1. PM Tune: a first step, a basic alignment of the PMTs is necessary. The High Voltage(HV) is adjusted in steps, going from a relatively low value and upwards.
2. Dynamic Correction (Dyncor): Since the default Dyncor Gain values do not give adequate image quality, the Dyncor is necessary.
3. Energy Calibration: It ensures that the digital representation of the energy spectrum matches window selections and the spectrum display. The calibration is based on a number of known isotope peaks exposing the detector.
4. Geometric Calibration: It adjusts the image geometry for symmetry and uniform spatial registration over the energy range.
5. Energy Correction: It is a spatially related energy correction map in a 256x256 format. The map is generated based on relative count rate information in two energy windows, one each side of the chosen isotope peak.
6. Linearity Correction: It consists of two spatial related position correction maps, done for the X direction and done for the Y direction. The maps are generated from two images acquired with X and Y linearity phantoms respectively.
7. Second Order Corrections: The detector is always calibrated with a basic isotope, such as Tc99m or Co-57. Application of additional isotopes requires a specific spatial correction for each additional isotope.

After installation, calibrations and corrections, a close physical inspection of the mechanical and electrical safety aspects of the cameras were done by the responsible physicist of the department. Planar system is based on measurement of system uniformity and resolution/linearity. Additional multiple window spatial registration. All tests procedures were performed by the manufacturer is called NEMA tests [2]

Intrinsic Uniformity: NEMA uniformity was done first by using the service manual [2]. It was used ~37 MBq Tc99m, 20 % energy window, 10-30 counts/second activity ,40 Million counts and it was set up the source approximately 1.5-2.0 meters from the detector. Another isotope uniformities were acquired with I-131,Tl-201 and Ga-67. They were evaluated qualitatively and quantitatively, but nonuniformities were observed, especially for detector II, The service engineer repeated all tests and made necessary corrections. We then repeated all the intrinsic uniformity tests. NEMA Uniformity values are given in table I. Other isotopes' uniformity values are given in Table II. Tc99m intrinsic image were also performed 5 million counts at ,"no correction", "no energy correction", "no linearity correction", "all correction" and "± 10 % off peak" modes and compared.

	Detector I	Detector II	Manufacturer's specifications
CFOV Integral	2.4 %	2.8 %	≤ 3.0
CFOV Differential	1.2 %	1.6 %	≤ 2.0
UFOF Integral	4.1 %	4.0 %	≤ 3.5
UFOV Differential	1.8 %	2.1 %	≤ 2.5

Table 1. NEMA Uniformity Values for detectors

	I-131		Tl-201		Ga-67	
	Detector I	Detector II	Detector I	Detector II	Detector I	Detector II
CFOV Integral	4.53 %	5.03 %	3.43 %	4.20 %	5.42 %	5.31 %
CFOV Differential	2.91 %	2.44 %	2.37 %	2.80 %	3.45 %	3.02 %
UFOF Integral	5.26 %	5.27 %	4,17 %	5,22 %	6.21 %	6.42 %
UFOV Differential	3.40 %	3.25 %	3.00 %	3.33 %	3.15 %	3.18 %

Table 2. I-131, Tl-201 and Ga-67 Uniformity Values for Detectors

Extrinsic uniformity: At the beginning, camera's the collimators were checked for defects visually and Co-57 sheet source check was done (LEGP; MEGP collimators, 128x128 matrix, 120 Million counts). Single defect was observed in one of LEGP collimators. This collimator was replaced by the manufacturer (Image I and Image II). Collimator test was also done by a point source at 10 million counts for each collimators. Images from both of collimators show the expected pattern of counts, indicating that the holes are perpendicular and parallel [3].

Resolution and Linearity: Quantitatively measurement of intrinsic resolution and linearity were done by NEMA linearity phantom [2]. An activity of 185 MBq Tc99m was used with 20 % energy window, 10-30 kcounts/second with both X-Direction and a Y-Direction NEMA phantom. The acquisition was set up the source approximately 1.5-2.0 meters from the detector. Resolution and linearity values were good and it was within the manufacturer's specifications limits. These are given in Table III, Table IV. Qualitatively intrinsic and extrinsic resolution test were done using bar quadrant phantom with point source, Co-57 sheet source respectively. Quantitatively extrinsic resolution by done two capillary tubes (inner diameter 1 mm) with 512x512 matrix, zoom: 2, X and Y directions, 2 million counts. FWHM was then calculated by a computer programme [1]. They are given in Table V

NEMA Resolution	Detector I	Detector II	Manufacturer's specifications
CFOV FWHM	3.7 mm	3.8 mm	≤ 3.9 mm
CFOV FWTM	7.1 mm	7.2 mm	≤ 7.6 mm

Table 3. NEMA Resolution Values

NEMA Linearity	Detector I	Detector II	Manufacturer's specifications
CFOV Absolute	0.5	0.5	≤ 0.5
CFOV Differential	0.1	0.1	≤ 0.2

Table 4. NEMA Linearity Values

	LEGP	LEGP
	Det 1	Det2
Vertical 5 cm	6.88 mm	6.95 mm
Horizontal 5 cm	7.11 mm	7.15 mm
Vertical 10 cm	9.42 mm	9.58 mm
Horizontal 10 cm	9.48 mm	9.68 mm

	MEGP	MEGP
	Det 1	Det2
Vertical 5 cm	7.17 mm	7.22 mm
Horizontal 5 cm	7.26 mm	7.25 mm
Vertical 10 cm	11.72 mm	12.05 mm
Horizontal 10 cm	11.96 mm	12.15 mm

Table 5. Extrinsic Resolution Values for LEGP and MEGP Collimators

Multiple Window Spatial Registration; Quantitatively analysis was performed using the NEMA method in the acquisition system which was developed by manufacturer. Highly collimated multiple energy point source (Ga-67) to be placed at the marked position on the detector and nine position have been acquired [2]. Maximum result in mm value is given in Table VI

Multiple Window Spatial Registration	Maximum result in mm	Manufacturer's specifications
Detector I	2.1 mm	≤ 2.0
Detector II	2.1 mm	≤ 2.0

Table 6. MWSR values

System Sensitivity was obtained by using 3 mm thickness petri dish and then it was calculated at 140 keV, 20 % energy window in the units of (count/second)/MBq, surface on the each collimator at the 10 cm height [1]. It is given in Table VII. Maximum count rates of detectors were measured and they were found as 246 kc/s, 250 kc/s, detector I and detector II respectively.

Collimator	Detector I	Detector II
LEGP	142.18 (cnt/sec)/MBq	144.71 (cnt/sec)/MBq
MEGP	129.50 (cnt/sec)/MBq	132.45 (cnt/sec)/MBq

Table 7. Sensitivity Values

Whole Body: Whole body scan was done with Co-57 sheet source. The poor images obtained at the beginning became better after the PMT gain adjustment and corrections were done by the service engineer [3].

Pixel Size was obtained by using 20 cm line source, at 5 cm height and it was done at 140 keV, 20 % energy window [1], then it was calculated for all of the matrix. They are given in Table VIII

	64x64	128x128	256x256	512x512
Det 1	8.40 mm	4.28 mm	2.14 mm	1.08 mm
Det 2	8.40 mm	4.28 mm	2.14 mm	1.08 mm

Table 8. Pixel Size Values

Tomography System is based on measurement of resolution, uniformity and center of rotation. Accurate center of rotation is important for high quality tomography. It was done with point source and it was within the acceptable limits [2]. System performance; An overall assessment of system performance was obtained by Jaszczak phantom. The phantom was filled with 444 MBq Tc99m activity. It was imaged under ideal conditions, i.e. minimum radius of rotation, LEGP collimator, 128x128 matrix, with 120 views and one

million counts/view, zoom 1.0 and zoom 1,33. All of conditions were taken from service manual [2]. After acquisition, reconstructions were done by using ramp, hanning filter with cut off 1,0. Chang's attenuation correction was used at threshold: 20 and coefficient: 0.105 setting and single pixel thick slices through the uniform section of the phantom was evaluated [2]. In spite of uniformity correction, ring artifact was observed. Resolution elements were evaluated for tomographic resolution; it was evaluated for zoom 1.0. But for zoom 1,33 "+" shaped artifact in of the sagittal and coronal slices was observed. Uniformity was performed with Co-57 sheet source at zoom 1,33. "+" shaped artifact insisted. The service engineer couldn't help and the production manager decided that they had a software problem for zoom 1,33. After they have developed new software, all tomographic acquisitions were repeated. No artifacts were observed.

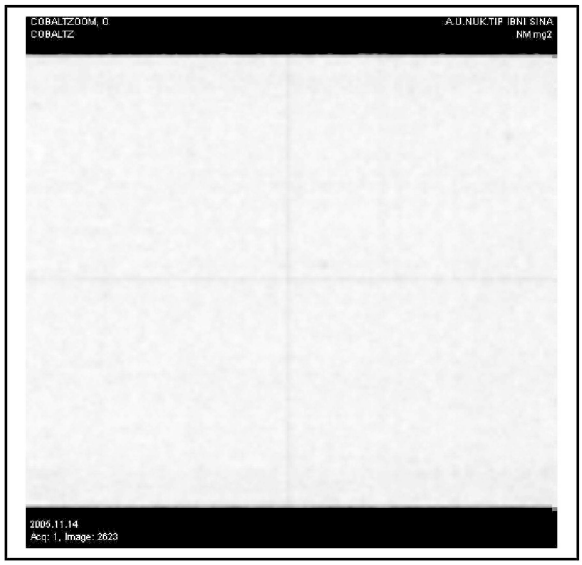


Image I. LEGP Collimator Defects and "+" shaped artifact, zoom: 1.33

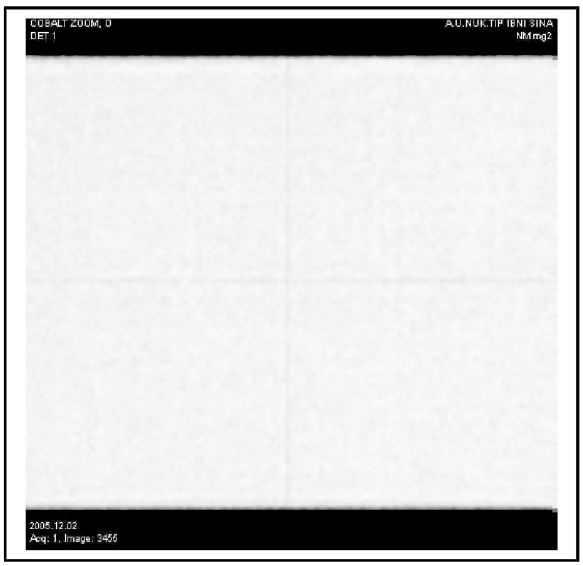


Image II. LEGP Collimator no Defects

3.CONCLUSION

The acceptance tests performed on a General Electric MG system with two detectors, two collimators gamma camera and were found within specified limits by the manufacturer except a "+" shaped artifact due to a software problem. This study emphasizes the importance of acceptance tests in the for a quality assurance program a newly acquired gamma camera in addition to the installation and calibrations/corrections studies done by the service engineer.

4.REFERENCES

1. Quality Control, Instrumentation and Radiation Safety Committee Draft, TURKEY

2. Millennium MG Nuclear Medicine Imaging System Service Manual, GE Medical Systems

3.IAEA Quality Control Atlas for Scintillation Camera System, IAEA 2003