The NEMA standards also advocate that a minimum of 4000 counts be accumulated in the center pixel for uniformity measurements. We investigated the reproducibility of uniformity measurements at increasing count densities and have found that one can achieve consistent estimates of the best uniformity achievable only when the counts in the center pixel exceed 8000 (Fig. 1). Measurements made with several different scintillation cameras all resulted in curves similar to those shown in Fig 1. Note that the uniformity values decrease as the count density increases and, though it represents a somewhat arbitrary cut-off, a value of 8000 counts in the center pixel will give uniformity values that represent the best performance of the camera. This may require that as many as 30–40 million total counts need to be collected in the flood-field image and, though this may well be regarded as excessive for routine quality control (*12*), it is a small price to pay when an acceptance test is being made or as a less frequent, but more rigorous, periodic quality-control test giving a numerical result. Flood-field images of 30 million counts have also been recommended for SPECT calibration (*13,14*).

NEMA standards are gradually being used by manufacturers for the specification of scintillation-camera performance. However, they are by no means fully implemented and it would therefore be advisable for users to ascertain under what measurement conditions performance specifications for their camera were obtained. For example, in addition to differential uniformity discussed above, other questions arise: were all, or only some, specifications obtained with uniformity-correction circuitry in action? Or were specifications of maximum count rate actually obtained without repeaking the analyzer window as required by the NEMA protocol? Because some manufacturers use their own protocols for final acceptance testing of their product before shipment, it is possible that acceptance testing at the user site using the NEMA protocols may result in measurements at variance with the manufacturer's specifications.

In conclusion, those using the NEMA standards to quantitate scintillation-camera performance are strongly urged to examine closely the full document (NU 1-80) on performance measurements and to be aware of pitfalls when comparing results with those of others. Differential uniformity should be calculated over a six-pixel range and the maximum differential uniformity determined and reported. Accuracy and reproducibility of the uniformity measurement become assured only at a minimum pixel count density of 8000 counts per pixel.

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REFERENCES

1. National Electrical Manufacturers Association: Standards Publication Nu 1-80. Performance Measurements of Scintillation Cameras, Washington DC, NEMA, 1980
2. MUEHLLEHNER G, WAKE RH, SANO R: Standards for performance measurements in scintillation cameras. *J Nucl Med* 22:72–77, 1981
3. Quality Assurance in Nuclear Medicine, World Health Organization, Geneva, 1982
4. American Association of Physicists in Medicine: Scintillation Camera Acceptance Testing and Performance Evaluation. AAPM Report No 6, American Institute of Physics, New York, 1980
5. HASEGAWA BH, KIRCH DL: The measure of a camera—pathways for future understanding. *J Nucl Med* 22:78–81, 1981
6. HIDALGO JU: Re: Standards for performance measurements in scintillation cameras. *J Nucl Med* 22:833, 1981
7. FINNEY C, HORN B, LUK K: The use of the NEMA standard for in-field acceptance testing of scintillation cameras. In *Nuclear Medicine and Biology, Proceedings of the Third World Congress of Nuclear Medicine*, Vol 4, Pergamon Press Paris, 1982, pp 2909–2911
8. RAIKUR UR, SONI PS, SAROJINI C, et al: New Quality Assurance Measures for Scintillation Cameras in Indian Environment. In *Proceedings World Congress on Medical Physics and Biomedical Engineering*, MPBE, Hamburg, 1982, No. 21.13 (abst)
9. NOSIL J, ROJEK H: Scintillation camera uniformity as a function of gamma ray energy. In *Proceedings World Congress on Medical Physics and Biomedical Engineering*, MPBE, Hamburg, 1982, no. 21.19 (abst)
10. SMITH AH: Proceedings of HPA Conference on Quality Assurance of Nuclear Medicine Instrumentation, London, Feb, 1983 (in press)
11. BUSEMANN-SOKOLE E, CRADDUCK TD: Effect of camera uniformity on ejection fraction measurements. *J Nucl Med* 24: 1983 (abst)
12. ROLLO FD: Quality assurance in nuclear medicine. In *Nuclear Medicine Physics, Instrumentation, and Agents.* Rollo FD, Ed. St. Louis, CV Mosby Co., 1977, pp 322–360
13. TODD-POKROPEK A: Quality control, detection and display. In *Radionuclide Imaging.* Kuhl DE, Ed. Paris, Pergamon Press, 1982, pp 27–76
14. ROGERS WL, CLINTHORNE NH, HARKNESS BA, et al: Field-flood requirements for emission computed tomography with an anger camera. *J Nucl Med* 23:162–168, 1982

The London Liver Phantom

Various organ phantoms have been developed for specific purposes; e.g., the thyroid phantom was useful with rectilinear scanners, and the brain and liver phantoms developed by the College of American Pathologists are very suitable for interlaboratory comparison studies and self-evaluation of laboratory technique. For assessment of clinical performance and instrumentation quality control, accurate simulation of an organ demands that the phantom be three dimensional and provide the advantages of realism and the facility to exercise practical techniques.

The London liver phantom (*1*) is useful in several areas: (a) to study the dependence of tumor resolution on lesion size and depth within the liver with variable tumor sizes and positions, using the variant of the phantom; (b) as a routine total performance quality control test phantom with tumors fixed in specified position within the liver (Fig. 1.); (c) for the study of fixed tumor sizes and positions in an interlaboratory comparison program, such as that undertaken by the Department of Health and Social Security (DHSS) (*2*) in the United Kingdom in 1976–1977, planned by WHO (*3*) in 1980 and is now in the process of analysis, and the program currently being undertaken in the United Kingdom by the DHSS as an extension of the work of Elliott, Short, Potter, and Barnes (*4*); and (d) to study ECT performance.

The purpose of this communication is to acquaint the nuclear medicine community with this liver phantom so that it can be made more readily available.* A *standard version*, which has been distributed by IAEA to several recognized nuclear medicine facilities in Latin America and Southeast Asia, is illustrated in Fig. 1. It contains three simulated tumors of various sizes and locations as follows: 2 cm on the anterior surface of the left lobe; 3 cm at the center of the posterior surface of the right lobe; and 2 cm on the

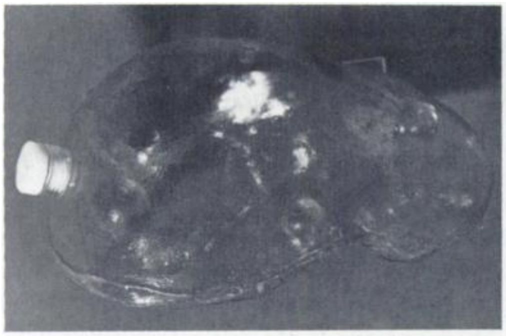

FIG. 1. **Standard version of London liver phantom containing three simulated tumors using solid plastic spheres. Screw-threaded plastic cap is on lateral aspect of right lobe for easy filling and emptying of liver shell.**

posterior surface in the region of the porta hepatis. The hard plastic liver shell containing the solid plastic sphere lesions is mounted on a plastic stand in the correct anatomical orientation. A plastic water tank, cross-section 30 cm by 30 cm and depth of 18.5 cm, is necessary to simulate the abdomen. The water level in such a tank is 1 cm above the top surface of the liver shell and 0.5 cm below the top of the tank. A plastic lid for the tank is advisable to prevent water splashing onto the collimator face—particularly important if a small amount of background activity has been introduced into the water. The emission-type phantom should be filled with water containing approximately 1 mCi technetium-99m activity. The alternative variant of the phantom is one without the plastic stand and water tank but instead uses a tissue equivalent rubber abdomen (*2,3*). This variant is suitable for interlaboratory comparison studies, and the liver shells can be covered with an opaque paint to ensure that the study is *blind* (*2,3*). Nonstandard variants can be constructed with different tumor sizes and locations.

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FOOTNOTE

* The phantom can be obtained directly from the Department of Medical Physics, Page Street Wing, Westminster Hospital, at the cost of materials and postage only.

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REFERENCES

1. MOULD RF: A liver phantom for evaluating camera and scanner performance in clinical practice. *Brit J Radiol* 44: 810–811, 1971
2. POTTER DC, MCCREADY VR, MOULD RF, et al: (DHSS Working Party Members): A survey of some radionuclide imaging instruments with an anthropomorphic liver phantom. DHSS publication STB/3/78, London, 1978
3. World Health Organisation: Quality assurance in nuclear medicine: A guide prepared following a workshop held in Heidelberg, Federal Republic of Germany, 17–21 November, 1980. WHO publication, Geneva, 1982, pp 52–53
4. ELLIOTT AT, SHORT MD, POTTER DC, BARNES KJ: Performance assessment of gamma cameras, Part 1. DHSS publication STB/11/80, London, 1980

BOOKS RECEIVED

Noninvasive Methods in Atherosclerosis Research (Atherosclerosis Reviews, Volume 10). Ruth Johnsson Hegyeli, Ed. New York, NY, Raven Press, 1983, 214 pp, $39.50

Nuclear Power: Management of High-Level Radioactive Waste. World Health Organization. Copenhagen, Denmark, World Health Organization, 1982, 63 pp, $5.00

The Coronary Circulation in Health and Disease. Melvin L. Marcus. New York, NY, McGraw-Hill, 1983, 465 pp, $45.00

The Human Cost of Nuclear War. Stephen Farrow, Alex Chown, Eds. Cambridge/Llandaff, Cardiff, United Kingdom, The Medical Campaign Against Nuclear Weapons (MCANW), 1983, 164 pp, £1.95

CRC Handbook of Chemistry and Physics (64th Edition 1983–1984). Robert C. Weast, Melvin J. Astle, William H. Beyer, Eds. Boca Raton, FL, CRC Press, 1983, 2303 pp, $69.95

Gamuts in Nuclear Medicine. Frederick L. Datz. Norwalk, CT, Appleton-Century-Crofts, 1983, 289 pp, $22.50