Letters to the Editor

Use of NEMA Protocols for Routine Quality Assurance

TO THE EDITOR: Because we have used the NEMA protocols—and particularly these for scintillation-camera uniformity—in several experiments (*1-3*) we read the paper by Raff, Spitzer, and Hendee (*4*) with considerable interest.

Several points arise that we feel need further discussion. Raff et al. correctly point out that the NEMA requirement for 4000 counts per pixel implies a flood image of the order of 12 million counts total, much more than the normally accepted 1 to 3 million counts routinely used for this parameter. Our own work (*5*) has shown that even the NEMA count level is inadequate to provide an image sufficiently free of random variations to reflect the cameras actual uniformity value. We concluded (*5*) that 8 to 10k counts per pixel were necessary before the measured uniformity (either integral or differential) reached a minimum value. This implies a flood image of about 40 million counts total. Thus the NEMA requirement of 4000 counts per pixel represents a deficiency in the protocol for uniformity measurement.

This deficiency is further evidenced by Fig. 2 of Raff et al. The daily uniformity measurements show considerable fluctuation. The authors suggest that the precipitous decreases can be attributed to field service. This does not explain the equally precipitous increases within the next few days, and it seems more likely that these variations are of a random nature. The error bars shown in our own Fig. 1 (*5*) indicate that variations of this order of magnitude may be expected at count levels of 4000 per pixel.

Another deficiency that became apparent to us was the ambiguity regarding the algorithm used to define differential uniformity. The difficulty is that the NEMA protocols are not clear as to whether one should use a five- or a six-pixel spread for calculation of this parameter. It appears that Raff et al. also recognized this ambiguity, but that they were unable to resolve it to their satisfaction. The ambiguity is clarified in Appendix A of the full NEMA standards publication (*6*), where it is stated that a range of six pixels is to be used.

The general thrust of the paper by Raff et al. is that the NEMA protocols can, and should, be adopted for routine quality assurance purposes. There is some merit to tthis because of the traceability of the NEMA-based measurements, but the result of a workshop, sponsored by the Federal Government of Germany in conjunction with the World Health Organization (WHO) and held in Munich in November 1983, tends to contradict this conclusion (*7*).

The objective of the Munich workshop was to compare the various protocols suggested by the WHO (*8*), the International Atomic Energy Authority (IAEA) (*9*), the Hospital Physicists' Association (HPA) (*10,11*), and the American Association of Physicists in Medicine (AAMP) (*12*), with a view to revising (if necessary) the document published by the WHO in 1982 (*8*). After putting the various protocols into practice, the workshop participants formulated a somewhat modified concept of quality control (QC). Rather than establishing rigorous QC schedules similar to those suggested by Raff et al. in their Table 1, and by the various organizations cited above (*8-12*), the workshop felt that recognition should be given to the fact that QC depends to a great extent on a continual state of awareness by the individuals involved. It was suggested that one total-system performance check (such as uniformity) should be performed daily and that other, more sophisticated, procedures should be used only in a decision-tree structure to isolate problems indicated by the simpler test, orr after major system overhauls or updates. QC procedures must be simple so that they can be performed in departments lacking sophisticated equipment and will not be neglected in busy departments that may have the equipment, but lack the time required.

It is generally acknowledged (*5,13*) that degradation of uniformity acts as a precursor to degradations in intrinsic resolution and linearity. On this premise the Munich workshop suggested that a uniformity check using either a point source (intrinsic) or a flood phantom (extrinsic) and the corresponding analog image would serve as the simplest and most expedient means of checking overall system performance, including the film processor. For those instances where experience dictates that more rigorous surveillance of intrinsic resolution is necessary, they advocated a weekly check of this parameter using some form of bar phantom.

It is true that many departments, particularly in North America and Europe, do have some form of computer-processing capability. This situation does not, however, apply in many other departments throughout the world. As a result, a simple QC check that depends upon critical visual evaluation rather than quantitative analysis is imperative. It is equally important that QC must never become the practice of a set of procedures that are performed by rote, with no subsequent appraisal, merely because 3, 6, or 12 mo have passed.

It would be very desirable if "action thresholds" could be placed on various parameters so that equipment could be withdrawn from service at some point when its performance is deemed unacceptable. The IAEA has suggested that a 10% variation on a performance parameter could reasonably be used as such an action threshold (*9*). There is, however, very little information currently available on the degree of degradation of performance that will affect an experimental result or, ultimately, a clinical diagnosis. Action thresholds should be established and acted upon in the light of local circumstances according to the performance parameter in question.

We commend Raff et al. in their efforts to regularize QC procedures so that the results can be compared with the manufacturer's NEMA specifications, but we caution against the establishment of QC procedures so rigorous that they occupy as much as 5 hr per months in addition to the routine 15-30 min per day (Ref. *5*, Table 1). Such a schedule would, in effect, take a camera out of service for almost a whole day and this would, we are sure, be unacceptable in most busy departments—particularly when such tests are unlikely to yield information that will result in substantial clinical benefits.

References

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REPLY: In response to the letter from Drs. Cradduck and Busemann-Sokole, we offer the following comments:

Our paper does not address any specific deficiencies of the NEMA standards. Our goal was to demonstrate that a set of traceable standards could be used for daily quality assurance. Other papers (*1,2*) have addressed deficiencies and recommended changes in the standards; these changes would not influence the measurements discussed in our paper (3).

TABLE 1
Integral and Differential Uniformity in % Using NEMA Definition (GE-400 AT)

Integral uniformity		Differential uniformity	
UFOV	CFOV	UFOV	CFOV
5.77 ± 0.37	4.39 ± 0.35	4.35 ± 0.44	2.6 ± 0.17

Drs. Cradduck and Busemann-Sokole identify certain topics (count density of the flood image and ambiguity about the number of pixels to be used in the calculation of the differential uniformity) that they believe are deficiencies of the NEMA protocol. In Fig. 1 of their reference it is difficult to detect an absolute minimum for integral uniformity. Our data reveal an uncertainty of 6% or less in the integral uniformity at 4000 counts/pixel. These data are presented in Table 1, where 18 uniformity measurements are reported for the same camera.

The daily monitoring of differential and integral uniformity revealed considerable fluctuations (up to 11%), as described in Fig. 2 of our paper. No more than 1% of the fluctuation in integral uniformity is attributable to random variation. In our paper we mention possible deficiencies in the NEMA description of differential uniformity under Ref. *19*. Whether the differential uniformity is computed from five or six pixels does not influence the practicality of the computation.

We agree that one major performance check (uniformity) should be performed daily and that other procedures can be performed less frequently, but we disagree that it should be done preferably according to a decision-tree structure. One drawback of this approach is the subjective nature of the decision to initiate additional performance tests. Tests of parameters such as linearity and resolution are not difficult if one or a few NEMA phantom images are analyzed by computer. We believe that a department should be able to spare 5 hrs monthly for quality-assurance work in addition to the 15–30 minutes designated daily for routine monitoring.

In our paper we are concerned with NEMA standards (4) that have been established for U.S.A. manufacturers of imaging equipment. Our recommendation is that NEMA protocols be adopted for quality assurance and acceptance testing of cameras that carry NEMA-based performance specifications. We disagree that visual evaluation of a flood image is imperative, especially if uniformity can be monitored with a simple number in a manner traceable to NEMA. The latter approach is much more likely to reveal a degradation in performance before the performance becomes a detriment to the diagnostic process.

References

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