Film Processors in Nuclear Medicine

Lisa Cyr, Debbie Dick, Walter Huda, and Sherry O'Connor

Health Sciences Centre, St. Boniface General Hospital; and the Manitoba Cancer Treatment and Research Foundation, Winnipeg, Manitoba, Canada

The film processor is probably the most important component of the nuclear medicine imaging chain, but it is often neglected in departmental quality assurance (QA) activities. This article reviews the essential components of a QA program for film processors in a typical nuclear medicine department.

Film processing is a critical step in the nuclear medicine imaging chain. The imaging process begins with the preparation of the radiopharmaceutical and its administration to the patient. It then continues with the imaging procedure using the scintillation camera, which is often associated with data processing by a computer, and concludes with film viewing and interpretation. The importance of the film processor in the imaging chain has been widely recognized and is generally considered to be a key component in a conventional radiology department (*1*). Considerable effort has been applied to develop quality assurance (QA) procedures for radiopharmaceuticals, dose calibrators, scintillation cameras, and computers (*2–4*). The film processor, however, is frequently ignored in the literature of nuclear medicine QA (*5,6*) and is also often omitted in many departments. This paper will describe the film processor QA procedures that have recently been introduced in our departments and discuss the major benefits that have been gained by including the film processor in the overall departmental QA program.

FILM PROCESSORS

The nuclear medicine department of the Health Sciences Centre has four cameras, one SPECT unit, and three independent computer systems. The film processor,* which is dedicated to the nuclear medicine department, routinely processes ~ 75 8 × 10 in. single-emulsion films daily. The department at St. Boniface General Hospital has three cameras and a computer system. A new film processor† was recently installed and routinely processes ~ 50 8 × 10 in. single-emulsion films daily.

A schematic diagram of a film processor is shown in Figure 1. The film is fed through tanks containing developer and fixer. After washing, the film is dried in a hot air blower with the complete cycle in an automatic processor normally taking 1.5–2.5 min. The temperature and chemical composition of the developer are the key factors in ensuring a high standard quality image in the processed films. An in-depth description of all aspects of film processing is provided by Jenkins (*7*).

For reprints contact: Walter Huda, Medical Physics, Manitoba Cancer Treatment and Research Foundation, 100 Olivia St., Winnipeg, Canada, R3E 0V9.

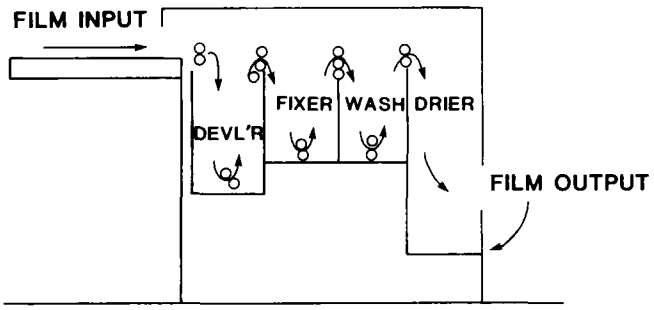

FIG. 1. Schematic diagram of an automatic film processor.

Nuclear medicine departments generally require low-volume automatic processors and can readily tolerate long processing times. Standby capabilities are distinct advantages because of the low-volume throughput. Easy maintenance and reliability are important factors because of the absence of a dedicated darkroom technician.

FILM PROCESSOR QUALITY ASSURANCE

The techniques used to monitor the performance of a film processor are well established (*1*). Film processor performance should be evaluated on a daily basis by using a standard film exposed to a constant light source in a sensitometer which has a wedge pattern as shown in Figure 2. It is important to ensure that the films from the same batch are used to minimize inter-batch variability and that they are exposed and processed in a consistent manner. The resultant exposed and processed film may have a total of 21 separate steps where the exposure ranges from a minimum (fog) value to a maximum (Dmax). The optical density (OD) of each of these steps can be measured using a standard densitometer. The OD is given by the relationship:

$$OD = \log_{10} \frac{I_o}{I},$$

where I_o is the light intensity incident on the film, and I is the light intensity transmitted through the film.

A typical film response curve is shown in Figure 3. For QA purposes, it is not necessary to obtain a full film response curve because the curve can be satisfactorily characterized by obtaining three parameters from only four OD measurements. The film base + fog value is obtained by measuring the OD value of Step 1 (fog). For most processors, this value is normally below 0.2. A film speed value is obtained by measuring the OD value of Step 12 (for most processors, the mean speed

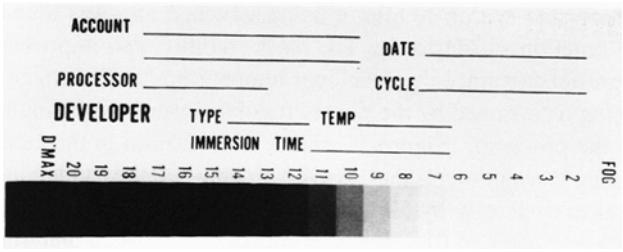

FIG. 2. Processed film that has been exposed to a 21-step wedge in a sensitometer.

is in the range of 1.0–1.5 with an acceptable variability of ~ ± 0.15). Film contrast value is obtained by taking the difference of the OD values of Steps 15 and 10 (for most processors, the mean contrast is in the range of 1.5–2.5 with an acceptable variability of ~ ± 0.15). The relationship of these three QA parameters to the film response curve is demonstrated in Figure 3. In addition, the developer temperature should also be recorded on a daily basis using a digital thermometer with an accuracy of ± 0.1 °F. Typical graphed results of the film base and fog, speed, and contrast values with developer tem-

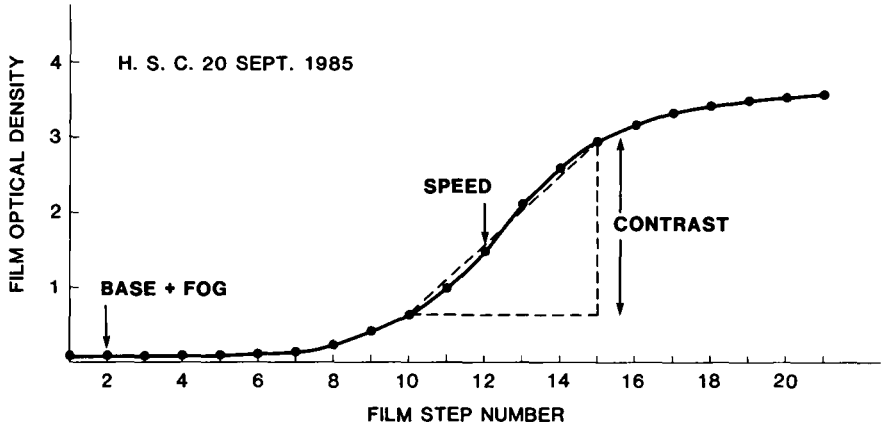

FIG. 3. Characteristic film response curve illustrating the measured optical density as a function of exposure of each step wedge. The graph illustrates the three film QA parameters, base + fog, speed, and contrast.

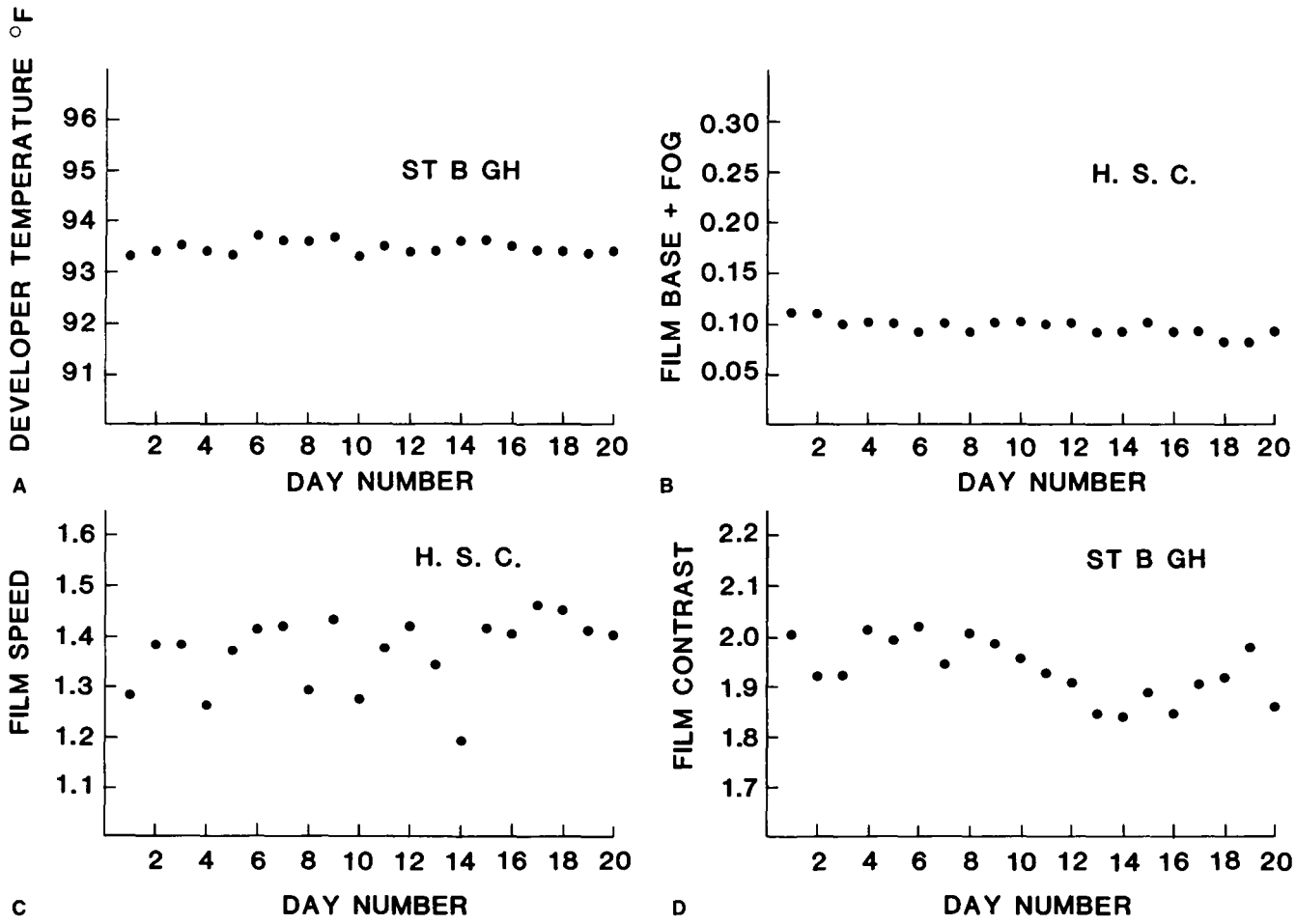

FIG. 4. Typical film processor QA results plotted on a daily basis and illustrating normal behavior of: (A) developer temperature, (B) film base + fog, (C) film speed, and (D) film contrast.

perature are shown in Figure 4 for our two film processors. The daily variations for each of the QA parameters is generally within the expected operating limits that are prescribed in the literature (*1*).

DISCUSSION

The daily film processor QA protocol can be performed easily by the technologist in ~ 5 min and provides useful information. Typical QA data that were obtained on two film processors when the QA program was first introduced are shown (Fig. 5). Figure 5A illustrates poor temperature control in the developer that was ultimately traced to a faulty electrical component in the temperature control circuitry. Following repairs, the stability of the developer temperature improved dramatically with a typical variability of ± 0.1 °F about the mean value of 93 °F.

Figure 5B shows changes observed in film speed measurements performed throughout the day. It is evident that the processor was taking ~ 1 hr to reach its equilibrium value and then demonstrated a variability in optical density of ~ 0.1 throughout the day. Investigation showed that the developer heater was not working and, upon its replacement, the film processor—within 10 min of being switched on—was found to function satisfactorily. The daily stability also improved significantly since the developer temperature was no longer being determined by the poorly regulated warm water input to the processor. Figure 5C shows the variation in the base + fog measurements that were obtained when the sudden increase in density by 50% on Day 6 coincided with the use of a new batch of film. It was eventually established that this was caused by a prefogged batch of film, which was returned to the manufacturer. The new film was introduced on Day 24, and the graph clearly shows the base + fog level returning to its normal level. Figure 5D shows the initial contrast measurements on an old film processor in which the daily variation is totally unacceptable. A number of attempts were made to identify the causes of this behavior before a decision was made to replace the film processor. The basis of this decision included not only factors such as age and service records, but also the QA results which had identified major problems. The considerably improved results obtained with the new unit are depicted in Figure 4D and demonstrate the variability in contrast of ~ ± 0.1 from the mean value.

In performing QA measurements, it is important to possess

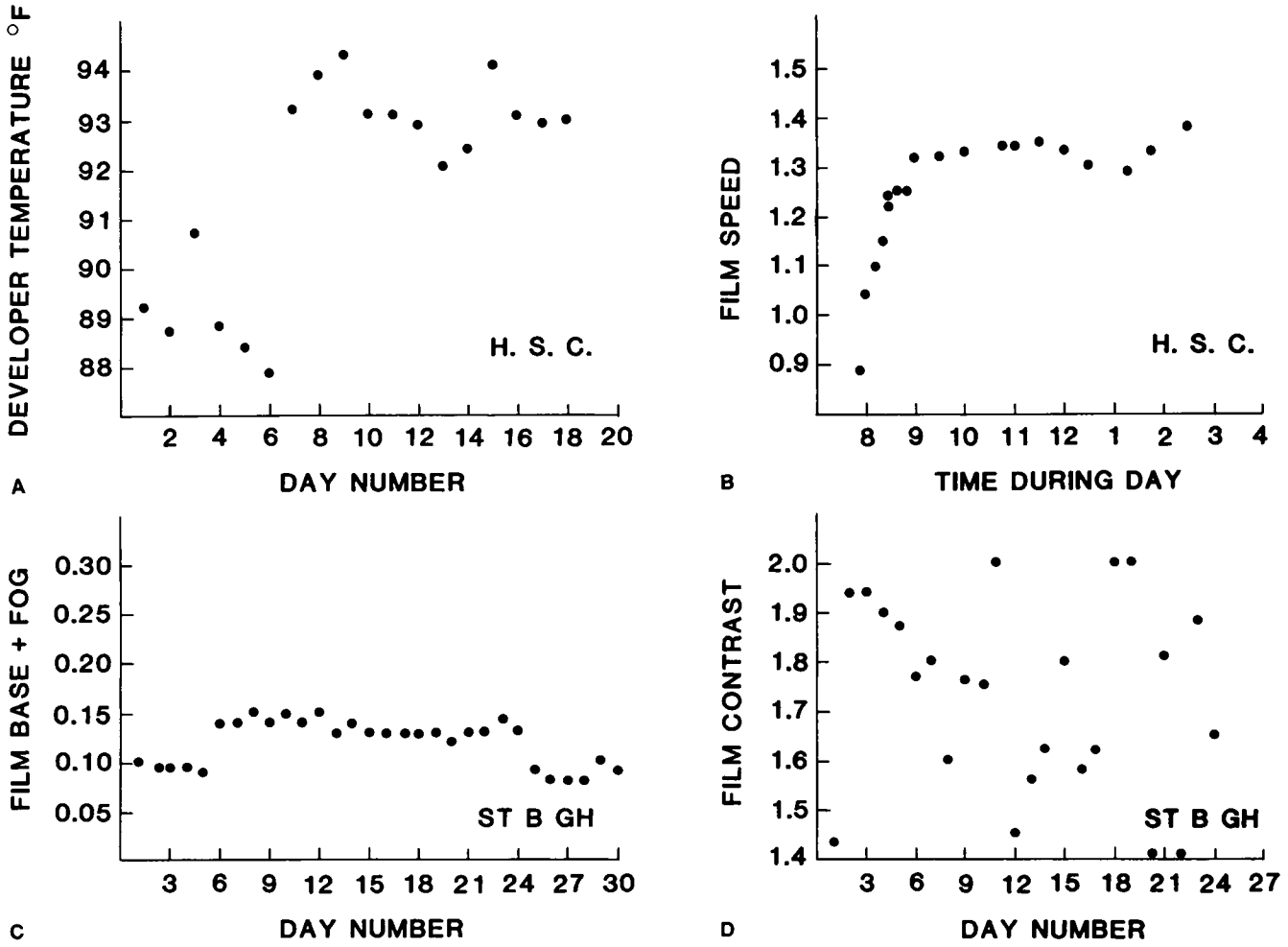

FIG. 5. Film processor QA demonstrating typical results when faults are encountered such as: (A) developer temperature, (B) film speed variation throughout a working day, (C) film base + fog, and (D) film contrast.

TABLE 1. Troubleshooting Check List For Film Processor QA Results

Fog	Speed	Contrast	Possible Fault	Cure
H*	H	N or L	Developer contaminated by fixer	Change developer Check processor Check developer replenishment
N	L	L	Low developer temperature	Check temperature
			No recirculation	Check recirculation
H	L	L	Oxidized developer	Replace developer Check developer replenishment Check for air leaks
H	N or H	N or L	Light leak	Check safelight, darkroom, and processor wet section

* H = High, N = Normal, and L = Low.

reliable data on the expected values of the QA parameters and their variability. When the normal operating limits are exceeded, it is essential that appropriate corrective action be taken. For film processors, it is relatively easy to identify problems on the basis of the available QA data. A typical troubleshooting guideline is shown in Table 1.

The introduction of film processor QA involves a modest investment of equipment and technologist's time, but it can prove to be extremely useful in ensuring the satisfactory functioning of the final stage of the imaging chain. A significant number of serious processor shortcomings can be identified and appropriate corrective action taken. The film processor QA has also been very useful in pinpointing scintillation camera problems such as faulty oscilloscopes when underexposed film images have been produced although the processor's QA results were satisfactory. To ensure satisfactory long term processor performance, it is important to perform regular maintenance. A typical servicing schedule, which we employ, is shown in Table 2.

TABLE 2. Film Processor Servicing and Maintenance Schedule

Item	Frequency
Rinse and clean splash guards and crosscovers	Daily
Check input water temperature	Weekly
Check developer/fixer replenishment rates	Monthly
Change developer/fixer chemistry and general cleaning of processor	4–6 weeks
Lubricate gears and bearings	As required by manufacturers

In conclusion, it is clear that departmental operations have benefited by the introduction of film processor QA, and that this practice should be considered an essential ingredient in all nuclear medicine departments.

FOOTNOTES

*Eastman Kodak Co. (Kodak RP X-OMAT), Rochester, NY.
†AFP Imaging Corp. (14 XL), Elmsford, NY.

REFERENCES

1. Gray JE, Winkler NT, Stears J, et al. *Quality Control in Diagnostic Imaging.* Baltimore: University Park Press, 1983:33–51.
2. Harris LJ, Avila MJ, Shadoan DJ, et al. A computerized radiochromatographic system for radiopharmaceutical quality control. *J Nucl Med Technol* 1984;12:126–30.
3. Kowalsky RJ, Johnston RE, Chan FH. Dose calibrator performance and quality control. *J Nucl Med Technol* 1977;5:35–40.
4. Huda W, Palser R, Shalev S, et al. Gamma camera quality control [Abstract]. *Med Phys* 1984;11:374.
5. Lovegrove F, Langan J, Wagner HJ. Quality control in nuclear medicine procedures. *J Nucl Med Technol* 1974;2:44–51.
6. Quality assurance in nuclear medicine. In: Hamilton DR, Herrera NE, Paras P, Rollo DF, McIntyre WJ, eds. *Proceedings of an International Symposium and Workshop.* Washington, DC: Federated Council of Nuclear Medicine Organizations and U.S. Dept. of Health and Human Services, 1984.
7. Jenkins D. *Radiographic Photography and Imaging Processes.* Baltimore: University Park Press, 1980.