An Inexpensive Medical X-Ray Image Quality Control Test Tool*

By Michel A. Périard and Paul Chaloner
Consumer and Clinical Radiation Protection Bureau
Health Canada

Many factors can contribute to the deterioration of x-ray image quality. Problems connected with these factors make it difficult for small medical x-ray facilities, particularly those located in remote areas, to produce good quality radiograms consistently. This article describes a quality control test tool that can be used to monitor the x-ray imaging system performance.

Introduction

Acceptable x-ray image quality is maintained by using a comprehensive quality control program, and is a function of x-ray output and film processing performance.[1] At large urban x-ray facilities, specialized personnel together with local supplier support make it a relatively easy task to maintain the desired image quality. At smaller hospitals, and especially at remote health care centres and nursing stations, many factors can make it difficult to produce consistently good image quality. These may include the use of less sophisticated equipment such as small mobile x-ray units, manual film processing, locally generated electrical power, and a lack of readily available technical support. Also, x-ray operators whose main responsibility is to provide general health care usually have limited training and experience in radiographic technique.

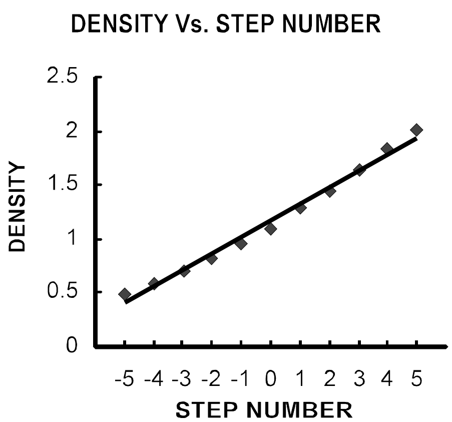
Variations in image quality are caused by changes in x-ray output and film processing techniques.[2] The change in x-ray output may be due to aging of the x-ray tube, variation in the electricity supply or in the x-ray machine parameters (kVp, mA, and timer calibration), or due to operator error. Improper film processing technique is the most frequent cause of poor x-ray image quality. This is due to the large number of variables such as the concentration level of the processing chemicals, the development time, and temperature. Most of these variables can be controlled by carefully following the manufacturer's recommendations. On occasion, it is difficult for a less experienced operator to determine which of the variables is at fault, which may lead to unnecessary expense (such as prematurely replacing processing chemicals). Thus, it can be seen that small x-ray facilities face a variety of constraints that make it difficult to maintain good quality radiograms.

***The article: "An Inexpensive Medical X-Ray Image Quality Control Test Tool" appeared in *The Canadian Journal of Medical Radiation Technology*, October 1999, 31(1), pgs. 5-8 (English), pgs. 18-21 (French).**

Materials and Methods

To overcome this difficulty, the X-ray Section of the Consumer and Clinical Radiation Protection Bureau recognized the need for a simple and reliable method of checking x-ray machine output and film processing system performance. The test method chosen[3,4] requires taking a radiogram of an attenuator under fixed conditions and measuring the optical density of the image.

FIGURE 1
REFERENCE FILM



The test tool design, similar to the Dental Radiographic Normalizing and Monitoring Device[5], incorporates an attenuator and a simple method to determine the image density without using a densitometer (as is usually required for this procedure). The image density is evaluated visually, using a view box, by comparing the density of the attenuator image against a series of 11 increasing density steps on a reference film with a median optical density of 1.1. In practice, the test tool incorporates the 11 reference densities displayed on a single sliding film strip with the density steps labelled from -5 to +5 and with the median density step labelled 0 (see Figure 1).

The thickness of copper attenuator selected is equivalent to 12.7 mm of aluminium at 80 kVp. This thickness can accommodate the output of various types of medical x-ray machines (three-phase, full-wave rectified and capacitor discharge units) and the wide range in image receptor speeds (200 to 800) currently in use.

The procedure involves irradiating the copper attenuator, placed on a loaded film cassette at a distance of 100 cm from the x-ray source (see Figure 2). The exposed film is processed following the manufacturer's recommendations and the density of the resulting image is compared as previously described. The standard x-ray tube voltage used is 80 kVp, and between 90-95 kVp for capacitor discharge units. Initially, this procedure is repeated, varying the loading factors (usually mAs), until the density of the attenuator image matches the reference film step 0. This initial procedure establishes the loading factors required to produce an image density equal to the step labelled 0. Typically, for three-phase x-ray units, with 400-speed image receptors, this is

FIGURE 2
SETUP

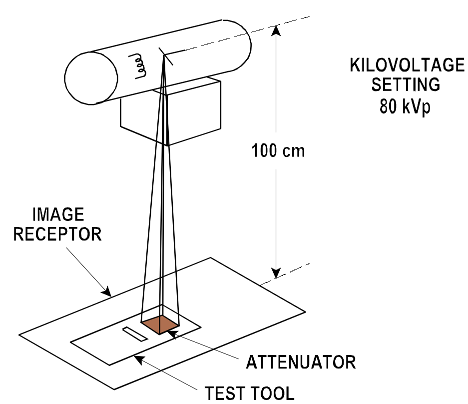


Figure 3: Noah Tassugat, a Basic Radiography Worker at the Clyde River Health Centre in Nunavut, uses the X-ray QC Test Tool for radiographic quality control of x-ray equipment and images.

achieved by using 5 mAs, while single-phase full-wave rectified units may require 15 to 20 mAs. The initial procedure should be performed only after the x-ray machine calibration has been checked, and new processing chemicals should be used.

These same loading factors are recorded, along with the image receptor identification, and are used with the test tool in all future tests to evaluate the performance of the x-ray imaging system on a periodic basis. Weekly monitoring is recommended (minimum monthly) or each time the imaging equipment performance is uncertain. If the density of the attenuator image falls outside the density step range labelled -2 to +2, indicating a trend away from the previously established norm, significant deterioration in image quality has occurred and corrective action is required. Initially, since it has been established that image quality is a function of x-ray machine output and film processing variables, corrective action will be in the form of careful checks on physical parameters such as the source to film distance, loading factors, development time and temperature. Subsequent action to re-establish the desired image quality may require some technical assistance.

Discussion

The adoption and use of this quality control procedure provides users with a simple non-invasive method to check the status of their imaging systems and to maintain image quality. This is especially important for x-ray facilities where the workload is low or the x-ray system has not been used for an extended period. When significant deterioration of image quality has occurred, the procedure will assist users in determining if it is the result of an imaging system problem or operator error. From this, with the help of some technical support, the required changes can be made to bring the system back to the previously established operating level.

Figure 3A: More than 250 test tool kits have been distributed for use at remote and/or small x-ray facilities across Canada.

Since mid-1994, the Consumer and Clinical Radiation Protection Bureau has distributed more than 250 test tool kits for use at remote x-ray facilities across Canada, including locations in northern Canada (see Figures 3 & 3A). The kits include an instruction manual and quality control charts to facilitate data recording for further evaluation. Where this has been implemented, requests for technical assistance have decreased. Also, the x-ray operators are now able to provide factual information about their imaging equipment problems when requesting technical assistance. This quality control method has increased their confidence in their ability to produce good quality radiograms and is reflected in a significant decrease in the number of repeated films.

This simple quality control method has been very well received by users and has since also been successfully implemented at other small (low workload) x-ray facilities, such as at penitentiaries, as well as at chiropractic and veterinary clinics. The Test Tool is also being used as an X-ray quality control teaching tool in the Mohawk College / McMaster University 'Basic Radiography Worker Program' in Hamilton Ontario, training First Nations health professionals working in remote northern Canadian communities.

Conclusion

The quality control test tool discussed in this article provides an effective, low-cost, low-maintenance method for monitoring x-ray imaging system performance. In field testing, it has proven particularly beneficial to smaller institutions that are challenged to find the necessary personnel and resources to devote to quality control, particularly those in remote areas of Canada.

Acknowledgements

The authors wish to thank the following people for their collaboration and assistance during the various development and production stages of the test tool: Captain B. Ruest, Sergeant C. Martel and the 1993-94 medical x-ray technology students who participated from the National Defence Medical Centre, Mr. C. Lavoie and Mr. P. Dvorak of the Consumer and Clinical Radiation Protection Bureau, Ms. J. Rothenberger of the Mackenzie Regional Health Service, and Mr. S. Bara and the 1997-98 medical x-ray technology students who participated from the Northern Alberta Institute of Technology. Discussions with and comments by the authors' colleagues are also gratefully appreciated.

References

1. Périard, M.A., Chaloner, P. (1996). Diagnostic x-ray imaging quality assurance: an overview. The Canadian Journal of Medical Radiation Technology**,** 27 (4), 171-177.

2. NCRP (1988). Quality Assurance for diagnostic imaging equipment. National Council on Radiation Protection and Measurements - Report no. 99, NCRP: Bethesda, MD, USA.

3. Crabtree, C.L. (1984). Quality assurance in dental radiography. In Supplement to Dental exposure normalization Technique (DENT) instruction manual - Section V. Department of

Health and Human Services, FDA, CDRH, Rockville, MD. USA.

4. Van Pelt, W. (1982). Dental radiographic system monitor test tool - report on evaluation study in 1982. Internal report, unpublished. FDA, CDRH, Rockville, MD. USA.

5. Dental Radiographic Devices. Dental Radiographic Normalizing and Monitoring Device. (Product data pamphlet). Silver Spring, Md. USA.

About the authors:

Michel A. Périard, BAppSc (MedImaging), Dipl. T. (Physics), CET, is A/Head, Inspection Unit of the X-ray Section, Consumer and Clinical Radiation Protection Bureau, Health Canada. Former positions held were: Radiation Safety Inspector with the X-ray Section, Health Canada; Physics Technologist, with National Dosimetry Services, Health Canada, where he worked in the research and development of thermoluminescent dosimeters; and, Physics Technologist with Defence Research Establishment Ottawa (DREO), Department of National Defence, in the research and development of radiation detection instruments for use by the Canadian Forces.

Paul Chaloner, BAppSc (MedImaging), DSR (R), is Manager, Quality Assurance and Planning with National Dosimetry Services, Radiation Protection Bureau, Health Canada. Former positions held were: Head, Inspection Unit, X-ray Section, Consumer and Clinical Radiation Protection Bureau, Health Canada, where duties included inspection of X-ray equipment; Radiation Health Officer for Workers' Health, Safety and Compensation, Alberta inspecting non-ionizing radiation sources and X-ray equipment; and, General Duty, Special Procedures and Area Supervisor Technologist at the Edmonton General Hospital.