KODAK Dental Radiography Series

Quality Assurance in Dental Radiography

DENTAL PRODUCTS

Quality Assurance in Dental Radiography

A complete quality assurance program is easy to establish and maintain. Quality assurance will pay for itself, not only in dollars and cents, but by reducing exposure to patients and personnel, and by helping the dental community provide better patient care.

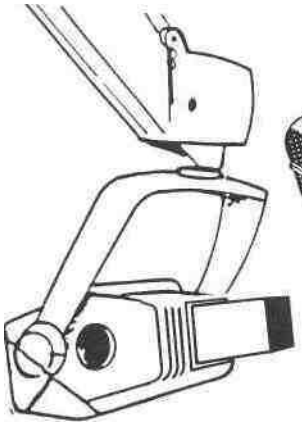
Quality assurance is a plan of action to ensure that a diagnostic x-ray facility will produce consistent, high-quality images with a minimum of exposure to patients and personnel.

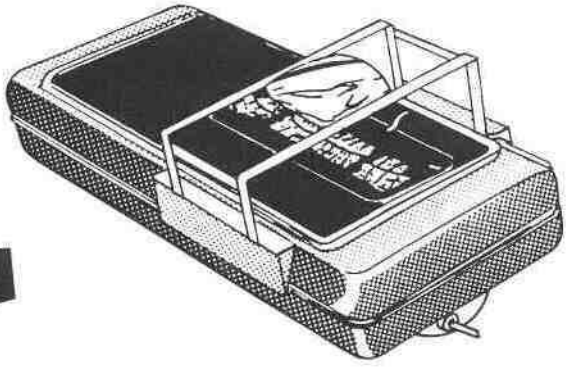
Quality assurance means regular testing to detect equipment malfunctions, planned monitoring and scheduled maintenance for consistent film processing, and regular assessment of other variables that affect image quality.

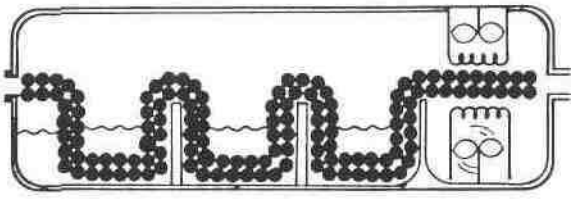
The benefits derived from a quality assurance program far outweigh implementation efforts and costs. In addition to aiding in diagnosis, a well carried out quality assurance program results in minimized radiation dosage to patients because radiographs are produced under the most favorable conditions.

Fewer repeat radiographs mean time and cost savings for both patients and operators; Regular testing also helps ensure compliance with state and federal regulations.

Quality Control







One of the most important facets of quality assurance is quality control; Quality control refers to the tests used for routine assessment of x-ray systems; These include tests of the basic performance of x-ray units, of manual and automatic processing, of image receptors, and viewing conditions;

Accurate calibration of x-ray machines promotes consistent equipment performance, and reduces the number of film retakes due to equipment malfunctions. All machines, both new and old, must be recalibrated at regular intervals by a qualified technician.

Annual Testing

In addition to regular calibration, the American Academy of Oral and Maxillofacial Radiology recommends that the following eight tests of x-ray generating equipment be conducted annually.

Annual X-ray Unit Tests

- X-ray Output
- Kilovoltage (kVp) Calibration
- Half Value Layer
- Timer
- Milliamperage (mA)
- Collimation
- Beam Alignment
- Tube Head Stability

All of these tests can be performed by dental practitioners, and require only film and test logs to provide written records of quality control checks and some basic testing materials. The tests can also be completed by the equipment manufacturers service representative.

Step-by-step procedures for performing each of these quality control tests are described in KODAK Publication No. ME-504A1, *"Quality Control Tests for Dental Radiography"* (see the inside back cover for ordering instructions for all Kodak publications mentioned in this booklet).

Film Processing

One of the most critical areas for quality control, and most frequently overlooked, is film processing. Even the best exposure conditions can be compromised with poor processing technique.

Manual Processing

For manual processing, it is crucial to adhere to the times and temperatures recommended by the film manufacturer. The chart below shows those for KODAK Intraoral and Extraoral Dental Films with KODAK GBX Chemicals.

Intraoral and Extraoral Manual Processing Recommendations

KODAK Intraoral Films	**Develop**		**Rinse**		**Fix**		**Wash**	
	KODAK GBX Developer and Replenisher		Fresh running water		KODAK GBX Fixer and Replenisher		Clean running water (approx 8 volume changes per hour)	
EKTASPEED Plus ULTRA-SPEED	68°F (20°C) 70°F (21°C) 72°F (22°C) 76°F (24.5°C) 80°F (26.5°C)	5 min 4 1/2 min 4 min 3 min 2 1/2 min	60-85°F (15.5-29.5°C)	30 sec. agitate continuously	60-85°F (15.5-29.5°C)	2-4 min or twice the clearing time, intermittent agitation	60-85°F (15.5-29.5°C)	10 min
KODAK Extraoral Films	**Develop**		**Rinse**		**Fix**		**Wash**	
	KODAK GBX Developer and Replenisher		Fresh running waler		KODAK GBX Fixer and Replenisher		Clean running water (approx 8 volume changes per hour)	
EKTAVISION T-MAT G T-MAT L T-MAT H	72°F (22°C) 80°F (26.5°C)	7 min 4 min	60-85°F (15.5-29.5°C)	30 sec	60-85°F (15.5-29.5°C)	2-4 min	60-85°F (15.5-29.5°C)	5 min
EKTAMAT G Rapid Process Copy X-OMAT 2 Duplicating	68°F (20°C) 80°F (26.5°C)	5 min 2 min	60-85°F (15.5-29.5°C)	30 sec	60-85°F (15.5-29.5°C)	2-4 min	60-85°F (15.5-29.5°C)	5 min
X-OMAT RP	68°F (20°C)	7 min	60-85°F	30 sec:	60-85°F	2-4 min	60-85°F	5 min

The process below is used for intraoral films when rapid processing is desirable; for example, during endodontic procedures;

Special Rapid Process Recommendations for Intraoral Films

Solution/Step	Temp	Time	Agitation
KODAK Rapid Access Dental Developer	72°F (22°C)	15 sec.	Continuous
KODAK Rapid Access Dental Fixer	60-85°F (15.5-29.5°C)	1 5 sec. or **until clear**	Continuous
Wash	60-85°F (15.5-29.5°C)	Quick rinse	Running Water

Note: Discard developer and fixer after processing the equivalent of 60 intraoral films (No. 2 size packets) in 5 ounces (148 mL) of solution or after 3 days, whichever comes first. Keep developer covered when not in use to reduce the rate of oxidation and evaporation and to prevent contamination.

If radiographs are to be retained, refix for 2 to 4 minutes in KODAK GBX Fixer or KODAK Rapid Access Dental Fixer, and rewash in running water for 1 0 minutes. Dry film in a dust-free area at room temperature or in a suitable drying cabinet (temperature not to exceed 120°F [49°C]).

A common error in manual processing is failing to check the temperature of the solution before development and making appropriate adjustments.

Unless temperature control units are used, solution temperature may vary significantly during the day because it is influenced by incoming water and by the surrounding environment. Even a slight increase in temperature can cause films to darken.

Dark images, like the one represented by this radiograph, may be caused by:

- Development time too long.
- Over-replenishment.
- Developer solution too hot.

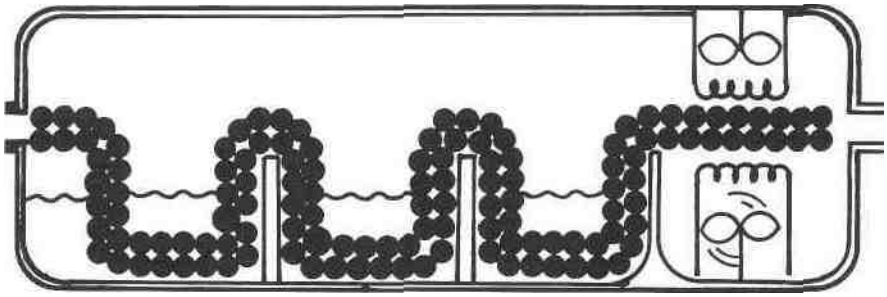
Light images, like the one represented by this radiograph, can result from:

- Development time too short.
- Underactive or exhausted solutions.
- Developer solution too cold.

Fresh or replenished chemicals designed for manual processing should be used in manual systems. KODAK GBX Developer and Replenisher, and KODAK GBX Fixer and Replenisher are available in a combination twin pack.

The concentration and purity of the chemical solutions in your manual processing tanks are important to the image quality of the resulting radiograph. Always keep separate, labeled, capped bottles of developer replenisher and fixer replenisher readily available.

For optimal image quality, we suggest that you add 8 ounces of the appropriate replenisher (236 mL) per one gallon (3.8 L) of developer and fixer working solutions every morning, *regardless of the solution levels visible in the tanks.* This will help ensure that the correct processing solution strength is present for the radiographs to be processed that day. It may be necessary to remove some of the existing solution *before* adding the replenisher, so that the processing tanks do not overflow. To guard against possible cross-contamination, always use separate paddles to mix each type of processing solution. Label the paddles to indicate the solution they are to be used for; always wash and dry the paddles after each use.



Automatic Processing

During automatic processing, the film is transported through the processing sequence mechanically. It moves through the developing, fixing, and washing stages at a controlled speed. With proper care, most mechanical processors can be efficient, reliable and consistent.

The chemicals used in automatic processing are specially designed to be used with mechanical transport systems. They operate at higher temperatures and do not require film rinsing between development and fixing.

Follow the chemical manufacturer's recommendations for mixing chemical solutions. Chemicals are available mainly in two forms: concentrate and ready-to-use. The concentrate requires mixing with water. Ready-lo-use chemicals, such as KODAK READYMATIC Dental Developer and Replenisher and KODAK READYMATIC Dental Fixer and Replenisher, do not require any mixing.

In some roller transport systems, the temperature of the chemicals is thermostatically controlled and the processing time is regulated by controlling the speed of the rollers in ihe transport mechanism.

The amount of time required to complete the processing cycle and the temperature selling for the developer varies from processor to processor and is set by the manufacturer. In today's equipment, the time required to complete the processing cycle for KODAK Intraoral Films, for example, ranges from 4 minutes at 85°F to 6 1/2 minutes at room temperature. Temperature and time in developer are inversely related; i.e., the higher the temperature, the shorter the time in the developer. KODAK READYMATIC Chemicals can be used in slower systems at room temperature as well as in faster systems at higher temperatures.

Some film processors employ an Endo Cycle, typically a 2 1/2-minute processing cycle, that provides a quick-look for non-archival quality periapical films. This process is used for dental surgical procedures where rapid processing is desired. For best image quality and archival results, use the full processing cycle or process manually using the guidelines stated in the *Manual Processing section.*

While some automatic processors will provide replenishment automatically, other equipment requires operator intervention to maintain the correct chemistry levels and strengths.

For those intraoral film processors without automatic replenishment, it is recommended that 8 ounces (236 mL) of replenisher be added to each working solution daily, based on an average daily run of 20 to 30 intraoral films. Even if no films are processed for a period of time, replenishment is necessary. If you process more than 30 intraoral films per day, you should increase the amount of

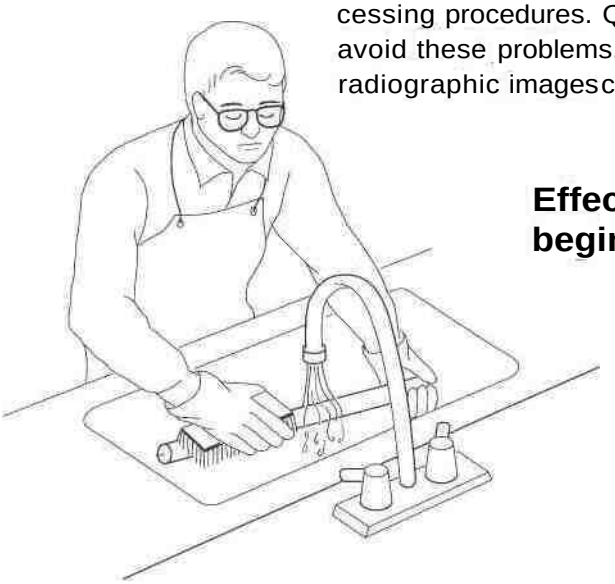
daily replenisher solution at the rate of 0.25 fluid ounce (7 mL) per additional film processed. For example, 50 intraoral films per day would require that 5 additional ounces (148 mL) be added to the daily 8 ounces, for a total of 13 ounces (384 mL).

All replenished solutions should be changed every 3 to 4 weeks under normal conditions. (Normal use is defined as 30 intraoral films per day.) Manufacturers of automatic non-roller type processors recommend that all non-replenished solutions be changed every two weeks.

For those processors incorporating daylight film-loading features, it is important that the processing unit be placed in subdued lighting (no direct, bright lighting). This will help to prevent film fogging through the filter of the loading units.

Quality Control in Film Processing

The majority of problems in radiography can be traced to improper film processing procedures. Quality control of processing is the most effective way to avoid these problems, and the most effective way to achieve high-quality radiographic imagesconsistently.



Effective quality control for automatic processing begins at each solution change:

1. Wearing rubber gloves, a rubber apron and protective goggles/glasses, clean the tanks and rollers thoroughly to remove chemical deposits and contaminants. For normal weekly or monthly cleaning, Kodak recommends using warm water and a non-abrasive brush to prevent scratching of ihe rollers. Periodically (2-4 times a year), use the systems cleaner recommended by your processor manufacturer to remove heavier buildup.
2. After cleaning with a systems cleaner, rinse for **twice** as long as the manufacturer recommends to remove any trace of cleaner. If not completely rinsed off, residual systems cleaner will contaminate your fresh chemicals resulting in poor image quality.

   Note: soaking rollers in water for a period of time is not an effective means of cleaning or rinsing.
3. Inspect the rollers, gears, and turning mechanism for signs of wear, and reassemble.
4. Always fill the fixer tank first. Rinse out the empty developer tank in case any fixer splashed into it while filling the fixer tank. Then, fill the developer tank. This prevents contamination of the developer.
5. After filling the processor, turn it on. If the processor has a thermostat to adjust temperature, let it reach the pre-deterrnined operating temperature. Periodically double-check the temperature of the unit by inserting a thermometer into each tank.

Simple quality control procedures assure high-quality patient radiographs:

When large numbers of radiographs are being processed; optimum quality control can be achieved using a sensitometer, which measures light, and a densitometer, which measures film density. A dental office, in general, does not process enough film to justify purchase of these tools.

In the dental office, there are three simple and inexpensive procedures that can be used for quality control of processing.

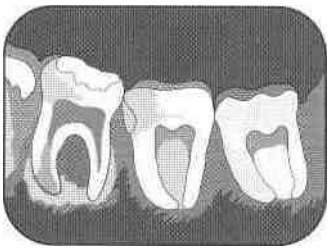
1. Create an intraoral or stepwedge reference radiograph and tape it to the viewbox.

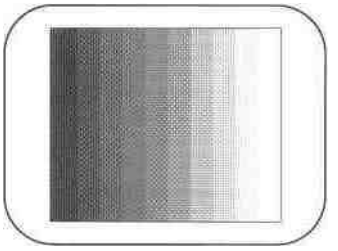
2. Use an aluminum stepwedge and periapical or larger film to create test monitor strips.

3. Use a Dental Radiographic Normalizing and Monitoring Device.

1. Reference radiograph

The reference radiograph can easily be created in the dental office. The image that appears on the reference radiograph is a personal choice. It could be of an intraoral image that you feel reflects the quality you seek or it could be of a stepwedge where the range of densities from white to black is recorded.





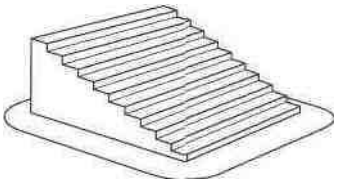
Whatever choice you make, it is very important to produce the reference radiograph under optimum conditions:

- Fresh, unexpired film that was properly stored.
- Correct exposure under the proper conditions. (Intraoral and extraoral exposure information is available from Kodak as a wall chart, KODAK Publication N-412. Exposure information for a single image of a stepwedge appears on the next page).
- Freshly-mixed chemicals.
- Chemical temperatures at recommended settings.

An intraoral or a stepwedge radiograph processed under these conditions would yield a quality image that could be used as a comparative/reference radiograph.

The radiograph should be viewed only when surrounded by an opaque frame to prevent incidental light from diminishing the overall intensity of the black, gray and white tones. Each day, as you process x-ray film, select one of the radiographs and compare the new image to the range of densities (the black, gray and white tones) that appear on the reference radiograph. Minor or major changes in densities would indicate problems with exposure, processing or solutions, and corrective action should be taken (see page 11).

To help you isolate the problem, use the appropriate publication referred to on the inside back cover of this booklet.



2. Stepwedge monitor strips

To prepare monitoring strips, expose about 20 films with a dental aluminum stepwedge using the same exposure factors and focal film distance. The exposure factors for a molar projection (kV 90, mA 10, 20 impulses) should produce a satisfactory image of the wedge.

Save 19 films by placing them in a cool, dry place protected from radiation. Process one film in your recently cleaned processor containing fresh chemicals. Use this film as the standard. View the film and select a density approximately in the middle of the step for monitoring purposes.

The following day, after replenishing the solutions and allowing the chemicals to reach their proper operating temperature, take out one monitoring strip and allow it to reach room temperature. Then, process the pre-exposed monitoring film strip. Compare the processed film with the standard processed the day before.

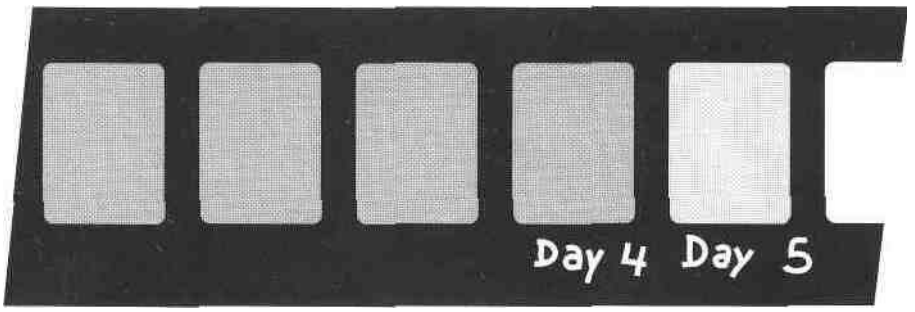
The films should be very close in appearance and density, since they were exposed under identical conditions. If the films look different, their difference can be attributed to film fog or faulty processing conditions. Repeat this procedure daily. If the daily film strips differ from the standard by more than two steps on the stepwedge, corrective action should be taken (see page 11).

3. Dental Radiographic Normalizing and Monitoring Device

A third procedure is to expose a *"D"* or *"E"* speed intraoral film, using your usual settings, while inserted under a copper filter provided with the "Dental Radiographic Normalizing and Monitoring Device".

After processing in fresh solutions, the film is compared with a 7-step film strip, also provided with the Device. If the processed film matches the mid-range of the film strip, skin exposure per film is within an acceptable range, If the exposure is below or above the mid-range, suggestions for correcting the exposure or processing are provided with the Device.

This simple monitoring method helps maintain a level of consistency in the imaging process. The drawing below represents films used to monitor a processor for five days. The matching film densities indicate that processing is affecting all the films in a consistent way.



However, between days 4 and 5 there was a drastic reduction in film density. After careful inspection, it was found that someone had changed the temperature setting. The temperature was adjusted and a second strip was processed; a matching density was achieved.

Ordering information for the Normalizing and Monitoring Device recommended by the American Academy of Oral and Maxillofacial Radiology can be found on the inside back cover of this booklet.

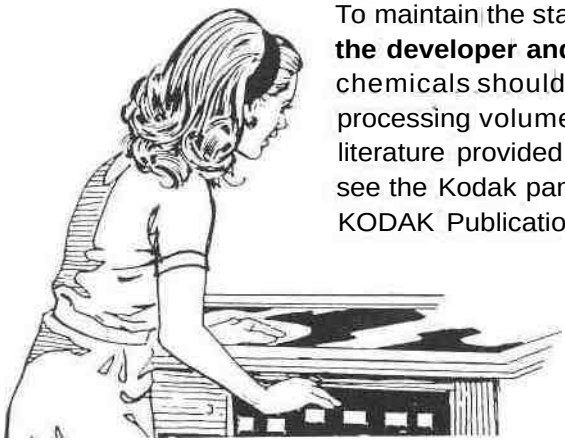
Corrective Actions

Should any of the quality control checks indicate a problem, here are some of the corrective actions which can be taken:

- Check operating temperature.
- Add replenisher daily.
- Change the processing solutions completely.
- Check darkroom for light leaks.

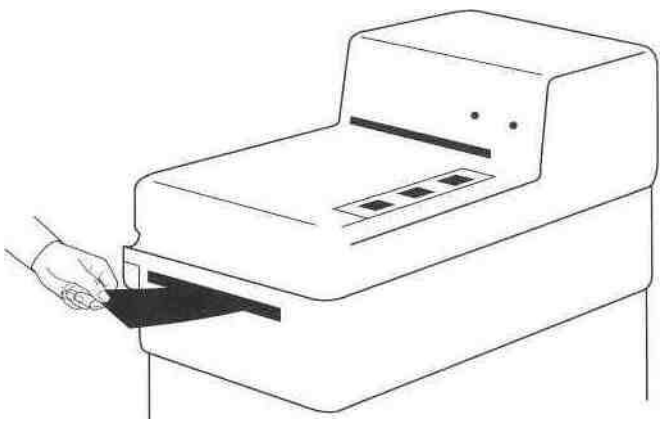
The advantage of performing daily processing checks is that the changes are often detected before they affect patient radiographs.

Daily Routine



To maintain the stability and consistency of the processing chemicals, **replenish the developer and fixer daily**. Regardless of whether or not films are processed, chemicals should be replenished daily to compensate for oxidation. If the processing volume is heavy, more replenishment may be needed. Consult the literature provided by the chemical manufacturers for recommendations. Also, see the Kodak pamphlet *"Exposure and Processing for Dental Radiography,"* KODAK Publication No. N-413.

First thing in the morning, processing solutions should be allowed to reach working temperature. To remove any residual gelatin or dirt on the rollers, run a piece of KODAK Roller Transport Cleanup Film through each side of the processor.



At the end of the day, remove the main cover and the developer and fixer covers, unless otherwise stated by the manufacturer, and allow chemical fumes to escape. This prevents condensation droplets from forming under the covers of automatic processors. These droplets soil the rollers, corrode metal parts and create film artifacts. In manual systems, cover the chemicals to reduce the oxidation process.

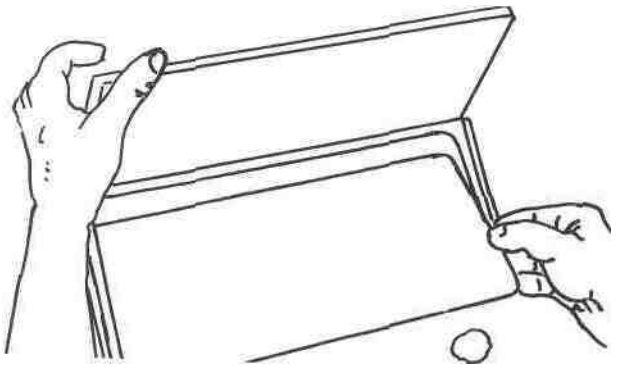
Maintain a log that lists the date that the processing solutions were changed, problems that were encountered, and any corrective action taken. Consistent care and preventive action promotes a reliable, predictable, high-quality work environment.

Film Storage & Handling

It is extremely important to store and handle film properly. Unexposed and *un-processed* film should be kept in a cool, dry place. Ideally, film should be stored at temperatures ranging between 50°F (10°C) and 70°F (21 °C), and between 30% and 50% relative humidity. Films kept at very low temperatures and brought out into room temperature can cause condensation on the film. High temperatures decrease contrast and increase gross fog. Film should be used ***before*** its date of expiration. Use the oldest film first. Observe this rule of thumb for using film: ***FIRST IN, FIRST OUT***.

Improper film handling can result in artifacts such as streaks, lines, and marks that may interfere with the diagnostic value of the radiograph. Films should be handled with care. Avoid bending the film or touching it with wet hands. Handle film by the edges, and always make sure it is protected from potential sources of fogging.

Screens and Cassettes



Proper care of screens is also important. They should be cleaned with KODAK Intensifying Screen Cleaner and Antistatic Solution, and inspected on a regular basis to assess film-screen contact and to check for light leaks and artifacts.

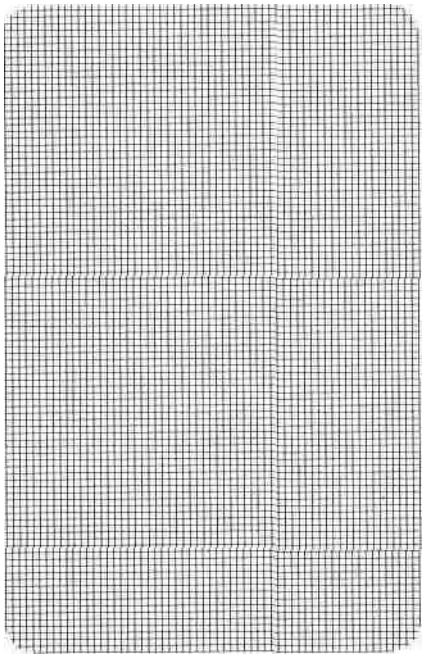
Because some cleaning agents produce residues which seriously affect the emission of the screen, use *only* denatured ethyl alcohol if KODAK Intensifying Screen Cleaner and Antistatic Solution is not available.
The following procedure is suggested for cleaning a cassette:

1. Open the cassette.
2. Look for worn or stained areas.
3. Dampen a clean gauze square or lint-free cloth with KODAK Intensifying Screen Cleaner and Antistatic Solution.
4. Wipe one screen at a time. Wipe in one direction only.
5. After cleaning, wipe each screen with a dry gauze square or lint-free cloth.
6. Leave the cassette open until the screens are thoroughly dry.

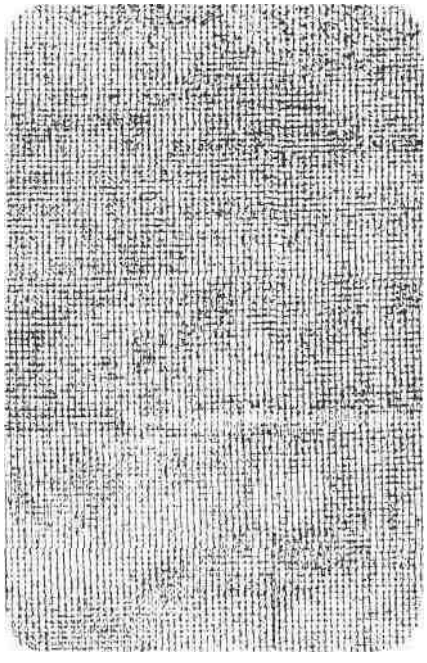
To test for screen-film contact, you will need a 1/8-inch brass or copper piece of wire mesh cut to fit on top of the cassette as the subject. Since the wire mesh will be handled frequently and you will want to protect it from damage, mount it between 2 sheets of cardboard or composition board. The following procedure is suggested:

1. Place the wire mesh on top of the cassette on a flat surface; check for evenness.
2. Position the tube at a 40-inch focal film distance, making the central ray perpendicular to the wire mesh and cassette.
3. Make an exposure using about 10 mA, 1 5 impulses at 70 kVp.
4. Process the film.
5. View the processed radiograph in a dimly lit room on an x-ray viewbox at a distance of about 6 feet.
6. Cassettes that exhibit areas of poor contact in the central position should be repaired or replaced.

The illustration below shows a cassette exhibiting good film-screen contact with sharp, uniform density, and a cassette exhibiting poor film-screen contact with blurred, fuzzy areas. Areas of poor contact will appear darker than areas of good contact.



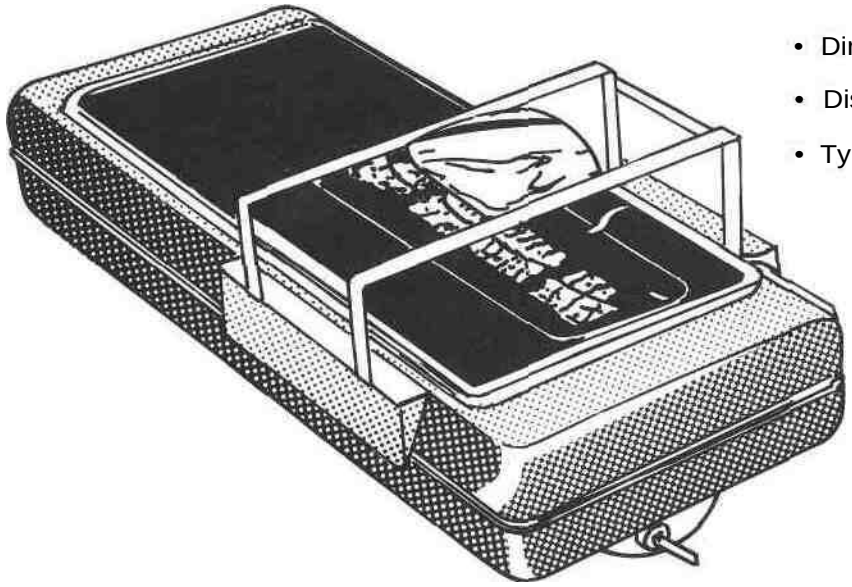
Good Contact



Poor Contact

Viewbox Maintenance

The condition of the viewbox or illuminator can have an effect on the perceived density and contrast of images. Variations or distortions can result from:



- Dirt on the Plexiglas.
- Discoloration of the Plexiglas front.
- Type or age of the bulb.

As a bulb approaches the end of its useful life, it will begin to blacken. If this happens, the lamp should be replaced before it burns out totally. The entire bank of lights should be replaced simultaneously and the illuminator fronts cleaned regularly.

Suggested Guidelines for Quality Assurance

A well-planned and well-executed quality assurance program can increase the likelihood of producing the best possible radiographs with the lowest possible radiation exposure to patients, the lowest cost, and the least number of retakes. Dental offices can very easily establish and maintain quality control procedures as part of their overall management system. Remember that your Kodak service and sales representative is always available for further consultation about quality control measures.

Quality control tests should be performed annually on dental x-ray generating equipment owned and operated by dental practitioners.

The best quality control procedures are invalid, however, without careful monitoring of film processing conditions. The highest quality images are usually produced under optimum processing conditions. To complement the quality control tests recommended for dental x-ray generating equipment, follow the suggested routines that follow:

Processor Maintenance:

- Clean processors and work areas at regular intervals.
- Change solutions at scheduled time.
- Replenish fixer as well as developer daily.
- Monitor time and temperature daily.
- Check the operating time and temperature of processors and the temperature of solutions daily.
- Perform quality control every morning (after replenishment and chemicals reach proper temperature).
- Use one of the three quality control methods described on pages 8 through 11 daily.

Film Storage and Handling:

- Store and handle film properly.
- Rotate film stock regularly.

Darkroom:

- Use KODAK GBX-2 Safelight Filters.
- Position safelight at no less than 4 feet (1.2m) from the film.
- Use a 15-watt frosted bulb.
- Check safelighting conditions every six months.
- Check for light leaks each month.
- Make sure ventilation is adequate.

Radiographic Screens:

- Clean with KODAK Intensifying Screen Cleaner and Antistatic Solution monthly.
- Inspect screens monthly.

Viewbox Maintenance:

- Clean the Plexiglas weekly.
- Inspect the fluorescent bulbs and replace them when necessary.

There is a great deal of helpful information about common film processing errors contained in two publications available from Eastman Kodak Company. *"Successful Intraoral Radiography"* (KODAK Publication No. N-418) contains helpful information on how to identify and correct common errors in intraoral radiography. *"Successful Panoramic Radiography"* (KODAK Publication No. N-406) details the common errors made in panoramic radiography and how to correct them. See below for information on how to order your copy free of charge.

To obtain a free copy of any of the Kodak publications referred to in this pamphlet:

- In the U.S.A., please call Kodak at **1-800-233-1650** or write:

  Eastman Kodak Company
  Advertising Distribution
  Order Entry, Dept. 454
  343 Slate Street
  Rochester, New York 14650-3009

  Order the publication by name and code number.

- Outside the U.S.A., all publication requests should be directed to the nearest Kodak Company, or write:

  Dental Business
  Health Imaging Division
  Eastman Kodak Company
  343 State Street
  Rochester, New York 14650-1122 U.S.A.

To obtain the Dental Radiographic Normalizing and Monitoring Device recommended by the American Academy of Oral and Maxillofacial Radiology, order from:

Dental Radiographic Devices
P. O. Box 9294
Silver Spring, Maryland 20916
(301)598-6543

To talk to a Kodak representative about quality control in dental radiography:

- In the U.S.A., phone (800) 933-8031
- In Canada, phone (800) GO-KODAK
- Elsewhere, phone the local Kodak subsidiary or (716) 724-5631

To contact Kodak via the Internet:

http://www.kodak.com/go/dental

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