

Exposure and Processing for Dental Radiography



Dental

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Quality diagnostic radiographs are essential in the practice of dentistry. Equally important is the need to *keep exposure to a minimum* for both the patient and the dental professional. To achieve quality radiographs with minimum exposure is your professional responsibility.

Like drugs, sharp instruments, and other hazardous materials in the dental office, x-radiation must be handled carefully.

This booklet describes a planned and systematic approach to exposing and processing radiographs; such an approach is essential for effective quality assurance.

You can produce radiographs of superior quality with minimum exposure by following the FOUR BASIC RULES:

1. Establish Correct Exposure Time

Dental film is often overexposed and compensated for by underdeveloping. This results in poor quality film and unnecessary radiation to the patient.

2. Maintain an Adequate Darkroom

Sensitivity of dental film demands strict attention to darkroom conditions.

3. Process Films Properly

Film processing demands strict attention to recommended procedures, including time and temperature processing and daily replenishment of chemicals, in order to obtain excellent image quality. Always observe good safety practices—wear rubber gloves, a rubber apron and glasses when mixing, replenishing, changing or disposing of chemicals.

4. Mount and View Radiographs Correctly

Viewing conditions are extremely important in interpreting radiographs.

Establish Correct Exposure Time

Be Aware of the Problem

All persons are exposed to radiation in their daily lives. The National Council on Radiation Protection (NCRP) has estimated the annual mean exposure from all sources in the United States as 3.6 mSv y^{-1} . Approximately 3 mSv of this exposure arises from naturally-occurring sources alone. Only 0.6 mSv comes from man-made sources, most of which is from diagnostic exposure in the health industry.

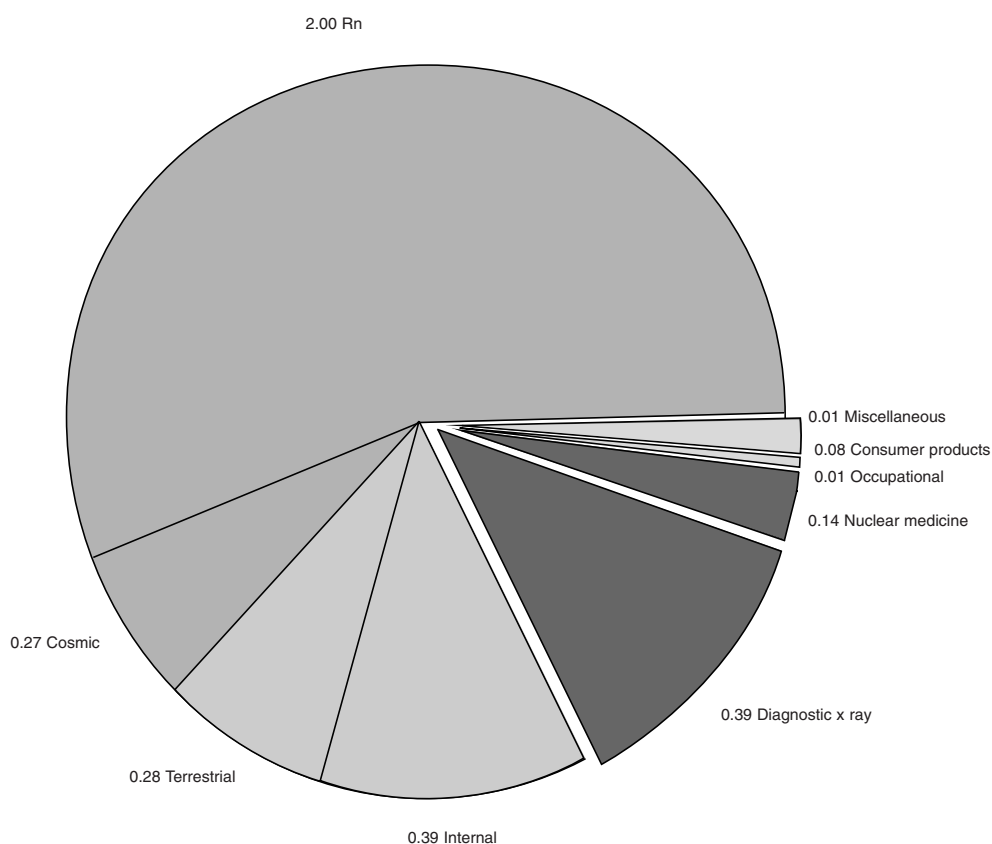


Fig. 1. Annual radiation exposure to an average American from all sources. The total (rounded) is 3.6 mSv y^{-1} . About 3 mSv of this is from naturally-occurring sources: 2 mSv from inhalation of radon and its radioactive decay products; 0.28 mSv from cosmic radiation; 0.28 mSv from radioactive materials in our surrounding earth, building materials, etc.; and 0.39 mSv from radioactive sources within our bodies. Most man-made radiation comes from diagnostic exposure in the health industry (0.53 mSv), with small quantities from occupational sources, consumer products such as smoke detectors or luminous watch dials, and miscellaneous such as air travel as a passenger. Data from NCRP (1987b).

Published data indicate that average dental occupational exposures are usually only a small fraction of the limit and are less than most other workers in the health industry (Table 1) (Kumazawa *et al.*, 1984). Occupational exposures have been declining (Figure 2) over recent decades in workers in both the medical industry in general and dentistry in particular (HSE, 1998; Kumazawa *et al.*, 1984). It seems reasonable to conclude that no dental personnel will receive occupational exposures exceeding the limit unless there are problems with facility design, equipment performance, or operating procedures.

Table 1—Occupational doses in the health industry, U.S., 1980.^a

Occupational Subgroup	Number of workers		Mean annual whole-body dose (mSv)	
	Total ^b	Exposed ^c	Total ^b	Exposed ^c
Hospital	126,000	86,000	1.40	2.00
Medical offices	155,000	87,000	1.00	1.80
Dental	259,000	82,000	0.20	0.70
Podiatry	8,000	3,000	0.10	0.30
Chiropractic	15,000	6,000	0.30	0.80
Veterinary	21,000	12,000	0.60	1.10
Total	584,000	276,000	0.70	1.50

^aKumazawa *et al.*, 1984.

^bAll workers with potential occupational exposure.

^cWorkers who received a measurable dose in any monitoring period during the year.

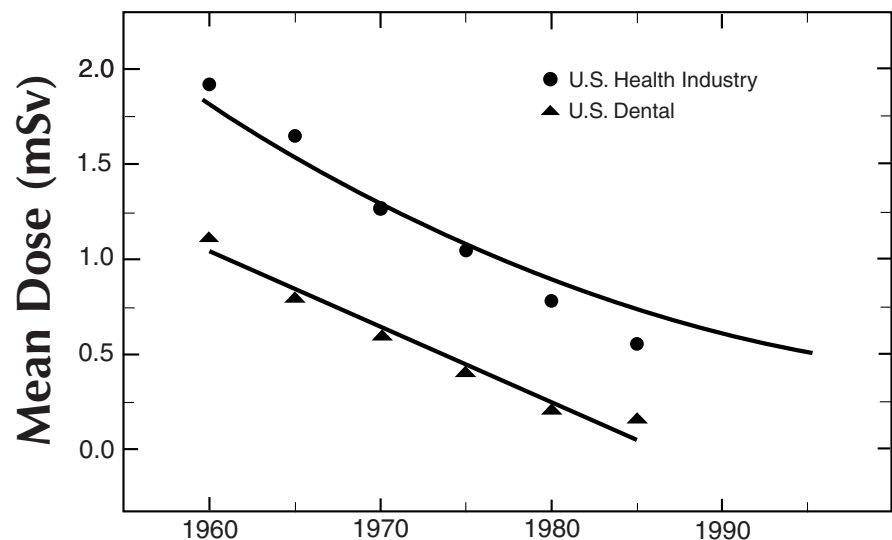


Fig. 2 U.S. decline in mean occupational exposures over recent decades. Data from 1960 to 1985 (projected) show decline in both medical and dental personnel (Kumazawa *et al.*, 1984).

Consult Exposure Guideline for Intraoral Projections

Variations and inaccuracies in kilovoltage, milliamperage, and timer settings have been reported for many dental x-ray machines. Therefore, for each of your x-ray machines *you must establish the correct exposure time* for the kilovoltage and milliamperage settings you have selected. (Acceptable film density is based on recommended processing procedures, as detailed in the section *Process Film Properly*.)

Use the chart that follows as a starting point in determining the combination of proper exposure factors that produce quality radiographs with minimum patient exposure. If your kilovoltage, milliamperage, or source-image distance is not shown, you should use the chart to estimate an exposure time.

The American Dental Association (ADA) recommends the use of a shielded, open-ended position-indicating device, or PID, preferably with rectangular collimation. This technique significantly reduces the volume of tissue exposed during intraoral radiography. Circular collimation can be easily converted to rectangular through the use of an insert available from manufacturers of radiographic products (see last page for suggested resource).

Table 2 —Exposure Guidelines for KODAK INSIGHT Intraoral Dental Film

exposure time in seconds*

Region	60kV 7 mA	60kV 8 mA	65kV 7.5 mA	65kV 8 mA	70kV 7 mA	70kV 8 mA	75kV 8 mA	80kV 8 mA
Maxillary								
anterior	.36	.24	.21	.19	.18	.16	.13	.12
premolar	.36	.24	.21	.19	.18	.16	.13	.12
molar	.46	.29	.27	.24	.23	.20	.17	.14
bitewing	.36	.24	.21	.19	.18	.16	.13	.12
Mandibular								
anterior	.27	.18	.16	.14	.14	.12	.10	.09
premolar	.36	.24	.21	.19	.18	.16	.13	.12
molar	.36	.24	.21	.19	.18	.16	.13	.12
bitewing	.36	.24	.21	.19	.18	.16	.13	.12

* Note: For larger patients, increase time by approximately 25%. For children, small or edentulous patients, decrease time by approximately 30%. To convert to impulses, multiply by 60.

Table 3 —Exposure Guidelines for KODAK ULTRA-SPEED Dental Film

Exposure Factors	65 kV 10 mA	65 kV 15 mA	70 kV 7 mA		70 kV 10 mA		70 kV 15 mA		80 kV 10 mA		80 kV 15 mA	
Source-Image Distance	8"	8"	8"	12"	8"	16"	8"	12"	8"	16"	8"	16"
Region	Approximate Exposure in Seconds*											
Maxillary												
Anterior	.25	.17	.22	.50	.15	.62	.10	.23	.12	.45	.07	.30
Premolar	.32	.22	.28	.63	.20	.78	.13	.30	.13	.56	.10	.38
Molar	.37	.25	.32	.72	.23	.90	.15	.33	.17	.65	.12	.43
Bite-Wing	.25	.17	.22	.50	.15	.62	.10	.23	.12	.45	.07	.30
Mandibular												
Anterior	.20	.13	.18	.40	.12	.48	.08	.18	.08	.35	.07	.23
Premolar	.22	.13	.18	.43	.13	.53	.08	.20	.10	.38	.07	.25
Molar	.25	.17	.22	.50	.15	.62	.10	.23	.12	.45	.07	.30
Bite-Wing	.25	.17	.22	.50	.15	.62	.10	.23	.12	.45	.07	.30

*Children: Reduce adult exposure time about one-third. Edentulous areas: Reduce exposure time about one-quarter. To convert to impulses, multiply by 60.

Record Correct Exposure Times for Your Machine

After exposing films at the selected exposure times, and processing as recommended, view the finished radiographs. If they are too light or too dark, adjust exposure times accordingly. After you have established correct exposure factors for your machine, enter them below.

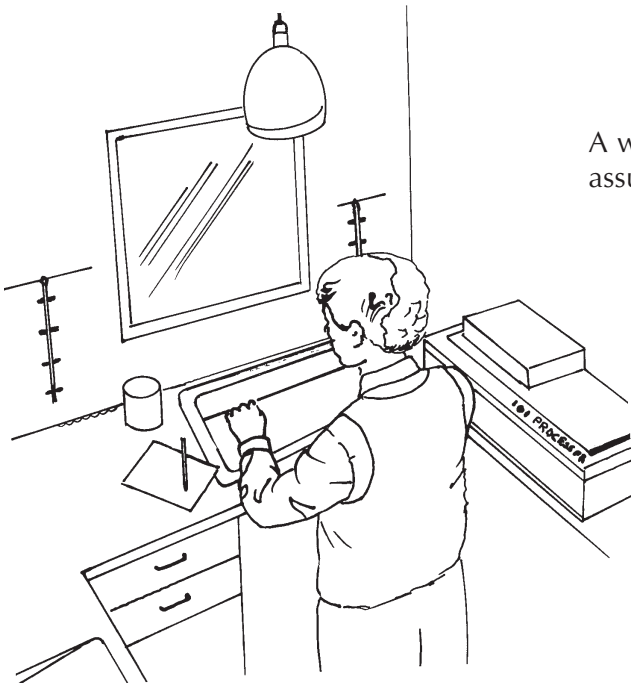
Kilovoltage settings _____
Milliamperage settings _____
Impulses or seconds _____

Using:

___ 8" Position-Indicating Device
___ 12" Position-Indicating Device
___ 16" Position-Indicating Device

NOTE: The exposure settings may have to be altered to compensate for such factors as size of the patient, age of the patient, and region of the mouth being radiographed. The end of the position-indicating device should be positioned as close to the patient's face as possible.

Maintain an Adequate Darkroom



A well-equipped and properly configured darkroom helps assure high-quality radiographic images.

- Eliminate light leaks
- Install proper safelighting
- Use quality processing chemicals
- Regulate water temperature

Eliminate Light Leaks



Light leaks cause fogging of films during processing, with substantial loss in detail and contrast.

To Detect Light Leaks:

- Close and lock door
- Turn off all lights
- Let your eyes adjust to the dark for at least 5 minutes
- Look for light leaks
- Mark light leaks with chalk

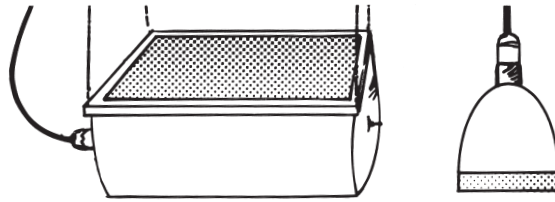
To Eliminate Light Leaks:

- Seal light leaks with black masking tape or weather stripping
- Use double doors or heavy curtains

Darkroom Tip:

Do you have a light leak? Is your safelight too bright? Take this simple test in your darkroom. With the door closed, regular lights out and safelight on, remove film from covering and place raw, unexposed film on countertop. Place a coin on top of the film, wait two minutes and then process the film. If you see the coin outline on the processed film, your darkroom is too bright.

Install Adequate Safelight



A proper safelight provides ample lighting during processing, yet it is safe for sensitive film. Safelighting that is too bright will fog the films. A safelight with a ruby red filter is recommended, as orange-yellow (amber) filters are likely to result in fogged film.

Recommendations for Safelighting:

- A KODAK GBX-2 Safelight Filter is recommended for use with both intraoral and extraoral dental films
- Place safelight at least 4 feet (1.2m) away from working surface; for a standard 110 V U.S.A. system, a 15W lamp is recommended; for a 220-240 V system, a 25W frosted or “pearl” lamp is recommended
- Check for cracked or faded filters
- The safelight filter is properly installed in the lamp when “GBX-2” can be read normally on the surface of the filter
- Keep safelighting exposure as short as practical

Use KODAK Solutions



KODAK processing solutions are especially formulated in Kodak research labs to obtain the highest-quality image when used with KODAK Dental Film. Follow the recommendations found in the KODAK Dental Products Catalog for proper usage.

To keep the solutions clean, change every 3 to 4 weeks under normal conditions. (“Normal” use is defined as 30 intraoral films per day.) Heavy workloads may require more frequent changes. Developer and fixer solutions should be replenished daily. If you process an average of 30 films per day, the following recommendations are appropriate:

For manual processing tanks (1 U.S. gallon/ 3.8 L size) and for automatic roller-type processors containing one gallon (3.8 L) of each solution, approximately 8 oz. (236 mL) of replenishment is required **daily** for developer and fixer, even if no film is processed. Automatic roller-type processors with larger solution capacity require approximately 12 oz. (355 mL) of replenishment daily. 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 oz. (7 mL) per additional film processed. For example, 50 intraoral films per day would require that 13 oz. (385 mL) be added daily—the usual 8 oz. (236 mL) for the first 30 films, plus an additional 5 oz. (148 mL) for the additional 20 films.

Manufacturers of automatic non-roller-type processors recommend that all solutions be changed every two weeks.

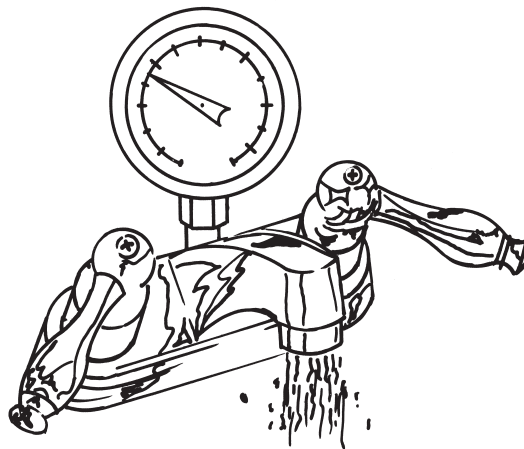
While some automatic processors provide replenishment automatically, other units require operator intervention to maintain the correct solution levels and strengths.

Daily replenishment is vital to maintain quality radiographs. While it appears that you are “throwing away” chemicals, you are actually preserving the chemical activity of the remaining solution. Solution life is dependent upon:

- Use factor—greater use means shorter life
- Exposure to air—causes oxidation of the chemicals and shortens effective life
- Temperature—the chemicals deteriorate from extreme heat; they become inactive in extreme cold

Each factor—use, air and temperature—works to deteriorate the activity of the solution. Fresh chemicals usually produce the best radiographs. In order to maintain that quality over several weeks, replenishment is added in small quantities each day.

Regulate Water Temperature



Water requirements vary among processors.

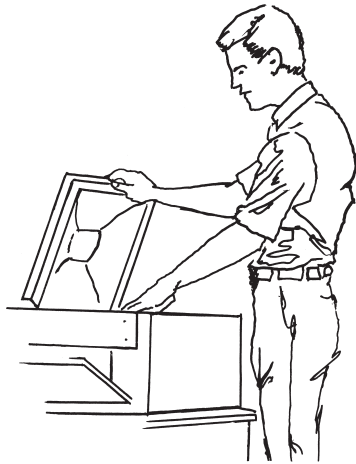
Most processors need only cold water, a few need tempered water, and some need no water at all.

If necessary, have some kind of temperature adjustment control for the incoming water.

Provide for constant water flow in the wash compartment during film processing. Automatic non-roller-type processors need water changed daily to avoid stagnation.

Automatic Processors: Process Films Properly

Follow a Set Routine . . .



At the beginning of each work day, as appropriate for your processor:

- Check to be sure there is a sufficient amount of chemicals in both replenishment containers or add KODAK Dental Developer and Replenisher and/or KODAK Dental Fixer and Replenisher directly to working solutions
- Turn power on
- Turn water on to begin stabilizing the solution temperatures
- In roller transport systems, insert clean-up film

Automatic Processing Recommendations for Intraoral Radiographs

KODAK ULTRA-SPEED Film

KODAK INSIGHT Film

KODAK READYMATIC Chemicals

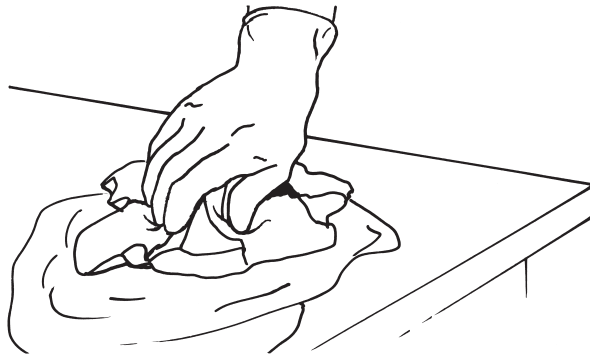
KODAK READYPRO Chemicals

The amount of time required to complete the processing cycle and the temperature setting for the developer varies from processor to processor and is set by the manufacturer.

In the equipment available today, the time required for the complete cycle ranges from 4 minutes at 85°F (29.5°C) 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.

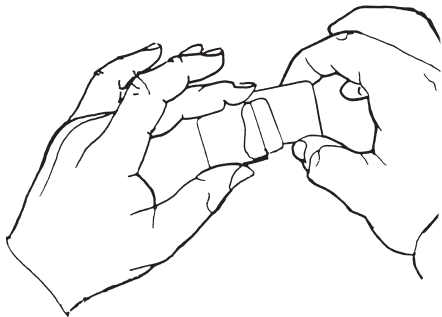
These values are provided only as examples to illustrate the relationship between time (cycle) and temperature. Follow the manufacturer's recommendations when setting up your processor.

Automatic Processors: Practice Good Housekeeping



- Wipe up spilled solutions immediately
- Clean rollers or transport system as recommended by the processor manufacturer; rinse thoroughly before reinstalling in processor, as residual cleaners may contaminate fresh chemicals
- Run KODAK Roller Transport Cleanup Film after you have turned the processor on to remove foreign matter (e.g., flecks of lint) that may have accumulated on the rollers during previous use

Automatic Processors: Unwrap Films Carefully



Turn off the room light and turn on the safelight.

Observe these rules for unwrapping films:

- Keep hands clean and dry
- Handle films by the edges to avoid finger marks and abrasions
- Insert film in unit to begin processing cycle

At the end of each work day, as appropriate for your processor:

- Turn off water to processing unit
- Turn off power to processing unit or place in standby mode

The correct automatic processing equipment and proper procedures contribute to the quality of the radiograph. While automatic processing equipment will mechanically perform many of the procedures done during manual processing, the manufacturer's recommendations must be followed for optimal results.

Maintain Automatic Processors

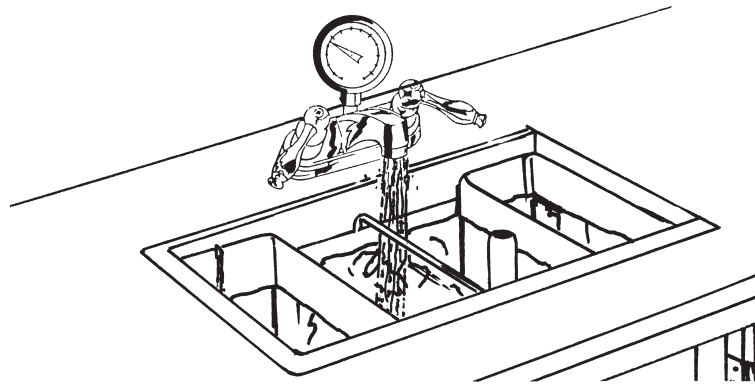
Automatic processors can do an excellent job of processing films, *BUT* they require an effective quality assurance program. You should follow a set routine to assure maximum performance, and establish a time schedule for regular maintenance:



- Check proper solution temperature
- Maintain proper solution levels
- Maintain activity of solutions by replenishing daily
- Perform routine preventive maintenance
- Keep working parts clean

Manual Processing: Process Films Properly

Follow Set Routine . . .



At the beginning of each work day:

- Turn on water to begin stabilizing the solution temperatures
- Uncover chemicals
- Bring solutions to proper levels by adding and replenishing as recommended
- Use a film hanger to check solution levels; solutions must completely cover the section that holds the film; do not use clips that will not be fully immersed in the solution
- Stir the solutions thoroughly to establish an even temperature and concentration; use separate stirring rod for each solution (plastic or stainless steel rods—*never wood*)

Manual Processing Recommendations for Intraoral Radiographs

KODAK ULTRA-SPEED Film
KODAK INSIGHT Film
KODAK GBX Developer
KODAK GBX Fixer

Quality radiographs begin with the selection of film and processing solutions. It is important to remember that Kodak products work best when used together and have been the choice of dentists since the first dental radiograph was taken in the U.S. in 1896.

The emulsion on KODAK Dental Film is a precise coating of dry chemicals waiting to interact with robust KODAK processing chemicals. KODAK INSIGHT Film and ULTRA-SPEED Dental films in combination with KODAK GBX Developer and Fixer were formulated to produce optimal image quality. In manual processing, attention to good housekeeping practices and processing guidelines are essential.

Manual Processing: Practice Good Housekeeping



- Wipe up spilled solutions immediately
- Wash hangers after each use (pay particular attention to hanger clips)
- Always use clean, dry hangers

Manual Processing: Use Time-Temperature Development

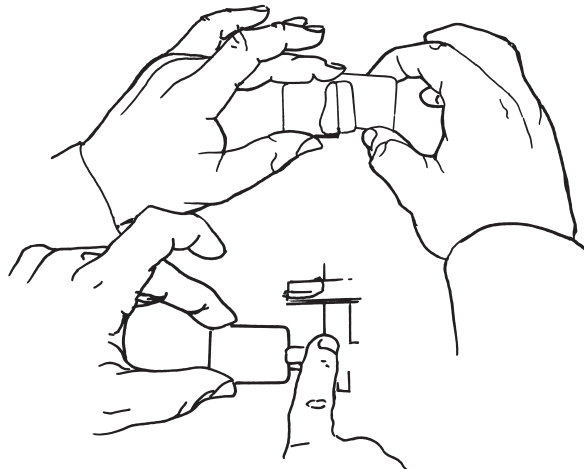
KODAK Intraoral Films	Develop	Rinse	Fix	Wash
KODAK ULTRA-SPEED Dental Film & KODAK INSIGHT Dental Film	KODAK GBX Developer and Replenisher	Fresh running water or KODAK Indicator Stop Bath	KODAK GBX Fixer and Replenisher	Clean running water (approx 8 volume changes hour)
	68°F (20°C) 5 min 70°F (21°C) 4½ min 72°F (22°C) 4 min 76°F (24.5°C) 3 min 80°F (26.5°C) 2½ 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

- Check temperature of developing solution—if possible, adjust temperature to the approximate setting 68°-80°F (20°-26.5°C)
- Consult time-temperature chart for recommended developing time
- Set timer

Do Not Sight Develop

The information contained in the illustration above is extracted from KODAK Publication N-410 and is available for use in your darkroom (see last page for ordering instructions).

Manual Processing: Unwrap and Clip Films Carefully



Turn off the room light and turn on the safelight.

Observe these rules for unwrapping and clipping films:

- Keep hands clean and dry
- Handle films by the edges to avoid finger marks and abrasions
- Attach films securely to the hanger
- Do not allow solutions to splash on unprocessed films

Manual Processing: Develop Properly

Develop

Prepare developer and fixer solutions according to the directions on the container. Set the timer according to the processing chart shown earlier. Immerse films (attached to a film hanger) quickly into the developer solution, dislodging air bubbles by vigorously moving the film hanger in the solution for 5 seconds. *Do not agitate film during development.* Remove the hanger from the developer when the timer sounds. *Do not drain excess developer back into the developer tank.*

Rinse

Immerse the film into the rinse tank for 30 seconds with *continuous agitation*.

Fix

Fix for 2-4 minutes with *intermittent agitation* (5 seconds agitation every 30 seconds). Allow excess fixer to drain back into the fixer tank before washing. *Do not turn on the darkroom light during fixing.*

Wash

Wash films for 10 minutes in clean running water (approximately 8 volume change per hour). Do not leave the films in the wash water for extended periods of time (over 12 hours) because damage to the image may occur.

Dry

Dry in a dust-free area at room temperature or suitable drying cabinet. The temperature of the dry should not exceed 120°F (49°C).

At the end of each work day:

- Turn off water
- Cover chemicals

Mount and View Radiographs Correctly



Use an opaque mount.

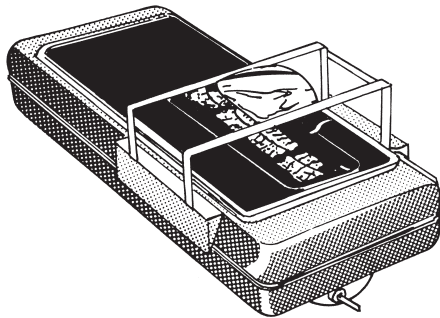
Keep hands clean and dry to avoid scratching and marring the image.
Thin, light cloth gloves can be worn.

Handle radiograph by edges.

Use a viewbox to facilitate correct mounting.

Label mounts properly for identification.

Follow Good Viewing Practices



Always use a viewbox for viewing radiographs.

- Viewbox must have uniform lighting
- A variable light-intensity viewbox is best

Use cardboard template on viewbox to eliminate distracting light around the mount.

Use a magnifying glass.

View radiographs in subdued room lighting.

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To Obtain a free copy of any of the Kodak publication 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 State 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 Products
Eastman Kodak Company
343 State Street
Rochester, New York 14650-1122 U.S.A.

To obtain inserts to convert round position-indicating devices to rectangular collimation, contact: Rinn Corp. Products for Dental Radiography at **1-800-323-0970** or **1-312-742-1115** or write:

Rinn Corporation
1212 Abbott Drive
Elgin, Illinois 60123-1819

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