PROCESSING THE RADIOGRAPH. Neill Serman. Sept. 2000
W + P. Chapter 6

THE STAGES IN THE PRODUCTION OF THE RADIOGRAPH

Many dentists who utilize manual processing, intentionally over expose patients and under process the radiograph in an attempt to save time resulting in radiographs that are inferior in diagnostic quality because of incomplete developing.

When an X-ray film has been exposed, it must be processed in order to produce a permanent **visible** radiographic image that can be kept without deterioration for a number of years. Processing transforms the **latent image** into a **visible image**. The term for the several procedures that collectively produce the visible, permanent image is **processing** and consists of developing, rinsing, fixing, washing and drying procedures

1. **Exposure** - Latent image created.
2. **Development** - Converts latent image to black metallic silver.
3. **Wash** [stop bath] - Removes excess developer.
4. **Fixing** and Hardening - Dissolves out unexposed silver halide crystals.
5. **Washing** - Removes products of processing.
6. **Dry** - Removes water.

For manual processing a **floating thermometer**, a **timer** and the **time** -**temperature** chart are essential.

1. LATENT IMAGE FORMATION.

The latent (invisible) image formation is the **ionization** of the exposed silver bromide crystals (by photon energy that emerges from the patient) occurring in the emulsion layer before processing occurs. The primary interaction with the bromide crystals is by Compton and photoelectric interactions, thereby knocking out electrons. Thus, a physical change occurs when the radiograph is exposed. When X-ray photons [or light photons] strike the silver bromide crystals in the emulsion, minute amounts of silver ions are formed on the surface of the crystal and bromine is liberated and is absorbed by the gelatin. Crystals are purposely constructed with **electron traps** (sensitivity specks) consisting of **sulfur** impurities but also because of the addition of silver **iodide**. Electrons are trapped by the sulfur in the sensitivity speck**s** giving it a negative charge. When this situation is created a latent image is produced in the film emulsion.

AgBr + X-ray photons = Ag+ + Br-

Silver bromide Silver ions + Bromine ions

The **latent image** is formed by deposits of free (ionized) silver ions that cannot be seen or detected by any physical test devised as yet. It remains in the emulsion of the X-ray film until it is changed into a **visible** silver image by chemical processing procedures.

The free electrons move through the crystal until they are attracted to a sensitivity site where they become trapped and impart a negative charge to the site.

2. PROCESSING THE EXPOSED FILM

Exposed radiographs that contain a latent image should be processed as soon as possible as they are more sensitive to energy. Film packets are only to be opened in the darkroom or under safe-light conditions. [in a daylight loader]

The **developer** solution is the first solution into which the films are placed. The developer chemically **reduces** the energized ionized silver bromide crystals by **donating** electrons, removing the halides and precipitating metallic silver in the emulsion layer. The negative charge attracts positively charged free silver ions and is reduced to **black metallic** atoms. This precipitation corresponds to the black (radiolucent) areas on the radiograph.

The concentration of the developer slowly **weakens** due to the number of films processed, [a chemical reaction] and with time by **oxidation** of the developer by exposure to air. Traditionally, the developer tank is placed on the left side of the other chemicals solutions

3. RINSING PROCESS / STOP BATH (WASHING)

When the film is removed from the developer the gelatin emulsion is soft and swollen and contains chemicals which are removed by placing the film in a water bath. By rinsing the film in the water the soluble chemicals are removed, the development reaction is stopped, and the alkalinity of the residual developer is reduced. The unexposed silver halide crystals are not water soluble and will not be washed away.

The film should be rinsed for 10-15 seconds in a bath of fresh, running water. The temperature of the water must be as close as possible to the temperature of the developer and fixer to avoid **reticulation -** uneven expansion and contractions of the emulsion layer. If this step were omitted, the alkaline developer retained by the film would soon neutralize the acid of the fixer. The fixing and hardening action of the fixer would be impaired and as a result, **brown stains** will be produced on the radiograph within a few weeks. Because the emulsion layer (gelatin) is soft when wet, the film **scratches easily.**

Safe-light conditions must be maintained when transferring the film from the developer to the wash tank and then to the fixing tank to avoid **fogging.**

For automatic processing there are "**squeegy**" rollers that remove the chemicals and thus the film goes from the developer solution straight into the fixer.

4. FIXING.

The **acidic** fixing solution removes the unexposed and undeveloped silver bromide **crystals** from the film emulsion and re-hardens the emulsion that has softened during the development process. For manual processing, if the film is placed in the developer solution for X amount of time it should be placed in the fixer for **2X** and in the final rinse for **3X**

amount of time. "X" is determined by the time-temperature chart. The ideal time to process radiographs in the developer is **68^0 F for 5 minutes.**

However, films may be removed from the fixing solution after five minutes for viewing only in cases of emergency - this procedure is known as wet reading \ viewing. The film must then be placed back in the fixer. If these unwanted silver bromide crystals are not removed, the resultant film will **discolor** after a few months. If the film is only partially fixed the film will turn brown in color with age.

The gelatin protective coating is hardened by the **potassium alum** so the film will resist abrasion / scratching

5. **FINAL WASH.**

The purpose of the final wash is to remove residual fixer chemicals i.e. acid, thiosulfate and silver salts from the film. Insufficient washing results in the film turning brown as all the chemicals have not been washed away. If the temperature difference between developer and / OR fixer and water exceeds 15 F, there is a possibility of unequal swelling and shrinkage of the emulsion layer, commonly referred to as reticulation. Also, prolonged washing tends to make the emulsion soft, and it then scratches more easily.

6. **DRYING.**

In most offices, films are dried merely by hanging them on a rack in the darkroom above a drip tray designed to catch the run-off excess water. Others use a fan to dry the film. The fan should not blow directly on the films. Cabinet dryers are available which are equipped with a fan and heating elements

Wet films are subject to damage from scratching and abrasion if not handled properly. If there is dust in the air, dirt will become easily embedded within the emulsion. Do not remove wet radiographs from their hangers until they are completely dry

In most darkrooms the developer will be in the **left-hand** tank as you face the tank, the water bath in the center and the fixing solution in the **right-hand** tank. The developer can be identified by its soapy feel, (alkali) the fixer by its **vinegary** odor when fresh and **acid taste**

An area of less density, say the pulp, will allow greater penetration of X-rays; therefore more X rays will reach that part of the film. Thus more silver bromide crystals will be energized and more silver will precipitate to give a black or radiolucent outline to the pulp chamber. Areas that have received smaller amounts of radiation will have correspondingly less silver precipitated and will appear gray. **Individually if a crystal is energized the whole crystal turns black.** The silver bromide behind a gold crown, will precipitate no or very little silver as there was minimal energy reaching that area, and will appear white, or radiopaque on the radiograph. Gold and amalgam have high z values.

The X-ray film is a delicate product, sensitive to many things, e.g. light photons, X-rays and gamma rays, pressure, to various gases and fumes, to heat and moisture and even aging causes a gradual change in it; known as fogging.

PROCESSING CHEMICALS.

A. **DEVELOPER** (Reducing Agent)

Chemical	**Action**
a) Hydroquinone	brings out sharp contrast. The reducer acts slowly Is a benzene product and made from dyes
Elon OR metol	acts faster [phenidone - is now often used instead of elon or metol]
	This reaction can only occur in an **alkaline** medium
b) Alkalizer [Accelerator] Na2CO3	Provides alkaline medium in which the reducer reacts. It softens and swells the gelatin emulsion and attracts the exposed silver bromide crystals
c) Preservative Na. Sulfite	Slows oxidation and therefore preserves the strength of the other chemicals If not present the strength of the other chemicals would rapidly weaken. This explains the darkening of the solution
d) Restrainer Pot. Bromide.	Restrains the developing agent from the strength. The developing agent will deposit silver in the unexposed crystals in the emulsion causing a silver deposit (**fogging**) on the film if the restrainer is not added
e) Vehicle Water	Provides a means for the chemicals in the developer to react (Ionize). Water helps to **soften** gelatin

The reaction does not occur unless alkalizer is present. The alkali "opens the doors" and permits the developing agents to enter the pores of the emulsion.

If the lid is left off the developing tank, the preservative will be rapidly become exhausted by **oxidation**.

In addition to the above a **fungicide** is added to prevent growth of fungi and a **buffer** is added to maintain the pH within specific limits.

B. **FIXING SOLUTION**

CHEMICAL.	**ACTION.**
a. Fixing Agent Sodium Thiosulfate (hypo)	Removes unexposed crystals

Ammonium Thiosufate	[Removes **all** crystals]
b. Preservative Sodium sulfite	Prevents deterioration of solution.
c. Hardening agent Potassium alum	Shrinks and hardens the gelatin
d. Acidifier Acetic acid	Provides acid medium. Alum reacts better in acid medium. Stops developing process
e. Vehicle Water	As above.

The fixing agent removes all the silver halide crystals and therefore if a film is first placed into the fixer solution, the processed film will appear clear.

TYPES OF PROCESSING.

1. Manual
2. Semi-automatic
3. Fully automatic.
    a. without replenisher
    b. with replenisher.

SOME DIFFERENCES BETWEEN MANUAL AND AUTOMATIC ROCESSING.

1. No stop bath between developer and fixer as rollers remove the chemicals
2. Higher temperatures for automatic processors. Therefore different chemicals required
3. Hardener placed in developer in automatic processors
4. Additional hardener is added to the fixer solution.
5. Because of the daylight-loader a darkroom is not required.
6. Because of the heater in the automatic processor, the process is a "dry to dry" process.

Rapid processing solutions are used for emergencies and endo where time is of the essence. The film is developed for 15 - 20 seconds and fixed for a similar period of time. The films do not have the same amount of contrast and will discolor with time so they must still be fixed and washed correctly to minimize the discoloration.