PROCESSING OF X-RAY FILMS

Introduction: -

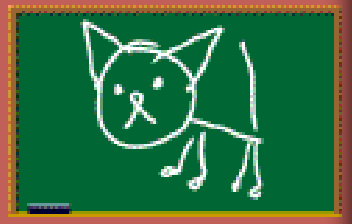
- When X- Ray film is exposed to the information-carrying beam of photons exiting an object, the photosensitive silver halide crystals in the film emulsion that interact with these photons are chemically changed.

- These chemically altered crystal are said to constitute the latent(invisible) image on the film.

FORMATION OF LATENT IMAGE

- The film emulsion is a suspension of tiny photosensitive silver bromide crystals and, to lesser extend, silver iodide crystals that have been precipitated in gelatin and layered on a thin sheet of transparent plastic base.

FORMATION OF LATENT IMAGE



- **The silver halide crystal are imperfect in various aspect:**

1. Interstitial silver ions: These are free in the spaces b/w the crystalline lattice.

2. Physical distortion are present in the regular rectangular array of silver and bromide ion crystals due to the presence of iodine atom occupying some of the bromide site.

3. The silver halide crystal are chemically sensitized by the presence of sulphur compounds which cause physical irregularities in the crystal produced by iodide ions, and called latent image sites.

Function of these latent image:

- Beginning of the process of image formation by trapping the electrons generated when the emulsion is irradiated.
- When the silver halide crystals are irradiated by X-Ray photons it will result in the release of electrons usually by the bromide ions, (by Compton and photoelectric interactions) which are converted to bromine atoms, by the removal of an electron(recoil electron).
- This recoil electron produced sufficient kinetic energy with which it moves in the crystal and strike the image site, imparting a negative charge to that region.

Processing Solution

- The primary action of the processing solutions are to convert the crystals with the latent images into black metallic silver grains that can be visualized and to remove the unexposed silver bromide crystals.

Processing Solutions

***Film processing involved the following procedures:**

1. Immersion of exposed film in developer solution.
2. Rinsing in running water.
3. Immersion in fixing solution.
4. Film washing.
5. Drying and mounting for viewing.

Processing Solution

These may be obtained in the following form:

- Powder.
- Ready to use liquid.
- Liquid concentrate.

The special chemical solutions are:

- Developer solution.
- Fixing solution.

Developer solution:

Developer solution:

- **Reducing agents:**

1. Hydroquinone (paradihydroxy benzene).
2. Mentol or elon(mono methyl- para amine phenol sulphate.
3. Mentol phenidone(1- phenyl-3-pyrazolidone).

Hydroquinone (paradihydroxy benzene) :

- It is a benzene derivative and is concerned with the production of high contrast in the radiograph.
- Hydroquinone becomes relatively inactive in low temperature.

Mentol or Elon: -

- Mono methyl-para amine phenol sulphate is a by-product of analine dyes and helps develop the shadow areas or shades of gray on the film and bring out the details.
- It does not produce a high contrast.
- It is less sensitive to temperature changes.

Mentol phenidone (1-phenyl-3-pyrazolidone)

- This serves as the first electron donor that converts silver ions to metallic silver at the latent image site.
- The electron transfer generates the oxidized form of phenidone.
- Hydroquinone provides an electron to reduce the oxidized phenidone back to its original active state so that it can continue to reduce silver halide grains to metallic silver.

Developer solution:

- **Preservative:** sodium sulphite.
- **Activator:** potassium carbonate / sodium carbonate.
- **Restrainer:** potassium bromide / benzotrizol.
- **Hardener:** Glutaraldehyde.
- **Fungicide:** To prevent the bacterial growth.
- **Buffer:** To maintain the pH(+7).

Developer solution:

- **Solvent:** Water-:

- It is used as a solvent of the chemicals & as a medium in which they react with the silver bromide of the film emulsion.

Sodium sulphite: -*(preservative)*

- Sodium sulphite inhibits the tendency of the developing agent to combine with the oxygen dissolved in water or in the air.

- Oxidation of the developing agent forms colored substances which would stain the film and add to the film fog.

Potassium/Sodium Carbonate *(Activator):*

- It is added to the developing solution to proving and maintain the degree of alkalinity in which the developing agent can function.
- Excessive alkalinity will cause rapid reduction even of unexposed silver bromide crystals and produce fog.
- A low degree of alkalinity will slow down the process of development.
- Sodium hydroxide in conjunction with sodium carbonate may be used to give higher contrast.

Potassium bromide or benzotriazole *(Restrainer):*

- Potassium bromide slows down the reduction action of the developing agent, and has its greatest retarding effect on the development of unexposed crystals.
- It prevents excessive fogging of the film and increases the contrast.

Glutaraldehyde *(Hardener)*

- This is added especially in automatic processing, to prevent the emulsion from softening and sticking to the rollers.

Developer Replenisher

Developer Replenisher:

- Developer becomes inactivated by exposure to oxygen.

- The recommended amount to added daily is 8 ounce of fresh developer (replenisher) per gallon of developing solution, if approximately 30 IOPA's or 5 panoramic films developed per day.

Rinsing

Rinsing

- After development the film emulsion swells and become saturated with developer.
- At this point the films are rinsed in water for 30 second with continuous gentle agitation before they are placed in the fixer.
- It also removes the alkali activator preventing neutralization of the acid fixer.

Fixing Solution

Fixing solution

- The primary function of the fixing solution is to dissolve and remove the undeveloped silver crystals from the emulsion.
- The 2nd function of fixing solution is to harden and shrink the film emulsion.
- As developer, fixer should be replenished daily at the rate of 8 ounces per gallon.

Fixing solution

- **Fixing solution are: -**

  Clearing agent – Ammonium/ Sodium thiosulphet

  Preservative - Sodium sulphite

  Acidifier - Acetic acid

  Hardener –Aluminum chloride/ Aluminum sulphite/ Potassium alum.

  Solvent – Water

Ammonium/ Sodium thiosulphate (*Clearing agent*)

- Hypo is the one of the few substances which will remove silver bromide without adverse effect on the film.
- The chemical reacts with the undeveloped silver bromide and converts it into a soluble substance which can be subsequently washed out of the film.

Sodium sulphite *(Preservative)*

- It prevents the oxidation of the clearing agent, which is unstable in the acidic environment.

- Sodium sulphite also bind with any colored oxidized developer carried over into the fixing solution, and thus prevents any oxidized developer from staining the film.

Acetic acid *(Acidifier)*

- The acetic acid buffer system (pH 4 to 4.5) help to keep to the fixer pH constant.
- This acetic pH is require to promote good diffusion of the thiosulphate into the emulsion and of silver thiosulphate complex out of the emulsion.
- The acidic solution also neutralized any developing agent carried over, thereby blocking any further development of any unexposed crystals while the film is in the fixing tank.

Aluminum chloride/ Aluminum sulphite/ Potassium alum *(Hardener)*

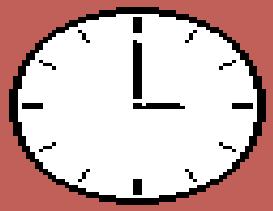
- These substance form complexes with the gelatin during fixing and prevent further damage to the gelatin during subsequent handling.
- The hardeners also reduce the swelling of the emulsion during the final wash.
- This lessons mechanical damage to the emulsion and limits water absorption, thus shortening the drying time.

Water (Solvent)

- The fixing solution should be made up in according with the manufacture’s instructions and used at a temperature of about 68° F (20° c).

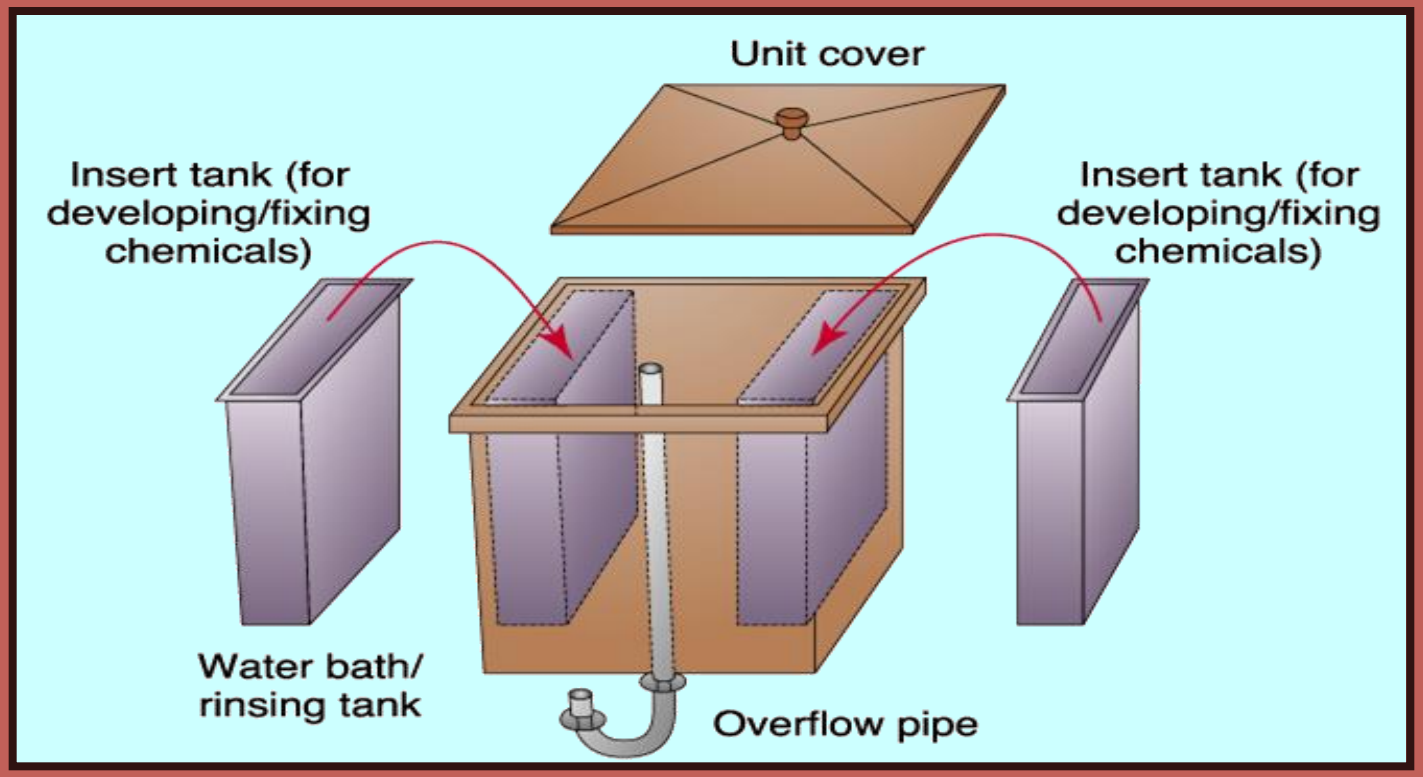
WASHING

Washing :



- After fixing, the processed film is washed in a sufficient flow of water for an adequate time to ensure removal of all thiosulphate ions and silver thiosulphate complexes.
- Washing efficiency declines rapidly when the water temperature falls bellow 60˚F.
- The film is washed for about 20 minutes in the water tank to remove the fixing solution from the emulsion.

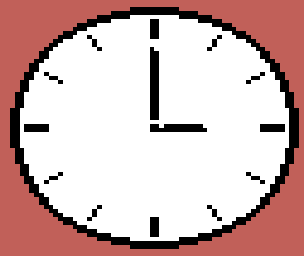
The development process



Different methods of processing:

1. Manual method
   i. Time temperature method
   ii. Visual method
   iii. Rapid processing method
2. Automatic method
3. Monobath method
4. Day light method
5. Digitized processing method
6. Self developing films

The development process



Manual Procedure:

- Lock the darkroom door from the inside.
- Stir the solution to equalize the temperature & the chemical distribution of the processing solution.

Manual Procedure:

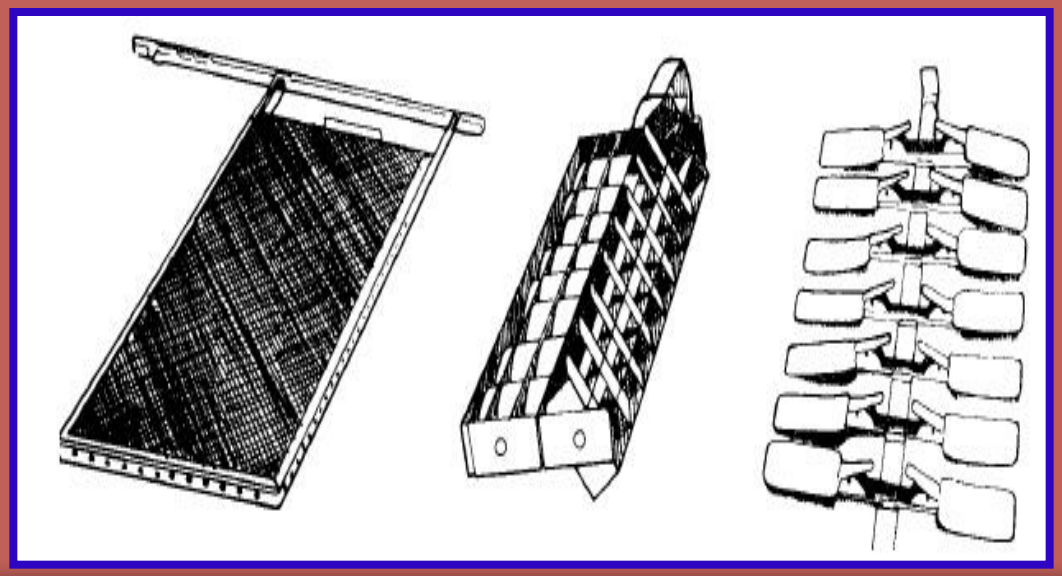
- Check the temperature and set the timer.
- Turn off the white light and turn on the safe light.
- Put on gloves and open the film packets, dropping the film onto the working surface. Discard contaminated film packets and /barrier wraps, remove gloves and load the film hanger.

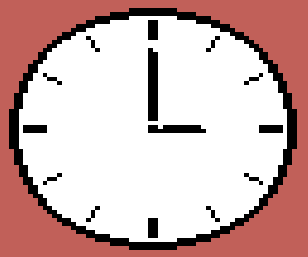
Solution temperature	Developer (in minutes)	Rinse	Fixer	Wash time
65 F	6	0.5	10-12	20
68 F	5	0.5	10	20
70 F	4.5	0.5	9-10	20
72 F	4	0.5	8-9	20
75 F	3	0.5	6-7	20
80 F	2.5	0.5	5-6	20

Procedure:

- Immersing the film hanger in developer and activate the timer, immediately raise and lower the hanger a few times so that the film surfaces are covered totally by solution.

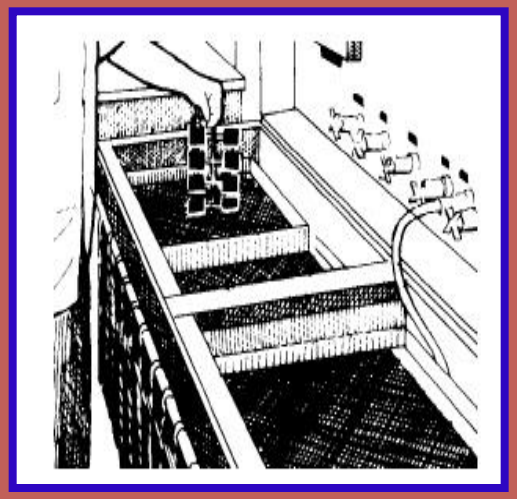
- Remove the film rack from the developer when the timer sounds.

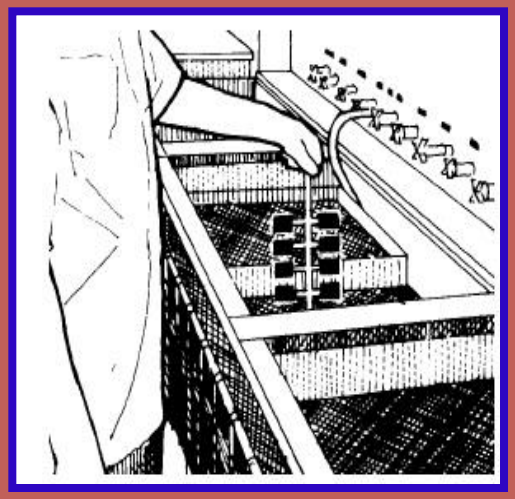




Procedure:

- Rinse thoroughly for 20 sec. in the water bath.
- Place the film rack in the fixer solution. Agitate the rack up and down. Film should remain in the fixer for a minimum of 10 minutes.
- Place the film in the running water bath for 20 min.
- Dry the film.





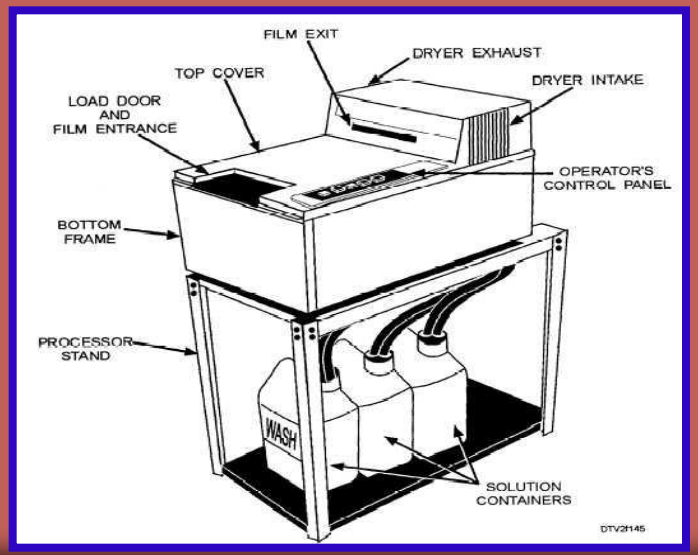
RAPID PROCESSING SOLUTIONS

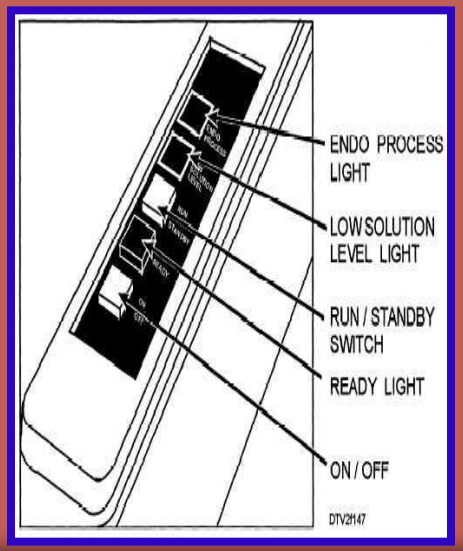
- Develops within 15 seconds at room temperature.
- High concentration of hydroquinone, more alkaline, emulsion swells more, greater access to developer.
- Applications in endodontics and emergency situations
- Less contrast and may discolor, if not fully washed

- kept in convention solution for 4 minutes and washed for 10 minutes.
- Minute, contrast improved ,film more stable in storage

Automatic processing

- Lock the darkroom from inside door.
- Turn on the processor or switch from the standby to the ready mode.
- Turn off white light and turn on the safelight.
- Put on gloves and open the film packets, dropping the films onto the working surface of the automatic processor.





Automatic processing :

- Be sure that the films are aligned with the film tracks and that they are not put in so quickly as to produce overlapping.
- Retrieve the dried films and place them in a mount.

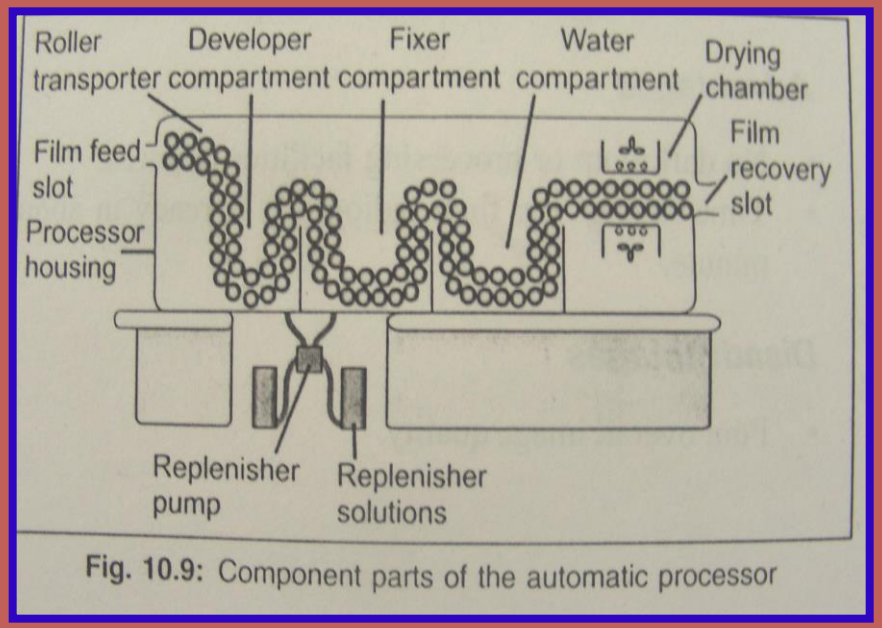


Fig. 10.9: Component parts of the automatic processor

ADVANTAGES:

- Rapidity ,less than 4-7 minutes
- Uniformity of result
- Less floor space, have a daylight loading capability
- No wet films to be handled, no film hangers no dryer
- no wet reading of films
- density and contrast consistent

DISADVANTAGES:

- Quality not high, more grain evident
- High cost of equipment and maintenance

MONOBATH METHOD:

The developer and fixer are combination in one solution.
The fixer is alkaline and dose not neutralized the developer.
A special water proof film packet and the film is developed by simply rubbing the film packet.

ADVANTAGES

- Ideal for root canal treatment, and quick spot diagnosis.

DISADVANTAGES

- Alkaline fixer rapidly oxidizes under atmospheric conditions
- Results unsatisfactory, fixing starts while developing process is in progress.

DAY LIGHT METHOD:

Special device, with safelight filters and two glove like compartments .

Film opened and processed in subdued daylight

Emulsion consists of a yellow dye and the film appears yellow and black instead of convention blue white and black.

ADVANTAGE

- No need of the dark room

DISADVANTAGE

- Requires a special day light film

SELF DEVELOPING FILMS:

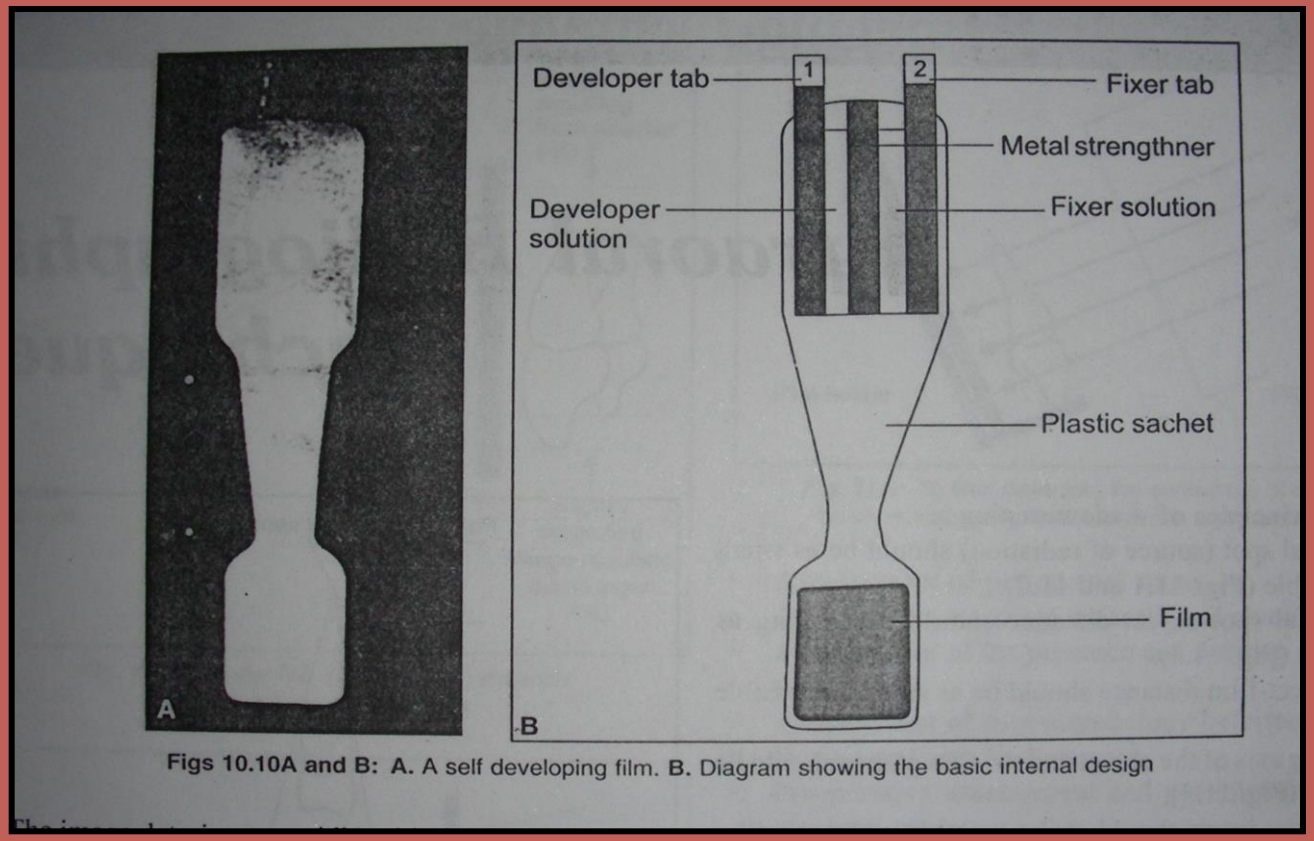
ADVANTAGE

- No darkroom or processing facilities required
- Time saving, ready in about a minute.

DISADVANTAGE

- Poor overall image quality
- Image deteorates rapidly with time
- No lead foil inside
- Film packet very flexible and easily bent
- Films are difficult to use in positioning holders.
- Relatively expensive.

SELF DEVELOPING FILMS:



Figs 10.10A and B: A. A self developing film. **B.** Diagram showing the basic internal design

PROPOSED MAINTAINENANCE SCHEDULE:

DAILY

- Temperature of developer :- 81-83 F
- Drain water section daily
- Transport sections checked regularly for proper alignment
- Cover processor, slightly open ,escape of chemical fumes.

WEEKLY

- Soak and wash roller sections,10-15 minutes, run two cleaning films before use
- Shange/ replenish solutions every 2-4 weeks

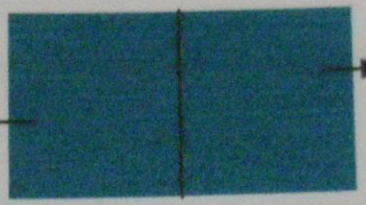
PROPOSED MAINTAINENANCE SCHEDULE:

MONTHLY

- Clean developer tank with special developer cleaner, (prevents fogging of films).
- Fixer section with water, (prevents formation of crystals on the rollers).
- Wash section with household bleach/water solution (prevent scum formation leading to spots and artifacts on films).
- Rinse all racks thoroughly with water.
- Visually check dryer and dust.
- All moving parts like gears, bearings, dryer mechanism, well lubricated prevent excessive wear of moving parts.

DIAGRAM SHOWING THE STAGES:

NON –EXPOSED FILM



GREEN SENSITIZED SILVER HALIDE EMULSION

GREEN NON-SENSITISED SILVER EMULSION

DEVELOPER

BLACK METALLIC SILVER

GREEEN SILVER HALIDE

WASH

FIXER

BLACK METALLIC SILVER

WHITE /TRANSPARENT

WASH AND DRY

FINAL BLACK AND WHITE IMAGE

The Darkroom

- The term light-tight is often used to describe the darkroom.
- When you are in the darkroom with the light turned off, no white light should be seen.
- X-ray film is *extremely* sensitive to visible white light.
- Any leaks of white light can cause film fog. A fogged film appears dull gray, lacks contrast, and is nondiagnostic.

Requirements for a Darkroom-

- At least 4 x 5 feet.
- Light proof.
- Should have light tight door.
- Door should have a lock to prevent accidental opening.
- Room should be well ventilated for the comfort and to exhaust the heat from the dryer and moisture from the drying films.
- Ceiling should be high, because if low humidity increases.

Requirements for a Darkroom-

- Floor should be antiskid, not slippery.
- Walls should be darkly painted to prevent reflection of light.
- Both a safelight and a source of white (normal) light and safelights should be provided at a safe location.
- Processing tanks for the developer and fixer solution and a circulating water bath.
- Temperature of the solution should be maintained between 65^0 -75^0 F.

.Requirements for a Darkroom-

- An accurate timer.
- An accurate floating thermometer.
- Be kept clean at all times.
- Container, labeled with a biohazard label, for contaminated film packets or barriers.
- Container for lead foil.
- Stirring rods or paddles to mix the chemicals and equalize the temperature of the solutions.

.Requirements for a Darkroom-

- Safe storage space for chemicals.
- Film hangers.
- A film-drying rack and a film dryer.

Types of Darkroom Lighting

- X-ray films are called as colour blind films.
- Dark room should be provided with white and safe light illumination.

Types of Darkroom Lighting

- Room lighting: An overhead white light that provides adequate lighting when performing tasks such as cleaning, restocking materials, and mixing chemicals is required.
- Safelighting: A safelight is a low-intensity light in the red-orange spectrum. Safelighting provides enough illumination in the darkroom to process films safely without exposing or damaging the film.

Safelight

- Safe light should be of long wavelength (orange-red).
- Low intensity that does not rapidly affect open film but permits one to see well enough to work in the area.
- Arrangement of safelight filters should provide 3 zones of illumination.

Safelight

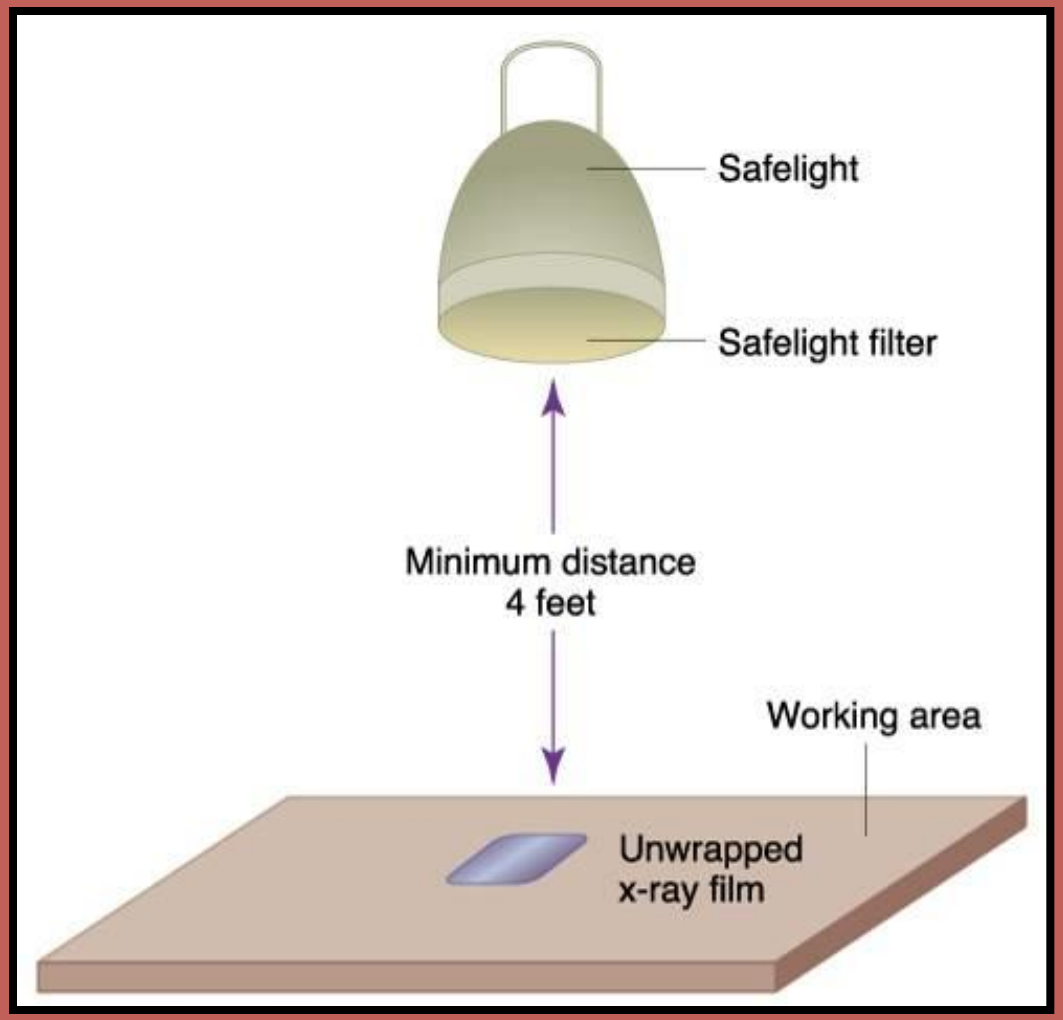
- Dimly lit zone – for loading and unloading films.
- Medium lit zone – for processing of films.
- Bright lit zone – for washing and drying of films.

- X-ray films are very sensitive to the blue-green range of spectrum and less sensitive to yellow and red wavelength

Safelight

- The safelight should be mounted at least 4 feet above the working area to minimize the fogging effect.
- Atleast 15 watt bulb should be used and for panoramic films $7^{1/2}$ watt bulb.
- Morlite filter(yellow)- for non screen films.
- GBX-2 filter- for screen films.

A minimum distance of 4 feet must exist between the safelight and the working area.



Safelight

- Film handling under a safe light in a dark room should be limited to about 5 minutes because film emulsion shows some sensitivity to light from safelight with prolonged exposure.

Testing for unsafe illumination

- Penny test / Coin test
- Unwrap the film in the darkroom.
- Place a penny or coin over the open film, keep it for 5 minutes.
- Process as usual.
- If the shadow of the penny / coin is seen over the processed film, that means light leakage is there in the dark room.

Testing for unsafe illumination

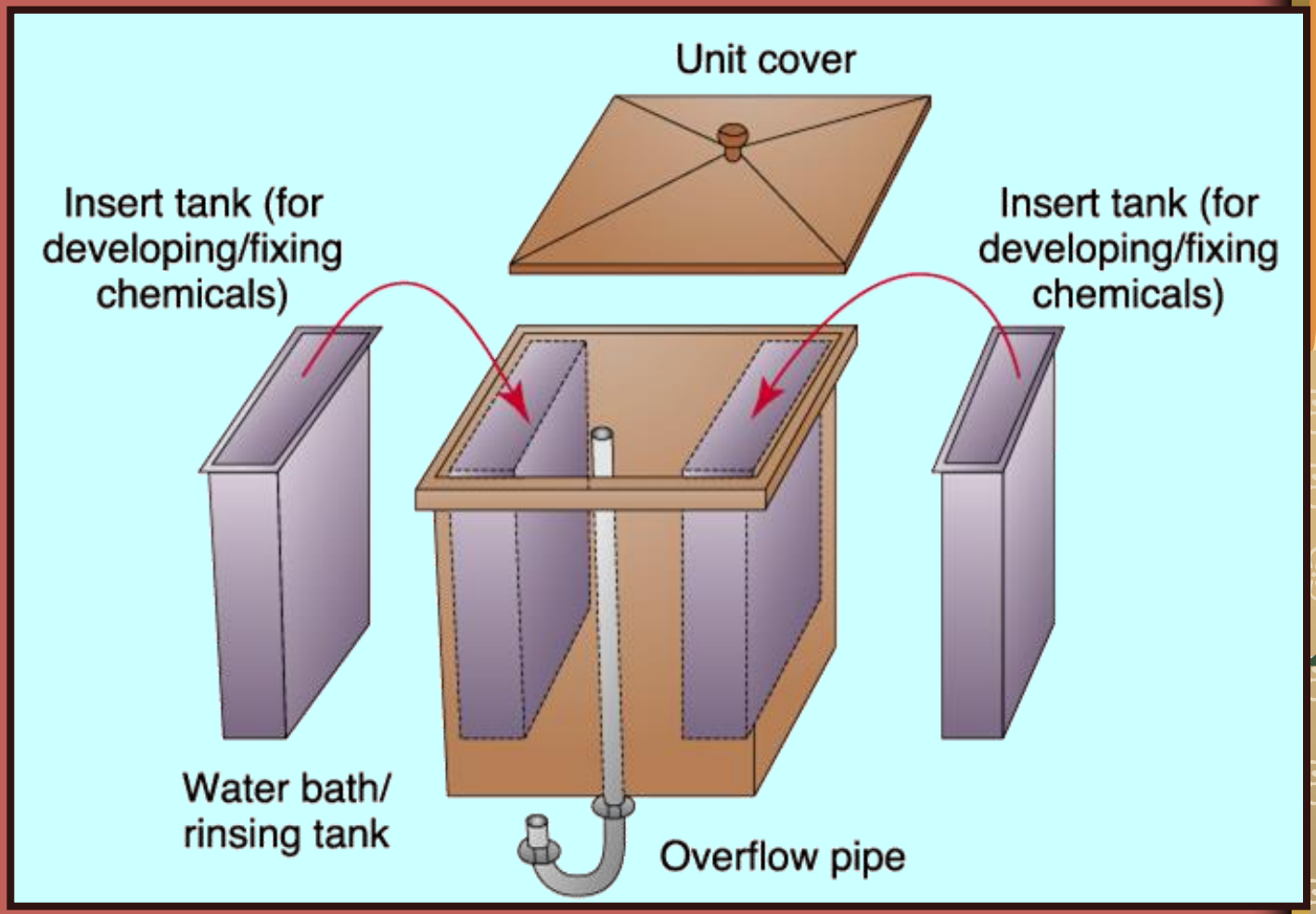
- Source of the light leaks may be determined by standing in the dark room for 5 minutes to allow the eyes to accommodate and mark light leaks with chalk or masking tape.
- If improper safelight-Fogging of film occurs.

  - Low contrast films.
  - Muddy gray appearance of films

Processing Tanks

- Manual processing is a method that is used to develop, rinse, fix, and wash dental x-ray films.
- The essential piece of equipment required for manual processing is a processing tank.
- The processing tank is divided into compartments to hold the developer solution, water bath, and fixer solution.
- A processing tank has two insert tanks and one master tank.

Processing tanks showing developing and fixing tanks inserts in bath of running water.



Processing Tanks

- Tank must be supplied with hot and cold water to maintain the temp between 65^0 -75^0 F.
- Master tank size 20 x 25 cm

(8 x 10) inches.

Insert tanks- 1 gallon capacity and placed inside the master tank.

o All the tanks are made up of stainless steel which will not react with processing solution and easy to clean. Master tank should have cover to prevent oxidation of solutions and minimize evaporation of solutions.

Thermometer

- The temperature of the developing, fixing and washing solutions should be closely controlled.
- A thermometer can be left in the water circulating through the master tank to monitor its temperature.
- Thermometer should contain alcohol or metal but not mercury because they could break and contaminate the processor or solutions.

Timer and Drying Racks

- The x-ray film must be exposed to the processing chemicals for specific intervals.
- Two or three drying racks can be mounted on a convenient wall for film hangers.
- Cabinet dryers that circulate warm air around the film and accelerate drying.
- Excessive heat must be avoided to prevent damage to the emulsion.

THANK YOU