Film construction

Radiographic film basically has two parts, the base and the emulsion, fig(1). Most x – ray film has the emulsion coated on both sides and therefore called double – emulsion film. Between the emulsion and the base is a thin coating of material, called the adhesive layer, this adhesive layer allows the emulsion and base to maintain proper contact and integrity during use and processing. The emulsion is enclosed by a protective covering of gelatin, called the supercoating. This supercoating protects the emulsion from scratching, pressure, and contamination during use and processing. The thickness of a sheet of radiographic film ranges from 150 to 300 μm (0.15 to 0.3 mm).

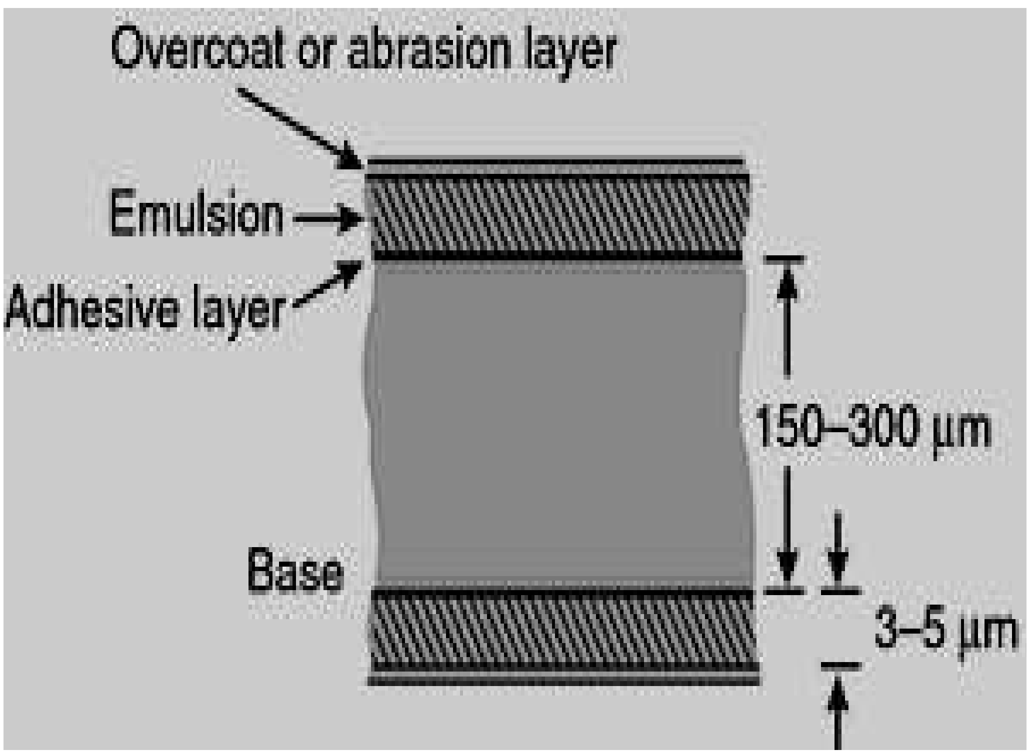


Fig (1): Cross-sectional view of radiocraphic film. The bulk of the film is the base.
The emulsion contains the diagnostic information.

The emulsion is the heart of the x-ray film. Its the material in which x-rays or light protons from screens interact and transfer information. The emulsion consists of a homogeneous mixture of gelatin and silver halide crystals. The gelatin is clear, so that it transmits light, and is sufficiently porous for the processing chemicals to penetrate to the crystal of silver halide during processing.

Its principle function is to provide mechanical support for the silver halide crystal by holding them uniformly dispersed in place.

The silver halide crystal is the active ingredient of the radiograph emulsion. In the typical emulsion, 95% of the silver halide are silver bromide; the remainder is usually silver iodide.

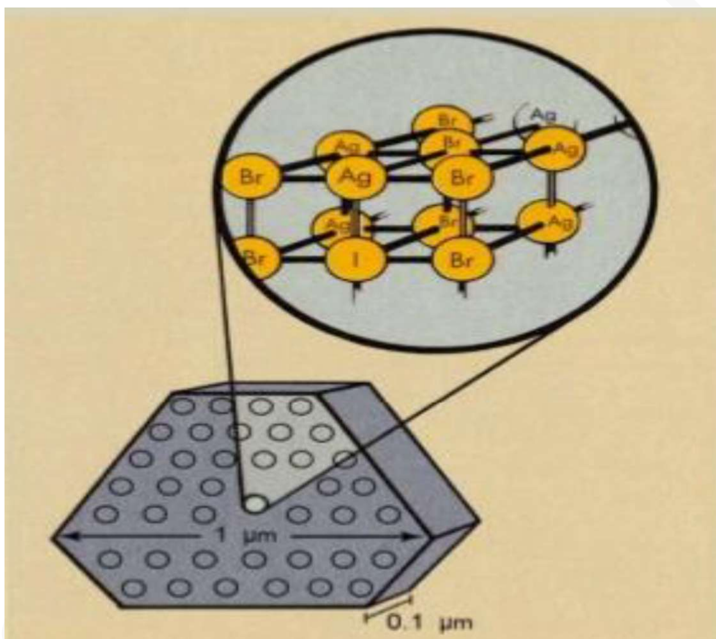


Fig (2): Silver halide crystal is triangular. The arrangement of atoms in the crystal is cubic.

Intensifying screens

<u>***Screen construction:***</u>

X – Ray intensifying screens resemble flexible sheets of plastic or cardboard. They come in sizes corresponding to film sizes. Usually the radiographic film is sandwiched between two screens; the film so used is double – emulsion film.

<u>In most screens there are four distinct layers:</u>

1 – Protective coating:

The layer of the intensifying screen closest to the x – ray film is the protective coating. It is 15 to 25 µm thick and is applied to the face of the screen to make the screen resistant to abrasion & damaged caused by handling. Naturally, the protective layer must be transparent to light.

2 – Phosphor:

The active layer of the x – ray intensifying screen is phosphor. The phosphor emits light during stimulation by x – ray. Phosphor layers vary in thickness from perhaps 150 to 300 µm, depending on the type of screen. The phosphor has one purpose: to convert the energy of the x – ray beam into visible light.

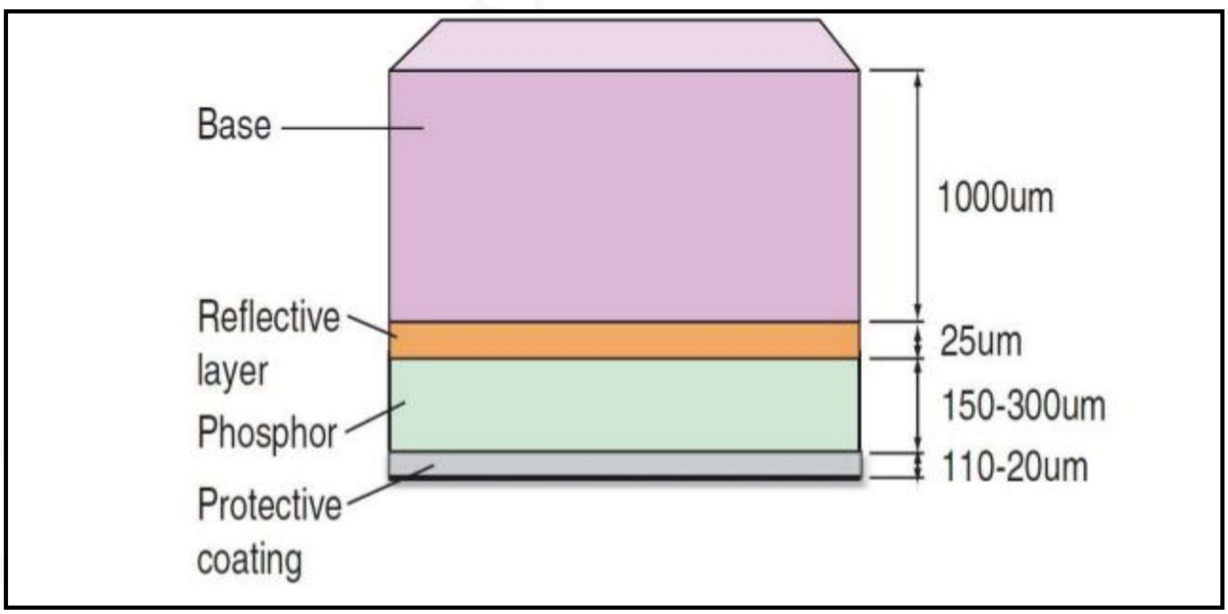


Fig. 3: Cross-sectional view of an intensifying screen, showing its four principal layers.

3 - Reflective layer:

Between the phosphor & the base is a reflective layer approximately 25 µm thick made of a shiny substance such as magnesium oxide or titanium dioxide. Its function is demonstrated in Fig.4. When x-rays interact with the active phosphor, light is emitted isotropically, that is, with equal intensity in all directions. Less than half the light is emitted in the direction of the film. The reflective layer intercepts light headed in other directions and redirects it to the film.

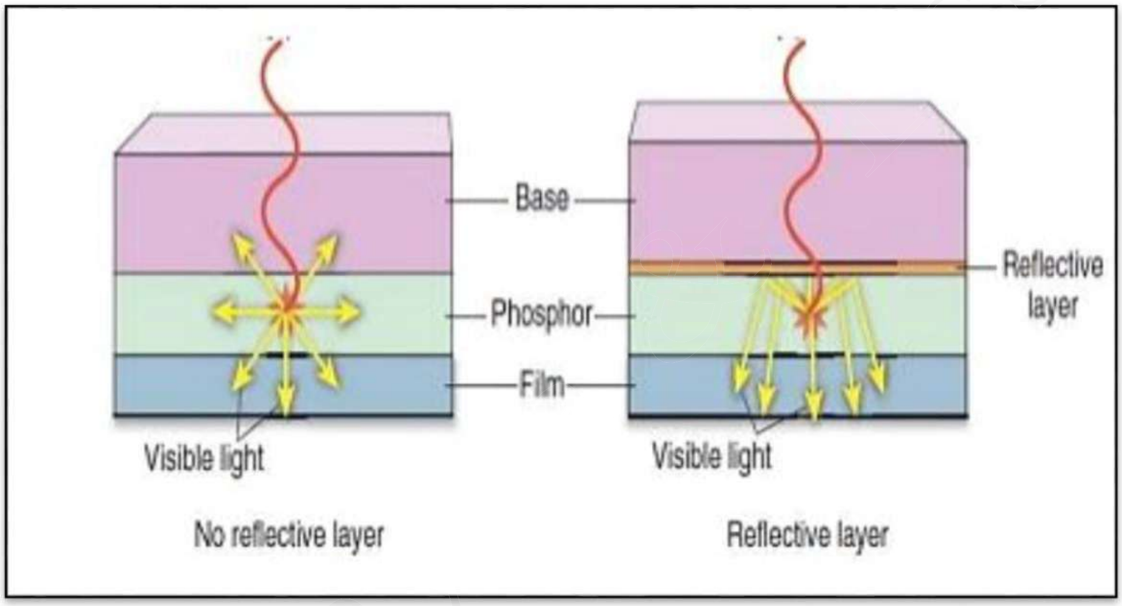


Fig.4: A. Screen without reflective layer. B, Screen with reflective layer. Screens without reflective layers are not as efficient as those with reflective layers,because fewer light photons reach the film.

4 - Base: The layer farthest from the film is called the base. The base perhaps 1 mm thick and serves principally as a mechanical support for the active phosphor layer. It is made of high – grade cardboard or polyester.

Screens – films combination

X-rays intensifying screens are nearly always used in pairs. Best results will be obtained if they are selected with this in mind. Figure (6) is a cross section of a properly loaded film cassette containing front and back screens with a double - emulsion film.

Cassette

The cassette is the rigid holder that contains the screens and film. Some of the important characteristics of a good cassette are indicated in Fig (6) .The front surface, *the side facing the x-ray source, should be made of material with a low atomic number,* such as plastic or cardboard. It should be as thin as practicable yet sturdy. Attenuation of the x-ray beam by the front cover of the cassette is undesirable. Attached to the inside of the front cover is the front screen, and attached to the back cover is the back screen. The radiographic film is loaded between these two screens.

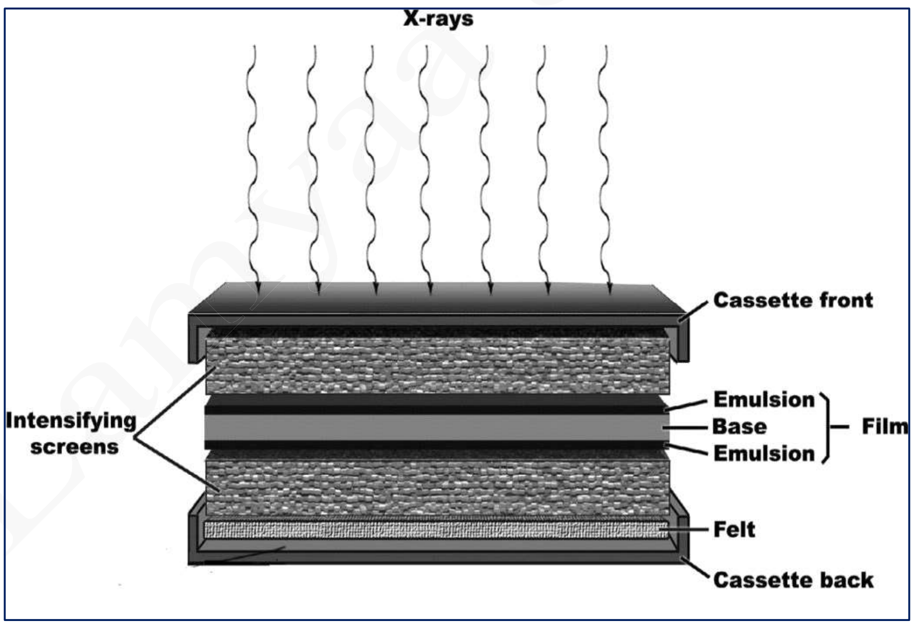


Fig (6).Cross-sectional view of cassette containing front,back screens and loaded with double-emulsion film.

Between each screen and the cassette cover will be some sort of compression device, such as felt or rubber that maintains close turn-screen contact when the cassette is closed and latched. The back cover is usually made of heavy metal to minimize backscatter. The x-rays transmitted through the screen-film combination to the back cover will be absorbed photoelectrically more readily in a high-Z material than in a low-Z material.

If the back plate were made of a low-Z material, x-rays could be transmitted through the entire cassette, and some might be scattered back to the film by the cassette holding device or a nearby wall. This is called backscatter radiation and results in decreased image contrast. Sometimes the cassette hinges or hold-down clamps on the back cover are imaged.

Manual & Automatic processing methods of radiographic film

The radiation exiting the patient and incident on the radiographic film deposits energy in the emulsion primarily by photoelectric interaction with the atoms of the silver halide crystal. This energy is deposited in a pattern representative of the object or part of the anatomy being radiographed. If one observed the film immediately after exposure, no image would be seen. There is, however, an image present, called a latent image.

The latent image is the invisible change induced in the various silver halide crystals. With proper chemical processing the latent image becomes a manifest image.

Nearly all radiographic processing is done automatically today, the chemicals involved in both (manual & automatic) are basically the same. But in automatic processing the times for each step are shorter, and the chemical concentrations and temperature are higher.

➤ ***Manual processing***

Sequence of events in processing a radiograph manually:

⅄ The first step in the processing sequence is to wet the film to loosen the emulsion so that subsequent chemical baths can reach all parts of the emulsion uniformly. The wetting agent is water, it penetrates through the gelatin of the emulsion, swelling it and causing it to expand. This step is often omitted in automatic processing, and the wetting agent is then incorporated into the second step, development.

⅄ Development is the stage of processing in which the latent image is converted to a manifest image. The principle action during development involves changing silver ions of the exposed crystals into metallic silver. phenidone and hydroquinone are examples of reducing agents.

⅄ After development, the film rinsed in an acid solution designed to stop the development process and remove excess developer chemicals from the emulsion. Photographers call this step stop bath, and in processing radiographs the stop bath is sometimes included in the next step, fixation.

⅄ During fixation, the silver halide that was not exposed to radiation is dissolved and removed from the emulsion. The gelatin portion of the emulsion is hardened.

⅄ Fixation is followed by a vigorous washing of the film to remove any remaining chemicals from the previous processing steps.

⅄ Finally, the film is dried to remove the water used to wash it and to make the film acceptable for handling and viewing.

Table (1) : Sequence of events in processing a radiograph

Step	Purpose
Wetting	Swelling of the emulsion to permit subsequent chemicals penetration.
Development	Production of a manifest image from the latent image .
Stop bath	Termination of development and removal of excess chemicals from the emulsion.
Fixing	Removal of remaining silver halide from the emulsion and hardening the gelatin.
Washing	Removal of excess any remaining chemicals from the previous processing steps
Drying	Removal of water and preparation of radiograph for viewing.

The steps of development and fixation are the most important to the processing of radiographic film.

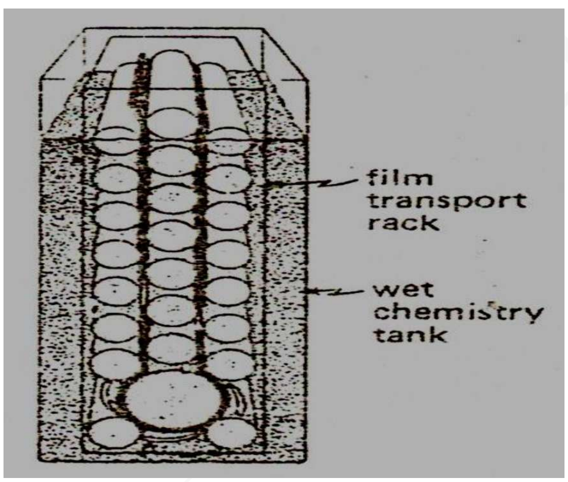
➤ *Automatic processing*

Automatic processing requires an electromechanical device called an automatic film processor, which transports the film from one solution to the next without any manual labor except for placing the film into the device. This shortens the overall processing time, increases the number of films that can be processed in a given period, and ensures less variability of overall film quality than manually processed films because the processing time, solution temperature, and chemical replenishment are automatically controlled. The disadvantages of automatic processing include higher capital and maintenance costs, increased chemical fog due to higher processing temperatures, and transport problems that can damage or destroy images during processing.

<u>The principal components of an automatic processor are:</u>

<u>1. The transport system:</u>

The transport system consists of three principal subsystems: rollers, transport racks and Drive motor. From the entrance rollers, the film is transported by rollers and racks through the wet chemistry tanks and drying chamber and finally is deposited in the receiving bin.



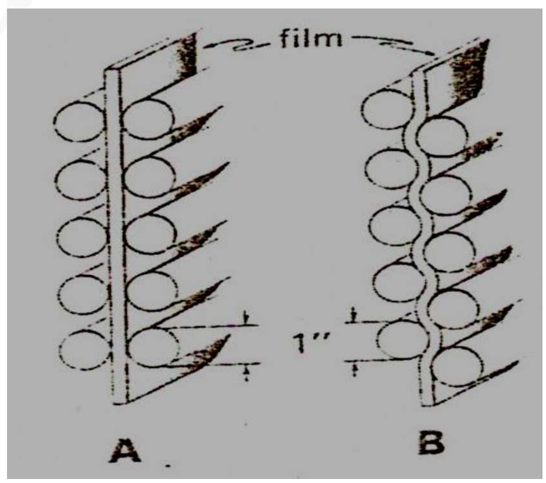


Fig (7): A, Transport rollers positioned opposite each other.

B, Transport rollers positioned offset from one another.

2. The temperature – control system:

The system is a thermostat-controlled heater that keeps the processing chemicals at optimal temperatures. The three chemistries, developer, fixer & washer require precise temperature control. Developer temperature is usually maintained at (35° C). Wash water temperature is usually maintained at (2.8° C) lower**.**

3. Circulation system:

Agitation is necessary to continually mix the processing chemistry (Dev. Fixer, wash water), to maintain a constant temperature throughout the processing tank. Agitation is provided by a circulation system that continuously pumps the developer and the fixer, keeping each tank in constant agitation.

4. Replenishment system:

This replaces the chemicals in the tanks as they are used up in the film development process. If neither the developer nor fixer were replenished, they would quickly lose chemical balance, the level of solution in each tank would drop, and shorter contact times with the chemistry would result. The replenishment system meter into each tank the proper amount of chemistry to maintain volume and chemical activity.

5. Dryer system:

If a finished radiograph were at all wet or damp, then it would easily pick up dust particles in the air that could result in artifacts, furthermore, a wet or damp film is difficult to handle in a view box. When stored it becomes sticky & be destroyed. Dryer system consist of a blower**,** ventilation ducts, drying tubes and exhaust system, it completely extracts all residual moisture from the processed radiograph so that it drops into the receiving bin dry. So, The film is squeegeed and a blower / heater directs clean heated air onto the processed film and it shrinks and seals the emulsion so the film can be handled safely.

6. Electrical system:

Electrical power must be provided to the thermal & the mechanical components of each of the previous systems, this is done through a proper wiring of the automatic processor.

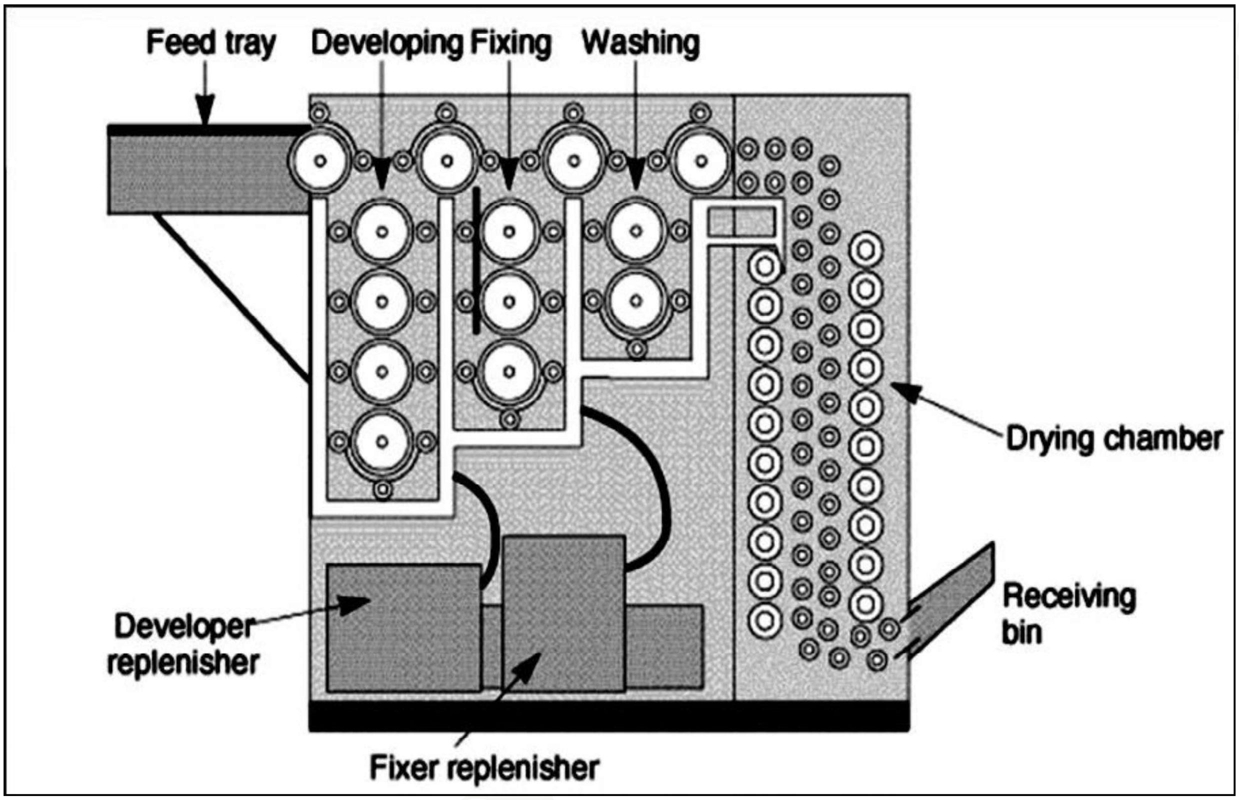


Fig. (8): component of automatic processor.