X-RAY FILM AND ACCESSORIES

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X-ray film:

The X-ray film is the medium that record the image of part exposed with X-rays. The x-ray film is somewhat similar to photographic film in its basic composition. However unlike photographic film, the light (*or radiation*) sensitive emulsion is usually coated on both sides of the base of X-ray film so that it can be used with intensifying screens.

The x-ray film is composed of following –

1: Film base: The central portion of the x-ray film is the base which supports the fragile photographic emulsion on both of its surface. Ideally the base must be flexible as well as quite strong so that the films can be repeatedly snapped into x-ray illuminators (*Viewing boxes*). Secondly, it must withstand any geometric distortion due to the heat of the developing process and finally, the base must provide a uniform, highly transparent, optical background.

Historically, photographic **glass plates** were used as the X-ray film base followed by cellulose nitrate in early 1920's. Later **cellulose triacetate** base was developed in 1924 to avoid the highly flammable nature of **cellulose nitrate**. Finally, a stronger, thinner, more dimensionally stable film base made of **polyester** was developed in 1960 and that has replaced all above materials for making of film base.

2: Film Emulsion: The X-ray film emulsion is composed of a mixture of gelatin (*derived from cadaver bones*) and small silver halide crystals (*grains*). The gelatin serves as a matrix which keeps the silver halide grains well dispersed and prevents their clumping. The developing and fixing solutions can penetrate the gelatin very rapidly without changing the strength or permanence of the gelatin. Small crystal grains of silver halide (1.0 to 1.5 microns in diameter) comprise the **light sensitive substance** in the emulsion. These grains, known as silver-iodo-bromide, are typically between 90 and 99% silver bromide and between 1 and 10% silver iodide.

The atoms in the silver-iodo-bromide crystal are arranged in a cubic lattice and each crystal contains many point defects, where a silver ion is displaced and is free to move through the crystal. It is the mobility of these silver ions that contributes to the formation of the latent image. In its pure form the silver halide crystal has low photographic sensitivity. The emulsion is sensitized by heating it under controlled conditions with a reducing agent containing sulphur. This result in the production of silver sulphide at a site on the surface of the crystal referred to as a ***sensitivity speck.*** *It is the sensitivity speck that traps electrons to begin formation of the latent image centres.*

In the process of film exposure, the energy from absorbing a photon of light is sufficient to liberate an electron from a bromide ion in the crystal. The electron travels freely through the crystal until it is trapped at a site of crystal imperfection such as a dislocation defect or a sensitivity speck composed of an AgS molecule. A free silver ion is attracted to the negative charge and combines with the charge (is reduced) to form an atom of metallic silver (which is optically black). The single atom of silver acts as an electron trap for another electron and then attracts another atom of silver which is then reduced to metallic silver. This process continues while the exposure to light continues.

3: Adhesive layer: In general, the emulsion and the base do not adhere to each other. For this reason, the emulsion must be attached to the film base using a thin layer of suitable adhesive which is generally a clear thin layer of gelatin only.

4: Protective layer: To protect the emulsion, which would be easily scratched and damaged by normal handling, a very thin outer protective layer is applied (*again usually made of gelatin*).

Types of X-ray films:

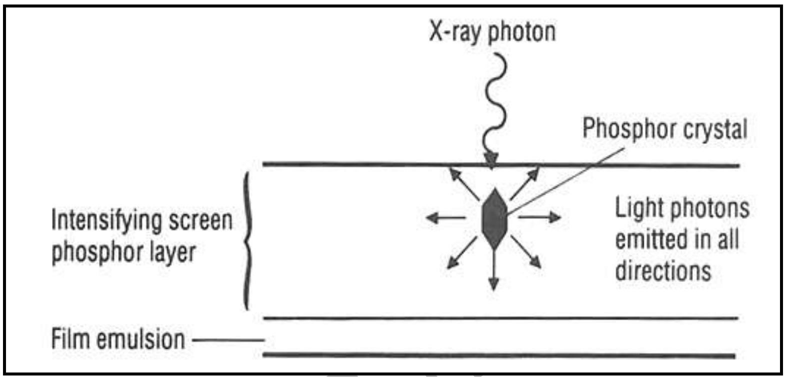
1. On the basis of photosensitive emulsion layers:

Single coated: In such type of x-ray films the photosensitive emulsion is coated only on one surface of film base. These films are used with single intensifying screen cassette with the film placed in front of the screen, *i.e.* on the side facing the X-ray tube. These are specific purpose films used when higher spatial resolution of image is desired.

Double coated: These are routine purpose x-ray films having photosensitive coatings on both sides of base and used with double screen cassette with the film sandwiched between the screens. Such films require lesser exposure factors and lesser processing times. For example the image can be produced in 1/2 the time required to produce an image on the single sided film.

2. On the basis of use with intensifying screens:

Screen films: These films are used along with intensifying screens and are therefore ultimately exposed by light and not the X-rays. These films require **lesser exposure factors** and **processing time** for development of radiographic image. The emulsion coating of such films is also thinner. Such films are versatile and used for most general purpose diagnostic radiography.



Non-screen films: These films are used without intensifying screens and **require more exposure factors and prolonged processing time** for production of comparable radiographic density to that of non-screen films. They have relatively thicker emulsion and therefore radiographic image formed on such films have excellent details. Such films are used for specific purposes such as detection of hail-line fracture or any subtle tissue change that remains unrecognized in traditional routine radiograph.

3. **On the basis of types of light sensitive emulsion coating:**

- **Blue light sensitive films:**
- **Green light sensitive Orthochromatic films:**
- **Red light sensitive Panchromatic films:**

The spectral sensitivity of the film must be matched to the emission spectrum of the intensifying screen in order to increase the sensitivity of the system. The principle emission from traditionally used calcium tungstate intensifying screens is blue light. Therefore, it is imperative that the films to be used with such intensifying screens must be sensitive more towards blue light. The photographic emulsion containing silver bromide is coincidently **cream**

coloured that absorbs ultraviolet and blue light, but reflects green and red light and therefore such films have been used without any problem with calcium tungustate intensifying screens.

However many rare earth intensifying screens principally emit greener lights and therefore, x-ray films to be used with such screens should be made sensitive to greener spectrum of light as well. For this, suitable dyes are added in their photosensitive emulsion of the films. (*Such green light sensitive orthochromatic films also require suitable change in x-ray darkroom safe light colour and intensity*). Now a day blue light emitting rare earth intensifying screens are also available.

- *"High lite" films from 3M company were more or less not sensitive to room light (particularly yellow lights) and therefore, allowed all the procedures of dark room in a yellow lighted room.*

4. On the basis of film speed:

Film speed refers to the relative sensitivity of X-ray film to a given amount of radiation. Faster films require lesser exposure but produce grainy images that lack definition. They also have narrow film latitude. Speed wise x-ray films may be categorized as following-

- **Standard or par speed films**
- **Fast speed films**
- **Ultrafast films**

Standard speed films are versatile as they have wide film latitude but require greater exposure.

Film Latitude: *It refers to the range of exposure factors that produce diagnostically useful range of radiographic densities.*

Handling and storage care of unexposed and exposed x-ray films:

1. Films should be stored in a cool (10-20^{0}c) and low humidity (40-60%) environment.
2. Film boxes should be kept vertically without any pressure on them.
3. Films should never be stored near a source of heat, irradiation or water.
4. Films should be loaded and unloaded from a cassette on a dry and clean bench inside the dark room under a proper safe light.
5. Films should be handled delicately and any accidental splashing of processing solutions should be avoided.
6. Films should not be used after their expiry period.

7. If an x-ray film has been exposed, the cassette should immediately be transferred to the dark room or in a lead shielded box to avoid inadvertent subsequent exposures particularly in cases where serial radiography is being done.
8. The wet processed film should be kept upright in a film drier for its drying.
9. The wet films should never be touched with fingers to avoid finger marks over films.

Intensifying screen:

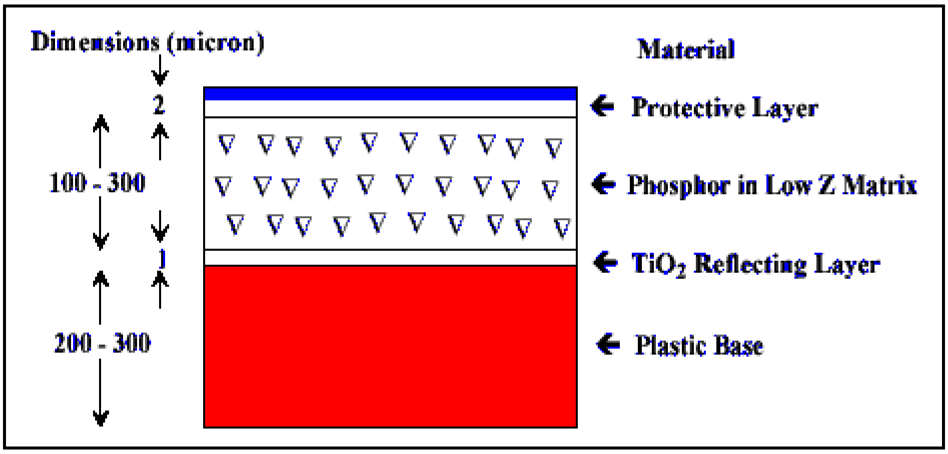
These screens are fitted in x-ray cassettes and interact with x-rays to convert most of their radiant energy (>95%) in to visible light thereby, exposing the x-ray film finally with light (*and not the x-rays*). The amount of light emitted by the intensifying screen is proportional to the amount of x-radiation passing through it.

Generally the x-ray films are more sensitive to light rays than the x-rays and therefore the use of intensifying screens allow reduction in the exposure factors without affecting the general quality of radiograph.

The intensifying screen typically has following components-

1. Base: Provides a strong, smooth, but flexible support for the fluorescent layer. This is constructed usually from paper, cardboard or polyester with total thickness not exceeding approximately 0.18 mm.

Ideal properties of an intensifying screen include: Chemically inert, moisture resistant, no discolouring with age



2. Substratum: It is the bonding layer between the base & the phosphor layer. It may be reflective, absorptive or transparent in nature.

3. **Phosphor (Fluorescent) Layer:** This is the "active" layer of the intensifying screen that consists of fluorescent crystals, which emit light when struck by x-radiation. Examples of typical phosphor materials include **calcium tungstate** & **rare earth phosphors**. Earlier barium lead sulphate and zinc cadmium sulphide were also used as phosphor materials.

The rare earth screens may have any of the following types of phosphor material-

- *Terbium activated gadolinium oxysulphide*
- *Terbium activated lanthanum oxysulphide*
- *Terbium activated yttrium oxysulphide*
- *Thulium activated lanthanum oxybromide*

X-ray absorption efficiency and their light conversion ratio of rare earth screens are far superior to calcium tungustate type films. For example rare earth screen film combination has 12 times faster speed than par speed tungustate screen film combination and exposure is reduced by 15-50%.

4. **Super-coat:** This is a transparent external protective layer which helps in resisting surface abrasion. It is constructed from cellulose acetate and has anti-static and waterproofing qualities.

Fluorescence: *It is a kind of luminescence where a cold (nonglowing) substance releases electromagnetic radiation in the form of visible light while absorbing another form of energy, but ceases to emit the radiation immediately upon the cessation of the input energy. The emission of light from an intensifying screen during absorption of X-rays is one example of fluorescence.*

*However, if the emission is delayed somewhat, it is called **phosphorescence** (after glow).*

Film holders (cassettes):

The material in the cassette box must be as little absorbing as possible. Presently, the best material for this is carbon fibre, giving a very rigid structure combined with low density and a low atomic number.