IMAGE PROCESSING TECHNOLOGY

MODULE ONE
UNIT ONE

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INTRODUCTION

- IMAGING is a science of producing permanent or temporary images as maybe desired e.g a picture,graph or sketch

- PROCESSING is a science of converting something from one form or from one status to another.

CONT’

- Technology involves a study of or use of technics,sciences ,art,skill to accomplish a process
- Images can be formed by several medias
    - Light in what we call photography
    - Sound in what we call ultrasound
    - Electromagnetic radiation for example xrays we call radiography
    - Magnetism in what we refer as magnetic Resonance Imaging(MRI)
    - Radionucleid isotopes in what we call nuclei medicine
    - Electrical signals in what we call digital imaging/electroencephalography

CONT’

- Images are either produced or formed are then recorded in a media
- It can be recorded on

1.DVD

2.screen

3.paper

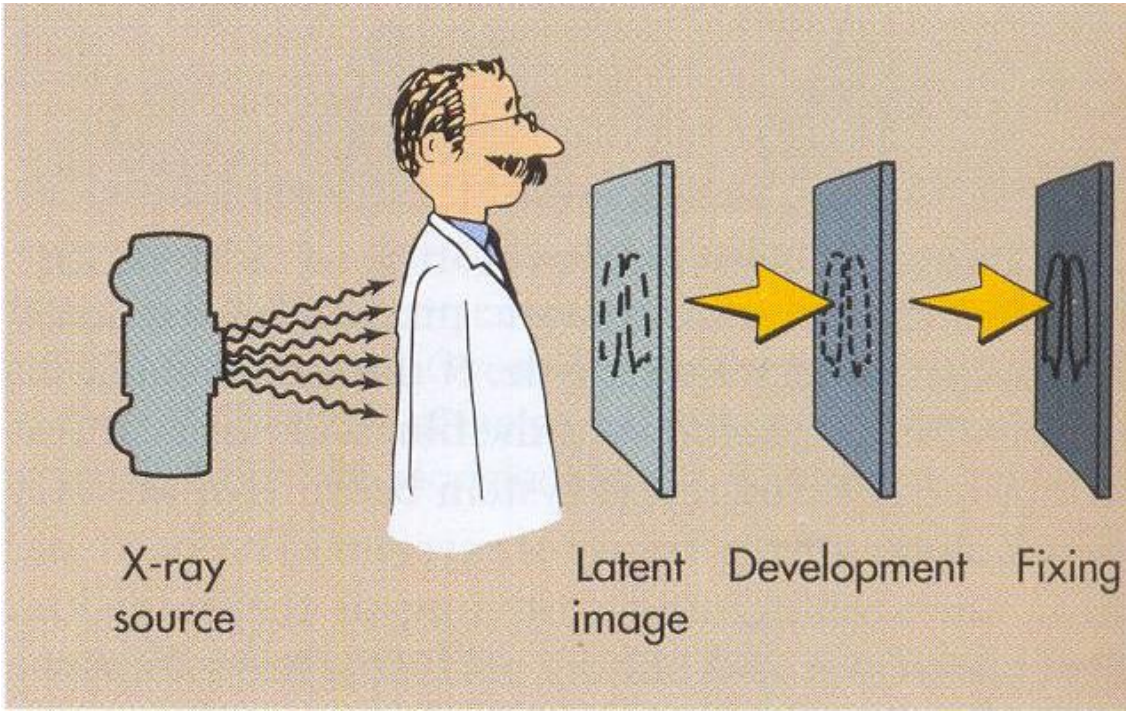
4.Film

- Production into a permanent form is done through chemical treatment refered to as **Film processing**

Cont'

- Image can be transferred by certain methods
  - Fascimile
  - Electronic Transfer
  - Digital system

The Chemistry of Image Production



CONT,

- In order to understand image production process,it is important to review the following concept
  - Electromagnetic spectrum
  - Electromagnetic radiation
  - The silver halides
  - The silver halide grains

Electromagnetic Spectrum

- Electromagnetic spectrum is a range of frequencies over which electromagnetic radiation are propagated
- They are range from low frequency for example radiowaves to high frequency example cosmic waves.
- They are measured in units called Hertz.
- They are commonly measured in terms called Nanometers
- The optical spectrum is usually 10^{-6} meters (400-700 Nanometer.)

Gamma rays x 10^{12}
X- rays x 10^{10}
Ultraviolet rays x 10^{-8}
Visible light x 10^{-4}
Infrared x 10^{-3}
Terrahezt rays x 10^{-2}
Microwaves
Radio waves

Visible Spectrum

Is between the range at which human eye perceives the wavelength changes as alteration in colour and is usualy gradual from red to violet as normally seen in the rainbow.

Convectional photography is mainly concerned with the films response to the visible spectrum which is conveniently at three levels of the spectrum (3 bands). This bands is blue to violet, the other is at green and Red.

1. Blue violet referred to monochromatic (400 – 500nm)
2. Green referred to orthochromatic (500-700nm)
3. Red referred to Panchromatic (600-700nm)

In radiographic imaging our concern is both in he visible spectrum and also the effects of ultraviolet, X-ray and gamma rays which are also propagated

- In shorter wavelength. A convectional X-ray film and X-ray intensifying screen produces an image that is made up of partly the effects of blue/green light produced by the screen produced by the screen and effects of X-ray exposure.

- Other forms of images are produced electronically and displayed in a computer or a television monitors or screens from where they could be recorded as soft copies or hard copies.

LIGHT SENSITIVE PHOTOGRAPHIC MATERIALS

Different materials undergo a change of some description when exposed to light or radiation.

a) Some dyes for example in those used in curtain material tends to become lighter and eventually fade away.
b) Some white wall paint may darken in colour and become creamish or brownish or yellow in colour.

Any of this materials could be used to produce an image but may require a very long time exposure to light and therefore being too slow for practical purposes. A need was found then to develop materials with certain fundamental suitable for photography and other imaging purpose.

That fundamental is basically the general character of light sensitive material and is only found in halogens elements.

- bromine, chlorine and iodine combine with silver to form salts which undergoes a change when exposed to light or x-rays and enables them to form a photographic image and therefore the salts that are used in preparation of a light sensitive service are referred to as ***silver halides*** and this includes:

a) Silver bromide
b) Silver chloride
c) Silver iodide

They are light in colour and they are very unstable when exposed to light they decompose and produce a black ***metallic silver*** which is dark in colour. They are inform of small grains of silver (smakk crystals) which cant be handled on their own. In this respect, they are suspended apart and evenly distributed in a binding medium called ***gelatine.***

- The mixture of gelatine and the silver halides (grains) refered to as ***emulsion.***

- The most commonly used is silver bromide in conjuction small quantity of silver iodide and this is most suitable for negative photographic film emulsion and therefore x-ray film are included.

SILVER SALTS

<u>Silver bromide</u>

- Most commonly used slide
- Usually used in conjunction with small quantities of silver and sometimes small quantities of silver chloride desired emulsion
- It is used in the **manufacture of a most all photographic materials** including those used in x-rays films and those for printing papers. Example in enlargement of photos.
- It is also used in emulsion of photographic paper are coated with a mixture of silver bromide and silver chloride. This are referred to as ***<u>chlorobromide</u>*** paper and the produce blackish brown paper

2. ***Silver Chloride***

- An emulsion containing silver chloride has the advantage of rapid development and fixing properties. However, it has the disadvantages of: photographic sensitivity.
- It is used mostly to make the emulsion of contact printing papers and slow latent plates and tends to produce a brown unit.
- 3. ***Silver iodide***
- A small quantity (of approximately 2% of silver bromide) of silver iodide is contained is the most high speed film emulsion. The emulsion of silver iodide increases time taken for the film to clear the picture out, it can never the less be used alone in the absence of chloride and bromide because of the surface sensitive.
- Its characteristic is high sensitive (speed) and is also prone to oxidation.

Photographic Emulsion

It consists of

a) Silver halide grains: held apart by unsuspended in a suitable binding medium called gelatine. This is the most suitable medium for suspension of halide grain because of different properties.
b) Gelatine: this is overly – like substance proteinous substance ; obtained or derived from animal tissues such as bones and skin. It is extracted at low temperature poses cohesive properties favouring formation of the jelly.

It can also be obtained artificially from sources like gum tree or other synthetics called query glue

- Production of photographic gelatine involve several stages.

i) Washing to remove blood, flesh and foreign matter
ii) Lining to remove hair, fat and albiminous matter. It may take several months.
iii) Deriving and washing
iv) Cooking to extract gelatine
v) Filtration and cooling to set a jelly.

Desirable/Characteristic of Gelatine for Ag Halide

They include:

a) It is viscous in nature:

This prevent undue aggregation of the halide grain during the emulsion preparation. It acts protectively from the surrounding mediums to avoid tampering with the salts. They don't dumb or cake.

b) It has no harmful reaction with halide grains or solution

c) Remain stable at normal temperature : for a long period of time. No change of size and shape. Uniformity

d) When placed in alkaline developer ***swells quickly*** therefore allowing access to the developing chemicals to suspended silver halide grains

e) When dried ***resumes its original size and shape*** with no shrinking or distortion.
f) Accepts added chemicals. This make it tougher and harder or less reliable to mechanic damage.
g) It contains impurities: naturally associated with it . Example sulphur which increases sensitivity or response to silver halide.

During the preparation of emulsion, several other additives to improve its characteristics has been discovered. Some of them specifically affect gelatine and others are sensitizers for the whole emulsion.

Gelatine having desirable properties for suspension of all halides. It also inhibits deficiencies that have to be overcomed, this are

a) Swelling excessively in the halide
b) It has inherent brittleness
c) It has a tendency of acquiring static charge
d) Being an organic substance, it supports bacterial growth and fungi.

THE PHOTOGRAPHIC EMULSION

Preparation:

The silver halide grains/crystals are produced in the emulsion by a processes referred to as double decomposition. This occurs when two soluble chemicals are mixed in a solution and produce an insoluble compound which is precipitated.

There are four stages in the manufacturing of a photographic emulsion. Though these stages a few other things happen. eg. A few additivies are added to the emulsion even unto the finishing stages of a photographic material.

PRODUCTION OF PHOTOGRAPHIC EMULSION

The stages are”

i) Precipitation or emulsification
ii) Ripening
iii) Shredding
iv) Washing
v) Digestion
vi) Finishing
vii) Coating

1.PRECIPITATION/EMULSIFICATION

Silver nitrate and potassium bromide solutions are mixed together with about 5% of the total gelatine that will be used. The process produces potassium nitrate a soluble which remains in the solution and a silver bromide insoluble suspended in a viscous fluid.)

$Ag + No_3 \quad = \quad AgNo_3$

$AgNO_3$ + KBr (soluble) AgBr + KNO_3(soluble)

KNO_3 dissolve in solution

- The grain sizes and the distribution is determined at this stage in the manufacture and this is done in a faster mixing of about 30 seconds will produce an emulsion of approximately same size and where the same size grains are formed is referred to as a ***flop-in-process***

- slow mixing of over a period of 30 minutes gives an emulsion containing grains of assorted size and is reffered to as **running-in-process.**

- The sizes of the silver halide grains produced during this stage of emulsification are too slow for a practical purposes and generally the emulsion is inert. (Insensitive to light)

  NB/ The size of the grains is directly proportional to its sensitivity. (Fast emulsion the grains are big while slow emulsion the grains small.)

2.RIPENING

The stage determines the sizes of the silver halide grains and thus speed (sensitivity) of the finished emulsion. In the presence of excess potassium bromide the silver halides grains are readily slightly soluble in potassium nitrate.

- The smaller grains are more soluble than the bigger grains. The emulsion is heated at 55^{o}F for a period between 30-60 minutes

The small grains dissolve, they pass out in the solution, they crystalize into a large grain. This is the ripening process. (The small grains fusing to large grain)

It is the increase in grains that increases the speed of the emulsion (sensitivity) while at this stage gelatine is added to make the total strength up to about 10%. The mixture is cooled and crystallized to form a jelly ***shedding***

3.Shredding.

This jelly is shredded by forcing it through a mesh of perforated silver or stainless steel plates, this produces small particles of emulsion known as ***noodles***

4.Washing

These are washed by placing them in a mesh basket or a canvas bag and then immersed in a running water. This removes potassium nitrate and (free potassium bromide)

5.Digestion(Pre-heating)

After ripening the emulsion is then reheated and the remaining gelotime which is 90% is added. Gelatin contains sulphur in the form of unstable organic compound which when heated deposits sulphur of the surface of silver halide crystals.

This sulphur forms sensitivity centres which aids in the formation of a latent image.Upto a certain point sensitivity increases with the time of heating during digestion.

6.FINISHING/DOCTORING

This is the stage at which all necessary additions are made to the emulsion to vary its characteristics.

- ✓ *Sensitizers*
- ✓ *Antifrothing agents*
- ✓ *Plasticizers*
- ✓ *Hardener*
- ✓ *Wetting agents*
- ✓ *Antifoggants*
- ✓ *Bacterizides*
- ✓ *Fungicides*

Cont’

- The emulsion is chilled and stored in a refrigerated room until when required for coating a photographic material.
- NB/ when the emulsion is required for coating, a large sheet of polyester/cotton base is used to manufacture specific film materials and this depends on the desired size.

The coating process

- The liquid emulsion is coated onto a transparent polyester base (film)
- To aid adhesion the base is pre-coated with a thin subbing layer (substratum)
- Constant thickness emulsion should be maintained
- Once the liquid emulsion has been applied it is allowed to set firmly

CONT'

- Then the thin protective super-coat of pure gelatin is applied
- Usually for x-ray films the emulsion is coated on both sides of the base
- Coating is a continuous process and the completed product is wound onto large rolls
- Finally it is cut into different sizes and packed.

Standard Screen-Film Sizes

- English Units (inches)
- 8” x 10”
- 10” x 12”
- 14” x 14”
- 12” x 15”
- 8” x 17”
- 14” x 17”
- 6’’ x 15”

- SI Units (cm)
- 18 X 24
- 24 x 30
- 35 x 35
- 30 x 40
- 18 x 43
- 35 x 43
- 15 x40

Dental films

- 22mm x 35mm
- 27mm x 54mm
- 32mm x 41mm
- 57mm x 76mm

Roll films

- 16mm
- 35mm
- 70mm
- 105mm

Classification of grain sizes

Fine grain 0.52 microns – 50,000 million per cm^3

Medium grain 1.02 microns – 20,000 million per cm^3

Large grain 2.5cm microns – 6000 million per cm^3

In $1cm^3$ there are 50,000 million

Emulsion size of negative material

When warm is 0.3mm

After cooling is 0.125mm

Contains 1.5mg of silver halides/cm^3

<u>Degree of response to exposure and processing</u>

a) Slow speed films
b) Regular speed films
c) High speed films

<u>MODE OF USAGE</u>

a) Screen films
b) Non-screen films
c) Industrial films

<u>Area of imaging</u>

a) Dental radiography
b) Photographic
c) Polanaoid – monitoring – theatre radiography, utra sonography

d) Radiation – monitoring – in personnel dosimetry

e) Fluorography – in fluorography

Subtraction used in special techniques done in radiography.

NB/ films for video imaging or video monitors eg. CT scan or ultra sound, nuclear medicine, digital subtraction anglography and magnetic Resonance imaging are single coated with a dye- pelloid backing for anti-halation protection. They are basically orthochromatic emulsion with high contrast.

FORMATION OF LATENT IMAGE

- Latent image is an invisible image formed in the film emulsion immediately after exposure. As an x-ray beam passes through a part of the human body/tissue, its intensity is decreased by selective absorption of the various tissue it penetrates
- The resulting variation in its intensity within the beam as it emerges from the body, causes differences in the amount of exposure given to the x-ray beam.
- The image pattern is recorded in the film and as it is not visible at this stage thus called ***latent image.***
- When the film is developed, these exposure differences are manifested by silver deposits referred to as (density) that vary in their concentration to compose a ***Radiographic*** image. This image could be of high or lower density depending on amount of blackening.

- The nature of the latent image and the development process are closely aligned and their understanding is dependent upon some knowledge regarding the atomic structure of the AgBr crystal including their reaction upon exposure and development
- Its formation (AgBr crystal) is explained by ***Gunny Motto*** theory which states:
- When a silver bromide grain is exposed to light or radiation, the first occurrence is that some of the bromide ions in the crystal lattice emit electron, the emitted electrons are able to travel through the crystal lattice with great speed and their rapid movement carry them into electron traps. These traps are called ***<u>Sensitivity specks or centers</u>*** which exists in the crystals. These then neutralizes +ve charges of silver ions at the centers making the atoms of black metallic silver

EXPLANATION

- During manufacture of a photographic emulsion normally done in darkness, there is electron movement of silver atom to a bromine atom (emulsification process)
- The outer shell of bromine atom contain 7 electrons but should accommodate an electron.
- Outer shell of silver atom contain only 1 electron. Therefore when mixing takes place the bromine atom completes its outer shell by taking off the 1 electron from the silver shell.

- During these process of electron snatching ,electrical properties of both atoms are affected. Bromine becomes a -vely charge ion since it has acquired a surplus electron from the Ag atom.
- The Ag becomes a +vely charged ion since it is deficient of an outer shell electron. When any atom gains an electron it becomes an ion with 12 positive. That’s how they stay as ions in emulsion thus unstable.
- These ions arrange themselves in a regular patterns to make up crystals is called the ***crystal lattice.***
- So the silver ions in the crystal lattice have a +ve charge the bromide –ve charge and since some of the silver ions are free to move and are able to travel when attracted to the –vely charged electrons in the sensitivity specks. They carry their charge and neutralize the –ve charge in sensitivity speck therefore rendering the grain developable.

- When exposure has been made either light or radiation. This process of ion and electron movement and their neutralization forming black metallic silver is instituted and amplified to a great extent by development, when developer solution is in contact during development it supplies more electrons and process become greatly amplified until the visible image is formed.
- SUMMARY

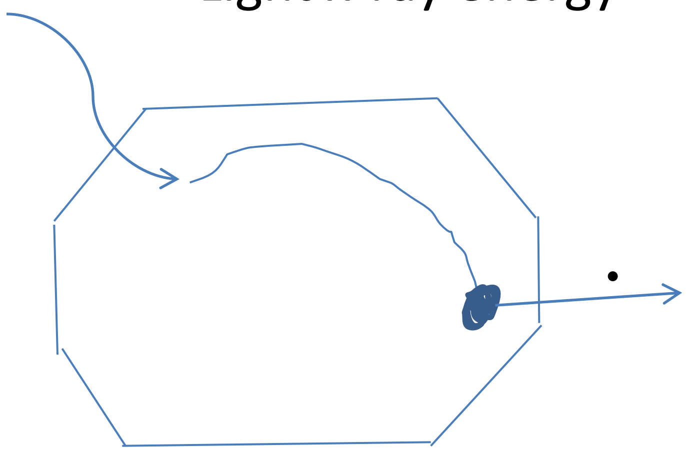
1. During manufacture bromide atoms have 7 electron in the outer shell it gains an electrons from silver and therefore stays as a –vely charged ion.
2. Silver atom emits electron to the bromine from its 1 electron in outer shell and then remains a +vely charged ion.
3. They then arrange themselves in a geometrical pattern called crystal lattice.

CONT’

- On exposure, bromide ions loses electrons which travel throughout the crystal and are trapped in electron traps called sensitive specks and these are areas of low energy because of impurity nature.
- When electrons are trapped they confer a –ve charge to them.
- The positive silver ions are emended in the gelatin but some are free to move, when they move, they are attracted to the sensitivity specks thereby neutralizing the electrons to form silver atoms.
- The developer solution penetrates the gelatin and interacts with the exposed and unexposed crystals of the silver iodide halide. This process is called absorption or attaching and this process occurs more readily in exposed crystals than the unexposed.
- When absorption takes place very unstable complex is formed between developer and silver bromide. This complex eventually breaks to form metallic silver and developer is oxidized and this continues to the process of developer exhaustion but already is visible.

LATENT IMAGE FORMATION

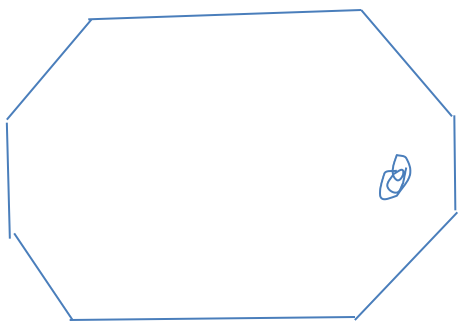
1. **Action of light energy (proton) on the AgBr crystals**
   - Light x-ray energy



- sensitivity speck.
(silver sulphide impurity

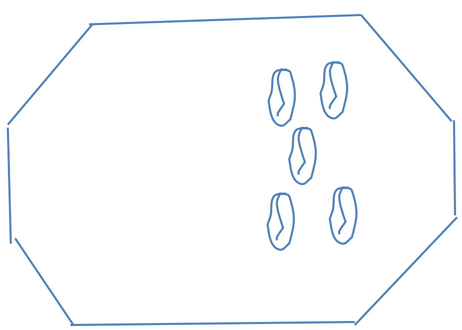
AgBr crystal made up of 5-10 million atoms

2. COMBINATION OF SENSITIVITY SPECK



- Silver ion (interstitial ions + electrons released by Bromide ions = silver atoms. (Metallic)

  $Ag^+ + e^- \longrightarrow$ Ag (atom)



5-10 silver Atoms collected at the sensitivity speck.

Latent energy $\longrightarrow$ latent image on the film

IMAGE RECORDING MATERIALS

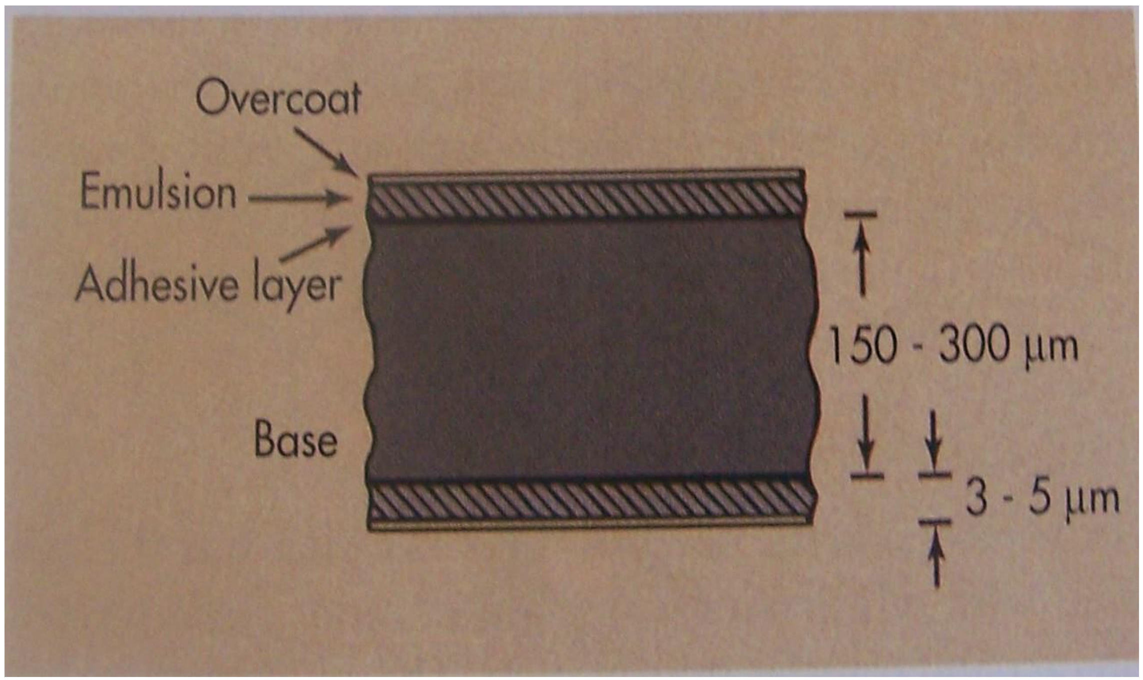
Module One

Unit Two

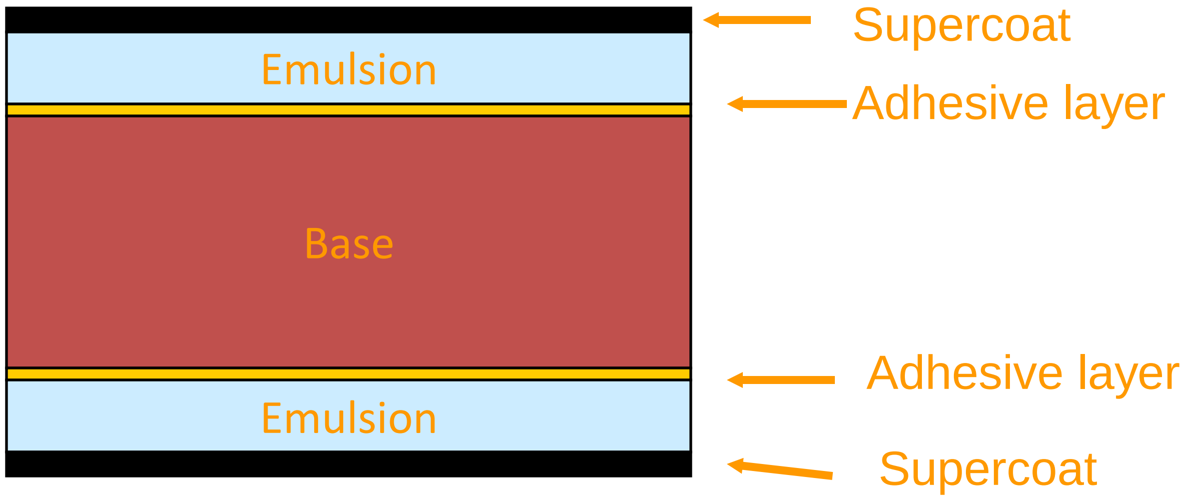
The Photographic (X-Ray) Film

- An adhesive layer attaches the emulsion to the base.
- The emulsion is enclosed in a protective layer or overcoat/supercoat.
- The emulsion consists of a very homogeneous mixture of gelatin and silver halide crystals.

THE PHOTOGRAPHIC (X-RAY) FILM



Radiographic Film Structure



Double Emulsion Film

THE PHOTOGRAPHIC/RADIOGRAPHIC (X-RAY) FILM

- The media on which the radiographic images of objects are recorded
- Images are stored as an unseen (latent) image that will be changed to a visible image by processing the film
- Radiographic Film has two basic parts.
    - Base
    - Emulsion

  Most film has two layers of emulsion so it is referred to as **Double Emulsion Film**

FILM MATERIALS

- There are two main types:
  - Screen film used with intensifying screens.
  - Direct exposure film or non-screen film.
- Special purpose films

SCREEN TYPE FILM

- Used with intensifying screens
- The latent image is formed by the light emission from the phosphorous screens
- The films must match with the color sensitivity of the I.S.
- Single emulsion film is used with a single sided screen e.g. in mammography
- Double emulsion is used with two screens on either side e.g. in normal radiography

SCREEN FILM FACTORS

- Main factors to be considered when selecting screen film;
  - Contrast & Speed
  - Crossover
  - Spectral matching
  - Safelights

Standard Screen-Film Sizes

- English Units (inches)
- 8” x 10”
- 10” x 12”
- 14” x 14”
- 12” x 15”
- 8” x 17”
- 14” x 17”
- 6’’ x 15”

- SI Units (cm)
- 18 X 24
- 24 x 30
- 35 x 35
- 30 x 40
- 18 x 43
- 35 x 43
- 15 x40

NON-SCREEN TYPE FILM

- Also called direct exposure or envelope wrapped film, does not use I.S.
- They are much slower because silver halide crystals interact directly with x-rays
- They have high resolution and can demonstrate fine details
- Examples; dental film and radiation monitoring films

Special Purpose Films

- **Polaroid films-** this are instant images printed by a special camera/printer used in ultrasound usually in roll form
- **Laser Film:** Used in medical radiography with a laser printer for digital radiography, CT and MRI.
- **Duplication Film:** special single emulsion film used to copy x-ray films. Sensitive to UV or blue light.

Cont'd

- **Subtraction Film:** used in angiography to do subtraction where the bone is removed for better visualize the arteries
- **Spot-film**: Special roll film of 70 to 105 mm width used in fluoroscopy in medical radiography.
- **Cine film**: 16 mm or 135 mm black & white film used in coronary angiography. Requires motion picture film processor.

SPECTRAL SENSITIVITY OF X-RAY FILMS

- The basic sensitivity characteristic of a film is determined by the composition of the emulsion.
- The size and shape of the silver halide grains have some effect on film sensitivity.
- Increasing grain size generally increases sensitivity.
- Although grain size may vary among the various types of radiographic film, most of the difference in sensitivity is produced by adding chemical sensitizers to the emulsion

cont’

- Each compound produces light of a color (wavelength) that is specific to that particular material.
- The light from intensifying screens is produced in either the ultraviolet, blue or green portion of the light spectrum, and intensifying screens are sometimes classified as either blue or green emitters.
- The significance of this is that a screen must be used with a film that has adequate sensitivity to the color of light the screen emits.

Cont’

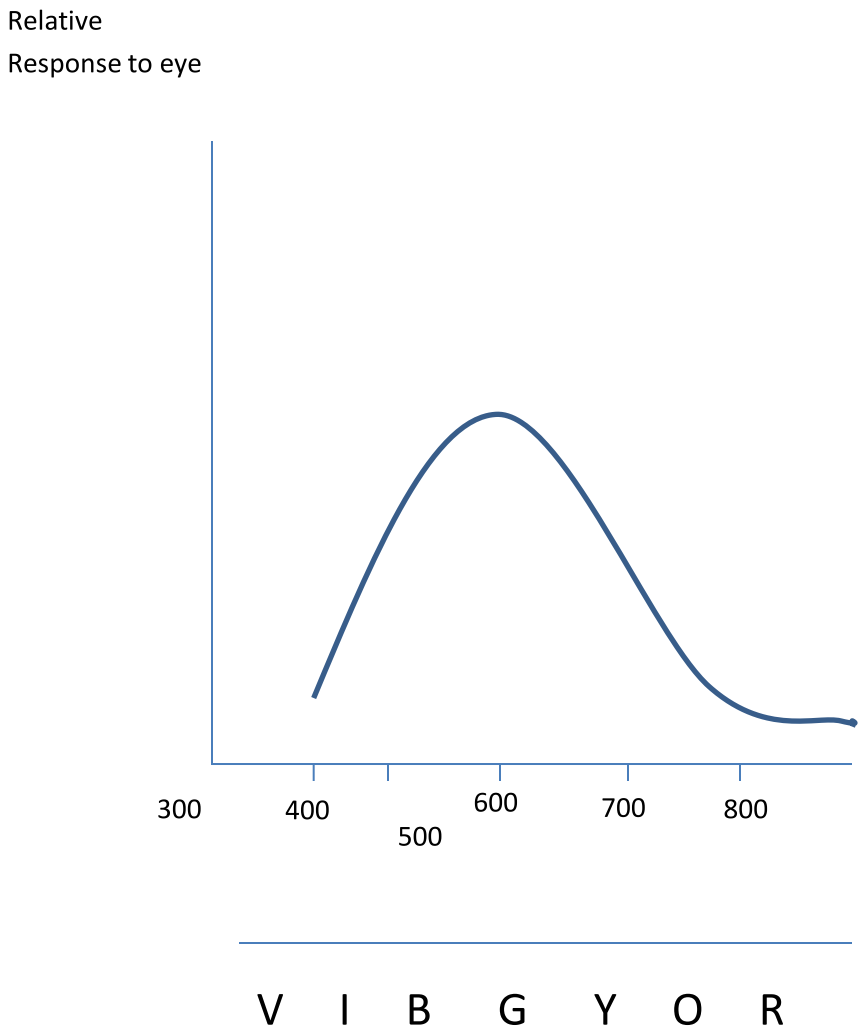
- Some radiographic films are sensitive only to **blue light (*monochromatic*)**; others are also sensitive to **green light (*orthochromatic*) .**
- ***Panchromatic*** are films **sensitive to all colors including red.**
- If screen and film spectral characteristics are not properly matched, receptor sensitivity is severely reduced

IMPORTANCE OF SPECTRAL SENSITIVITY

- Spectral sensitivity is important in matching the film – screen emissions
- It is also essential in aiding the choice of color type of the safelight to be used in the darkroom

- **SPECTRAL SENSITIVITY IN FILMS**
- Spectral sensitivity is the color sensitivity of photo graph films.
- Photographic materials are sensitive to color in different ways to human eye. The human eye is sensitive to electromagnetic Radiation (EMR) of wave length ranging from about 450-620nm

Relative response to eye



- The understanding of spectral sensitivity of particular film is important in determining:-

➢ A color of safe light to be used in processing.

➢ The type of intensifying screens to be matched with the film material for max benefit in terms of radiographic output.

- The spectral sensitivity of the film must be matched with the spectral emission of the intensifying screen.
- The natural sensitivity of the silver bromide emulsion can be increased so that for a given exposure to light or x-rays strong latent image is formed.
- This is achieved by using chemical sensitizers' chiefly gold compounds; therefore a classification is formed according to response of a particular emulsion to a specific emission wavelength.

Photographic materials

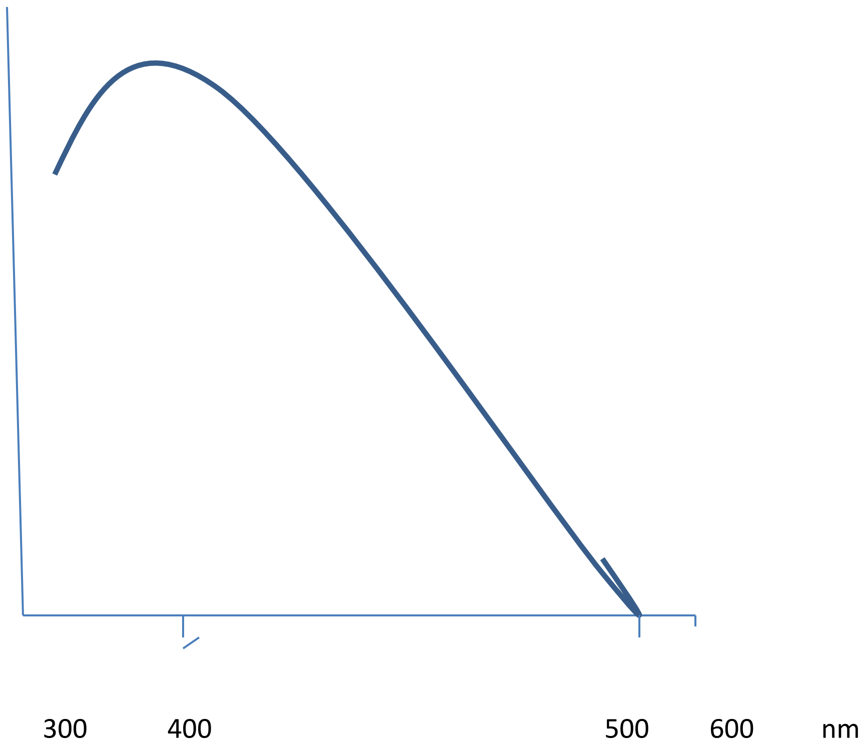
- Photographic materials are classified into four main groups based on their spectral sensitivity
  - ➢ Monochromatic film (blue sensitive)
  - ➢ Orthochromatic film (Green sensitive)
  - ➢ Panchromatic film
  - ➢ Infra-red film.

Monochromatic film

- It is also referred to as non color sensitive or ordinary film
- No optical dye sensitizers’ added to them sensitive to only one color –blue e.g. most screen type films , all non screened films are processed using red or orange safe lights..
- Film response is greatest to radiation of around 400-450 nm

Graph of relative film response

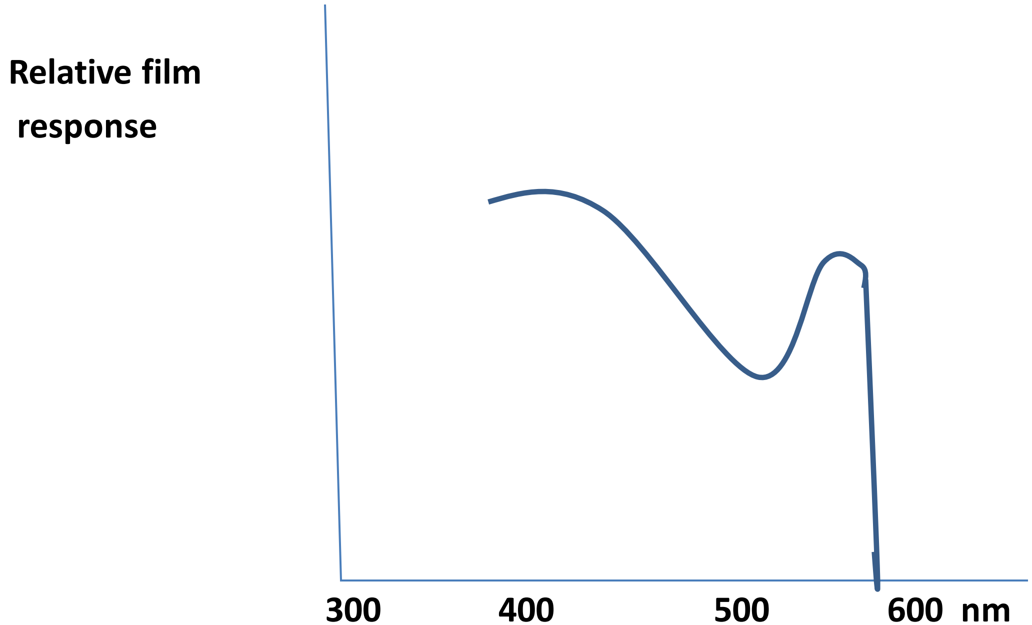
Relative film response



Orthocromatic film

- This type of film has emulsion that is sensitive to all wavelength less than about 620nm with max response at a green part of the visible spectrum
- Example include – flourographic films and are processed using red safe light

Graph of relative film response in Orthocromatic film



Films for fluorography

- Fluorography is the process of recording on film by means of suitable camera the fluorescent image which result from the stimulation of phosphor by x-rays.
- These effects occur during use of such equipments as image intensifiers or the odelca camera which employs mirror lens system to obtain miniature radiographs of the chest its association with image intensifiers and with fluoroscopic tables and their sport film camera fluorographic film is sometimes listed as spot film or as film for mass miniature radiography (mmR)

Duplicating film

- It is a single sided copy film.
- Suitable for producing direct duplicate of radiographs by means of printer i.e the material produces a negative from a negative and should be able of copying the densities of original faithfully
- Processed either manually for 5 minutes at 20^0C in an x-ray or by means of any standard automatic x-ray film processor.
- A light red dark room illumination is suitable
- Both contains 50 or 100 nil sheet.

Examples

- Examples of restricted groups of film sizes are:
- 24cm*30cm
- 30cm*40cm
- 35cm*43cm
- 35cm*35cm
- 18*cm24cm

Subtraction film

- Special materials are available for radiographic subtraction techniques.
- There is a clear distinction between subtraction film and subtraction film point
- Fine grain and low contrast and desirable features of emulsions to be used for making positive masks
- Subtraction point emulsion (High contrast) is characterized by high maximum density and step graduation.
- Subtraction films is usually quite suitable for making final copy i.e if desired.
- Available in boxes containing 50 or 100 sheets examplesof sizes are
- 27cm*30cm,35cm*35cm and 35cm*43cm

Radiation monitoring film

- It is by means of film badge requiring special emulsion and packs.
- Available in two types.
- Appropriateness to one or the other being referable to the type of radiation to which it may be exposed during use.

Radiation monitoring

- Is a film for monitoring personnel, equipment and locations where exposure to x-ray or gamma rays is?
- Emulsion is double sided and double coated i.e both sides are coated with two emulsions of a fast one and a slow one
- To measure small quantities of radiation both emulsion are used together, for large doses half the areas of the fast emulsion is stripped from the base and slow emulsion is used.

Personnel neutron monitoring film.

- Is for measuring by means of film badge dose received by wearer when exposure is fast or slow neutrons.
- A neutron beam is the emission produced by certain equipment used in radiotherapy

Films for radiotherapy.

Films which therapeutic beams is the source of exposure to the films. The purpose for this is

- To determine the position of treatment field by means of radiograph taken before treatment.
- As part of dosage estimations and verification of field orientation by means of a film placed beneath the point.
- Both situations requires an emulsion which is slow for direct exposure to x rays or gamma radiation and has a high contrast fine grain.
- Verification film is subject to exposure of relatively long duration e.g. 2 minutes i.e has low speed.
- Radio diagnostic radiographs may have high energy patients (young children fast radiographic emulsions.

Film sizes

- 25.4cm x30.5cm
- 35.6cmx43.2cm
- Films are automatically processed under usual x-ray dark room

Kidney surgery film

- High specialized pack for radiographic exposure of the kidney to be made extra-abdominally during surgery for removal of renal stones.
- Emulsion is of direct exposure type.
- It is necessary to be packed within a container which allow cold sensitization of its self without harm to included film

Container is polythene packet which is

- Light tight
- Water proof
- Flexible.

Each packet contains 2 films which are not twin pair the emulsions have different characteristic to make detection of small calculi of unknown radiopacity more certain and provide a margin of error in choice of exposure.

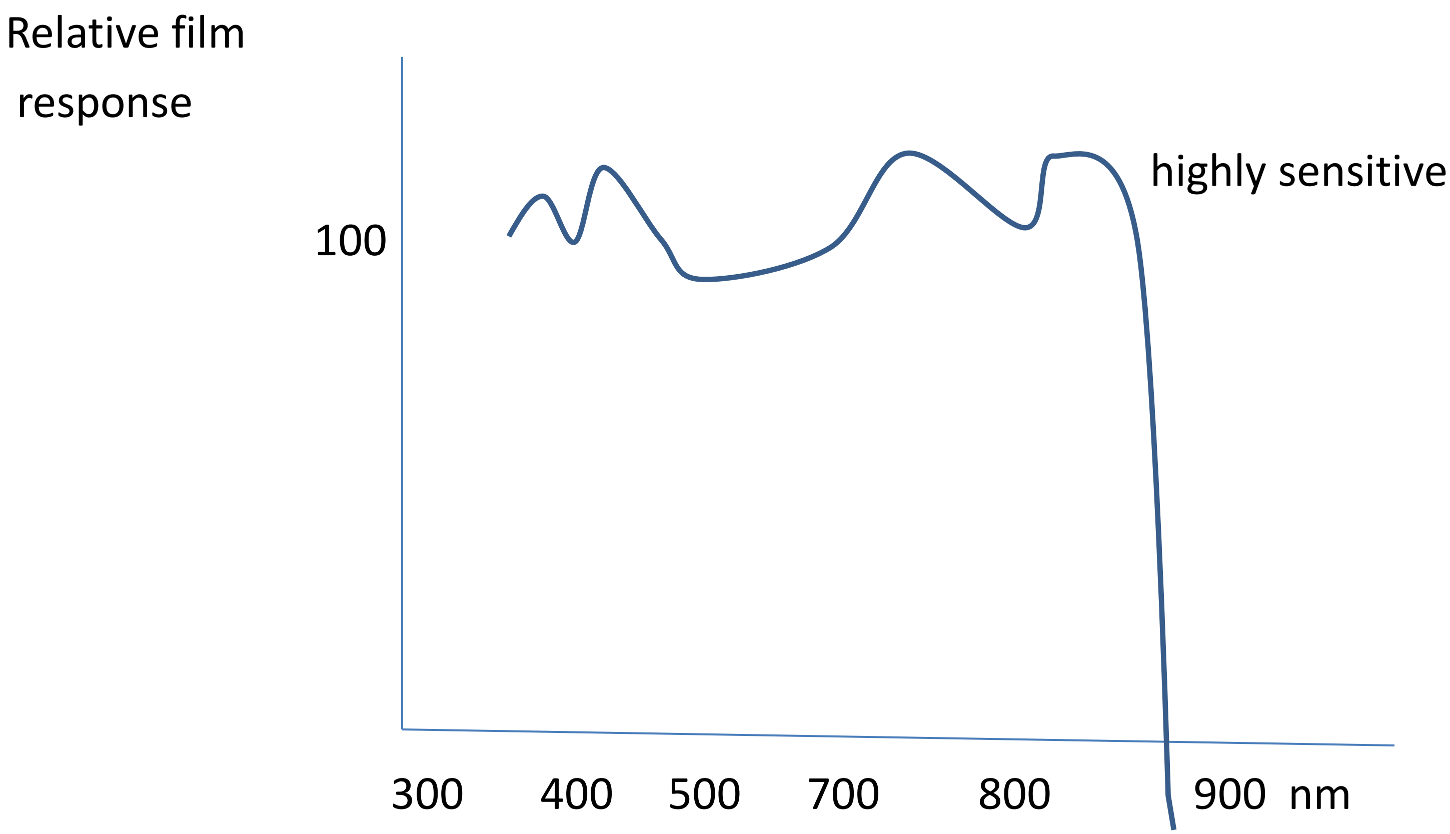
- **Factors that eliminate confusion of occurrence of processing artifacts**
- Packet size of films 11.5cmx13.6cm
- Contain (usual box) 5 films pairs.
- Suitable for automatic and manual processing tolerant of conventional x-ray darkroom safelighting (amber

Panchromatic film.

- The sensitivity of this type of film has been extended to include the whole of the visible spectrum.
- Most film for cine fluorography fall under this category. These films are processed in total darkness

Infra Red film

- The film has its sensitivity extended further than the red portion of the spectrum and its response include to wave length of infra red ray.
- Infra red color is about 900nm



Relative film
response
100
highly sensitive
300
400
500
700
800
900 nm

Application of the above film

- Aerial photography where longer wavelength penetrate
- Medical image where infra red rays penetrate superficial skin and superficial veins are seen

Handling and Storage of Radiographic Film

- Film storage facilities must be shielded from both light and radiation.
- The darkroom adjacent to the x-ray room must be shielded.
- If film use is low more shielding may be required.
- Poor film storage may lead to increased fog and poor contrast

Cont’

- Improper handling of the film will result in poor image quality due to artifacts.
  - Avoid bending, creasing or otherwise rough handling the film.
  - Avoid sharp objects contacting the film.
  - Hands must be clean and dry when contacting a film.
  - Avoid hand creams, lotions or water free hand cleaners.
  - Static electricity or a dirty processor can cause artifacts.
- Artifacts must be avoided.

Cont'

- Heat and Humidity must be controlled.
- Film is sensitive to heat and humidity from the time it is manufactured until the time it is viewed.
  - Heat and humidity causes fog or a loss of contrast.
  - Film should be stored at 20º C (68º F).
  - Humidity should be between 40% and 60%.

Cont'

- Light will expose the film thus film must be handled and stored in the dark.
  - If low level light exposes the film, fog is increased.
  - Luminous watches, cell phone and darkroom light leaks should be avoided.
  - Bright light causes gross exposure.

Cont’

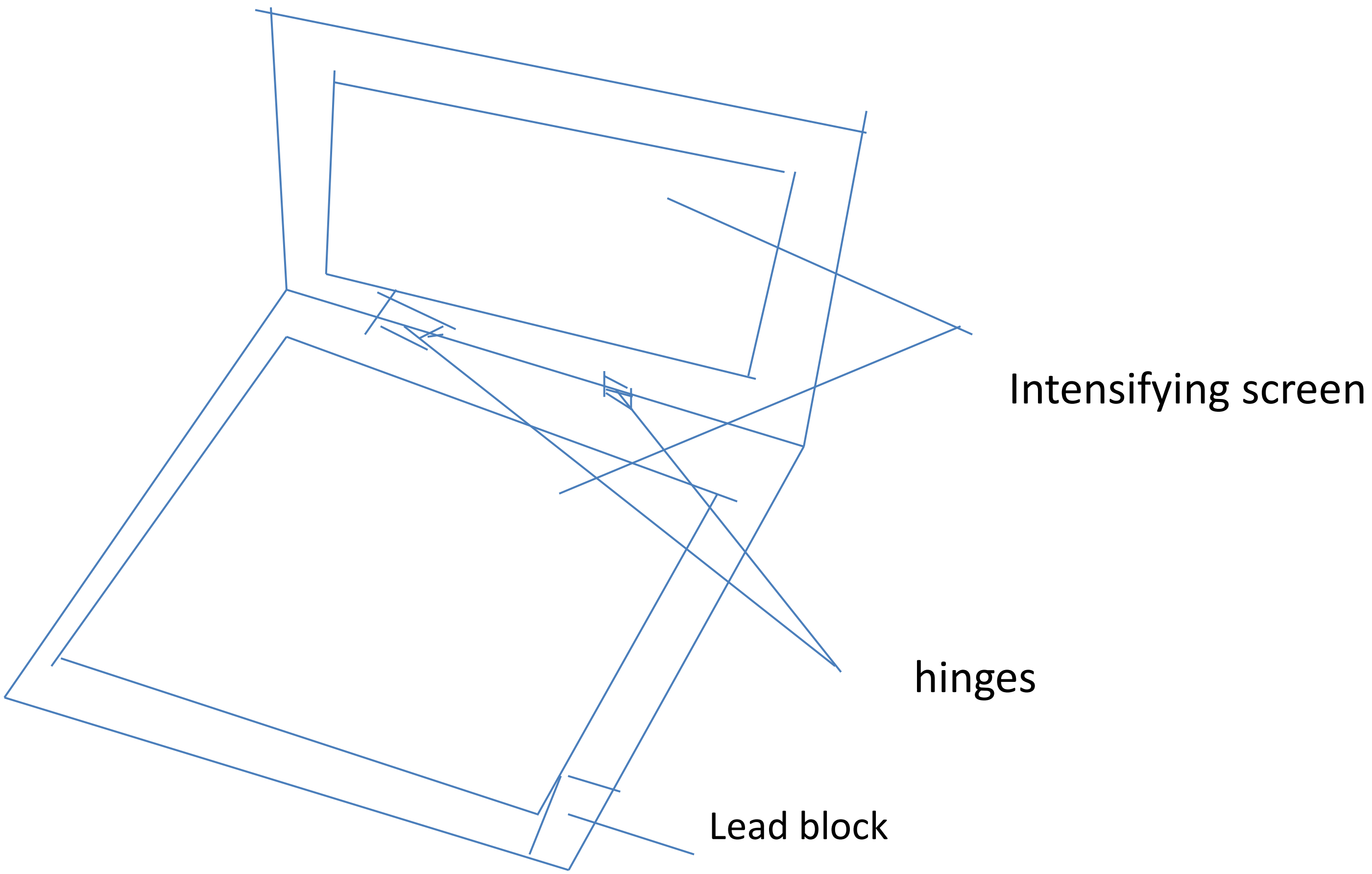
- Shelf life - All film are supplied in boxes with an expiration date that should be noted.
- The oldest film in stock should always be used first.
- Stock control and rotation in usage is important.
- Expired films will loose speed and contrast and have increased fog.

X-RAY CASSETTES.

- Introduction
- Demonstration
- Types
- Uses and functions
- Cleaning and maintenance
- Intensifying screen and construction
- Care and maintenance
- Monitoring and cleaning
- Test and records

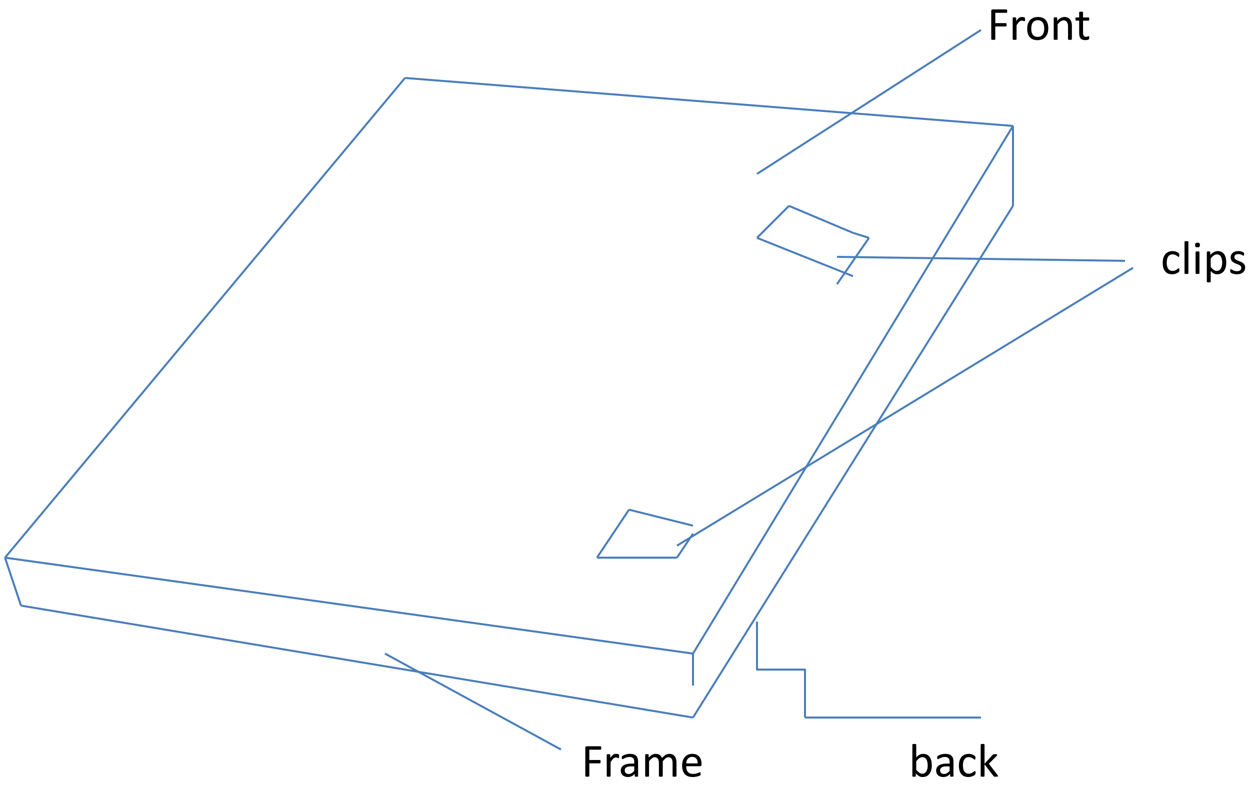
X-RAY CASSETTE

- An x-ray cassette is a book like light tight device which is used to contain the x-ray film and protects the film from light, moisture, heat and mechanical damage.


Intensifying screen
hinges
Lead block

•

-


Front
clips
Frame
back

-

Function

- To exclude light and protect the light sensitive film from external light.
- It is temporary store for unexposed film
- It is for protection of intensifying screens (mounted) from mechanical damage.
- It protects the film from physical damage

- To help maintain good film screen contact
- To prevent back seatter from reaching the film.
- Provides relatively radioinscent front which allows the x-ray to reach the film.
- Gives support for the felt pad which helps maintain good screen –film contact

Construction

Materials

These materials should be:

- Robust
- Light
- Such that it doesn't change at 7^0 of 50^0 to destabilize the size and size of cassette
- Easy to operate
- Not have any effect on the photographic character of x-ray film and intensifying screens

PARTS

The cassette is composed of 7 parts.

- The front
- The back
- The frame
- The felt pad
- The clips
- The hinges
- The lead block.

- The cassette when opened up will have a hollow part on the front which is called the well of the cassette or cassette bed.

The front

- This is made up of a material which should be radio inscent and should not alternate considerable radiation
- Should be of uniform thickness to maintain a uniform alternation of the x-ray beam.
- Materials
- Aluminum
- Plastic of suitable choice
- Bakelite

NB: The aluminium front material should give a filtration of 1.6mm all equivalent at @60kvp single phase unit which has a total filtration of 2mm Al(British Reccommendation).

The back

- usually referred to as the lid of the cassette
- It should absorb back scatter
- It is made of stainless steel lined with lead foil.
- Should have at least 0.12mm lead equivalent @150kup with constant potential unit.
- **NB:** If the timer used is an automatic one (ionization chamber or phototimer) then the back of the cassette should not be lead lined.

The frame

- should be fairly robust coz it is more prone to mechanical damage when the cassette falls down.
- Should be made of a material which should allow rounding off the corners and edges.

The clips (locking devices)

- The back and front of the cassette are usually held together by spring chips.
- Should be made of material that is repairable and should be easy to operate.
- Should not allow unwanted opening of the cassette.

The hinges.

- Should be made up of durable material
- The pivoting bars should be easy to work with so that the can fit into the groove easily.

Qualities of a cassette

- **Weight of cassette**- Should be light if it will be carried around to the wards.
- **The robust status**- It should be rigid, have rounded corners
- **Easy of operation**- Opening/closing should be easy considering the limited light conditions in the dark room.
- **Light tightness**- Should not allow light entry

Type of examination

Measurements of film sizes available

- **Cost-** Should be cheap so that enough are bought
- **Absorption rate-** should be within acceptable rates
- **Thickness of the front-** should be uniform.
- if the back is painted the paint should not flaked
- Cassette should not be too cold for the contacts with the point of patients comfort

Identification of cassette

Reasons

- To help in checking of faults.
- To identify the right cassette
- Help in knowing the no. of cassette in the department
- To ensure proper distribution of cassette so that some are only used in specific rooms
- For storage purposes.

Methods

- Numbering the cassette (internally and externally)
- Letters only or both letters and numbers
- Color coding

Records of cassette

Importance

- To determine the number of sizes of cassette kept.
- To identify the type of cassette available
- To know the date of purchasing of a given cassette
- To know the dates the intensifying screens were mounted(to access durability of screens from given manufacturer)

- To determine the cost and year cassette is bought
- To provide information for research purposes.
- To know when the cassette was last cleared and serviced
- To know the fault identified on a given cassette and type of service done
- The records will provide a means of accounting for the cassette

The intensifying screen

- This is a sheet of material which fluoresces and amplifies the effect of x-rays when irradiated.
- It is made of phosphor material and emits light when irradiated during radiographic exposure.
- They are used in conjunction with x-ray cassette with good contact sand witching the film during exposure
- The fluorescence produces a viable blue light to which x-ray film is more sensitive.

Advantages

The advantages of intensifying screen used in medical radiography is important to note

- Reducing patient x-ray dosage.
- Extending useful life of x-ray tube.
- Making possible use of low power x-ray equipment
- Reducing the possibility of blurring of radiography image

When x-ray fall upon certain substances light is emitted i.e. the substance glows. The emission of light from a substance bombarded by radiation is termed as luminescence.

Types of luminescence.

- Fluorescence
- Phosphorescence

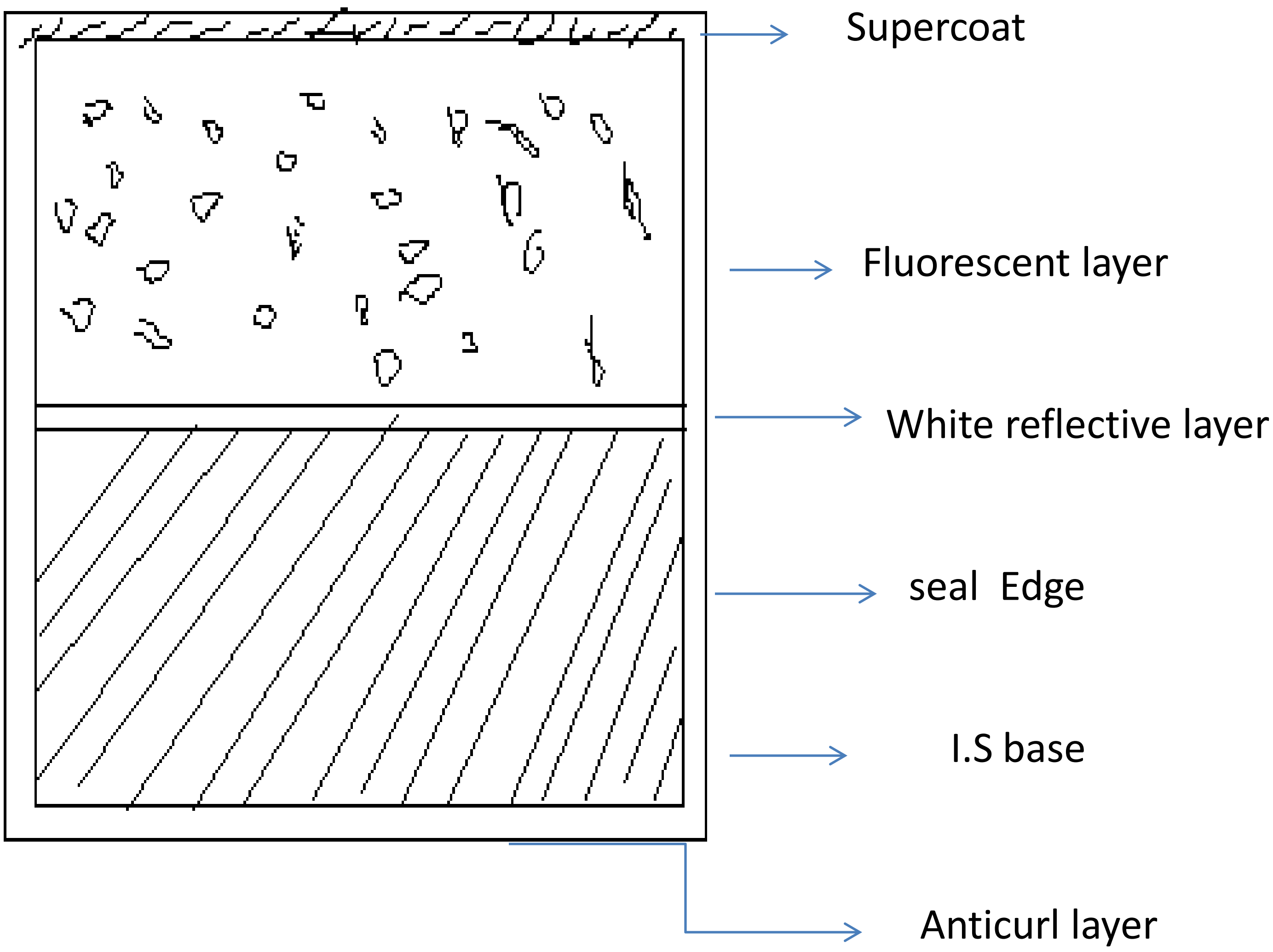
Fluorescence means luminescence is excited during the period of radiation and will die upon termination of x-ray exposure.

Phosphorescence means afterglow i.e irradiated material continous to emit light after cessation of exposure. It is undesirable and intensifying screen if it is sufficiently prolonged it may transfer radiographic image from one terminal to the next film with which the cassette is loaded.

Luminescence effect is used radiographically in two ways

- To obtain on fluorescent screen an image which may be observed by the eye as in fluoroscopy.
- To increase photographic response of Aghalide emulsion the fluorescence material in this case is called an intensifying exposure its function is to enforce the action of the x-rays by subjection of the sensitive emulsion to the visible light as well as x-rays radition.

Construction (structure) of intensifying screen



A typical I.S consist of phosphor partial suspended in a transparent binder material and coated in a plastic base. The layers include

- Supercoat
- Fluorescent layer
- White reflective layer
- Base or support
- Articurl layer

NB: The basic function of intensifying screen is to absorb a part of incident radiation and convert it to visible light thus the use of intensifying screen provide a method of converting an x-ray to another light radiation to which photographic emulsion is more responsive.

Supercoat

- It is about 0.001-0.002 in thickness
- It protect the screen surface from dirt, pressure and friction
- It is not galatine but a form of vanish
- It is a thin waterproof protective made of cellulose acetate.

- Must be thin and transparent to allow the light produced by fluorescent layer to reach
- At the edges the supercoat forms a seal preventing the fluorescent layer i.e allows the use of fluid in cleaning of the screen.

Fluorescent layer

- It consists of particle of fluorescent material suspended in a binding substance.
- NB: Materials which convert visible radiation to luminance radition are phosphorus in radiography only after are used.
- Calcium tungstate which gives off emission of uv, violet and blue light
- Barium flourocloride
- Gadiolinium oxybromides and oxysulphides
- Lanthunium oxybromides and sulphides
- Yttrium oxysulphides

- The binding materials usually polyurethane serve to hold the fluorescent material together and may contain a pigment. This pigment reduces internal reflection within the fluorescent layer thus reducing the screen contribution and sharpness I.e reduces irradiation

Diagram

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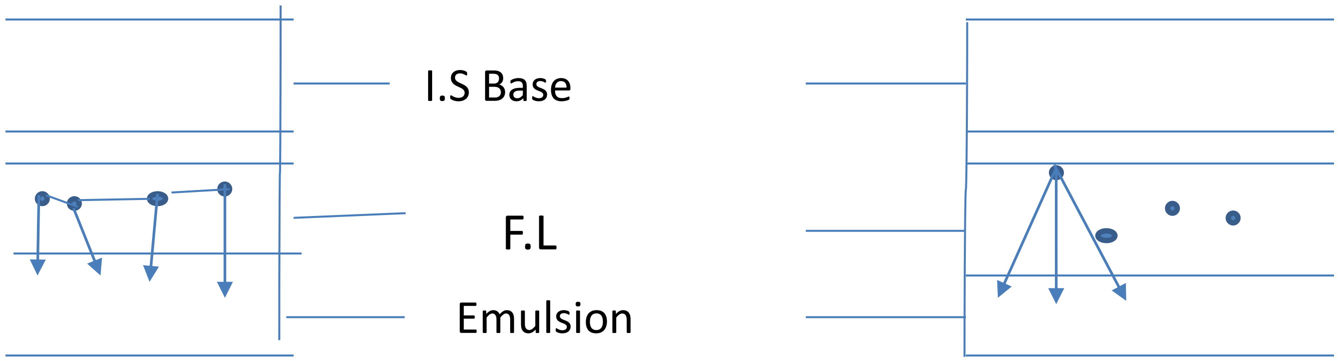


a)Binder without pigment causes irradiation b Binder with pigment causes no irradiation

Cont'

- Irradiation as used in the context of I.screens to scattering of lights within the fluorescent layer through reflection from phosphor particle to phosphor particle
- Eventually the scattered light may reach the film and produce latent image.
- Light emission from a single phosphor particle can thus spread over a large film. This overlapping produced by emission of phosphor particle. These constitute considerable unsharpness and reduction in image contrast.

Cont’

- In situation (a) the light emitted by a single phosphor particle is scattered to a considerable extent due to the transparency of the binder and the presence of reflective layer and the other phosphor particles. This gives rise to an extensive and unsharp image of the particle that emitted the light but since all the light emitted has reached the film, the image density is high.

Cont’

- In ‘b’ the pigmented binder presents a relatively high capcity to light and tends to preferentially absorb the light following long path of the film i.e scattered light allowing light following much shorter path to reach the film. This leads to a less extensive image and less unsharpness but unfortunately since light reaches the film the image density is much lower it may be said that the screen in ‘a’ is faster than that in ‘b’
- Pigmented binders are used in high resolutions screens and also in some intensified screen sets used in

Multi-section cassette

- Here the concentration of pigmentation decreases from the first pair of screen to the last in a direction away from tube side in an effort to equalize the screen speed.

Disadvantages of pigment material.

- It constitutes a loss in speed in the intensifying screens. To overcome the same modern screens employ the use of carbon granules in the binder (usually gelatin) instead of pigment material.

THE WHITE REFLECTIVE LAYER.

- It function is to prevent back scatter of light from the phosphor particle such that all light is directed towards to the film from a forward direction. This increases the speed of the particles of intensifying screen.
- Also serves the purpose of reflecting light
- In general and I screen with this layer is faster than one without and is made of titanium dioxide

BASE OR SUPPORT

Is usually made of polyester or clear plastic or cellulose acetate. Base is coated on one side with an anticurl layer and the other side with a white reflective layer.

ANTI-CURL LAYER.

- Is made up of cellulose acetate and us basic function is as in a single sided film.
- It compensates the tendancy of the fluorescent layer to curl by itself curling in the opposite direction in the same degree thus maintaining the screen in a flat shape.
- N.B caused (curl) by simply temperature variations.

Additional notes

Phosphor

- Is a chemical compound which is capable of absorbing electromagnetic radiation of short wavelength (x-rays) and emitting radiations of a longer wavelength (visible light).
- The effect of fluorescence can be used in radiology in the following areas:
  - In the use of intensifying screen
  - In a visual examination technique
  - In radio photography
  - In image intensifiers

SCREEN LIGHT EMISSION

- The intensifying screen glow off light through ionization process similar to that involving the production of x-teristic radiation
- The emission of light is influenced by two principle factors
  - The phosphor crystal size
  - The screen thickness

Cont’

- The longer the size of the crystal the greater the light emission, and up to certain level of thickness the emission will increase with every increase in screen thickness
- Some of the factors that will cause the screen to loose speed or emit less light than usual are

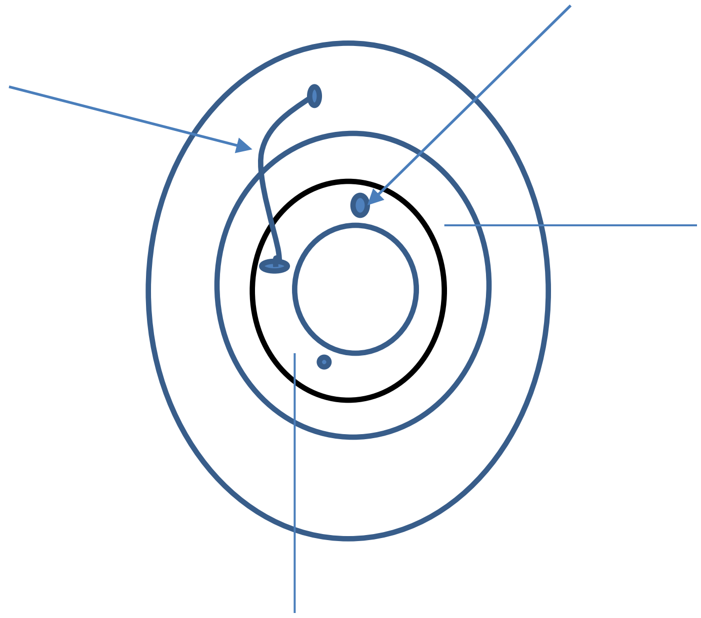
Cont’

- Wear and tear that goes with use
- Absorption of moisture on screen surface
- Dirt which shades the light from the film surface

PROCESS OF LIGHT EMISSION IN SCREENS

- There is a big potential energy difference between the filled zone where vacancies are created and the electron traps entering x-ray photon causes a vacancy in the filled zone by ejecting out an electron from it. Those electron travels to fill the vacancies must give up some of their energies in form of visible light

Diagram



CLASSIFICATION

- The response of intensifying screens to x-rays is described in terms of screen speed. Those screens that emit light more readily and in sufficient quantity would be described as fast screens where as those responding slowly and emitting less light for a given amount of radiation would be described as slow screens.

Cont’

- The screen speed is actually dependant on crystal size and can be placed in three categories.
  - **Slow screen speed-**Has fine grain size and produce best image definition.
  - **Average speed-**Has average grain size and produce a good image
  - **Fast screen (High speed)-**Has large grain size and produce poor image definition

PROCESSING PROCEDURE.

- The descriptive procedure to follow while processing include;
- The darkroom under safelight the film is unloaded from its cassette
- The film is identified by means of a suitable marker if this has not already been done before the entry of the cassette to the darkroom
- The film is placed in a processing hanger of an appropriate size.
- The lid is removed from the developing tank.

Cont'

- The loaded hanger is suspended in the solution. The solution's level must be adequately high to cover the film completely.
- Time is then noted from a darkroom clock which is usually 4 min.

Cont’

- Agitation of the solution is made by slightly raising and lowering each hanger in turn while keeping the film below surface of the solution.
- The lid of the developing should be replaced. Its purpose is to protect the solution from the occurance of aerial oxidation as much as possible and from contamination by dust and similar matter

cont’

- The hanger is removed from the solution when the appropriate development time has elapsed and transferred to the rinse tank where it is subjected usually to a continous stream or fine spray of water for 5-10 sec.
- After rinsing hanger and film are put in the fixer for an interval of which the duration is much less critical than the case of the developer but should be at least twice the clearing time.

Cont'

- The last wet stage of processing the radiograph is transferred in its hanger into the wash section again taking care to allow some drainage of solution to occur when the hanger is evaluated above the fixer.
- The film is dried and ready to be delivered.

DEVELOPMENT AND DEVELOPERS

- Following exposure, x-ray film can be chemically heated or processed in order to produce permanent radiographic image that can be viewed to establish the diagnosis.

Cont’

- Complete processing cycle comprises of
- Development
- Rinsing
- Fixing
- Washing
- Drying

Cont’

- The aim of the cycle is to finally produce the dry radiograph with an image which can be viewed and kept over a number of years without distortion if stored in satisfactory condition.

DEVELOPMENT

- This is the first stage of film processing. It is the production of visible metallic silver image from the latent one which exist in sensitive material after exposure to light or x-radiation.

cont’

- The fundamental changes is that the silver halide grains in the emulsion that have been exposed to light or x-rays become converted to metallic silver and those grains that have not been exposed remain unchanged.
- In practice, the developer solution is not completely selective and will develop all the Ag halide grains exposed and unexposed given long enough time.

- Silver resulting from development of unexposed grain is called development fog and is undesirable
- A good developer solution is therefore one that shows the biggest difference in its action upon exposed and unexposed grain, and processes radiograph with minimum fog.

- A silver radiographic image can be formed by action of light alone but the process is painfully slow and image formed is of very low density.
- The developer amplifies the action of light by 1 million time (i.e without developer exposure required to give optimum densities with action of light alone will be 1 million times the normal range of exposure.

- Photography is not possible without light or x-radiation. It is essential that these radiation initiate the process of photography.
- All that is needed is very minute amount of radiation for photography to be made practical by use of developer.

Action of Developer

- The basic action of developer is to convert to metallic silver the silver ions resulting from exposed silver halides.
- Achieved by the developer donating electrons to the silver ions in the grains, thus neutralizing them.

Cont’

- Any chemical which achieves its action by donating electron becomes oxidized since the action of loosing electrons represent oxidation. The acceptance of electrons by a substance represent chemical reduction of that substance.
- The developer donates electrons which are accepted by Ag halide in the emulsion.

Cont’

- The developer becomes oxidized and Ag halide is reduced. The developer can be said to be reducing agent for Ag halide and tends to reduce all the remaining Ag halide in each of the exposed Ag halide crystal in the emulsion.
- The negative Br- ions disperse into the developer solution as free bromine ion since there are no silver ions to keep them in place.

Cont’

- Each unexposed Ag crystal in the emulsion is surrounded by negatively charged barrier of bromide ions and tends to repel the electrons from the developer.

- Thus the developer does not develop the unexposed Ag Bromide crystal within the normally employed time of development.
- Unexposed AgBr crystal has a gap (weakness in its electron barrier where the latent image has formed (at sensitivity speck)
- Thus the developer develops the exposed AgBr crystal the basic photographic action the conversion of AgBr to black metallic silver.

Cont’

a) Initiated by light and x-rays

i) Silver bromide -----bromide ions + silver ions

ii) Silver ions + electrons (at sensitivity speck) – silver atoms continued by action of the developer.

Ag + electron (from the developer) = (image) Ag atoms

Cont’

- The developer finds it easier to give electrons to expose Ag Br crystals; this have some Ag ions already as a result of light or xray action as there are breaks in the negative charge around the crystal containing this Ag atoms.
- Electrons from the developer gain access to reduce the whole exposed crystal of metallic silver.

QUALITIES OF A GOOD DEVELOPER

i)High speed

ii)High contrast

iii)Long life

iv)Maintained activity

THE PH SCALE

- The ph-scale is used to express the degree of acidity or alkalinity of a solution.
- Water contain negative hydroxyl ions (OH-) and positive hydrogen ions(H+)
- Pure water contain the above two ions in equal concentration

cont’

- If a solution is made acidic the hydrogen ion are present In greater concentration than hydroxyl ions.
- If alkaline the hydrogen ions are less than the hydroxyl (OH-)

Cont’

- A scale of acidity can be made based on the hydrogen concentration and that scale is PH-scale. In a neutral solution the hydrogen ion concentration is 10-7 gramme ion per litre or mol/litre and the PH is seven(7) Acidic solution have higher hydrogen concentration ranging from 10-6 to 10-1 (PH 6 – PH1)

- An alkaline solution have lower hydrogen concentration ranging from 10-13 to 10-8 (PH 13 – PH8)
- Consider the scale

- Most radiographic developers function at a PH of 7 and required to be kept constant at 0.1 and 0.2 on the scale.
- Most fixer function at average of about 5 on the PH scale. The PH scale is logarithmic and small changes in PH means large changes in acidicity

- A change from one to 2 in logarithmic scale indicate an alteration that is tenfold.

- 10-2 to 10-1 means changed 10

- PH is there defined as the logarithm to base 10 of the reciprocal of the hydrogen ion concentration expressed in mols/litres.

- 12 for pure water H+ concentration is 10^{-7} mol per litre which its reciprocal=10^{-7}

- Log of reciprocal 10^{7} = 7 which implies that the water has a PH of 7.

CONSTITUTION OF THE DEVELOPING SOLUTION

- The constituents of a typical developing solution for manual processing are
  - a) Developing agent
  - b) Accelerator
  - c) Restrainer
  - d) Preservative
  - e) Buffer
  - f) Sequenting Agents
  - g) Solvent
  - h) Bacteriocides

Developing Agent

- A developing agent is a substance able to change silver halide into metallic silver.

- It is a reducing agent which itself becomes oxidized (by donating electrons) during the photographic process.

Cont’

- These agents donates electrons with varying freedom those that ready donate eletcrons are referred to as having high reduction potential and those that do it less readily have a low reduction potential

Cont’

- Three developing agents normally used in radiography and general photography are:
- Phenidone
- Metol
- Hydroquinone

They are used in Parts as :

Metol –hydroquinone

Phenidone-hydroquinone

Metol

- Metol as a developing agent produces rapid development and readily reduces silver halide which has received only a slight exposure (thus high reduction potential)
- Once the reduction is initiated, the progress is much slower. The densities produced are not sufficiently high and the resulting image lacks the required contrast.

Cont'

- The activity of metol is depressed by bromine ions released as the normal result of silver halide reduction process without efficient regeneration metol becomes easily exhausted
- Metol tends to fog without a bromide acts as a restrainer i.e it becomes unselective between exposed and unexposed grains
- Metol is used in powder (manual) developer)

PHENIDONE

- This developing agent is used in liquid concentrates developers. It produces a similar image to metol i.e an image density with low contrast. The density is low and less rapidly produced than with metol.
- Phenidone has a slightly higher selectivity than metol

Cont’

- When used alone phenidone is less active than metol but used with hydrquinone it demonstrate a greater superadditivity than the metal hydroquinone combination.
- Phenidone is less affected by an organic restrainer than metol.

HYDROQUINONE

- This developing agent is slower than either metal or phenidone. It needs an alkaline solution for reasonable activity and is almost inactive below PH-9
- It has high selectivity and produces image density of high contrast.

Cont’

- The density is also high but is produced slowly.

- The speed of action is increased by raising the PH but this has disadvantage of reducing selectivity

	Metal	Phenidone	Hydroquinone
➢ Selectivity activity	Low	Low	High
➢ Reduction potential	High	High	High
➢ Contrast	Low	Low	High
➢ Density	Low	Low	High
➢ Rate of exhaustion	High	High	Low

- The selectivity may be improved by using an organic restrainer but this again depresses the activity though not as much as with metol.
- A compromise is therefore necessary, solution may combine metal with hydroquine (MQ) or phenidone with hydroquinone (PQ)

SUPERADDITIVITY

- Phenidone as a developing agent, produce its own different effects. When used in combination the solution is expected to combine the characteristic of the two and the amount of each agent could effect the result obtain.
- On practice, there is a hidden bonus in using these combination i.e the photographic properties and an improvement in the sum of these of each agent.
- This phenomenon where we achieve something for nothing is referred to as superadditivity

- Not every combination of developing agents concentration form a superadditivity but metol-hydroquinonone (mQ) and phenidone hydroquinone (pQ) do produce superadditivity

The developer solution

- A combination of 2 developing agent in the same solution combines the characteristics of the two; the resultant is increase in photographic effect.
- Density – greater than the sum of densities obtained by metol and hydroquinone acting separately this phenomenon is called superadditivity

- Combinations normally comes from the mQ (powder)
- Or PQ(liquid) developers.

Phenidone-hydroquinone combines (PQ)

- This combination is the best choice for automatic processing- reason being that it can tolerate high tempretures.
- Phenidone has a high speed but low contrast just like metol, it tends to fog but its not affected markedly by bromide concentration

- Hydroquinone work best in alkaline solution, initiates the development less readily and has less effect on un-exposed grains.
- It gives high contrast and once the process has commenced it acts vigorously.
- The superadditive effect of PQ combination than MQ combination

- PQ developer are cheaper than the equivalent MQ developers because only a little phenidone is required as compared to metol. Note also that PQ is less likely to stain your clothes and hands.
- PQ is less likely or has a less risk of causing dermatitis. The (PQ) combination produces superadditivity effect much greater than that of (MQ).

Applications

- MQ combination (in powder form) is used in manual processing while PQ (liquid concentrate) are used in both manual and auto processing.
- Phenidone is regenerated by hydroquinone with greater efficiency than metol and this prolongs the working life of the solution.

- Phenidone is much less susceptible than metol to the restraining influenced by the increased bromide concentration which occurs as the developer acts and therefore (PQ) developers do not exhaust as quickly as their (MQ) counterparts

THE ACCELERATOR

- For the developing solution to be fully effective, it must be alkaline. Its activity increases with increasing alkalinity. Too little alkalinity makes it sluggish and too much alkalinity makes it overactive and unselective so that it develops both exposed and unexposed grains resulting into fog.

- The PH range of developers is 9-11.5. the alkaline used in the developing solution is called accelerator examples include:
- Sodium carbonate (Na_2Co_3)
- Sodium hydroxide (NaOH)
- Potassium carbonate (K_2CO_3)
- Potassium hydroxide (KOH)

- The hydroxide are more strong alkaline and used with hydroquinone it results in a developer of high activity and contrast.

Cont’

- E.g potassium rather than sodium salts are preferred because they are more soluble and thus can be used in higher concentrations e.g KCO_3 is used as an accelerator in PQ in manual processing while the more active KOH is used as accelerator in automatic processing .

cont’

The more active alkaline is used when:

a) A normal contrast is required in short time

b) When a higher contrast is required in normal time (by addition of replenisher when using a partially exhausted developer solution.)

- Besides being accelerator, the alkaline has 2 other functions.
- It neutralizes the hydrobromic acid formed during development.

- The negatively charged bromine ions passes from the emulsion into the developer in the form of hydribromic acid (Hbr)
- The presence of the acid is undesirable since the developer solution must be maintained as alkali.

The accelerator

- The accelerator rapidly neutralizes the acid and the reaction produces sodium or potassium bromide depending on which salt has been used as an accelerator.ie
- $NaOH + Hbr \longrightarrow NaBr + H_20$
- It causes some decomposition of developer oxidation products thus slowing down the rate on developer exhaustion.

- Oxidation products of developer are unstable at high PH.
- Controlled high alkalinity has its advantages and disadvantages.

Advantages

- Reduce the period of development
- Increases image contrast

Disadvantages

- Increases grainess
- Increases developer activity which implies high oxidation rate
- Decrease selectivity
- Burning effect to skin and dangerous to eyes.

The restrainer (Anti-Foggant)

- It is called anti-foggant

Function

- Is to improve the selectivity and hence image contrast of developer
- it prevent fog by checking action of un exposed silver halide grains.
- As the films develop the bromine ions from the film adds to the restrainer content of the developer and developer activity decreases.
- The restrainer acts by increasing the hhhh of negative charged bromine ions existing around the silver bromide crystals.

Cont’

- The usual(inorganic) restrainer is sodium or potassium bromide.
- In PQ developers a small amount of organic restrainer(e.g Benzotriazole) is required in addition to the inorganic bromide restrainer because Pq combination are highly active and therefore less selective to the restraining effect of bromine.
- There are also able to minimize fog with less action on the development of exposed silver halide grains and are therefore referred to as antifoggants.

Preservative

- During development the developer donates e- and this represent oxidation of the developer, the oxidation products so formed promote further oxidation and the developer rapidly detorior.
- The preservertive (sodium or potassium sulphite) is included to prevent further oxidation by reacting with oxidation and hence developer life may be prolonged.
- N/B Developer agent releases with giving oxidation products in a process called oxidation.

- Then these products are being acted on by sulphates forming sulphonates.
- The preservative doesn’t extremely stop aerial oxidation but does reduce the rate at which it occurs and minimizes the more damaging effect.
- To minimize aerial oxidation, a lid must always be placed over the developer and replenishes solution.

The solvent

- The solvent used in making photographic solution is water and selected for the following reasons:
- Cheap and universally available
- Acts as a vehicle in which the film emulsion and processing chemicals can react.
- Allows chemicals to penetrate the emulsion

- Acts as a diluents to produce the required activity and concentration
- Allows chemical to obtain active ionic form

Water may have varying degree of hardness depending with the soil through which original real water passed the hardness is due to the presence of the following in water:

a.Calcium bicarbonate ($Ca(CO3)2$)

b.Calcium sulphate ($Ca2SO4$)

c.Magnesium bicarbonate ($Mg(Co3)2$

d.Magnesium sulphate ($Mg So4$)

- Bicarbonate confer temporary hardness removed by boiling whereas sulphates confer permanent hardness un affected by boiling.
- In general these dissolved substances are not much of photographic hazard but in extreme cases may react with developer to form unsoluble precipitates.

- These precipitates are notable in liquid concentrates and are apparent upon drying as chaltry deposits or scum on films and difficult to remove.
- To soften the water and avoid the formation of precipitates, squinting agents are added to the liquid therefore, the water used to mix solutions is not important so long as it doesn’t contain obvious unsoluble impurities e.g grit and rust or any other particular H2O.

- Water that has stood for too long in H2O pipes is likely to contaminate the developer leading to some fog.

The buffer

- A solution is said to be buffered when it is capable of accepting appropriate quantities of an acid or alkaline without any substantial alteration in PH.
- In developing solution the PH must be maintained at fairly constant value through out a working life.

- A buffer system is included in the developer to absorb hydrogen ion (H+) formed during development thus preventing change in PH.
- The system used in usually combination of weak acid and weak alkaline one example is Boric acid and NaOH

BACTERIOCIDE

- Many different chemicals can perform the function of preventing bacterial activity on developer. Certain bacteria can reduce sulphate from preservative to sulphide thus producing a powerful fogging agent thus must be avoided.

The anti-swelling Agent

- The addition of sodium sulphate to manual processing solution prevent the swelling to emulsion.
- Excessive swelling causes:
- In automatic processing the developer work at much higher temp than manual processing. In addition to anti swelling agents, hardening agents are also added. They are (aldehydes) and prevent damage to film as they pass through the rollers.

Summary

- Constituents of developer and its functions

    1. **Reducing agent.**

- Metol (powder) suitable for manual processing solution
- Phenidone and hydroquinone suitable for automatic processing

Function

- Converts the exposed silver bromide crystal into black metallic silver.

Accelerator / Activators (Alkali)

- 1. Na2Co3 powder manual –potassium hydroxide (liquid)

Function

Softens and swells the emulsion so that the reducing agent may work more effectively. They therefore provide the required alkalinity for the reducing agents.

Restrainer

- Potassium iodide (1% powder) potassium bromide (liquid)

Function

- To restrain, prevent the reducing agent from developing unselectively and therefore producing fog.

Preservatives

- Sodium sulphite (powder) potassium sulphate (liquid)

Function

- Prevent rapid oxidation of developing agents.

Buffer

- Boric acid plus sodium Hydroxide
- $Na2Co3$ + $No2(Co3)2$
- $No2(Co3)2$ and $Co3$ is to maintain PH value

Wetting agents

Function

- Is to reduce the surface tension of the gelatin

Types available

1. An ionic wetting agent

- These are normally salts of strong acids and bases i.e NaOH, KOH, NH4OH, tri-ethanol melamine cyclohexylyne.

Non ionic wetting

- These are not ionized solution e.g ethylene oxide or substances of neutral origin like extracts of ox-gall and synthetic polyoxy

Solvents

- 1. Water is a liquid of choice for dissolving chemicals.

NB: in case of any acceleration in the constituents of developer solution the following effects may occur.

a. Change in amount of developing agents and the ratio of different agent in relation to each other time required to reach a given contrast and density will be altered i.e they alter development time required

- b.Change in the amount of alkali

- Alters the needed time to reach agiven contrast and density

- c. Increasing the amount of restainers.

- Reduces the fog level where it exists but also results in longer development time to reach a given contrast

- ➢ Alteration in the amount of preservatives
- Affects the protective properties of the solution
- ➢ Alteration in amount of water.
- This will affect the dilution of the developer either conc or dilute the more con the solution the shorter the development required

- Given the understanding of the process which takes place in the development it is easily seen through the development outline the requirement of a replenishing solution which is to restore its activity. This solution must achieve 2 tasks. while replenishing

a. To maintain the level of soln in the tank

b. To regenerate the solution chemically

- To achieve the above it is safe to say
- i. Since the developing agents are used up to replenish should contain them in a higher concentration than the original developer.
- Since the PH falls in use the replenisher should contain a high concentration of alkaline to affect it.

- i. Since the preservative in the developer is used up some extra sulphite must be included in the replenisher, other additives to maintain adequate buffering of solution is necessary
- ii. Maintaining the solution level is necessary and termed as repleshments

Replenisher for development

- Replenisher solution is packed in three pack
- Its concentration is normally higher than usual developer.
- Sometimes more significant in manual processing
- The typical MQ replenisher normally has 3 parts
- 1. Metol hydroquinone
- 2. Sodium sulphite or sodium carbonate
- 3. Crome Alum
- These constituents have different compositions and concentrations.

- Typical MQ Developer/Replenisher.
- Ingredient comp Developer Replenisher
- Metol ` 2.2gms
- Hydroquinone 8.8 gms
- Na2Co3 4.8 gms
- Na2SO4 72 gms
- NaOH 0
- KBr (stator) 3.2 gms

Cont'

- For the PQ developers have phenidone instead of metol .For MQ some concentration of all other ingredients do not change as in the above table.
- This significance in manual is that chemicals are mixed separately while in automatic,two significant methods are available are in practical
- a. Inspection method
- b. Time temperature method.

Inspection method

- This is where usually a film is immersed in the developer solution and after agitation is removed regularly for checking of the progress of image formation development.
- It has an advantage that:
- The over exposed films or under exposed films may eventually produce an acceptable image.

Disadvantage

- Those very sensitive films get fogged by the constant removal of the film from the developer to the air for inspection. Fogging is caused by oxidation, inspection, light and safe lights laminator in the dark.
- This fogging is prevalent with faulty safe light if not suspected.

Time temperature

- This is the best preferred method of development as it gives he best results without much accident as long as the tube has the same output that is not deteriorating and the radiographer is also competent
- In this instance the temperature of developer is noted and radiograph is processed in it through inspection method.

- The time it takes for the radiograph to come out clear is noted. This is done to the developer solution at various times and conditions of the developer e.g. when the developer is fresh, when it is mid way strong or when it is nearly exhausted

- Time temperature is the best development method because:

  i. You process many films at the same time provided you put them at the same time.

  ii. No risk of aerial fog.

  iii. No risk of scratching.

  iv. No chemical wastage or spilling.

- The characteristic curve of emulsion changes under different conditions such as of stores or processing or of exposure.
- When development time varied and another remain constant the above graph is realized that the slope of the curve is changed the contrast the speed increases with development time

- The curve therefore moves to the left and becomes steeper.
- The basic fog goes up with longer development time, the shift to the right is rapid at first and then become constant thus it is essential to state the conditions of development when presenting a characteristic curve

- Since the emulsion may be of the speed and contrast at one development e.g. one and half minutes and this difference on another development time e.g. 3mins

INSERT RINSING.

Temperature control

- The control of temperature can be attained in a number of ways in some cold countries for instance it involves raising of the temperatures level while in tropical environment it is lowering of temperatures levels therefore means must be found for keeping the solutions sufficiently cool or warm for satisfactory operation the common methods available for the task are:

i. Thermostatic element.
ii. Immersion element
iii. Water mixing values.
iv. Refrigeration
v. Ice cubes.
vi. Evaporation

a. Thermostatic element

- These are electric heating element controlled by a thermometer regulator device. They keep the solution temperature at preselected values constantly with limits of 10c there are 2 types used

i.Dial type thermometer

- Placed on the outside of the processing until it has two pointers one of which is manually set to the desired temperature while the other moves across the scale to show the actual temperature in water socket. When the two pointers are in register or the temperature indicating needle reads a temperature above the present pointer, the heating dense disconnects automatically and no current is passed through the heating element, when the temperature of the water jacket drops below the present minimum the heating unit is brought into work automatically.

Thermometer bulb is placed on the inside of the unit situated halfway between the water surface and the bottom of the water so as to read the main temperature of the water jacket.

- This bulb contains a gas which is connected to the recording diode by means of capillary tubing.

a. Immersion heaters

- Electrically heated pocket type of element which must be insulated and earthed to prevent overheating and subsequent damage to the element.
- It must be inserted in the water jacket before being switched on likewise it should be switched off before removing from the water jacket.
- It is recommended for use in the water socket and not in the developer solution directly.
- If immersed in the developer solution local heating may cause decomposition to the solution.

a. Water mixing valve

- The temp of water jacket may be controlled between certain limits by introducing warm and cold water from the supply. This can be done manually but water making valve is more appropriate.
- These are constructed such that the amount of cold water and hot water pass through can regulated to give the emergent water required temperature

Cont’

- Some designers can incorporate thermometer in actual valve to but it is customary to provide a unit fit water mixing value with dial thermometer on the outside of the thermometer which is connected to a thermometer value within water jacket.
- Some types of water mixing values thermostatically control the water flow within the limits of available water supply.
- However care should be taken in case of a faulty flow meters

a. Refrigeration

- In units designed for the tropical use the temperature of incoming water may lead to blow up this can be accomplished by passing through a refrigerating control.

- The cool water therefore is passed into a water tank from where it overflows into the water socket.

- Most cooling units incorporate a flow control which is preset to deliver water at a certain temperature to the cooling unit. If the temperature of the incoming water increases the flow control restrict amount of water entering refrigerating will the reduce flowing rate thus keeping the amount of work within the capacity of the cooling unit.

- Most processing unit fitted with cooling device also has the same form of heating device fitted incase of extreme climatic changes

a. Ice cubes.

- To rapidly cool the developer ice may be packed around the top of developer tank and outside can also be packed in a rubber of plastic packs and immersed in the developer

- Should not be dropped in the solution naked because on melting it will dilute developer solution

a. Evaporation

- By surrounding the tank with a wet of most sack exposed to air may accomplish the process of coling as the water from sacking evaporates the heat is carried away from the tank surface and this lowers the temperature of the solution.

FIXATION

OBJECTIVES.

1. Name or list the basic constituents of the fixer .
2. Describe the functions of each constituent.
3. State factors affecting fixing time.
4. Describe out of factors named affect fixation
5. Describe characteristics of exhausted fixer solution
6. Describe the methods of fixer regeneration
7. Explain the process of x-ray film fixation
8. Generally give a general description of fixer solution.

- Fixation process begins when the exposed and developed crystals of silver halides emulsions are stopped from blackening.
- When unexposed silver halide is not developed neither does it blacken to form an image. It is not soluble in water but remains in the emulsion as a light sensitive material.

- If left their to stay therefore it will blacken eventually and spoil the image un altered against a translucent background.
- If it is removed by being changed into a complex silver substance which is soluble in water and then dissolved by water in the mixing solution at the same time no further development is allowed to continue due to developer absorbed in the swollen gelation of the film.

- The extent of swelling is checked by the hardening process of the fixing agent and thus protecting the film from damage.

Aims of fixing

1. Makes the developed image permanent
2. To stop further action of developer dissolved in geletin
3. To clear and dissolve the soluble complexes and leave a clearly desirable image
4. To harden the gelatin and leave it undamaged by preventing it from softening and excessive swelling.
5. To have no appreciable negative effect on silver image.

Constituents of fixing solution

a.Fixing agents

b.Acidifiers

c.Preservative

d.Buffer

e.Hardener

f.Solvent

a. Fixing agent.

- This is sometimes referred to as clearing agent.
- It converts the Ag halides into silver complexes and most suitable of these agents is called sodium thio-sulphate also called Hypo
- It reacts with AgBr to form poly-syllabic compound this can be expressed as AgBr (silver bromide)

- The agentodiasulphate and sodium bromide is soluble Hypo is normally in powder form called Hydrous and also in crystal form and always used in manual processing.
- Ammonium thiosulphte:

 Available in liquid form

 Diluted by water to form a suitable solution

 Reacts with AgBr to a simple compound same with below reaction

- Agbr + Amonium thiousulphate Ammonium salt of mono gento diosulphuric acid + Ammonium bromide

- Both monoagento-diosulphuric acid and ammonium bromide are soluble
- Ammonium silver complex are highly soluble + water and also washed quickly from the film.
- However ammonium complex formed is less stable than Na complex formed when hypo is used as fixing agent

cont’

That means:

1. That if the films are not completely washed will stay and deteriorate very readily when ammonium complex is present.
2. That the ammonium thiosulphate fixer when splashed on a white coat will stain it beyond laundry removal

b. Acidifier

- Is called acetic acid. The acid stops the action of developer carried into the fixing solution by neutralizing the alkaline developer

- Stronger acids are never used because they attach hypo+precipitate sulphur

c. Preservative

- The stabilizer is a preservative which prevents thio-sulphate solutions from decomposing because once they decompose they start precipitating the sulphur.

- When acetic acid is used as acidifier the Na2Co3 is used as the preservative.

d.Buffer

- Is included to maintain the PH of the fixing bath. The bath should be maintained at PH of 4.5-5.0
- Due to carry over rate of the developer the PH in the fixing bath increases and this necessitates buffering agent those used are sodium acetate, acetic acid with sodium sulphate.

Effects of absence of Acidifier, stabilizer and buffer

1. **Dichroic fog**

- Greenish-bluish fog formation – a stain which appear greenish blue when viewed by transmitted light.
- Produced by the action of developer reducing the silver salt which the fixer has put into the solution.
- Can also occur when fixer solution contaminates the developing solution.

Cont’

- Brown stains due to developer oxidation

- Streaks on the radiograph due to prolonged developer after film has left developer tank. Causes: dirty processor roller, inadequate washing, inadequate drying

N/B

- During fixation there are times intervals between the clearing and fixing, the fixing time is a time the film takes in the fixing solution before it is adequately fixed and is twice the clearing time.
- Clearing time is time taken for the milky solution formed on the film when it is immersed on the fixer solution to clear away.

e. Hardener

- In alkaline medium the film emulsion absorbs moistures and swells. The hardener prevents excessive swelling of the emulsion.

Advantages of efficient hardener

- The temperature at which gelatin solution softens is raised meaning a higher temperature can be used for drying film.
- Gelatin absorbs less water meaning drying time shortens

- The film is less susceptible to physical damage i.e abrasion.
- Also means rapid driers with increased temperature and rollers can be used safely.
- Hardening agents are effective only in acid solutions and this is a further reason why an acid is included in the ingredients of a fixer solution.

Examples of hardeners are:

i) Chrome potassium Alum
ii) Potassium Alum
iii) Aluminum chloride

Most hardening agents are affected by the PH range of the fixer solution.

lowered Sulphiding (Yellow sulphur formation)	Optimum Ph of hardener	high Loss of hardening efficiency

Chrome Alum

- It has a higher hardening efficiency than the potassium Alum.
- It is suitable for immediate use but detoriates with time whether used or not.
- More preferred for theatre film processing
- Sensitive to PH variations and its optimum range between 3.5 – 4.7 above 4.7 it hardening efficiency drops below 3.5 sulphiding occurs most efficient above 3.5

Potassium Alum

- This retains its activity for a long time and therefore most widely used,

It has the greatest efficiency at PH 4.5 – 4.9 at above 5.5 its activity decreases and forms a white bloom which is a precipitate of Aluminium hydroxide Al (OH)2 which appears on film surface

Aluminium chloride

- Is associated with ammonium thiosulphate fixer which is normally used in auto processing.
- It is very fast hardening agent and thus used with the fastest fixing agent.
- Remains efficient at the PH of the fixer.

f) Solvent

- Water is the medium of choice acting as a solvent as well as diluents.

Factors affecting the use of the fixer

Those factors affecting clearing time and fixing rate

1.Types of fixing agent used

Ammonium thiosulphtae clears so rapidly than sodium thiosulphate

2.Concentration of fixing agent

The higher the concentration the longer the clearing time, however manufactures instructions must be adhered to.

3. Temperature of the solution

The higher the temperature, the faster the clearing time and so decreases as the temperature decreases, because at higher temperature the diffusion process takes place more quickly and the gelatin become more readily permeable.

- The temperature of the solution (fixer) is normally controlled by the temperature of the neighboring solutions. However, temperature of 15^{o}c- 21^{o}C is adequate for optimum conditions of fixing

4.Presence of hardeners

An unhardened emulsion is more swollen than the one hardened and the diffusion path becomes longer thus giving a longer time for diffusion.

However potassium Alum and aluminium chloride lengthens clearing time as compared to chrome alum.

5.**Types of the film material**

The following features of an emulsion alter the rate at which the material clears.

a. **Silver halide used**-because silver bromide fixes easily than silver iodide

b. **Grain size** – small grains dissolve in less time than the large grains in other words slow speed films clears faster than the higher speed films

c. **Thickness of emulsion layer** – the thinly coated materials clear faster than the thickly coated material because of diffusion efficiency.

d. **Film agitation** – Agitation increases the rate of clearing since clearing of fixing time depends on mostly on diffusion.

- Agitation prevents accumulation or collection of a layer of exhausted fixer near the film surface.
- If film is agitated on the 1st few seconds on its arrival to fixing bath, any developer carried over is soon neutralized.

6.Exhaustion of fixing bath

With use, the following changes occur with the composition of the solution and slow the action.

i) Increased dilution of the fixing bath due to carry over range(COR)

ii) Steady accumulation of the soluble Ag complex

iii) Steady accumulation of the soluble halide with the amount of work and type of work soluble halides are deposited into the fixing bath and they slow the fixing action.

Factors affecting fall solution level

- When the film is transferred from developer tank to the next stage, a certain volume of the solution is carried over by: the film surface, film emulsion, the hanger, users fingers: in all some amount is removed and constitute to the fall in solution level.

- When a film is drained for about 5-10 sec some solution goes back to the tank which would otherwise be carried out to the rinsing bath.

This fall in solution level is therefore influenced by the following factors:-

I) Number of film processed

II) Surface area of film processed

III) technique in processing

IV)Time given for draining (5-10sec) otherwise can cause aerial fog

Remedy of exhaustion

- When the exhaustion is suspected, the solution should be replenished.
- The replenishment is a process of continuous restoration of fixer strength by a special fixer solution called replenisher.
- Its work is to counteract the effect of exhaustion since the task of developing agents is to reduce the silver halide to metallic silver, the reducing agents are continuously used up thus loosing the strength of the solution. To restore this strength is referred as **regeneration.**