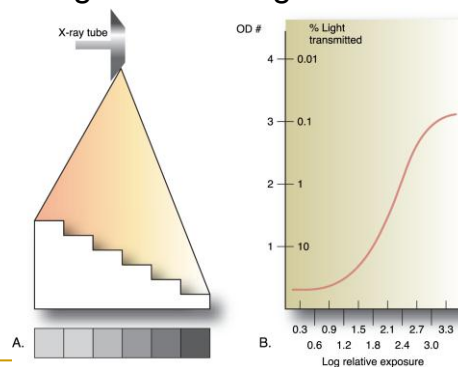


Principles of Imaging Science II (RAD120)

Film Sensitometry

Film Sensitometry

- Measures the response of film to exposure and processing
- Accomplished by exposing and processing a film, then evaluating the resulting densities



Purpose of Sensitometry

- Evaluation and maintenance of exposure factor systems
- Evaluation of intensifying screens
- Monitoring of processing equipment

Sensitometric Equipment

- Penetrometer or sensitometer
 - Used to create a uniform set of densities on a film
- Densitometer
 - Provides measurement of light transmitted through film
 - Measures optical density

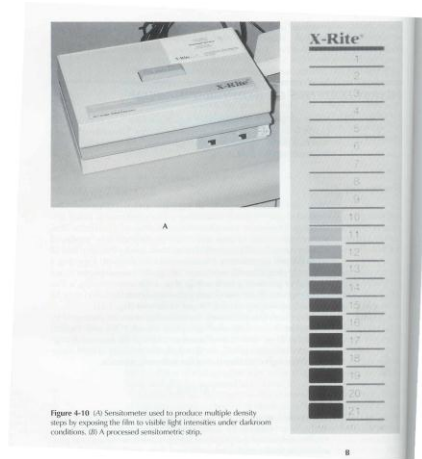


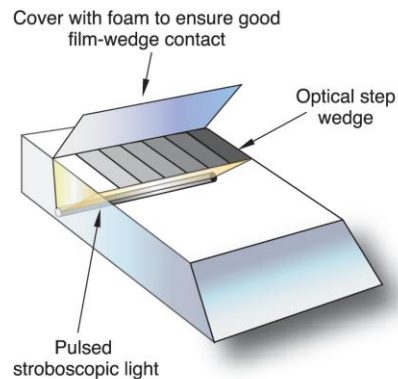
Figure 4-10 (A) Sensitometer used to produce multiple density steps by exposing the film to visible light intensities under darkroom conditions. (B) A processed sensitometric step.

Penetrometer

- Stepwedge
- Used to monitor x-ray equipment
- Also used to monitor film/screen combinations
- Not recommended for processor monitoring

Sensitometer

- Uses a controlled light source
 - Produces same amount of light each time it is triggered

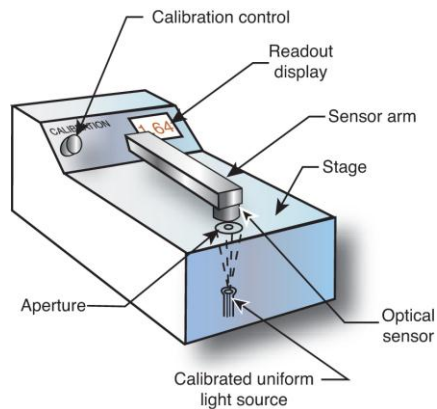


Sensitometer

- Available in 11- or 21- step versions
 - 11 step version increases density by a factor of 2 for each step
 - 21 step version increases density by a factor of the square root of 2 (1.41) for each step

Densitometer

- Uniform light source and an optical sensor
- Calibration control allows for easy calibration



Optical Density Numbers

- Formula:
 - $OD = \log_{10} I_o/I_t$
- If 100% of the light is transmitted through the film, it has an OD of 0
- If none of the light transmits through film the OD is 4

Opacity

- Ability of a film to stop light transmission
- Formula:
 - I_o/I_t

The D Log E Curve

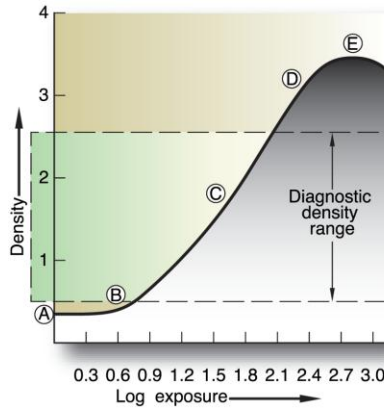
- Describes relationship between density and exposure
 - This is done through sensitometry
-

The D Log E Curve

- AKA
 - Sensitometric curve
 - Characteristic curve
 - Hurter and Driffield (H & D) curve
 - Sensitometry's roots lie in analysis of photographic film
-

The Sensitometric Curve

- Plots OD vs. LRE
- Log relative exposure
 - Allows large range of exposure displayed in a few numbers
- Parts of Curve
 - A: Base + Fog
 - B: Toe- D_{min}
 - Where the density becomes light
 - C: Straight line portion
 - Used to demonstrate the relationship to the film's exposure vs. the density transmitted
 - D: Shoulder- D_{max}
 - Where the density becomes dark
 - E: Solarization



The Sensitometric Curve

- Log relative exposure
 - $\log_{10}2$ represents doubling exposure
 - $\log_{10}2 = 0.3$

Densitometer

- Reads on a scale of 0-4
 - 0 meaning that all light is transmitted
 - 4 meaning that no light transmits through the film
- Typical diagnostic densities range between 0.25 to 2.5

Film Properties

- Base density
 - Inherent in a piece of film due to dyes etc.
 - Value is usually 0.1 OD
- Fog Density
 - Inadvertent exposure during storage handling etc.
 - Fog density should not exceed 0.2 OD

Base + Fog

- Cannot separate base and fog density measurements
- Typical range of OD for Base + fog
 - 0.18 to 0.23
 - Should not exceed 0.25

Toe

- D_{\min}
- Controlled by phenidone
 - Fast acting reducing agent in developer
 - Produces gray tones on film

Straight Line Portion

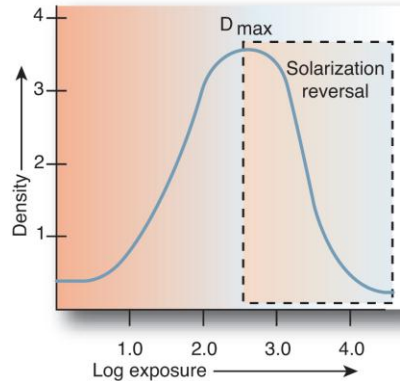
- Area of curve between toe and shoulder
 - Contains range of useful densities
 - Typically 0.25 – 2.5 or 3.0
-

Shoulder

- D_{\max}
 - Controlled by hydroquinone
 - Slow acting reducing agent in developer
 - Produces blacks in image
-

Reversal or Solarization

- Once a film has been exposed to D_{\max} , it will begin to lose density after further exposure
- Duplication film has been solarized



Film Characteristics

- Resolution
- Speed
- Contrast
- Latitude

Resolution

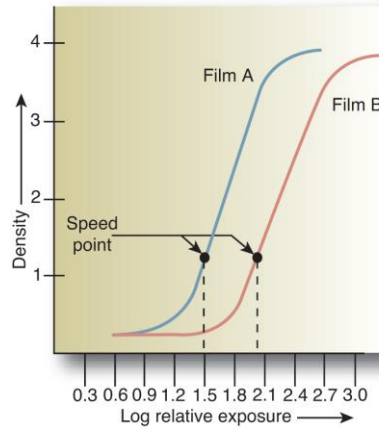
- Ability to accurately image an object
 - AKA
 - Detail
 - Sharpness
 - Definition
 - Resolving power
-

Resolution

- Inversely related to size of silver halide crystals
-

Speed

- Ability of an IR to respond to low exposure measures its sensitivity or speed
- Speed index
 - Specified by $1.0 + \text{base} + \text{fog}$



Speed

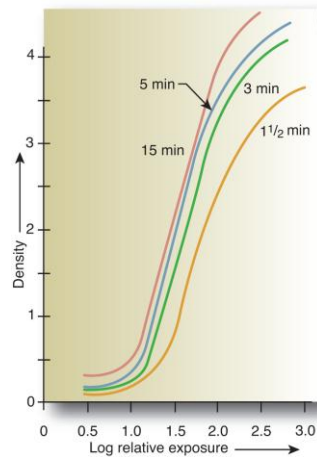
- Faster film will have a curve closer to y-axis of graph

Speed

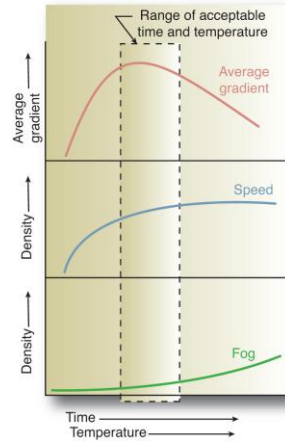
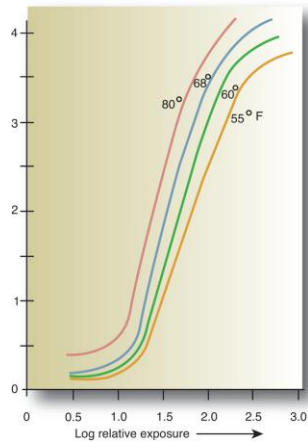
- Film sensitivity is affected by:
 - Size of silver halide crystals
 - Number of sensitivity specks
 - Thickness of the emulsion
- All of the above are directly related to film speed

Speed

- Affected by processing
 - Immersion time
 - Solution temperature
 - Chemical activity



Speed

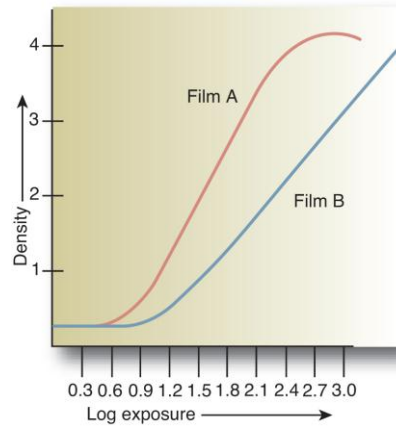


Contrast

- Contrast is controlled by hydroquinone
 - Hydroquinone establishes the shoulder
 - Thus, it affects slope of the straight line portion of curve

Film Contrast and Curve

- Film contrast is defined by straight line portion of the characteristic curve
 - Gamma slope of straight line

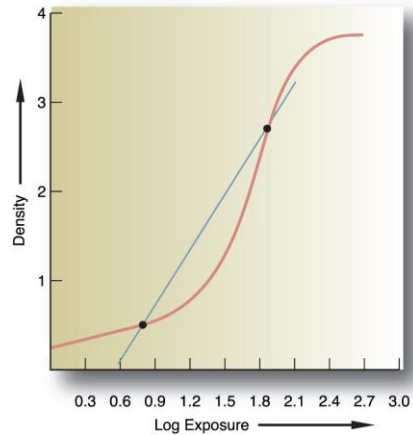


Film Contrast and Curve

- As the line becomes more vertical the contrast gets higher

Average Gradient

- Used to identify contrast of a film by manufacturers
- Slope of line that is drawn between
 - 0.25 above base and fog density

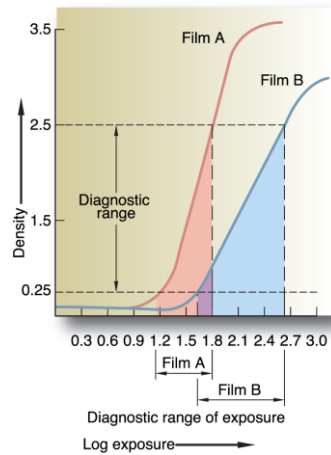


Average Gradient

- Slope of line that is drawn between
 - And 2.0 above base and fog density
- Higher the average gradient, the higher the contrast

Latitude

- The lower the slope (the more horizontal the line) the wider the latitude



Latitude

- Long scale of contrast in film (low contrast)
 - More latitude
 - Margin of error higher