Chapter

10.1

Motion Picture Film

Kenneth G. Lisk

10.1.1 Introduction

Motion picture film has been an integral part of television from the earliest days of broadcasting. Film has—in fact—been the standard by which each successive video format—from black-and-white, to color, to HDTV—has been measured. Film has also demonstrated a remarkable ability for improvement. It is clear that film will continue to be an important part of television for decades to come.

10.1.2 Basic Film Parameters

The film *exposure index* (El) is a measurement of film speed that can be used with an exposure meter to determine the aperture needed for specific lighting conditions. The indices reported on film data sheets by film manufacturers are based on practical picture tests but make allowance for some normal variations in equipment and film that will be used for the production. There are many variables for a single exposure; individual cameras, lights, and meters are all different. Coatings on lenses affect the amount of light that strikes the emulsion. The actual shutter speeds and *f*-numbers of a camera and those marked on it sometimes differ. Particular film emulsions have unique properties. Camera techniques can also affect exposure. All these variables can combine to make a real difference between the recommended exposure and the optimum exposure for specific conditions and equipment. Data sheet EI figures are applicable to meters marked for ISO or ASA speeds and are used as a starting point for an exposure series.

For measurement exposure, there are three kinds of exposure meters: The *averaging reflection meter* and the *reflection spot meter* are most useful for daylight exposures, while the *incident light exposure meter* is designed for indoor work with incandescent illuminations.

10.1.2a Exposure Latitude

Exposure latitude is the range between overexposure and underexposure within which a film will still produce usable images. As the *luminance ratio* (the range from black to white) decreases, the exposure latitude increases. For example, on overcast days the range from darkest to lightest narrows, increasing the apparent exposure latitude. On the other hand, the exposure latitude decreases when the film is recording subjects with high luminance ratios such as black trees against a sunlit snowy field.

10.1.2b Lighting Contrast Ratios

When artificial light sources are used to illuminate a subject, a ratio between the relative intensity of the key light and the fill lights can be determined. First, the intensity of light is measured at the subject under both the key and fill lighting. Then the intensity of the fill light alone is measured. The ratio of the intensities of the combined key light and fill lights to the fill light alone, measured at the subject, is known as the *lighting ratio.*

Except for dramatic or special effects, the generally accepted ratio for television color photography is 2/1 or 3/1. If duplicate prints of the camera film are needed, the ratio should seldom exceed 3/1. For example, if the combined main light and fill light on a scene produce a meter reading of 6000 fc (6.48×10^4 lm/m^2) at the highlight areas and 1000 fc (1.08×10^4 lm/m^2) in the shadow areas, the ratio is 6/1. The shadow areas should be illuminated to give a reading of at least 2000 and preferably 3000 fc to bring the lighting ratio within the permissible range.

10.1.2c Reciprocity Characteristics

Reciprocity refers to the relationship between light intensity (illuminance) and exposure time with respect to the total amount of exposure received by the film. According to the reciprocity law, the amount of exposure H received by the film equals the illuminance E of the light striking the film multiplied by the exposure time t. In practice, any film has its maximum sensitivity at a particular exposure (i.e., normal exposure at the film's rated exposure index). This sensitivity varies with the exposure time and illumination level. This variation is called the *reciprocity effect.* Within a reasonable range of illumination levels and exposure times, the film produces a good image. At extreme illumination levels or exposure times, the effective sensitivity of the film is lowered, so that predicted increases in exposure time to compensate for low illumination or increases in illumination to compensate for short exposure time fail to produce adequate exposure. This condition is called *reciprocity-law failure* because the reciprocity law fails to describe the film sensitivity at very fast and very slow exposures. The reciprocity law usually applies quite well for exposure times of 1/5 to 1/1000 for black-and-white films. Above and below these speeds, black-and-white films are subject to reciprocity failure, but their wide exposure latitude usually compensates for the effective loss of film speed. When the law does not hold, the symptoms are underexposure and change in contrast. For color films, the photographer must compensate for both film speed and color-balance changes because the speed change may be different for each of the three emulsion layers. However, contrast changes cannot be compensated for and contrast mismatch can occur.

10.1.2d Filter Factor

Because a filter absorbs part of the light that would otherwise fall on the film, the exposure must be increased when a filter is used. The *filter factor* is the multiple by which an exposure is increased for a specific filter with a particular film. This factor depends principally upon the absorption characteristics of the filter, the spectral sensitivity of the film emulsion, and the spec-

Table 10.1.1 Conversions of Filter Factors to Exposure Increase in Stops

Filter Factor	+ Stops	Filter Factor	+ Stops	Filter Factor	+ Stops
1.25	+ 1/3	4	+ 2	12	+ 3-2/3
1.5	+ 2/3	5	+ 2-1/3	40	+ 5-1/3
2	+ 1	6	+ 2-2/3	100	+ 6-2/3
2.5	+ 1-1/3	8	+ 3	1000	+ 10
3	+ 1-2/3	10	+ 3-1/3		

tral composition of the light falling on the subject. Table 10.1.1 shows conversions of filter factors to exposure increase in stops.

10.1.3 Sensitometry

Sensitometry is the science of measuring the response of photographic emulsions to light. *Image structure* refers to the properties that determine how well the film can faithfully record detail. The appearance and utility of a photographic record are closely associated with the sensitometric and image-structure characteristics of the film used to make that record. The ways in which a film is exposed, processed, and viewed affect the degree to which the film's sensitometric and image-structure potential is realized. The age of unexposed film and the conditions under which it was stored also affect the sensitivity of the emulsion. Indeed, measurements of film characteristics made by particular processors using particular equipment and those reported on data sheets may differ slightly. Still, the information on the data sheet provides a useful basis for comparing films. When cinematographers need a high degree of control over the outcome, they should have the laboratory test the film they have chosen under conditions that match as nearly as possible those expected in practice.

10.1.3a Sensitometric Information

Transmission density D is a measure of the light-controlling power of the silver or dye deposit in a film emulsion. In color films, the density of the cyan dye represents its controlling power to red light, that of magenta dye to green light, and that of yellow dye to blue light. Transmission density may be mathematically defined as the common logarithm (log base 10) of the ratio of the light incident on processed film (P_o) to the light transmitted by the film (P_1):

$$D = \log \frac{P_o}{P_1} \tag{10.1.1}$$

The measured value of the density depends on the spectra1 distribution of the exposing light, the spectral absorption of the film image, and the spectral sensitivity of the receptor. When the spectral sensitivity of the receptor approximates that of the human eye, the density is called

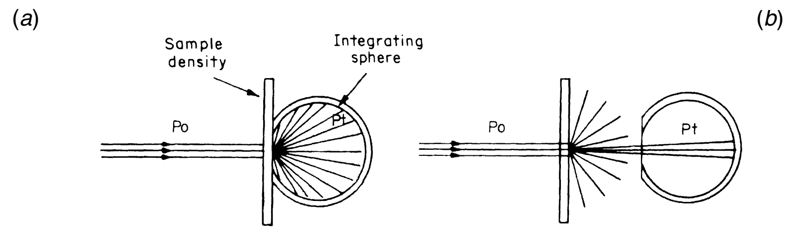

Figure 10.1.1.Transmission density measurement: (*a*) totally diffuse density measurement, (*b*) specular density measurement. (*Courtesy of Eastman Kodak Company.*)

visual density. When it approximates that of a duplicating or print stock, the condition is called *printing density.*

For practical purposes, *transmission density* is measured in two ways:

- *Total diffuse density* (Figure 10.1.1*a*) is determined by comparing all the transmitted light with the incident light perpendicular to the film plane ("normal" incidence). The receptor is placed so that all the transmitted light is collected and evaluated equally. This setup is analogous to the contact printer except that the "receptor" in the printer is film.
- *Specular density* (Figure 10.1.1*b*) is determined by comparing only the transmitted light that is perpendicular ("normal") to the film plane with the "normal" incident light, analogous to optical printing or projection.

To simulate actual conditions of film use, totally diffuse density readings are routinely used when motion-picture films are to be contact-printed onto positive print stock. Specular density readings are appropriate when a film is to be optically printed or directly projected. However, totally diffuse density measurements are accepted in the trade for routine control in both contact and optical printing of color films. Totally diffuse density and specular density are almost equivalent for color films because the scattering effect of the dyes is slight, unlike the effect of silver in black-and-white emulsions.

A *characteristic curve* is a graph of the relationship between the amount of exposure given a film and its corresponding density after processing. The density values that produce the curve are measured on a film test strip that is exposed in a sensitometer under carefully controlled conditions and processed under equally controlled conditions. When a particular application requires precise information about the reactions of an emulsion to unusual light—filming action in a parking lot illuminated by sodium vapor lights, for example—the exposing light in the sensitometer can be filtered to simulate that to which the film will actually be exposed. A specially constructed step tablet consisting of a strip of film or glass containing a graduated series of neutral densities differing by a constant factor is placed on the surface of the test strip to control the amount of exposure, the exposure time being held constant. The resulting range of densities in the test strip simulates most picture-taking situations in which an object modulates the light over a wide range of illuminance, causing a range of exposures (different densities) on the film.

After processing, the graduated densities on the processed test strip are measured with a densitometer. The amount of exposure (measured in lux[1]) received by each step on the test strip is multiplied by the exposure time (measured in seconds) to produce exposure values in units of

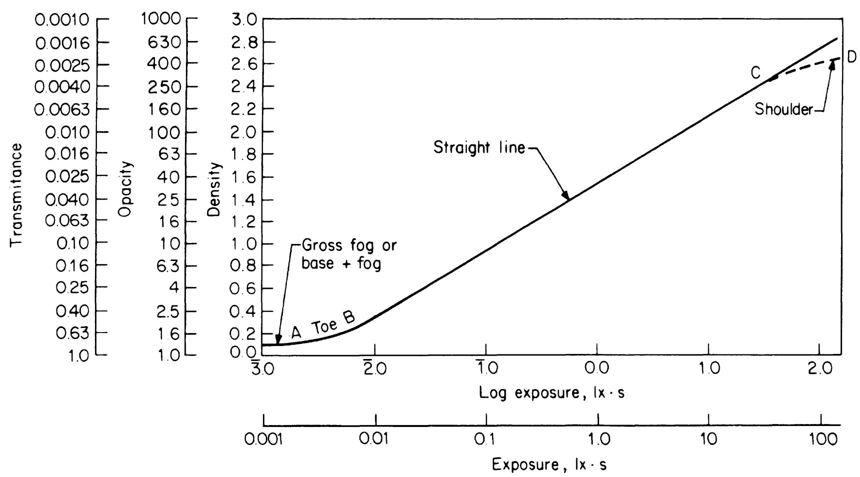

Figure 10.1.2 Typical sensitometric, or Hurter and Driffield (HD), characteristic curve. (*Courtesy of Eastman Kodak Company.*)

lux-seconds. The logarithms (base 10) of the exposure values (log H) are plotted on the horizontal scale of the graph, and the corresponding densities are plotted on the vertical scale to produce the characteristic curve. This curve is also known as the *sensitometric curve*, the D log H (or E) curve, or the HD (Hurter and Driffield) curve.

In Figure 10.1.2 the lux-second values are shown below the log exposure values. The equivalent transmittance and opacity values are shown to the left of the density values.

The characteristic curve for a test film exposed and processed as described here is an absolute or real characteristic curve of a particular film processed in a particular manner. Sometimes it is necessary to establish that the values produced by one densitometer are comparable with those produced by another. *Status densitometry* is used for this purpose.

Status densitornetry refers to measurements made on a densitometer that conforms to a specified unfiltered spectral response. When a set of carefully matched filters is used with a densitometer, the term *status A* densitometry is used. The densities of color-positive materials (reversal, duplicating, and print) are measured by status A densitometry. When a different set of carefully matched filters is incorporated in the densitometer, the term *status M* densitometry is used. The densities of color preprint films (color negative, internegative, intermediate, low-contrast reversal original, and reversal intermediate) are measured by status M densitometry.

Representative characteristic curves are those that are typical of a product and are made by averaging the results from a number of tests made on a number of production batches of film. The curves shown in the data sheets are representative curves.

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1. Illumination of 1 lx (=1 lm/m^2) is produced by 1 standard candle from a distance of 1 m. When a film is exposed for 1 s to a standard candle 1 m distant, it receives 1 lx s of exposure.

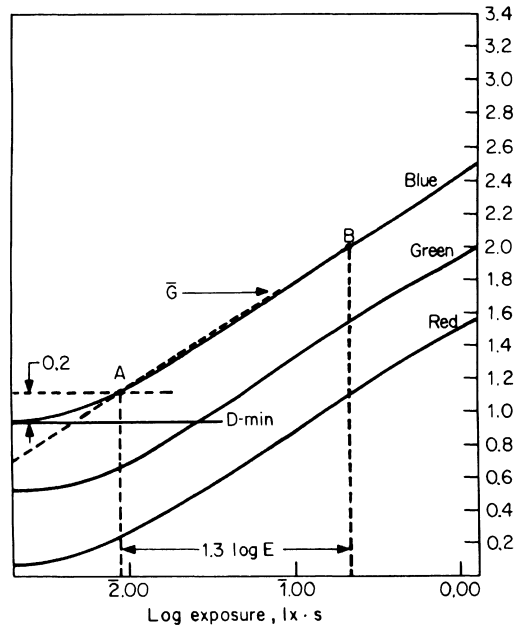

Figure 10.1.3 Typical characteristic curve of negative color film. (*Courtesy of Eastman Kodak Company.*)

Relative characteristic curves are formed by plotting the densities of the test film against the densities of a specific uncalibrated sensitometric step scale used to produce the test film. These are commonly used in laboratories as process control tools.

Black-and-white films usually have one characteristic curve. A color film, on the other hand, has three characteristic curves, one each for the red-modulating (cyan-colored) dye layer, the green-modulating (magenta-colored) dye layer, and the blue-modulating (yellow-colored) dye layer (see Figures 10.1.3 and 10.1.4). Because reversal films yield a positive image after processing, their characteristic curves are inverse to those of negative films.

10.1.3b General Curve Regions

Regardless of film type, all characteristic curves are composed of five regions: D-min, the toe, the straight-line portion, the shoulder, and D-max.

Exposures less than at *A* on negative film or greater than at *A* on reversal film will not be recorded as changes in density. This constant density area of a black-and-white film curve is called *base plus fog.* In a color film, it is termed *mini mum density* or D-min.

The toe (*A* to *B,* Figure 10.1.2) is the portion of the characteristic curve where the slope (or gradient) increases gradually with constant changes in exposure (log *H*). The straight line (*B* to *C*) is the portion of the curve where the slope does not change; the density change for a given log-exposure change remains constant or linear. For optimum results, all significant picture information is placed on the straight-line portion. The shoulder (*C* to *D*) is the portion of the

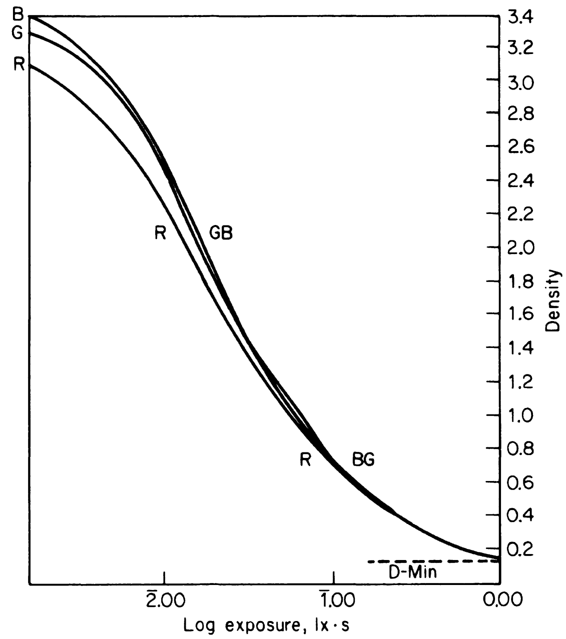

Figure 10.1.4 Typical characteristic curve of positive color film. (*Courtesy of Eastman Kodak Company.*)

curve where the slope decreases. Further changes in exposure (log *H*) will produce no increase in density because the maximum density (D-max) of the film has been reached.

Base density is the density of fixed-out (all silver removed) negative-positive film that is unexposed and undeveloped. Net densities produced by exposure and development are measured from the base density. For reversal films, the analogous term of D-min describes the area receiving total exposure and complete processing. The resulting density is that of the film base with any residual dyes.

Fog refers to the net density produced during development of negative-positive films in areas that have had no exposure. Fog caused by development may be increased with extended development time or increased developer temperatures. The type of developing agent and the pH value of the developer can also affect the degree of fog. The net fog value for a given development time is obtained by subtracting the base density from the density of the unexposed but processed film. When such values are determined for a series of development times, a time-fog curve (Figure 10.1.5) showing the rate of fog growth with development can be plotted.

10.1.3c Curve Values

From the characteristic curve, additional values can be derived that not only illustrate properties of the film but also aid in predicting results and solving problems that may occur during picture-taking or during the developing and printing processes.

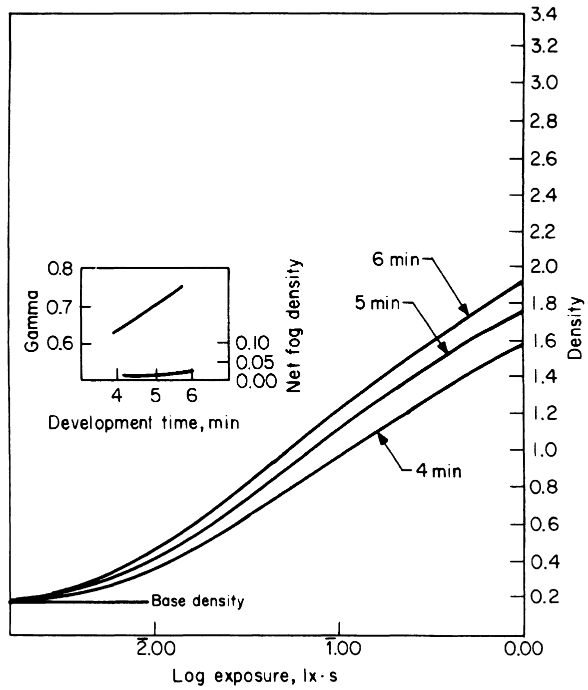

Figure 10.1.5 Curves for a development-time series on a typical black-and-white negative film. (*Courtesy of Eastman Kodak Company.*)

Speed describes the inherent sensitivity of an emulsion to light under specified conditions of exposure and development. The speed of a film is represented by a number derived from the film's characteristic curve.

Contrast refers to the separation of lightness and darkness (called *tones*) in a film or print and is broadly represented by the slope of the characteristic curve. Adjectives such as *flat* or *soft* and *contrasty* or *hard* are often used to describe contrast. In general, the steeper the slope of the characteristic curve, the higher the contrast. The terms *gamma* and *average gradient* refer to numerical means for indicating the contrast of the photographic image.

Gamma is the slope of the straight-line portion of the characteristic curve or the tangent of the angle α formed by the straight line with the horizontal. In Figure 10.1.6 the tangent of the angle α is obtained by dividing the density increase by the log exposure change. The resulting numerical value is referred to as gamma.

Gamma does not describe contrast characteristics of the toe or the shoulder. Camera negative films record some parts of scenes, such as shadow areas, on the toe portion of the characteristic curve. Gamma does not account for this aspect of contrast.

Average gradient is the slope of the line connecting two points bordering a specified log-exposure interval on the characteristic curve. The location of the two points includes portions of the curve beyond the straight-line portion. Thus, the average gradient can describe contrast characteristics in areas of the scene not rendered on the straight-line portion of the curve. Measurement of an average gradient extending beyond the straight-line portion is shown in Figure 10.1.7.

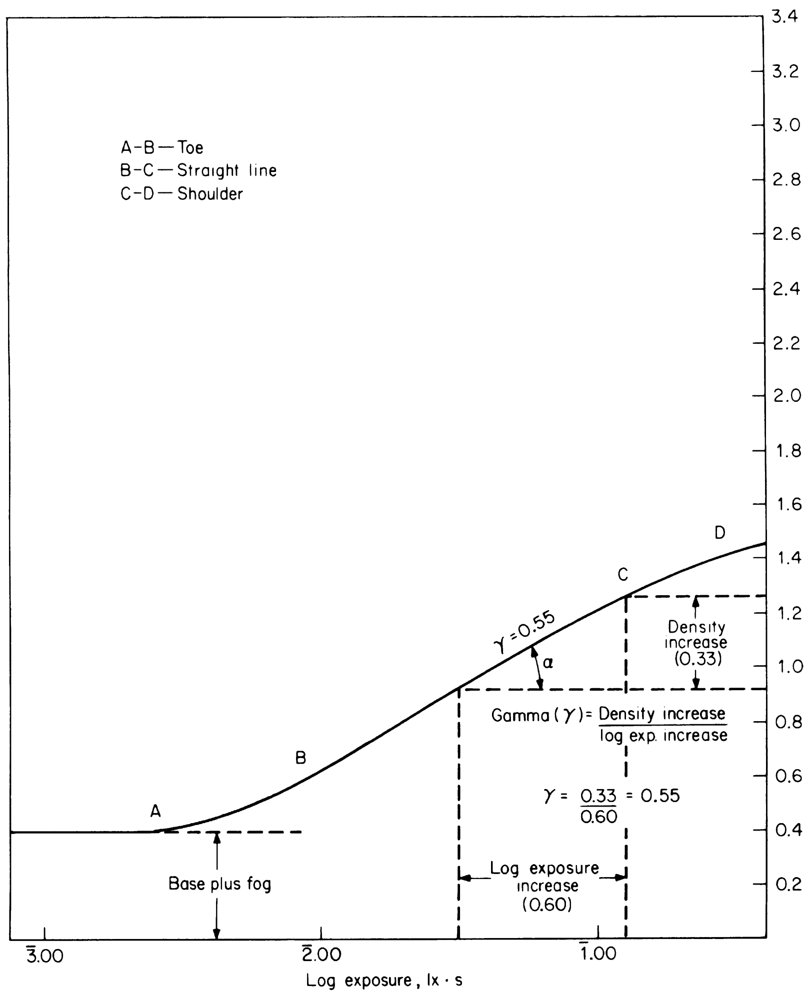

Figure 10.1.6 Gamma characteristic. (*Courtesy of Eastman Kodak Company.*)

10.1.4 Image Structure

The sharpness of image detail that a particular film type can produce cannot be measured by a single test or expressed by one number. For example, resolving-power test data give a reasonably good indication of image quality. However, because these values describe the maximum resolving power a photographic system or component is capable of, they do not indicate the capacity of the system (or component) to reproduce detail at other levels. For more complete analyses of detail quality, other evaluating methods, such as the *modulation-transfer function* and *film granularity*, are often used. An examination of the modulation-transfer curve, rms granularity, and

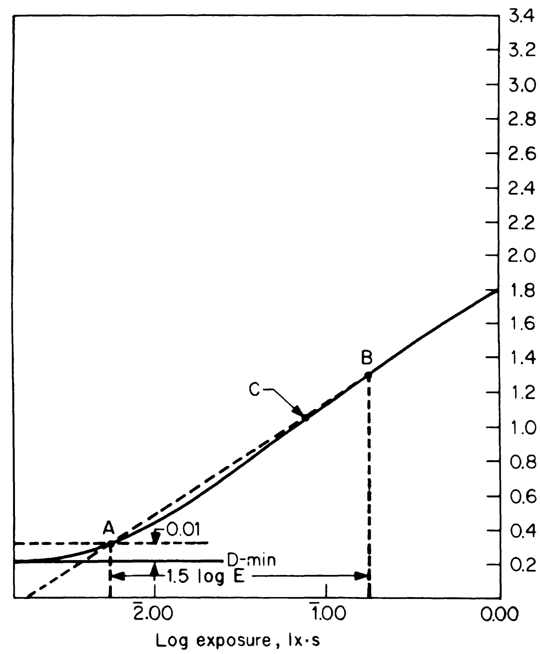

Figure 10.1.7 Average gradient determination. (*Courtesy of Eastman Kodak Company.*)

both the high- and low-contrast resolving power listings will provide a good basis for comparison of the detail-imaging qualities of different films.

10.1.4a Modulation Transfer Curve

Modulation transfer relates to the ability of a film to reproduce images of different sizes. The modulation-transfer curve describes a film's capacity to reproduce the complex spatial frequencies of detail in an object. In physical terms, the measurements evaluate the effect on the image of light diffusion within the emulsion. First, film is exposed under carefully controlled conditions to a series of special test patterns. After development, the image is scanned in a microdensitometer to produce a trace. The resulting measurements show the degree of loss in image contrast at increasingly higher frequencies as the detail becomes finer. These losses in contrast are compared mathematically with the contrast of the portion of the image unaffected by detail size. The rate of change or modulation M of each pattern can be expressed by the following formula in which E represents exposure

$$M = \frac{E_{max} - E_{min}}{E_{max} + E_{min}} \tag{10.1.2}$$

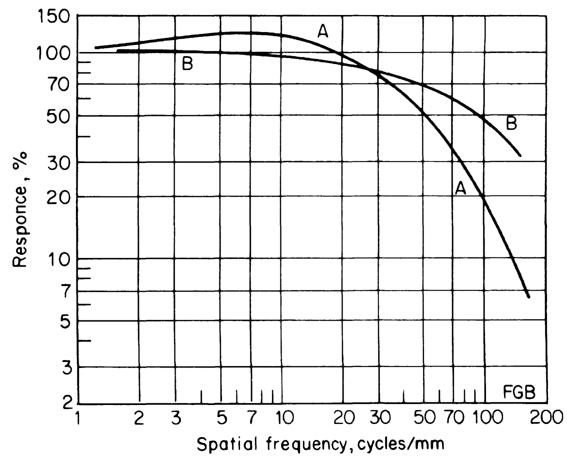

Figure 10.1.8 Modulation transfer curves. (*Courtesy of Eastman Kodak Company.*)

When the microdensitometer scans the test film, the densities of the trace are interpreted in terms of exposure, and the effective modulation of the image (*M*) is calculated. The modulation transfer factor is the ratio of the modulation of the developed image to the modulation of the exposing pattern (M_o), or M_i / M_o. This ratio is plotted on the vertical axis (logarithmic scale) as a percentage of response. The spatial frequency of the patterns is plotted on the horizontal axis as cycles per millimeter. Figure 10.1.8 shows two such curves. At lower magnifications, the test film represented by curve *A* appears sharper than that represented by curve *B*; at very high magnifications, the test film represented by curve *B* appears sharper.

10.1.4b Understanding Graininess and Granularity

The terms *graininess* and *granularity* are often confused or even used as synonyms in discussions of silver or dye-deposit distributions in photographic emulsions. The two terms refer to two distinctly different ways of evaluating the image structure. When a photographic image is viewed with sufficient magnification, the viewer experiences the visual sensation of graininess, a subjective impression of nonuniformity in an image. This nonuniformity in the image structure can also be measured objectively with a microdensitometer. This objective evaluation measures film granularity.

Motion-picture films consist of silver halide crystals dispersed in gelatin (the emulsion) that is coated in thin layers on a support (the film base). The exposure and development of these crystals forms the photographic image, which is, at some stage, made up of discrete particles of silver. In color processes, where the silver is removed after development, the dyes form dye clouds centered on the sites of the developed silver crystals. The crystals vary in size, shape, and sensitivity, and generally are randomly distributed within the emulsion. Within an area of uniform exposure, some of the crystals will be made developable by exposure; others will not.

The location of these crystals is also random. Development usually does not change the position of a grain, and so the image of a uniformly exposed area is the result of a random distribution of either opaque silver particles (black-and-white film) or dye clouds (cloud film) separated by transparent gelatin. Although the viewer sees a granular pattern, the eye is not necessarily seeing the individual silver particles, which range from about 0.002 mm down to about a tenth of that size. At magnifications where the eye cannot distinguish individual particles, it resolves random groupings of these particles into denser and less dense areas. As magnification decreases, the observer progressively associates larger groups of spots as new units of graininess. The size of these compounded groups becomes larger as the magnification decreases, but the amplitude (the difference in density between the darker and lighter areas) decreases. At still lower magnifications, the graininess disappears altogether because no granular structure can be detected visually.

10.1.5 Film Systems

Negative film produces an image that must be printed on another stock for final viewing. Because least one intermediate stage is usually produced to protect the original footage, negative camera film is an efficient choice when significant editing and special effects are planned. Printing techniques for negative-positive film systems are very sophisticated and highly flexible; hence, negative film is especially appropriate for complex special effects. All negative films can go through several print "generations" without pronounced contrast buildup.

Reversal film produces a positive image after processing. With certain exceptions, reversal camera films are designed to be projected after processing. Because processing can be the only intermediate step between the camera film and the projection print, reversal film is a good choice for an absolutely accurate record without intervening duplication stages. Additional prints can be made by direct printing onto reversal print films. If more than two or three prints are needed, an internegative is usually made from *flashed* (a reduction in contrast by an overall flash exposure before development) and processed camera film and used to print onto positive print stocks for optimum economy and protection of the original.

Color-reversal films are balanced for projection at 5400 K, which is suitable for both television broadcast and conventional motion-picture projection. These films can be exposed at effective film speeds ranging from one-half to two times the normal exposure indices (one-half to one stop) with little loss in quality. When some loss in quality is acceptable, the effective film speed can be increased by two full lens stops.

10.1.5a Laboratory and Print Films

The filmmaker can maximize the effectiveness of the camera films he or she chooses by understanding the laboratory techniques through which camera film is transformed into the finished production. While films have been categorized as *laboratory films* or *release print film*, in actual practice both are used in the laboratory and in the production of finished screen versions derived from camera originals.

While reversal camera film original can be the finished production, it is rarely used this way if prints are desired. Usually a work print is made and editing worked out and tested before the original is cut. The original material is then cut and assembled to conform to the work print and used to produce internegatives or reversal release prints. Negative film requires printing for both editing and final use. Master positives and duplicate negatives are generally produced to generate optical effects and to protect the camera original from damage during printing operations when a large number of release prints are being produced. A color reversal intermediate is a means of obtaining a duplicate negative without going through a master positive stage.

10.1.5b Color Balance

Color balance relates to the color of a light source that a color film is designed to record without additional filtration. All laboratory and print films are balanced for the tungsten light sources used in printers, while camera films are nominally balanced for 5500-K daylight, 3200-K tungsten, or 3400-K tungsten exposure.

When filming is done under light sources different from those recommended, filters over the camera lens or over the light source is required. Camera film data sheets contain starting-point filter recommendations for the most common lighting sources.

10.1.6 Film Characteristics

The term *color sensitivity* describes the portion of the visual spectrum to which the film is sensitive (Figure 10.1.9). All black-and-white camera films are panchromatic (sensitive to the entire visible spectrum). Some films, called *orthochromatic,* are sensitive mainly to the blue-and-green portions of the visible spectrum. Films used exclusively to receive images from black-and-white materials are blue-sensitive. Some films are sensitive to blue light and ultraviolet radiation. The extended sensitivity in the ultraviolet region of the spectrum permits the film to respond to the output of cathode-ray tubes.

While color films and panchromatic black-and-white films are sensitive to all wavelengths of visible light, rarely are two films equally sensitive to all wavelengths. Spectral sensitivity describes the relative sensitivity of the emulsion to the spectrum within the film's sensitivity range. The photographic emulsion has inherently the sensitivity of photosensitive silver halide crystals. These crystals are sensitive to high-energy radiation, such as X rays, gamma rays, ultraviolet radiation, and blue-light wavelengths (blue-sensitive black-and-white films). In conventional photographic emulsions, sensitivity is limited at the short-wavelength (ultraviolet) end to about 250 nm because the gelatin used in the photographic emulsion absorbs considerable ultraviolet radiation. The sensitivity of an emulsion to the longer wavelengths can be extended by the addition of suitably chosen dyes. By this means, the emulsion can be made sensitive through the green region (orthochromatic black-and-white films), through the green and red regions (color and panchromatic black-and-white films), and into the near-infrared region of the spectrum (infrared-sensitive film).

In Figure 10.1.10, three spectral sensitivity curves are shown for color films—one each for the red-sensitive (cyan-dye forming), the green-sensitive (magenta-dye forming), and the blue-sensitive (yellow-dye forming) emulsion layers. One curve is shown for black-and-white films. The data are derived by exposing the film to calibrated bands of radiation 10 nm wide throughout the spectrum, and the sensitivity is expressed as the reciprocal of the exposure (ergs/cm^2) required to produce a specified density. The radiation expressed in nanometers is plotted on the horizontal axis, and the logarithm of sensitivity is plotted on the vertical axis to produce the spectral sensitivity curves shown.

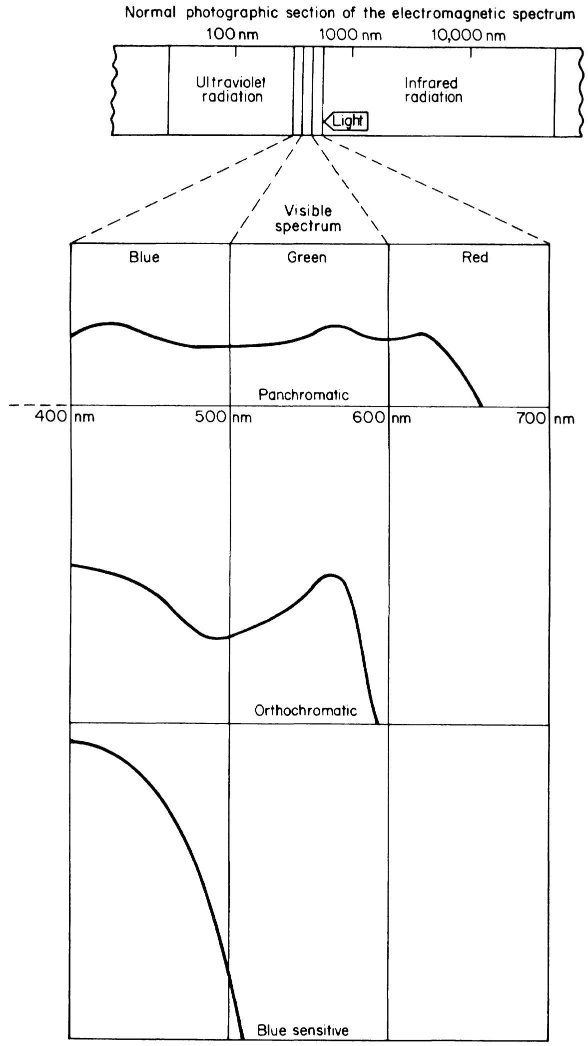

Figure 10.1.9 Film sensitivities. (*Courtesy of Eastman Kodak Company.*)

10.1.6a Equivalent Neutral Density

When the amounts of the components of an image are expressed in the unit *equivalent neutral density*, each of the density figures tells how dense a gray that component *can* form. Because each emulsion layer of a color film has its own speed and contrast characteristics, equivalent neutral density (END) is derived as a standard basis for comparison of densities represented by the spectral sensitivity curve. For color films, the standard density used to specify spectral sensitivity is as follows. For reversal films, END = 1.0; for negative films, direct duplicating, and print films, END = 1.0 above D-min.

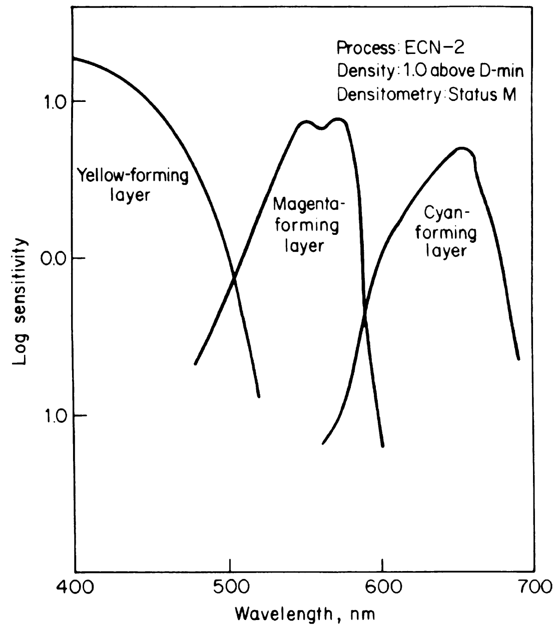

Figure 10.1.10 Typical color film spectral sensitivity curves. (*Courtesy of Eastman Kodak Company.*)

10.1.6b Spectral Dye-Density Curves

Processing exposed color film produces cyan, magenta, and yellow dye images in the three separate layers of the film. The spectral dye-density curves (illustrated in Figure 10.1.11) indicate the total absorption by each color dye measured at a particular wavelength of light and the visual neutral density (at 1.0) of the combined layers measured at the same wavelengths.

Spectral dye-density curves for reversal and print films represent dyes normalized to form a visual neutral density of 1.0 for a specified viewing and measuring illuminant. Films that are generally viewed by projection are measured with light having a color temperature of 5400 K. Color-masked films have a curve that represents typical dye densities for a midscale neutral subject.

The wavelengths of light, expressed in nanometers, are plotted on the horizontal axis, and the corresponding diffuse spectral densities are plotted on the vertical axis. Ideally, a color dye should absorb only in its own region of the spectrum. All color dyes in use absorb some wavelengths in other regions of the spectrum. This unwanted absorption, which could prevent satisfactory color reproduction when the dyes are printed, is corrected in the film's manufacture.

In color negative films, some of the dye-forming couplers incorporated in the emulsion layers at the time of manufacture are colored and are evident in the D-min of the film after development. These residual couplers provide automatic masking to compensate for the effects of unwanted dye absorption when the negative is printed. This explains why negative color films look orange.

Because color reversal films and print films are usually designed for direct projection, the dye-forming couplers must be colorless. In this case, the couplers are selected to produce dyes

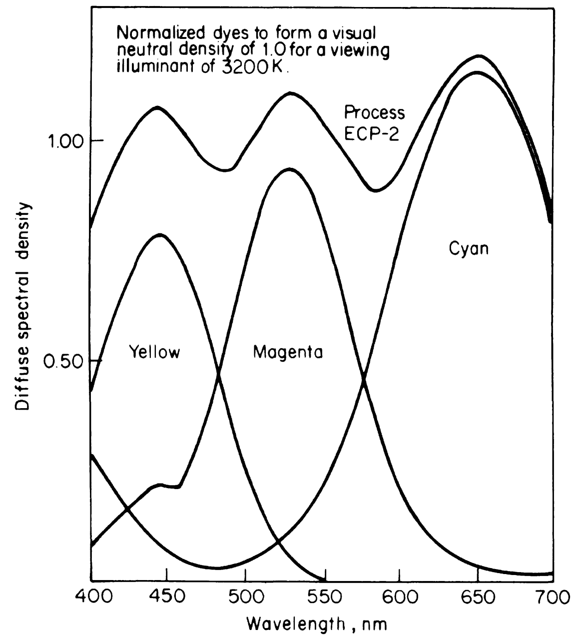

Figure 10.1.11 Typical spectral dye-density curves.

that will, as closely as possible, absorb in only their respective regions of the spectrum. If these films are printed, they require no printing mask.

10.1.7 Bibliography

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