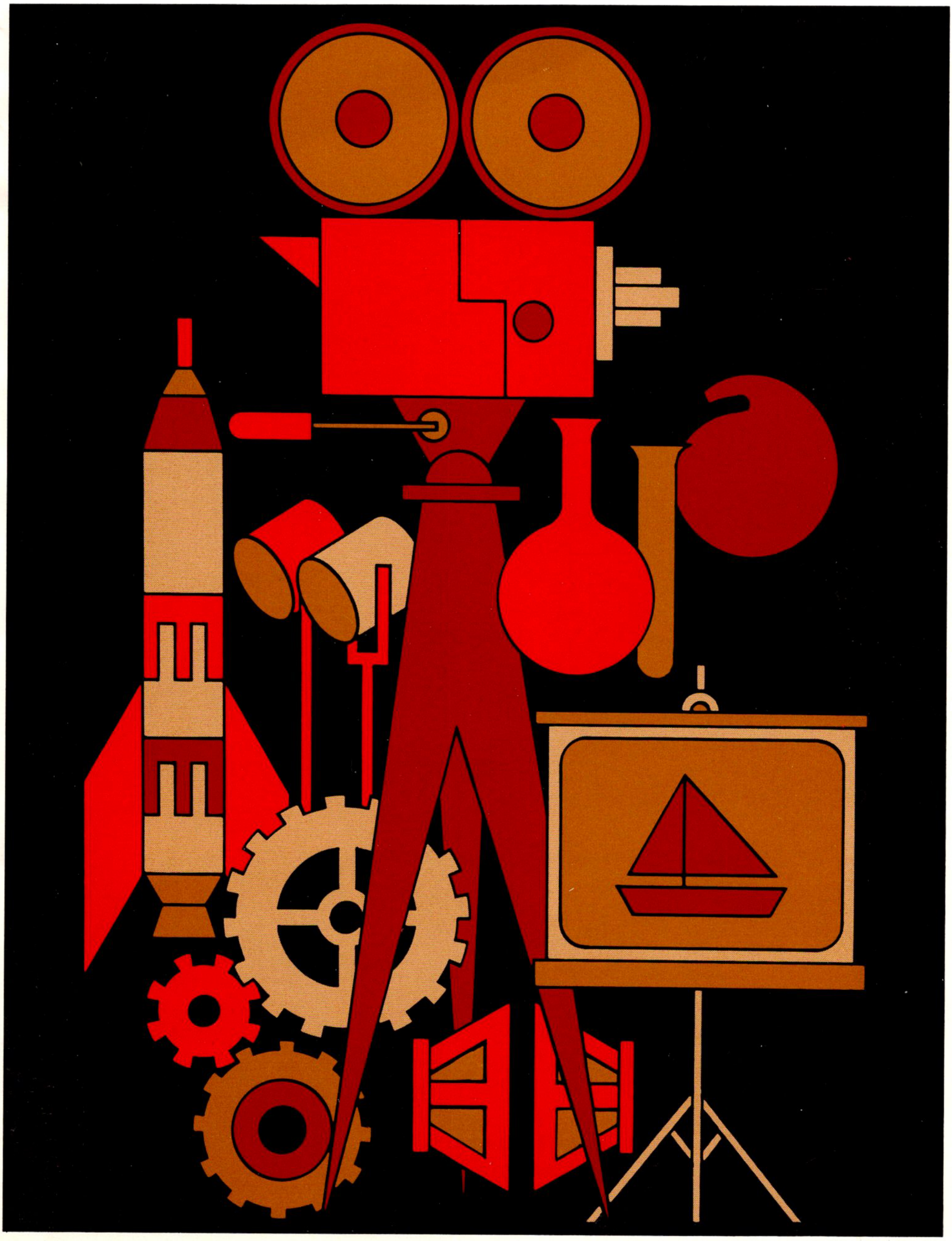
$1.25

# EASTMAN KODAK
## MOTION PICTURE FILMS
### FOR PROFESSIONAL USE



# EASTMAN KODAK
## MOTION PICTURE FILMS
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This book is designed to help you understand the characteristics of motion picture films and some aspects of film handling. We hope the information offered here will make it easier for you to choose the film best suited to a particular application and to obtain the best results from the film you have selected.

In this Fourth Edition we present an up-to-date discussion of physical and photographic properties of motion picture films, including a brief explanation of the new measure of image-forming ability called "modulation-transfer function." A section on processing gives the formulas for the latest processing solutions recommended for Eastman Kodak black-and-white motion picture films and includes information on viscous-layer processing. Other sections deal with filters and the storage of films.

Detailed technical data for individual films are given in the data sheets that are available on request.* This arrangement allows easy insertion of new or revised sheets as they become available.

*The price of this book includes your choice of film data sheets. See the request form in the center of the book.

# Contents





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# Emulsion Characteristics

## SENSITOMETRIC PROPERTIES

Most image-recording properties of a photographic emulsion can be evaluated by means of sensitometry, the science of measuring the response of an emulsion to light. The following discussion of basic principles and procedures is presented in terms of sensitometry as applied to black-and-white materials, but much of it applies also to color materials. Many standard photographic textbooks offer more detailed information on sensitometry of black-and-white films. For an excellent discussion of color sensitometry, see the book *Principles of Color Sensitometry,* available from the Society of Motion Picture and Television Engineers, 9 East 41st Street, New York, New York 10017.

### The Characteristic Curve

In a *sensitometer,* the film is subjected to a series of reproducible exposures to light of the proper intensity and color quality, each exposure increased by a constant factor over the preceding one. The film is processed under carefully standardized conditions and the optical density is determined with a *densitometer.* Characteristic curves, or D-log E curves, are obtained by plotting the known exposure values on a logarithmic horizontal scale and the corresponding density readings on the vertical scale. Interpretation of these curves gives the required sensitometric data.

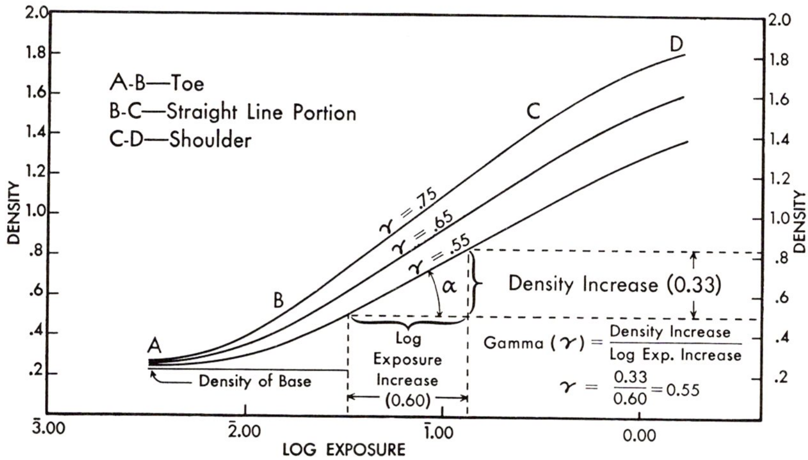
The characteristic curve can be divided into three regions (see illustration):

**Toe.** This is the portion of the curve from *A* to *B,* where the slope, or gradient, increases with increasing exposure. For exposures less than that at *A,* no image density is produced on the film. At *A,* and for greater exposures, densities greater than fog result, and exposure differences are reproduced as density differences.

**Straight-Line Portion.** From *B* to *C,* the density change for a given log-exposure change remains constant; that is, the relationship between density and the logarithm of the exposure is linear.

**Shoulder.** On the portion of the curve above *C,* the gradient decreases with further increases in exposure. Eventually, the curve becomes horizontal and no longer records exposure differences as density differences. The shape of the shoulder region is often an important consideration in selecting a film for certain applications.

Reversal-type films, which yield a positive image directly through normal exposure and reversal processing, have a characteristic curve




Typical characteristic curves.

that is the inverse of the ones shown above. With such films, an increase in camera exposure results in a decrease in density.

In order to provide meaningful data for multilayer color films, it is the usual practice to derive a set of three sensitometric curves, each indicating the rate of change of density to red, green, or blue light for a given increment in log exposure. With one method the film is exposed in a sensitometer in which the color quality of the illumination is adjusted to yield a neutral scale in the processed film. The densities of this scale are then determined, using red, green, and blue filters separately in the densitometer. Another method involves separate exposures to red, green, and blue light in the sensitometer and the measuring of the resulting dye scales in the processed film with appropriate filters used in the densitometer.

### Time-Scale vs Intensity-Scale Exposures

In the early days of photography, it was thought that the effect of exposure on a photographic material could be expressed as the product of illumination and time by the simple equation:

$$E = I \times t$$

It was soon found that this relationship, often referred to as the "reciprocity law," holds only over a limited range, and departures may be considerable for different light-intensity levels. Thus, an exposure produced by a very intense light source operating for a short time would not be equivalent to an exposure produced by a light source of very low intensity operating for a longer time, even though the products of illumination and time were equivalent in each case.

Because of this failure of the reciprocity law, the results obtained when photographic materials are exposed for a series of times at a constant intensity level will usually differ from those obtained under conditions of constant time and variable intensity level. The intensity-scale type of sensitometer is considered preferable to a time-scale instrument because it gives exposures that are most nearly like those given to a film in actual use, such as in a camera, printer, or recorder. *Even with an intensity-scale instrument, however, care must be taken to see that the intensity level and exposure time are comparable to those occurring in practical use of the film, if sensitometric results are to be correlated with picture- or sound-quality judgments.* For processing-control purposes, such correlation is not always required and some compromises can be permitted.

### Published Sensitometric Curves

Sensitometric curves given in the specification sheets for EASTMAN KODAK Motion Picture Films are based on averages for normal, seasoned products. Although they do not correspond precisely to those obtained in any particular commercial laboratory, they furnish a reliable guide to comparative characteristics because the conditions of exposure, development, and density measurement have been standardized throughout.

The characteristic and time-gamma curves are representative of the results that will be obtained from control samples exposed on a non-intermittent intensity-scale sensitometer. For EASTMAN Fine Grain Sound Recording Films, Types 5373 and 5375, additional curves have been provided that more nearly represent the results obtained in a sound recorder.

Sensitometric data published in the specification sheets have been determined from film strips processed in appropriate solutions, such as KODAK Developer D-96 for negative materials and D-97 for positive materials. Formulas for these solutions are in the section "Formulas for Black-and-White Processing." For reversal films, the formulas recommended for use in the popular types of commercial reversal-processing machines have been adopted.

The densities of the processed strips are expressed in terms of USA Standard Diffuse Density.* Because some commercially available densitometers yield measurements that are not strictly in accord with this standard, density readings and the resulting curves obtained with these instruments may differ somewhat from those given in the specification sheets.

Sensitometric curves are not included in specification sheets for

**USA Standard Method of Determining Transmission Density of Motion-Picture Films*, PH22.27-1960 (including PH2.19-1959).

color films because differences in the measuring instruments can lead to radically different data and curve shapes. For this reason, it is important that each laboratory determine such curves with its own equipment.

### Interpretation of the Characteristic Curve

Certain numbers that can be derived from the characteristic curve can be useful in predicting results and solving problems in exposure and processing. Some of these numbers and their uses are described in the following paragraphs.

**Gamma** serves as a measure of the extent of development. It is defined as the slope of the straight-line portion of the characteristic curve, or the tangent of the angle that the straight-line portion forms with the horizontal. Since the tangent of this angle ($a$ in the illustration on page 3) is equal to the density increase divided by the log exposure increase that produced it, the numerical value of gamma can easily be calculated. If characteristic curves are determined for a series of development times and the gamma of each curve is plotted against the time of development, a curve showing the rate of growth of gamma with development is obtained. This time-gamma curve can be used to find the developing time which will produce any desired gamma value.

The particular gamma to which a film is developed depends on the type of material and its application. Suggested control gamma values, where significant, are given on the specification sheets. Gamma, by itself, does not define the contrast of a picture negative or print. It is only one of many factors contributing to the subjective contrast of a given type of reproduction.

**Average gradient** is defined as the slope of the line connecting two points that embrace a specified log exposure interval on the curve.

**Fog** is the slight density produced on the film during development, even in areas that have had no exposure. The net fog value for a given development time is obtained by subtracting the total density of the base and fixed-out emulsion from the density of the unexposed but processed film. When such values are determined for a series of development times, a time-fog curve, showing the rate of growth of fog with development, can be plotted. If modern films are handled properly, fog levels seldom become objectionable.

**Speed** is a number derived from the characteristic curve to describe the inherent sensitivity of an emulsion under specified conditions of exposure and development. It is usually defined as the reciprocal of the exposure required to produce a specific result, such as a fixed density value or a fixed gradient.

At the present time there is no USA Standard covering the measurement of the speed of camera films or other types of materials used in motion-picture work.

**Exposure index** is a number which can be used with photoelectric exposure meters to help obtain correct exposure. This number varies with the sensitivity and latitude of the emulsion, its development, its intended field of use, and the spectral quality of the light that illuminates the subject. In order to insure good results under a variety of conditions, the exposure index includes a safety factor whenever it is permitted by the latitude of the film and the requirements of the reproduction process.

The exposure-index values given in the specification sheets for EASTMAN KODAK Motion Picture Films have been determined on the basis of practical picture tests. Suitable safety factors have been included to allow for differences in equipment, variations in technique, and other conditions. These index values are intended only as starting points from which the actual working values can be determined for the particular equipment, methods of use, and working conditions.

## EXPOSURE TABLES FOR INCIDENT-LIGHT MEASUREMENTS

Under circumstances where the illumination is very low or where reflected-light measurements cannot be made conveniently, it is possible to use certain meters to read the illumination (incident light) directly in foot-candles. For readings made in this way, it is convenient to refer to a table that gives the correct aperture setting for a camera speed and foot-candle reading. Tables for use with tungsten light are included in the specification sheets for those films where such information would be of use. The values given in the tables refer to measurements made with the meter held at the subject position and pointed directly toward the camera. It is essential that the meter be calibrated to read the illumination in foot-candles.

## SPECTRAL SENSITIVITY

The spectral sensitivity of an emulsion is the measure of its response to light of various colors. Sensitivity is defined as the reciprocal of the exposure (expressed in ergs per square centimeter) that is required to produce a specified density. The spectral sensitivity of a photographic material can be expressed by a *spectral-sensitivity curve*. To make such a curve, the material is given a series of exposures to isolated narrow sections of the spectrum. It is then given the development that would produce the desired gamma in normal practice. The logarithm of sensitivity is plotted against wavelength for each exposure, producing the spectral-sensitivity curve.

## IMAGE STRUCTURE

### Graininess and Granularity

When an individual frame of a motion-picture negative or print is greatly enlarged and viewed directly or by projection on a screen, the image may be seen to possess a grainy or granular structure that is most noticeable in areas of uniform density. This impression of nonuniformity in the image is called *graininess*. It results from masses of silver arranged in random fashion, layer upon layer, with the depth depending on the density of the image.

The subjective impression of graininess in the image is primarily determined by the *granularity* of the negative. This is an objective quantity that is published in the specification sheets for most EASTMAN KODAK Motion Picture Films as the root-mean-square (rms) granularity value. To obtain this value, a uniformly exposed and developed film sample is scanned by a microdensitometer that has an optical system aperture of *f*/2.0 and a circular scanning aperture $48_{\mu}$ in diameter. From the density variations recorded by the microdensitometer, a mathematical value is derived that represents the standard deviation in density produced by the granular structure of the material. This standard-deviation value is multiplied by 1000 to obtain the rms granularity figure. The value is proportional to the sensation of graininess that would be received by a person viewing the sample at a magnification of 12×. When the magnitude of the graininess is great enough to be apparent to the normal eye, a difference of about 6 percent in the effective value of rms granularity corresponds to a *just noticeable difference* in the visual impression of graininess.

Inherent granularity differs with emulsion types; in general, when all other factors are held constant, the faster a film, the greater its granularity. However, many advances in emulsion manufacture have made possible increased speed without increased granularity. Some present-day camera materials have more than twice the speed of earlier films, yet their granularity is definitely lower. Even the highest speed materials have only moderate granularity.

In motion-picture production the use of special fine-grain developers is seldom practical. Many fine-grain developers cause a decrease in the effective speed of the emulsion, so that in some instances better results might be obtained with a slower material processed in the regular negative developer.

In addition to the inherent characteristics of the emulsion and the properties of the developing solution, there are a number of other factors that affect the granularity of the negative and the resulting graininess in the prints. Among the more important of these are:

**1.** *Degree of Development of the Negative.* The granularity of the negative increases with higher density and gamma, both of which result from an increased degree of development. However, the increase in granularity with greater development of the negative may not necessarily produce an increase in graininess of the print, since the positive normally will be developed to a lower gamma to offset the higher gamma produced by the increased development of the negative.

**2.** *Density.* Granularity increases with the density of the negative; therefore it is important to avoid overexposure.

**3.** *Processing Conditions.* If there are appreciable differences among the temperatures of the various baths, there may be a considerable increase in the apparent graininess due to incipient reticulation of the gelatin. It is important that all solutions be kept at approximately the same temperature.

Graininess in the final print is strongly influenced by the granularity of the negative, but is also affected by several other factors. The most important of these are:

**1.** *Over-all Reproduction Contrast.* There is a change in granularity from negative to print that is roughly in proportion to the contrast of the print material. For example, if a negative of granularity value 10 is printed onto a material of contrast 2.0, the granularity of the resulting print will be approximately doubled to 20.

**2.** *Type of Image.* Graininess is more apparent in images that have large areas of uniform density, particularly if these occur in the lighter middle tones.

**3.** *Granularity of Intermediate Materials.* The graininess of a print from duplicate negatives, for instance, is markedly improved by the use of fine-grain duplicating materials.

A positive made on a reversal material (by the bleach-and-redevelopment procedure) usually exhibits lower graininess than a print made from a negative material of comparable sensitivity. When a reversal material is used as a negative material, as is often done, the graininess characteristics are frequently not as good as those obtained when the material is used in the intended manner.

**4.** *Viewing Magnification.* The sensation of graininess will increase or decrease as the viewing magnification increases or decreases. That is, if the viewing magnification is doubled, the apparent graininess will be approximately doubled. For color materials, however, this change may not be directly proportional to the change in magnification, and the resulting relative graininess may be different from that indicated by the granularity values given in the specification sheets.

### Photographic Definition

One of the most important properties of a motion-picture film emulsion is its ability to produce pictures that have good screen definition. This property is not easily defined because it embraces several subjective concepts that contribute to an observer's estimate of the over-all quality of the screen image. One of the major aspects is that of *sharpness,* which is primarily related to the character of the edges of the image elements. Another is *resolution* or *resolving power,* which is associated with the ability of the emulsion to separate fine detail. Also contributing in a subtle and less understood manner are the patterns associated with graininess and the arrangement of the various tones in the picture.

**Acutance.** Many attempts have been made to express the subjective concept of definition in terms of some objective laboratory measurement of the film image itself. One such measurement is acutance, which can be calculated directly from microdensitometer measurements across the image of a knife edge. Acutance is a function of the density gradient across this image. Values of acutance have been shown to correlate very well with an observer's estimate of the sharpness characteristics of the image. Frequently there is also good correlation between acutance and definition, but this is not always the case.

**Resolving Power.** Resolving power refers to the ability of an emulsion to record fine detail distinguishably. In measuring resolving power, a parallel-line test chart is photographed at a great reduction in size. The lines on the test chart are separated by spaces of the same width as the lines. Examination of the image under a microscope is used to determine the greatest number of recognizable separate lines per millimeter. Lines closer together (more lines per millimeter) than indicated by this number will appear on the film, not as individual lines, but as an indistinct, gray mass. The resolving power depends on the particular type of test chart used and its contrast, the degree of lens correction, and the exposure and development of the film. Resolving-power values often fail to classify various materials in the same order as do subjective sharpness judgments, acutance values, or over-all estimates of definition.

### Modulation Transfer

The modulation-transfer function of a film, formerly called "sine-wave response," indicates the efficiency with which the film reproduces details of the image that falls upon it. Factors such as diffusion of light within the emulsion and adjacency effects in development affect the quality of reproduction.

To obtain modulation transfer data, the film is exposed to test patterns having a sinusoidal variation in illuminance in one direction, with a variation in spatial frequency of the patterns. After development, the photographic image is scanned in a microdensitometer, the densities of the trace are interpreted in terms of exposure, and the modulation-transfer factor of the film at each of the test-object frequencies is calculated. The modulation-transfer curves in the specification sheets for EASTMAN KODAK Motion Picture Films show a log-log plot of this factor as a function of the spatial frequency of the patterns in cycles per millimeter.

The image-detail characteristics of a print can be predicted by multiplying together, ordinate by ordinate, the modulation-transfer curves for all of the films and optical systems that will be used in making the print.

More detailed information and help in working with modulation transfer (sine-wave response) can be found in the references below.

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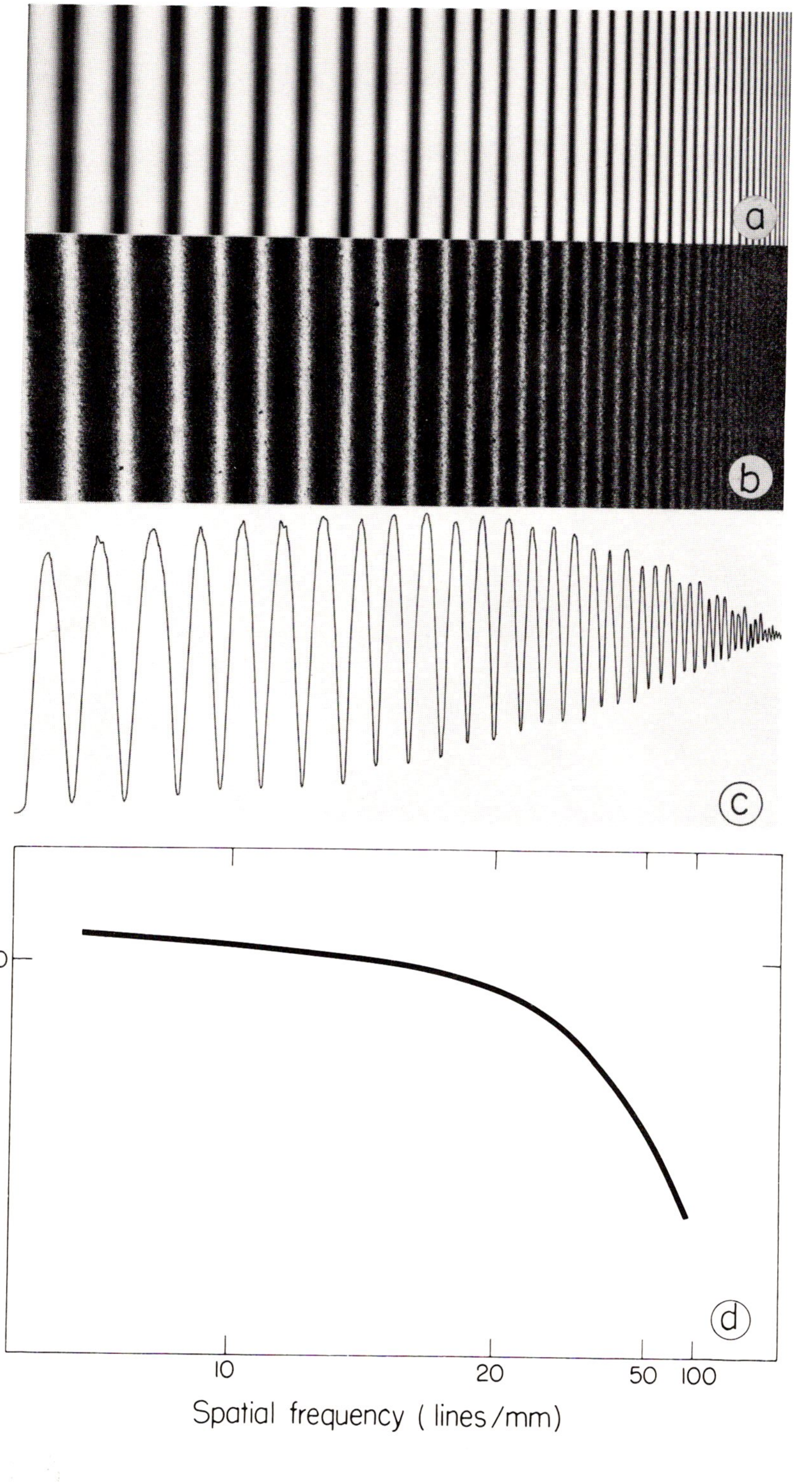
Perrin, F. H., "Methods of Appraising Photographic Systems," Journal of the SMPTE, *69*: 151-56, March, and 239-49, April, 1960.

Lamberts, R. L., "Measurements of Sine-Wave Response of a Photographic Emulsion," Journal of the Optical Society of America, *49*: 425-28, May, 1959.

The top panel on the facing page is the sinusoidal test object; the middle panel, the photographic image (magnified to the size of the original test object); and the bottom panel, the microdensitometer trace of the image.

A plot of the effective exposure of the film, with the lens characteristics eliminated, is shown in the curve at the bottom of the page. This is the modulation transfer response of the film alone. Usually the scale of frequencies is either linear or logarithmic, but here it is arranged to correspond to the frequencies of the original test object.


a
b
c
d
100
0
10
20
50
100
Spatial frequency ( lines/mm)

# Filters

## FILTERS FOR BLACK-AND-WHITE MOTION PICTURE PHOTOGRAPHY

Filters are used chiefly with panchromatic negative films that are being exposed to daylight. These filters provide emphasis to clouds in the sky, reduce the brightness of blue sky or water, penetrate haze in distant landscapes, increase tonal contrast between colored objects, and produce special effects (such as simulated night scenes). Under artificial lighting, filters are usually used for special effects only.

The requirements of black-and-white motion picture work for general purposes are met satisfactorily by a rather small number of filters. Yellow filters commonly used for haze penetration and darkening of the sky are the KODAK WRATTEN Filters No. 3 (Aero 1), 8 (K2), 12, and 15 (G) in the order of increasing absorption for blue light. The KODAK WRATTEN Filter No. 8N5 is also used and is similar to the No. 8, but incorporates a neutral density of 0.5 for additional reduction of exposure. This is often desirable in order to avoid increased depth of field caused by the use of small apertures and also to make the image quality of exterior scenes comparable with that of interior scenes.

For further darkening of the sky and increased haze penetration, filters ranging from light orange to deep red, represented by Nos. 21, 23A, 25, and 29, are sometimes used. These filters provide varying degrees of blue-light and green-light absorption.

When exposures are being made in sunlight with films of extremely high speed and no color correction of the sky or foreground is desired, neutral-density filters must be used to avoid overexposure, even when small camera apertures are employed.

Contrast filters must be combined with underexposure to obtain a simulated night effect under daylight conditions. The sky can be darkened by using yellow-orange or red filters, such as the KODAK WRATTEN Filters No. 23A, 25, 29, or 72B. However, these filters may render fleshtones too light; a combination of Nos. 23A and 56 (light green) produces better results.

The KODAK POLA-SCREEN is recommended for subduing undesirable reflections from nonmetallic surfaces (such as glass, water, wood) and for controlling the brightness of the sky. Using a POLA-SCREEN for controlling the brightness of the sky has a number of advantages over the use of color filters. (1) The color rendering of objects in the foreground is not altered. (2) It is easy to determine the effect produced by the POLA-SCREEN by checking the appearance of the image on the focusing screen or by looking through the POLA-

SCREEN when it is held at the same angle as used on the camera. (3) Filters can be used with the POLA-SCREEN to control the color rendering of objects in the foreground, while at the same time the brightness of the sky is controlled independently by the POLA-SCREEN.

The amount of polarized light from a particular area of the sky varies according to the position of the area with respect to the sun, the maximum occurring at an angle of 90 degrees from the sun. Panning of the camera should be avoided when a POLA-SCREEN is used; otherwise variable darkening of the sky will result for different camera positions.

For further details regarding the characteristics of the filters mentioned here, see the Data Book *KODAK WRATTEN Filters for Scientific and Technical Use*, available through Kodak dealers.

### Filter Factors

A filter absorbs part of the light which would otherwise fall on the film, so the exposure must be increased to make up for this loss of light. The number of times the exposure must be increased over the unfiltered exposure is the *filter factor*. This factor depends principally on the absorption characteristics of the filter, the spectral sensitivity of the photographic material, and the spectral composition of the light falling on the subject.

Definite factors are not given for the filters used in obtaining night effects in daylight, since the exposure increase varies with the effect to be produced. As a rough guide, the exposure should be increased three times for the No. 23A filter, five times for the No. 25, twelve times for the No. 29 or 72B, and six times for the combination of Nos. 23A and 56.

## FILTERS FOR COLOR PHOTOGRAPHY

The filters commonly used in black-and-white photography cannot be used in the exposure of color films, because the pictures would show an over-all cast of the same color as the filter.

In exposing color films and in making color prints and duplicates, there are a number of conditions under which good color rendering can be secured only by the use of correcting filters.

Not only do daylight and artificial light differ from one another in spectral color quality, but each type of light is individually subject to considerable variation. Since it is impractical to supply special types of color films that are balanced for every type of light source, it has been necessary to standardize on a few films designed for use with the most common light sources. When other lighting conditions are employed, correction filters can be used to adjust the spectral color quality of the illumination to that for which the film is balanced.

KODAK WRATTEN Filters can be used to modify the quality of the existing illumination considerably. For example, EASTMAN Color Negative Film, Type 5251, which is balanced for use with 3200 K tungsten lamps, can be exposed under daylight conditions with the KODAK WRATTEN Filter No. 85. Other types of color materials may require different filters to accomplish the same result. In each case, the appropriate filter is noted in the specification sheet for the film.

Filters that absorb only in the blue and ultraviolet regions of the spectrum are often needed for photographing distant scenes, mountain views, sunlit snow scenes, or aerial pictures. Among the several KODAK WRATTEN Filters available for this purpose, the No. 2B is the most generally used.

In cases where only slight corrections in color quality are needed, a special series of very light filters (KODAK Light Balancing Filters) is available. Several bluish filters and yellowish filters are provided in this series, their purpose being to raise or lower the effective color temperature of the exposing light.

Another series of filters, known as KODAK Color Compensating Filters, is used to make changes in the over-all color balance of pictures made with color films. These filters are also used to compensate for deficiencies in the spectral quality of the light by which color films must sometimes be exposed. There are numerous situations where such corrections are required: for example, in making color prints from a color negative, in making reversal color prints, in photography with unusual light sources, or when heat-absorbing or opal glass is used in an optical system. KODAK Color Compensating Filters are available in several density values for each of the following colors: cyan, magenta, yellow, red, green, and blue.

Night effects on color films can be produced in daylight by adding high-contrast lighting and underexposing the camera film to suppress shadow detail. In addition, it may be desirable to introduce an over-all bluish cast to simulate the appearance of moonlight. To do this with a color-negative camera film, the normal correction filter for daylight is retained and the normal daylight exposure is reduced by ½ to 1 lens stop. During the printing operation, increased density and desired color effects can be introduced. For color-reversal camera films, the normal daylight-correction filter is omitted to obtain the color effect, and the normal daylight exposure is reduced by ½ to 2 lens stops. If additional darkening of sky areas is desired, the KODAK POLA-SCREEN can be used in exposing either type of camera film.

The specification sheets for motion picture color films describe specific applications and recommendations for certain filters, but there are many special applications for which it is not possible to make specific recommendations. Frequently, the type of filter to be employed and the technique to be followed must be determined by practical tests.

## FILTERS FOR COLOR PRINTING

Filters that are used for the correction of light sources in motion-picture printers do not always have to be placed in an image-forming part of the optical system. The optical quality of the filters need not be as perfect as that of gelatin or glass-mounted filters that are used over camera lenses or other image-producing components. For this purpose, a series of filters known as KODAK Color Printing Filters (Acetate) is provided in 5-, 6-, 8-, and 12-inch squares with a thickness of 0.006 inch. The spectral transmittance characteristics of these filters are intended to match those of the KODAK Color Compensating Filters. The Color Printing Filters are available in four density values —0.05, 0.10, 0.20, and 0.40—for each of the following colors: cyan, magenta, yellow, and red. An acetate filter similar to the KODAK WRATTEN No. 2B is also available. It is designated as KODAK Color Printing Filter (Acetate), CP2B.

## HEAT-ABSORBING GLASSES

Motion-picture printers used with color films require high-wattage lamps that emit a considerable amount of heat. Heat-absorbing glasses are necessary to protect the color filters from damage. In the specification sheets for color-duplicating and release-print materials, it is recommended that a Pittsburgh No. 2043 Heat Absorbing Glass, 4mm thick, be included in the beam. Air-tempered glasses of this type, in 2- and 3-inch squares and in disks 2 inches in diameter, can be ordered directly from the Motion Picture and Education Markets Division, Eastman Kodak Company, Rochester, N.Y. 14650.

# Processing

## PROCESSING BLACK-AND-WHITE NEGATIVE AND POSITIVE FILMS

### Developer Composition

Because of the wide variety of processing equipment in use throughout the motion-picture industry, it is difficult to give specific formulas for use with either negative or positive black-and-white films. The choice of the developer formula is dependent upon a number of factors. In the first place, the formula adopted should be compatible with the particular materials to be processed, permitting their characteristics to be shown to best advantage. It should give high effective emulsion speed; that is, it should be capable of producing the needed density at normal contrast without requiring greater-than-average exposure of the film in the camera, recorder, printer, or other equipment. The formula should provide a characteristic-curve shape that will yield good tone reproduction in the final print. In addition, it should provide good resolution, minimum graininess, and maximum sharpness consistent with the use for which the particular film is intended.

Consideration of the equipment to be used for processing is also a factor in the selection of a formula. The rate of development must be such that the necessary contrast will be obtained with the available number of racks and tanks, machine speed, degree of agitation, replenisher supply, etc. Moreover, the solution-equipment combination must permit the required production output. The solution should not be unduly sensitive to small temperature changes nor to localized variations in the degree of agitation. Mixing should be easy and the ingredients should be as inexpensive as possible in order to assure the greatest economy of operation. Keeping properties of the solution should be good, and the formula should allow convenient replenishment for continuous-processing machines.

### Black-and-White Negative Developers

Modifications of developer formulas must always be made to satisfy individual laboratory requirements. In general, for black-and-white negative films, a low-contrast developer of the ELON-hydroquinone-borax type is used in order to obtain the best photographic quality and the most accurate control of development. Adjustments are made in the ELON-hydroquinone ratio and in the alkalinity of the solution to give the proper development rate and to give adequate rendering of shadow detail in the negative. The pH of the solution is generally of the order of 8.5 to 9.0. A high sodium sulfite content is generally used to give some silver halide solvent action, which keeps the granularity at a minimum without excessive loss in effective emulsion speed. KODAK Developer D-96 is a negative developer in which modifications can be made, if necessary, to suit the requirements of each laboratory.

### Black-and-White Positive Developers

A more active developer with a higher hydroquinone-to-ELON ratio and a higher pH (9.5 to 10.5) is generally used for positive films. As is the case with negative developers, modifications are required to suit the individual equipment. KODAK Developer D-97 is generally satisfactory as a starting formula to serve as a basis for further modification.

### Sound-Negative Developers

Variable-density sound films can be processed in regular black-and-white negative developers. Variable-area sound films can be processed in the solutions used for release positive films.

### Determination of Development Time

The extent of development of a photographic material depends upon the formula used, and the temperature, time, and particular agitation conditions provided by the processing equipment. These factors vary so widely among motion-picture laboratories that it is impractical to make specific recommendations. Each laboratory must determine the appropriate development times and temperatures for the films being processed in a particular machine. This is most easily accomplished by processing a series of sensitometric strips for several different times and determining the resulting gamma values from the plotted density and log exposure values. The gamma values are then plotted against the time of development to give the time-gamma curve. From this curve, the development time is selected that corresponds to the recommended control gamma given in the specification sheet for the film being considered. As noted earlier, some modification in the control-gamma aim may be necessary when certain types of sensitometers and densitometers are to be used.

If no sensitometer is available, a printer can be used for making sensitometric exposures if a step tablet is incorporated in a loop to serve as the exposure modulator.* If neither a sensitometer nor a

*Gale, R. O., and Graham, J. J., "Use of a Motion-Picture Printer as a Sensitometer," Journal of the SMPTE, *69*: 84-86, February, 1958.

printer is available, the development time must be determined on the basis of picture-quality tests.

### Control of Development

To insure uniformity of results, the temperature of the developer solution should be controlled to within ±0.5 F of the temperature adopted as the laboratory standard. Many commercial motion-picture laboratories are finding it feasible, and profitable in terms of consistent quality, to control temperatures to within ±0.25 F, or even less.

Whenever possible, the temperature of the other processing solutions should be held within 2 degrees of the developer temperature. If this is not practical, and it is necessary to work at temperatures much above normal, special precautions should be taken to avoid excessive swelling and softening of the emulsion.

Times of development cannot be specified, as noted earlier, because of the dissimilarity of various types of continuous-processing machines. Footage speed, extent of developer exhaustion, rate of circulation of the developer, and degree of agitation affect the time of development and may also affect the characteristic-curve shapes obtained.

The correct chemical condition of the developer solution must be maintained to prevent day-to-day variations in quality. To insure the production of constant density and gamma for a given time of development, accurate sensitometric control is necessary. Chemical analysis is also very desirable, since it is of great assistance in establishing correct replenishment rates and determining the causes of any quality variation. In addition, many laboratories have found that the adoption of chemical-control methods has resulted in reduced operating costs. Information regarding analytical procedures for use in chemical control of typical black-and-white processing solutions can be obtained from the Motion Picture and Education Markets Division, Eastman Kodak Company, Rochester, N.Y. 14650.

An excellent textbook on the subject of process control is *Control Techniques in Film Processing,* available from the Society of Motion Picture and Television Engineers, 9 East 41st Street, New York, N.Y. 10017.

### Fixing

KODAK Fixing Bath F-25, an acid-hardening fixing bath containing potassium alum and boric acid, has a very low sludging tendency and a long hardening life. It is recommended for general use.

A suitably compounded chrome alum bath, such as KODAK F-23, gives a greater degree of hardening than can be obtained with potassium alum baths, but the decline in hardening power with exhaustion is more rapid unless the bath is suitably replenished. The degree of hardening produced by a potassium alum bath (such as F-25) is usually sufficient; however, if the wash water is warm, or rapid drying at high temperatures is necessary, the use of KODAK F-23 may be desirable.

The time of fixation should be at least double that required to clear the film. Fixing times cannot be specified, since the time of clearing depends on the nature and thickness of the emulsion, the degree of agitation during fixing, and the composition, temperature, and degree of exhaustion of the fixing bath. In general, fine-grained emulsions fix more rapidly than those containing coarser grains.

For maximum permanence, fixation should be carried out in reasonably fresh solutions. As the concentration of silver in the bath becomes excessive, removing silver ions from the film by washing becomes increasingly difficult.

## Recovering Silver from Fixing Baths

The recovery of silver from used fixing baths can be profitable because of the value of the recovered silver and because, in some situations, this process can allow more efficient use of the fixing-bath chemicals. Basically, there are two methods of silver recovery: chemical-precipitation and electrolytic. Both methods can be used, either singly or in combination, depending on which is more suitable for the particular needs of the processor. One chemical-precipitation unit that is simple, efficient, and inexpensive is the KODAK Chemical Recovery Cartridge. This item consists of a compact, replaceable recovery drum filled with spun metal. The KODAK Circulating Unit attaches to the top of the drum and is connected by a hose to the fixer overflow of the processor or to a drain line of a fixer collection tank. Then the used solution is forced through the spun metal, depositing the silver, and the effluent is discharged to any convenient sewage outlet.

There are many other silver recovery systems on the market that are suitable for various types and sizes of processing laboratories.

## Washing

Thorough washing of the film after fixation is important because any thiosulfate salts (hypo) left in the processed material can cause fading of the silver image by converting it partially to silver sulfide. Effective washing of motion-picture film requires an adequate flow of fresh water and a sufficient washing time to reduce the hypo content of the film to the proper level. A number of factors influence the amount of water and the time of washing required. Among these factors are the composition of the fixing bath, the fixing time, the extent of carryover of the fixing bath, the temperature and degree of agitation of the wash water, and the arrangement of the washing facilities (single stage or multiple stages).

Washing time can be reduced considerably by the use of hypo eliminators such as KODAK Hypo Clearing Agent. This can be an important factor in conserving water in areas where water shortages exist. The effectiveness of the washing procedure can be evaluated by an analytical determination of the residual hypo content of the film.* Suggested limits for residual hypo content for films intended for both commercial and archival storage are given in a separate booklet.†

### Drying

Drying of motion-picture film can be carried out either in conventional drying cabinets or by the impingement method.‡ The latter technique produces a somewhat glossier emulsion surface on the dried film than that produced by conventional drying methods.

Air supplied to the drying cabinets or impingement dryers should be filtered to eliminate dust and oil particles. Both the temperature and relative humidity (RH) of the air supplied to the drying cabinets should be controlled so that the film will have the proper degree of dryness at the completion of the drying cycle. Insufficient drying will cause the film to be too tacky; overdrying will cause excessive curl and brittleness. Ideally, the film should be in equilibrium with air of about 50 percent RH at the end of the drying period. As a general guide, the drying conditions should produce dry film, without tackiness, when the film is about three-quarters of the distance through the drying cabinet.

## PROCESSING BLACK-AND-WHITE REVERSAL FILMS

For black-and-white reversal materials of the bleach and redevelopment type, processing conditions may vary even more widely among commercial laboratories than for the processing of negative and positive films. As a result, sensitometric curves and other data for the reversal films may show considerable departure from the information given in the specification sheets. The data are useful, nevertheless, in indicating the type of results that might be expected in average reversal processing with recommended formulas and procedures.

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**USA Standard Method for Determining the Thiosulfate Content of Processed Black-and-White Photographic Film and Plates*, PH4.8—1958. Available from the United States of America Standards Institute, 10 East 40th Street, New York, New York 10016.

†*The Storage and Preservation of Motion Picture Film.* Available through Kodak dealers.

‡Miller, F. D., "Rapid Drying of Normally Processed Black-and-White Motion Picture Film," Journal of the SMPTE, *60*: 85-104, February, 1953.

Reversal processing steps for KODAK 4-X Reversal Film 7277, KODAK TRI-X Reversal 7278, KODAK PLUS-X Reversal 7276, and EASTMAN Reversal Duplicating, Type 7361, developed in a continuous processor, are given in the following table. KODAK Reversal Liquid Chemicals can be used, or solutions can be prepared from the formulas on pages 26 through 28.

| Processing Step | Time of Treatment | | |
|---|---|---|---|
| | 68 F (20 C) | 95 F (35 C) | 110 F (43 C) |
| 1. First Developer | 2 min | 40 sec | 13 sec |
| 2. Running Water Rinse* | 30 sec | 20 sec | 5 sec |
| 3. Bleach | 50 sec | 40 sec | 10 sec |
| 4. Running Water Rinse | 30 sec | 20 sec | 5 sec |
| 5. Clearing Bath | 30 sec | 20 sec | 5 sec |
| 6. Running Water Rinse | 30 sec | 20 sec | 5 sec |
| 7. Re-exposure | 800 foot-candle-seconds | | |
| 8. Redeveloper | 30 sec | 20 sec | 5 sec |
| 9. Running Water Rinse† | 30 sec | 20 sec | 5 sec |
| 10. Fixer | 50 sec | 30 sec | 5 sec |
| 11. Running Water Wash | As required‡ | | |
| 12. Dry | As required (approximately 1 minute in a typical machine) | | |

*Do not use an acid stop bath at this point.

†An acid stop bath, such as KODAK Stop Bath SB-1a, can be used in place of a water rinse following redevelopment.

‡The amount of washing needed is determined by the efficiency of the water application and the permissible residual hypo concentration for the intended use.

**NOTE:** The times given are suggested starting points. They may require modification for your processor.

## PROCESSING MULTILAYER COLOR FILMS

The processing of multilayer color films, such as EASTMAN Color Negative and Color Print Films and the associated intermediate color materials, requires more exacting conditions than the processing of black-and-white materials. Close adherence to a specific set of formulas and procedures is required in order to obtain the correct degree of development in each of the separate layers of the film.

In addition to rigid control of the mechanical factors, both sensitometric and chemical control procedures are mandatory if the best picture quality is to be achieved. During the initial period of processing, careful tests must be made to establish the mechanical control standards that are specific for the particular processing machine in use. Sensitometric standards based on measurements made with available instruments must also be determined and correlated with Eastman standards for the particular product. Chemical analytical procedures must be used to insure that all constituents of the various solutions are within the limits specified. Once these standard conditions have been decided upon, they must be maintained within certain control limits as processing is continued. If attempts are made to correct one off-standard condition by introducing another off-standard condition, the results may be inconsistent, especially when different emulsion numbers of the same film are being used.

Information on processing EASTMAN KODAK Color Films is available from the Motion Picture and Education Markets Division.

## VISCOUS-LAYER PROCESSING

In viscous-layer processing a uniform coating of a specially formulated developer solution that contains a thickening agent is applied to the emulsion surface under controlled temperature and humidity conditions. After the proper reaction period, the coating is removed by a water spray jet, and the film passes into the fixer or other solutions. The solutions following the developer may be in viscous, spray, or the usual liquid form.

Viscous-layer processing offers several important advantages over the conventional deep-tank method. Fresh chemicals are applied to the film and discarded after use, eliminating the problems of replenishment and involved chemical-control procedures. Since the chemicals remain undisturbed on the film during the prescribed treatment time, agitation is not a factor; the degree and uniformity of development can therefore be held constant. Processing dirt is practically eliminated because only clean chemicals come in contact with the film.

The EASTMAN VISCOMAT Processor permits rapid processing of certain types of motion-picture film at elevated temperatures by the application of viscous coatings. This equipment represents an outstanding achievement in engineering design and incorporates a number of novel features. It is not, however, intended for large-scale processing. Many commercial laboratories have nevertheless become interested in the possible adaptation of the viscous-layer technique to their operations.

Information on equipment and proprietary chemical mixes made by the Eastman Kodak Company for viscous-layer processing can be obtained from the Motion Picture and Education Markets Division.

# Formulas for Black-and-White Processing

## MIXING SOLUTIONS

When photographic solutions are being mixed, it is essential that the constituents be dissolved in the proper order to prevent undesirable reactions. In mixing developers, for instance, if the developing agent is dissolved first and then the alkali is added, considerable aerial oxidation and formation of colored oxidation products can occur before the preservative, sodium sulfite, is dissolved. For reasons such as this, Kodak formulas name the ingredients in the order in which they should be dissolved.

## FORMULAS FOR PROCESSING NEGATIVE AND POSITIVE FILMS

### KODAK Developer D-96

**For motion picture negative films**

| | *Avoirdupois—U.S. Liquid* | | *Metric* |
|---|---|---|---|
| Water, about 125 F (50 C) | 90 gallons | 96 ounces | 750.0 ml |
| KODAK ELON Developing Agent | 1½ pounds | 90 grains | 1.5 grams |
| KODAK Sodium Sulfite, desiccated | 75 pounds | 10 ounces | 75.0 grams |
| KODAK Hydroquinone | 1½ pounds | 90 grains | 1.5 grams |
| KODAK Potassium Bromide | 6½ ounces | 24 grains | 0.4 gram |
| or Sodium Bromide | 5½ ounces | 20 grains | 0.35 gram |
| KODAK Borax, granular, decahydrated | 4½ pounds | 260 grains | 4.5 grams |
| Water to make | 120 gallons | 1 gallon | 1.0 liter |

### KODAK Replenisher D-96R

**For use with KODAK Developer D-96**

| | *Avoirdupois—U.S. Liquid* | | *Metric* |
|---|---|---|---|
| Water, about 125 F (50 C) | 90 gallons | 96 ounces | 750.0 ml |
| KODAK ELON Developing Agent | 2 pounds | 115 grains | 2.0 grams |
| KODAK Sodium Sulfite, desiccated | 80 pounds | 10½ ounces | 80.0 grams |
| KODAK Hydroquinone | 2 pounds | 115 grains | 2.0 grams |
| KODAK Borax, granular, decahydrated | 5 pounds | 290 grains | 5.0 grams |
| Water to make | 120 gallons | 1 gallon | 1.0 liter |

Replenishment Rate—1 gallon per 250 feet of 35mm film (15 ml per foot).

## Kodak Developer D-97

### For motion picture positive films

| | Avoirdupois—U.S. Liquid | | | | Metric | |
|---|---|---|---|---|---|---|
| Water, about 125 F (50 C) | 90 | gallons | 96 | ounces | 750.0 | ml |
| Kodak Elon Developing Agent | ½ | pound | 30 | grains | 0.5 | gram |
| Kodak Sodium Sulfite, desiccated | 40 | pounds | 5¼ | ounces | 40.0 | grams |
| Kodak Hydroquinone | 3 | pounds | 175 | grains | 3.0 | grams |
| Kodak Sodium Carbonate, monohydrated | 20 | pounds | 2 oz 290 | grains | 20.0 | grams |
| Kodak Potassium Bromide | 2 | pounds | 115 | grains | 2.0 | grams |
| or Sodium Bromide | 1¾ | pounds | 105 | grains | 1.75 | grams |
| Water to make | 120 | gallons | 1 | gallon | 1.0 | liter |

## Kodak Replenisher D-97R

### For use with Kodak Developer D-97

| | Avoirdupois—U.S. Liquid | | | | Metric | |
|---|---|---|---|---|---|---|
| Water, about 125 F (50 C) | 90 | gallons | 96 | ounces | 750.0 | ml |
| Kodak Elon Developing Agent | 11 | ounces | 40 | grains | 0.7 | gram |
| Kodak Sodium Sulfite, desiccated | 70 | pounds | 9¼ | ounces | 70.0 | grams |
| Kodak Hydroquinone | 11 | pounds | 1 oz 205 | grains | 11.0 | grams |
| Kodak Sodium Carbonate, monohydrated | 20 | pounds | 2 oz 290 | grains | 20.0 | grams |
| Kodak Potassium Bromide | 2½ | ounces | 9 | grains | 0.15 | gram |
| or Sodium Bromide | 2¼ | ounces | 8 | grains | 0.13 | gram |
| Kodak Sodium Hydroxide | 2 | pounds | 115 | grains | 2.0 | grams |
| Water to make | 120 | gallons | 1 | gallon | 1.0 | liter |

**Replenishment Rate—1 gallon per 1900 feet of 35mm film (2.0 ml per foot).**

## Kodak Hardening Bath SB-3

### For use at 65 F to 75 F (18 C to 24 C)

| | Avoirdupois—U.S. Liquid | | Metric |
|---|---|---|---|
| Water | 120 gallons | 1 gallon | 1.0 liter |
| Kodak Potassium Chrome Alum | 30 pounds | 4 ounces | 30.0 grams |

For maximum hardening, film should remain in the hardening bath at least 3 minutes, with frequent agitation. An unused bath keeps well, but the hardening properties of a partially used bath decrease rapidly on standing.

With use, the hardening properties of the bath decrease as a result of the addition of developer, and sufficient sulfuric acid should be added at intervals to bring the acidity to a pH value of 3.0. At this point maximum hardening is obtained with unrinsed film that has been developed in developers containing an average quantity of alkali (Kodak D-96 or D-97). The amount of acid to be added can be determined by titration, using bromphenol-blue as the indicator. With care, it is possible to establish a schedule for the addition of acid on a footage basis. If a sludge forms in the bath, or on the film, or the bath ceases to harden after revival with acid, it should be discarded.

When film has been put through a chrome alum hardening or fixing bath, it should be wiped or squeegeed carefully after washing and before drying; otherwise any chromium scum that may have been formed on the film will leave residues. After the film has dried, such residues are almost impossible to remove.

## KODAK Hardening Bath SB-4

### For use above 75 F (24 C)

| | Avoirdupois—U.S. Liquid | | Metric |
|---|---|---|---|
| Water | 120 gallons | 1 gallon | 1.0 liter |
| KODAK Potassium Chrome Alum | 30 pounds | 4 ounces | 30.0 grams |
| *KODAK Sodium Sulfate, desiccated | 60 pounds | 8 ounces | 60.0 grams |

*If the crystalline salt is preferred, use 2¼ times the quantity.

Agitate the film for 30 to 45 seconds when it is first immersed in the hardener, or streakiness will result. Leave the film in the bath for at least 3 minutes between development and fixation. If the temperature is below 80 F (26 C), rinse the film for 1 or 2 seconds in water before immersing it in the hardening bath.

The hardening bath is a violet-blue color by tungsten light when freshly mixed, but it ultimately turns yellow-green with use; it then ceases to harden and should be replaced with a fresh bath. The hardening bath should never be overworked. An unused bath keeps well, but the hardening properties of a partially used bath decrease greatly on standing for a few days.

## KODAK Fixing Bath F-23

### Solution A

| | Avoirdupois—U.S. Liquid | | Metric |
|---|---|---|---|
| *KODAK Sodium Thiosulfate (Hypo) | 240 pounds | 2 pounds | 240.0 grams |
| KODAK Sodium Sulfite, desiccated | 12½ pounds | 1 oz 290 grains | 12.5 grams |
| Water to make | 90 gallons | 96 ounces | 750.0 ml |

*A bath that fixes more rapidly can be obtained by increasing the hypo concentration to 2½ pounds per gallon (300 grams per liter).

### Solution B

| | Avoirdupois—U.S. Liquid | | Metric |
|---|---|---|---|
| Water | 18 gallons | 20 ounces | 150.0 ml |
| KODAK Sodium Sulfite, desiccated | 5 pounds | 290 grains | 5.0 grams |
| **Sulfuric Acid (5% solution) | 4¾ gallons | 5 ounces | 40.0 ml |
| KODAK Potassium Chrome Alum | 32 pounds | 4¼ ounces | 32.0 grams |
| Water to make | 30 gallons | 32 ounces | 250.0 ml |

**To prepare 5% sulfuric acid, add 1 part by volume of Sulfuric Acid C.P. (concentrated) to 19 parts by volume of cold water, slowly with stirring. **Caution:** The acid must be added to the water; otherwise the solution may boil with explosive violence and if spattered on the hands or face will cause serious burns.

Solutions A and B must be cooled to about 70 F before they are mixed, in order to avoid sulfurization. Add Solution B to Solution A while stirring the latter thoroughly. It is not desirable to store Solution B as a stock hardener, because it loses its hardening properties on keeping.

The hardening properties fall off rapidly with use, and sulfuric acid should be added at regular intervals to maintain the proper acidity. The quantity required can be determined by titrating 30 ml of the fixing bath with a 2.5% solution of sulfuric acid, using brom-phenol-blue as the indicator. Sufficient acid should be added to change the color of the solution to yellow.

## Kodak Fixing Bath F-25

| | *Avoirdupois—U.S. Liquid* | | *Metric* |
|---|---|---|---|
| Water, about 125 F (50 C) | 60 gallons | 64 ounces | 500.0 ml |
| Kodak Sodium Thiosulfate (Hypo) | 300 pounds | 2 lbs 8 ounces | 300.0 grams |
| *Kodak Sodium Sulfite, desiccated | 5 pounds | 290 grains | 5.0 grams |
| Kodak Acetic Acid (glacial) | 1 gal 26 ounces | 1¼ ounces | 10.0 ml |
| **Kodak Boric Acid, crystals | 5 pounds | 290 grains | 5.0 grams |
| Kodak Potassium Alum | 10 pounds | 1 oz 145 grains | 10.0 grams |
| Water to make | 120 gallons | 1 gallon | 1.0 liter |

*This bath contains a minimum quantity of sulfite and is satisfactory for use at 65 to 70 F (18 to 21 C) if kept not longer than 3 or 4 weeks. If the temperature is apt to rise above 70 F (21 C), the quantity of sulfite should be doubled.

**Crystalline boric acid should be used as specified. Powdered boric acid dissolves only with great difficulty and its use should be avoided.

Dissolve the hypo in one-half the total volume of water and add the remaining chemicals in the order given, after dissolving each in a small quantity of water. Dilute to the required volume.

Revival is unnecessary with this fixing bath since its hardening properties and freedom from sludge are maintained throughout the useful life (about 400 feet of film per gallon). Unless the developer is excessively alkaline, the degree of alkalinity of the fixing bath can be determined by adding 1.0 ml of a 0.04% solution of brom-cresol-purple to a 10.0 ml sample of fixing bath. The color, which is yellow when the bath is fresh, deepens during exhaustion and reaches a distinct reddish tint when the bath is exhausted. This occurs at a pH value of approximately 5.6, and although the bath will still harden, it should be discarded because most of the acid has been neutralized and further exhaustion might lead to developer stains.

# FORMULAS FOR PROCESSING REVERSAL FILMS

## Kodak Developer D-94

### First Developer

| | *Avoirdupois—U.S. Liquid* | | *Metric* |
|---|---|---|---|
| Water, about 70 F (21 C) | 96 ounces | 90 gallons | 750.0 ml |
| Kodak Elon Developing Agent | 35 grains | 9½ ounces | 0.6 gram |
| Kodak Sodium Sulfite, desiccated | 6¾ ounces | 50 pounds | 50.0 grams |
| Kodak Hydroquinone | 2 oz 290 grains | 20 pounds | 20.0 grams |
| Kodak Potassium Bromide | 1 oz 30 grains | 8 pounds | 8.0 grams |
| or Sodium Bromide | 400 grains | 7 pounds | 7.0 grams |
| Kodak Sodium Thiocyanate | 350 grains | 6 pounds | 6.0 grams |
| Kodak Sodium Hydroxide | 2 oz 290 grains | 20 pounds | 20.0 grams |
| Water to make | 1 gallon | 120 gallons | 1.0 liter |

## Kodak Replenisher D-94R

### For use with Kodak Developer D-94

| | *Avoirdupois—U.S. Liquid* | | *Metric* |
|---|---|---|---|
| Water, about 70 F (21 C) | 96 ounces | 90 gallons | 750.0 ml |
| Kodak Elon Developing Agent | 75 grains | 1 pound, 5 oz | 1.3 grams |
| Kodak Sodium Sulfite, desiccated | 6¾ ounces | 50 pounds | 50.0 grams |
| Kodak Hydroquinone | 3½ ounces | 26 pounds | 26.0 grams |
| Kodak Sodium Thiocyanate | 1 ounce | 7½ pounds | 7.5 grams |
| Kodak Sodium Hydroxide | 4½ ounces | 34 pounds | 34.0 grams |
| Water to make | 1 gallon | 120 gallons | 1.0 liter |

**Replenishment Rate—1 gallon per 1700 feet of 16mm film (2.2 ml per foot).**

## KODAK Developer D-95
### Redeveloper

| | Avoirdupois—U.S. Liquid | | | | Metric | |
|---|---|---|---|---|---|---|
| Water, about 70 F (21 C) | 96 | ounces | 90 | gallons | 750.0 | ml |
| KODAK ELON Developing Agent | 60 | grains | 1 | pound | 1.0 | gram |
| KODAK Sodium Sulfite, desiccated | 6¾ | ounces | 50 | pounds | 50.0 | grams |
| KODAK Hydroquinone | 2 oz 290 | grains | 20 | pounds | 20.0 | grams |
| KODAK Potassium Bromide | 290 | grains | 5 | pounds | 5.0 | grams |
| or Sodium Bromide | 260 | grains | 4½ | pounds | 4.5 | grams |
| KODAK Potassium Iodide | 15 | grains | 4 | ounces | 0.25 | gram |
| KODAK Sodium Hydroxide | 2 | ounces | 15 | pounds | 15.0 | grams |
| Water to make | 1 | gallon | 120 | gallons | 1.0 | liter |

## KODAK Replenisher D-95R
### For use with KODAK Developer D-95

| | Avoirdupois—U.S. Liquid | | | Metric |
|---|---|---|---|---|
| Water, about 70 F (21 C) | 96 | ounces | 90 gallons | 750.0 ml |
| KODAK ELON Developing Agent | 130 | grains | 2 pounds, 3 oz | 2.2 grams |
| KODAK Sodium Sulfite, desiccated | 6¾ | ounces | 50 pounds | 50.0 grams |
| KODAK Hydroquinone | 6¾ | ounces | 50 pounds | 50.0 grams |
| KODAK Sodium Hydroxide | 6¾ | ounces | 50 pounds | 50.0 grams |
| Water to make | 1 | gallon | 120 gallons | 1.0 liter |

Replenishment Rate—1 gallon per 5000 feet of 16mm film (0.75 ml per foot).

## KODAK Bleaching Bath R-9

| | Avoirdupois—U.S. Liquid | | | | Metric |
|---|---|---|---|---|---|
| Water | 1 | gallon | 120 | gallons | 1.0 liter |
| KODAK Potassium Dichromate | 1¼ | ounces | 9½ | pounds | 9.5 grams |
| Sulfuric Acid, concentrated* | 1½ | ounces | 1 | gallon, 52 oz | 12.0 ml |

*Caution: Always add the sulfuric acid to the solution slowly, stirring constantly, and never add the solution to the acid; otherwise, the solution may boil and spatter the acid on the hands or face, causing serious burns.

## KODAK Replenisher R-9Ra
### For use with KODAK Bleaching Bath R-9

| | Avoirdupois—U.S. Liquid | | Metric |
|---|---|---|---|
| Water | 1 gallon | 120 gallons | 1.0 liter |
| KODAK Potassium Dichromate | 4 ounces | 30 pounds | 30.0 grams |
| Sulfuric Acid, concentrated* | 3 ounces | 3 gallons | 25.0 ml |

Replenishment Rate—1 gallon per 1900 feet of 16mm film (2 ml per foot).

*Caution: Always add the sulfuric acid to the solution slowly, stirring constantly, and never add the solution to the acid; otherwise, the solution may boil and spatter the acid on the hands or face, causing serious burns.

## KODAK Clearing Bath CB-2

| | Avoirdupois—U.S. Liquid | | Metric |
|---|---|---|---|
| Water | 96 ounces | 90 gallons | 750.0 ml |
| KODAK Sodium Sulfite, desiccated | 1¾ pounds | 210 pounds | 210.0 grams |
| Water to make | 1 gallon | 120 gallons | 1.0 liter |

## KODAK Replenisher CB-2R

### For use with KODAK Clearing Bath CB-2

| | Avoirdupois—U.S. Liquid | | Metric |
|---|---|---|---|
| Water | 96 ounces | 90 gallons | 750.0 ml |
| KODAK Sodium Sulfite, desiccated | 2 pounds | 240 pounds | 240.0 grams |
| Water to make | 1 gallon | 120 gallons | 1.0 liter |

Replenishment Rate—1 gallon per 1900 feet of 16mm film (2 ml per foot).

## KODAK Stop Bath SB-1a

| | Avoirdupois—U.S. Liquid | | Metric |
|---|---|---|---|
| Water | 1 gallon | 120 gallons | 1.0 liter |
| KODAK Acetic Acid, 28%* | 16 ounces | 15 gallons | 125.0 ml |

## KODAK Fixing Bath F-10

| | Avoirdupois—U.S. Liquid | | Metric |
|---|---|---|---|
| Water, about 125 F (50 C) | 64 ounces | 60 gallons | 500.0 ml |
| KODAK Sodium Thiosulfate (Hypo) | 2¾ pounds | 330 pounds | 330.0 grams |
| KODAK Sodium Sulfite, desiccated | 1 ounce | 7½ pounds | 7.5 grams |
| KODALK Balanced Alkali | 4 ounces | 30 pounds | 30.0 grams |
| KODAK Acetic Acid, 28%,* or | 9 ounces | 8½ gallons | 72.0 ml |
| KODAK Glacial Acetic Acid | 2½ ounces | 2 gallons, 44 oz | 20.0 ml |
| KODAK Potassium Alum | 3 ounces | 22½ pounds | 22.5 grams |
| Water to make | 1 gallon | 120 gallons | 1.0 liter |

## KODAK Replenisher F-10R

### For use with KODAK Fixing Bath F-10

| | Avoirdupois—U.S. Liquid | | Metric |
|---|---|---|---|
| Water, about 125 F (50 C) | 64 ounces | 60 gallons | 500.0 ml |
| KODAK Sodium Thiosulfate (Hypo) | 3½ pounds | 420 pounds | 420.0 grams |
| KODAK Sodium Sulfite, desiccated | 1 oz 145 grains | 10 pounds | 10.0 grams |
| KODALK Balanced Alkali | 4 ounces | 30 pounds | 30.0 grams |
| KODAK Acetic Acid, 28%,* or | 15½ ounces | 14½ gallons | 120.0 ml |
| KODAK Glacial Acetic Acid | 4¼ ounces | 4 gallons | 33.0 ml |
| KODAK Potassium Alum | 3 ounces | 22½ pounds | 22.5 grams |
| Water to make | 1 gallon | 120 gallons | 1.0 liter |

Replenishment Rate—1 gallon per 3700 feet of 16mm film (1 ml per foot).

*To make approximately 28% acetic acid from glacial acetic acid, dilute 3 parts of glacial acetic acid with 8 parts of water.

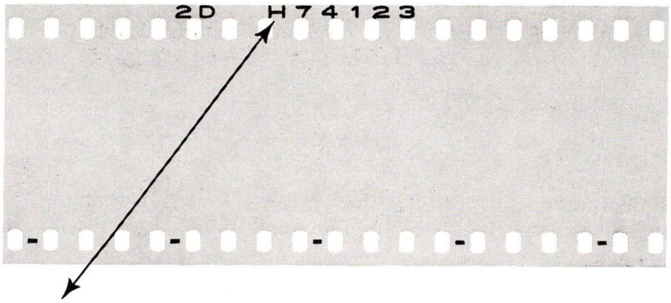
# Physical Characteristics

## FILM SUPPORT

Since 1950, all EASTMAN Motion Picture Films intended for regular motion-picture production work have been supplied only on safety support of the cellulose triacetate and acetate-propionate types. The latter is used only for some reversal-type multilayer color films. Certain films have been furnished on a polyester safety base, called KODAK ESTAR Base, so that they can be used in instrumentation and related applications. However, the information given in this data book applies only to films with cellulose triacetate or acetate-propionate base.

## EDGE MARKING

Where considered necessary for editing and other purposes, consecutive edge numbers are placed every 6 inches (20 frames) on 16mm films and every 12 inches (16 frames) on 35mm films. The numbers are printed in ink or as latent images; the manner of printing is indicated on the specification sheets. Frame-line markings are printed in black ink after every fourth perforation, as illustrated, on all 35mm films.




An initial, like the one indicated here, is printed just ahead of the edge number on many of the 35mm EASTMAN KODAK Motion Picture Films to identify the film. The letter H in the illustration identifies EASTMAN PLUS-X Negative Film, Type 4231. For 16mm films that are edge numbered, no code initial is used. In the illustration given, the figure and letter (2D) located to the left of the code initial are for use in manufacturing operations and do not identify the film.

## ANTIHALATION BACKING

Light penetrating the emulsion of a film is reflected from the back of the support and strikes the emulsion again, causing halation around the images of bright objects. In many of the films described in this book, a light-absorbing gray dye is incorporated in the support to reduce the intensity of the reflected light and nearly eliminate halation. The dye does not bleach out in the processing solutions, but its presence has no effect on the printing quality. In addition to the dye, some of the films have an antihalation undercoat between the emulsion and the base to further reduce halation and increase sharpness. This undercoat is removed in the processing.

On certain types of films, as noted in the specification sheets, a jet-black coating is applied to the back of the film to provide protection from halation. This backing is removable during processing, but requires special treatment in alkaline solutions, followed by spray washing and buffing for its complete removal.

## MAGNETIC STRIPING

Most EASTMAN KODAK 16mm camera films are available with magnetic sound striping for use in single-system sound cameras fitted with magnetic recording heads. The films, perforated along one edge and furnished in Winding B (see page 38), are striped on the base side only. A recording stripe 0.100 inch wide is applied along the unperforated edge and a 0.030-inch-wide balance stripe of the same material as the recording stripe is applied along the perforated edge. This meets the specifications of USA Standard PH22.87–1958.

## PERFORATIONS

EASTMAN KODAK Motion Picture Films are slit and perforated in accordance with the USA Standard Dimensions for Motion Picture Film. The specifications are summarized on pages 45 through 48.

Each type of perforation is identified by a letter symbol, which refers to those who developed the particular perforation, and by a number, which indicates the pitch dimension. The symbol BH (Bell and Howell) refers to the negative-type perforations on films used for making picture negatives and duplicates, and for use in special-effect processes. The letters KS (Kodak Standard) are used for the positive-type perforations on most positive and sound-recording films. The letters DH (Dubray-Howell) designate a perforation that has the same height as the Bell and Howell perforation and the straight sides of the Kodak Standard perforation; it is used at present only for color-print film. The letters CS (CinemaScope) designate the smaller perforations used for release prints in which additional space must be provided for multiple sound tracks. On 16mm films, the symbols 1R (one row) and 2R (two rows) identify film perforated along one edge and two edges, respectively.

In addition to letter symbols, numbers following the letters are used to designate the perforation pitch, which is the distance from the bottom edge of one perforation to the bottom edge of the next perforation. Thus the designation BH 1866 indicates a film having Bell and Howell perforations with a pitch dimension of 0.1866 inch, appropriate for negative and duplicating materials.

### Optimum Pitch for Printing

The printing of motion-picture film is usually done on continuous printers designed so that the negative or original film and the raw stock pass in contact around the printing sprocket, with the raw stock on the outside. To prevent slippage between the two films during printing (which would produce an unsharp or unsteady image on the screen), the negative or original film must be slightly shorter in longitudinal pitch than the positive raw stock. With the Bell and Howell continuous printers commonly used, the diameter of the printing sprocket is such that the pitch of the negative or original film should be 0.2 to 0.4 percent (theoretically 0.3 percent) shorter than the positive raw stock. With the older nitrate and safety films this condition was achieved by natural shrinkage of the negative during processing and early aging. Because the substantially lower shrinkage of present safety-base films makes such a natural adjustment impossible, negative film is now manufactured with the pitch slightly shorter than the pitch of the print film. For 35mm film, the pitch dimensions are .1870 inch for print film and .1866 inch for negative film; for 16mm they are .3000 inch and .2994 inch respectively.

## DIMENSIONAL-CHANGE CHARACTERISTICS

Motion picture film changes size with changes in atmospheric conditions. It swells during processing, shrinks during drying, and continues to shrink at a decreasing rate throughout its life.

Dimensional changes in film may be classified into two types: *temporary* or *reversible*, and *permanent* or *irreversible*. Temporary size changes are caused by a change in the moisture content or the temperature of the film. Permanent shrinkage is due to loss of residual solvents, loss of plasticizer, and, to a slight extent, the gradual elimintion of strains introduced during manufacture or processing. Permanent shrinkage occurs in aging of the raw stock, in processing, and in aging of the processed film. Both temporary and permanent size changes are largely dependent on the film support. However, the emulsion is considerably more hygroscopic than the base, and this too has a marked influence on humidity size changes.

Values for the dimensional-change characteristics of current EASTMAN Motion Picture Films are given on page 33.

### Temporary or Reversible Size Changes

**Moisture Content.** The relative humidity of the air that is in contact with the film is the major factor affecting the moisture content of the film and this governs the amount of temporary expansion or contraction that occurs at constant temperature. For reversal color and for negative films the humidity coefficients are slightly higher than for positive films. The humidity coefficients given in the table are averages for the range of 20 to 70 percent RH, where the relationship between film size and relative humidity is approximately linear. Slightly higher coefficients are found at relative humidities below and above this range. When a given relative-humidity level is approached from above, the exact dimensions of a piece of film will be slightly larger than when the level is approached from below. This phenomenon is known as *hysteresis*.

**Temperature.** As with most materials, photographic film expands with heat and contracts with cold. The thermal coefficients for present films are listed in the table. It often happens, however, that the relative humidity in an unconditioned atmosphere drops when the temperature rises, and since the effect of humidity is greater than that of heat, the net result in such cases is a contraction. Where the film is confined in a camera or a storage container, moisture changes occur very slowly, if at all, and in these cases a change in temperature will cause expansion or contraction according to the thermal coefficients.

**Rates of Change.** Following a change in the relative humidity of the air surrounding a single strand of film, humidity size changes occur rapidly in the first ten minutes and continue for about an hour. If the film is in roll form, this time will be extended to several weeks because of the longer path that moisture must follow. In the case of temperature changes, a single strand of film that comes in contact with a hot metal surface, for example, will change size almost instantly. A roll of film, on the other hand, requires several hours to change size when placed in warmer air.

| Approximate Dimensional-Change Characteristics of Current EASTMAN KODAK Motion Picture Films | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Film | Base | Humidity Coefficient of Expansion, % per 1% RH (a) | | Thermal Coefficient of Expansion, % per 1 F. (b) | | Processing Shrinkage, % (c) | | Potential Aging Shrinkage, % (d) | |
| | | Length | Width | Length | Width | Length | Width | Length | Width |
| Black-and-white camera negative, duplicating negative, Color Negative, Color Internegative, Color Intermediate, EKTACHROME Commercial, EKTACHROME MS, EKTACHROME EF, EKTACHROME ER, and variable-area sound recording films. | Triacetate (negative) | .007 | .009 | .0025 | .0035 | .04 | .06 | 0.2 | 0.25 |
| Black-and-white release positive, duplicating positive, variable-density sound-recording films, and EASTMAN Color Print Film. | Triacetate (positive) | .0055 | .007 | .0025 | .0035 | .04 | .06 | 0.4 | 0.5 |
| 16mm KODACHROME Films and EASTMAN Reversal Color Print. | Acetate-Propionate | .0095 | .0105 | .003 | .004 | .10 | .08 | 0.45 | 0.55 |

(a) Measured between 20% and 70% RH at 70 F (21 C).

(b) Measured between 120 F (49 C) and 70 F (21 C) at 20% RH.

(c) Tray processing. Measured at 70 F and 50% RH after preconditioning at low relative humidity.

(d) Over a period of years at normal conditions, and shorter times at elevated temperatures or humidity.

### Permanent Size Changes

**Processing Swell and Shrinkage.** Motion picture film swells during processing and contracts during drying. At 70 F the maximum swell is approximately as follows:

| Film Type | Base | Swell, % | |
|---|---|---|---|
| | | Length | Width |
| Negative | Triacetate | 0.4 | 0.6 |
| Positive | Triacetate | 0.3 | 0.5 |
| Reversal Color | Acetate-Propionate | 0.6 | 0.8 |

In processing solutions at 70 F the rate of swell of film is rapid during the first ten minutes and continues slowly for about an hour. At higher temperatures the rate of swell becomes increasingly more rapid. During drying, the film shrinks to slightly less than its original dimensions at a rate corresponding to the rate of drying.

The net result of processing is a slight shrinkage if the film is not stretched and if it is conditioned as indicated on page 33. However, when the film approaches a specific relative-humidity level from above, as usually happens in drying after processing, the net processing shrinkage of current film is very close to zero. Some commercial processing machines have a high enough tension to stretch the wet film (particularly 16mm film); consequently, a lower processing shrinkage or even a slight permanent stretch may result.

**Aging Shrinkage.** It is important that motion picture negatives, internegatives, and color originals have low aging shrinkage, so that satisfactory prints or duplicates can be made from them even after many years of storage. With motion picture positive film intended for projection only, shrinkage is not especially critical, because it has little effect on projection.

The rate at which permanent shrinkage occurs depends on the conditions of storage and use. It is accelerated by high relative humidity (because the diffusion of solvents is aided by the presence of moisture) and by high temperature. Shrinkage of film in roll form, especially if it is confined in a taped can, is less rapid than shrinkage of a single layer of film open to the air.

Immediately after slitting and perforating, motion picture film is placed in cans which are then taped. Until the film is removed, the gain or loss of moisture or loss of solvents is extremely low; in 35mm film in 1000-foot cans, the lengthwise shrinkage will rarely exceed 0.1 percent during the first four or five months. In 16mm film, somewhat greater shrinkage may be found, particularly in the case of small rolls.

Shrinkage of exposed film is minimized when the film is in tightly wound rolls. However, if such rolls are handled in very dry air, buckling of the film may be caused by differential shrinkage of the outside edges. Handling these rolls in very moist air may produce fluted edges, due to differential swelling and stretching of the edges of the film. Neither of these effects occurs to any great extent with ordinary use of the film, but a tight roll of film exposed overnight to very high or very low humidity may be severely damaged.

The potential aging shrinkage of current motion picture films is given on page 33. In the case of processed negatives made on stock manufactured since June, 1954, the potential lengthwise shrinkage of about 0.2 percent is generally reached within the first two years and then almost no further shrinkage occurs. (This is the actual size change and must be added to the initial deviation from standard pitch in the perforating operation to obtain the total deviation from standard pitch. See page 31.) A size change of this magnitude represents a considerable improvement in shrinkage characteristics over negative materials that were available in the past and assures good printing capability after long periods of keeping.

For release positive films, the severity of the conditions encountered during handling and projection produces a somewhat more rapid shrinkage than is found in film stored under normal conditions but not used. Ordinarily, the lengthwise shrinkage of release prints made on today's films will be about 0.1 to 0.3 percent for 35mm film and 0.1 to 0.4 percent for 16mm film during the first two years. Higher shrinkage may occur over a longer period, as indicated on page 33.

In this discussion, the aging shrinkage of motion picture film has been separated from temporary size changes. Actually, however, both types of change can occur simultaneously. Humidity and thermal size changes may either increase or decrease the apparent shrinkage that results from aging of the film. For more detailed information on the complex subject of dimensional changes, see the following references:

Carver, E. K., Talbot, R. H., and Loomis, H. A., "Effect of High-Intensity Arcs Upon 35mm Film Projection," J. Soc. Mot. Pict. Eng., *41*:69-87, July, 1943.

Calhoun, J. M., "The Physical Properties and Dimensional Behavior of Motion Picture Films," J. Soc. Mot. Pict. Eng., *43*:227-66, October, 1944.

Talbot, R. H., "Some Relationships Between the Physical Properties and the Behavior of Motion Picture Films," J. Soc. Mot. Pict. Eng., *45*:209-17, Sept., 1945.

Fordyce, C. R., "Improved Safety Motion Picture Film Support," J. Soc. Mot. Pict. Eng., *51*:331-50, October, 1948.

Fordyce, C. R., Calhoun, J. M., and Moyer, E. E., "Shrinkage Behavior of Motion-Picture Film," J. Soc. Mot. Pict. and Tel. Eng., *64*:62-66, February, 1955.

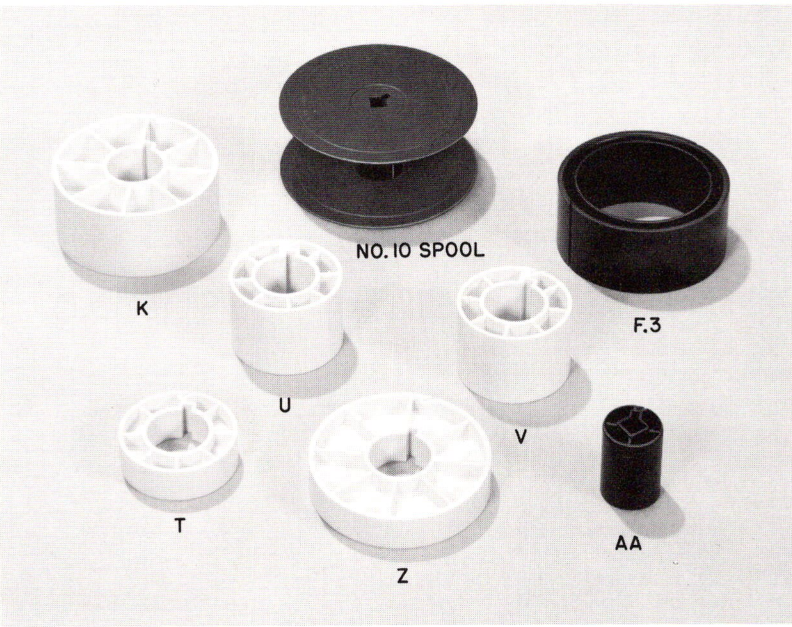
Adelstein, P. Z., and Calhoun, J. M., "Interpretation of Dimensional Changes in Cellulose Ester Base Motion-Picture Films," J. Soc. Mot. Pict. and Tel. Eng., *69*:157-63, March, 1960.

Miller, A. J., and Robertson, A. C., "Motion-Picture Film—Its Size and Dimensional Characteristics," J. Soc. Mot. Pict. and Tel. Eng., *74*:3-11, January, 1965.

# Cores, Winding, and Packaging

## CORES

EASTMAN KODAK Motion Picture Films are furnished on several types of cores, the design of the core depending on the equipment in which the films are to be exposed. The standard core types are shown in the illustration on this page. The expressions "wound on" and "inserted" used in the following descriptions of the cores are also used in the specification sheets for the individual films. "Wound on" indicates that the film is wound tightly on the core and the core cannot be removed from the roll except by unwinding the film. "Inserted" means that the film is initially wound on a collapsible mandrel, which is then removed, and the core is inserted in the cavity of the roll; thus the film is not actually attached to the core.




Standard core types for EASTMAN KODAK Motion Picture Films.

**No. 10 Spool—35mm.** A metal camera spool with flanges 3⅝ inches in diameter, finished in matte black. Both flanges are provided with square holes that have single keyways. The two keyways are aligned. This spool is used with 100-foot lengths of picture negative materials, and the film is wound emulsion side in unless otherwise specified. A spool of this type is required by the DeVry, Eyemo, and certain other cameras.

**Type AA—35mm.** A plastic core 1 inch in diameter. It is used with 200-foot lengths of picture negative materials for the Akeley and certain other cameras and with 200- and 400-foot lengths of positive materials. The core is inserted in the center of the roll after it is wound.

**Type U (Universal)—35mm.** A TENITE core provided with a keyway that extends all the way through the center. This is the core customarily used for picture negative, sound, and television recording films, and positive films that are used in title cameras. Films supplied on Type U cores are always wound on.

**Dimensions and Tolerances—Type U Core**

| | | |
|---|---|---|
| Outside Diameter | 1.968 ± 0.010 inches | 49.99 ± 0.25mm |
| Inside Diameter | 1.020 ± 0.008 inches | 25.91 ± 0.20mm |
| Width of Core | 1.375 inches, maximum | 34.92mm, maximum |
| Width of Keyway | 0.157 ± 0.008 inch | 3.99 ± 0.20mm |
| Depth of Keyway | 0.157 ± 0.008 inch | 3.99 ± 0.20mm |

**Type K—35mm.** A TENITE core similar to the Type U core and with the same dimensions except for the outside diameter, which is 3.055 ± 0.07 inches (77.6 ± 1.78mm). It is used for longer lengths (2000 and 3000 feet) of negative, sound, and television recording films. Such films are wound on.

**F.3 Core—35mm.** A plastic core 80mm in diameter on which 1000-foot rolls of negative film are wound, emulsion out, for use in the Debrie Super Parvo Camera.

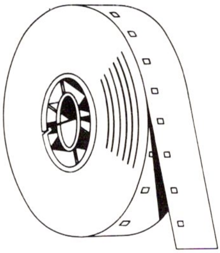
**Type V—32mm.** A TENITE core similar in construction to the Type U core, but 32mm maximum (1.252 inches) in width instead of 35mm.

**Type T—16mm.** A TENITE core similar in construction to the Type U core, but 16mm maximum (0.627 inch) instead of 35mm in width. It is normally used with all 16mm films up to 400 feet in length, except 100- and 200-foot lengths of picture negative materials. These two lengths are generally furnished on camera spools with integral leaders and trailers, suited for loading under subdued light.

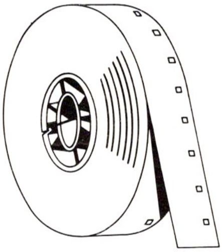
**Type Z—16mm.** A TENITE core similar to the Type T core, but 3.0 ± 0.016 inches (76.2 ± 0.4 millimeters) in diameter instead of 2 inches. It is used with 16mm camera and laboratory films in roll sizes longer than 400 feet.

## WINDING

Two different windings, designated as Winding *A* and Winding *B*, are used with 16mm films that are perforated along one edge. Both types are required for use on existing equipment, and the particular winding that is needed should be specified when ordering 16mm raw stock with the perforations along one edge. The following sketches illustrate the two types of windings:



Winding **A**
Emulsion Side In

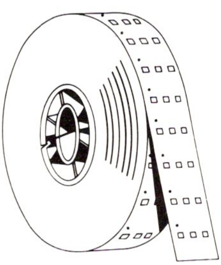


Winding **B**
Emulsion Side In

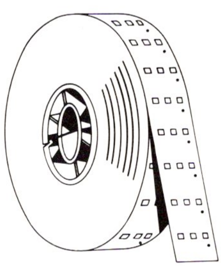
In the above sketches, the film is wound on cores and the emulsion side of the film faces the center of the roll. When the roll is held so that the end of the film or leader leaves the roll at the top and toward the right, Winding *A* has the perforations along the edge of the film toward the observer and Winding *B* has the perforations along the edge away from the observer.

Sixteen-millimeter film for use in single-system sound cameras is regularly furnished in Winding *B*. This film, perforated along one edge and supplied on 100-, 200-, and 400-foot spools, fits most cameras.

Thirty-five-millimeter films with 16mm and 8mm perforations have a series of small round holes punched along one edge between perforations to identify the edge that will be discarded in the finishing operations. When the rolls are held as in the sketches below, Winding *L* has the round holes along the edge toward the observer and Winding *R* has the holes on the edge away from the observer.



Winding **L**
Emulsion Side In



Winding **R**
Emulsion Side In

## PACKAGING AND PACKING

Most EASTMAN Motion Picture Films are wound on cores, wrapped in black paper envelopes, and packaged in taped metal cans. The black paper envelopes serve only as protection against exposure to light. They provide a tight fit and prevent excessive movement of the roll in the can during shipment. When shorter lengths of film are packaged in standard-size cans, bands of brown crepe-paper filler are wound around the envelopes to take up empty space in the cans.

The tape used on the outside of film cans serves as a seal between the cover and body of the can and prevents, to a considerable extent, the interchange of moisture between the inside of the can and the external atmosphere. This tape is produced for the specific purpose of packaging film and is designed to provide resistance to the flow of air and moisture vapor. It is used on all cans, including the one for the No. 10 spool. No black paper envelope, however, is used around the No. 10 spool when it is placed in the can. A paper retaining band is provided to hold the film securely on the spool.

All cans in which EASTMAN KODAK Motion Picture Films are packaged are clearly labeled with the film name, and numbers that identify the product type, emulsion number, and roll number. For example, EASTMAN PLUS-X Negative Film is identified by name and by numbers such as: 4231-12-24. In this case, the number 4231 designates the film type, the emulsion number is 12, and the roll number is 24. For all film wound on cores, similar numbers are perforated in the film itself at the beginning of each individual roll of raw stock.

Cans containing 35mm films are packed in corrugated shipping cases. To supply extra protection for negative and duplicating films, a corrugated wrap is placed around each can before it is packed in the shipping case. With some exceptions, 16mm films are packaged two rolls to the can and placed in corrugated shipping cases.

# Storage

EASTMAN KODAK safety films are listed by the National Board of Fire Underwriters as: "Film—slow burning. Hazards in the use and storage are small, being somewhat less than would be presented by common newsprint paper in the same form and quantity." These films also meet the requirements (difficult to ignite, slow burning, and low in nitrogen content) of the USA Standard Specifications for Safety Photographic Film, PH1.25—1965, copies of which are available from the United States of America Standards Institute, 10 East 40th Street, New York, New York 10016.

Although current EASTMAN KODAK Motion Picture Films are supplied on safety base only, it will be a considerable time before older nitrate-base materials are completely out of circulation or no longer in storage. The large inventory of nitrate picture and sound negatives, duplicate negatives, and positives built up before 1950 has continuing interest and is likely to be drawn upon periodically. Since much of this nitrate film can be expected to remain in physically acceptable condition for at least 40 years, it is apparent that chemical degradation will not eliminate the hazards of nitrate film before 1990 at the earliest. It is important that some positive means be available for proper identification of nitrate and safety-base materials so that one can be segregated from the other, and proper storage facilities can be provided for the highly inflammable nitrate-base material. This subject is discussed fully in a booklet entitled *Hazard in Handling and Storage of Nitrate and Safety Motion Picture Film.* Copies of this booklet can be obtained by writing the Motion Picture and Education Markets Division, Eastman Kodak Company.

## STORAGE OF RAW STOCK

Virtually all photosensitive materials deteriorate with age. There may be a loss in sensitivity, a loss in contrast, a growth in fog level, or all three. In color films, the rates at which the various color-sensitive layers lose speed may differ under adverse conditions and thus upset the color balance of the material. This type of deterioration is increased by both heat and moisture.

Reduced storage temperatures are required for motion picture negative film stock in order to maintain the initial speed of the film as long as possible. Low storage temperatures for color films help to maintain the proper color balance as well as sensitivity. With black-and-white motion picture positive stock, on the other hand, high uniformity from roll to roll is more important than preservation of the initial speed. For this reason, it is more important for the positive stock to be stored at a constant temperature, uniform throughout the storage area, than that the temperature be especially low.

Maximum temperatures recommended for the storage of motion picture raw stock are given in the table below. There is no harm in using lower temperatures than those recommended.

**Recommended Maximum Temperatures for Film Storage**

| Type of Film | Maximum Storage Temperature for Periods up to 6 Months |
|---|---|
| Black-and-White Film | |
| 1. Negative, reversal, and sound films. | 55 F |
| 2. Positive films. | 65 F |
| Color Film | |
| 1. EASTMAN Color Films. | 50 F |
| 2. KODACHROME and KODAK EKTACHROME Films. | 65 F |

When the film is removed from storage, it must be allowed to warm up until its temperature is above the dew point of the laboratory air before the can is unsealed; otherwise, moisture condensation and spotting of the film may occur. For film in standard packages, suggested warm-up times are as follows:

**Approximate Warm-Up Time for Film Packages to Avoid Moisture Condensation after Removal from Cold Storage**

| Room temperature minus refrigerator temperature | 25 F | | 100 F | |
|---|---|---|---|---|
| Relative humidity in room | 70% | 90% | 70% | 90% |
| | Warm-up time (hours) | | | |
| Single 16mm roll | 0.5 | 1 | 1 | 1.5 |
| Single 35mm roll (or double 16mm) | 1.5 | 3 | 3 | 5 |
| Carton of ten 35mm rolls | 12 | 28 | 30 | 46 |

Humidity control in the storage area is of much less importance than temperature control for the storage of raw stock in the original sealed cans. *(The cans should remain sealed until the film is to be used.)* However, very high relative humidities (70 percent or over) in the storage area should be avoided because of possible damage to labels and cartons from moisture and mold, and to cans from rust. Low humidities cause no harm before the package seal is broken.

## STORAGE OF EXPOSED FILMS

High temperature or high relative humidity can produce undesirable changes in the latent image, so films should be processed as soon as possible after they have been exposed. This is particularly important with color films, since such changes occur in each of the separate layers and may be different for each layer, thus upsetting the color balance.

Films should not remain in the camera or magazines longer than necessary. Loaded cameras or magazines and carrying cases containing film should be protected from direct sunlight, even in temperate climates. Films in loaded cameras, magazines, or even in original packages should never be left in closed spaces that may trap heat from the sun or other sources. The temperature in closed automobiles, parked airplanes, or the holds of ships, for example, can easily reach 140 F or more. A few hours under such conditions, either before or after exposure, may severely impair the quality of the film.

Special provision must be made for keeping exposed film cool and dry if several days or weeks of adverse climatic conditions (temperature above 75 F or relative humidity above 60 percent) are to be expected before the film can be processed. Sixteen-millimeter film that has been in a camera in a humid atmosphere for more than a day or two should be dried by means of desiccants before being resealed in its original container.

Satisfactory drying of 35mm films by means of desiccation is not possible because of the slow transfer of moisture through a large roll. Therefore, it is necessary to avoid excessive moisture take-up when handling film than to depend on removing the excess moisture after it has been absorbed.

All rolls of film should be kept in their original taped cans (which will prevent any exchanges in moisture between the rolls and their surroundings) up to the time they are to be exposed. Magazines that are loaded a long time ahead of use should be held in an air-tight metal box until they are needed for camera exposure.

Immediately after exposure, the film should be returned to its can and retaped to prevent any increase in moisture content over that picked up during actual exposure. If there are delays of a day or more in shooting, a magazine containing partially used film should be removed from the camera and placed in a moisture-tight dry chamber. This will prevent any absorption of moisture by the film during the holding period. In warm weather, exposed film, whether dried or not, should be stored in taped cans inside a mechanical refrigerator, if available, until it can be processed or shipped to a processing laboratory.

## STORAGE OF PROCESSED FILM

Storage of processed film differs from the storage of the raw stock because the film is no longer photosensitive, it is seldom sealed against moisture, and much longer storage periods are generally involved. The conditions to be employed depend on considerations such as the value of the records and the length of time they are to be stored. Storage of processed black-and-white films is discussed in a separate booklet, *Storage and Preservation of Motion Picture Film,* available through Kodak dealers.

### Storage of Processed Color Film

Because they contain dyes that may fade and cause deterioration of the image and changes in color balance, color films require more care in handling and storage than do black-and-white films. The recommendations given below should be followed in the storage of processed color films.

**1.** Each film must receive adequate washing to remove residual chemicals. A test should be made to see whether the film contains residual silver due to inadequate bleaching. It is also important to make sure that the residual hypo level does not exceed the recommended maximum.

**2.** The film should be treated in the recommended stabilization bath for the proper time to provide stabilization of the dye images. In addition, the pH of the emulsion should be checked to see that it is at the proper level.

**3.** Wetting agents for prevention of water spots and detergents for cleaning processed film should be selected with great care. Some compounds may release sulfur dioxide or trioxide on keeping and these compounds will affect the dye images. Anti-mold agents in some wetting agents may also be harmful to the dyes. KODAK Photo-Flo Solution is satisfactory in all of these aspects.

**4.** If alkaline or detergent solutions are used to clean film, it is recommended that the film be restabilized in the proper stabilizer solution.

**5.** Film should not be stored in an atmosphere containing acid vapors, fumes of sulfur dioxide or hydrogen sulfide; it also should not be stored in an area with high relative humidity.

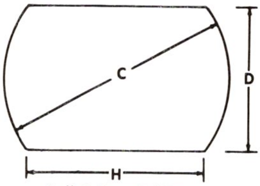
**6.** Controlled temperature and humidity provide the best conditions for storage of film. A relative humidity of 40 to 50 percent at a temperature of 70 F or less is best. Where it is not feasible to furnish controlled humidity conditions, the film should be kept in a taped can. Before the can is taped, the area in which the film (in or out of the can) is kept should have an equilibrium humidity of 50 percent.

**7.** Where conformed footage, consisting of original color negatives and color duplicate negatives, is to be stored, the temperature should be held at 55 F or less to minimize differential fading of the dye image and to avoid the need for re-timing when additional prints are wanted.

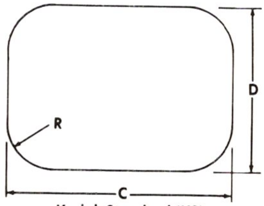
**8.** Experience is limited with respect to long-term storage of color films where the storage period may be several years in length. In such circumstances, extremely low storage temperatures of the order of 0 F would most likely be of benefit. However, for positive insurance against total loss of valuable original color-negative or optical-effects footage due to dye fading, it is recommended that black-and-white separation positives be made on EASTMAN Panchromatic Separation Film, Type 5235.

# USA Standard Dimensions for Motion Picture Films

## PERFORATION DIMENSIONS



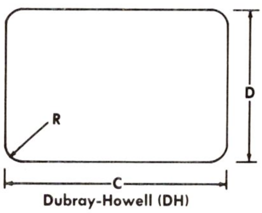
Bell & Howell (BH)



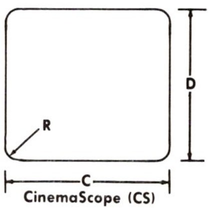
Kodak Standard (KS)

| Dimension | Perforation Type | | | | Tolerances ± | |
|---|---|---|---|---|---|---|
| | Bell & Howell | | Kodak Standard | | | |
| | Inches | MM | Inches | MM | Inches | MM |
| C | 0.110 | 2.794 | 0.110 | 2.794 | 0.0004 | 0.010 |
| D | 0.073 | 1.854 | 0.078 | 1.981 | 0.0004 | 0.010 |
| H* | 0.082 | 2.08 | | | | |
| R | | | 0.020 | 0.51 | 0.001 | 0.03 |

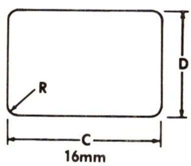
*Dimension H is a calculated value.



Dubray-Howell (DH)



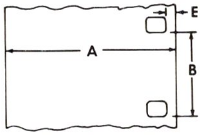
CinemaScope (CS)



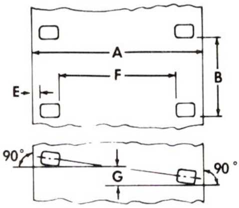
16mm

| Dimension | Perforation Type | | | | | | Tolerances ± | |
|---|---|---|---|---|---|---|---|---|
| | Dubray-Howell | | CinemaScope | | 16 Millimeter | | | |
| | Inches | MM | Inches | MM | Inches | MM | Inches | MM |
| C | 0.110 | 2.794 | 0.078 | 1.981 | 0.072 | 1.829 | 0.0004 | 0.010 |
| D | 0.073 | 1.854 | 0.073 | 1.854 | 0.050 | 1.270 | 0.0004 | 0.010 |
| R | 0.013 | 0.33 | 0.013 | 0.33 | 0.010 | 0.25 | 0.001 | 0.03 |

## FILM DIMENSIONS
### 16mm

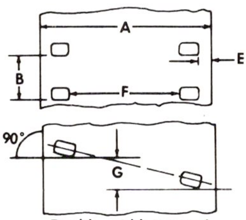


Perforated one edge

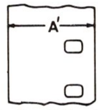


Perforated two edges

| Dimension | Perforation Type and USA Standard Number | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1R-2994 (PH22.109) | | 1R-3000 (PH22.12) | | 2R-2994 (PH22.110) | | Tolerances ± | |
| | Inches | MM | Inches | MM | Inches | MM | Inches | MM |
| A | 0.628 | 15.95 | 0.628 | 15.95 | 0.628 | 15.95 | 0.001 | 0.03 |
| B | 0.2994 | 7.605 | 0.3000 | 7.620 | 0.2994 | 7.605 | 0.0005 | 0.013 |
| E | 0.0355 | 0.902 | 0.0355 | 0.902 | 0.0355 | 0.902 | 0.0020 | 0.051 |
| F | | | | | 0.413 | 10.49 | 0.001 | 0.03 |
| G (max) | | | | | 0.001 | 0.03 | — | — |
| L* | 29.94 | 760.5 | 30.00 | 762.0 | 29.94 | 760.5 | 0.03 | 0.8 |



Double width original



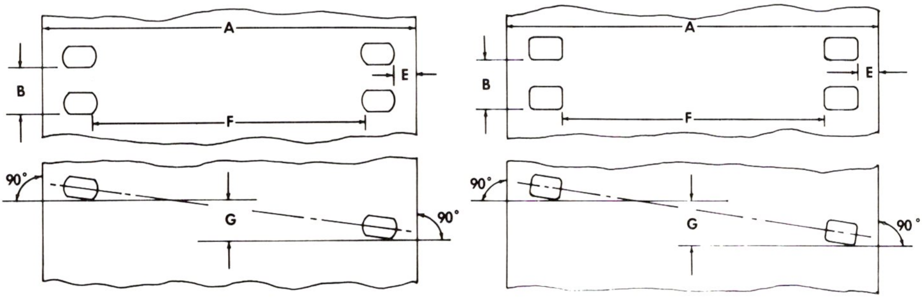
Single width after Processing and Slitting

16mm perforated 8mm

| Dimension | Perforation Type and USA Standard Number | | | | | |
|---|---|---|---|---|---|---|
| | 2R-3000 (PH22.5) | | Perf. 8mm, 2R-1500 (PH22.17) | | Tolerances ± | |
| | Inches | MM | Inches | MM | Inches | MM |
| A | 0.628 | 15.95 | 0.628 | 15.95 | 0.001 | 0.03 |
| A' | | | 0.314 | 7.98 | 0.002 | 0.05 |
| B | 0.3000 | 7.620 | 0.1500 | 3.810 | 0.0005 | 0.013 |
| E | 0.0355 | 0.902 | 0.0355 | 0.902 | 0.0020 | 0.051 |
| F | 0.413 | 10.49 | 0.413 | 10.49 | 0.001 | 0.03 |
| G (maximum) | 0.001 | 0.03 | 0.001 | 0.03 | — | — |
| L* (2R-3000) | 30.00 | 762.0 | | | 0.03 | 0.8 |
| L* (2R-1500) | | | 15.00 | 381.00 | 0.015 | 0.38 |

*This dimension represents the length of any 100 consecutive perforation intervals.

## FILM DIMENSIONS
## 35mm



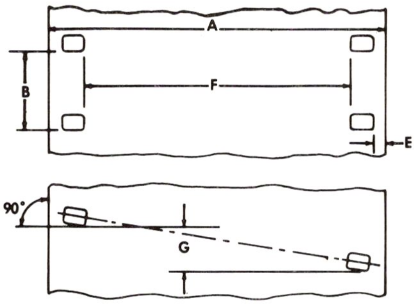

| Dimension | Perforation Type and USA Standard Number | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | BH-1866 (PH22.93) | | BH-1870 (PH22.34) | | CS-1870 (PH22.102) | | Tolerances ± | |
| | Inches | MM | Inches | MM | Inches | MM | Inches | MM |
| A | 1.377 | 34.975 | 1.377 | 34.975 | 1.377 | 34.975 | 0.001 | 0.025 |
| B | 0.1866 | 4.74 | 0.1870 | 4.75 | 0.1870 | 4.75 | 0.0005 | 0.013 |
| E | 0.079 | 2.01 | 0.079 | 2.01 | 0.086 | 2.18 | 0.002 | 0.05 |
| F | 0.999 | 25.37 | 0.999 | 25.37 | 1.049 | 26.64 | 0.002 | 0.05 |
| G (max) | 0.001 | 0.03 | 0.001 | 0.03 | 0.001 | 0.03 | — | — |
| L* | 18.66 | 474.00 | 18.70 | 474.98 | 18.70 | 474.98 | 0.015 | 0.38 |

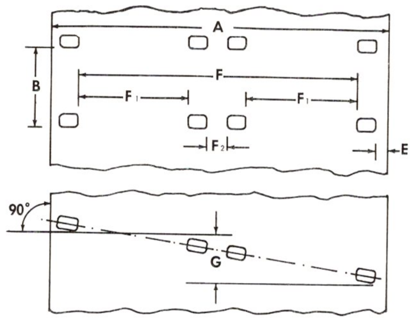
| Dimension | Perforation Type and USA Standard Number | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | DH-1870 (PH22.1) | | KS-1866 (PH22.139) | | KS-1870 (PH22.36) | | Tolerances ± | |
| | Inches | MM | Inches | MM | Inches | MM | Inches | MM |
| A | 1.377 | 34.975 | 1.377 | 34.975 | 1.377 | 34.975 | 0.001 | 0.025 |
| B | 0.1870 | 4.750 | 0.1866 | 4.740 | 0.1870 | 4.750 | 0.0005 | 0.013 |
| E | 0.079 | 2.01 | 0.079 | 2.01 | 0.079 | 2.01 | 0.002 | 0.05 |
| F | 0.999 | 25.37 | 0.999 | 25.37 | 0.999 | 25.37 | 0.002 | 0.05 |
| G (max) | 0.001 | 0.03 | 0.001 | 0.03 | 0.001 | 0.03 | — | — |
| L* | 18.70 | 474.98 | 18.66 | 474.00 | 18.70 | 474.98 | 0.015 | 0.38 |

| Dimension | Perforation Type and USA Standard Number | | | | | |
|---|---|---|---|---|---|---|
| | Perf. 32mm, 2R-2994 (PH22.73) | | Perf. 32mm, 2R-3000 (PH22.138) | | Tolerances ± | |
| | Inches | MM | Inches | MM | Inches | MM |
| A | 1.377 | 34.98 | 1.377 | 34.98 | 0.001 | 0.03 |
| B | 0.2994 | 7.605 | 0.3000 | 7.620 | 0.0005 | 0.013 |
| E | 0.096 | 2.44 | 0.096 | 2.44 | 0.002 | 0.05 |
| F | 1.041 | 26.44 | 1.041 | 26.44 | 0.002 | 0.05 |
| G (max) | 0.001 | 0.03 | 0.001 | 0.03 | — | — |
| L* | 29.94 | 760.5 | 30.00 | 762.0 | 0.03 | 0.8 |

*This dimension represents the length of any 100 consecutive perforation intervals.

## FILM DIMENSIONS
## 65mm and 70mm




## 65 and 70mm

| Dimension | Perforation Type and USA Standard Number | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 65mm, KS-1866 (PH22.145) | | 65mm, KS-1870 (PH22.118) | | 70mm Perf. 65mm, KS-1870 (PH22.119) | | Tolerances ± | |
| | Inches | MM | Inches | MM | Inches | MM | Inches | MM |
| A | 2.558 | 64.97 | 2.558 | 64.97 | 2.754 | 69.95 | 0.002 | 0.05 |
| B | 0.1866 | 4.740 | 0.1870 | 4.750 | 0.1870 | 4.750 | 0.0005 | 0.013 |
| E | 0.117 | 2.97 | 0.117 | 2.95 | 0.215 | 5.46 | 0.003 | 0.08 |
| F | 2.104 | 53.44 | 2.104 | 53.44 | 2.104 | 53.44 | 0.003 | 0.08 |
| G (max) | 0.002 | 0.05 | 0.002 | 0.05 | 0.002 | 0.05 | — | — |
| L* | 18.66 | 474.00 | 18.70 | 474.98 | 18.70 | 474.98 | 0.015 | 0.38 |

*This dimension represents the length of any 100 consecutive perforation intervals.

## WEIGHTS AND MEASURES CONVERSION TABLES

In American photographic practice, solids are weighed by either the Avoirdupois or the Metric system and liquids are measured correspondingly by U.S. Liquid or Metric measure. The following tables give all the equivalent values required for converting photographic formulas from one system to the other:

### Avoirdupois to Metric Weight

| Pounds | Ounces | Grains | Grams | Kilograms |
|---|---|---|---|---|
| **1** | 16 | 7000 | 453.6 | 0.4536 |
| 0.0625 | **1** | 437.5 | 28.35 | 0.02835 |
| | | **1** | 0.0648 | |
| | 0.03527 | 15.43 | **1** | 0.001 |
| 2.205 | 35.27 | 15430 | 1000 | **1** |

### U.S. Liquid to Metric Measure

| Gallons | Quarts | Ounces (Fluid) | Drams (Fluid) | Milliliters | Liters |
|---|---|---|---|---|---|
| **1** | 4 | 128 | 1024 | 3785 | 3.785 |
| 0.25 | **1** | 32 | 256 | 946.3 | 0.9463 |
| | | **1** | 8 | 29.57 | 0.02957 |
| | | 0.125 | **1** (60 mins.) | 3.697 | 0.003697 |
| | | 0.03381 | 0.2705 | **1** | 0.001 |
| 0.2642 | 1.057 | 33.81 | 270.5 | 1000 | **1** |

### Conversion Factors

| | | | | |
|---|---|---|---|---|
| Grains per 32 fluid oz | multiplied by | 0.06847 | = | grams per liter |
| Ounces per 32 fluid oz | multiplied by | 29.96 | = | grams per liter |
| Pounds per 32 fluid oz | multiplied by | 479.3 | = | grams per liter |
| Grams per liter | multiplied by | 14.60 | = | grains per 32 fluid oz |
| Grams per liter | multiplied by | 0.03338 | = | ounces per 32 fluid oz |
| Grams per liter | multiplied by | 0.002086 | = | pounds per 32 fluid oz |

Grams per liter approximately equals ounces per 30 quarts
Grams per liter approximately equals pounds per 120 gallons
Ounces (fluid) per 32 oz multiplied by 31.25 = milliliters per liter
Milliliters per liter multiplied by 0.032 = ounces (fluid) per 32 oz

cm × .3937 = inches        inches × 2.5400 = cm

*Motion Picture and Education Markets Division*

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