Motion Picture Laboratory Practice

and

CHARACTERISTICS OF EASTMAN MOTION PICTURE FILMS

EASTMAN KODAK COMPANY

ROCHESTER, N. Y.

1936

CHAPTER II

Eastman Motion Picture Films

Introduction

It is the purpose of this chapter to provide certain data, sensitometric and otherwise, pertaining to the different films manufactured by the Eastman Kodak Company for the motion picture industry—data which we believe will be of value to those in the industry, and of interest to those in other fields of motion picture work. A complete study of any emulsion should include both sensitometric and practical tests; this chapter, however, is concerned primarily with the characteristics of the different materials as determined by sensitometric and spectrographic tests.

The sensitometric data for each material have been calculated from a large number of tests and may be taken as representing the general characteristics of the material under consideration. The instruments and methods employed are, in general, similar to those used in the processing laboratory, namely, the Eastman Sensitometer, Type IIb, and the Eastman Densitometer. The standard negative set-up was used in exposing the negative materials, and the positive set-up for the positive, sound-recording, and duplicating materials. The color temperature of the light incident on the photographic material is in the first case approximately 5000° K and in the second 3100° K, the former simulating average noon sunlight and the latter the tungsten sources in general use for printing, duplicating, and sound recording. The use of light of tungsten quality in the case of negative materials would result in a change in the inertias of the different films and produce a slight change in the gamma for a given time of development, but would not alter the general shape of the *D*-log *E* curve.

The negative materials were developed in an Elon-hydroquinone-borax developer (Formula D-76) (seasoned), and the positive materials in an Elon-hydroquinone positive formula (D-16). Emulsion No. 1359, when used for variable-width sound recording, is usually developed in a positive-type developer, and when used for variable-density recording in a negative-type developer. Hence, curves are shown for this material both in Elon-Hydroquinone-Borax Formula D-76, and in Elon-Hydroquinone Positive Formula D-16. The time-gamma curves show approximately the time of development required for different gammas, and the processing

latitude of the various materials. It should be pointed out, however, that the time of development for a given gamma depends upon a number of factors, the most important aside from the emulsion and developer characteristics being temperature and the degree of agitation. The time-gamma curves reproduced in this chapter apply only to the conditions of development as employed in the Kodak Research Laboratories, and should not be regarded as indicating exactly the time of development required to obtain a specified gamma under other processing conditions.

The spectrograms were made on a wedge spectrograph of the type described in Chapter I, using light of daylight quality as defined by the Seventh International Congress of Photography,* and a tungsten source operating at a color temperature of 3000° K.

The glass wedge employed in the instrument possesses greater absorption for short-wave than for long-wave radiation; hence, wedge spectrograms should not be used for comparisons of total sensitivity nor for the precise determination of the distribution of spectral sensitivity for a particular material. They may be used, however, for qualitative comparisons of the color sensitivity of the different materials.

The absorption of short-wave radiation by the glass wedge of the spectrogram has the effect of causing panchromatic materials to appear more sensitive to long-wave than to short-wave radiation. This, however, is not true for any of the materials described assuming a light source of sunlight quality.

The materials discussed in this chapter include the following:

Name	Code Number	Color of Base
(1) *Negative Materials*		
Eastman Negative Motion Picture Film	1201	Clear
Eastman Background Panchromatic Negative Motion Picture Film	1213	Clear
Eastman Super Sensitive Panchromatic Negative Motion Picture Film	1217	Gray or Clear
Eastman Super X Panchromatic Negative Motion Picture Film	1227	Gray or Clear
(2) *Positive Materials*		
Eastman Positive Motion Picture Film	1301	Clear
Eastman Sonochrome Tinted Positive Motion Picture Film		Various

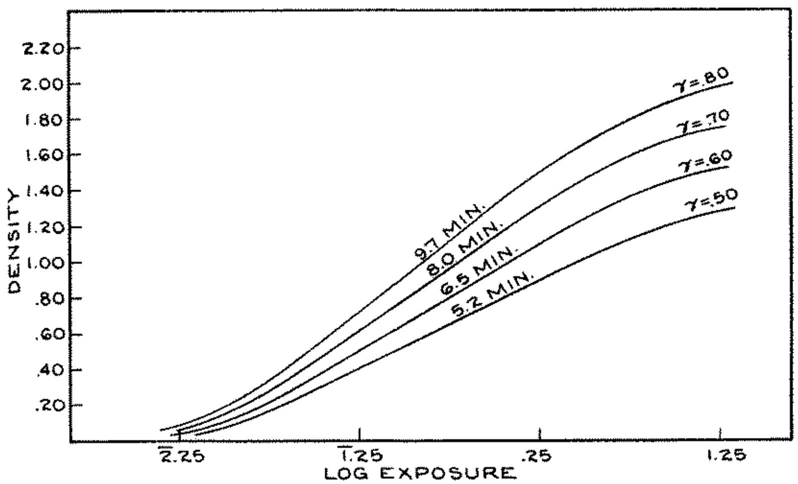
*Jones, L. A.: *J. Soc. Mot. Pict. Eng., Vol. 18* (1932), p. 341; "Photographic Sensitometry," *Eastman Kodak Co.* (1934), p. 144.

(3) *Sound-Recording Material*

Name	Code Number	Color of Base
Eastman Sound Recording Motion Picture Film	1359	Clear
(4) *Duplicating Materials*		
Eastman Duplicating Positive Motion Picture Film (Regular)	1355	Lavender
Eastman Duplicating Positive Motion Picture Film, Type B	1362	Lavender
Eastman Duplicating Negative Motion Picture Film (Regular)	1503	Clear
Eastman Duplicating Negative Motion Picture Film (Fast)	1505	Clear

Eastman Negative Motion Picture Film (No. 1201)

This is a high-speed, blue-sensitive negative material, and is used where the rendering of color is not important and extreme speed is not required. Typical characteristic curves of this emulsion and a time-gamma curve are shown in Figure 17.



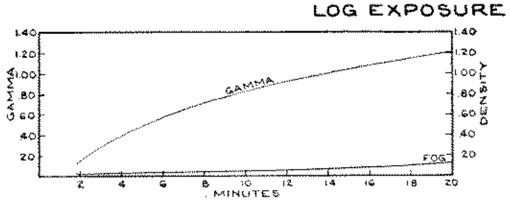


FIG. 17—*Above:* Characteristic or *D*-log *E* curve of Eastman Negative Motion Picture Film (No. 1201) in D-76.

At left: Time-gamma curve of the same film. For description of conditions under which these curves were obtained, see page 40.

The characteristic curve indicates a material of excellent latitude and a comparatively high speed. The lower extremity of the linear portion of the curve is reached at a relatively low density, and the shape of the lower portion of the curve, or the toe, indicates a

Eastman Motion Picture Negative (No. 1201) — DAYLIGHT / TUNGSTEN

Eastman Background Panchromatic Negative (No. 1213) — DAYLIGHT / TUNGSTEN

Eastman Super Sensitive Panchromatic Negative (No. 1217) — DAYLIGHT / TUNGSTEN

Eastman Super X Panchromatic Negative (No. 1227) — DAYLIGHT / TUNGSTEN

Eastman Motion Picture Positive (No. 1301); Sound Recording (No. 1359); Duplicating Positive (Regular, No. 1355, and Type B, No. 1362)—Tungsten.

Eastman Duplicating Negative (Regular, No. 1503, and Fast, No. 1505)—Tungsten.

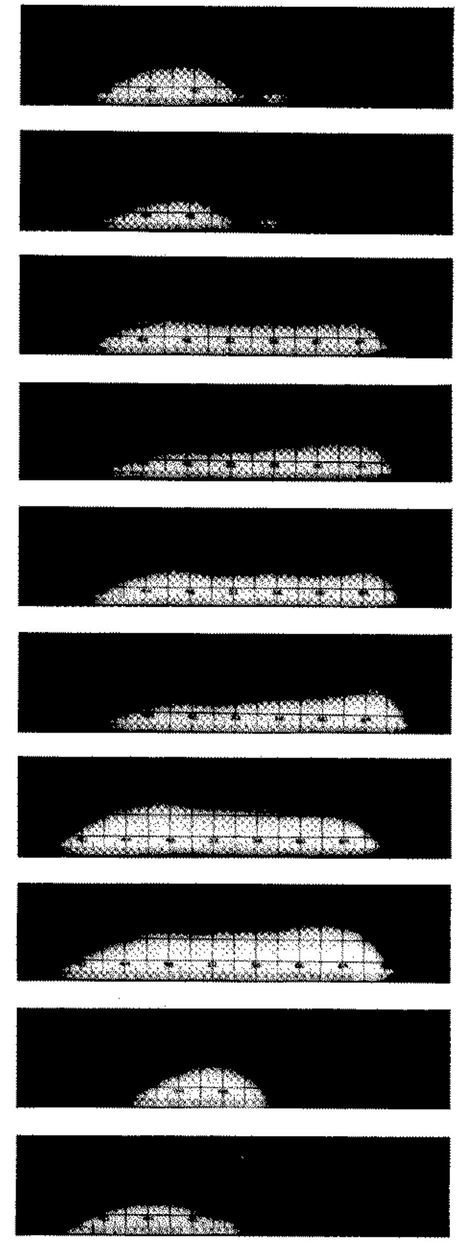


FIG. 18—Wedge spectrograms showing the comparative sensitivity of various Eastman motion picture films.

gradient which is sufficient to result in good differentiation of shadow detail.

The time-gamma curve indicates a regular increase in gamma with the time of development, and satisfactory processing latitude within the range of gammas to which negative materials are ordinarily developed.

Since Eastman Negative Motion Picture Film is not color-sensitized, its sensitiveness (Figure 18) extends from the ultra-violet through the violet and blue to the blue-green. It is, therefore, relatively fast to daylight, the white flame arc, and other light sources in which these portions of the spectrum predominate. It is much less sensitive to tungsten illumination, as the energy of tungsten illumination in the spectral region to which it is sensitive is relatively low. A comparison of speed should not be made from the spectrograms in Figure 18, as these have been made to show the regions of the spectrum to which the emulsion is sensitive, rather than to show the sensitivity in any particular spectral region.

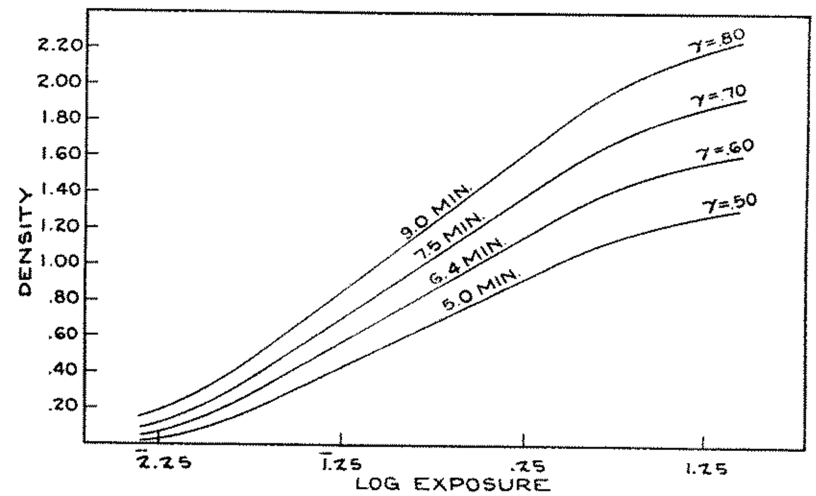
While light yellow filters may be used on open exterior subjects, the use of a panchromatic material greatly extends the possibilities of control over the final result through the use of color filters.

Eastman Super Sensitive Panchromatic Negative Motion Picture Film (No. 1217)

This material is characterized by an exceptionally high speed with tungsten illumination. It is only slightly faster than Eastman Negative Motion Picture Film with daylight, or light of daylight quality, but it is approximately twice as fast as the latter with tungsten illumination. Typical characteristic curves and a time-gamma curve are shown in Figure 19, and wedge spectrograms in Figure 18.

It is evident from the spectrograms not only that Eastman Super Sensitive Panchromatic Negative Motion Picture Film has a high total sensitivity, but that its response is exceptionally high in the yellow, orange, and red portions of the spectrum. The energy of the shorter (violet and blue) wave lengths in tungsten illumination is very low, but it increases rapidly toward the longer wave lengths at the red end of the spectrum. Thus, the spectral region which is represented in tungsten illumination by a comparatively low energy level is that to which a non-color-sensitized material, such as Eastman Negative Motion Picture Film (No. 1201) is most sensitive, while the major part of the illumination is in portions of the spectrum to which the film is practically insensitive. However,

with a material such as Eastman Super Sensitive Panchromatic Negative Motion Picture Film, the sensitivity is high in the spectral region in which the energy level in tungsten illumination is also



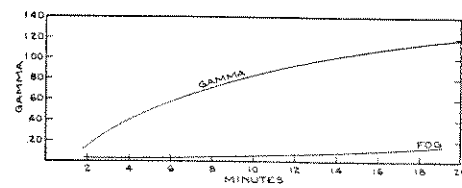


FIG. 19—*Above:* Characteristic or *D*-log *E* curve of Eastman Super Sensitive Panchromatic Negative Motion Picture Film (No. 1217).

At left: Time-gamma curve of the same film. For description of conditions under which these curves were obtained, see page 40.

high. In other words, the color-sensitivity characteristics are to some extent complementary to the spectral-energy distribution characteristics of tungsten illumination, so that materials of this type are especially suitable for use with tungsten illumination.

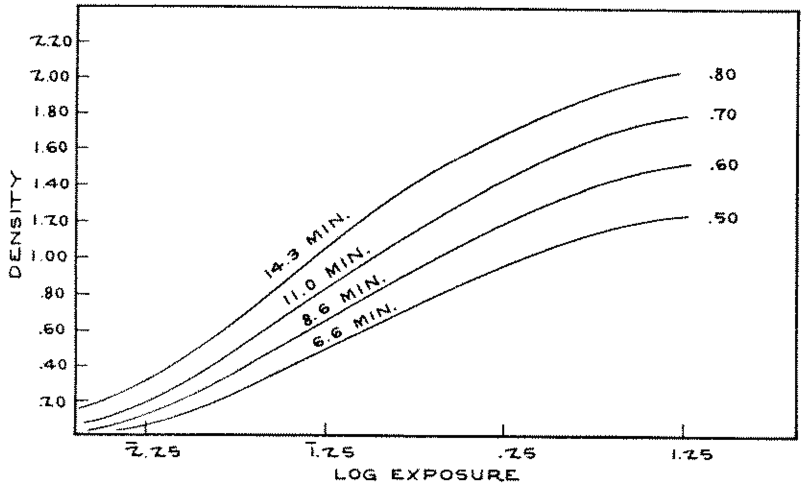
On exteriors the high color sensitivity of this film results in good differentiation in color values, and filters may be used in accordance with the effect desired, as the factors are relatively low even for deep red filters.

Filter Factors for Eastman Super Sensitive Panchromatic Negative Motion Picture Film (No. 1217) in Daylight

Aero 1	1.25
Aero 2	1.5
3N5	4
5N5	5
G	3
23A	3
N.D. 0.25	1.8
N.D. 0.50	3.1

Eastman Super X Panchromatic Negative Motion Picture Film (No. 1227)

This film was introduced early in 1935. Sensitometric data are contained in Figure 20. In general, it is similar to Eastman Super Sensitive Panchromatic Negative Motion Picture Film, except in speed and in the time of development required for a given gamma.



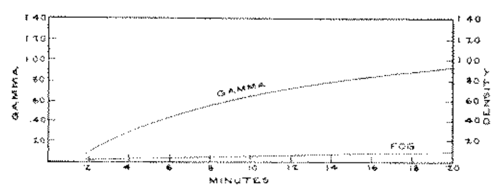


FIG. 20—*Above:* Characteristic of *D*-log *E* curve of Eastman Super X Panchromatic Negative Motion Picture Film (No. 1227) in D-76.

At left: Time-gamma curve of the same film. For description of conditions under which these curves were obtained, see page 40.

When the two materials are developed to the same gamma, Super X is approximately 50% faster than Super Sensitive. The time of development for different gammas is shown in the time-gamma curve (Figure 20). As Super X is inherently of lower contrast than Super Sensitive, the time of development for any required gamma is necessarily longer. The actual difference in the time of development for any particular gamma depends upon the developing formula and conditions of development. Eastman Super X differs only slightly from Super Sensitive in color-sensitivity characteristics (Figure 18), and despite the increased speed there is no material difference in graininess. It is well adapted to general production requirements and especially to newsreel work when the

light is poor as well as to actual night exteriors and projection-background composite exposures.

Filter Factors for Eastman Super X Panchromatic Negative Motion Picture Film (No. 1227) in Daylight

Aero 1	1.25
Aero 2	1.50
3N5	4
5N5	5
G	3
23A	4
25	5
58	6
47	5

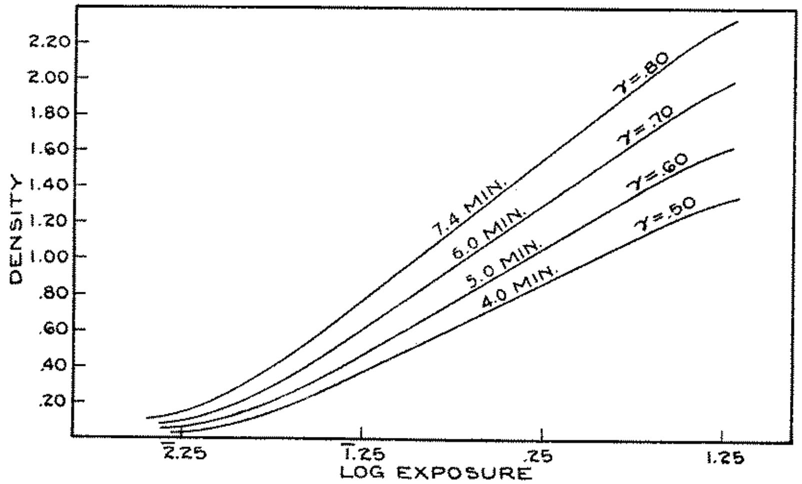
Gray-Base Film

Difficulty is sometimes experienced in photographing scenes in which bright lights appear, due to the halo which surrounds such objects in the picture. This halo is due to two causes: (1) irradiation, or the spreading of light within the emulsion; and (2) halation which is produced by the reflection of light from the rear surface of the base back into the emulsion. The halo around bright objects in the picture, so far as it is due to halation, may be improved or prevented entirely by backing the emulsion support with a light-absorbing substance which will prevent the reflection of light back into the emulsion. For motion picture work a soluble backing in the rear of the film is not desirable, and, therefore, in 1931, the Eastman Kodak Company introduced gray-base film, in which the backing is an integral part of the film base and involves no danger in processing. The increased density of the negative (approximately 0.25) is readily compensated for by increasing the printing exposure.

Eastman Background Panchromatic Negative Motion Picture Film (No. 1213)

This material is designed especially for negatives from which positives are to be made for background projection. It has an extremely fine grain—an important feature, since it prevents an appearance of graininess and lack of definition in the background. In Eastman Background Negative Film (No. 1213), a fine-grain material has been produced without sacrificing any of the requirements of a satisfactory negative material excepting high speed. Its color sensitivity, latitude, and general emulsion characteristics are similar to those of Eastman Super Sensitive Panchromatic Negative Film (No. 1217), but it requires approximately twice the exposure, with either daylight or tungsten illumination.

The filter factors are the same as for Eastman Super Sensitive Panchromatic Negative Film (No. 1217). Gamma, for given conditions of development, is slightly greater than with Super Sensitive. This is usually advantageous, as positive contrast slightly greater than that employed for release prints is favored for the background positive in order to compensate for projection losses and those



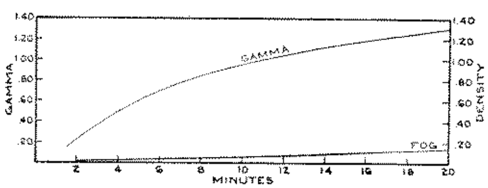


FIG. 21—*Above:* Characteristic or *D*-log *E* curve of Eastman Background Panchromatic Negative Motion Picture Film (No. 1213) in D-76.

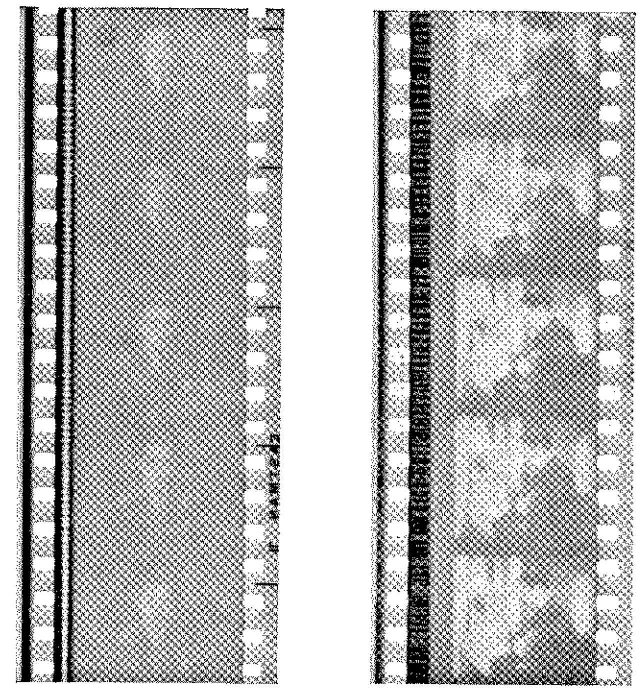
At left: Time-gamma curve of the same film. For description of conditions under which these curves were obtained, see page 40.

resulting from stray light reaching the background screen. By developing the background negative for the same time as Super Sensitive, a higher gamma is obtained, and prints developed to the regular positive gamma have the higher contrast desired for background projection.

Sound-Recording Materials

The various methods employed in recording sound on the film are too well known to those engaged in motion picture production to require a detailed description in this work. Those not acquainted with the subject should consult "Recording Sound for Motion Pictures," published by the McGraw-Hill Publishing Company, Inc., New York (1930).

The methods of recording in commercial use result in two types of sound record, known as variable-width, and variable-density. In the first mentioned, the film is moved at a uniform velocity past a slit, or an optical image of it, and by suitable means the length of the slit is modified so that the dimensions of the exposed area vary, producing a sound record of the type shown in *A* of Figure 22. With



A VARIABLE-WIDTH RECORD *B* VARIABLE-DENSITY RECORD

FIG. 22—Types of sound records.

this type of recording, the exposure is constant, both factors—namely, intensity and time—remaining unaltered. In variable-density recording with the light-valve, the width of the illuminated slit, or its optical image, is modified in such a way that the *time* of exposure is varied, while with the "glowlamp" recording the width of the slit is fixed, but the *intensity* of the light incident thereon is varied. Thus, in the variable-density record the modulated exposures are represented in terms of density, while in variable-width recording the area exposed, and not the density, varies (*B* of Figure 22).

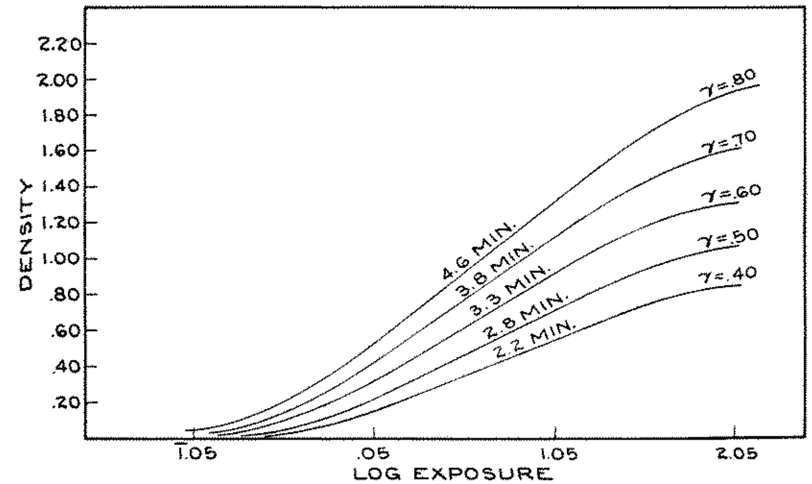
A sensitive material for variable-density recording should have a high degree of resolution and wide latitude at a comparatively low gamma, with sufficient speed to permit satisfactory exposure with existing equipment. High resolution is necessary in order that the structure which constitutes the sound record, and on which the quality of the reproduced sound depends, may be correctly reproduced. Closely allied with high resolving power is freedom from irradiation, or scatter of light within the emulsion, and halation, the reflection of light from the back of the support, as both of these affect the sharpness of the image. A comparatively wide exposure range is necessary in order that the variation in exposure produced by the recording mechanism may be properly recorded by the photographic material. All of these desirable qualities must be obtained at a comparatively low gamma.

From the standpoint of the emulsion maker, it is difficult to make an emulsion having the high degree of resolution required for the best results and at the same time retain a sufficiently wide exposure range at a low gamma, as unfortunately these two factors bear, in general, a reciprocal relation. Eastman Sound Recording Motion Picture Film (No. 1359), however, meets these stringent requirements admirably when developed in a negative developer, such as Formula D-76. The sensitometric characteristics of this material are shown in Figure 23. The latitude within a gamma range extending from 0.4 to 0.8 is adequate for existing variable-density recording and reproducing equipment, while the resolving power within the density range employed is sufficient for present requirements.

The requirements for variable-width recording are different in some respects from those of the variable-density methods. In the variable-area record the exposed area should develop to a high density while the unexposed areas remain clear, and the boundary line between two areas should be as sharp as possible. These requirements necessitate the use of a fine-grain material with a high resolving power, and the ability to produce an image with a high contrast and free from fog. Sensitometrically such a material is represented by a D-log E curve having a short toe, a steep straight-line portion, and a high maximum density.

The usual method of expressing speed in terms of inertia is without significance in the case of a material used in this manner, and the effective speed is determined by the exposure required to produce the required density in the exposed area with the degree of development employed.

Eastman Sound Recording Film (No. 1359) fulfills these requirements when developed in a positive developer of the type represented by formula D-16. (See Figure 24.) Gammas ranging from 2.0 to 2.2 (as specified for variable-width recording) are readily obtained with a comparatively short time of development, and as the maximum gamma is considerably in excess of the values used in practice there is no difficulty in obtaining the required values without in any way forcing development. The maximum density obtainable with this material is considerably in excess of that required (1.35 to 1.45), the fog value is low, and the resolving power sufficient for all practical purposes.



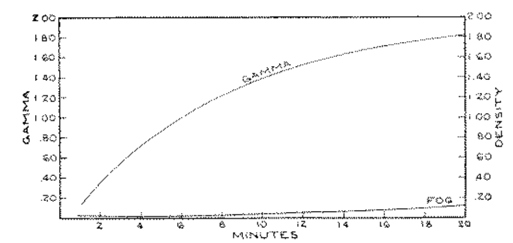


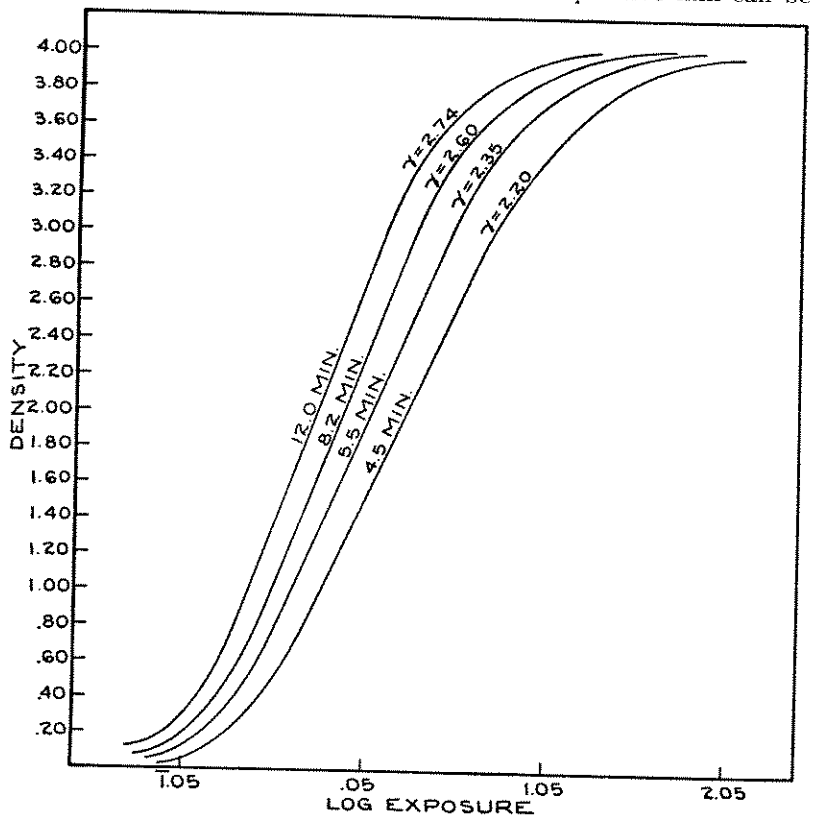
FIG. 23—*Above:* Characteristic or D-log E curve of Eastman Sound Recording Motion Picture Film (No. 1359), developed in negative formula D-76 for variable-density recording.

At left: Time-gamma curve of the same film. For description of conditions under which these curves were obtained, see page 40.

Eastman Positive Motion Picture Film (No. 1301)

This is a relatively slow, fine-grained, non-color-sensitive emulsion intended for projection positives. Typical characteristic curves and a time-gamma curve are shown in Figure 25, and a wedge spectrogram indicating the spectral distribution of sensitivity to tungsten illumination in Figure 18.

The curves in Figure 25 are typical of those produced in fresh D-16 developer at the gammas shown. It is well known, however, that the shape of the characteristic curve for positive film can be



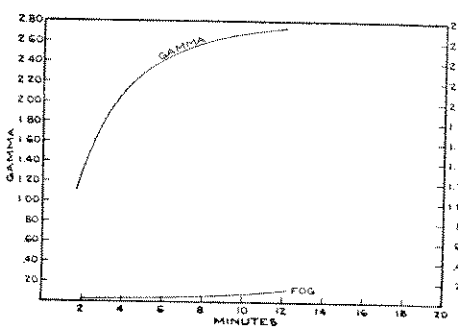


FIG. 24—*Above:* Characteristic or *D*-log *E* curve of Eastman Sound Recording Motion Picture Film (No. 1359), developed in positive formula D-16 for variable-width recording.

At left: Time-gamma curve of the same film. For description of conditions under which these curves were obtained, see page 40.

modified profoundly by the composition of the developer, and many laboratories use developers which produce curves quite different from those shown in Figure 25. In some cases, for example, the transition between the "toe" and the "straight-line" portions of the

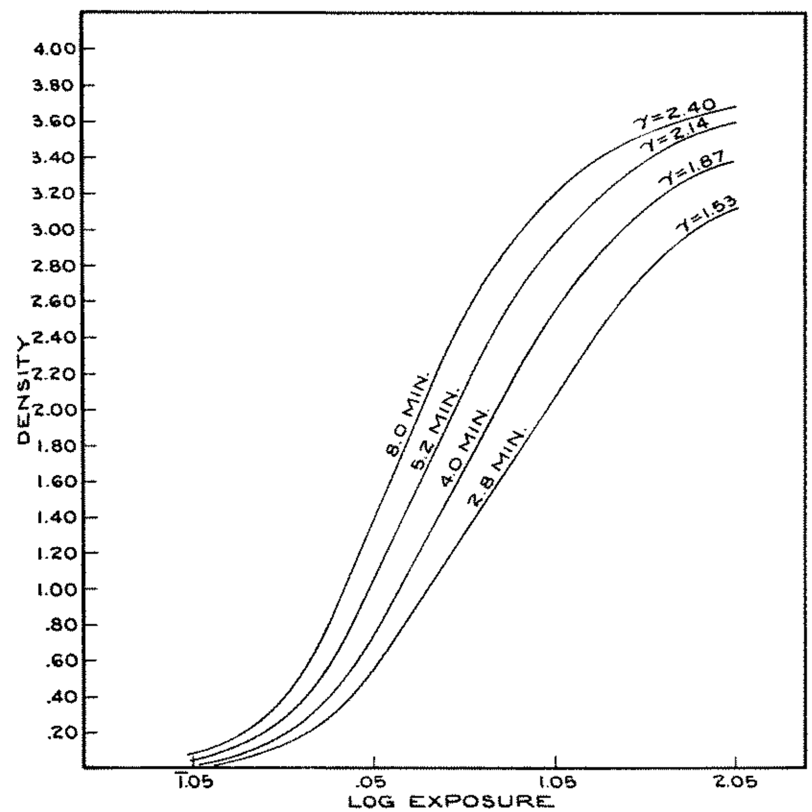
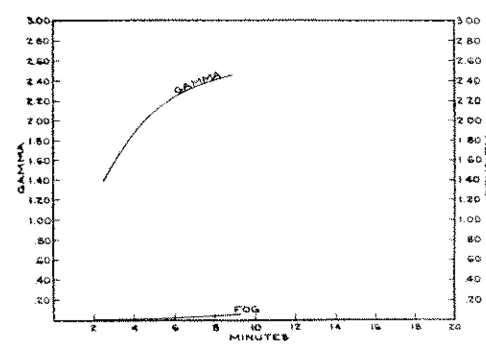


FIG. 25—*Above:* Characteristic or *D*-log *E* curve of Eastman Positive Motion Picture Film (No. 1301) in D-16.

At right: Time-gamma curve of the same film. For description of conditions under which these curves were obtained, see page 40.



curve takes place at relatively low densities, while in other cases this transition may occur at much higher densities. In the first case the "toe" is comparatively short, while in the second case it is much longer and is frequently referred to as "basket-shaped."

When the conditions are such as to produce on positive material a characteristic curve having a long, sweeping or "basket-shaped" toe, we would naturally expect a screen image in which the gradation within the highlight region is relatively soft, as compared with that in the halftones and shadows, while with processing conditions resulting in a short toe the gradation would be more or less uniform up in the highlights, breaking sharply in the extreme highlights.

The point of transition between the straight-line portion of the curve and the "shoulder" is also influenced by processing conditions. However, this is generally of minor importance, as the density at which the transition occurs is, in the vast majority of cases, beyond that which is practically useful in a positive for projection.

Eastman Positive Motion Picture Film is much slower than negative film; its speed, however, is sufficient for printing from average negatives with the printing machinery in general use. Since it is not color-sensitive, an abundance of greenish yellow light, such as provided by a Series 0A Wratten Safelight, may be used with comparative freedom from fog, thus facilitating the handling of raw stock in printing and in development.

Eastman Sonochrome Tinted Positive Motion Picture Film

Eastman positive film is supplied in several tinted bases under the name of Sonochrome Tinted Positive Motion Picture Film. The emulsion is the same as regular positive No. 1301; only the base color is different. The tinted bases include Argent, a silvery, hueless base, designed for use in place of regular positive, and several other tints which run the entire gamut of useful colors. Eastman Sonochrome Tinted Positive Film does not interfere with the reproduction of sound, as the light to which the photo cells in use respond passes freely through all of the tints.*

Duplicating Materials

A good duplicate negative is one capable of giving a print which is a facsimile of a print made from the original negative. It should not only reproduce accurately the tones of the original (unless the quality of the original is to be modified in the interest of better

*Jones, L. A.: "Tinted Films for Sound Positives," *J. Soc. Mot. Pict. Eng., Vol. 13, No. 37* (May, 1929), p. 199.

printing quality), but the definition and graininess of the print from the duplicate negative should compare favorably with a print from the original negative.

To attain such results, special emulsions are necessary. The emulsions employed in making the master positive and the duplicate negative must have the following characteristics:

1. Sufficient latitude to reproduce correctly the greatest scale of densities likely to be met with in original negatives.
2. High resolving power—the ability to reproduce fine detail; otherwise, the definition of the image will be affected.
3. A low order of graininess; otherwise, the cumulative increase in graininess in making a master positive and a duplicate negative will produce objectionable granularity in the exhibition print.
4. It must have sufficient speed for use on optical printers where the light intensity is usually lower than on contact printers.
5. Straight-line start at a low density.

The best results as regards freedom from graininess are obtained when the master positive is developed to a relatively high gamma and the duplicate negative to a much lower gamma.* This is due to the fact that with negative emulsions the graininess increases very rapidly with an increase in gamma, while with positive material the graininess rapidly reaches a maximum, and over the useful range of gammas remains very nearly constant.** Consequently, the emulsion used for making the master positive should produce an image free from undue graininess and have an exposure range (latitude) sufficiently extended to result in satisfactory reproduction at a relatively high gamma. The emulsion used for making the duplicate negative should, on the other hand, have all of these characteristics at a much lower gamma. It should differ from a negative emulsion designed for camera use primarily in having a much higher resolving power and a lower order of graininess.

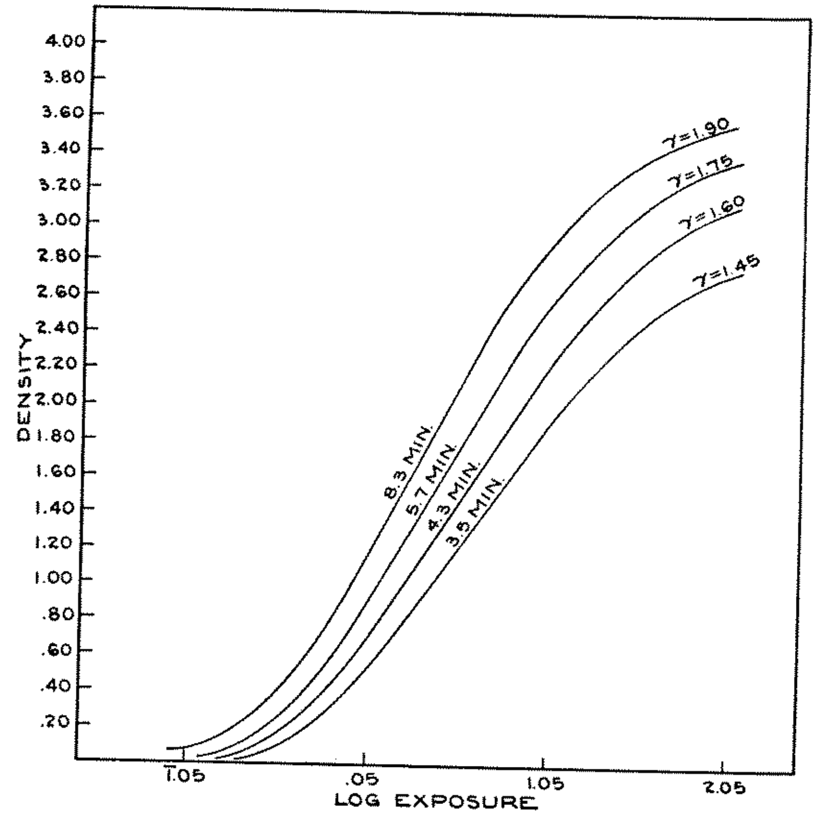
Eastman Duplicating Positive Motion Picture Films

Two Eastman duplicating films are available for the master positive: Eastman Duplicating Positive Film, Regular (No. 1355), and Eastman Duplicating Positive, Type B (No. 1362). The sensitometric characteristics of these materials are shown in Figures 26 and 27, respectively. Both have the high resolving power, fine grain, and latitude required in a duplicating emulsion, but the latter has the higher maximum contrast and is more suitable for use at high

*Crabtree, J. I. and Schwingel, C. H.: "The Duplication of Motion Picture Negatives," *J. Soc. Mot. Pict. Eng., Vol. 19* (1932), pp. 891, 908.

**Crabtree, J. I.: "The Graininess of Motion Picture Film," *Trans. Soc. Mot. Pict. Eng., Vol. 28* (July, 1927), p. 223.

gammas, as its latitude and general quality are superior to those of Eastman Duplicating Positive Film, Regular, at gammas greater than 1.8. The time-gamma curve of Eastman Duplicating Positive Film, Regular, begins to flatten out at gammas above 1.7, while that of Eastman Duplicating Positive Film, Type B, does not begin



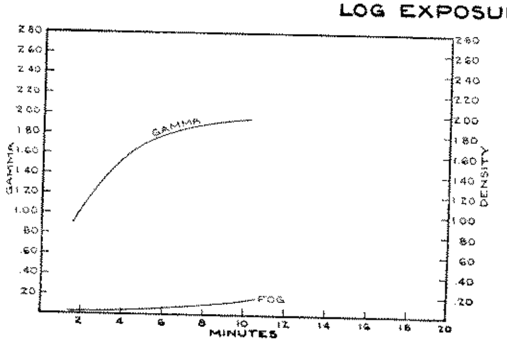


FIG. 26—*Above:* Characteristic or *D*-log *E* curve of Eastman Duplicating Positive Motion Picture Film (No. 1355) in D-16.

At left: Time-gamma curve of the same film. For description of conditions under which these curves were obtained, see page 40.

to flatten out until a gamma of approximately 2.4 is reached. The former is, therefore, better adapted for use at gammas ranging from 1.6 to 1.8, and the latter from 2.0 to 2.4.

These films are coated on a lavender base for identification purposes, to prevent possible confusion with Eastman Positive Film.

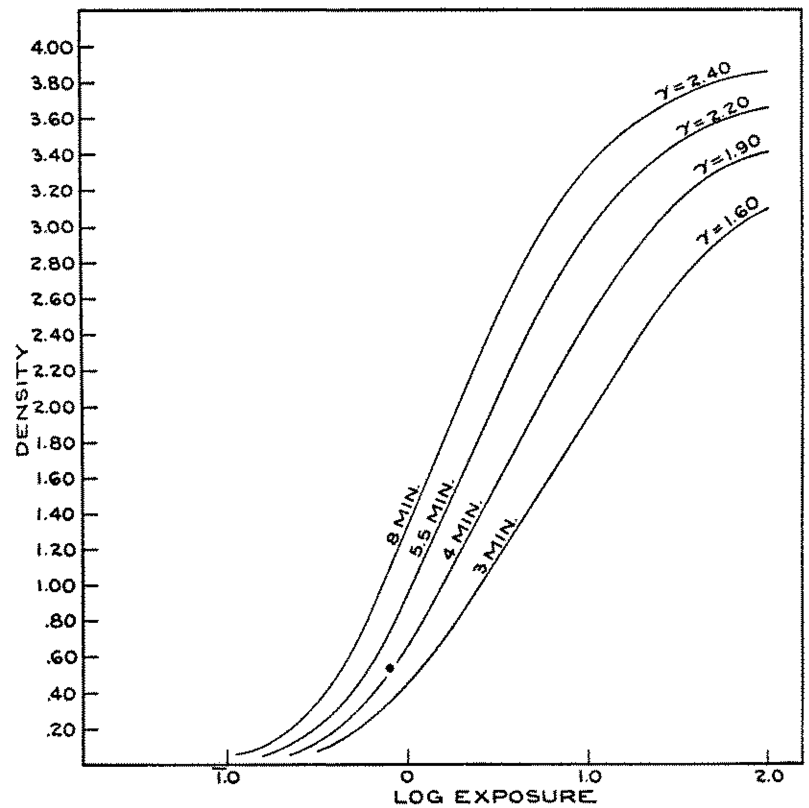
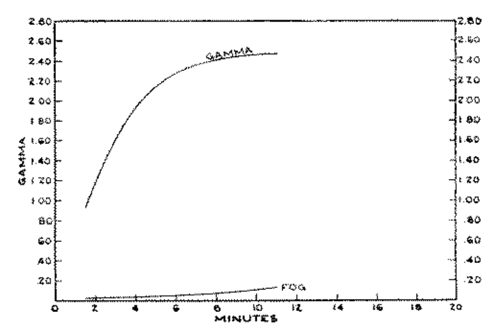


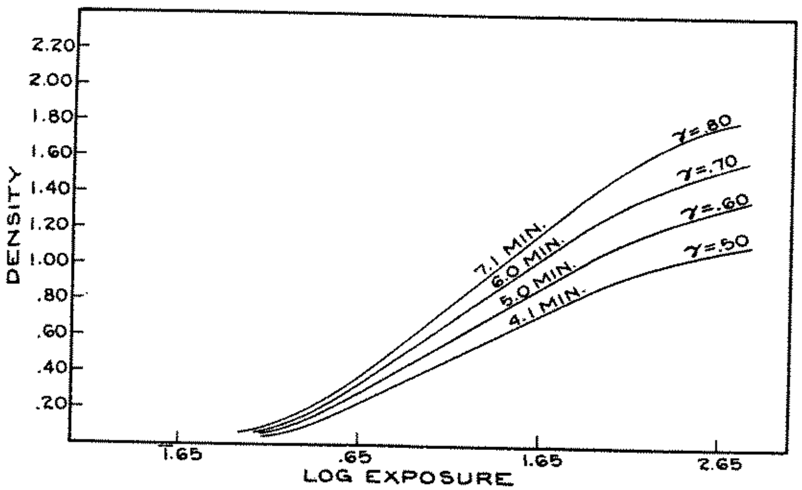
FIG. 27—*Above:* Characteristic or *D*-log *E* curve of Eastman Duplicating Positive Motion Picture Film, Type B (No. 1362) in D-16.

At right: Time-gamma curve of the same film. For description of conditions under which these curves were obtained, see page 40.



Eastman Duplicating Negative Films

Two Eastman duplicating films are available for the duplicate negative: Eastman Duplicating Negative, Regular (No. 1503), and Eastman Duplicating Negative, Fast (No. 1505). The sensitometric characteristics of these films are shown in Figures 28 and 29, respectively.



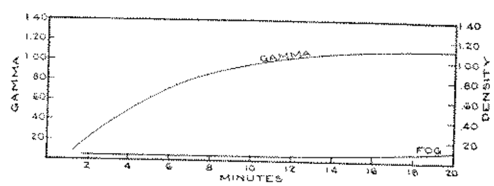


FIG. 28—*Above:* Characteristic or *D*-log *E* curve of Eastman Duplicating Negative Motion Picture Film (No. 1503) in D-76.

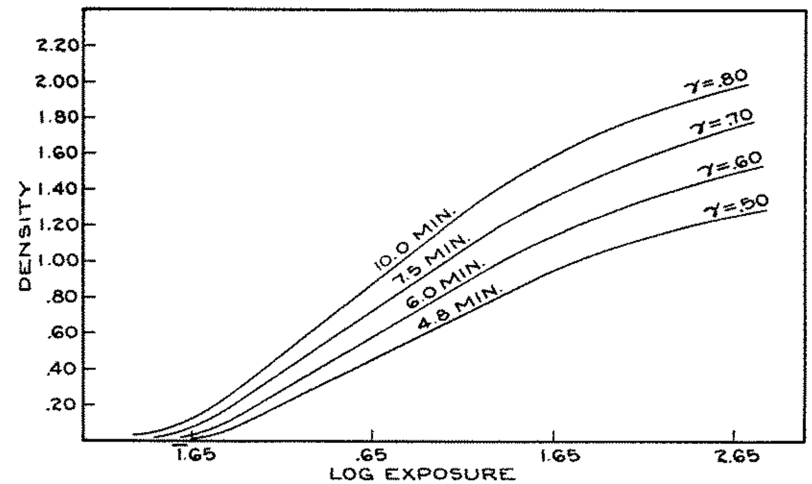
At left: Time-gamma curve of the same film. For description of conditions under which these curves were obtained, see page 40.

In general, the two materials are much the same except with regard to speed, Eastman Duplicating Negative, Fast, being approximately two and one-half times as fast as Eastman Duplicating Negative, Regular. The higher speed is desirable in projection printing and also tends to compensate for the greater density of the master positive, so that light sources of the same intensity may be used as for regular positive film.

A yellow dye is incorporated in the emulsion of both of these films. The addition of a yellow dye to a fine-grain non-color-sensitive emulsion increases the resolving power by reducing irradiation, or the scatter of light within the emulsion, extends the exposure range, or latitude, and lowers the maximum contrast of the emulsion. In this way, an emulsion is produced which has an exceedingly

fine grain with high resolving power, and the latitude and low contrast required in a material for duplicate negatives.

The time-gamma curve of No. 1505 is flatter than that of No. 1503, and within the range of gammas to which the duplicate negative is ordinarily developed the processing latitude is slightly



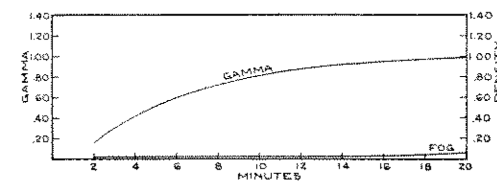


FIG. 29—*Above:* Characteristic or *D*-log *E* curve of Eastman Duplicating Negative Motion Picture Film (No. 1505) in D-76.

At left: Time-gamma curve of the same film. For description of conditions under which these curves were obtained, see page 40.

greater. The maximum gamma, on the other hand, is greater for No. 1503 than for No. 1505. The difference, however, is slight and is not of any practical advantage, owing to the control possible in making the master positive.