Choosing Eastman Color Negative Film 5247 or Eastman Color High-Speed Negative Film 5294

By Richard C. Sehlin, Glenn L. Kennel, Edward F. Ortman, and Frank R. Reinking

Since the introduction of high-speed color negative films, the cinematographer is frequently faced with selecting between shooting medium-speed (EI-125) Eastman color negative film 5247 or high-speed (EI-400) Eastman color high-speed negative film 5294. As an aid in making this decision, several objective parameters are examined as a function of exposure. In addition, general guidelines are presented for choosing the most appropriate film for different exposing conditions.

With the advent of high-speed color negative films in the 1980s, professional moviemakers acquired much more creative freedom and flexibility than ever before. Along with this new-found freedom, however, came the complication of using two different-speed films in a single production.

The choice of exposure and lighting for a particular film is predicated on the specific "look" or feeling the cinematographer is trying to convey. Thus in the initial learning period in which cinematographers discover the advantages of using each film stock, it is appropriate to examine the technical parameters associated with each film at several probable exposure conditions. By examining these technical parameters, one may more easily identify the film and exposure most suitable for achieving a particular look. More importantly, understanding the relationship between technical parameters, film type, and exposure allows one to more effectively choose a film stock, predict the look, and then be able to repeat the process.

The choice of high-speed negative for low-light-level night scenes or EI-125 speed negative for high-light-level daylight scenes is obvious. There are conditions (between EI-125 and 400), however, where the choice is more difficult. In some special situations, the cinematographer may select a particular exposure index based on light level and desired depth of field. In these situations, a knowledge of the technical parameters of 5247 and 5294 film at various exposure conditions is critical in selecting which raw stock to use.

This article relates common objective measurements of film performance (technical parameters) to actual film performance at various exposure conditions. We begin by reviewing some objective measurements of color negative films, illustrating how these characteristics change as a function of exposure using Kodak Ektacolor 74 paper prints made from the corresponding Eastman color negative film. Following this review, we compare 5247 and 5294 films at various exposure levels.

Tone Reproduction

The exposure received by the original negative is based on the luminance or brightness of the objects photographed. The response of a camera-original film to exposure is represented by its sensitometric or characteristic curve. The density of the processed negative is plotted versus log exposure. Figure 1 shows a typical sensitometric curve (green only) of a camera negative film and the exposure range that scenes with 10:1 and 100:1 brightness ratios would cover. If a typical 10:1 brightness-ratio scene is normally exposed, the whites and blacks will be placed on the sensitometric curve approximately as shown. For a typical 100:1 brightness-ratio scene, however, the blacks and whites fall more toward the toe and shoulder of the sensitometric curve. The slope of the straight-line portion of these characteristic curves defines film contrast.

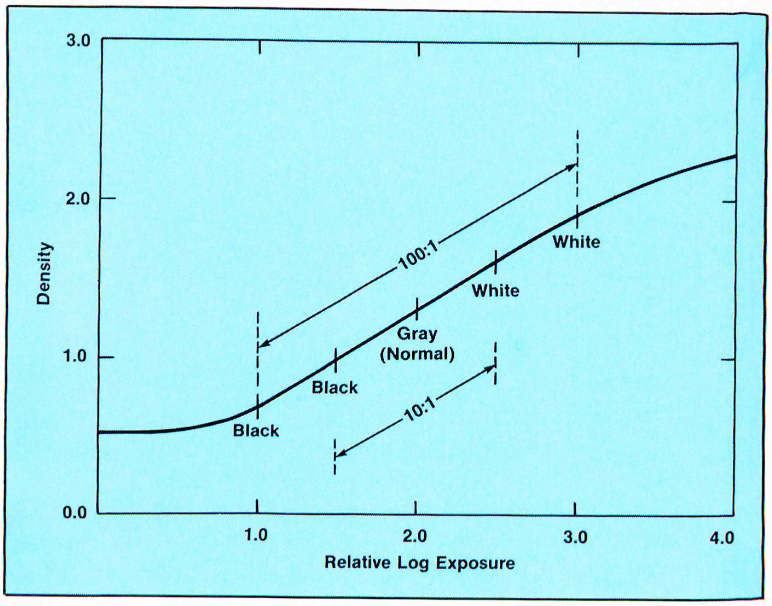

Figure 1. Typical sensitometric curve (green-sensitive layer) for a camera negative film.

Presented at the 125th SMPTE Technical Conference in Los Angeles (paper No. 125-40) on November 2, 1983. Richard C. Sehlin (who read the paper), Glenn L. Kennel, Edward F. Ortman, and Frank R. Reinking are affiliated with Eastman Kodak Co., Rochester, N.Y. This article was received in final form on September 14, 1984.

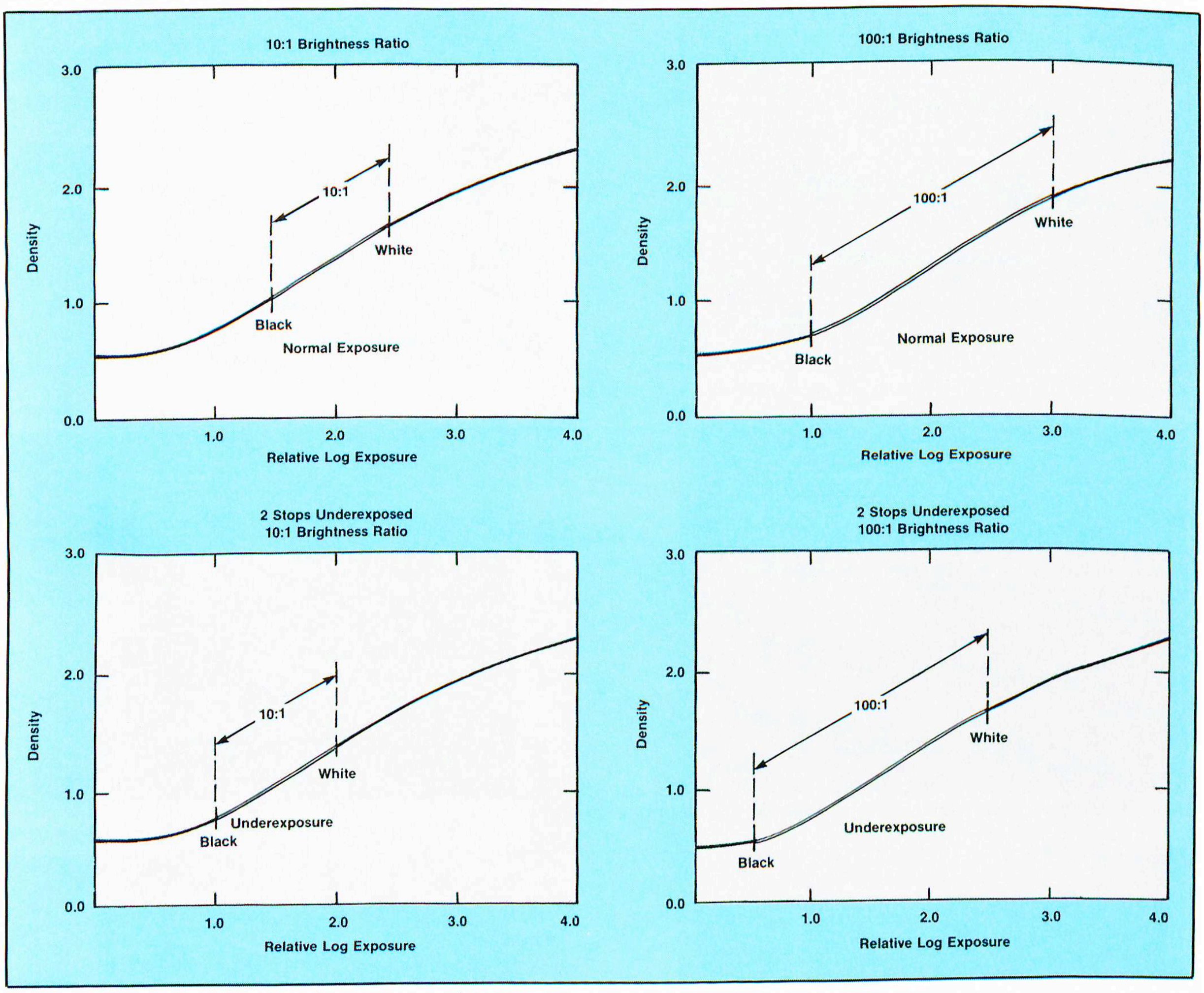

Figure 2. Picture placement — normal exposure vs. underexposure.

Although the film is exposed with light reflected from objects in the scene, cinematographers often measure incident light when setting up a scene. This is effective when used with practical experience and judgment. The reflectance characteristics of different objects vary considerably, however. For example, a darkly stained wood panel in the background that is illuminated two stops down from the subject in the foreground will actually be recorded by the film four to five stops under. Reflectance light meters are available but are difficult to use and generally less accurate. Consequently, to understand how a camera negative film records information, it is necessary to consider scene-brightness ratio.

In Fig. 1, the placement of the blacks and whites corresponds to normally exposed 10:1 and 100:1 brightness-ratio scenes. Underexposing these scenes simply shifts the placement toward the toe of the sensitometric curve (Fig. 2). Underexposing the low-brightness-range scene shown in Fig. 3 has little effect on the final print sensitometry. Most scene information is still recorded on the straight-line portion of the sensitometric curve. Underexposing the 100:1 brightness-ratio scene shown in Fig. 4, however, has a more significant effect. Although the majority of the scene information is still accurately recorded, the blacks now fall in the toe or nonlinear region of the sensitometric curve. This results in a loss of detail in the shadows and lower shadow densities in the print.

Overexposing 10:1 and 100:1 brightness-ratio scenes simply shifts the placement toward the shoulder of the sensitometric curve. As shown in Fig. 5, overexposing a low-brightness-ratio scene has little effect on final print sensitometry. Overexposing high-brightness-ratio scenes is more significant. Whites may appear muddy and lose detail, and blacks tend to become blacker, as shown.

The overall effect of exposure is visually summarized in Fig. 6. The portions of the sensitometric curves used in two-over, normal, and two-under exposures are superimposed for both 10:1 and 100:1 brightness-ratio scenes. These curves show that the sensitometry of scenes with low brightness ratios is much less affected by over- and underexposure than is the sensitometry of scenes with high brightness ratios. Overexposing high-brightness-ratio scenes tends to produce muddy whites and blacker blacks. Underexposing tends to produce smoky, less dense blacks.

Consequently, scene brightness ratio must be considered when choosing a film and exposure because it defines what cinematographers call scene contrast and also affects the perceived under- and overexposure latitude of a

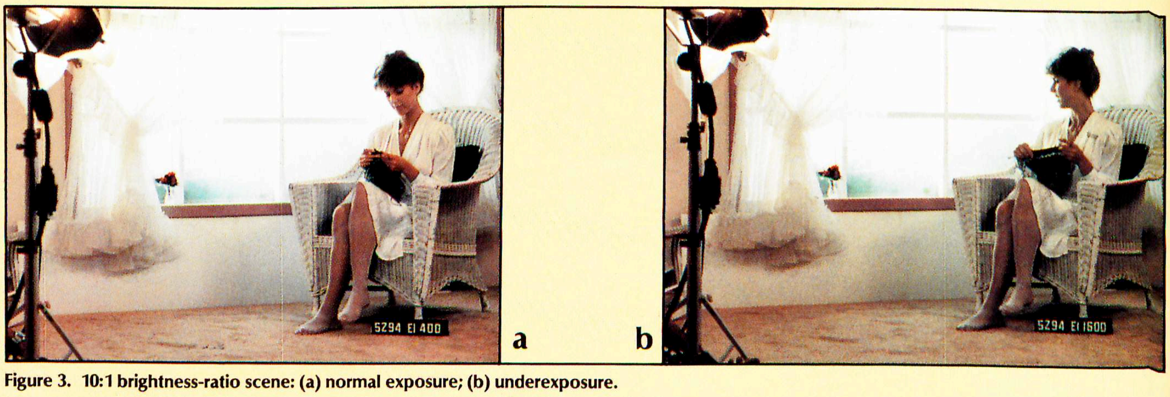

Figure 3. 10:1 brightness-ratio scene: (a) normal exposure; (b) underexposure.

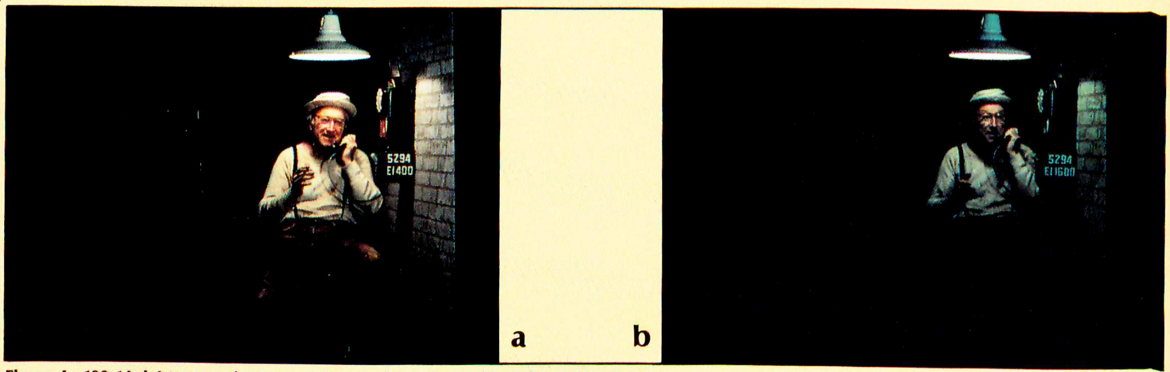

Figure 4. 100:1 brightness-ratio scene: (a) normal exposure; (b) underexposure.

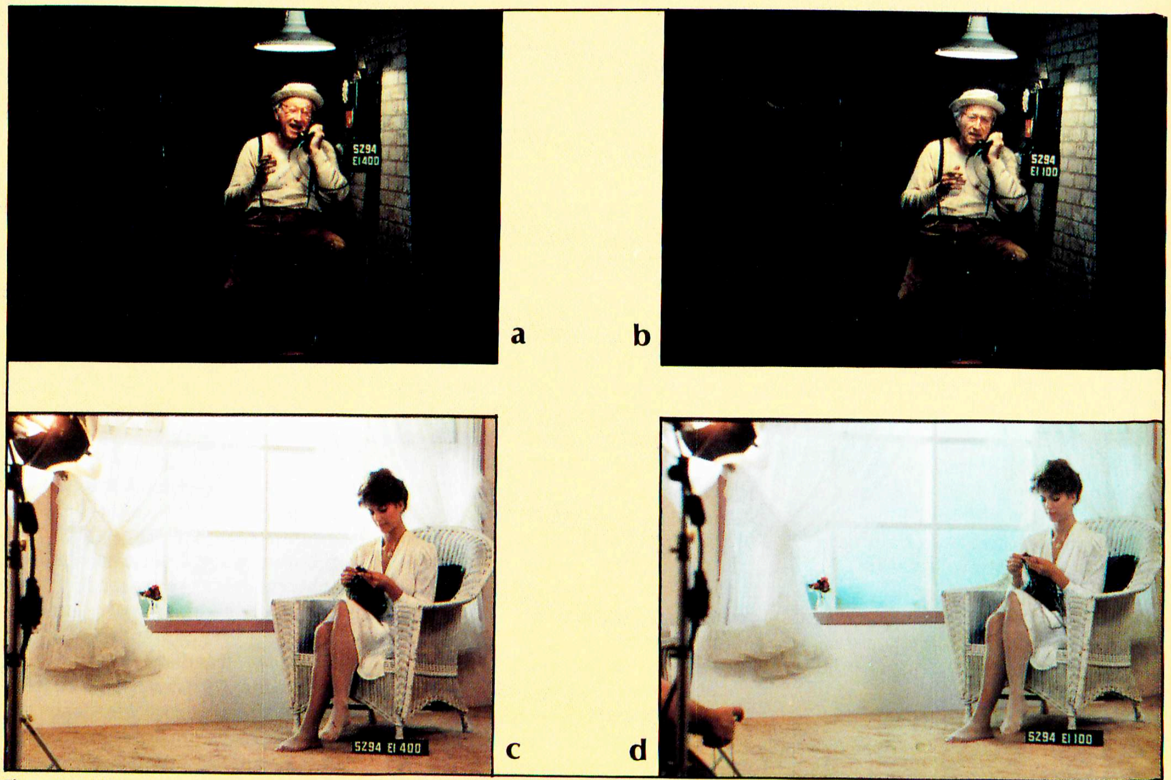

Figure 5. (a) Normal exposure, 100:1 brightness ratio; (b) overexposure, 100:1 brightness; (c) normal exposure, 10:1 brightness; (d) overexposure, 10:1 brightness.

camera-original film. The brightness range recorded by the film is highly dependent on scene reflectance. Other factors, however, such as lighting contrast, lens flare, and the use of special-effect filters, can modify the effective brightness range. Although a cinematographer uses incident light readings and lighting ratio to set the mood of a scene, the film actually records the luminance or brightness of the objects in the scene as transmitted to it through the lens and filters.

In addition to affecting sensitometry, exposure also affects negative image structure and thereby the print graininess and sharpness.

Graininess

Jones and Deisch[1] define graininess as "the sensation or impression of nonuniformity that a photographic deposit produces upon the consciousness of the observer when such a deposit is viewed." Thus graininess is a subjectively perceived variable. The objective parameter that correlates to graininess is granularity.

Root-mean-square (RMS) granularity is a statistical parameter (standard deviation) describing the density fluctuations recorded by a microdensitometer scanning a uniformly exposed and processed film area. Negative granularity can be examined as a function of exposure and lighting ratio. Figure 7 shows the green granularity of 5247 and 5294 film as a function of exposure. Granularity generally decreases as exposure increases. Consequently, as the negative film is underexposed, the scene will be recorded at higher granularity levels, resulting in prints that appear grainier.

Figure 8 shows the portion of the granularity range bounded by the brightest and darkest objects in a scene with a 100:1 brightness ratio photographed on 5294 film. The superimposed granularity ranges for a scene with a 100:1 brightness ratio recorded at five different levels of exposure are shown in Fig. 9. Assuming the negatives are all printed in such a way that a neutral gray (18%) in the scene is printed to the same density (1.0 equivalent neutral density [END]), then the most overexposed negative will produce the lowest perceived graininess and the most underexposed, the highest (Fig. 10).

The superimposed granularity curves (100:1 brightness ratio) at

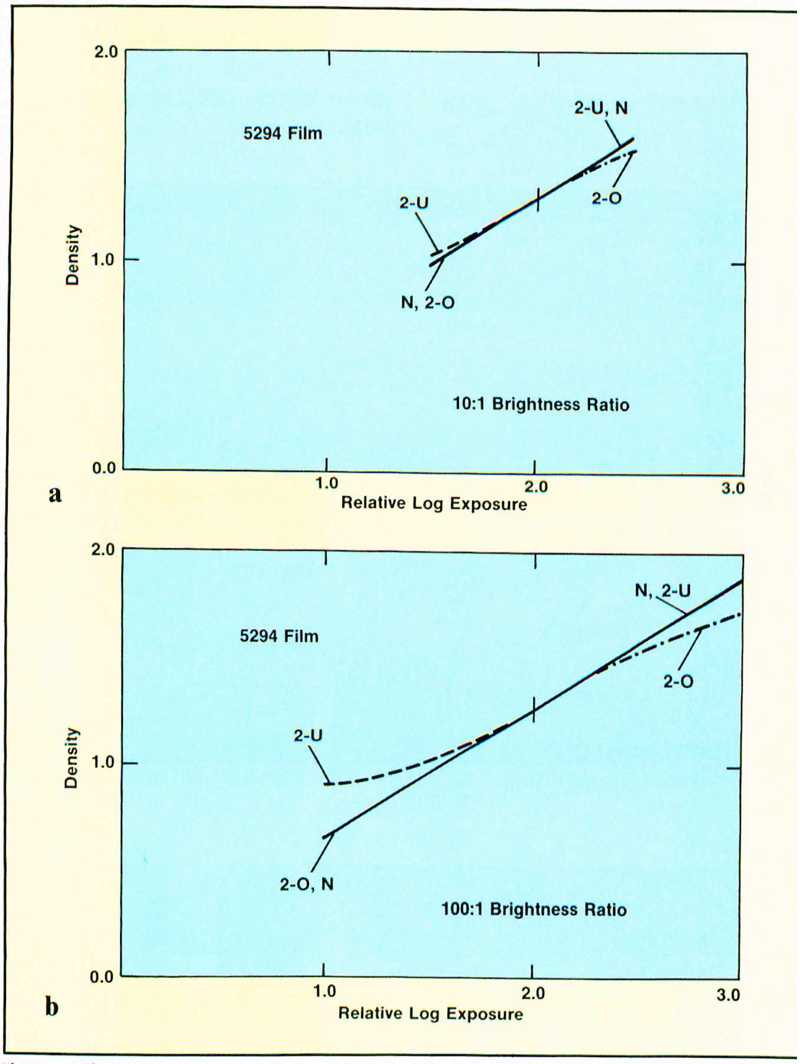

Figure 6. Picture placement — normal versus under- and overexposure: (a) 10:1 brightness ratio (b) 100:1 brightness ratio.

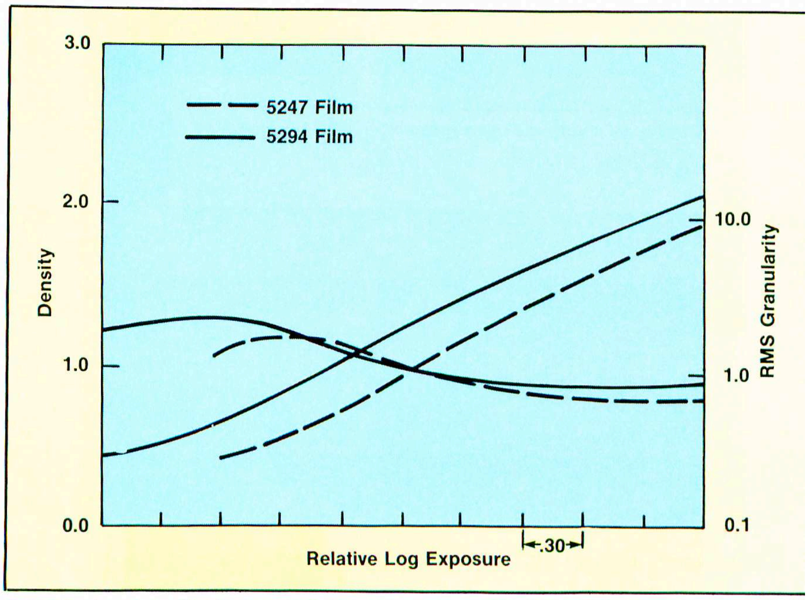

Figure 7. Green-sensitive layer granularity measurements of 5247 and 5294 film.

two-under, normal, and two-over exposure conditions for both 5294 and 5247 film are shown in Fig. 11. It is clear that overexposing either 5294 or 5247 film significantly decreases granularity and that underexposing either film significantly increases granularity. This is true to essentially the same degree at either a high or low brightness ratio.

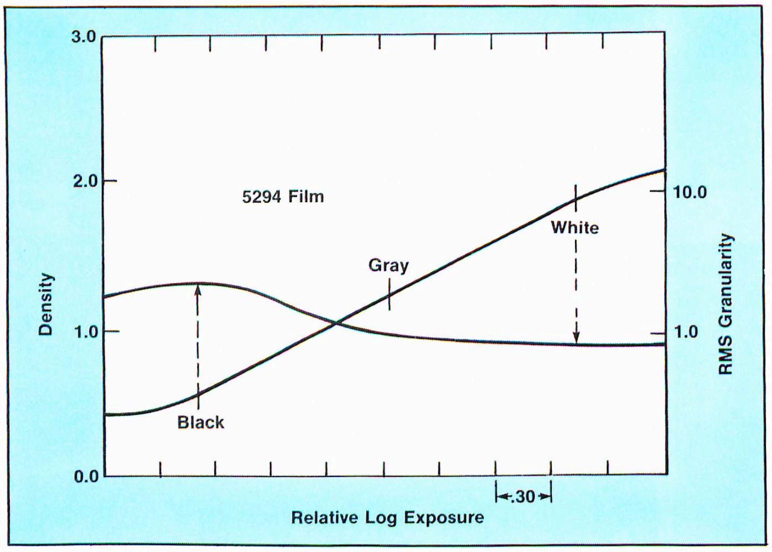

Figure 8. Granularity related to picture placement — 100:1 brightness ratio scene, normal exposure.

Sharpness

Sharpness is a subjective variable. The objective correlate of sharpness is normally derived from the system modulation transfer function (MTF). Figure 12 shows the MTF as a function of exposure. Film response increases with increased exposure, and this response improvement is independent of scene-brightness ratio. Although these MTF differences are not large, sharpness differences are perceived in some scenes. This perceived improvement is partially due to the improved MTF, and partially a result of neutral sensitometry differences and increased color saturation; i.e., higher neutral-scale contrast or color saturation result in the perception of improved sharpness.

Color Saturation

To illustrate the effect of exposure on color saturation, let us examine neutral and separation exposures on a color negative film. Figure 13 presents the status *M* green density of a neutral exposure (G_N) versus that of a green light separation exposure (G_G). As shown, if the separation sensito-

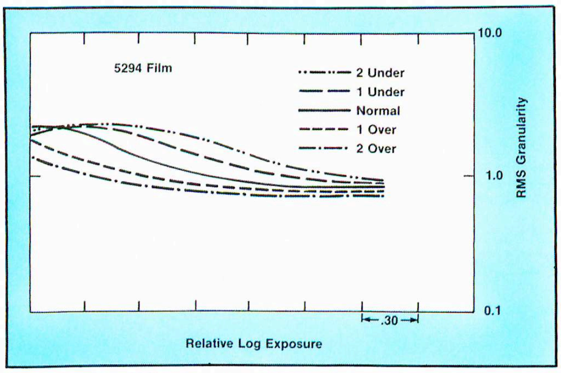

Figure 9. Granularity vs. under- and overexposures — 100:1 brightness-ratio scene.

a

b

c

Figure 10. Graininess vs. under- and overexposures: (a) EI-100; (b) EI-400; (c) EI-1600.

metric curve lies above the neutral sensitometric curve, the film is said to be over-corrected and will tend to reproduce colors relatively more saturated and brighter than if the neutral and separation curves overlay one another (even correction). If the separation lies below the neutral curve, the film is under-corrected and will tend to reproduce colors darker and desaturated.

Films 5247 and 5294 are generally over-corrected to produce bright, saturated colors. The effect of exposure can be seen most easily if we examine the neutral-to-separation curves. Figure 14 shows the green sensitometric curves resulting from neutral and separation exposures on 5294 film. The difference in the green density of a neutral exposure, G_N, and that of a green exposure, G_G, is a measure of color (green) saturation and brightness in the final print. The larger the difference in density, the greater the color saturation.

Consequently, because Eastman color negative films are generally over-corrected, color saturation increases as exposure increases. Note the increase in color saturation and brightness when comparing 5294 film exposed at EI-100 (two stops overexposed) versus EI-400 (Fig. 15). These saturation and brightness effects are most easily seen when comparing short-brightness-range scenes, where neutral scales are essentially unaffected by two-under or two-over exposures. If a large-brightness-range scene is under- or overexposed, the neutral-scale differences may tend to obscure differences in color saturation.

To summarize the effects of exposure on neutral sensitometry, sharpness, graininess, and color saturation for low and high-brightness-range scenes:

1. Overexposing low-brightness-range scenes has little effect on neutral-scale sensitometry, improves sharpness, decreases grain, and increases color saturation.
2. Overexposing high-brightness-range scenes degrades whites (muddy) and deepens blacks, improves sharpness, decreases graininess, and increases color saturation.
3. Underexposing low-brightness-range scenes produces slightly smoky blacks, decreases sharpness, increases grain, and decreases color saturation.
4. Underexposing high-brightness-range scenes significantly de-

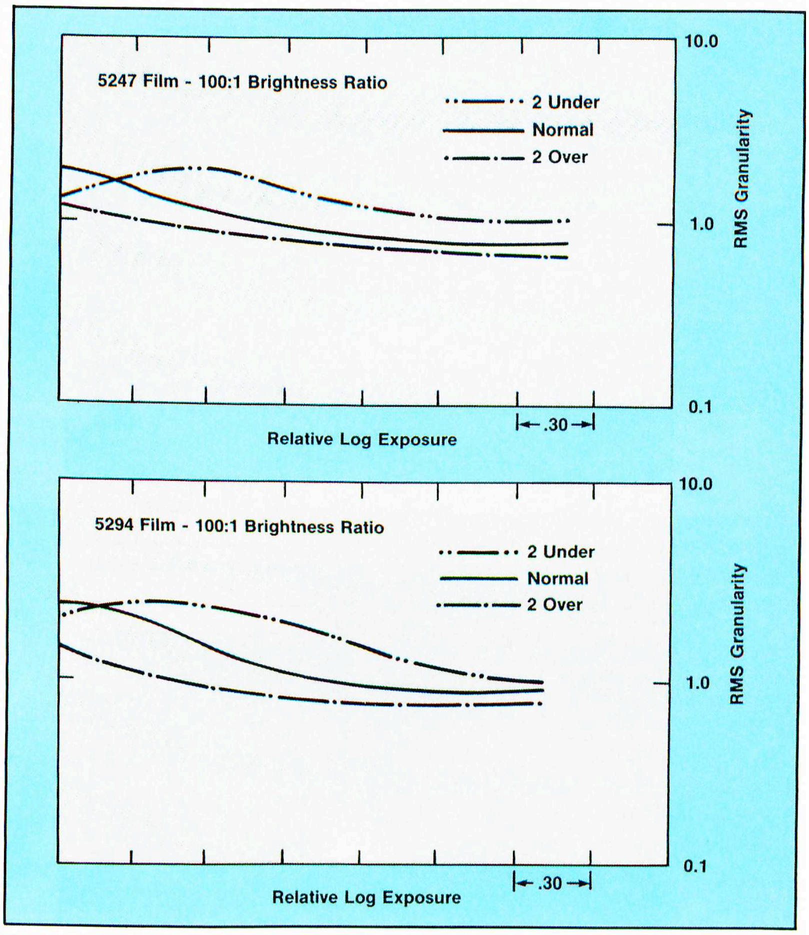

Figure 11. Granularity vs. exposure: (a) 5247 film; (b) 5294 film.

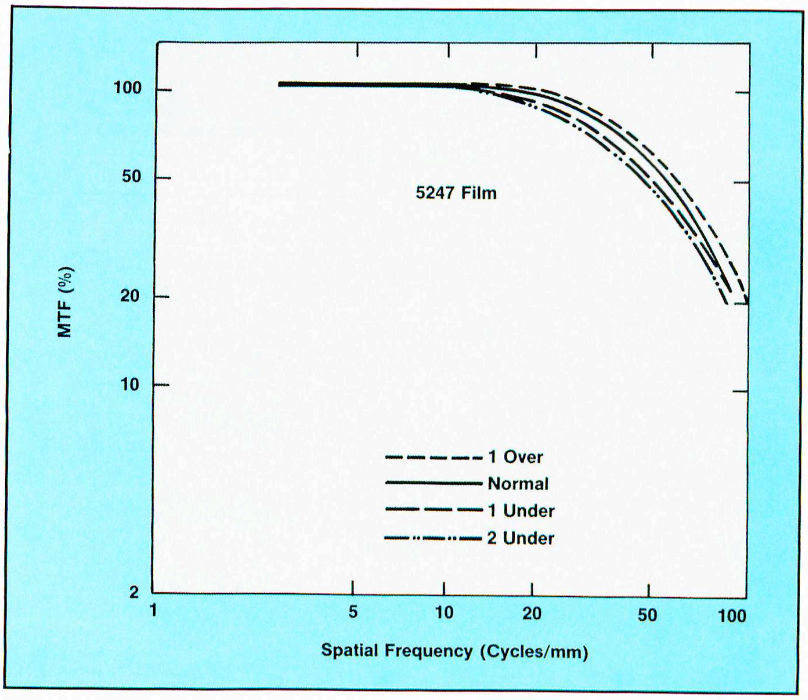

Figure 12. Modulation transfer function vs. exposure.

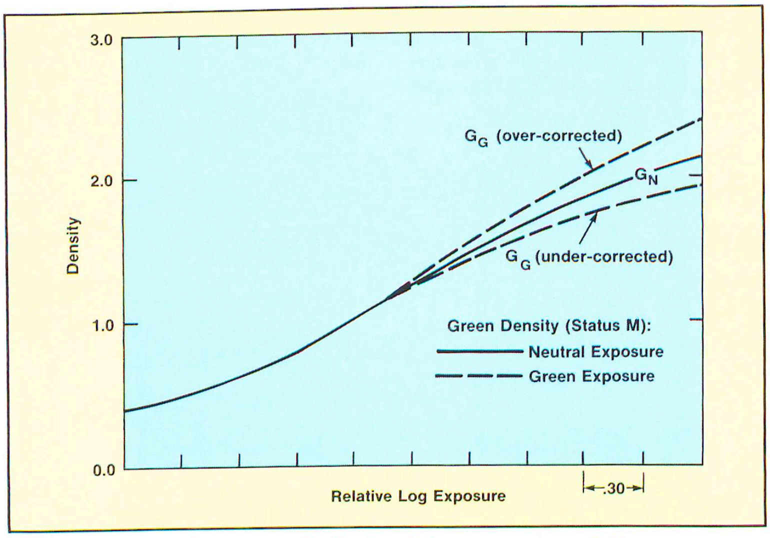

Figure 13. Color saturation — green density of neutral exposure vs. green light exposure.

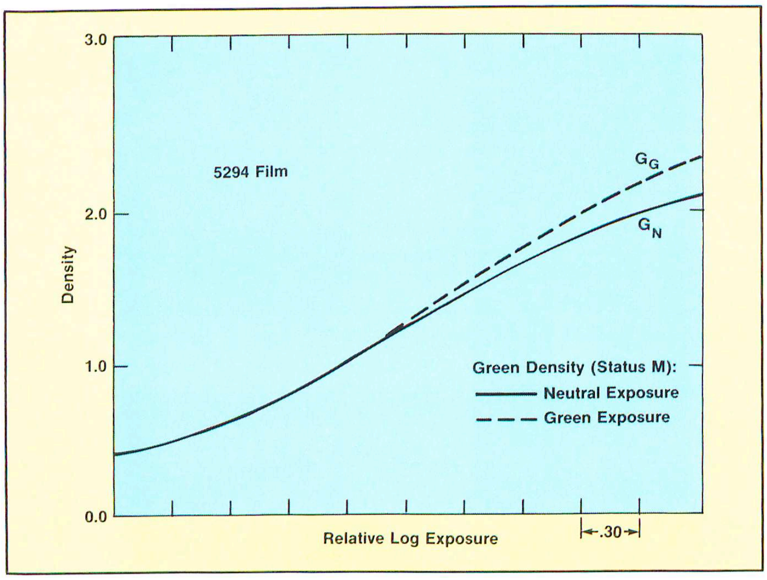

Figure 14. Color saturation — green sensitometric layer curves for 5294 film.

Table 1 — Effects of Exposure on Low- and High-Brightness-Range Scenes

	Two-Under Exposure	Normal Exposure	Two-Over Exposure
Low-Brightness-Range Scenes			
Sensitometry	Little effect	—	No effect
Sharpness (MTF)	↓	—	↑
Granularity	↑	—	↓
Color Saturation	↓	—	↑
High-Brightness-Range Scenes			
Sensitometry	Smoky shadows	—	Deeper blacks Muddy highlights
Sharpness (MTF)	↓	—	↑
Granularity	↑	—	↓
Color Saturation	↓	—	↑

grades blacks (smoky), decreases sharpness, increases graininess, and decreases color saturation.

These generalizations are summarized in Table 1. With these conclusions in mind, let us look at two exposure series comparing 5247 to 5294 film at common exposure levels. Figure 16 shows prints from a high-brightness-ratio, low-key scene exposed from EI-100 to EI-1600 in one-stop increments. Figure 17 shows prints from a low-brightness-ratio, high-key scene, also exposed from EI-100 to EI-1600. The recommended exposure indices are EI-125 for 5247 film and EI-400 for 5294 film. The exposure series was begun at EI-100, not at EI-125, for ease in shooting and presentation.

Guidelines

Guidelines for choosing between 5294 film and 5247 film are simple and easy to define on one hand, and extremely complex and difficult to define on the other.

Simple Guidelines

The simple guidelines can be summarized:

1. Low-light-level scenes (10 to 60 fc) normally are most effectively recorded using 5294 film.

2. High-light-level (daylight, 500 to 1000 fc) scenes normally are most effectively recorded using 5247 film. The use of 5294 film in these applications would require stopping down to *f*/11 or adding neutral-density filters to the lens to prevent highlight burnout.

Complex Guidelines

For the in-between situations, guidelines for choosing between 5294 and 5247 film depend on the particular scene being shot and the look the director of photography desires. Consider the following specific types of scenes.

Low Light Level/Low Brightness Range

Low light levels/low brightness ratios yield the look that many Hollywood cinematographers currently desire. These scenes are lit so that no deep blacks exist. The ability to "look into the shadows" and see detail is required. Table 2 compares expectations for 5294 and 5247 film, assuming an exposure index of EI-800 and a low brightness ratio.

Comparing 5247 and 5294 film under these conditions, we would expect

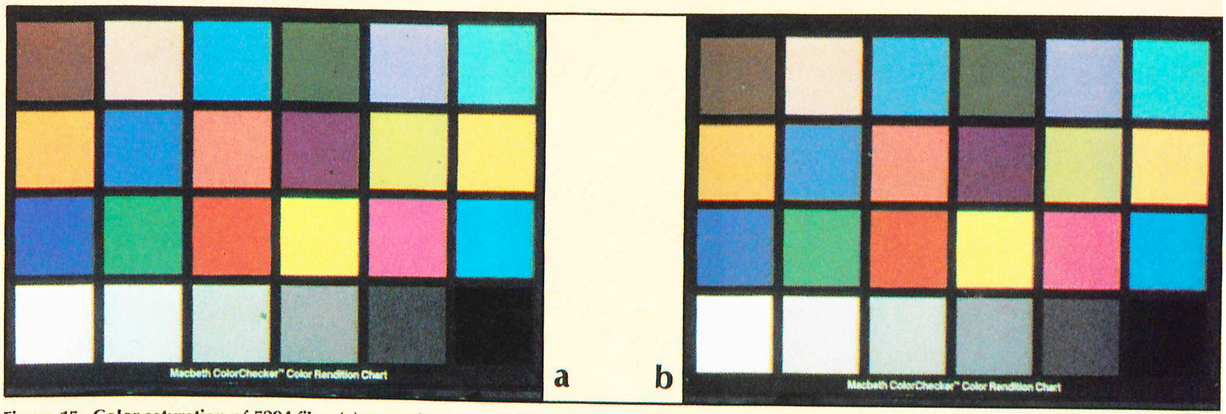

Figure 15. Color saturation of 5294 film: (a) normal exposure; (b) overexposure.

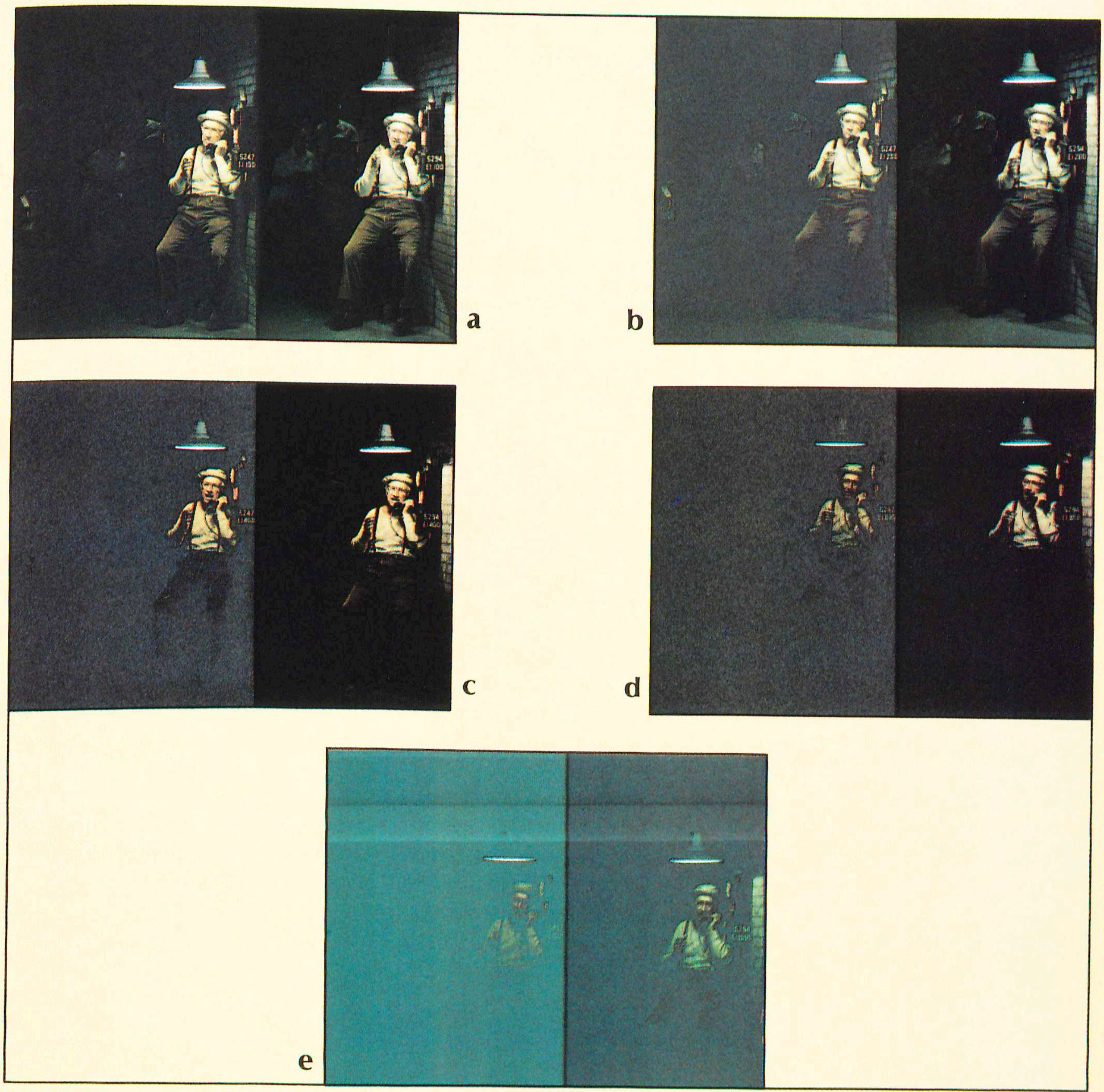

Figure 16. Exposure series — high-brightness-ratio, low-key scene.

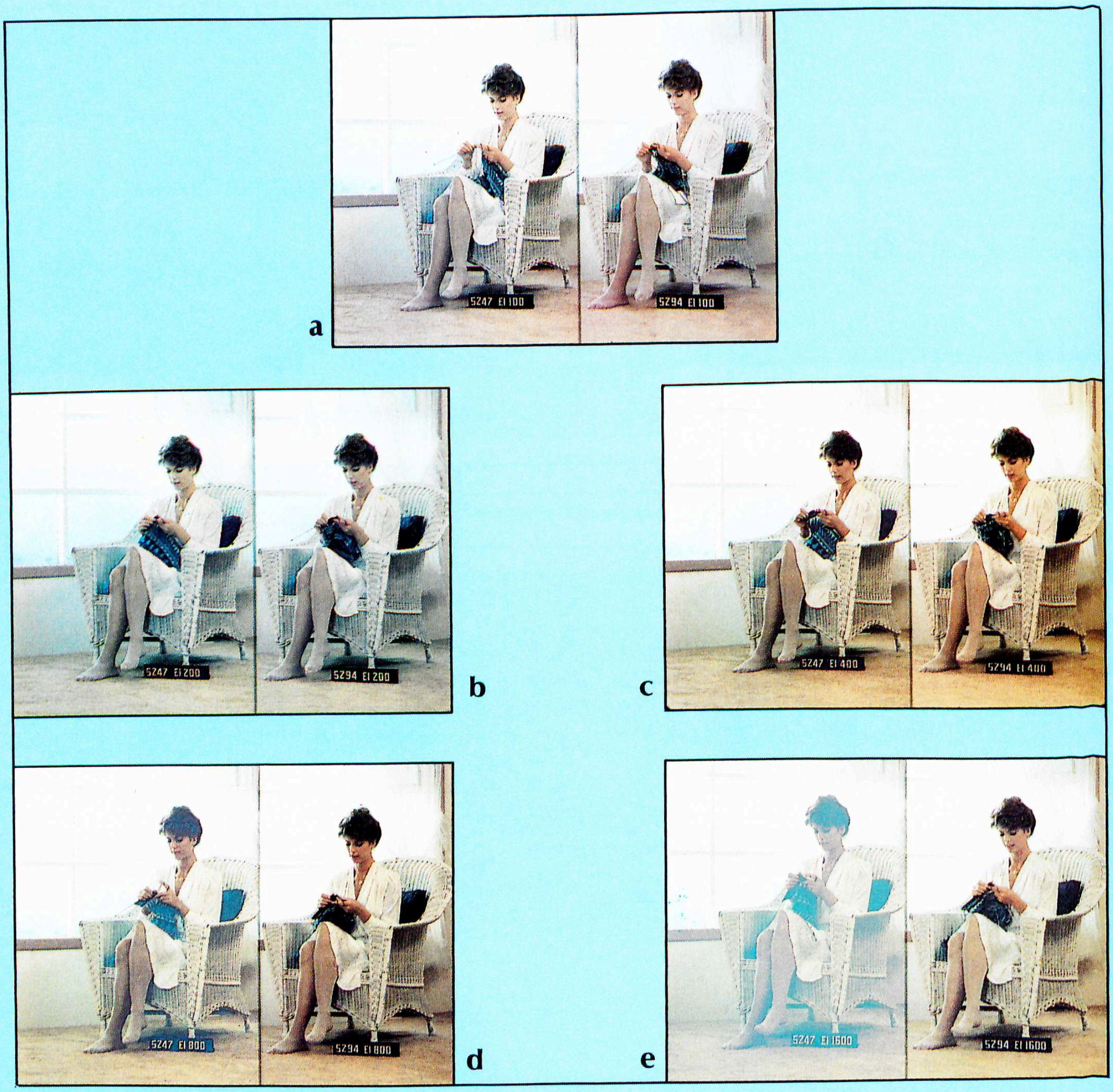

Figure 17. Exposure series — low-brightness-ratio, high-key scene.

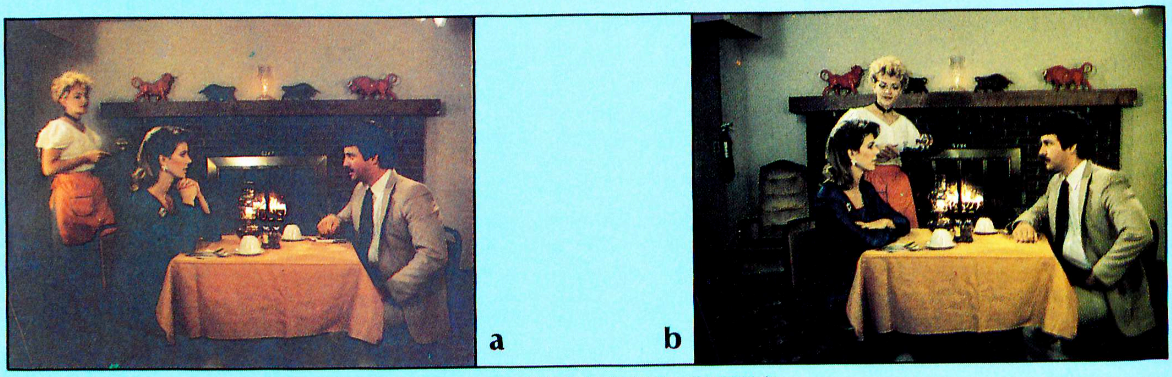

Figure 18. Low-brightness-ratio, low-light-level scene exposure at EI-200: (a) 5247 film; (b) 5294 film.

5247 film to exhibit degraded blacks, lower color saturation, increased graininess, and decreased sharpness. Film 5294, on the other hand, should exhibit (principally because of the low brightness ratio) only a minor decrease in D_{max}. Graininess should be slightly higher and sharpness slightly lower, relative to its optimum exposure of EI-400. Film 5294 should provide the look desired with only minor D_{max} changes. A typical scene of this description, exposed at EI-800 on both films, is shown in Fig. 18. Film 5247 exhibits significantly smoky blacks; sharpness is lower and grain higher. Film 5294 provides increased shadow density, better sharpness, and lower graininess. Thus 5294 film appears to produce the look desired.

Table 2 — Comparison of 5247 and 5294 Films — EI-800, Low Brightness Ratio

	Sensitometry	Sharpness	Grain	Color Saturation
5247 (2⅔ under)	Very low D_{max} (very smoky shadows)	↓↓	↑↑	↓↓
5294 (1 under)	Slightly lower D_{max}	↓	↑	↓

Table 3 — Comparison of 5247 and 5294 Films — EI-200

	Sensitometry	Sharpness	Grain	Color Saturation
5247 (⅔ under)	Low D_{max} (decrease)	↓	↑	↓
5294 (1 over)	Slightly muddy whites	↑	↓	↑

Table 4 — Comparison of 5247 and 5294 Films — EI-50

	Sensitometry	Sharpness	Grain	Color Saturation
5247 (1⅓ over)	No effect	↑	↓	↑
5294 (3 over)	Significantly muddy whites	↑↑	↓↓	↑

Table 5 — Comparison of 5247 and 5294 Films — EI-160, Low Brightness Ratio

	Sensitometry	Sharpness	Grain	Color Saturation
5247 (⅓ under)	Slightly smoky blacks	↓	↑	↓
5294 (1⅓ over)	Slightly muddy whites	↑	↓	↑

Moderate Light Level/High Brightness Range

Often a cinematographer desires a more realistic look, as opposed to the more subtle mood just discussed. To achieve realism, he may wish to emphasize image sharpness and color saturation and minimize grain. Table 3 compares expectations for 5247 film versus 5294 film, assuming an exposure index of EI-200.

This comparison shows that there are only slight differences in neutral-scale reproduction: 5247 film tends toward slightly smoky shadows and 5294 film toward slightly muddy whites. Depending on the type of scene, this difference may dictate the choice. Film 5294 exposed at one-over has a slight advantage in sharpness and graininess compared to 5247 film at one-under. If white reproduction is not critical, then 5294 film should provide the look desired at this intermediate exposure condition. Figure 19 shows a typical scene of this type exposed at EI-200 on both films.

High Light Level/High Brightness Range

Suppose the look the cinematographer desires is created by high-contrast lighting where image structure, rich blacks, clean whites, and high color saturation are desirable. Table 4 compares expectations for 5247 film compared with 5294 film, assuming an exposure index of EI-50.

Film 5247 exhibits essentially no degradation in its sensitometric scale when slightly overexposed. On the other hand, 5294 film may exhibit a loss in highlight detail and muddy whites at this high level of overexposure. Both 5247 and 5294 films show some improvement in sharpness. The graininess position of 5247 film is somewhat improved, while 5294 film is significantly improved. Although the color saturation of 5294 film should be significantly higher, the effect of the muddy highlights negates this potential advantage. In general, the guideline in this case is to use 5247 film to preserve neutral tone-scale reproduction (particularly highlights). Figure 20 shows a typical high-light-level/high-brightness-range scene exposed at EI-50.

Medium Light Level/Low Brightness Range

At times, a cinematographer may wish to produce the "subtle-artistic look" at medium exposure conditions. Table 5 compares expectations of 5247 film and 5294 film, assuming an exposure index of EI-160 and a low scene-brightness ratio.

Under these conditions, 5247 film should exhibit shadows that are slightly less dense than with a normal exposure, slightly lower color saturation, slightly decreased sharpness, and increased graininess. Film 5294, on the other hand, should produce slightly increased color saturation and sharpness, and decreased graininess. Consequently, a more subtle mood is produced using 5247 film compared to 5294 film. As experienced cinematographers know, a subtle mood or a "soft look" may also

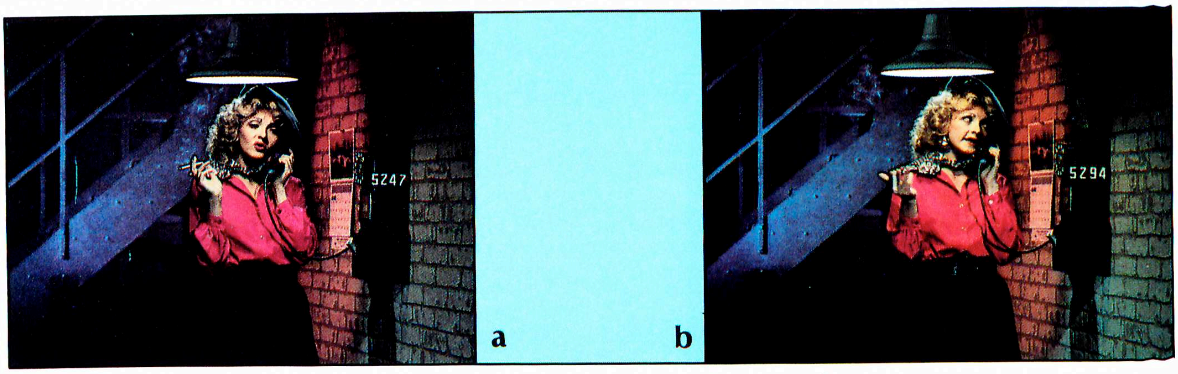

Figure 19. High-brightness-ratio, moderate-light-level scene exposure at EI-200: (a) 5247 film; (b) 5294 film.

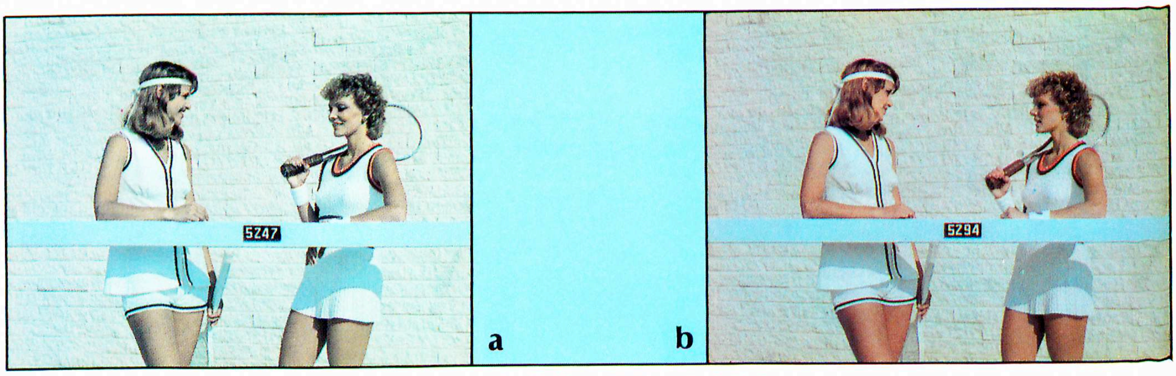

Figure 20. High-brightness-ratio, high-light-level scene exposed at EI-50: (a) 5247 film; (b) 5294 film.

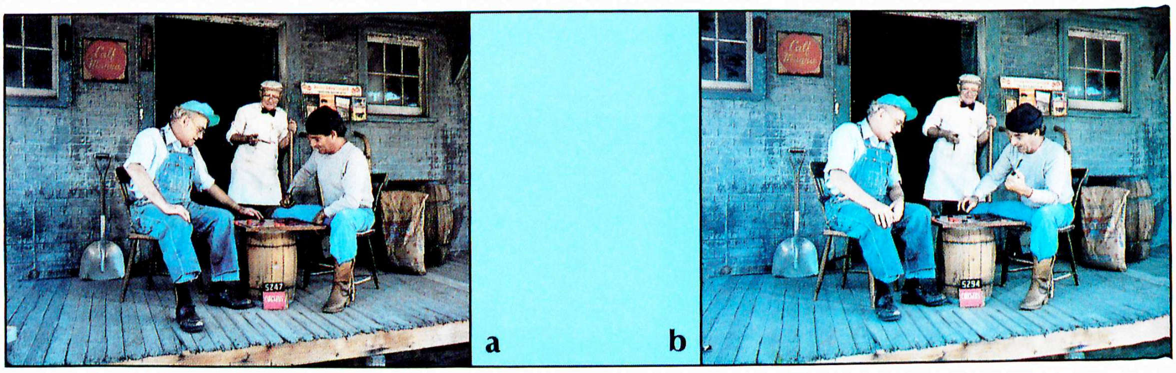

Figure 21. Low-brightness-ratio, medium-light-level scene exposed at EI-160: (a) 5247 film; (b) 5294 film.

be achieved using contrast reduction or fog filters. Figure 21 illustrates the look achieved by exposing a typical medium-light-level/low-brightness-range scene at EI-160 on both films.

Conclusion

We have examined some technical performance parameters as a function of exposure and scene brightness ratio. In general, image structure improves with either product as exposure increases. Neutral-scale reproduction is degraded with either over- or underexposure, particularly in high-brightness-ratio scenes. Color saturation increases as exposure increases.

Guidelines for choosing 5247 or 5294 film generally suggest that 5294 film should be used in low-to-moderate exposure conditions and 5247 film in moderate-to-high exposure conditions. The choice in the moderate-exposure condition must be made on the basis of the specific look the cinematographer desires. Our evaluation reinforces the basic point that these versatile films are flexible tools to be used artistically by the cinematographer to create and interpret. The potential exists in the film — the decision is in the hands of the cinematographer.

Acknowledgments

The authors wish to acknowledge the contributions of Paul Yarrows and Art Hightower of the Eastman Kodak Co. Marketing Education Center in the design and preparation of this article.

Reference

1. L. A. Jones and N. Deisch, "The Measurement of Graininess in Photographic Deposits," *J. Franklin Inst.*, *190*:657-671, 1922.