Norman L. Fritz
*Eastman Kodak Company*
*Rochester, NY 14650*

# Filters: An Aid in Color-Infrared Photography

## Filters may be used to obtain optimum balance or to compensate for keeping conditions or process variations with color-infrared photography.

### Introduction

The amount of information that can be derived from color aerial photographs is often greatly dependent on the color balance of the final imagery. One balance may be better for illustrating a particular feature of the earth's surface, another may emphasize a different feature, and yet neither may be that of the film as manufactured. Too often, users do not realize that it is possible and frequently desirable to modify the balance in color characteristics, and the relationship between the color of the camera filter and the resulting image color balance is not well understood by all photographers. Color infrared photography may require the greatest variability of balance, but it also may provide the greatest benefit from achieving optimum color rendition. Because the photograph cannot be compared directly to the scene in order to determine a normal balance—as can be done with normal-color photographs—there are fewer constraints or guidelines to order to optimize the results for a particular application.

Abstract: *It is necessary at times to change the color balance of infrared-sensitive color films in order to obtain optimum results for a particular application. This change may be needed because the optimum balance for one application is different from that required for another or to compensate for changes in the film caused by keeping conditions or process variations. Because of the unique color characteristics of these films, the selection of filters and the understanding of their effects is not as straightforward as with normal-color films. In order to clarify the use of filters and to illustrate how they can be used effectively, descriptions of the filters, their effects on the sensitometric characteristics and on the visual effects in the processed film are described. Viewing filters also can be used to some extent to assist in the analysis of the results obtained.*

The color balance of the final photographic image, whether from the negative-positive or reversal system, can be changed by using filters over the camera lens when the photographs are made. When prints are made, modifications also can be made at that stage. These procedures are standard practice with normal-color films and are rather straightforward in concept. However, infrared-sensitive color films have unique follow, and the selection of optimum requires careful analysis of specific objectives. Here one is well-advised to maximize the information content for the specific application rather than to assume that a "pleasing" color balance is optimum. For these reasons, this paper will describe the use of filters only with the Kodak Aerochrome infrared films. However, many of the principles discussed are directly applicable to normal-color photography and will be found useful with these films as well.



Photogrammetric Engineering and Remote Sensing,
Vol. 43, No. 1, January 1977, pp. 61-72.

## Background

The most numerous uses for photography with infrared-sensitive color films are for applications which involve the photography of plants. The purpose may be to determine if plants are present or not, to find or differentiate some condition or characteristic of the plants, to infer the characteristics of the soil in which the plants are growing, or to learn something about the materials under the soil. Consequently, the color balance of the film has been optimized for these applications.

There are a number of reasons why a different color balance might be needed in order to produce maximum information. For example, in such applications as studies in geology, engineering, soils, etc., the reflective characteristics of the objects being photographed are quite different from those of normal foliage. Also, uses such as range management or urban planning may require only an indication of whether or not foliage is present, there being no need to distinguish its specific characteristics.

There is some practical evidence which indicates that a more red color balance is required for photography made from higher altitudes. Although this effect is primarily due to atmospheric haze, it may also result from the smaller scale and the fact that many such applications need only an indication that foliage is present.

Because the reflectance characteristics of aerial scene elements (particularly foliage) change with the season, there is the possibility that for maximum discrimination of reflectance differences, a seasonal modification in balance may prove beneficial. This seems logical but has not been rigorously proven.

In some cases the best color balance may not be known because a new application is being evaluated or because the reflectance characteristics of the objects being photographed have not been determined. Under these circumstances, it is often desirable to make a series of photographs in which the color balance is varied systematically around the anticipated optimum balance, and from these tests to select the one which provides the maximum information.

The keeping characteristics of these films are such that it is sometimes necessary to compensate for changes in color caused by the temperature at which the film has been stored. In one film the infrared-sensitive cyan layer tends to decrease in speed as the film ages, and the speed of the green-sensitive layer increases slightly, particularly at room temperatures or higher. These effects may not be significant if the film is refrigerated as recommended.

The films are manufactured to produce standard results with machine processing, but rewind and spiral-reel processes, which match the standard process as closely as possible, have been devised. These, as well as the commercial Kodak process E-4 all give results which are slightly different in color balance from those of machine processing.

There are other factors which often make it impossible to obtain identical pictorial results on every roll of film. These factors include: atmospheric conditions such as aerial haze, solar altitude, and clouds; geographical location and scene type; normal manufacturing variation in the film; and processing repeatability. It is often difficult to correct for these variables because they are unpredictable in magnitude and color, but known conditions may suggest some correction.

From the foregoing, it can be seen that for critical applications, it is desirable to test the film before use to determine its color balance under practical conditions. Filters can then be used to adjust this balance as required, following the procedures to be described.

## Principles of Reversal False-Color Photography

Before detailing the relationships between camera filters and their photographic effects, let us first review briefly some of the basic principles of false-color photography. Figure 1 shows the arrangement of the principle layers of the infrared-sensitive color films. The bottom layer is sensitive to radiation in the red spectral region and, on processing, forms a magenta positive image. The middle layer is sensitive to radiation in the green spectral region and forms a yellow positive image, and the top layer is infrared sensitive and forms a cyan positive image.

The relationship between the sensitivities of the individual layers and the dyes formed

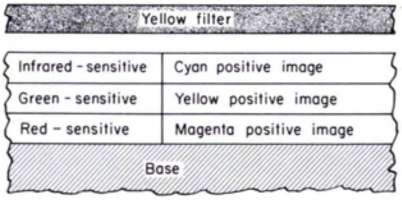


Fig. 1. Arrangement of the layers and filters for Kodak Aerochrome infrared film 2433 (Estar base).

TABLE 1. PRINCIPLES OF OPERATION OF KODAK AEROCHROME INFRARED FILM, 2443.

| | | | | | |
|---|---|---|---|---|---|
| Spectral region | Ultraviolet | Blue | Green | Red | Infrared |
| Aerochrome Infrared film sensitivities | Ultraviolet | Blue | Green | Red | Infrared |
| Sensitivities with yellow filter | | | Green | Red | Infrared |
| Color of dye layers | | | Yellow | Magenta | Cyan |
| Resulting color in photograph | | | Blue | Green | Red |

is illustrated differently in Table 1. Here, on the first line, the spectral region to which photographic films are sensitive has been divided into the ultraviolet, which includes wavelengths shorter than are visible, the blue, green, and red regions of the visible spectrum, and the infrared, which is at longer wavelengths than can be seen. The sensitivities of the three film layers to the green, red, and infrared regions and also the blue and ultraviolet sensitivity of all three layers are shown on the second line. A yellow filter is always used between the scene and the sensitive layers of the film in order to absorb the blue and ultraviolet radiation and prevent it from exposing the film (line 3). Without going into the details of the photographic process, positive images composed of yellow, magenta, and cyan dyes are formed in the respective three layers (line 4). Combinations of these dyes produce a blue image where the film received a green exposure, a green image where the film received a red exposure, and a red image where the film received an infrared exposure.

For simplicity, Table 1 depicts the sensitivities of the film layers as broad spectral regions with no indication of variability in sensitivity over the regions. Figure 2 shows the actual sensitivity of each of the film layers plotted as a function of the wavelength of the exposing radiation. The rather general blue, green, red, and infrared regions of the spectrum are shown at the bottom of this figure.

Proceeding from the inherent sensitivity characteristics of the film to the photographic characteristics, consider first that a photographic scene is composed of areas of various brightness and color. If the gray areas are arranged in an orderly array, a step wedge will be formed; and when it is photographed, a corresponding array of densities will be found in the processed film. When these densities are measured and plotted as a function of the brightnesses of the original areas, the sensitometric or characteristic curve of the film results. Since there are three layers in a color film, there are three sensitometric curves, each representing the film response in the spectral region to which that layer is sensitive. Figure 3 shows sensitometric curves for Kodak Aerochrome infrared film 2433 (Estar base). It can be seen

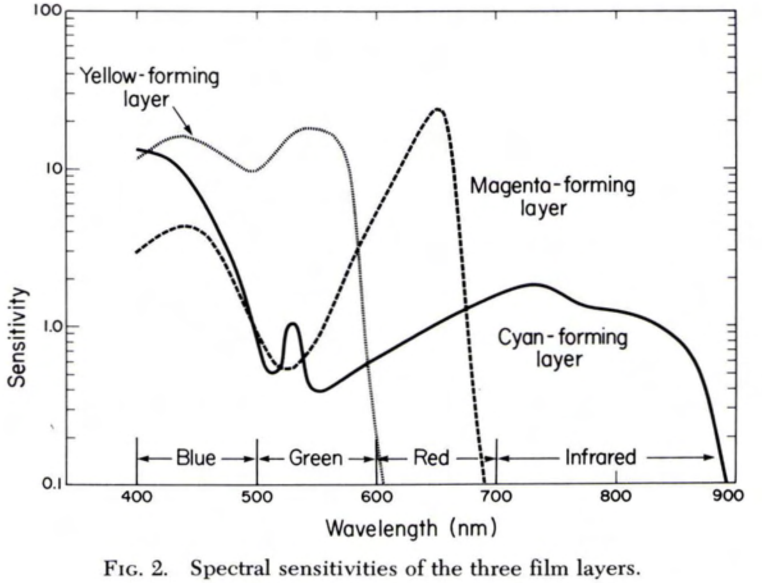


FIG. 2. Spectral sensitivities of the three film layers.

that more exposure is required to produce a given density in the cyan-forming layer than in the other two layers; and thus, the cyan layer is said to be "slower" than the magenta and yellow layers. This layer has deliberately been made slower in order to compensate somewhat for the high infrared reflectance of foliage. If the sensitivity were not so decreased, the layer would be grossly overexposed, and there would be no variation in cyan density when there were differences in infrared reflectance.

Color balance is generally thought of as the overall color appearance of a photograph, not considering the colors of the individual objects themselves. It is also the direction of color bias of the reproduction of gray subjects and is thus dependent on the relationship between the amounts of dyes formed for a gray exposure. This relationship can be seen from the sensitometric curves of the three layers of the film. If the three curves superimpose, gray objects will reproduce as gray in the photographs provided the appropriate kind of densitometry has been used. With the Aerochrome infrared film, the slow cyan layer will result in more cyan dye being formed than yellow and magenta for a given gray exposure, and thus, the color balance is cyan. A different relationship between the sensitometric curves will obviously produce a different color balance for the film. This relationship will be discussed more thoroughly after considering the effects of filters on the sensitivities of the films and thus on the sensitometric curves.

## Relationship Between Filter Transmittances and Film Sensitivities

There are many types of filters used for color aerial photography, each with certain characteristics which make its use efficient in changing film response for a particular application. The most important types are the sharp-cutting and color-compensating filters, with others such as bandpass, band rejection, light balancing, conversion, and photometric being used for special applications. Each, though, affects the color balance by changing the apparent sensitivities of the individual layers of the film by selectively absorbing the radiant energy in the appropriate spectral regions.

In order to describe the effects of using

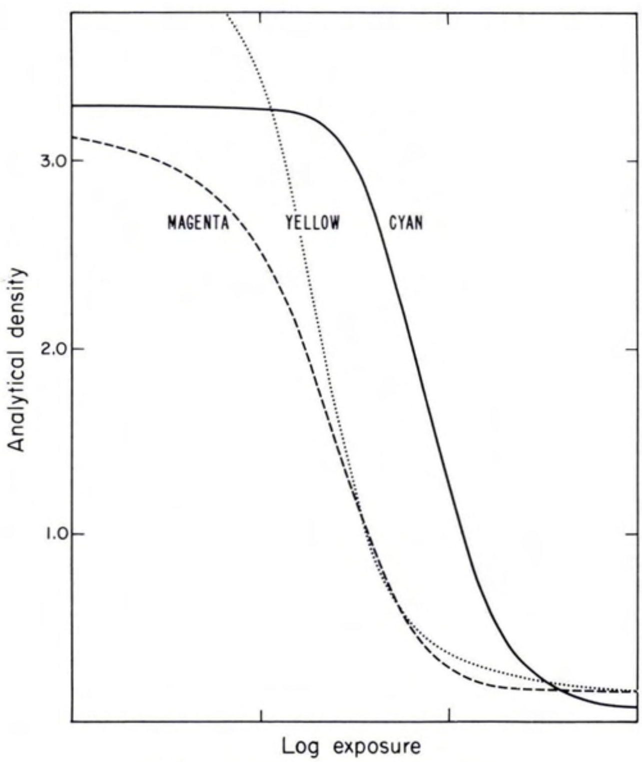


Fig. 3. Typical sensitometric curves.

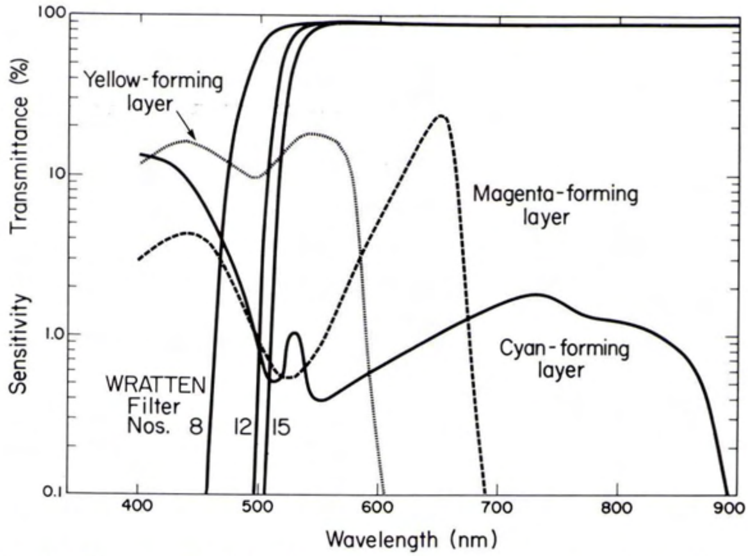


FIG. 4. The spectral relationship between three sharp-cutting Kodak Wratten filters and the film sensitivities.

filters over the camera lens, consider again the spectral sensitivity curves of Aerochrome infrared film. Figure 4 shows these curves and on the same graph the spectral transmittance curve of a sharp-cutting Kodak Wratten filter No. 12 which is recommended for use with this film. At wavelengths shorter than about 500 nanometers, the filter has alsmost no transmittance, thus preventing radiation in the blue and ultraviolet spectral regions from reaching the film. Also plotted on the same graph are the transmittances of two other sharp-cutting filters, the Wratten filters No. 8 and No. 15, which are sometimes used in place of the No. 12. The primary difference in the effects of these filters is in their ability to change the response of the yellow-forming layer. The Wratten No. 8 allows a greater wavelength range to affect this layer and thus effectively increases its apparent sensitivity and speed. Conversely, the Wratten No. 15 decreases the range and, similarly, the apparent sensitivity and speed of the layer. As can be seen, these filters also modify the response of the other two layers slightly, but this effect is secondary.

The Kodak color compensating filters modify the spectral energy distribution reaching the film in a manner different from that of the sharp-cutting filters just described. Figure 5 again shows the spectral sensitivities of the film and also the spectral transmittances of two color-compensating filters, a CC-50 magenta and a CC-50 cyan. These filters partially absorb radiant energy in rather broad spectral regions, each of which coincides with the sensitivity of one of the layers of the film. Thus, each filter will reduce the amount of radiation reaching the film in the region of maximum sensitivity of one layer and will, consequently, decrease the apparent sensitivity and speed of that layer. These filters are available in a series of concentrations and so can be used to control the response of the layer by a selected amount.

A color-compensating blue filter is a composite of the magenta and cyan filters shown in Figure 5 and is often used to change the color balance of Aerochrome infrared film by reducing both the green and red exposures. Its blue transmittance is not significant because the Wratten No. 12 prevents this radiation from reaching the film. A characteristic of all geltain filters is that they transmit freely in the infrared spectral region, so there are none that will effectively control the sensitivity of the cyan-forming layer. It is necessary to use a glass filter for this purpose, and it has been found that a Corning filter No. 3966 is satisfactory. Figure 5 also shows the spectral transmittance of this filter. Variations in absorption can be obtained by grinding the glass to different thicknesses, which is rather difficult and costly. However, it is the only practical technique available to adjust the sensitivity of the infrared-sensitive layer with filters.

Bandpass filters, which generally transmit in only one spectral region, and band-

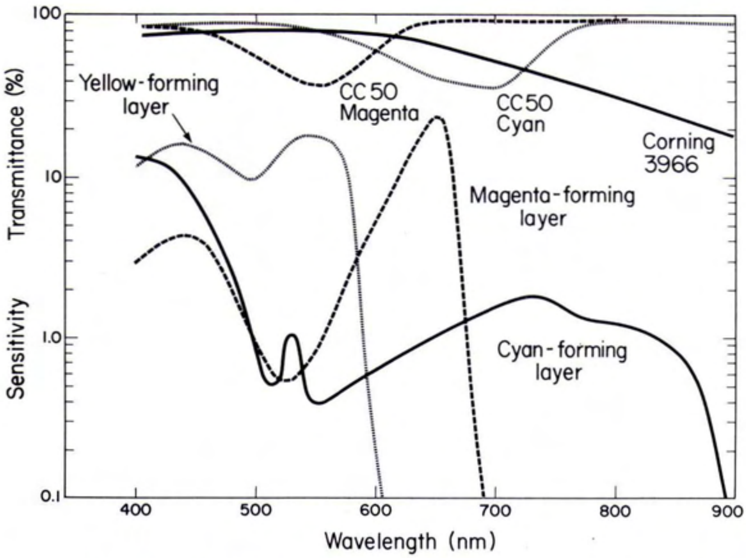


FIG. 5. Transmittances of typical Kodak color compensating filters superimposed on the spectral sensitivity curves.

rejection filters, which are highly absorbant in one spectral region, are little used as camera filters in color photography. They tend to change the color balance of a film so drastically as to limit its usefulness as a color film. Bandpass filters are used, though, to assist in the analysis of the color film images; and this use will be described later.

Light-balancing, conversion, and photometric filters are generally used to compensate for differences in illuminant quality, as when using indoor film outdoors; they are sometimes used, however, to replace certain combinations of color-compensating filters. The equivalence between filters can be estimated by comparing their densities in the spectral regions where the film layers have maximum sensitivity. Their actual effects have to be determined sensitometrically or by practical photographic tests.

## Effect on Sensitometry and Photography

Consider now the effects of filters on the sensitometric characteristics of color films and, as a consequence, their effects on the appearance of the photographs. Obviously, a filter can only decrease the apparent sensitivity of a layer of film; it can never increase it. The effect of decreasing the sensitivity of a layer is that less response (higher density for reversal films) is obtained from a given exposure or, conversely, that more exposure is required to produce the same density. For a sensitometric curve, the result is that a filter will cause a given density to be plotted at a greater log E value; and the amount of shift will correspond to the density of the filter. The net effect is to move the sensitometric curve to the right, which is illustrated in Figure 6 where a CC-10 magenta filter has been used to slow the response of the yellow-forming layer. The other two layers also will be slowed a little due to the slight density of the filter in the red and infrared regions, but only the net effect is shown here.

The sharp-cutting Wratten No. 15 filter decreases the apparent sensitivity of the yellow-forming layer more than the Wratten No. 12 does, as was shown in Figure 4; and it has been found that the effect of a CC-10 magenta filter is closely equivalent to that of the change from No. 12 to No. 15. The similarity of these effects is used when the Aerochrome infrared film is to be processed in the regular Kodak process E-4 or in the modified E-4 processes required for rewind or spiral-reel equipment. All these processes tend to increase the speed of the yellow-forming layer somewhat, so recommendations state that, when they are to be used, either a CC-10 magenta be used in addition to the Wratten No. 12 or a Wratten No. 15 be used in place of both over the camera lens when the exposures are made. The added blue absorption thus compensates for the increased speed caused by processing.

Having established the effects of filters on

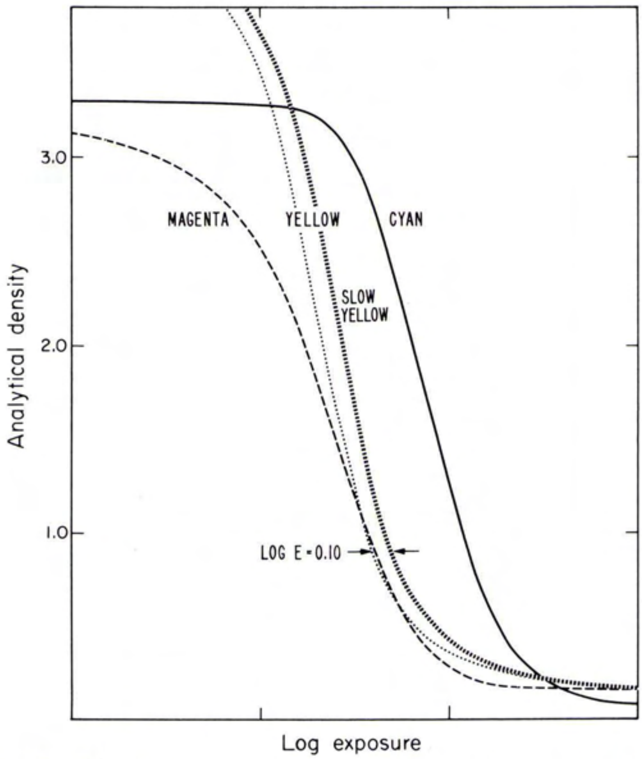


FIG. 6. The effect on sensitometric curves of a color compensating 10 magenta camera filter.

the sensitometric curves, consider how the changes caused by them affect the appearance of the photographs. With a normal-color film, the relationship is apparent: if a greenish filter is used over the camera lens when making the photographs, the resulting pictures look greenish. Because of the different relationships between the sensitivities and the dyes formed with the Aerochrome infrared film, the results are not so straightforward. First consider the effect of a color-compensating magenta filter. This was shown in Figure 6 to decrease the effective speed of the yellow-forming layer. For any given exposure, more yellow dye will be formed than if the filter had not been used; the photograph will then appear more yellow, and we say the color balance has shifted in the yellow direction. Similarly, the use of a CC cyan filter will slow the response of the magenta-forming layer, and the color balance will go in the magenta direction. Occasionally, two different color-compensating filters will produce the same effect with this film. For example, both the cyan and green filters change the color balance in the magenta direction. The cyan filter transmits blue, green, and infrared radiation, whereas a green filter transmits green and infrared; but the Wratten No. 12 prevents the difference in the blue region from affecting the film.

Table 2 lists the color balance changes

TABLE 2. CAMERA FILTERS REQUIRED TO PRODUCE VARIOUS COLOR BALANCE SHIFTS.

| Color Balance Shift Needed | Required Camera Filter |
|---|---|
| Yellow | Kodak CC* magenta or CC red |
| Magenta | Kodak CC green or CC cyan—Series 1 |
| Cyan | Corning 3966 |
| Blue | Kodak CC cyan—Series 2 or Kodak CC cyan—Series 1 plus Corning 3966 |
| Green | Kodak CC magenta plus Corning 3966 |
| Red | Kodak CC blue |

* Kodak color compensating filters.

produced by various filters and combinations of filters. It can be used to assist in the selection of a camera filter when the evaluation of photographs indicates that for a particular application, film, process, keeping effect, etc., a different color balance is required. The table lists only the direction of color change; the amount of change, and thus the concentration of filter needed, will have to be judged for the individual application.

If one is able to make and process sensitometric exposures along with the photography, the required filters can be selected more readily and the concentration more precisely determined than if reliance must be placed on visual interpretation of the photographs. The color balance produced by the sensitometric curves shown in Figure 3 has been found to be optimum for many of the applications of this film to date. These curves were generated under the test conditions used by the Eastman Kodak Company, but somewhat different ones may be obtained for different sensitometers, processes, densitometers, etc. If one can determine what sensitometric curves produce a color balance which provides maximum information in the photographs, then deviations from this can be corrected by finding what filters are needed in the sensitometer to provide the correct balance. The same filters are then used over the camera lens.

As has been mentioned, it is sometimes desirable to make a series of photographs in which the color balance is systematically varied over a sizeable gamut of colors in order to determine optimum reproduction for an application. Because all filters have some absorption in their regions of highest spectral transmittance and because the three layers of a color film have somewhat overlapping sensitivities, the effect of adding filters is not only to change the color balance but also to decrease the exposure. Table 3 shows a complete set of filter combinations and exposures which have been found helpful in producing such a color balance gamut with 2433. The exposures assume a clear day with the solar altitude above 40°.

## Viewing Filters

It is often difficult to assess a color photograph visually and to know with certainty

Table 3. Filters and Exposures Required to Produce Color Balance Gamut with 2443.

| Filter Combinations | Aperture (for 1/500-second exposure time) | | |
|---|---|---|---|
| Filter No. 12[1] | f/4.7 | f/5.6 | f/6.7 |
| Filter No. 12 + CC−10M[2] | f/4.7 | f/5.6 | f/6.7 |
| Filter No. 12 + CC−20M | f/4.7 | f/5.6 | f/6.7 |
| Filter No. 12 + CC−30M | f/4.7 | f/5.6 | f/6.7 |
| Filter No. 12 + CC−40M | f/4.0 | f/4.7 | f/5.6 |
| Filter No. 12 + CC−10B | f/4.0 | f/4.7 | f/5.6 |
| Filter No. 12 + CC−10B + CC−10M | f/4.0 | f/4.7 | f/5.6 |
| Filter No. 12 + CC−10B + CC−20M | f/4.0 | f/4.7 | f/5.6 |
| Filter No. 12 + CC−10B + CC−30M | f/4.0 | f/4.7 | f/5.6 |
| Filter No. 12 + CC−20B | f/4.0 | f/4.7 | f/5.6 |
| Filter No. 12 + CC−20B + CC−10M | f/4.0 | f/4.7 | f/5.6 |
| Filter No. 12 + CC−20B + CC−20M | f/4.0 | f/4.7 | f/5.6 |
| Filter No. 12 + CC−20B + CC−30M | f/4.0 | f/4.7 | f/5.6 |
| Filter No. 12 + 1/2 C3966[3] | f/4.0 | f/4.7 | f/5.6 |
| Filter No. 12 + 1/2 C3966 + CC−10M | f/4.0 | f/4.7 | f/5.6 |
| Filter No. 12 + 1/2 C3966 + CC−20M | f/4.0 | f/4.7 | f/5.6 |
| Filter No. 12 + 1/2 C3966 + CC−30M | f/4.0 | f/4.7 | f/5.6 |
| Filter No. 12 + 1/2 C3966 + CC−40M | f/3.4 | f/4.0 | f/4.7 |
| Filter No. 12 + C3966 | f/3.4 | f/4.0 | f/4.7 |
| Filter No. 12 + C3966 + CC−10M | f/3.4 | f/4.0 | f/4.7 |
| Filter No. 12 + C3966 + CC−20M | f/3.4 | f/4.0 | f/4.7 |
| Filter No. 12 + C3966 + CC−30M | f/3.4 | f/4.0 | f/4.7 |
| Filter No. 12 + C3966 + CC−40M | f/2.8 | f/3.4 | f/4.0 |

[1] Kodak Wratten filter number
[2] Kodak color compensating filter
[3] Corning filter number.

the direction of a color balance shift or the direction required to bring it back to normal. For example, with Aerochrome infrared film, a more yellow balance often looks redder; and blue, green, and cyan balances are frequently confused with each other. The ability to make correct analyses comes with practice and is often aided by the use of appropriate viewing filters. These filters will not only assist in determining which layer needs to be corrected, but in some cases will indicate the degree of correction required.

Color-compensating filters superimposed over a photograph will often assist in the analysis. It is important to place them close to, but not directly on, the photograph rather than over the eyes; because when the latter is done, the color of the photograph and surround both are changed, the adaptation of the eyes change, and the difference in balance is not apparent. When the filter which produces the needed color change has been determined, the camera filter required to produce the appropriate color balance shift can be found in Table 2. Thus, a CC magenta camera filter will be required to produce a yellow color balance shift. It is important to use this method with caution because viewing through a filter does not produce exactly the same effect as does changing the color balance by means of camera filters. For example, viewing through a yellow filter will increase the blue density in all areas of the photograph equally, which sensitometrically is the same as shifting the entire yellow curve in a vertical direction. This effect is shown in Figure 7 and can be compared to the one shown in Figure 6 where a camera filter has produced a horizontal shift in the curve position. In the mid-scale region, the effects are the same; that is, the blue density is higher. But the toe or highlight region of the photograph viewed through the filter is more yellow than it is in the other one. Therefore, care should be taken to make such judgments only in the mid-scale regions.

The quantitative relationship which must be taken into consideration is that a filter produces more effect when used as a camera filter than if used for viewing. As an example, the contrast of the yellow layer is about 3.5 at a density of 1.3, which is the region

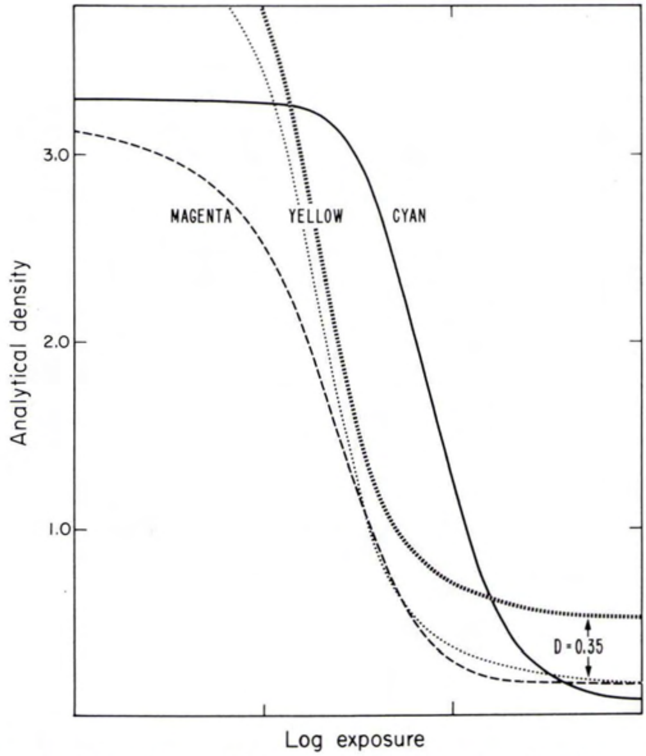


FIG. 7. The apparent effect on sensitometric curves of a color compensating 35 yellow viewing filter.

where foliage will be recorded in a well-exposed photograph. In this region, a 0.1 log E speed shift is equivalent to a density change of about 0.35. Therefore, a CC-10M camera filter will provide the same compensation shown to be needed by a CC-35Y viewing filter. This equivalence is shown by comparing Figures 6 and 7.

Another method of determining which layer must be corrected—or sometimes to find if a layer has received a reasonable exposure—is to study the layers individually. This can be accomplished by viewing the photographs through bandpass filters whose peak transmittances (lowest densities) correspond in wavelength with the greatest difference in absorption between the film dyes. In this case, the filters should be held directly over the eyes. Figure 8 shows the spectral densities of the Aerochrome infrared film dyes in addition to the densities of Wratten filters No. 47B, No. 58, and No. 29, which can be used for such viewing. Also shown are narrower bandwidth filters which will isolate the individual layers better but which are somewhat darker in use. It is not necessary that the red filter have high density at the long wavelength end of its pass band because the sensitivity of the eye is decreasing very rapidly in this region. It is obvious that this method does not allow viewing of one layer exclusively, because each of the dyes has unwanted absorptions in the spectral regions other than where its peak lies. However, the primary response is that of a single layer, and the method has proved to be very useful.

After some experience has been gained in viewing photographs having good color balance through the above filters, it is possible to obtain considerable information from those with less than optimum balance. For example, a film with too slow a cyan layer will appear dark through the red filter. There have been occasions when it was thought that the infrared sensitivity of the film had been lost, but inspection through the red filter showed that there was indeed red light modulation. This modulation could only be caused by changes in cyan density, which in turn was due to different exposures from infrared reflectances in the scene photographed.

### Densitometer Filters

Closely related to the viewing filters just

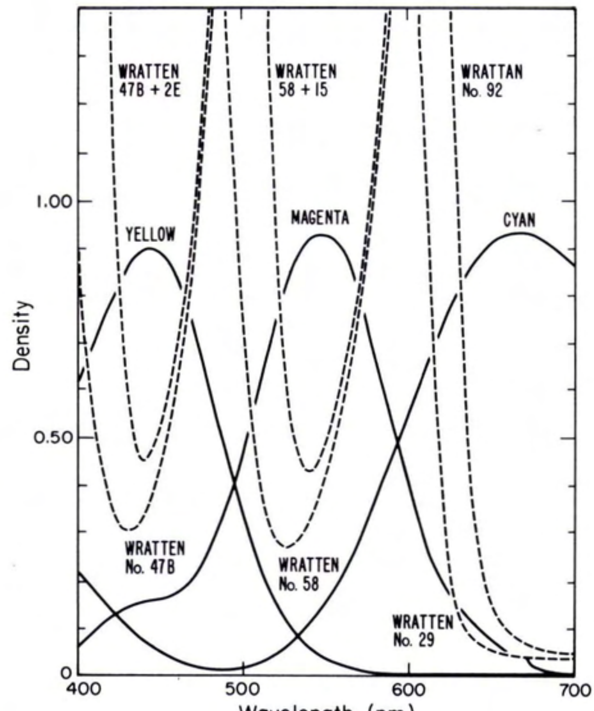


Fig. 8. Spectral densities of the film dyes and various Kodak Wratten bandpass viewing filters.

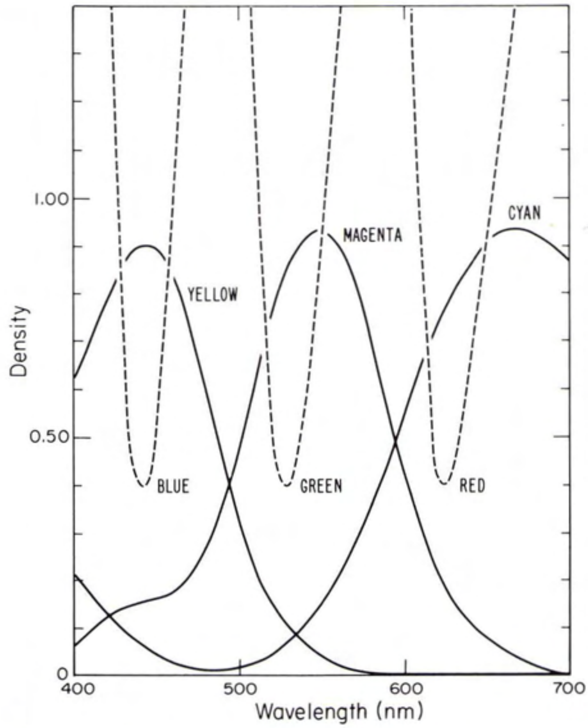


FIG. 9. Typical densitometer spectral response functions and spectral densities of the film dyes.

described are the densitometer filters which are used in the measurement of the response of color films. Frequently more information can be derived from photographs by measuring the densities of the layers than from visual inspection alone. Several investigators are measuring the red densities of Aerochrome infrared film for the detection of diseased plant life, because it can often be detected this way before it is visible in the photographs.

The requirements for the densitometer filters are similar to those of the bandpass filters needed for visual inspection. The spectral characteristics of the filters should be such that the densitometer response is peaked at the wavelengths where the greatest separation between the absorptions of the dyes exist. There are, though, special circumstances under which this condition cannot always be met. In contrast to the viewing filters, the bandwidths of these filters can be narrower because the photocell in a modern densitometer is more sensitive than the eye for this kind of measurement. As with viewing filters, the densitometer response is not just that due to one layer because of the unwanted absorptions of the other two dyes. Although it is beyond the scope of this paper to describe the method, these red, green, and blue densities can be rather simply transformed to give the responses of the individual layers. The densities so determined are known as analytical densities.

Figure 9 shows a set of typical densitometer spectral response curves superimposed over the spectral dye density curves of the film. It can be seen that the red response does not meet the criterion that its pass band be at the wavelength of maximum dye density difference. The reason for this choice of pass band is that the photo-cell response is decreasing rapidly at longer wavelengths in this region; and thus, the shorter wavelength filter provides more response.

## CONCLUSION

When trying to accomplish a particular objective with color aerial photography, it is neither necessary nor always desirable to accept the results of a given mission as being optimum for the application. The results often can be modified and improved by the proper selection of camera filters. Often a careful modification of results with the materials and techniques at hand can change an unsuccessful experiment to a successful one. For this reason, the time necessary to learn the details of the use of filters is well spent.

REFERENCES

1. Fritz, N. L. "Optimum Methods for Using Infrared-Sensitive Color Films," *Photogrammetric Engineering*, Vol. 33, No. 10, October, 1967, pp. 1128-1138.
2. "Kodak Filters for Science and Technical Uses," Kodak Publication No. B-3.

# *New Sustaining Member*

## Aerial Photo Service, Inc.

AERIAL PHOTO SERVICE, INC. is an old established firm serving Tulsa and the Midwest since 1939 with professional quality aerial photography and mapping. It is numbered among the few organizations in the Midwest offering a complete photogrammetric service. It is one of the first firms to offer wide angle distortion-free color and black-and-white aerial photography. The company's record of continued growth in the field of photogrammetry can be attributed to the reputation gained by performance, technical competence, and application of sound professional principles.

Their two Cessna 206 tubo aircraft equipped with Wild RC-8 cameras enable them to take advantage of all good photography weather. They operate throughout the Midwest and Rocky Mountain Region.

Aerial Photo Service's photogrammetry staff and survey crews have been provided with and are experienced in the use of the latest first order surveying and stereo plotting equipment essential to a highly accurate, efficient, and economical photogrammetric mapping section. In addition to their two Wild Universal RC-8 cameras, they have two B-8 Aviographs and one B-8-5 Aviograph for second order map computation. One of the B-8 Aviographs is digitized for automatic recording of photogrammetric cross section.

Aerial Photo Service, Inc. specializes in precision aerial photography, including color and Infrared color; Aerial Triangulation with MK2 Monocomparator; and Precision Surveying using Wild T-2 Theodolites and Hewlett-Packard 3800 EDM equipment. Their main office is located at 324 Main Mall, Tulsa, Oklahoma 74103.

## Rangeland Remote Sensing Symposium

The American Society of Photogrammetry and the Society for Range Management are co-sponsoring a Rangeland Remote Sensing Symposium in conjunction with the 30th Annual Meeting of the Society for Range Management. The meeting will be held in Portland, Oregon, February 14-17, 1977, at the Portland Hilton. The Symposium will be on Thursday afternoon, February 17. It is designed to present real applications of remote sensing techniques as a tool for inventory and evaluation of the range environment. The symposium succeeds a morning workshop designed to remove the magic aura of remote sensing for range environmental analysis. Dr. Richard S. Driscoll, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, and Dr. Robert H. Haas, Range Science Department, Texas A&M University, are co-chairmen of the sessions.