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INVESTIGATION OF A NEW COLOR FILM FOR
WATER PENETRATION PHOTOGRAPHY

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INVESTIGATION OF A NEW COLOR FILM FOR WATER PENETRATION PHOTOGRAPHY

ABSTRACT

Eastman Kodak S.O. 224, a two-emulsion color film specially designed for aerial photography of underwater objects, incorporates special peak sensitivities for each emulsion layer plus improved resolution and higher gamma. Improved visual discrimination results from the complementary colors of the two layers. Eliminating the red-sensitive layer helps make this emulsion superior to standard color films in recording the maximum underwater detail. Technical Photography Group (L-Div.) experiments established a film speed at 0.1 ms, compatibility of processing in E.K. - ME-4 chemistry, methods to further increase film speed, and the effect on resolution of increased film speed.

INTRODUCTION

S.O. 224 is a unique color film in that the red-sensitive layer has been eliminated. Previous tests proved that the red band failed to penetrate to 10 m of water. Further research showed that the red-sensitive layer provided information mainly about surface objects and the state of the sea's surface, obscuring subsurface information. In order to penetrate the relatively clear ocean and coastal waters, the blue-green layer was peaked at 480 nm. The green-sensitive layer was peaked at 550 nm for greater penetration in turbid bay water.

Although the film is sensitive mainly in the green and blue-green areas, interpretation of the results was maximized by using a magenta dye in the blue-green sensitive layer (480 nm). The green-sensitive layer (550 nm) remained green. Figure 1 diagrams these emulsion layers.

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Fig. 1. Cross section of S.O. 224 emulsion layers..

Higher contrast (gamma) and improved resolution, as compared to standard color films, was also incorporated in this film. Previous tests¹ have proved S.O. 224 superior over regular color films for delineating underwater detail.

Based on earlier experiments by Eastman Kodak Company, the film was estimated to have an effective aerial speed of about forty when compared to Ektachrome M.S. For our experiments Ektachrome-X was used as a standard. Previous tests on this emulsion proved this film could be pushed in the first developer in the ME-4 process to increase film speed. Exposure indexes have already been established on Ektachrome-X by the Technical Photography Group. Furthermore, the normal exposure index for processing Ektachrome-X (64) is relatively close to that of S.O. 224.

EXPERIMENT

An EG&G MK-4 sensitometer* was equipped with a standard 21-step tablet with a density range of approximately 0-3.00. The sensitometer contained the necessary attenuation and color correction filters to balance the Kelvin of the source for daylight exposures. The exposure was pre-set for 0.1 ms. All tests in this report were made at this exposure time.

In addition, Eastman Kodak Company recommended the use of a #4 Wratten filter to help balance the color on S.O. 224. This filter was used for all exposures in the sensitometer on S.O. 224. Exposures were made on both emulsions and processed for normal development in the ME-4 processor. Visual microscopic examination determined that S.O. 224 was compatible in this chemistry.

The processed step tablets were then measured on a McBeth densitometer and this data was plotted to produce H & D curves. Figure 2 is a

1. M.R. Specht, D. Needlor, and N.L. Fritz, A New Color Film for Water-Penetrating Photography, Research Laboratories, Eastman Kodak Co.

* Reference to a company or product name does not imply approval or recommendation of the product by the University of California or the U.S. Atomic Energy Commission to the exclusion of others that may be suitable.

Fig. 2. H & D curves comparing the sensitivities of S.O. 224 Ektachrome-X for normal development.

direct comparison of both emulsions when measured through a 106 filter on the densitometer. This filter matches the instrument's light-dark response (luminosity function) to that of the average eye. Because both curves are approximately in the same position, a relative exposure index of 64 was assigned to S.O. 224 at 0.1 ms exposure time.

Additional density readings were measured through the three primary colors on the densitometer and again plotted as a function of each color to produce H & D curves. Figure 3 is Ektachrome-X response and Fig. 4 is S.O. 224.

From these encouraging experiments the next step was to determine if S.O. 224 could produce a higher film speed by extended development. Additional step tablet exposures were made and processed on both films for the normal 1,2, and 3 stop-push on the ME-4 color machine. Again, examination confirmed that no visual damage resulted on S.O. 224 with extended processing times.

Figure 5 is a family of H & D curves for Ektachrome-X as a function of extended development. Figure 6 is a similar family of curves for S.O. 224. Both Figs. 5 and 6 were measured with the 106 filter. To establish relative speed curves in visual density, Figs. 7 and 8 were constructed from both families of the H & D curves. Due to the close relationship of these curves, relative speed could be established as a function of increased first developer times (see Table 1).

Table 1. Film speeds for various Technical Photography Group ME-4 machine settings.^a

	Settings			
	Normal	Plus 1	Plus 2	Plus 3
Ektachrome-X	64	130	260	520
S.O. 224	64	130	200	260

^aAll relative speeds were normalized to nearest one quarter stop with the exception of the normal runs.

Fig. 3. H & D curves comparing the Ektachrome-X response to various primary colors for normal development.

Fig. 4. H & D curves comparing the S.O. 224 response to various primary colors for normal development.

Fig. 5. H & D curves as a function of extended development for Ektachrome-X.

Fig. 6. H & D curves as a function of extended development for S.O. 224.

Fig. 7. Relative film speed comparison of Ektachrome-X and S.O. 224 at normal development.

Fig. 8. Relative film speed comparison of Ektachrome-X and S.O. 224 under extended development.

The final experiment was to examine the relative resolution of both emulsions and the effect on each when additional speed is required. The Technical Photography Group constructed a series of resolution targets that can be placed over each of the twenty-one steps in the step tablet on the sensitometer. Each step in density allows a different exposure (resolution target) over the entire density range. With the aid of a microscope the optimum relative resolution can be evaluated. Photomacrographs (Fig. 9) confirm the resolution superiority of S.O. 224 over Ektachrome-X, even with extended development.

CONCLUSIONS

S.O. 224, for special applications, can be processed successfully in ME-4 and color chemistry. In addition, increased film speed can be obtained when required and programmed in the ME-4 processor. The resolution of the S.O. 224 is superior in both normal processing and extended development when compared to Ektachrome-X. B-Division has already applied this film for special high speed photography and plans additional use of S.O. 224 in the future.

Ektachrome-X — Normal

S.O. 224 — Normal

Ektachrome-X — Plus 2 stop push

S.O. 224 — Plus 2 stop push

Line pairs/mm

A - 12.5

B - 25

C - 50

D - 100

Fig. 9. Ektachrome-X and S.O. 224 film images under normal and extended development, all approximately X60 at optimum contact resolution.

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