A New Gevacolor Negative Film Type 682

By A. VERVOORT and H. STAPPAERTS

Gevacolor negative film Type 682 is a color negative film for 35-mm and 16-mm professional motion picture photography. It is rated 100 ASA when exposed under tungsten illumination at 3200 K. The film can be processed according to the specifications of the ECN-2 process. A description of the film's internal structure is given with special reference to the advanced emulsion technology used, resulting in a camera material with remarkable photographic characteristics such as superior sharpness and granularity. Due to its intrinsic properties, Gevacolor negative film Type 682 is an interesting and versatile tool for the professional filmmaker. It increases his technical and artistic possibilities.

Prior to 1964 and before the merger of Agfa AG and Gevaert Photo-Producten N.V., both companies had a long tradition in the manufacture of professional color negative motion picture film. As far back as 1939 feature film productions were using Agfacolor negative film, and Gevaert introduced their first Gevacolor negative film with a speed rating of 16 ASA in 1948. By today's standards this appears slow, but at that time it was considered to be quite an achievement. From these beginnings Agfa and Gevaert have continued to introduce new negative color films, each time improving granularity, definition, and, of course, speed. Agfa-Gevaert N.V. introduced their first 100 ASA masked color negative film Type 655 in 1968. This film was designed for the Agfa-Gevaert process. In early 1974, Type 680 was introduced. It is compatible with the ECN-I process.

The new Gevacolor negative film Type 682 (ECN-2 process) is a further improved color negative well suited for professional motion picture photography in both 16 mm and 35 mm. High quality prints can be obtained not only directly from the negative but via existing color intermediate films onto color positive film such as Gevacolor print film Type 982 (ECP-2 process) or Type 986 (ECP 1).

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Design and Structure of the New Color Negative Film

Gevacolor negative film Type 682 consists of a triacetate base coated with blue sensitive, green sensitive, and red sensitive emulsion layers. The three light-sensitive layers contain specific colorless dye couplers that will form partial yellow, magenta, and cyan images during processing. Apart from the colorless dye couplers in the green and red sensitive layers, yellow and red colored "mask" couplers are also incorporated in these layers. These couplers form masks that will correct and compensate the unwanted secondary absorptions of the magenta and cyan dyes.

Figure 1 shows the printing sensitometry of a selectively red exposed unmasked negative. When appropriate masking dyes are used, the unwanted absorptions are compensated in such a way that at any dye concentration, the integrated sum of the unwanted absorption of the imaging dye and of the masking dye is constant. This is clearly shown by the sensitometric printing curves in Fig. 2, obtained after the selective red exposure of the masked negative. The result is a regular red printing sensitometry and constant values of blue and green printing densities over the entire exposure range.

A wide exposure latitude, retaining excellent image characteristics, is achieved by the application of the double layer emulsion technique. This means that every emulsion layer is composed of two layers, one being of medium speed with a fine grain (Fig. 3A), the other of fast speed with a coarser grain (Fig. 3B), both having the same spectral sensitivity. In this way, high speed can be linked with fine grain and a wide exposure latitude can be obtained.

The DIR Coupler

To obtain a further improvement of the granularity-speed relation for the green and red sensitive layers, an extra coupler known as DIR coupler is used. As described in the literature,[1] DIR couplers — which stand for Development Inhibitor Releasing couplers — are chemical compounds, which during color formation release an inhibitor that will slow down further development of the image. It may be worthwhile to recall that the speed of photographic emulsions is strongly linked with the size of the light-sensitive silver halide crystals, with increasing size corresponding to increasing speed. As already mentioned, the use of DIR couplers results in development to a smaller extent of the silver halide crystals; thus, for a given crystal size, the color granularity is reduced (Fig. 4). To obtain the desired normal gamma the amount of silver halide can now be increased, whereas without the DIR coupler, layers with a high silver content would show too high a gradation (Fig. 5).

In this way, a certain density is composed of many image forming areas. One may recall that, as a rule of thumb, the RMS granularity is inversely proportional to the square root of the number of image forming areas. As can be seen from Table I, an increase of 30% of image forming areas results in a 12% lower RMS granularity, σ_D.

Apart from the improvement of granularity, the use of DIR couplers yields a considerable improvement of definition since the release of the development inhibitor strongly enhances edge effects. It therefore becomes obvious that with the use of the DIR coupler technology both definition and granularity are greatly improved without loss in speed.

Figure 6 shows the schematic structure of the negative film including the yellow filter layer between the blue and green sensitive layers. The back of the film is coated with a removable carbon black layer specially selected for its antihalation and antistatic properties. The whole emulsion pack is coated with a protective top layer.

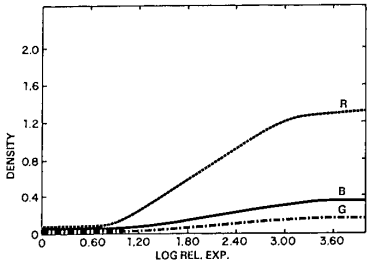

Fig. 1. Printing sensitometry of a selectively red exposed unmasked negative.

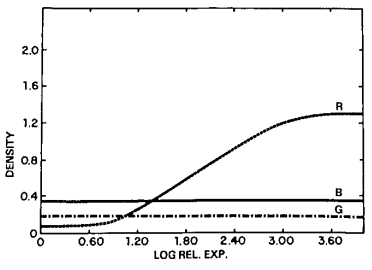

Fig. 2 Printing sensitometry of a selectively red exposed masked negative.

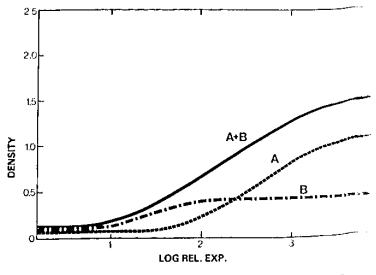

Fig. 3. Schematic representation of the double layer technique.

Sensitometric and Photographic Properties

Gevacolor negative film Type 682 has an exposure index of 100 ASA when exposed to light having a color temperature of 3200 K. It can also be used in daylight or any other lighting condition in conjunction with a suitable conversion filter. The method of incident-light measurement is widely used for exposure determination. With an illumination level of 1076 lx (100 ft/cd), favorable results are obtained with a lens aperture of *f*/2.8 and an exposure time of 1/50 s, or any equivalent exposure. The spectral sensitivity of the three emulsion layers (Fig. 7) provides a good overall speed characteristic with only slight overlapping of the three spectral response curves composing the total range.

Figure 8 shows the spectral density curves of the three dyes formed in the emulsions after development. Due to the careful choice of dyes and the masking of the unwanted side absorptions of these dyes an excellent and faithful color rendition is obtained. The color rendition is illustrated in the U-V chromaticity diagram (Fig. 9) giving the chromaticity loci of nine selected color patches exposed on Gevacolor negative film Type 682 and Type 680 and printed on color positive film. These nine colors are blue, green, red, yellow, magenta, cyan, foliage, sky blue, and skin tone. From this graph it can be concluded that Gevacolor negative film Type 682 has indeed a good color rendition, similar to that of the Type 680, which received high praise for pleasant color reproduction.

Figure 10 shows the sensitometric curves of the Type 682 film. The relative quantities of the yellow, masked magenta, and masked cyan dyes have been determined in such a way that optimum results with regard to the reproduction are obtained in the final print.

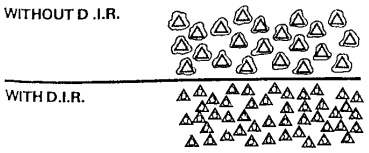

Fig. 4. Reduction of the color granularity for a given crystal size as a result of the use of DIR couplers.

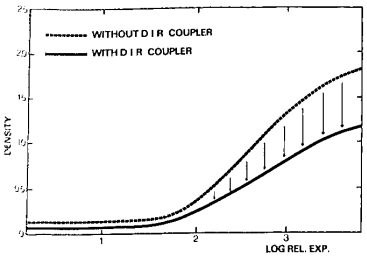

Fig. 5. Influence of the DIR coupler technique on the gradation (gamma).

Definition

In addition to the color reproduction and speed of the negative, definition constitutes a most important factor, and high definition has been made possible due to the use of closely packed emulsion layers, and as already stated by applying the DIR coupler technology. Furthermore, efficient antihalation protection is obtained by the colored masking coupler in the red sensitive layer and the black antihalo backing layer.

Figure 11 represents the modulation transfer function curves of the Type 682 film and illustrates the high definition of the material. Through an appropriate choice of emulsions, the application of the double layer technique (which makes it possible to use fine-grain emulsions for the most critical densities), and through the use of the DIR technique a negative is obtained with reduced granularity. RMS granularity measurements expressed in σ_D are showing the lowest granularity in the green sensitive layer especially in the most critical mid-density range (Fig. 12).

The importance of both granularity and definition of the negative film upon the image quality of the overall result of a negative-positive reproduction system can best be evaluated by means of the relative signal-to-noise ratio. The technique of determining the relative signal-to-noise ratio of reproduction systems is extensively discussed by Karel Staes in his paper "Image Quality Transfer Through Film and Television," (No. 7 on the 121st SMPTE Conference program). Some results of this research are presented in Table II. The "theoretical negative," which appears in this table, has the same gradation as the Gevacolor negative film Type 682, but a granularity and a MTF that would result from not using DIR couplers and closely packed silver halide layers. The relative signal-to-noise ratio has been calculated for three different cases: (1) for a conventional 16-mm negative-positive reproduction system; (2) for a blow-up from 16-mm negative to 35-mm positive; and (3) for the case where the 16-mm print is viewed at the same screen size as the 35-mm print. In the first two cases, the lateral magnification was 200 diameters, whereas in the third

Table I. The RMS granularity, $\sigma_D \cong 1/\sqrt{n}$, of Gevacolor negative film Type 682.

Number of image forming centers n (%)	Relative negative granularity σ_D
100	1.00
110	0.95
120	0.91
130	0.88

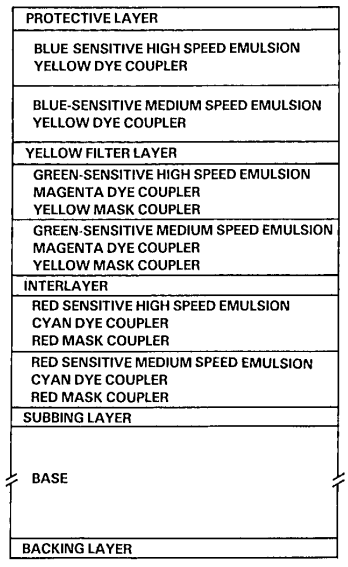

Fig. 6. Structure of the negative color film.

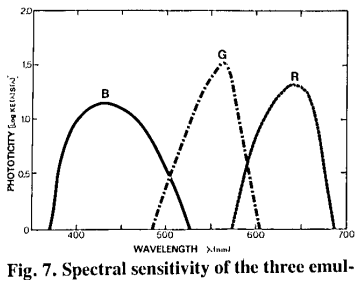

Fig. 7. Spectral sensitivity of the three emulsion layers.

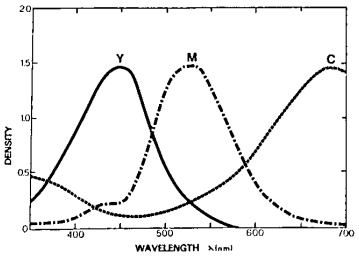

Fig. 8. Spectral density curves of the three dyes formed in the emulsions.

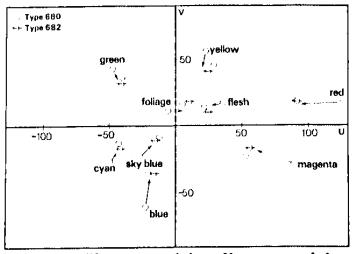

Fig. 9. U-V chromaticity diagram, giving the loci of nine selected color patches exposed on Gevacolor negative film.

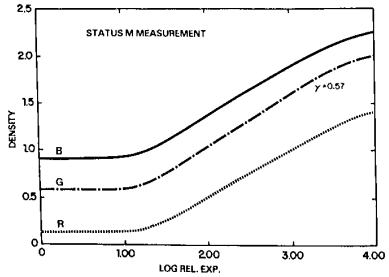

Fig. 10. Sensitometric curves of the new Gevacolor negative film.

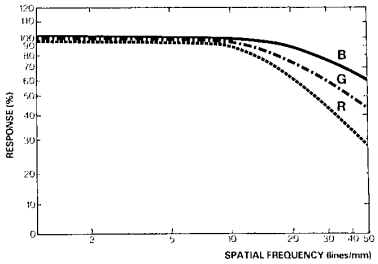

Fig. 11. Modulation transfer function curves of Gevacolor negative film Type 682.

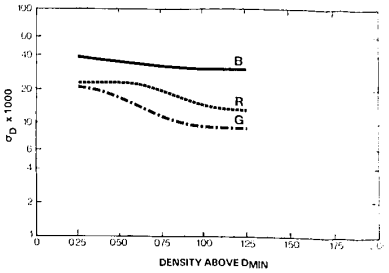

Fig. 12. RMS-granularity measurements expressed in σ_D.

Table II. Relative signal-to-noise ratios of several reproduction systems using Gevacolor negative film Type 682.

Reproduction system	Magnification in diameters	S/N_1	S/N_2
Gevac. Neg. T682(16)-Gevac. Pos. T982(16)	200	5.7	0.0
Theor. Neg. (16)-Gevac. Pos. T982(16)	200	4.0	−1.7
Gevac. Neg. T682(16)-Gevec. Pos. T982(35)	200	−2.5	1.2
Theor. Neg. (16)-Gevac. Pos. T982(35)	200	−4.9	−0.9
Gevac. Neg. T682(16)-Gevac. Pos. T982(16)	500	−4.1	−0.4
Theor. Neg. (16)-Gevac. Pos. T982(16)	500	−6.9	−2.8

Note: All evaluations were made at a viewing distance equal to five times the screen diagonal.

Table III. Trimmer settings and filters on a typical additive printer when printing Type 682 negative film on Type 982 print film.

	Red	Green	Blue
Prefilter	ND30	ND30	ND30
Filter	—	ND10	ND60
Manual light control	12	12	12
Automatic light control	25	25	25

case the magnification of the 16-mm print was 500 diameters. Because in all cases the viewing distance had a fixed proportion to the screen diagonal the viewing angle subtended under which the screen image was observed was the same in all cases.

In Table II, S/N_1 and S/N_2 are the respective relative signal-to-noise ratios (logarithmic values) for large and small image details. It is apparent that these image quality parameters of the negative film are very important for achieving good overall image quality.

Process Compatibility

Intensive studies have been carried out regarding the photographic behavior of Type 682 with regard to variations in treatment conditions such as time, temperature, agitation, different constituents of the chemical baths, contamination, etc. They were completed by practical processing tests on a large scale in motion picture laboratories having conventional processing machines for the ECN-2 process. Total compatibility has been confirmed. Thus, the new film can be processed by any motion picture laboratory in existing equipment and existing chemistry without modification.

Table III gives an example of trimmer setting and values for a typical additive printer when Type 682 is being printed on Gevacolor print film Type 982. It should be noted that the difference between the settings required for Type 682 and other similar materials is very small under the same general printing conditions.

Storage Conditions

As for storage conditions, a distinction must be made between raw film stock, exposed film, and processed film. The sensitometric properties of color negative raw film might change under the influence of heat and humidity during extended storage periods. Consequently, it is recommended that for a longer period of storage the temperature be kept below 12°C (54°F). Exposed film is preferably processed as soon as possible. If this proves to be inconvenient, the same storage conditions apply as for unexposed film. Although the dyes are very stable, it is recommended that the processed negatives be kept in closed cans in an atmosphere of 21°C (70°F) and 40 to 60% relative humidity for nonarchival storage.

Conclusion

Due to its intrinsic properties such as very good definition and ultra-fine grain, remarkable color rendition, and compatibility with ECN-2 processing, the new Gevacolor negative film Type 682 is an interesting and versatile tool for the professional filmmaker, because it increases his technical and artistic possibilities.