

Fig. 6. The log E positions of the negatives that gave the "first-excellent" prints.

tives obtained from the camera-exposure series and were based on the camera exposures required to produce the negatives which yielded the first-excellent prints. It is seen that the deepest shadow lies, on the average, about 0.04 below the fractional-gradient speed point. The log exposure interval between the maximum and minimum densities of the five negatives is, on the average, 1.85. This value should be compared with the "classical" value of 1.5 determined a number of years ago when lenses did not have an antireflection coating. The present results are believed to be typical of a camera with a coated lens and an average sunlit scene.

Figure 7 shows the log E positions and densities for the five negatives having the camera exposures prescribed by the exposure meter used with the ASA exposure index. The safety factor, as shown, is 2.4.

Figure 8 summarizes the results given in Fig. 7 and, in addition, shows the average log E positions

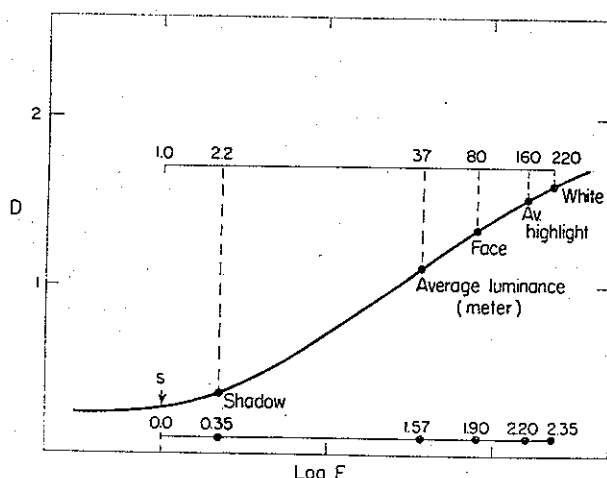


Fig. 8. The exposure levels, for various scene elements, associated with the safety factor of 2.4.

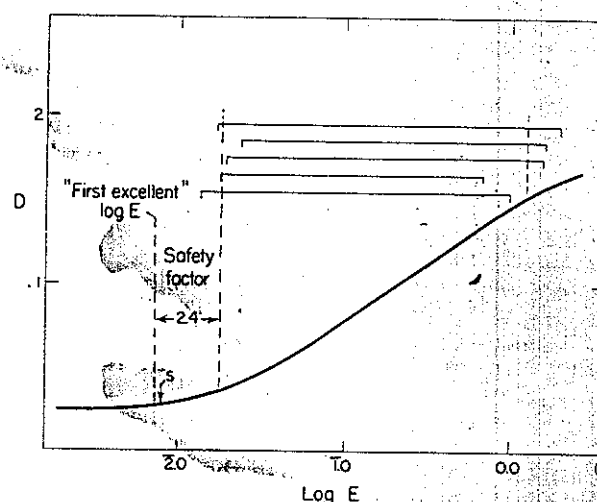


Fig. 7. The log E positions of the negatives exposed as prescribed by a calibrated exposure meter used with the ASA exposure index of the film.

for the "average luminances," the light tones of the faces, and the white objects. Again, these data apply to the camera exposures indicated by the calibrated exposure meters used with the ASA index. The face tones are seen to lie at an exposure which is 80 times greater than the exposure at the speed point. In terms of the logarithmic units shown near the bottom of the graph, the faces are recorded 1.9 units and the white objects 2.35 units to the right of the speed point. Thus both the faces and the white objects are recorded a remarkably great interval above the speed point. The resulting densities are higher than those desired for convenient printing of negatives.

Proposed Level of Exposure

The results of this study support the conclusions reached by many photographers, manufacturers of

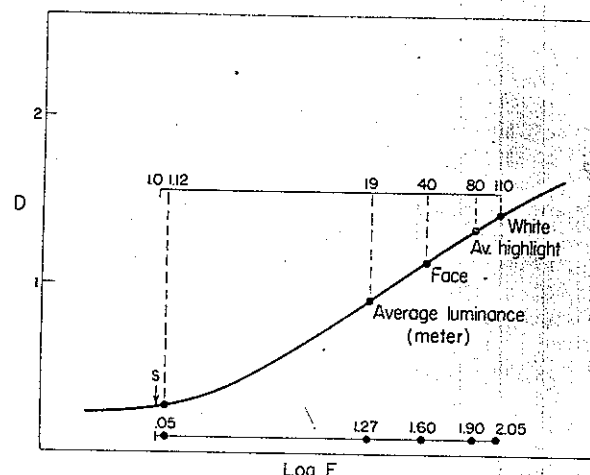


Fig. 9. The exposure levels, for various scene elements, associated with the proposed safety factor of 1.2.

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photographic materials and equipment, and by the members of ASA committees concerned with this subject, that the safety factor should be reduced by a factor of about 2. The effect that this proposed change will have on the densities in the negatives is illustrated in Fig. 9. The faces will be recorded at an exposure which is about 40 times, or 1.6 in log E units, above the exposure at the speed point. If the negative material is developed to a gamma of 0.7 and its curve has an average shape, the density of the faces will be about 0.93 above fog density, and the density of the white objects will be about 1.25 above fog density. The shadows will fall slightly above the speed point. This level of exposure, corresponding to a safety factor of slightly more than 1.2, appears to be suitable for most practical work.

Although the conclusions given previously were drawn from data on the photography of typical sunlit scenes, a similar study made with portrait scenes seems to indicate that the proposed reduction in the safety factor will also be satisfactory for this type of photography. Certain types of scenes will undoubtedly be encountered in both interior and exterior photography in which the luminance distribution is such that under-exposure will occur if the meter reading of average luminance is used with the proposed higher film ratings. It is believed that these unusual scenes can be described and "classified" so that they will be recognized by the photographer, who can then make a correction in the camera exposure.

Relation between Black-and-White and Color Films

Of special interest is the effect that the proposed change in the safety factor will have on the relation between black-and-white negative films and color reversal films. Since no change in the ratings of the color films is planned, the proposed increase of approximately two times in the ratings of black-and-white films means that the two types of films will be rated so that their true relative sensitivities or basic "speeds" will be properly indicated.

Exposure indexes, by incorporating a large safety factor for the one type of film and a small safety factor for the other, have the shortcoming of not revealing the fact that a color reversal film having an exposure index of 32, for example, is *slower* (in terms of the minimum camera exposure that will give a picture of excellent quality) than a black-and-white film having the same exposure index of 32. Not all photographers have been aware that the black-and-white film rating can be increased to 80 without an appreciable loss in picture quality, while the color reversal film rating can be increased only to 40, when the normal rating is 32 for both films.

An experiment was carried out to demonstrate the actual speed relation between a black-and-white film and a color reversal film having the same exposure index. Kodak Ektachrome Film, which has an

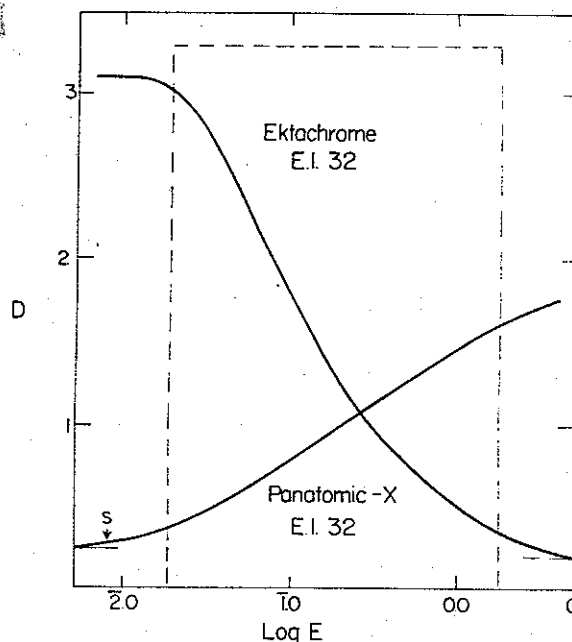


Fig. 10. The density vs. log-exposure curves for Kodak Panatomic-X and Kodak Ektachrome Films used in the present study.

exposure index of 32, was chosen for comparison with a sample of Kodak Panatomic-X Film which also had a measured exposure index of 32. The sensitometric D -log E curves for these two films are shown in Fig. 10.

Photographs were made of three sunlit scenes with these two films, using an identical series of camera exposures for each film. Exposure-meter readings were made of the scenes by the reflected-light method. The final photographs, which were 35mm transparencies in one case and 5- by 7-in. enlargements on Kodak Medalist Paper in the other case, were judged for quality.

The picture-quality vs. log-camera exposure curves for this experiment are shown in Fig. 11. The camera

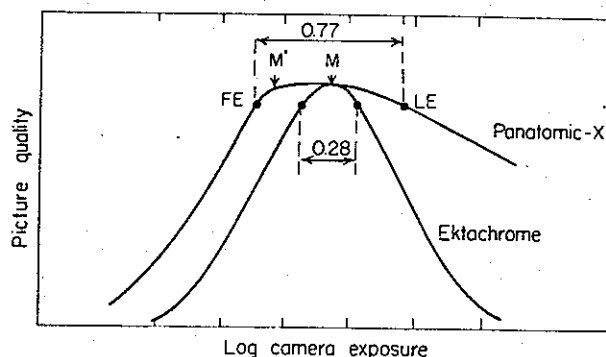


Fig. 11. The picture-quality vs. log-camera-exposure curve for the black-and-white film compared with the corresponding curve for the color reversal film having the same exposure index. FE represents "first excellent;" LE, "last excellent." M represents the present exposure level; M', the proposed exposure level for the black-and-white film.

exposure prescribed by the exposure meter is indicated on the graph by the letter "M." This "meter exposure" was found to lie at the peak of the quality curve for the color film, and near the center of the useful range of camera exposures for the black-and-white film. As the camera exposure was decreased from this point, the quality of the color pictures decreased rapidly, while the quality of the black-and-white pictures remained constant over a considerable exposure interval. The "first-excellent" black-and-white picture, marked "FE" on the graph, occurred at a camera exposure lying $0.41 \log E$ units (or slightly more than one and one-third camera stops) to the left of the point "M." The "first-excellent" color picture, on the other hand, occurred at a camera exposure lying only 0.13 in $\log E$ units to the left of the point "M." This result shows that the basic speed of this black-and-white film is approximately two times greater than the basic speed of the color film, whereas their exposure indexes are equal.

The proposed reduction in the safety factor for the black-and-white films will eliminate this discrepancy, and will lead to film ratings that indicate the true speed relationships between films.

Proposed Change in Speed Criterion

The reduction in the safety factor could be accomplished simply by changing the constant in the ASA formula for deriving the ASA exposure index from the ASA fractional-gradient speed of the film. The present formula, which gives a safety factor of about 2.4, is

$$\text{Exposure Index} = \frac{\text{Fractional-Gradient Speed}}{4} \quad (11)$$

$$\text{or Exposure Index} = \frac{1}{4 E_s} \quad (12)$$

where E_s is the exposure in meter-candle-seconds at the fractional-gradient speed point and $1/E_s$ is the ASA fractional-gradient speed. If the constant of $\frac{1}{4}$ were replaced by a constant of $\frac{1}{2}$, a new type of "exposure index" would be obtained which would provide the proposed lower safety factor of about 1.2.

There are several reasons, however, for adopting not only a new constant but also a different speed criterion. The fractional-gradient criterion was originally chosen because it has the desirable feature of giving speeds that correlate closely with speeds obtained by practical picture tests.⁹⁻¹¹ It has the objectionable feature, however, of being somewhat inconvenient and difficult to use. Consequently, a simpler and more convenient criterion, such as that based on a fixed density above fog density, is often desired. Fortunately, as shown by the

recent data of Nelson and Simonds,^{12,13} a good correlation exists between fractional-gradient speed and speeds based on a density of 0.1 above fog, provided the development conditions are controlled so that a fixed "average gradient" is obtained. This average gradient is measured on the portion of the D -log E curve of the film lying between two exposures, E and $20 E$, where E is the exposure at a density of 0.1 above fog. The specification of a fixed average gradient in an American Standard would be justified by the fact that such a specification corresponds to the common photographic practice of developing negatives so that they print satisfactorily on a "normal" grade of photographic paper. Thus the adoption of the 0.1 fixed-density speed criterion in combination with a suitable development specification would offer the advantages of convenience and practical significance.

Another important advantage to be gained by adopting the fixed-density speed criterion as part of an American Standard is that this step would encourage eventual agreement on an international standard for photographic speed. The fixed-density criterion¹⁴⁻²¹ has for many years been a preferred criterion in a number of countries. The use of this criterion in the DIN system,¹⁸ for example, is particularly well known.

The reported⁹⁻¹¹ lack of correlation between fractional-gradient speeds and fixed-density speeds is now known¹² to be due mainly to lack of agreement on a suitable development specification. It was originally thought that the variation in the length of the toes of the D -log E curves of the negative materials would always prevent the realization of a high correlation between the speeds obtained by the two criteria. The more recent study,^{12,13} however, reveals that good correlation exists even for materials differing greatly in toe length if the development is controlled so that a constant average gradient is maintained. Gamma, the slope of the straight-line portion of the D -log E curve, is not as satisfactory as the average gradient for specifying the development because gamma does not take into account the different toe lengths. The increasing use of a smaller safety factor in camera exposures means that the toe portion of the D -log E curve is being used more fully. The proposed average gradient, which involves part of the toe and part of the straight-line portion, is more significant than gamma as an indication of the "contrast" of the camera negatives.

Figures 12 and 13 show some of the data from the recent study¹² of the relation between fractional

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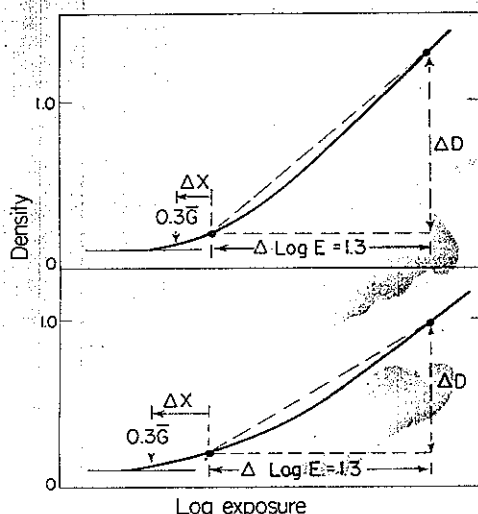


Fig. 12. D-log E curves showing the inverse relation between ΔD and ΔX . ΔX increases when ΔD decreases.

gradient speeds and 0.1 fixed-density speeds. The interval, ΔX , in Fig. 12, is the log E interval between the fractional-gradient speed point and the fixed-density speed point on the D-log E curve of the film. If this interval were constant, the two types of speed would correlate perfectly. The value of ΔX is seen to be small when the average gradient is high and large when the average gradient is low. The density difference, ΔD , shown in Fig. 12 is simply another way of expressing this average gradient, since the log E interval is constant. The "inverse" relation between ΔX and average gradient (or ΔD), as illustrated in Fig. 12, suggests that ΔX should be plotted against average gradient or ΔD for a number of different films processed in different developers for several development times. This experiment was carried out with ten films of current manufacture, including films having different toe lengths (Fig. 13). It is seen that the logarithmic difference, ΔX , between the fractional-gradient speed and the fixed-density speed varies from 0.10 to 0.48 when ΔD is allowed to vary from 0.45 to 1.5. When ΔD is held constant at any arbitrary value, however, ΔX becomes nearly constant. If ΔD is 0.80, for example, ΔX becomes approximately 0.29.

Thus when development is controlled so that ΔD remains constant, a good correlation exists between speeds based on a density of 0.1 above fog and fractional-gradient speeds.

A new formula for speed can be derived which will make use of the 0.1 fixed-density speed criterion and will also provide the desired safety factor of approximately 1.2. If a specification is adopted requiring development to a ΔD of 0.80 or an average gradient of 0.62, for example, the log E difference (ΔX) between the two types of speed becomes 0.29; and the exposure, E_d , at a density of 0.1 above fog becomes 1.9 times greater than the exposure, E_s , at the fractional-gradient speed point.

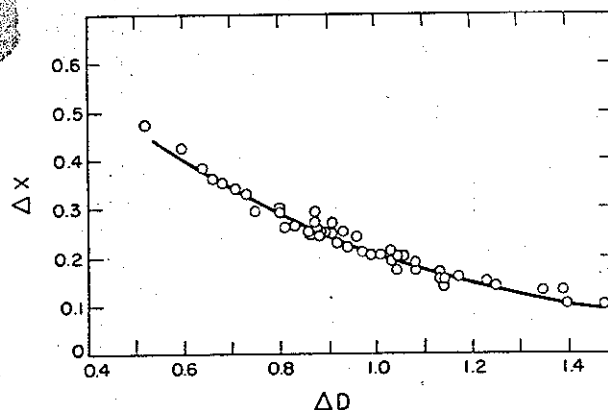


Fig. 13. Data for a number of different films and various development conditions showing ΔX plotted against ΔD , where ΔX is the log E difference between the exposure at a density of 0.1 above fog and the exposure at the fractional-gradient speed point.

A revised form of Eq. (12), giving a new kind of film rating or speed that would provide a safety factor of 1.2, may be expressed as follows:

$$\text{Speed} = 1/2E_s. \quad (13)$$

Since $E_d = 1.9 E_s$ for the assumed development condition, the equation may be rewritten as

$$\text{Speed} = 1.9/2E_d \quad (14)$$

or

$$\text{Speed} = 0.95/E_d. \quad (15)$$

A change in the spectral quality of the light to be used in the sensitometer, from simulated sunlight to simulated daylight (sunlight plus skylight), is also contemplated which will have the effect of requiring a constant of slightly more than 0.8 in place of 0.95 in Eq. (15) in order to keep the safety factor at 1.2. If this change in light quality is adopted, the formula for the new photographic speed will be

$$\text{Speed} = 0.8/E_d \quad (16)$$

where E_d is the exposure in meter-candle-seconds required to obtain a density of 0.1 above fog when the development is such that the average gradient is 0.62 and ΔD is 0.8. This formula will give speeds that, if used with accurate exposure meters and cameras, will provide a safety factor of slightly over 1.2, since the constant in Formula (16) was rounded off to 0.8.

The fractional-gradient speed criterion (and its approximate equivalent, the simpler ΔX speed criterion described in Ref. 12) will continue to be useful as a supplement to the fixed-density speed criterion when an evaluation is desired of the effective picture-taking speeds of films that have been developed to average gradients higher or lower than the proposed standard average gradient. The fixed-density criterion tends to underrate films that are developed to a lower average gradient and to overrate films that are developed to a higher average gradient. A new constant in the formula for

fractional-gradient speed is desirable for this non-standard application in order to provide a safety factor of about 1.2 and thus make the speeds comparable with the proposed fixed-density speeds. The fractional-gradient speeds (as distinct from exposure indexes) have heretofore had the disadvantage of being expressed by numbers that do not fit exposure meters. Although the fractional-gradient speeds were originally based on the "minimum camera exposure that would yield a negative capable of giving an excellent print," they were arbitrarily expressed on a scale of numbers which, if used with a typical exposure meter, would have led to exposures that were consistently about two-thirds of a camera stop less than the minimum exposure required for an excellent print. To correct this situation, a change in the formula is suggested. The formula, $S = 0.5/E_s$, gives the desired adjustment of the speed scale when simulated sunlight is used in the sensitometer but, since the use of simulated daylight is proposed, the appropriate formula is:

$$\text{Fractional-Gradient Speed} = 0.4/E_s \quad (17)$$

where E_s is the exposure in meter-candle-seconds at the 0.3 G fractional-gradient point¹ on the D-log

E curve of the negative material. This formula provides a safety factor of slightly over 1.2, as does Formula (16) for the proposed Standard speed based on a density of 0.1 above fog.

Acknowledgments

Scott Grover and Rodger Grimes made the photographs used in this study, and John Kelch assisted in the analysis of the data. J. L. Tupper, Chairman of ASA Subcommittee PH2-18 on Photographic Speed and Exposure Index, and M. G. Anderson, Chairman of ASA Sectional Committee PH2 on Photographic Sensitometry, encouraged the writer to prepare this communication. To these persons the writer wishes to express his high appreciation and thanks.

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• Book and Journal Reviews

Journal of the Society of Scientific Photography of Japan

Vol. 22, No. 1, March 1959 (in Japanese)

Résumés by S. Kikuchi and T. H. James

Review of Recent Patents for Photographic Addition Agents: III — Chemical Stabilizers

KIYOSHI MUROFUSHI, pp. 1-5

U.S. patents of the period 1950-1957 are reviewed.

The Effect of Stabilizers on the Formation of Silver Sulfide by Labile Sulfur: I—The Inhibiting Action of Triazaindolizine on the Formation of Silver Sulfide by Thiourea

TEIJI HABU, pp. 6-11

Birr (*Z. wiss. Phot.*, 50:107, 124 (1955)) concluded that the stabilization of photographic emulsions by 5-methyl-7-hydroxy-2,3,4-triazaindolizine depends on the action of that agent in the gelatin phase rather than an action of the agent adsorbed by the silver halide. The present author investigated the effect of the triazaindolizine on the formation of silver sulfide. Preliminary experiments with the Vogel reaction, in which silver or silver sulfide is formed by reaction of silver ions with active components

of the gelatin, showed that the addition of 5×10^{-4} mole of the triazaindolizine per liter prevented the formation of color in the test, whereas the control without the triazaindolizine was intensely colored.

The following procedure was used in the main part of the investigation. Five-gram samples of silver bromide were placed in 100 cc Erlenmeyer flasks with thiourea and a phosphate buffer to give the desired pH; the mixture was then digested at 56.5°C. The reaction could be stopped at any time by the addition of glacial acetic acid to drop the pH below 3.5. The supernatant liquid was poured off through a filter, unreacted silver bromide was dissolved in acidic 1 M thiosulfate solution, the silver sulfide was dissolved by heating with concentrated nitric acid, and the resulting silver nitrate was determined by potentiometric titration with potassium bromide. The controls were run with digestion times of 10, 20, 40, and 80 min. In the experiments with stabilizer, the triazaindolizine was added to the silver bromide-thiourea mixture at 10, 20, or 40 min after the start of the digestion and reaction was stopped at a later time, e.g. 80 min. When the thiourea:triazaindolizine ratio was 10^{-3} mole/l: 10^{-4} mole/l, no silver sulfide was formed at pH 8.04 after the addition of the stabilizer; formation of silver sulfide was retarded at pH 7.61; the stabilizer had no effect at pH 7.10 and 6.61, and the formation of silver sulfide was accelerated at pH 5.85. When the ratio was 10^{-4} : 10^{-2} , the formation of silver sulfide was prevented.

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