

Safety Factors in Camera Exposures

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Many photographers give less camera exposure for black-and-white films than is indicated by exposure meters used with the American Standard exposure index of the film. This practice is successful because the "standard exposure" contains a substantial safety factor and the reduced exposure gives negatives that are better for enlarging. The magnitude of the safety factor has for many years been assumed to be 2.5, but the validity of this assumption has been questioned. The present study of the magnitude of this factor was undertaken in connection with the proposed reduction in the safety factor by means of a revision of the American Standard for photographic speed and exposure index. This study, which included independent mathematical and experimental approaches, indicates that the safety factor is approximately 2.4 for sunlit scenes when accurate meters, shutters, and lens apertures are used. Data are also presented showing the speed, exposure index, and camera-exposure latitude relationships between color reversal films and black-and-white negative films. A proposed change in the sensitometric speed criterion for the black-and-white films is discussed.

During the past three or four years, much criticism has been aimed at the safety factor involved in the use of American Standard exposure indexes' with exposure meters calibrated in accordance with American Standard procedures.² A number of articles in photographic magazines have pointed out the penalties and disadvantages resulting from the use of too large a safety factor and have urged that a smaller safety factor be introduced by means of a revision in the American Standard for determining ASA exposure indexes for black-and-white negative films. The general spirit of these articles is illustrated by the following title of one of them: "ASA Exposure Index: Dangerously Safe."³

A safety factor exists in a camera exposure whenever that exposure is greater than the minimum camera exposure that will produce a negative from which a print of excellent quality can be made. The ratio of the actual camera exposure to this minimum camera exposure is, by definition, the safety factor.

If a large safety factor is used, the negatives obtained will, on the average, be much denser than is required for making a high-quality print. A small safety factor means thinner negatives. The main advantages of negatives resulting from the use of a small safety factor are:

1. Easier focusing of enlargers
2. Shorter printing times
3. Less graininess in enlargements
4. Sharper pictures
 - a. Greater depth of field
 - b. Reduced subject-motion blur
 - c. Reduced camera-motion blur

Another advantage, found with the use of some films (especially if they have been overdeveloped), is that the shape of the part of the density-vs.-log exposure curve which is used for the thinner negatives is better than the shape of the part of the curve used for the heavily exposed negatives.

Because of these advantages, many photographers are convinced that the best camera exposure is one which is only slightly greater than the minimum camera exposure required for a print of high quality.

The main disadvantage of a small safety factor is that occasionally an underexposed negative will be obtained as a result of an error in camera exposure. The original purpose of the safety factor was to absorb such errors. Present-day experience with color reversal films, for which a large safety factor cannot be used, shows, however, that the number of underexposed pictures resulting from the use of a small safety factor is remarkably small.

If a large safety factor is undesirable at the present time, why was it thought to be necessary when the American Standards for film ratings and exposure meters were first adopted in the 1940's? The first reason is that exposure meters, camera shutters, and lens apertures were not as accurate in the 1940's as they are in 1959. The second reason is that the camera-exposure latitude of black-and-white films was effectively greater in those earlier years, largely because the increase in print graininess with increase, in camera exposure was not as evident with

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1. *American Standard for Determining Photographic Speed and Exposure Index, PH2.5-1954*, American Standards Association, 70 E. 45 St., New York 17, N.Y.
2. *American Standard for Photographic Exposure Meters, Photoelectric Type, PH2.12-1957*, American Standards Association, 70 E. 45 St., New York 17, N.Y.
3. Lloyd E. Varden, *PMI (Photo Methods for Industry)*, 1: 39 (May 1958).

the large cameras, large negatives, and small degree of enlargement or contact printing then commonly used. The great increase in the number of small cameras in recent years and the increase in the degree of enlargement has made the graininess problem more acute.

Many photographers have adopted the practice of giving less exposure than is indicated by the use of ASA exposure indexes with exposure meters. The American Standard indexes for black-and-white films are used by them only as a starting point for deriving a new kind of exposure index which is obtained by the simple procedure of doubling the Standard exposure index. This practice, of course, has the effect of cutting the safety factor in half, giving the preferred thinner negatives.

In recognition of this practice, a new Subcommittee, PH2-18, of the American Standards Association was formed a little more than a year ago for the purpose of revising the *American Standard for Determining photographic speed and Exposure Index*. Under the chairmanship of J. L. Tupper, this Subcommittee has prepared a draft of a new Standard which will very likely be officially approved soon by the ASA Sectional Committee PH2 on Photographic Sensitometry (M. G. Anderson, Chairman), the Photographic Standards Board, and the officials of the American Standards Association. In this proposed Standard, the level of the numbers used for rating black-and-white films is approximately doubled. Such a change would have the effect of reducing the safety factor to one half its present value.

There are no plans for reducing the safety factor by means of a change in the calibration formula or exposure meters because there are too many meters in existence with the present calibration and because the meters are also used for color film for which no change in exposure level or film rating is required or desired.

The present magnitude of the safety factor is usually assumed to be somewhere between 2 and 4. The most common estimate is 2.5. A few writers have stated that it is 4. It is a remarkable fact that the exact size of the safety factor has not been definitely known. It is not mentioned in either the standard on exposure indexes or the Standard on calibration of exposure meters. The published papers⁴⁵ of Jones and Condit on the computation of camera exposures give considerable information on the problem of determining how large the safety factor should be to absorb errors in equipment, variations in camera flare, and variations in scene illuminance range, but they do not deal directly with the question of what the size of the safety factor actually is.

The purpose of the present paper is to present new evidence on the magnitude of the safety factor in the photography of average sunlit scenes. Two independent approaches were used, one theoretical and the other experimental.

⁴⁵ L. A. Jones and H. R. Condit, *J. Opt. Soc. Am.*, **31**: 651 (1941).

⁴⁶ *rttd.*, **38**: 123(1948); **39**: 94(1949).

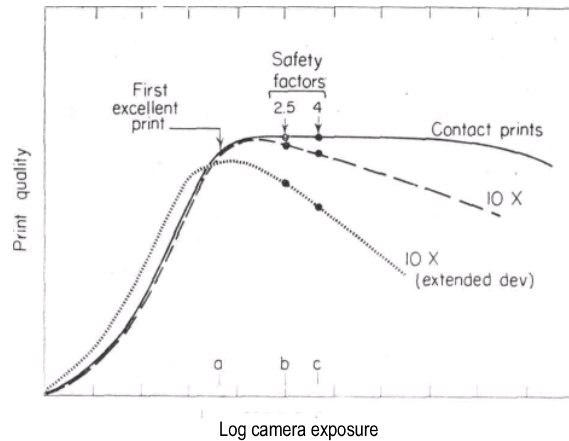


Fig. 1. Print quality vs. log camera exposure for a high-speed negative film. Solid line—contact prints; dashed line—10-diameter enlargements; dotted line—10-diameter enlargements from negatives given extended development.

This study was undertaken by the writer as a member of the ASA Subcommittee on film speed and exposure index, and as a member of the ASA Subcommittee on exposure meters.

Effect of Graininess on the Optimum Safety Factor

A preliminary experiment was carried out, the results of which are worth reviewing at this point because they illustrate the effect which the change from contact printing to enlarging has in reducing the camera-exposure latitude of a typical high-speed negative black-and-white film. The results also illustrate the reduction in camera-exposure latitude caused by over-development of negatives.

The results are summarized in Fig. 1. The solid curve shows that the quality * of the contact prints increases rapidly at first as the camera exposure increases and then reaches a plateau, where it remains constant over a long range of camera exposures. Eventually, the quality decreases. The range of camera exposures over which the print quality remains nearly equal to the maximum quality is defined as the *camera-exposure latitude*. Each of the intervals marked along the camera-exposure axis is one camera stop. In the case of the solid curve, where the contact prints were made from 4- X 5-in. negatives of a studio portrait scene, using the optimum grade of paper for printing each negative, the camera-exposure latitude was 32 times, or five camera stops. The camera exposure marked *a* corresponds to a safety factor of 1. The camera exposures marked *b* and *c* correspond to safety factors of 2.5 and 4, respectively. There was, obviously, no loss in print quality at either of these

* The method of determining the quality of each print is described in paragraph 6 of the section of this paper on Experimental Determination of the Safety Factor (page 52).