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**EKIT REPORT NO.11**

# COMPARATIVE EVALUATION OF SO-340 AND SO-166

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# 1. SUMMARY

This report, no. 11 in the EKIT series, contains a comparative evaluation of Eastman Kodak types SO-340 and SO-166 aerial film in terms of their application in satellite night photography. The factors discussed below must be taken into consideration when comparing these two films.

## 1.1 CONSIDERATION FOR NIGHT PHOTOGRAPHY

Night photography requires that a film have certain characteristics which enhance its capability to record this unique type of imagery. A majority of this imagery consists of points or groups of points of light. It is important, therefore, that the film have the ability to record point sources of light (resulting in an Airy disk image distribution) of low luminous flux.

The prime consideration in night aerial photography is the ability to detect ground activity. The perception of this activity is not a function of resolution but rather the emulsion's capability to record information, i.e., its speed. A film, therefore, selected for the purpose of night photography can tolerate a tradeoff from resolution to speed.

The range in luminous flux of a night scene requires that the film have an extended useful log exposure range. The characteristic curve should ideally have a very small toe and shoulder, and the straight line portion should spread over several decades of log E. Concurrently, there should be a wide density range to enable the recording of small objects (see Section 3). The fog level is relatively unimportant because the concern over the shadow detail is effectively eliminated because of the configuration of the imagery. However, excessive fog will limit the detection of objects which have a low luminous flux.

The imagery from an aerial scene is in the form of an Airy disk which is further spread due to the granular nature of the film. A film with low granularity, therefore, confines the image to a small area and allows for smaller objects to be recorded (see Section 3). As a rule, the spectral content of a ground source has a tungsten distribution. This distribution has a high red content, therefore, the sensitivity of the film should be high in the 600- to 700-millimicron range. Filtration is not necessary and, in fact, is a wasted effort.

## 1.2 CONCLUSIONS

The following is a list of conclusions drawn from the comparative evaluation of SO-340 and SO-166.

1. In general, SO-166 is twice as fast as SO-340.
2. SO-166 produces higher fog levels than SO-340.
3. SO-166 produces a lower gamma at short development times, and equal gamma at long development when compared to SO-340.

4. SO-166 and SO-340 have equal resolution and filter factors.
5. The granularity of SO-166 is somewhat better than SO-340.
6. SO-166 can detect objects having a lower luminous flux than can SO-340.
7. Low gamma processing is not recommended.
8. Static distribution from the camera system produces fog (which will limit the usefulness of the imagery in the KH-4B System) at pressure levels above 1 micron and below 100 microns for the SO-340 and above 1 micron and below 150 microns for the SO-166.
9. SO-166 has a real advantage over SO-340 for night photography because of its increased speed and slightly lower granularity at high contrast processing levels. If low contrast processing is to be used, there is very little difference in the two materials.

## 2. SENSITOMETRIC EVALUATION

A basic sensitometric evaluation was conducted on SO-166 and compared with SO-340. The specific tests were:

1. Emulsion speed
2. Filter factors for Wratten nos. 12, 21, and 25
3. Resolving power
4. The rms granularity

### 2.1 LABORATORY PROCEDURE

#### 2.1.1 Sensitometry

Sample strips of both SO-166 and SO-340 were exposed for 0.01 second on the Kodak 1B Sensitometer to a Corning 5900 daylight correction filter producing a color temperature of 6,100 °K. In some cases, a 0.6 neutral density filter was added to further correct the exposure. The films were then processed in a series of developers at different times and at temperatures consistent with the requirements of the developers. Nitrogen burst agitation was employed at the rate of 1 second burst every 8 seconds at a pressure of 10 pounds per square inch. Processed film samples were measured on a MacBeth TD-100 densitometer calibrated in reference to a National Bureau of Standards certified diffuse density step tablet.

#### 2.1.2 Filter Factors

To obtain filter factors, film samples were sensitometrically exposed to simulated daylight which was modified in turn by each of the filters. The samples were processed in D-19 developer concurrent with a control sample. The log exposure shift was then measured at a point on the straight line portion of the curve 1.0 density units above gross fog.

#### 2.1.3 Resolving Power

Resolution tests between SO-340 and SO-166 were performed on the Itek Mark III resolution power camera. This camera is essentially an inverted microscope system with a resolution capability, with Eastman Kodak Spectroscopic type 649-GH film, exceeding 2,000 cycles per millimeter. The resolution tests were performed in accordance with the ASA draft standard for evaluating the resolving power of black and white silver halide emulsions. A series of target contrasts were employed and the films were processed in D-19 developers. This enabled emulsion thresholds (AIM curves) to be constructed for the two materials.

#### 2.1.4 The RMS Granularity

Exposures were made on individual samples of SO-340 and SO-166 with a point source light at a distance of 4 feet and at varying exposure times. These samples were developed in D-19 for 8 minutes at 68 °F and traced on the Intectron microdensitometer using a 24-micron circular aperture. The rms granularity calculations were made on the range of density patches, and a granularity versus density function was drawn.

## 2.2 RESULTS

### 2.2.1 Sensitometry

The results of the sensitometric analysis are summarized in Table 2-1 and are shown graphically in Figs. 2-1 through 2-10.

#### 2.2.1.1 Emulsion Speed

The AEI speed of SO-166 is approximately twice that of SO-340 with the exception of the MX 642-1. The D-19 developer produces a speed range of 42 to 148 on SO-340 and 112 to 406 on SO-166. The fog level in all situations remains at an acceptable level, not exceeding 0.24. The speed range of SO-340 in D-76 is 125 to 256 and for SO-166 remains constant at 280. However, an objectionable fog level of 0.79 is produced with SO-166 at a 16-minute time. The MX 642-1 gives the highest speeds, ranging from 370 to 490 for the SO-340 and 370 to 760 for SO-166. The fog on SO-340, however, reaches a maximum of 0.39 at 4 minutes development. The DK-50 speeds are 122 to 256 for SO-340 and 256 to 350 for SO-166. The SO-166 reaches a maximum at 8 minutes, and longer development times result in an insignificant gain in speed. The G-4 produces erratic speeds with SO-166, which is attributed to the method for calculating the speed. The AEI speed is based on the gamma, and the low gamma of this set of curves along with the high fog will result in erroneous speeds. The speed values, therefore, can be misleading at times. It is suggested that a comparison of the actual sensitometric curves be made for cases when the speed values are close. The SO-340 speed range is from 175 to 350 in the G-4 chemistry. An objectionable fog of 0.39 results on SO-166 at 6-minute development times.

#### 2.2.1.2 Fog

The SO-166 film produces approximately two times more fog than SO-340 but, in general, the level of both films is acceptable at all processing levels with all developers tested. The SO-340 has the lowest fog in D-19, D-76, and DK-50 developers ranging from 0.10 to 0.15, while its highest range (0.15 to 0.35) is in MX 642-1 and G-4 developers. The fog level of SO-166 remains reasonably constant in all developers, ranging from 0.15 to 0.28. Three cases of objectional fog are 0.79 in D-76 at 16 minutes, 0.39 in G-4 at 6 minutes, and 0.39 in MX 642-1 at 4 minutes.

#### 2.2.1.3 Gamma

The difference in gamma between the two films is dependent on the type of developer. In most situations, however, SO-340 has twice the gamma of SO-166 at short development times and equal gamma at long times. The SO-340 has a range of approximately 0.74 to 1.68 in all developers except G-4 where its range is 0.28 to 0.50. On the other hand, SO-166 shows the wide range in MX 642-1 of 0.50 to 3.01, an intermediate range of 0.30 to 1.92 in D-19 and D-50, and a low range of 0.17 to 0.59 in D-76 and G-4.

Table 2-1 — Fog, Speed, and Gamma of SO-340 and SO-166

| Time, minutes | Developer / Film | D-19 SO-340 | D-19 SO-166 | D-76 SO-340 | D-76 SO-166 | MX 642-1 SO-340 | MX 642-1 SO-166 | DK-50 SO-340 | DK-50 SO-166 | G-4 SO-340 | G-4 SO-166 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Speed | | | | | 370 | 370 | | | | |
| | $\gamma$ | | | | | 0.82 | 0.50 | | | | |
| | Fog | | | | | 0.14 | 0.19 | | | | |
| 1.5 | Speed | | | | | 405 | 465 | | | | |
| | $\gamma$ | | | | | 1.02 | 0.72 | | | | |
| | Fog | | | | | 0.22 | 0.20 | | | | |
| 2 | Speed | 42 | 112 | | | 435 | 490 | | | 175 | 1,110* |
| | $\gamma$ | 0.74 | 0.30 | | | 1.22 | 1.09 | | | 0.28 | 0.17 |
| | Fog | 0.10 | 0.15 | | | 0.22 | 0.22 | | | 0.17 | 0.19 |
| 3 | Speed | 112 | | | | 470 | 675 | | | 175 | |
| | $\gamma$ | 1.04 | | | | 1.54 | 2.11 | | | 0.34 | |
| | Fog | 0.10 | | | | 0.28 | 0.24 | | | 0.17 | |
| 4 | Speed | 120 | 280 | 125 | 280 | 490 | 760 | 122 | 256 | 140 | 1,290* |
| | $\gamma$ | 1.26 | 0.60 | 0.48 | 0.21 | 1.52 | 3.01 | 0.88 | 0.40 | 0.41 | 0.18 |
| | Fog | 0.10 | 0.20 | 0.08 | 0.16 | 0.39 | 0.26 | 0.10 | 0.20 | 0.19 | 0.28 |
| 6 | Speed | 140 | 280 | 140 | | | | 165 | 280 | 220 | 1,770* |
| | $\gamma$ | 1.64 | 1.12 | 0.62 | | | | 0.95 | 0.69 | 0.52 | 0.29* |
| | Fog | 0.11 | 0.21 | 0.10 | | | | 0.11 | 0.22 | 0.20 | 0.39 |
| 8 | Speed | 148 | 315 | 158 | 280 | | | 245 | 340 | 350 | |
| | $\gamma$ | 1.68 | 1.46 | 0.72 | 0.36 | | | 1.08 | 0.92 | 0.50 | |
| | Fog | 0.12 | 0.22 | 0.11 | 0.28 | | | 0.12 | 0.24 | 0.25 | |
| 12 | Speed | | 406 | 256 | | | | 224 | 345 | | |
| | $\gamma$ | | 1.92 | 1.00 | | | | 1.45 | 1.35 | | |
| | Fog | | 0.24 | 0.12 | | | | 0.13 | 0.25 | | |
| 16 | Speed | | | 200 | 280 | | | 256 | 350 | | |
| | $\gamma$ | | | 1.20 | 0.59 | | | 1.56 | 1.62 | | |
| | Fog | | | 0.12 | 0.79 | | | 0.15 | 0.26 | | |

* These unrealistic emulsion speeds are attributed to inaccuracies in the AEI method of calculating the speed at very low gammas.

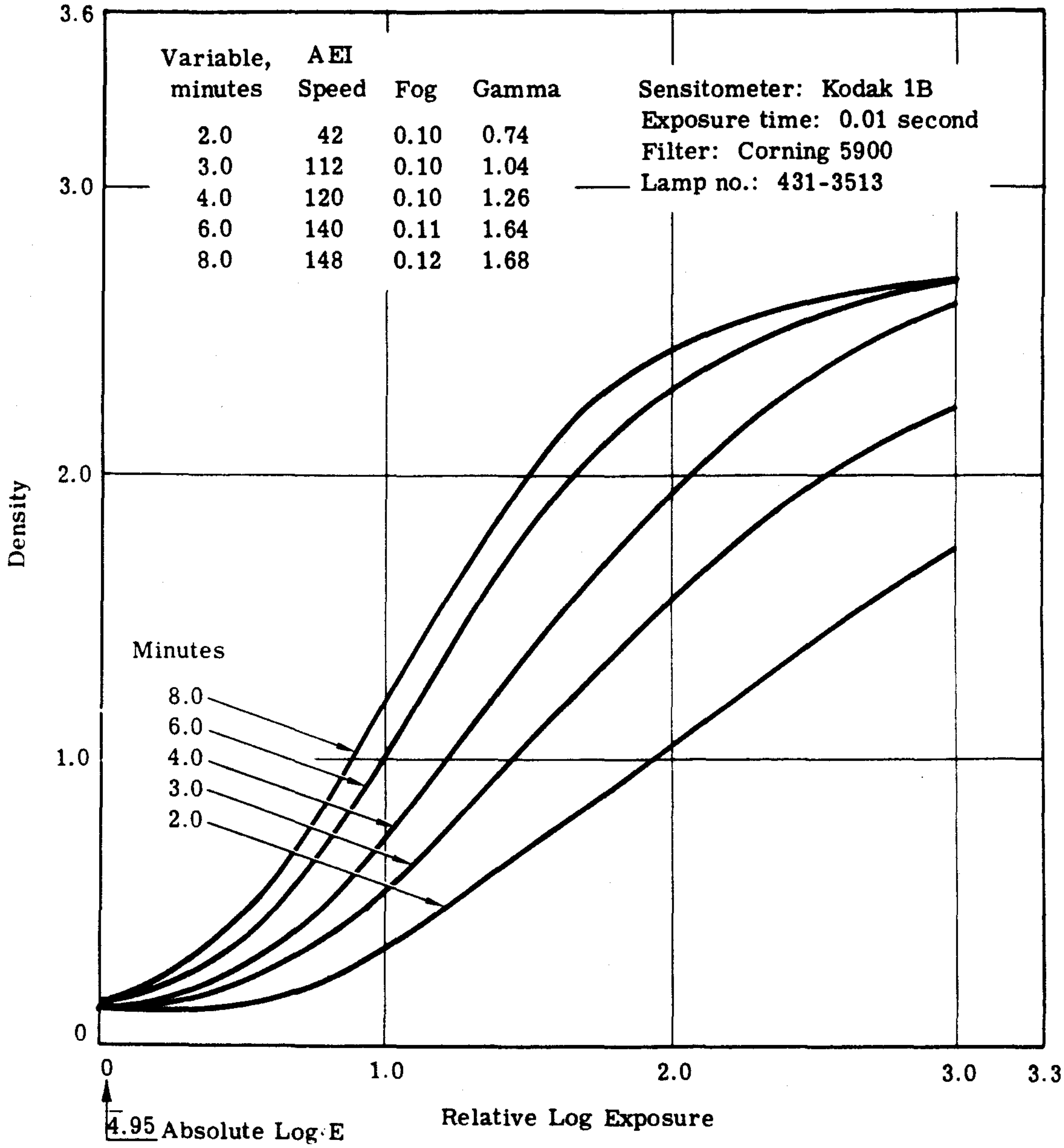



Fig. 2-1 — Sensitometric data sheet, SO-340, D-19 developer, 68 °F temperature

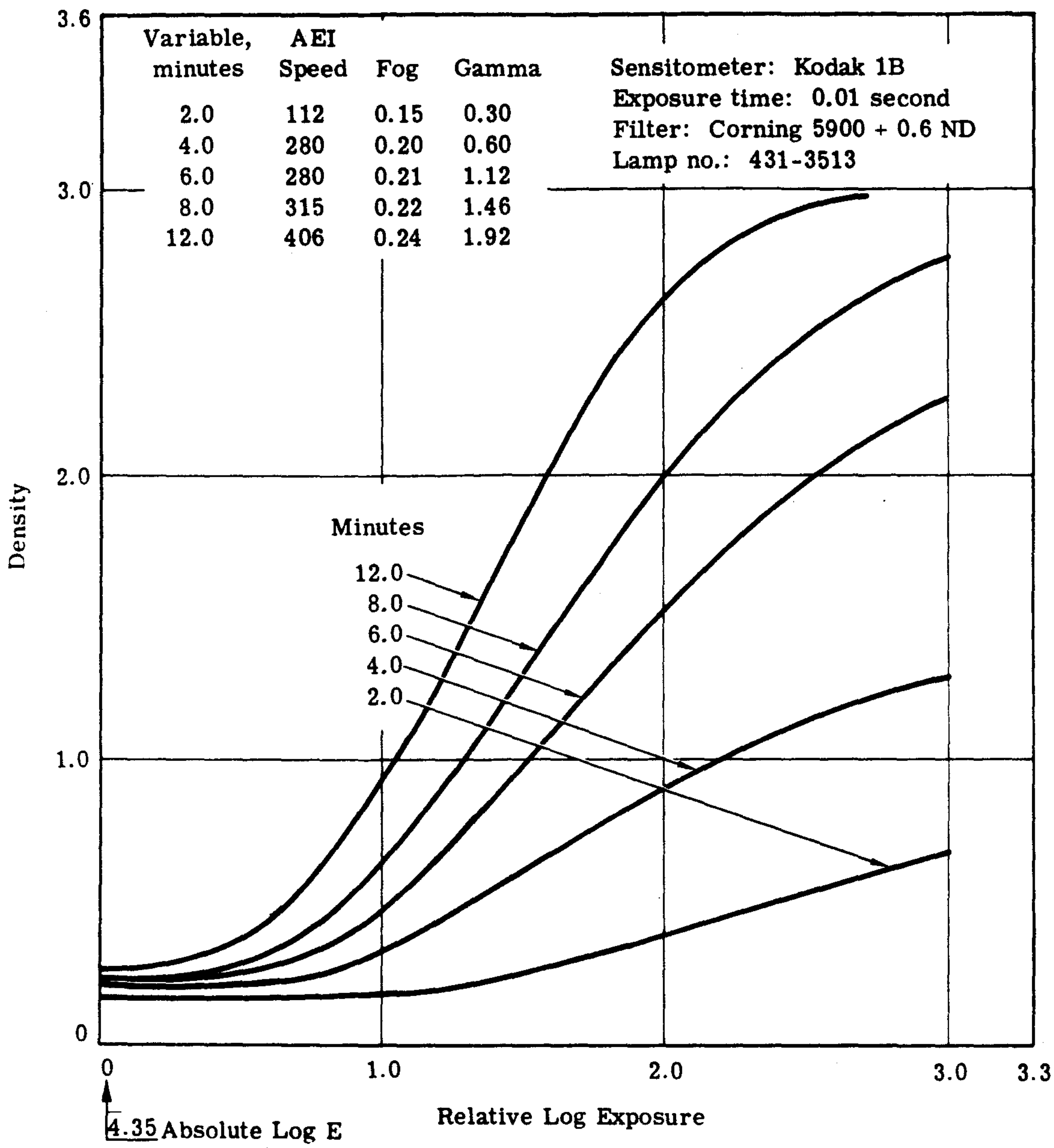



Fig. 2-2 — Sensitometric data sheet, SO-166, D-19 developer, 68 °F temperature

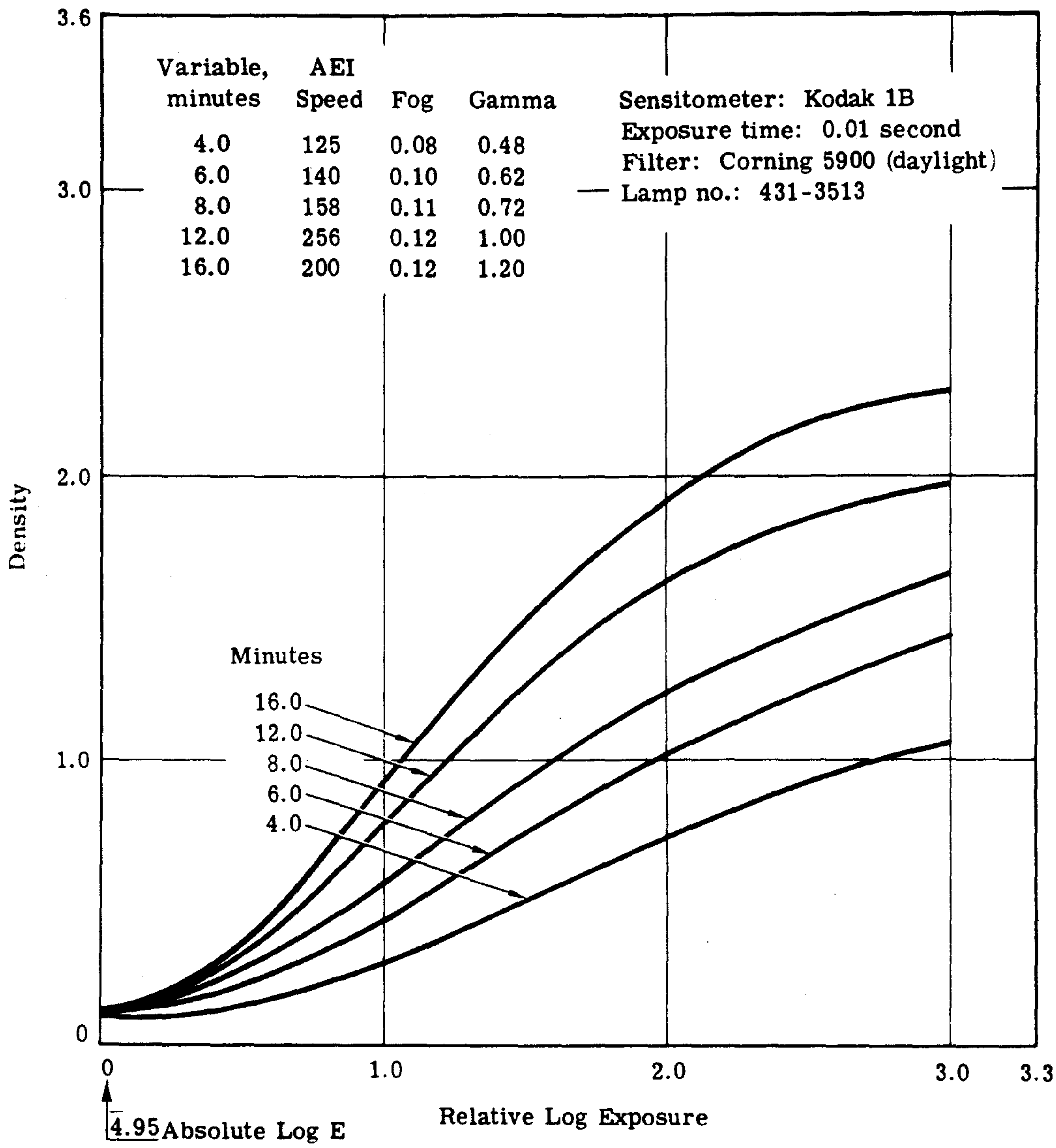



Fig. 2-3 — Sensitometric data sheet, SO-340, D-76 developer, 68 °F temperature

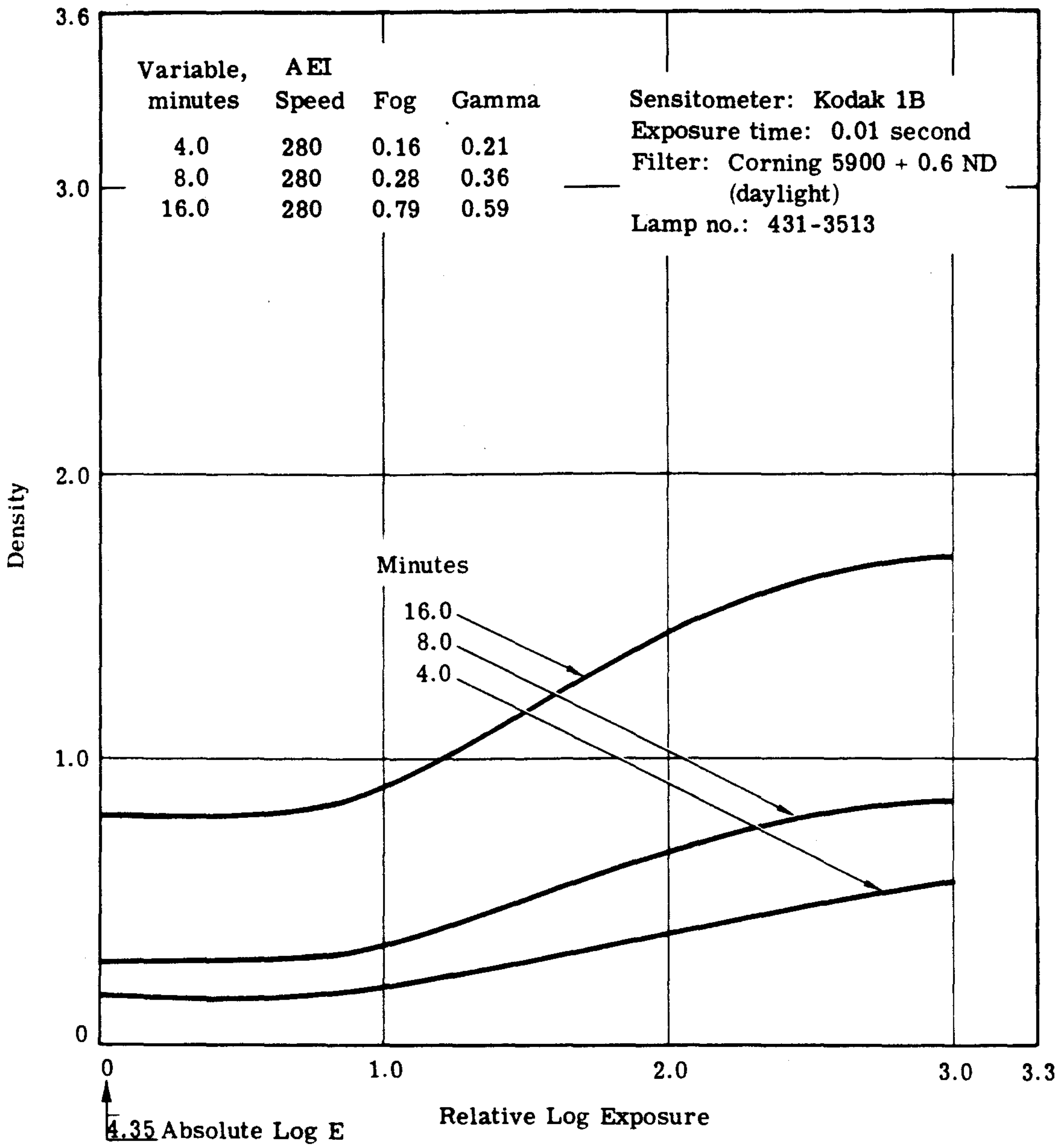



Fig. 2-4 — Sensitometric data sheet, SO-166, D-76 developer, 68 °F temperature

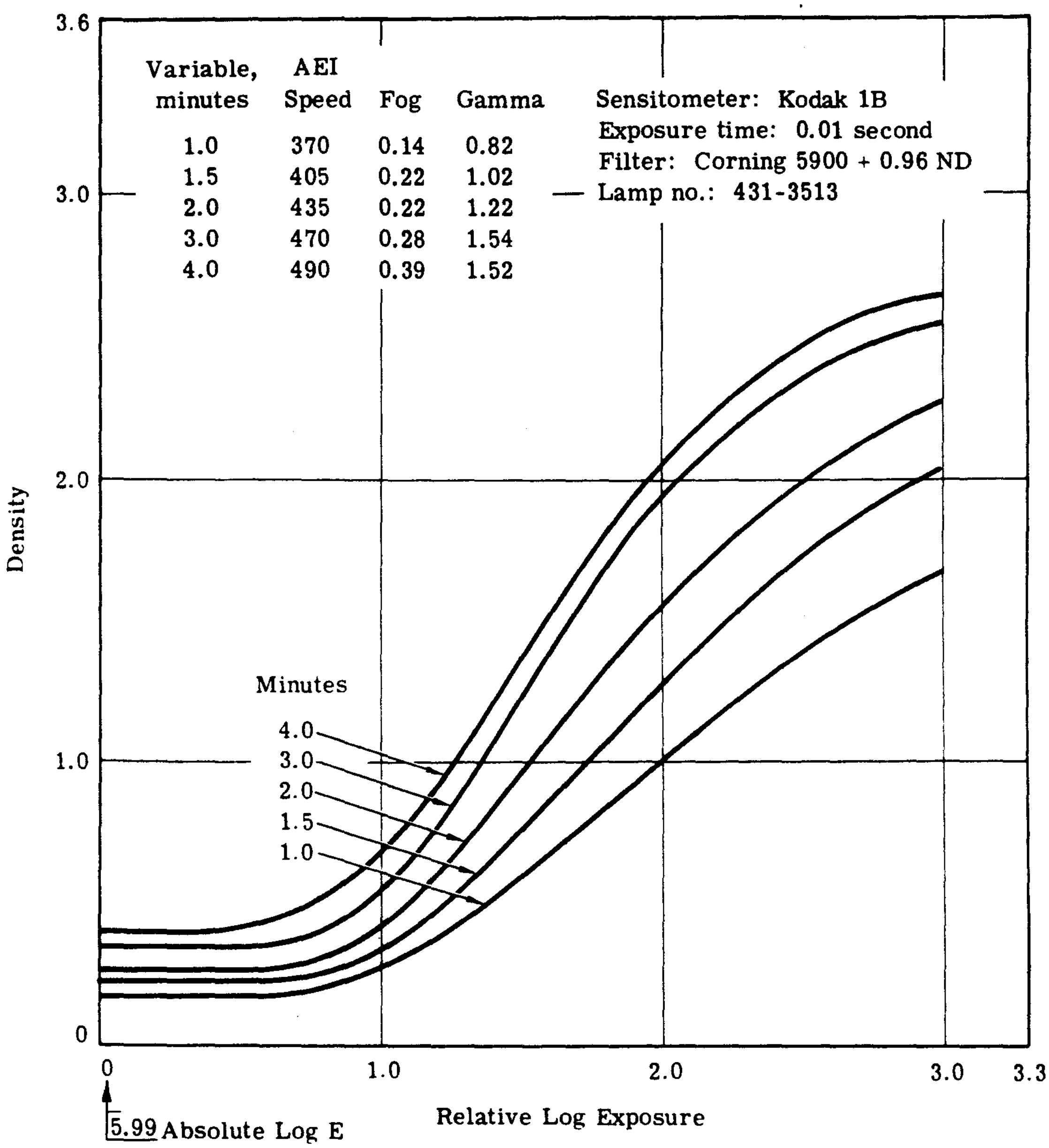



Fig. 2-5 — Sensitometric data sheet, SO-340, MX 642-1 developer, 90 °F temperature

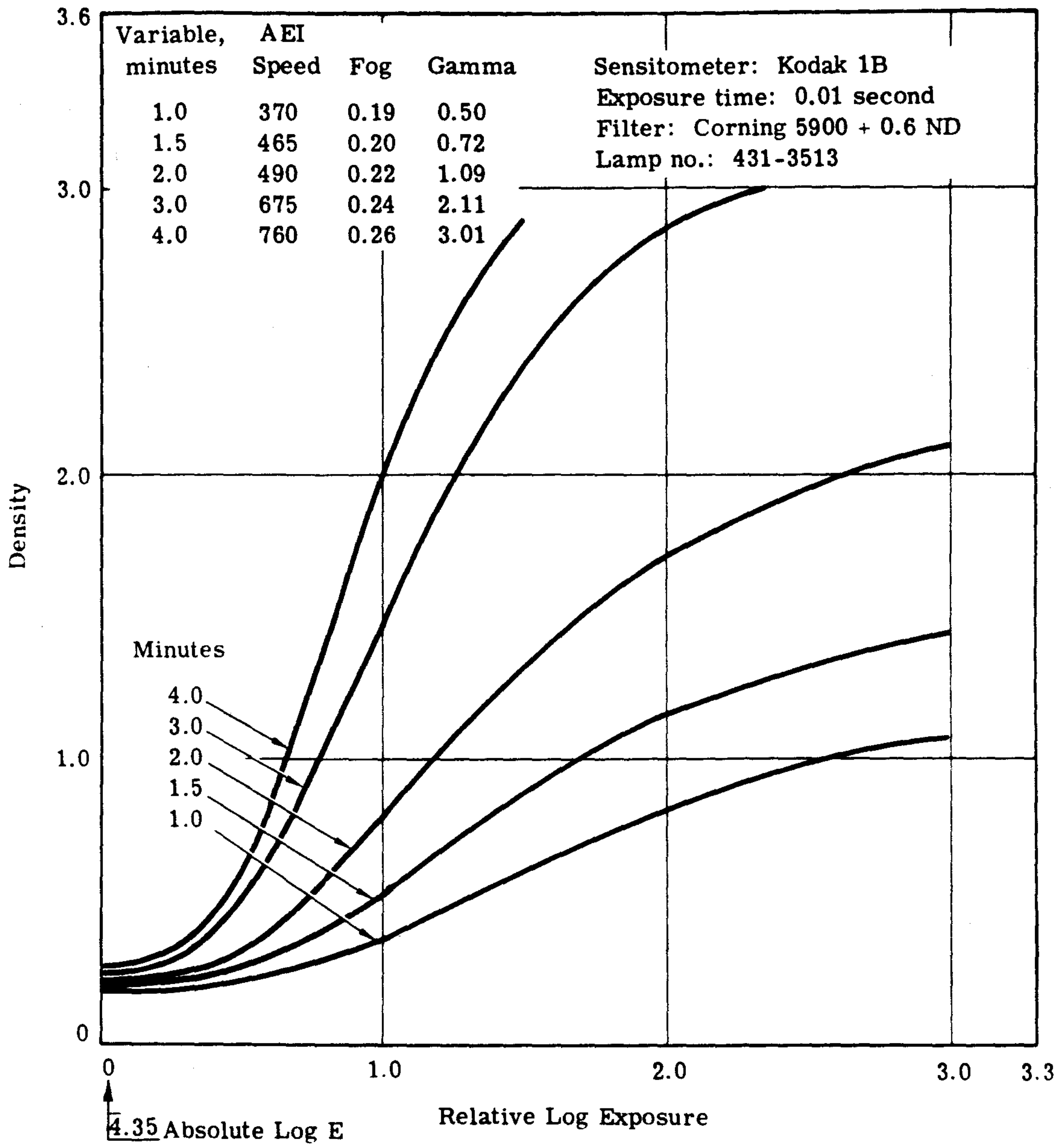



Fig. 2-6 — Sensitometric data sheet, SO-166, MX 642-1 developer, 90 °F temperature

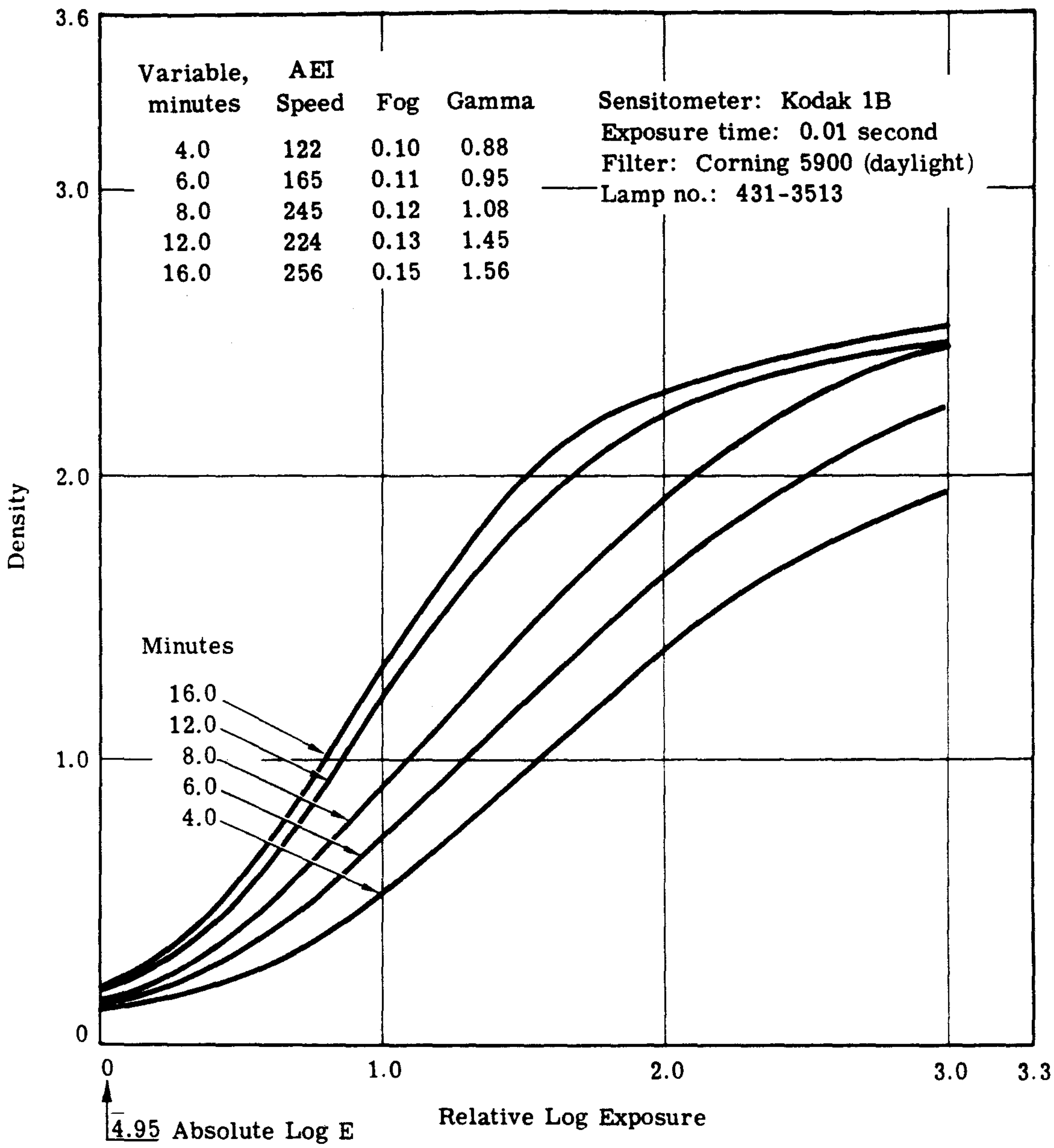



Fig. 2-7 — Sensitometric data sheet, SO-340, DK-50 developer, 68 °F temperature

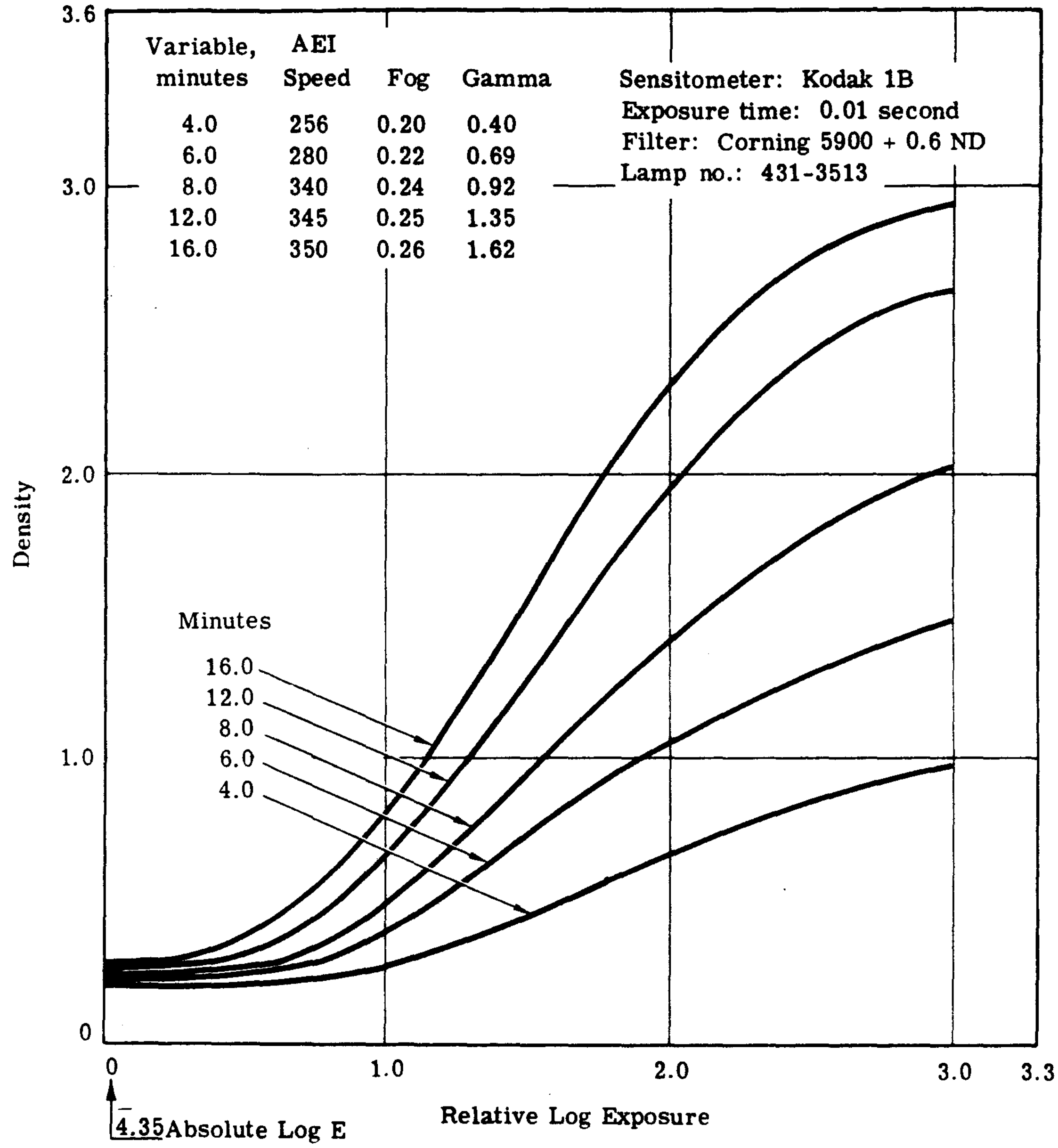



Fig. 2-8 — Sensitometric data sheet, SO-166, DK-50 developer, 68 °F temperature

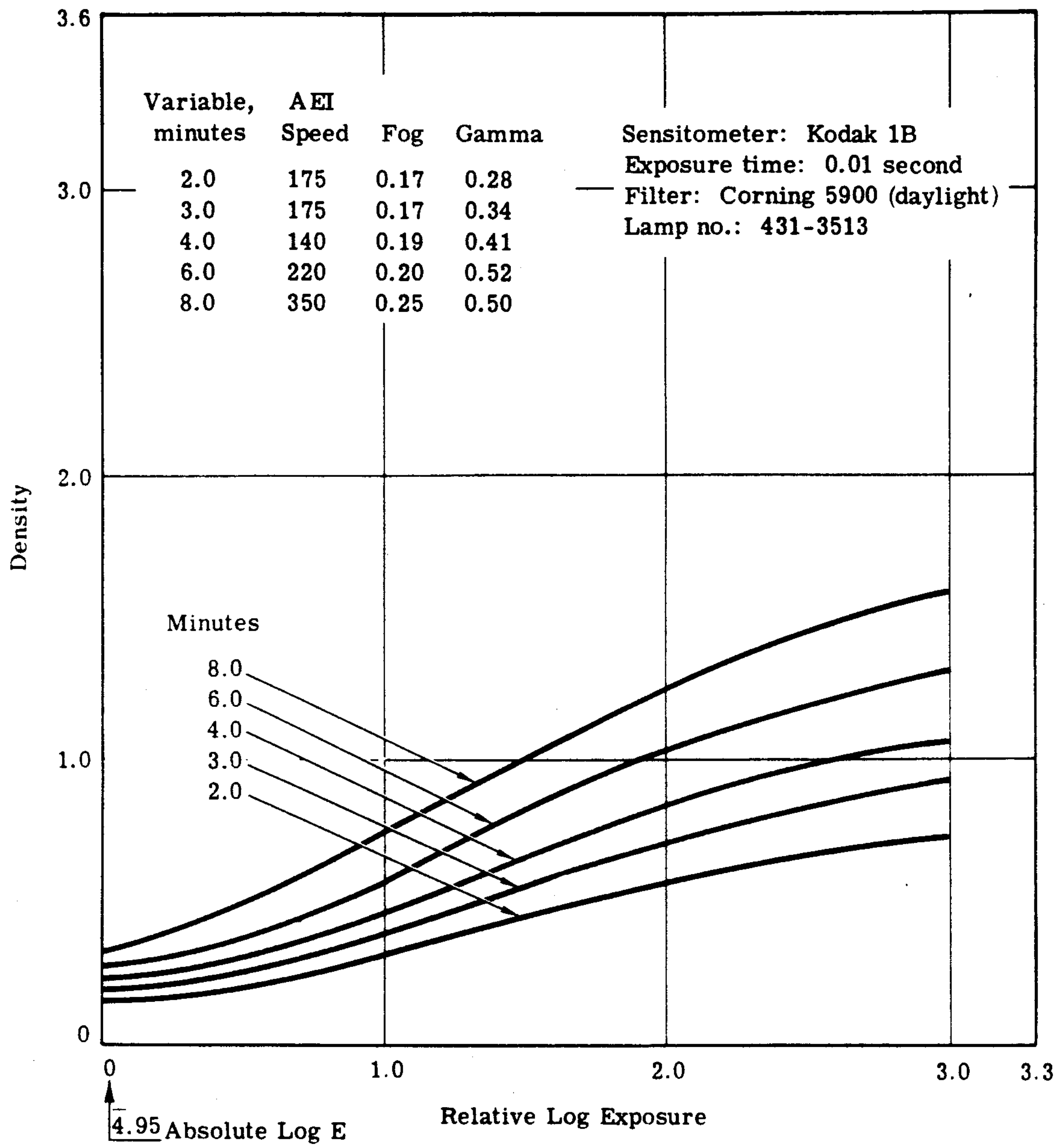



Fig. 2-9 — Sensitometric data sheet, SO-340, G-4 developer, 68 °F temperature

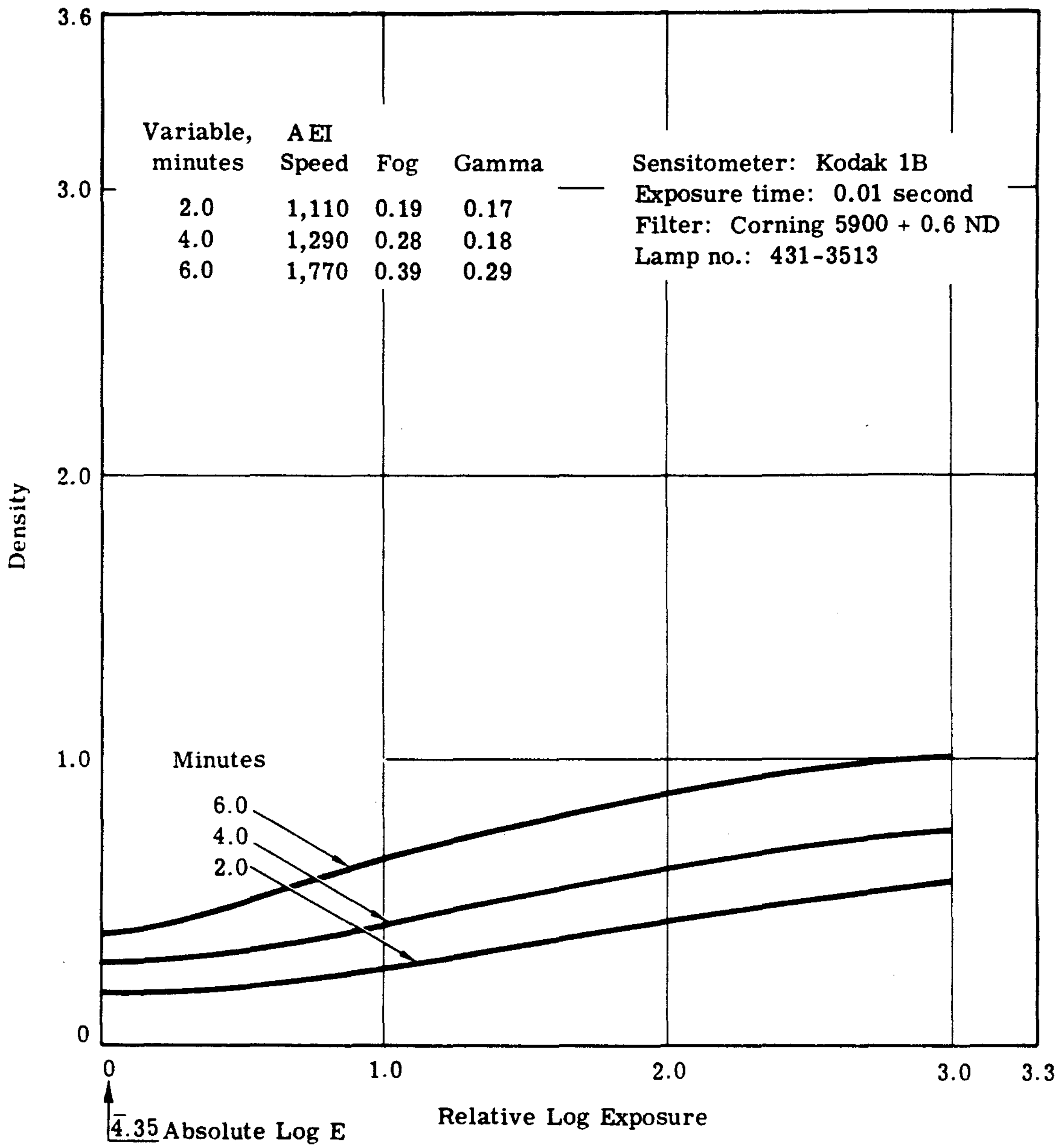



Fig. 2-10 — Sensitometric data sheet, SO-166, G-4 developer, 68 °F temperature

2.2.1.4 Recommended Developer and Development Time

The recommended developer and development time is based on the requirements set forth in Section 3, which describes image detection capabilities. The D-19 developer, for both films, at times of 4 to 6 minutes for SO-340 and 6 to 8 minutes for SO-166 provides the best compromise between a maximum speed, and extended log E range, and a wide density range. Higher speeds can be obtained with MX 642-1, however, the log E range is limited.

2.2.2 Filter Factors

The filter factors for the Wratten nos. 12, 21, and 25 filters are shown in Table 2-2. For all practical purposes the factors for both films are equivalent.

Table 2-2 — Filter Factors

| Film | Wratten Filter No. | | |
|---|---|---|---|
| | 12 | 21 | 25 |
| SO-340 | 2.0 | 3.4 | 4.5 |
| SO-166 | 2.5 | 3.0 | 4.8 |

2.2.3 Resolving Power

The resolving powers of SO-340 and SO-166 are shown in Table 2-3. This table quotes the resolving power in the conventional manner of resolution at two target contrasts. From the data it is concluded that there is no significant difference in resolution between the two films.

Table 2-3 — Resolving Power

| Film | Target Contrast | |
|---|---|---|
| | 1,000:1 | 6.3:1 |
| SO-340 | 63 | 48 |
| SO-166 | 63 | 43 |

2.2.4 The RMS Granularity

The results of the granularity comparison are shown in Fig. 2-11. At a net density of 1.0, SO-340 possesses a granularity of 0.094 and SO-166 has a granularity of 0.088. This represents a difference of 0.006 which should not be considered as highly significant. The difference, though, is much greater as the density level increases.

A contradiction exists between the speeds of SO-340 and SO-166 and their corresponding granularity. It is generally true that an increase in speed will be accompanied by an increase in granularity. This is not the one with these two films. An explanation for this situation might be

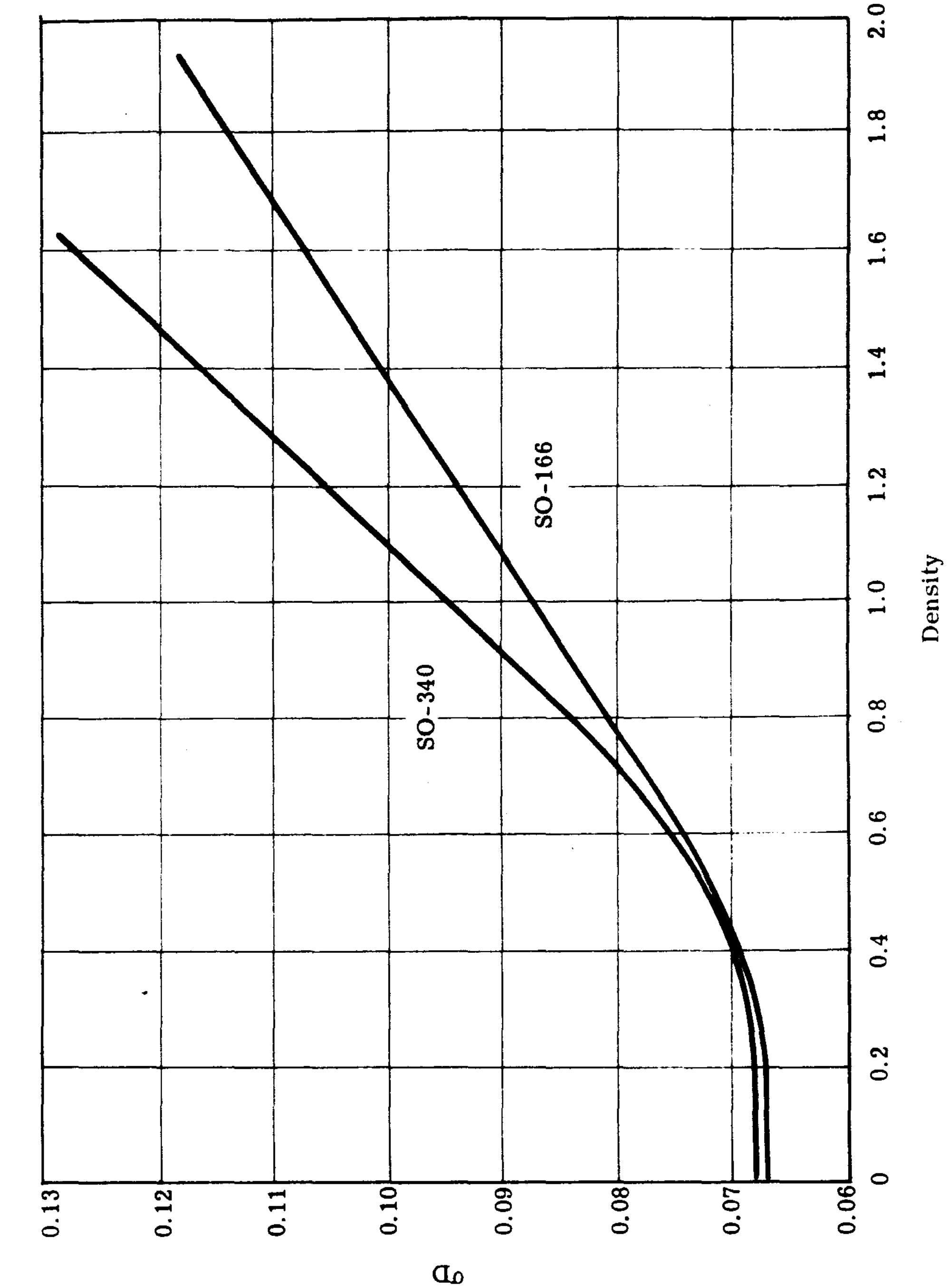



**Fig. 2-11 — The rms granularity of SO-340 and SO-166 as a function of density level**

found by examination of processing conditions used to produce the granularity samples. The SO-166 samples were not developed to a level which utilizes its full speed potential. If this was done, it is expected that the granularity of SO-166 would become higher than that of SO-340.

### 2.2.5 Processing Characteristics

The increase in speed of SO-166 is accomplished by the addition of silver iodide to the emulsion. However, in processing, the silver iodide leeches out into the developer and with continuous processing techniques causes severe degradation to the chemical's effectiveness. According to the manufacturer, approximately 200 square feet of film is the limit which can be run through the developer before a complete change in chemistry is required. This corresponds to approximately 800 feet of 70-millimeter film.

## 2.3 LOW CONTRAST PROCESSING WITH SO-340

The KH-4B mission planned for this spring is scheduled to run a night photographic test with SO-340. EKIT Report No. 6 (Night Detection Photography) recommended, based on aircraft tests, that the KH-4B night photography use low gamma processing of the original processing of the original negatives. A gamma of 0.3 was suggested in order to reproduce the greatest number of tones. With the G-4 processing, it is possible to obtain a characteristic curve that closely fits this recommendation. However, after producing the required sensitometric characteristics, it was realized that there would be loss in the detection capability of the material due to the lower maximum density. Since the points of light to be detected will be very small, a high $D_{max}$ will be required in order to detect them. It is recommended, therefore, that low gamma processing not be used in the forthcoming KH-4B night photographic experiment.

# 3. TECHNICAL CONSIDERATIONS

## 3.1 THEORY

Information in the form of a silver image can be defined in two classifications, (1) imagery that can be resolved, and (2) imagery that is observable but unresolvable. Consideration will be given here not to resolvable imagery, but to that which is formed by points of light recorded on the film. These points are too small to be recorded in detail, but will produce an observable image into a form commonly known as an Airy disk. The following analysis was performed to determine how big and how bright ground objects must be in order to be recorded as an Airy disk on SO-340 and SO-166 and aerial emulsions.

Selwyn's granularity constant is

$$G = \sigma_D \sqrt{A}$$

or

$$G = 0.88\, \sigma_D\, (d)$$

where G = Selwyn's constant
$\sigma_D$ = rms granularity
A = area of the scanning aperture
d = diameter of the aperture

It has been found the G holds constant for microdensitometer scanning apertures of from 6 to 300 microns in diameter. The rms granularity and $\sigma_D$ varies according to the size of the aperture, while the material remains constant. Therefore, G is a better number to characterize an emulsion granularity, since implied within it is the scanning aperture diameter.

If an image were to be exposed on a film within a uniform background density, its average density, $D_2$, would be greater than that of the average background density, $\bar{D}_1$. If, however, the random fluctuations, $\sigma_D$, due to the grain pattern were the same as this difference, would the image be detected? By the normal statistical variations in the scan, 16 percent of the background measurements would, by chance, be equal to or greater than the average image density. In this case, where $\bar{D}_2 = \bar{D}_1 + \sigma_D$, the signal-to-noise ratio is unity. The signal could be detected either if the signal itself were strengthened, or the noise were reduced.

Assuming the signal cannot be strengthened, the next best approach is to reduce the noise. Since Selwyn's law states that $\sigma_D$ varies as the square root of the area of the aperture, or directly as a function of the aperture diameter, the noise can be reduced by simply enlarging this aperture. In order to do this, though, the image area must also be appropriately enlarged. This fact now enables a relation to be made between the size of the target area to be detected and the granularity of the film. Since the $G_D$ is only a density difference, it can be related to an exposure difference through the sensitometric curve of the film when plotted as D versus E instead of the ordinary method of D versus log E. Therefore, the size of the target areas can in turn be related to the illumination necessary to detect them with a microdensitometer. However, the problem of detection of these signals is a visual process, not an instrumented one. Tests at Eastman Kodak have shown that the threshold of detection of a signal density level on a grainy background occurs at a point where the signal-to-noise ratio is about 8:1. Thus, with this data, the visual detection of targets of various sizes can then be related to the illumination on them.

Rearranging the equation:

$$\sigma_D = G/0.88d$$

$$\Delta D_V = 8\sigma_D$$

$$\Delta D_V = 8G/0.88d = 9G/d$$

where $\Delta D_V$ = the density difference needed for visual detection

Since the granularity of a film is a function of the density level, the value of G had to be computed for both SO-340 and SO-166 at the three density levels that were used in this analysis (see Table 3-1).

The following is a sample calculation for a single point, including the assumptions that were made to determine this point.

At the scales involved in the KH-4B System, a spot diameter of 8 microns covers an image area of approximately 6.3 feet in diameter on the ground.

From Table 3-1, 9G is 12.9 at a minimum density of 0.25 for SO-166.

$$\Delta D_V = 9G/d = 12.9/8 = 1.6$$

Adding this density to the base density

$$0.25 + 1.6 = 1.85$$

Interpolating from the characteristic curve for SO-166, Fig. 3-1, this density is produced by an exposure of 0.0178 meter-candle-second, or dividing by 10.76, 0.00166 foot-candle-second. The luminous intensity (candlepower or candela) of the ground object can be computed by the equation:

$$I = \frac{(E)\ H^2}{ArT_1T_2Mt}$$

where I = candelas of the ground object

E = required exposure on the film expressed in foot-candle-seconds

H = camera altitude expressed in feet

A = area of the entrance pupil of the lens expressed in feet

r = ratio between the area of the Airy disk to the area of the entrance pupil

Table 3-1 — $\sigma_D$, G, and 9G for Three Background Densities

| | Background Density | $\sigma_D$ | G | 9G |
|---|---|---|---|---|
| | 0.25 | 0.0680 | 1.436 | 12.9 |
| SO-166 | 0.50 | 0.0717 | 1.514 | 13.6 |
| | 1.00 | 0.0877 | 1.852 | 16.7 |
| | 0.25 | 0.0685 | 1.447 | 13.0 |
| SO-340 | 0.50 | 0.0726 | 1.533 | 13.8 |
| | 1.00 | 0.0944 | 1.994 | 17.9 |

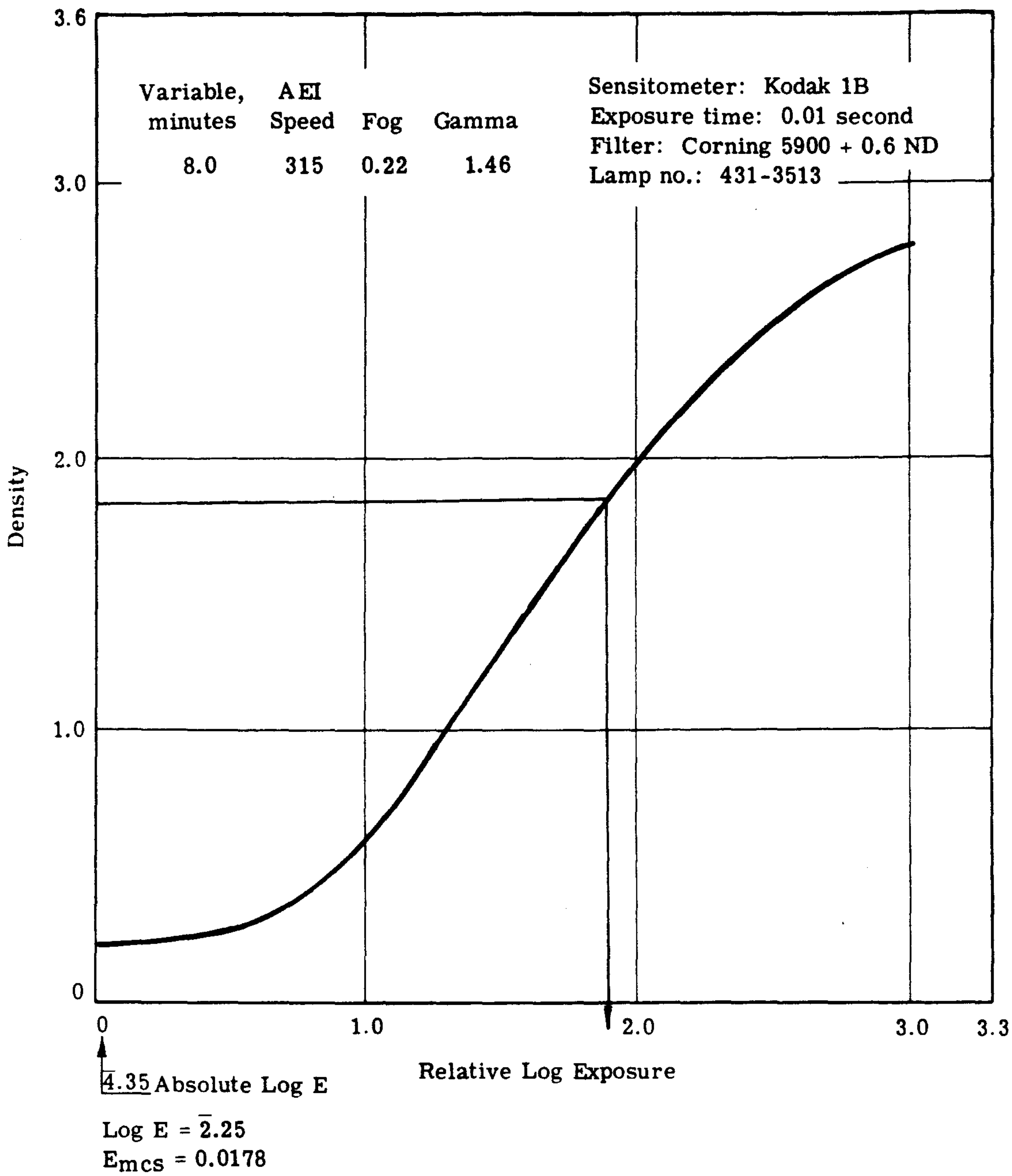



Fig. 3-1 — Characteristic curve of SO-166 processed for 8 minutes in D-19 developer at 68 °F temperature

$T_1$ = transmission of the atmosphere
$T_2$ = transmission of the lens
M = energy in the central portion of the Airy disk
t = exposure time expressed in seconds

The diameter of the Airy disk is

$$d \text{ (Airy disk)} = \frac{1.22\ (\tau)}{N' \sin U'}$$

where $\tau$ = wavelength
$N'$ = index of refraction
$U'$ = angle the entrance pupil makes with the optical axis

If

$\tau$ = 0.55 micron

$N'$ = 1.0

$U'$ = 8 degrees, 24 feet

then

$$d = 1.22\ (0.55)/\sin = 4.6 \text{ microns}$$

The ratio of the image area micron to the entrance pupil is then

$$r = \frac{(2.54 \times 10^4)\ (r_1)^2}{r_2^{\,2}}$$

If

$2.54 \times 10^4$ = conversion factor from inches to microns

$r_1$ = 3.5 inches

$r_2$ = 2.3 microns

then

$$r = \frac{(2.54 \times 10^4)\ (3.5)^2}{2.3} = 1.5 \times 10^9$$

The required intensity of the ground object (assuming a camera altitude of 480,000 feet, an atmosphere transmission of 0.80, a lens transmission of 0.90, the energy in the Airy disk as 0.84, and an exposure time of 0.02 second) is, therefore:

$$I = \frac{(1.66 \times 10^{-3})\ (4.8 \times 10^5)^2}{(2.67 \times 10^{-1})\ (1.5 \times 10^9)\ (0.80)\ (0.90)\ (0.84)\ (0.02)} = 56.5 \text{ candelas}$$

Thus, a 6.3-foot diameter area on the ground could be visually detected above a background density of 0.25 if it acted as a luminous source emitting 56.5 candelas. The procedure was carried out for SO-340 and SO-166 at other aperture sizes and at background density levels of 0.25, 0.5, and 1.0. Fig. 3-2 illustrates the detectability curves for both films at the three background densities.

3.2 RESULTS

There are several characteristics of the detectability curves which require recognition. The curves, in all six cases, become approximately parallel to the abscissa at a ground object size of 80 feet. It can be concluded, therefore, that the ground illumination necessary for image detection reaches a minimum for an object size of 80 feet, and any increases in the ground dimension results in no additional probability of detection. The approximate minimum ground illumination for each film at the three background density levels under which no object can be detected is shown in Table 3-2.

Table 3-2 — Minimum Allowable Ground Illumination (Candelas) Required for Detection of Large Objects at Three Background Densities

| | Background Density | | |
|---|---|---|---|
| | 0.25 | 0.50 | 1.00 |
| Film SO-340 | 8.7 | 16.0 | 33.9 |
| Film SO-166 | 3.9 | 8.8 | 23.3 |

A second observation is that SO-340 requires more ground illumination than SO-166 for any object size and at any background density.

It should be realized that these conclusions are based heavily on the speed calculations and the shape of the characteristic curves, and of these the speed factor is the more important. Although the granularity at the three density levels is incorporated into the procedure, the difference between the SO-340 and SO-166 granularity is practically negligible at those densities. Variations in the displacement of the SO-166 and SO-340 curves in Fig. 3-2 could be accomplished, therefore, by merely choosing the developer type and processing time which would result in curves and speed values that would be identical. Ideally, these calculations should be performed using the processing conditions which would actually be incorporated in the flight tests.

In conclusion, SO-340 will require, for these particular processing conditions, a higher minimum ground illumination for detection of large objects than SO-166. As the background density (fog level) increases, the detection ability of both films becomes limited.

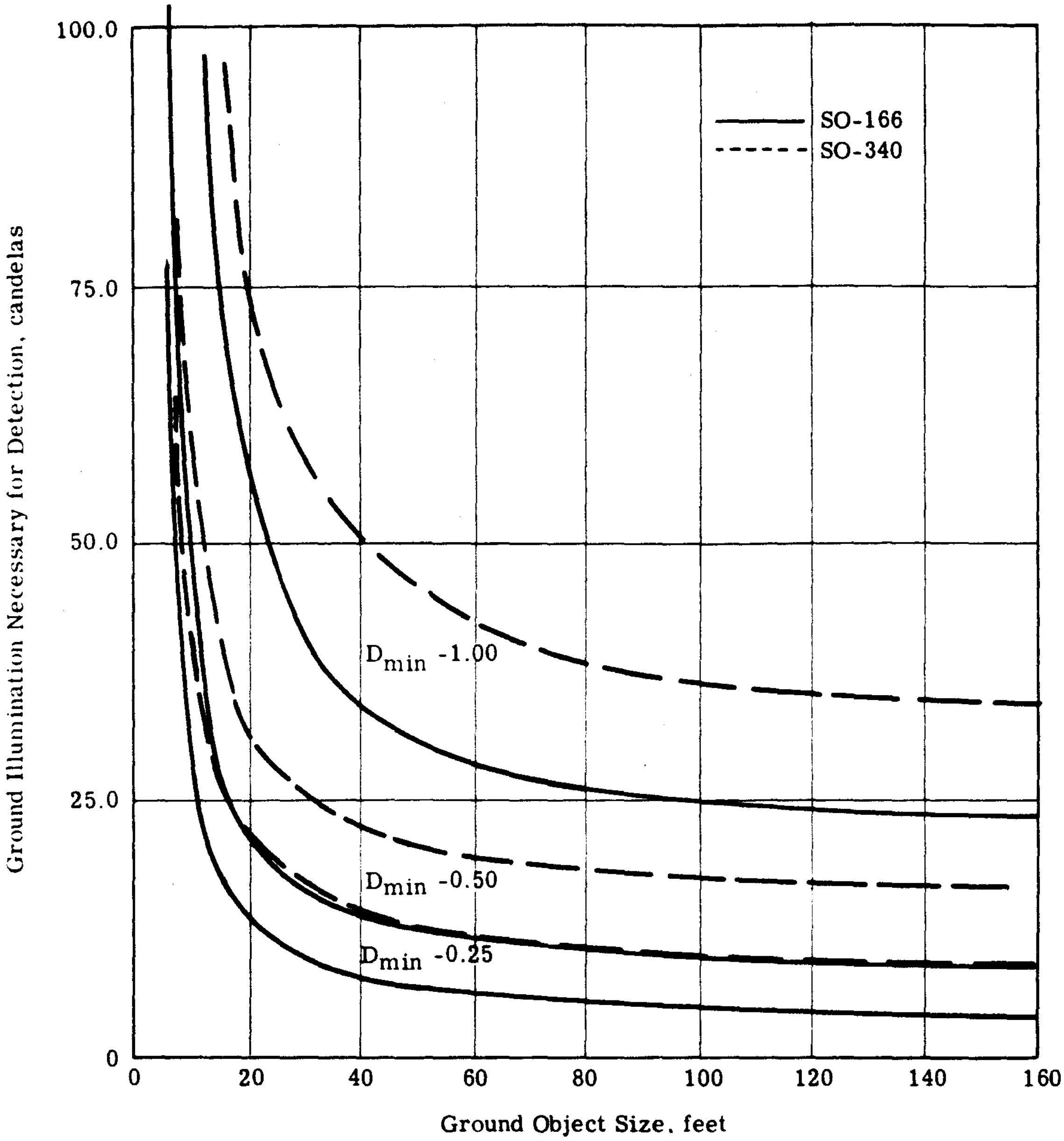



Fig. 3-2 — Ground object size versus illumination necessary for detection at three background density levels

# 4. ELECTROSTATIC DISCHARGE TESTS

## 4.1 INTRODUCTION

The pressure level of the environment in which the KH-4B Camera System is used produces electrostatic discharges resulting in the production of fog with high speed emulsions. The severity of this static was reduced to a substantial degree in the early stages of the program; however, it was never completely eliminated. The need to do so was not emphasized because the emulsion speed of the film used in the system was not fast enough to record the phenomenon in the form of emulsion fog. With the use of night photography in the KH-4B System, a much faster film (as much as 100 times) is required, and this situation has stimulated a renewed interest in the static discharge because excessive fog is produced with these high emulsion speeds.

A static discharge test series was run on SO-340 using a vacuum chamber to simulate actual satellite flight conditions. The levels of vacuum employed were: 1, 10, 20, 60, 100, and 150 microns. It should be pointed out that the present normal operating pressure for the system is in the range of 20 microns.

## 4.2 RESULTS

Fig. 4-1 shows the results of the test. Note that these illustrations are positive prints of the static discharge pattern and that black areas indicate no static while the white areas result from static. It is evident that the order of preference for the six pressure conditions increases as the pressure increases, with the exception of the 1-micron level. However, a slight increase to the 3- to 5-micron level produces extremely severe static. It should be recognized, therefore, that the 1-micron level is favorable for minimum discharge but undesirable under operational conditions if the pressure should rise by a few microns.

The 20-micron condition (normal operating level) will severely limit the usefulness of aerial photography in the KH-4B System. The fog produced at this pressure would obscure the information, especially the unique type which results from night photography.

The 100-micron pressure produces just acceptable fog with SO-340 but the additional speed (2×) of SO-166 would make that level undesirable for the latter film. Unquestionably the best condition of static discharge is at 150 microns. Both SO-340 and SO-166 would produce negligible fog at that pressure.

(a) 1 micron

(b) 10 microns

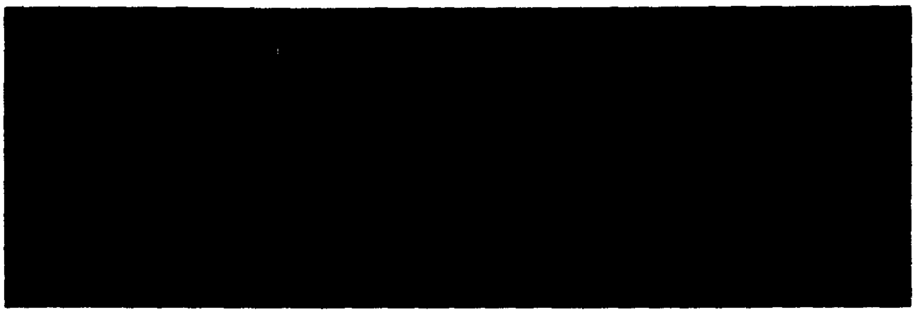
(c) 20 microns

Fig. 4-1 — Static discharge pattern



TOP SECRET
NO FOREIGN DISSEMINATION

(d) 60 microns



(e) 100 microns

(f) 150 microns

Fig. 4-1 — Static discharge pattern (Cont.)

## 5. CONCLUSIONS

The following conclusions are drawn from these laboratory tests and theoretical studies.

1. In general, SO-166 is twice as fast as SO-340. The most notable exception to this statement occurs in low gamma processing. At gammas of 0.5 to 0.7, there is essentially no speed difference between the two materials. SO-166 does not produce gammas above 0.3 in G-4 developer and, therefore, can not be compared except at the very low gammas.

2. SO-166 produces higher fog levels than SO-340. In general, the fog level is twice as high as that of SO-340 under equal processing conditions.

3. In general, shorter development times result in lower gammas for SO-166, although with longer development times, the gamma of SO-166 surpasses that of SO-340. A very wide range of gammas can be obtained in MX 642-1 developer (from 0.5 to 3.0) by varying the development time.

4. SO-166 and SO-340 have equal resolution and approximately equal filter factors. Both films are sensitive to the entire visible spectrum.

5. The granularity of SO-166 is somewhat better than that of SO-340. At densities up to 1.0, the difference is quite small. Above a density of 1.0, however, the granularity of SO-340 is considerably higher.

6. SO-166 can detect objects having a lower luminous flux than can SO-340. Therefore, SO-166 can be used as a better detector of activity than SO-340.

7. Low gamma processing is not recommended. The information lost due to the lowered $D_{max}$ from low gamma processing would be greater than that gained by having all of the tones within a specific contrast range.

8. Static distribution from the camera system produces fog (which will limit the usefulness of the imagery in the KH-4B System) at pressure levels of above 1 micron and below 100 microns for the SO-340 and above 1 micron and below 150 microns for the SO-166. Steps should be taken to adjust the pressure in the vehicle when night photographic passes are to be made. The most desirable pressure is 1 or 150 microns (but not between). A slight increase to 3 to 5 microns will produce very serious discharging. If there is a chance that the pressure will rise to that range during the night coverage, it is recommended that an attempt be made to make up the pressure to above 100 to 150 microns. The normal pressure of 20 microns will result in serious static discharges.

9. SO-166 has a real advantage over SO-340 for night photography because of its increased speed and slightly lower granularity at high contrast processing levels. It does have the disadvantage, however, of being more sensitive to static than SO-340.

10. SO-166, according to the manufacturer, has a degrading effect on the developer chemistry when large quantities of film are to be processed.

11. SO-340 is specifically designed for aerial photography and, therefore, has a hardened emulsion in contrast with SO-166 which may exhibit some curl because of its softer coating.