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EKIT REPORT NO.1

MODEL COMPARISON OF SO-362 AND 3404 FILMS

22 AUGUST 1966

Itek

ITEK CORPORATION LEXINGTON 73, MASSACHUSETTS

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FIGURES

TABLE

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1. SUMMARY

A simulated photographic experiment was used to determine the comparative image quality characteristics of Eastman Kodak SO-362 and 3404 films. A subjective evaluation showed a subtle but definite improvement in the detection capability of minute detail with the 3404, which has also been found to be less sensitive than the SO-362 to changes in exposure level.

The MTF of the 3404 system is higher than that of the SO-362 system at the normal exposure level. However, since the SO-362 MTF was found to vary as a function of exposure (whereas that of the 3404 did not), there were MTF's from the SO-362 system that were better than MTF's from the 3404. However, tonal detail was lost in these underexposed images.

It is concluded that, on an equal treatment basis, the 3404 performs in a manner superior to that of the SO-362. It does not, however, answer the question of their relative quality in an operational system where equal treatment is not the case and the exposure-time/image-motion factor is included.

Approved by: [redacted]

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2. MODEL PHOTOGRAPHY

In order to simulate an aerial scene, a model was used that consisted of wooded terrain, highways, secondary roads, a railroad, and a small town. The illumination was arranged to represent a sun: sky ratio of 3:1 with the sun at a solar altitude of 55 degrees. In order to more fully simulate the operational system, a lens was chosen so that the low contrast resolution of the system would be on the order of 100 cycles per millimeter. Fig. 2-1 illustrates the model.

A series of exposures were made and the "normal" exposure was chosen for its overall qualities (i.e., enough shadow detail without blocked-up highlights). The remaining two images were compared for over- and underexposure relative to the best exposure.

All negatives were duplicated on Eastman Kodak 8430 film in order to obtain a good positive image. Since the original negatives included a wide range of exposures, the criterion for duplication was that a good positive be obtained no matter what negative was being printed. This criterion was again used with reference to the tonal reproduction of both the shadow and highlights.

Subjective evaluations were made on both the original negatives and the duplicates. Physical measures were made on the original negatives.

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Fig. 2-1 — Model used in film comparison

[redacted]

3. SUBJECTIVE ANALYSIS

A microscopic examination of the negatives from the two systems revealed that the fine detail achieved in the 3404 imagery was superior to that of the SO-362. Objects such as railroad switching (Fig. 3-1), radar dish antenna, and houses reproduced better at the normal exposure level with the 3404. It required a very high magnification (100×), however, to detect these differences. At 15× magnification, absolutely no difference was detected in the two materials at the normal exposure. At the higher magnifications, the increased graininess of the SO-362 (Figs. 3-1 and 3-2) is immediately apparent.

It should be noted that several observers have differed on the relative merits of the two materials in specific instances. Fig. 3-2 has been included in this report to show one such case. The difference in graininess and contrast has made these particular areas appear to have similar detail.

An examination of several areas as a function of exposure has shown that there is a definite increase in image degradation with the SO-362 at the higher exposure levels. Areas such as the fine structures of the house under construction blocked up to the extent that the studs could not be seen on the overexposed SO-362. The 3404 film, though, had the ability to retain the identity of the studs on its overexposed samples. Figs. 3-3 and 3-4 illustrate the differences in the two materials at one stop over and one stop under normal exposure. The resolution figures from the targets also indicated a similar trend (see Table 3-1). The normally exposed samples of 3404 achieve approximately 16 percent higher resolution. The trend of decreasing resolution with increasing exposure is evident in the SO-362 figures, while the differences in the 3404 figures are slight. The underexposed sample of SO-362 achieves resolution closer to that of the normally exposed 3404, but these should not be compared since there are tonal losses in the SO-362 that contribute to a loss in information.

Table 3-1 — Resolution Comparison of SO-362 and 3404 Film

Film	Aperture	Resolution, lines per millimeter, at contrast ratio of 4:1	Resolution, lines per millimeter, at contrast ratio of 2:1
SO-362	1 stop under	145	107
	Normal	133	94
	1 stop over	125	67
3404	1 stop under	148	105
	Normal	155	110
	1 stop over	141	100

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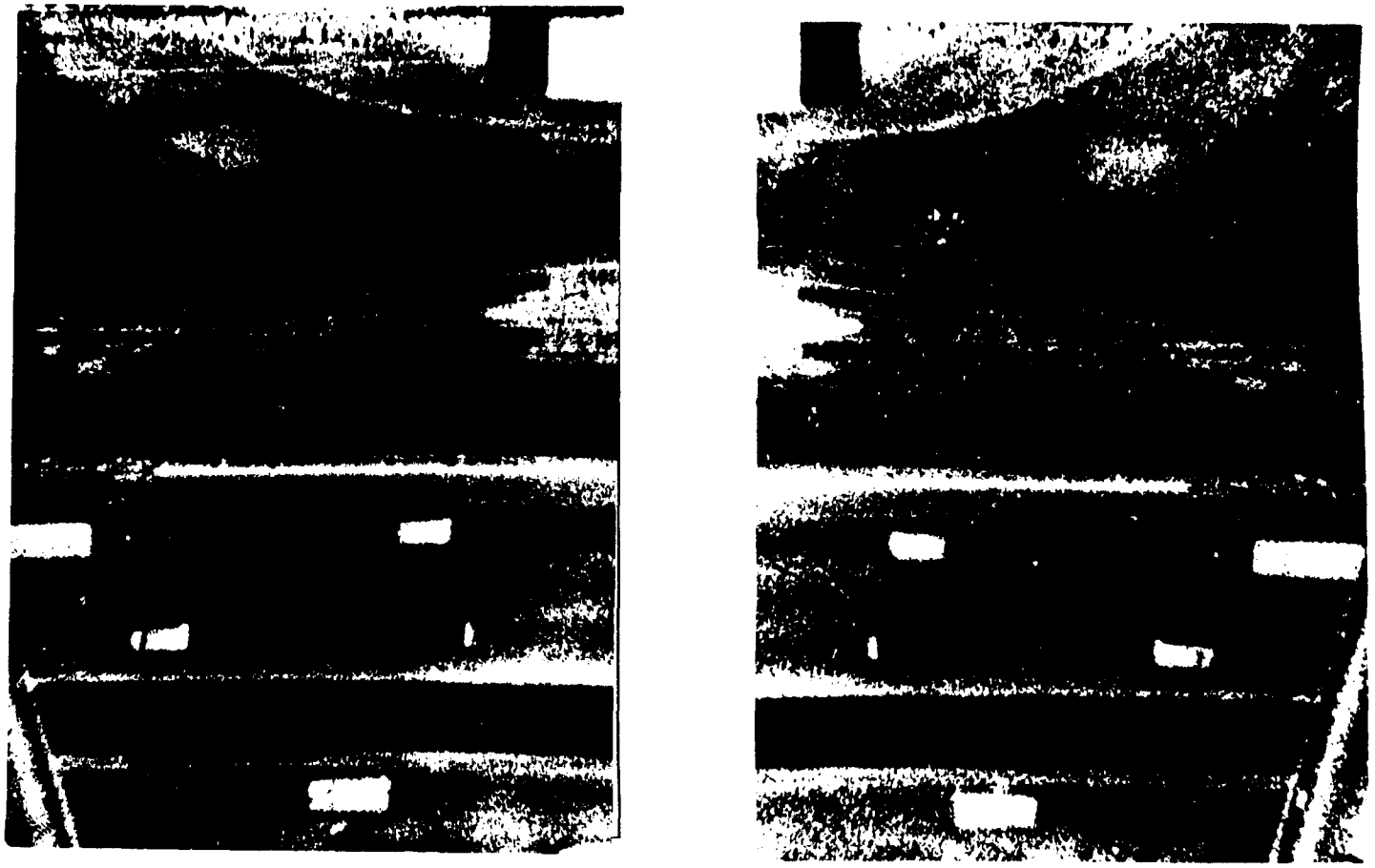


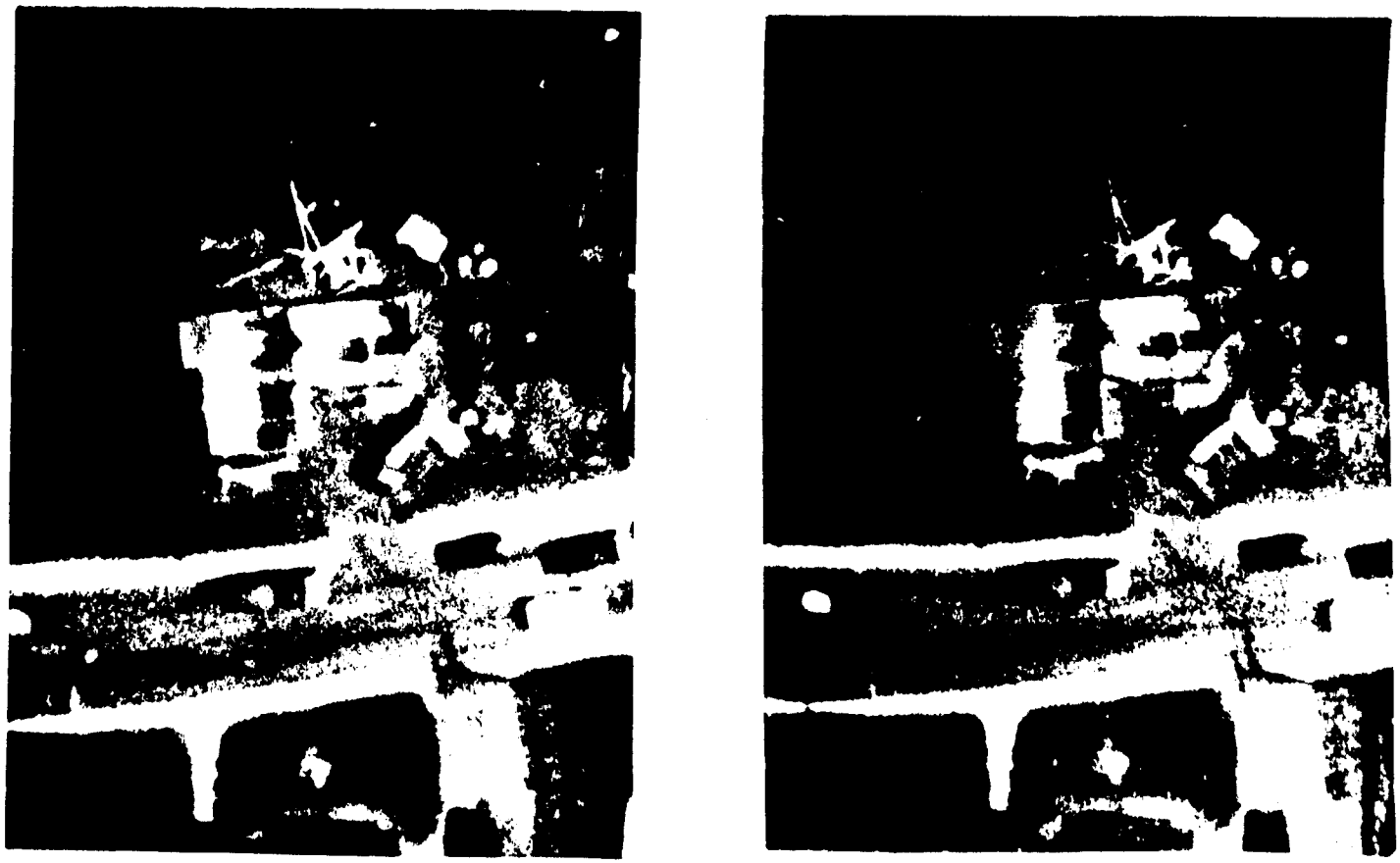
3404 SO-362

Fig. 3-1 — 110× microphotographs of railroad tracks with 3404 and SO-362 at the normal exposure levels

3404

SO-362

Fig. 3-2 — 110× microphotographs of house construction with 3404 and SO-362 at the normal exposure levels



3404 SO-362

Fig. 3-3 — 110× microphotographs of house construction with underexposed SO-362 and 3404 film

3404 SO-362

Fig. 3-4 — 110× microphotographs of house construction with overexposed SO-362 and 3404 film

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4. PHYSICAL EVALUATION

During the original photography, a simulated CORN target array was placed in the scene. All photography, therefore had low contrast resolution targets and edges from which MTF measurements could be made. Edge traces were obtained by scanning the edge of the photometric path in the resolution target with an effective 0.6-micron slit. To ensure against an error being introduced by scanning an image that was perhaps slightly out of focus, all four replicate pictures were scanned at each exposure level of both films. MTF's were obtained for the SO-362 film at the one stop under, normal, and one stop over exposure levels. The MTF's for the 3404 film were obtained only at the one stop under and normal exposure levels. Since the shoulder of the 3404 characteristic curve is lower than that of the SO-362, considerable error was introduced in the 3404 overexposed MTF measurements. However, the long straight line portion of the SO-362 permitted more reliable determination of its overexposed images MTF.

Fig. 4-1 represents the two characteristic curves for the materials as used in the test. Since the SO-362 is designated as a special order film, one should not interpret its characteristic curve as representative of the material as it will be in its production run form.

The variation in MTF for the SO-362 system as a function of exposure is illustrated in Fig. 4-2. There is a distinct improvement in the measured MTF as the exposure is decreased The characteristic curve of the SO-362 encompasses a very large log exposure range. Thus it is possible to obtain reliable MTF measurements over a wide range of exposure. The experi mental error in these measurements is in comparison to the differences in these MTF's down to a modulation of 10 percent. Compare the order of transfer function with that of the resolutioi in Table 3-1. The trend of decreasing quality with increasing exposure is present in both the MTF's and resolution values.

The MTF's for the two exposure levels of the 3404 system are illustrated in Fig. 4-3. In this case no significant difference is found in the two MTF's. A comparison of resolution values (refer to Table 3-1) also indicates that there is no conclusive difference in the image quality; in fact, there is hardly any difference over the range of two stops in exposure.

A comparison of the MTF's for the two systems is made by comparing the 1-sigma spread of the data in both materials' MTF's, as shown in Fig. 4-4. The MTF of the system using 3404 is clearly higher over most of the transfer function.

The MTF's for the microdensitometer and for the 3404 film were divided into the 3404 system MTF. The AIM curves (from Eastman Kodak's laboratories) were used at the 4:1 and 2:1 contrasts in Fig. 4-5. The predicted resolution for the 4:1 contrast is 125 cycles per millimeter, while that of the corresponding resolution target was 146 cycles per millimeter. The lower contrast prediction is ~~100~~ 114 cycles per millimeter as compared to the ~~114~~ 150 from the resolution target. In both cases, the predicted values are in error by 14 percent; however, in one case it is high and in the other case it is low. This gives an indication of the inherent error in this type of measurement, that is, plus or minus approximately a target element.

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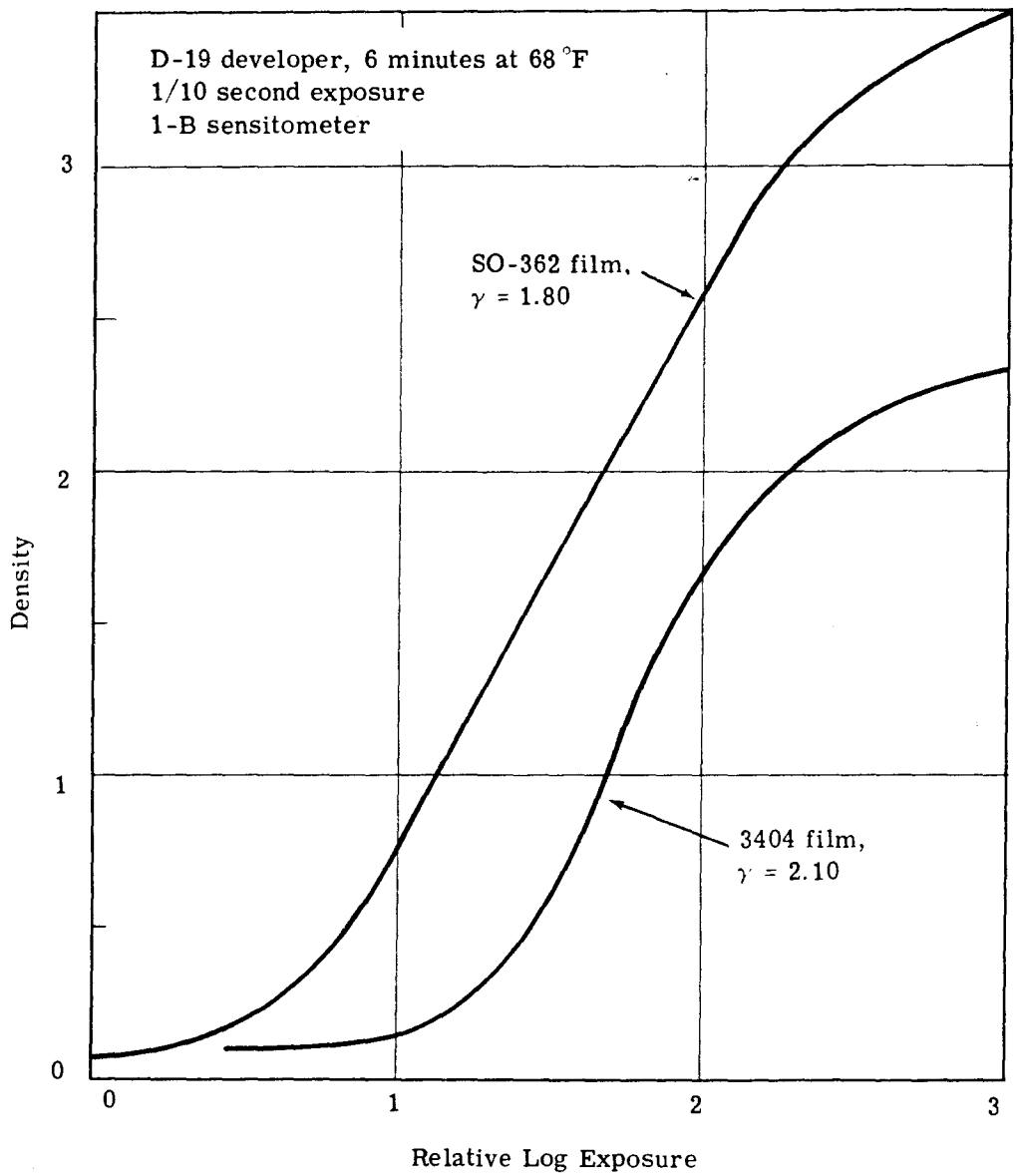

Fig. 4-1 — Characteristic curves for SO-362 and 3404 films

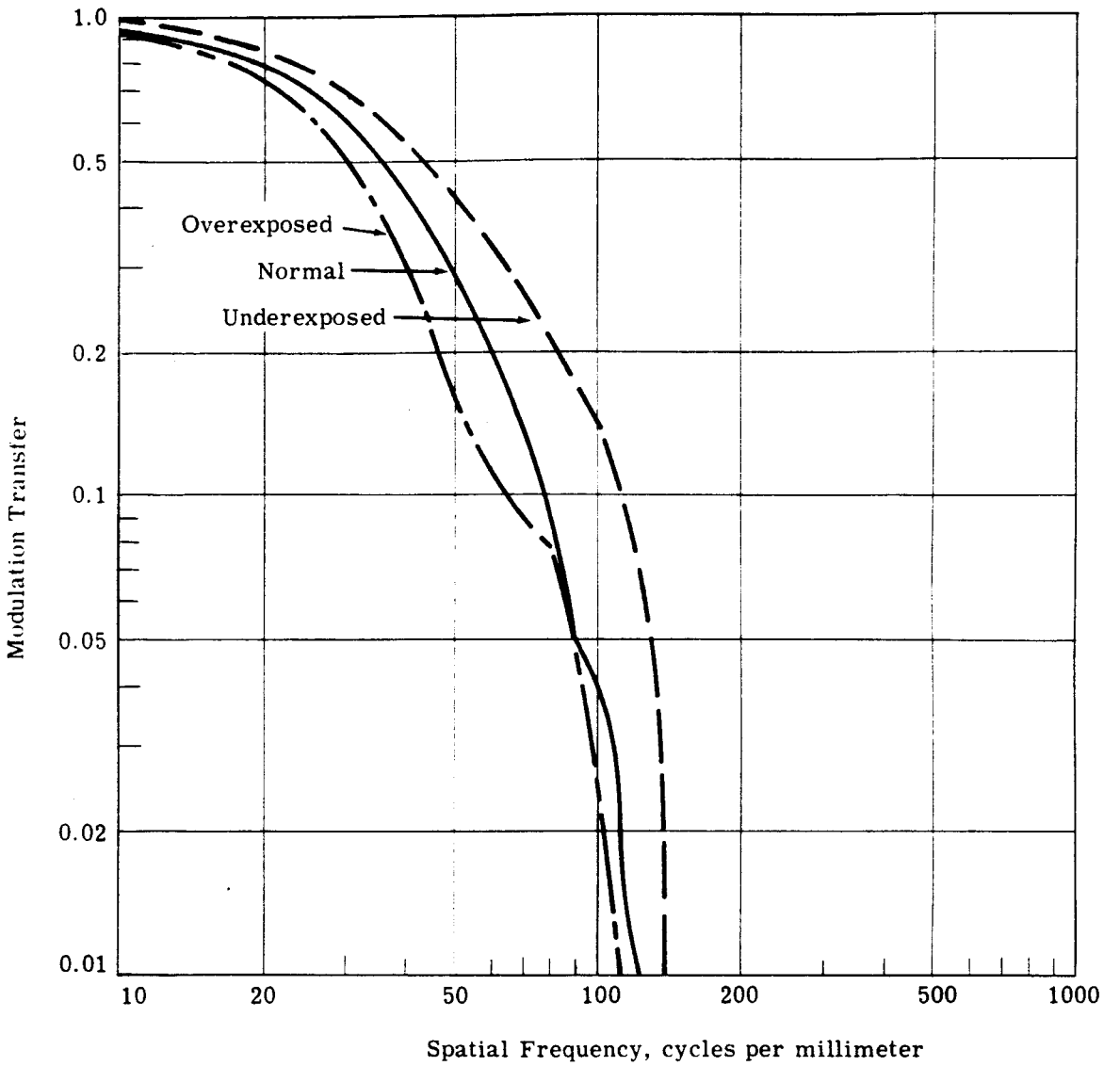

Fig. 4-2 — MTF for the SO-362 system at three exposure levels

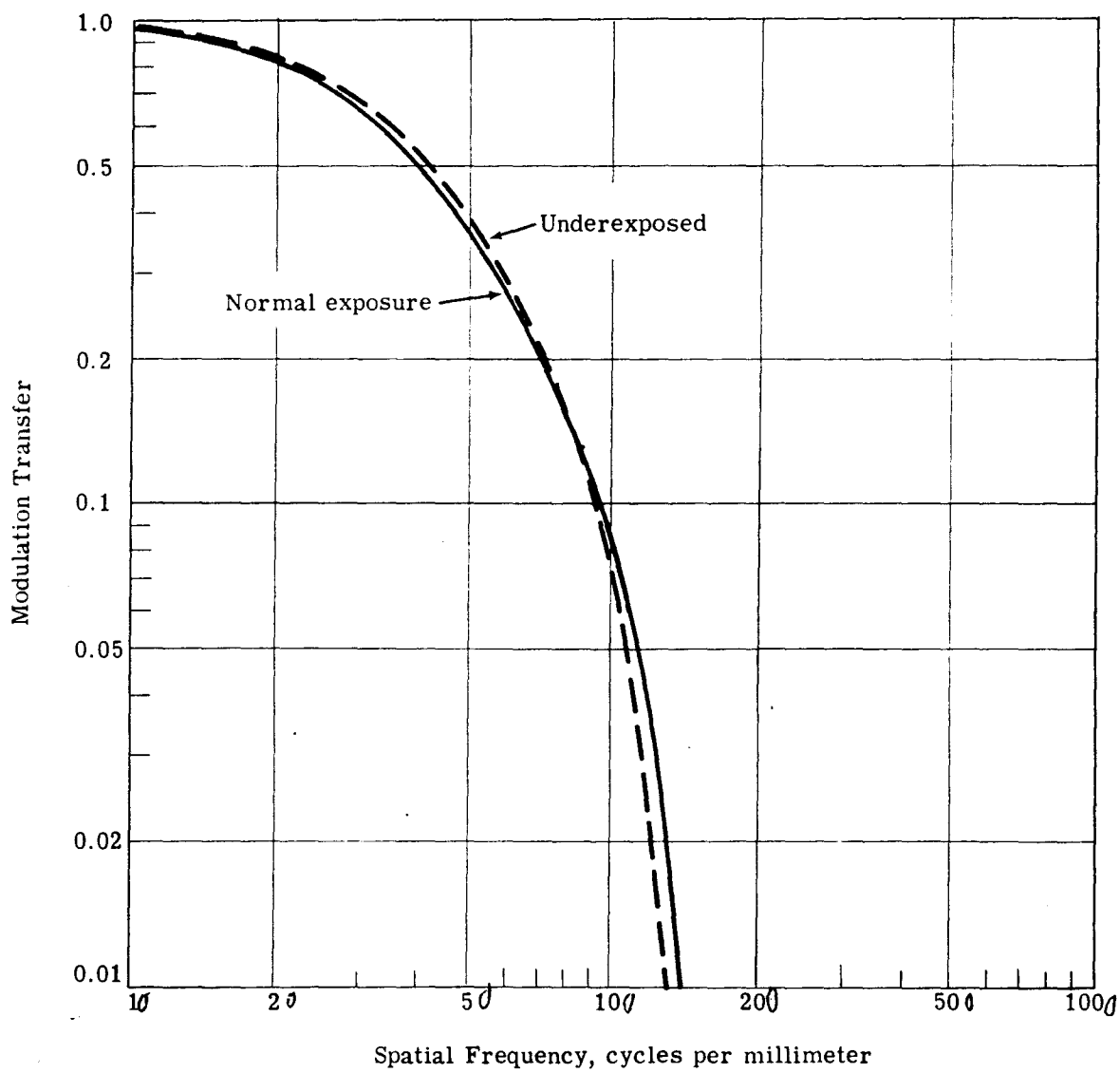

Fig. 4-3 — MTF for the 3404 system at two exposure levels

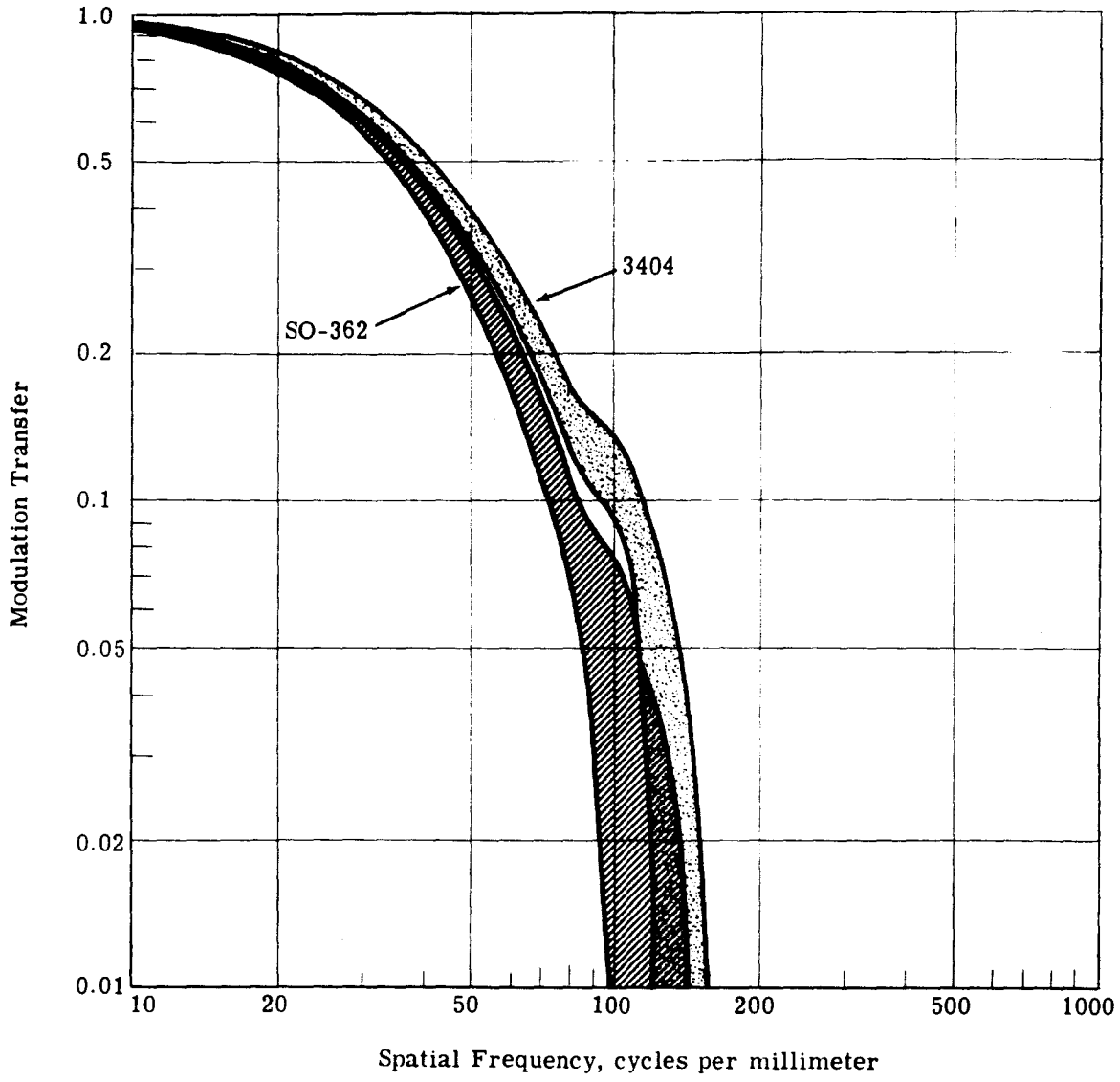

Fig. 4-4 — Comparison of SO-362 and 3404 systems (shaded area indicates 1-sigma variation in the data)

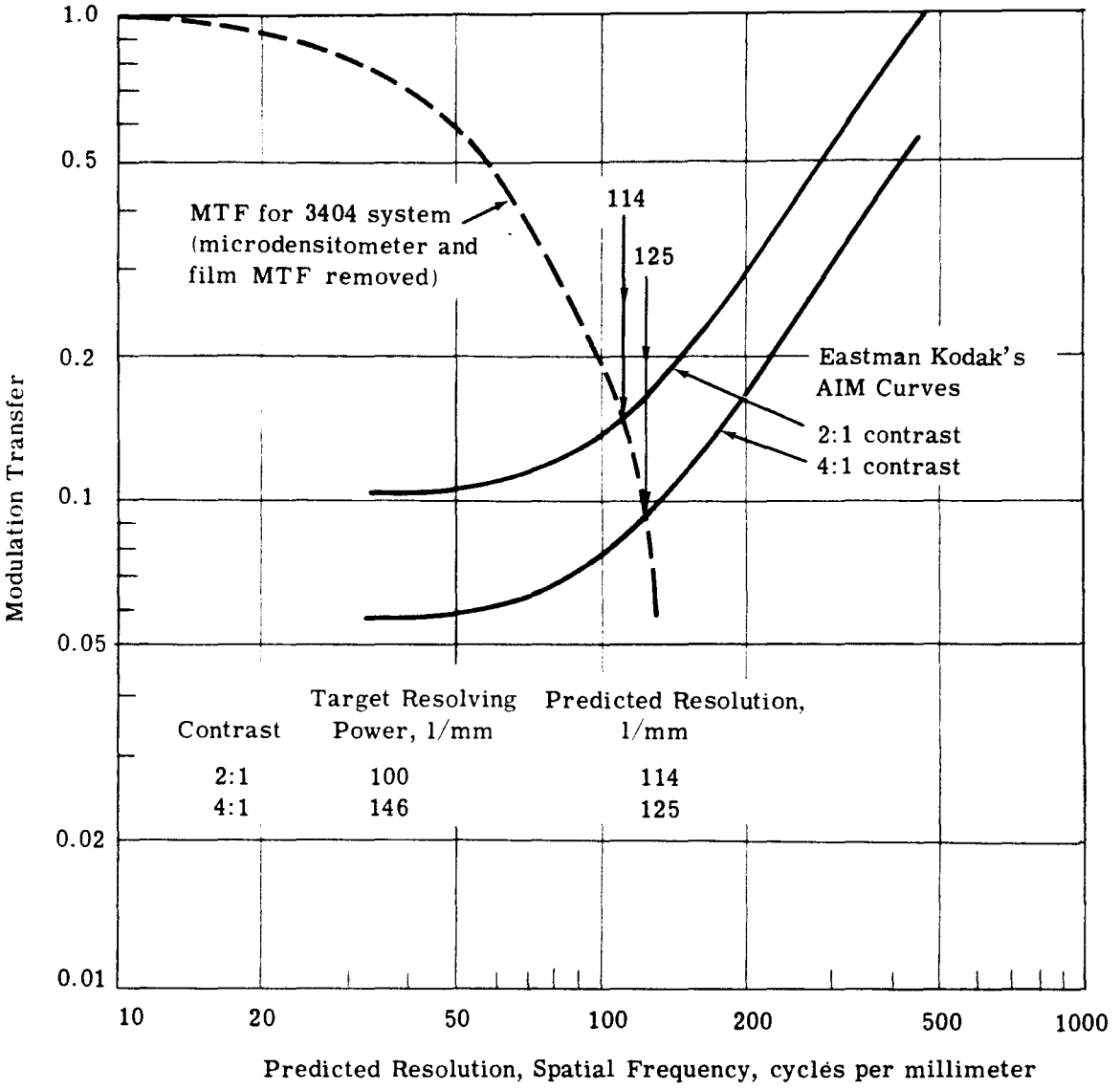

Fig. 4-5 — Predicted and observed resolution for the 3404 system with normal exposure