DEPARTMENT OF COMMERCE · UNITED STATES OF AMERICA

National Institute of Standards and Technology

Certificate

Standard Reference Material 1010a

Microcopy Resolution Test Charts

(ISO Test Chart No. 2)

This Standard Reference Material is intended to be used to determine the resolving power of microcopy systems. It meets all of the requirements for ISO Test Chart No. 2, as described in International Standard ISO 3334-1989. This SRM consists of five identical charts with 26 patterns. The patterns are black bars on a white background, the length of the bars are 24 times their width, and the bars and spaces are of equal width. The charts are printed on white photographic paper with a glossy surface.

The patterns range in spatial frequency from 1 to 18 cycles/mm. Each pattern is made up of two groups of five parallel bars, the bars in the two groups being oriented perpendicular to one another. The number associated with each pattern is the number of cycles/mm on that pattern.

Optical examinations and measurements leading to certification were made by L. E. Fink of the Radiometric Physics Division, NIST National Measurement Laboratory.

The support aspects involved in the original issuance of this Standard Reference Material were coordinated through the Standard Reference Materials Program by R.W. Seward and are now coordinated by R.L. McKenzie.

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(over)

INSTRUCTIONS FOR USE

The useful reduction ratio of a microcopying camera is limited by the nature of the material to be copied, the resolving power of the lens, the resolving power of the photographic material, accuracy of focusing, vibration, and systematic relative motion of the optical image with respect to the photographic material. The resolving power of a system in cycles/mm is the number of the pattern resolved in an image multiplied by the inverse of the reduction ratio.

To measure the resolving power of the microcopying system, photograph the charts in the same manner as documents. The charts are placed at the center and the corners of the camera field of view. The corner charts should be oriented so that one group of bars is directed toward the center of the field. Additional charts may be placed at the center of the long side or anywhere in the field at the users discretion. Examine the processed film images with a microscope, using a magnification from 1/3 to 1 times the number of cycles/mm of the resolving power to be observed. For example, to view an image from a system with resolving power of 100 cycles/mm, the magnification should be between 30 and 100.

If the camera is slightly out of focus, the copy of the chart may have other than 5 bars in some groups. This is "spurious resolution" and is sometimes accompanied by failure to resolve at one spatial frequency when apparent resolution occurs at a higher frequency. If there is no evidence of spurious resolution, find the smallest pattern in which the bars can be counted with reasonable assurance. For example, if the finest resolved pattern is marked "4.0" and the reduction ratio is 1:29, the resolving power is 116 cycles/mm.

Away from the center of the field, the resolution of bars directed toward the center is often not equal to the resolution perpendicular to that direction because of lens aberrations. If the patterns perpendicular to one another are not equally resolved at the center of the field, one should suspect camera vibration or other image motion with respect to the film.

The resolution required to copy type depends on the size of type, the reduction ratio, and the quality of reproduction required. For most practical purposes; R, the resolving power in cycles/mm; e, the height in millimeters of the lower case "e" in the type to be copied; r, the inverse of the reduction ratio; and q, an arbitrary "quality index", are related by the following equation:

$$R = \frac{qr}{e}.$$

For excellent copy, in which the details of type are clearly defined, q must be 8 or more. If q is assigned a value of 5, the copy may be read without difficulty although serifs and fine details of type are not clear. If q is 3, the copy may be read with difficulty, the letters e, c, and o being partly closed.

As a general "rule of thumb," the resolving power of a lens-film combination R is related to the resolving power of lens r_1 and the resolving power of the film r_2 by the following equation:

$$\frac{1}{R} = \frac{1}{r_1} + \frac{1}{r_2}.$$

The resolving power of a lens is limited by the wave nature of light. The maximum resolving power of the lens depends on the wavelength of light, the form of the patterns observed, and the condition of observation. The maximum axial resolving power A (expressed in cycles/mm), of a lens at various wavelengths can be obtained by using Rayleigh's criterion*, $A = \frac{1000000}{1.22b\lambda}$, where b is the f-number and λ the wavelength in nanometers.

For example, if the wavelength of the system's illumination is 546 nanometers and the f-number of the lens being used is 4.0, the maximum axial resolving power of the lens would be 375 cycles/mm. As suggested by this relationship, many fine modern lenses have their highest resolving power at full aperture, but the image contrast is generally more satisfactory if the aperture is closed one or two steps from full aperture.

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* Warren J. Smith, *Modern Optical Engineering - Design of Optical Systems*, McGraw-Hill, Inc., 1966.