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PEOPLE'S REPUBLIC OF CHINA**

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Optical transfer function -- Part 2: Directives of measurement

光学传递函数 第2部分：测量导则

(English Translation)

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1 Scope

This Part of GB/T 4315 specifies general guidelines for the construction and use of the optical transfer function (OTF) measuring equipment of the imaging system.

This Part describes various important factors that may affect OTF measurement.

At the same time, it specifies the general rules for measuring equipment performance requirements and environmental controls.

This Part specifies the points that must be paid attention to to ensure accurate measurement, as well as the correction factors for the measured data.

The optical transfer function measuring equipment described in this Part is limited to analyzing the radiation distribution on the image plane of the optical imaging system under test. This equipment does not include interferometer- based instruments.

2 Normative references

The following documents contain provisions which, through reference in this

Part of GB/T 4315, constitute provisions of this Part. For the dated references, their subsequent amendments (excluding corrections) or revisions do not apply to this Part. However, the parties who enter into agreement based on this Part are encouraged to investigate whether the latest editions of these documents are applicable. For undated reference documents, the latest editions apply to this Part.

GB/T 4315.1 Optical transfer function - Part 1: Terminology and symbol (GB/T 4315.1-2009,

ISO 9334:2007, Optical transfer function - Definitions and mathematical relations, MOD)

JB/T 5521 Optical transfer function for microscope

JB/T 5522 Optical transfer function application - 35 mm camera interchangeable lens

JB/T 6784 Optical transfer function - Application - Lenses for office copiers

The temperature and humidity must be kept within the specified tolerances. And they shall be recorded. In order to avoid the influence of air disturbance and stratification on the measurement, a protective cover can be used.

4.2.2 Vibration

In order to reduce vibration, it is recommended to use a vibration-isolation base.

For a given measurement accuracy, the degree of vibration isolation depends on the characteristics of the vibration, the measurement method, and the spatial frequency range. If the measurement method is based on the measurement of line spread function, the displacement of the image on the image analyzer caused by vibration shall not exceed 1/20 of the maximum intensity half-width of the test slit image.

4.2.3 Electromagnetic interference

The change of power supply, the influence of external electromagnetic field, and the influence of surrounding light intensity must be reduced to not affect the OTF measurement.

4.3.1 Optical table

Any measuring equipment must consist of a sturdy optical bench or optical table.

It is used to place test target unit, test sample, image analyzer, and other auxiliary units.

According to the different conditions of the imaging system under test, different requirements shall be put forward for the linearity of each adjustment link and the parallelism of slideways. The change in MTF measurement, caused by deviation from any of the above requirements, shall not be more than 1/3 of the allowable or specified measurement accuracy.

4.3.2 Defocusing tolerance

The defocusing effect, generated from the misalignment of the optical bench, causes the measurement error of the MTF. The defocus and degree of change of MTF are related to spatial frequency and F-number. Table 1 shows the defocusing amount $\pm\Delta Z$ for the ± 0.05 MTF change caused by a diffraction-limited lens of incoherent illumination with a circular pupil. The wavelength of the light is 500 nm.

4.4.2 Test target unit

The test target unit consists of a test target and a radiation source.

4.4.2.1 Test target

According to the characteristics of the test sample, circular apertures, slits, edges, gratings, and self-luminous test targets with known geometric shapes can usually be used. The spatial frequency spectrum of the test target used to measure the OTF must be known. The geometry shall be very accurate. For example, in the case of using slits, the width of the slits shall be consistent throughout the effective length. The parallelism tolerance of the two edges of the slit is 2% of its average width. The straightness of the edges shall not exceed 10% of the average width. While specifying the tolerance of the slit itself, it is also necessary to specify the transmittance around the slit. According to the required measurement accuracy, within the specified spectral range, the ratio

OF the total radiant flux emitted by the open part of the slit TO the total radiant flux emitted by the surrounding dark part must be greater than 1000.

In order to be able to perform OTF measurements in different orientations, the orientation of the non-rotationally symmetrical test target must be changeable.

Some imaging systems need to rotate the image of the test target. So in order to turn the image of the test target or the analysis element to the proper orientation required for analysis, a precise adjustment mechanism is required.

In order to be able to check and meet the conditions of the isoplanatic region, the size of the test target must be adjustable.

4.4.2.2 Radiation source

During the measurement, the spectral emission of the light source and the radiation distribution in the whole space must be kept constant. Light pulsation shall be eliminated.

The test target must be irradiated or radiate uniformly, at least in the scanning direction.

Filters can be used to obtain the required spectral distribution. It is necessary to prevent the test target from being damaged by overheating. Radiating grids, diffusers, finite apertures, or other elements can be used to obtain the required radiation angle distribution.

Full attention must be paid to the incoherence of the radiation emitted by the test target. When the numerical aperture of the condenser on the test target side is twice the numerical aperture of the test sample, sufficient incoherence can be obtained. In addition, between the light source and the test target, a of the detector from significantly affecting the measurement accuracy.

The radiation transmitted to the detector from the dark part around the analysis element

must be kept extremely small. According to the required measurement accuracy, within the specified spectral region, the energy transmitted by the light-transmitting part must exceed 1000 times the energy transmitted by the dark surrounding part.

If the spectrum of the image is analyzed by an analog electric filter, then the bandwidth of the filter must be narrow enough to be able to distinguish the spatial frequency of the OTF. If multiple filters are used to decompose the frequency spectrum, the gain and phase in the passband of each filter must be compensated or corrected.

4.4.5 Auxiliary imaging system

The auxiliary imaging system includes a collimator, a microscope objective lens, and other auxiliary components. If a collimator lens is used, in the effective spectral region, its wavefront aberration must be small enough so that it can be ignored compared with the measured sample, which can be 1/10 of the wavefront aberration of the measured sample. The collimator is not allowed to limit the entrance and exit apertures of the test sample.

When using a microscope objective lens to magnify the image of the test target, its numerical aperture shall be large enough, to avoid vignetting during on-axis and off-axis measurement. And its aberration shall be small compared with the test sample.

When using incoherently-coupled auxiliary imaging systems, their OTF must be known, so that their influence on the measured OTF can be corrected by the product rule. Since there are auxiliary optical elements, such as windows or gratitudes, between the object field and the image field of the test sample, these elements must be simulated in the measuring equipment.

It shall be ensured that the spectral characteristics of all auxiliary imaging elements are compatible with the spectral characteristics required for the measurement.

5.1 General

Before the actual measurement, the measurement conditions, which specify a specific imaging state of the test sample, must be adjusted to their specified values. And the adjusted accuracy shall be recorded. At the same time, various

If a lens or a mirror system must be tested under infinite conjugate, the measurement layout shall be in accordance with 4.4.1.

If the test sample is a photoelectric imaging element (such as an image intensifier), the imaging scale must be determined by an appropriate method.

The imaging scale of any auxiliary optical system in the measurement system must be adjusted independently of each other. If the test sample is composed of several optical elements or of optical elements and optoelectronic elements, the imaging scale of each individual element must be individually adjustable.