INTERNATIONAL STANDARD

ISO 11421

First edition
1997-09-15

Optics and optical instruments — Accuracy of optical transfer function (OTF) measurement

Optique et instruments d'optique — Exactitude du mesurage de la fonction de transfert optique (OTF)

Reference number
ISO 11421:1997(E)

Contents

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet central@iso.ch
X.400 c=ch; a=400net; p=iso; o=isocs; s=central

Printed in Switzerland

Foreword

ISO (the International Organization for Standardization) is a world-wide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75% of the member bodies casting a vote.

International Standard ISO 11421 was prepared by Technical Committee ISO/TC 172, *Optics and optical instruments*, Subcommittee SC 1 *Fundamental standards*.

Annex A forms an integral part of this International Standard.

Annexes B, C and D are for information only.

Introduction

The optical transfer function (OTF) is one of the main criteria used for objectively evaluating the image-forming capability of optical, electro-optical and photographic systems.

The terms used in the measurement of OTF are defined in ISO 9334, whilst ISO 9335 covers the actual principles and procedures of measurement. A further International Standard, ISO 9336, deals with specific applications in various optical and electro-optical fields and is in several parts, each dealing with a particular application.

Although ISO 9335 lists the main factors which influence the accuracy of OTF measurement and describes procedures which are aimed at achieving accurate and repeatable results, it does not cover in detail the techniques and procedures for evaluating the accuracy of OTF measuring equipment and for estimating the uncertainty in measurements made on specific imaging systems.

The present International Standard lists the main sources of inaccuracy in OTF measuring equipment and provides guidance on how these can be assessed and how the results of these assessments can be used in estimating the error band in any measurement of OTF. One of the aims in preparing this International Standard is to encourage the setting of more realistic uncertainty levels for the results of OTF measurements. Another is to encourage the use of methods of expressing the accuracy of OTF test equipment which recognize the fact that the accuracy of a particular measurement is a function of both the equipment and the test piece.

Optics and optical instruments — Accuracy of optical transfer function (OTF) measurement

1 SCOPE

This International Standard gives general guidance on evaluating the sources of error in optical transfer function (OTF) equipment and in using this information to estimate errors in a measurement of OTF. It also gives guidance on assessing and specifying a general accuracy value for a specific measuring equipment, as well as recommending methods of routine assessment.

The main body of this International Standard deals exclusively with the modulation transfer function (MTF) part of the OTF. The phase transfer function (PTF) is dealt with relatively briefly in annex A.

2 NORMATIVE REFERENCE

The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 9334:1995 *Optics and optical instruments - Optical transfer function - Definitions and mathematical relationships*

3 DEFINITIONS AND SYMBOLS

3.1 DEFINITIONS

For the purposes of this International Standard, the following definitions apply.

3.1.1 standard lens

Single- or multi-element lens which has been constructed with a level of accuracy which is sufficient to ensure that for precisely specified conditions of measurement the MTF will be equal to that predicted from theoretical calculations to an accuracy of better than 0,05 (MTF units).

NOTE - In order to achieve this accuracy, standard lenses are usually of simple construction and therefore of limited performance. An example of a widely used lens is the 50 mm focal length plano-convex lens described in reference [3]. This and several other standard test lenses (including afocal systems and lenses operating in the infrared wavelength bands) are available commercially.

3.1.2 audit lens

Single- or multi-element lens of stable construction whose accuracy of construction is not sufficient to enable the MTF to be predicted by calculation from design data (usually as a result of the complexity of the lens), but whose "accepted" values for the MTF under precisely defined measuring conditions have been obtained by measurements done by a reputable authority (preferably a national standards laboratory, if such a service is available).

3.2 SYMBOLS

Symbol	Meaning	Unit
h	object height	mm, mrad, degree
h'	image height	mm, mrad, degree
$\Delta h'$	error in image height	mm, mrad, degree
l	object conjugate	mm
l'	image conjugate	mm
$\Delta l'$	error in image distance	mm
Δz	departures from straightness of object slide	mm
$\Delta z'$	departures from straightness of image slide	mm
Δa	angular departure of object slide from perpendicularity to reference axis	rad
$\Delta a'$	angular departure of image slide from perpendicularity to reference axis	rad
ΔZ	total departure from ideal object plane	mm
$\Delta Z'$	total departure from ideal image plane	mm
M	magnification	dimensionless
r	spatial frequency	mm^{-1}, $mrad^{-1}$, $degree^{-1}$
Δr	error in spatial frequency	mm^{-1}, $mrad^{-1}$, $degree^{-1}$
$m(r,h)$	rate of change of MTF with object focus (for image intensifier and similar systems)	mm^{-1}
$m'(r,h')$ or $m'(r,\omega)$	rate of change of MTF with image focus	mm^{-1}
$p'(r,h')$ or $p'(r,\omega)$	rate of change of MTF with image height	mm^{-1}, $mrad^{-1}$, $degree^{-1}$
$q'(r,h')$	rate of change of MTF with image distance	mm^{-1}
ω	field angle	mrad, degree
$\Delta\omega$	error in field angle	mrad, degree
f	focal length	mm
ψ	azimuth angle	degree
$\Delta\psi$	error in azimuth angle between slits	degree
R	(test lens focal length)/(collimator focal length) or (decollimator focal length)/(collimator focal length)	dimensionless
g'	width of slit referred to image plane	mm
L'	length of shorter slit referred to image plane	mm
MTF_c	MTF of relay lens	dimensionless
r_o	spatial frequency for zero field angle	mm^{-1}, $mrad^{-1}$, $degree^{-1}$
$n'(r, h')$	rate of change of MTF with spatial frequency	mm, mrad, degree
$\Delta MTF(r)$	error in MTF	dimensionless
$\Delta MTF_c(r)$	MTF error of the relay lens	dimensionless
ΔMTF_{rl}	MTF errors resulting from aberrations of relay lens error	dimensionless
Δl	error in setting collimator focus	mm
$\Delta MTF(random)$	total error in MTF random sources	dimensionless
ΔMTF (systematic)	total error in MTF systematic sources	dimensionless
$\Delta MTF(total)$	total error in MTF from all sources	dimensionless
$\Delta MTF(rand)_n$	error in MTF from nth source of random error	dimensionless
$\Delta MTF(syst)_n$	error in MTF from nth source of systematic errors	dimensionless

NOTE - The notation $m(r,h)$, $m'(r,h')$, $p'(r,h')$ etc. denotes that these parameters are functions of both spatial frequency r and image height h' or h (i.e. the value of the parameter will be different for different frequencies and different image heights).