TRIOPTICS

TRIOPTICS GMBH · OPTISCHE INSTRUMENTE

OPTOMATIC

Fully Automatic Optical Bench

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DESCRIPTION

OPTOMATIC is the first fully automated optical test instrument featuring rapid, ultra-accurate and objective performance characterization of a wide variety of optical components and lens systems.

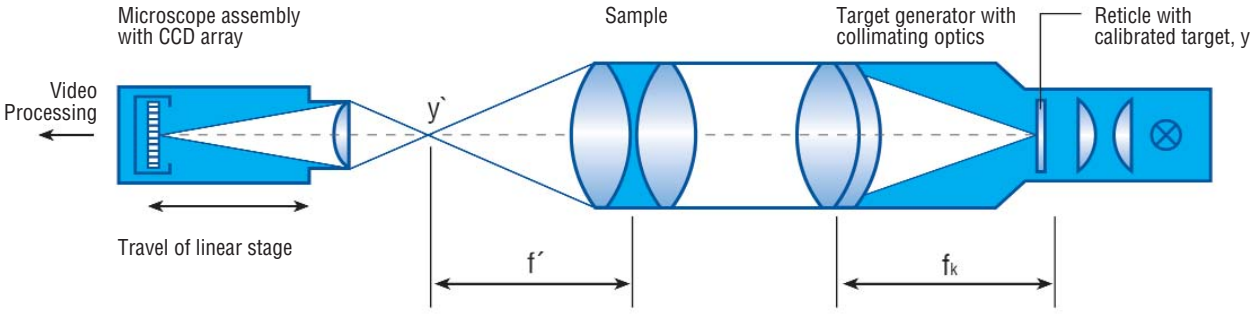
Responding to customer requirements for increased speed and accuracy in measurement of optical parameters, OPTOMATIC provides dramatically increased overall accuracy and software control of the complete measuring procedure.

Almost all optical parameters of lenses with diameters from 0.5mm to 200mm can be automatically measured: effective focal length, back focal length, flange focal distance, centration errors in transmission and reflection, angle and power of wedges, MTF, etc.
The operation is simple: once the test parameters for one lens are defined, these can be saved to a set up file and used for further measurements. The measured data are accurate and repeatable.
The software package designed to work under all Windows operating systems provides menu-driven operator guidance and advanced data management.

MEASUREMENT PRINCIPLE

Effective Focal Length

A highly corrected collimator projects the image of a special target to infinity. The parallel ray bundles enter the lens under test parallel to the optical axis and emerge from the lens as a convergent beam intersecting in the focal plane.
The target image formed in the focal plane of the lens under test is collected by a microscope assembly and focussed on the high resolution CCD array accurately located in the focal plane of the microscope.
The microscope assembly with the CCD array is mounted on a motorised linear stage driven by a stepper motor.
A computer-controlled Auto-Focus System allows for automated and accurate finding of the focal plane of the lens under test. Simultaneously the size of the projected collimator target is precisely determined and thus the effective focal length (EFL) of the lens under test.



Optomatic: Optical Diagram for measuring focal length

$$f' = -f_k \frac{y'}{y}$$

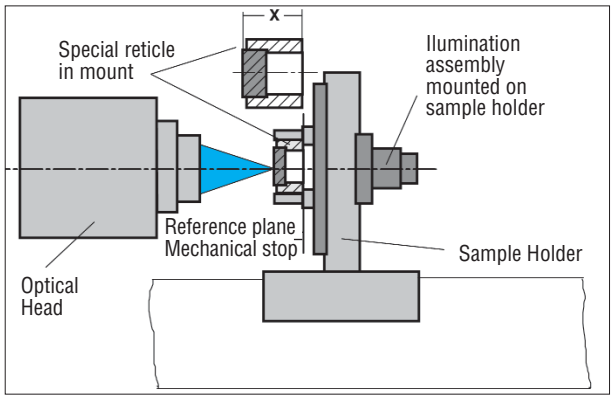
All aspects of the data acquisition starting with the powerful Auto-Focus System, scanning of the CCD array, self-calibrating and displaying the measured data are under software control and fully automated. The set up and measurement parameters for one lens type can be stored to a file and loaded again when necessary. This reduces considerably the set up time, so that an operator measuring a new batch of lenses starts producing reliable measuring data in 5-10 seconds.

Flange Focal Length

The Flange Focal Length (FFL) or the Flange Focal Distance (FFD) is the distance between the locating surface of the lens mount and the image plane. This parameter is especially important for the photographic lenses as distance between the locating surface of the lens mount and the film (image) plane.

The self-centering sample holder of the OPTOMATIC has three stable pins with a diameter step providing a precise mechanical stop for the lens mounts. The pins are made of hardened and grinded steel to ensure the necessary stability. The locating surface of the lens mount must be in ferm contact with the pin step as mecanical stop. To determine the position of the mechanical stop and thus of the locating surface of the lens mount, a special reticle in mount is positioned into the sample holder. The optical head of the OPTOMATIC will automatically focus and accurately ascertain the position of the the illuminated special reticle.

Since the thickness of the reticle mount (dimension X) is accurately measured before, the position of the mechanical stop is easily calculated. After this, the serial measurement of FFL can start: the image plane of the sample is measured and the FFL is automatically calculated and displayed.

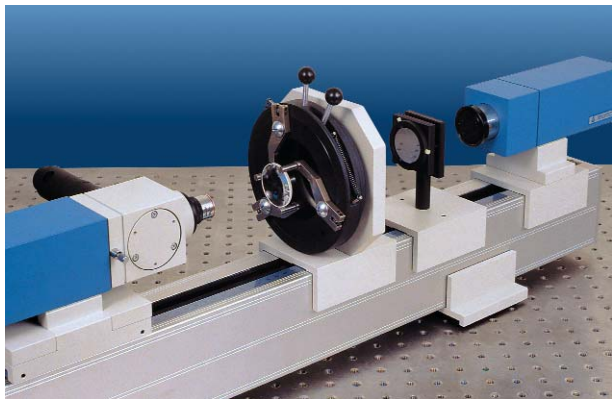


Set up for FFL-Measurement

Besides the absolute measurement of FFL a relative measurement is also possible. In this case a master lens is measured as a reference. The data are stored and then compared with the results of the serial measurement.

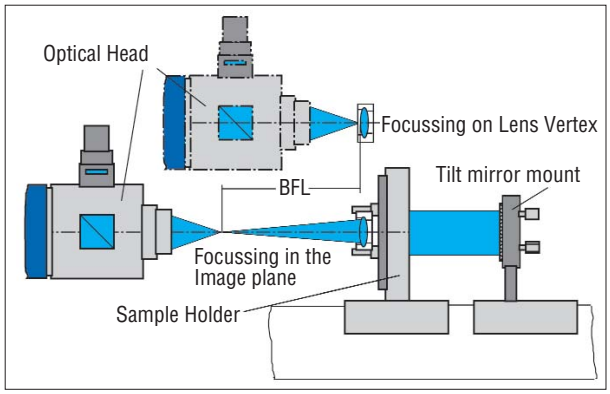
Back Focal Length

The Back Focal Length (BFL) is the distance from the vertex of the lens to the second focal point. The optical head for BFL-measurement is



BFL-Measurement with OPTOMATIC

designed as a special autocollimating device incorporating a special target, beamsplitter and imaging optics. A fiber optic illumination with condenser optics illuminates the target. The projected image of the target is automatically focussed on the vertex and in a second step in the focal plane of the lens under test.

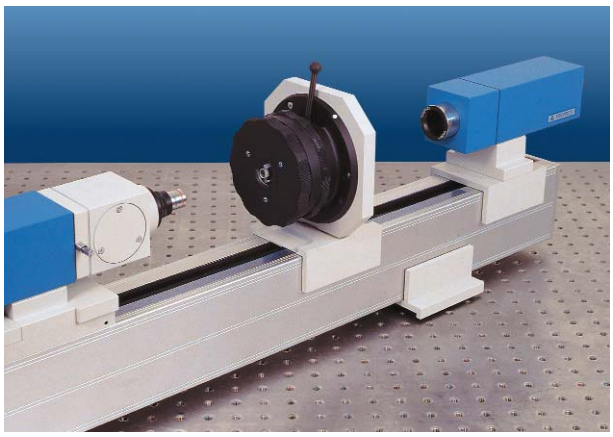


Set up for BFL-Measurement

Each position of the two focussing planes (lens vertex and focal plane of the lens) is accurately measured. The distance between the two focussing positions is the BFL.
The collimated beam for the focal plane measurement is provided either by a tilt mirror located behind the lens under test or by the collimator included in the optical set up of the OPTOMATIC. When using the standard collimator, a second illumination unit with a shutter is needed. Each illumination unit is active when the corresponding focussing (on to the vertex or in focal point) is accomplished.

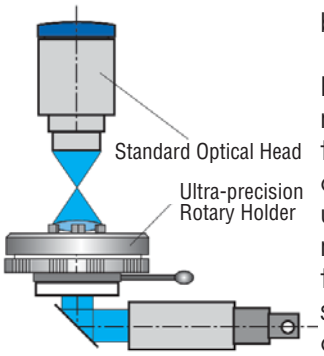
Centration Errors

The normal procedure to identify the centering errors is to rotate the sample in transmitted or



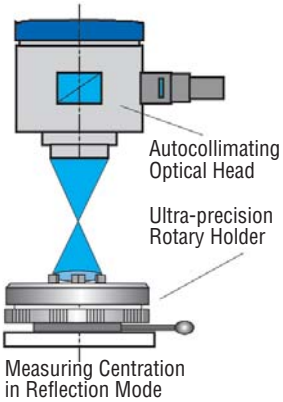
Measurement of centering errors in Transmission Mode with OPTOMATIC

reflected light. For the measurement in Transmission the standard optical head and the collimator is needed. The parallel beam emerging from the collimator is focussed in the focal plane of the sample to be measured.

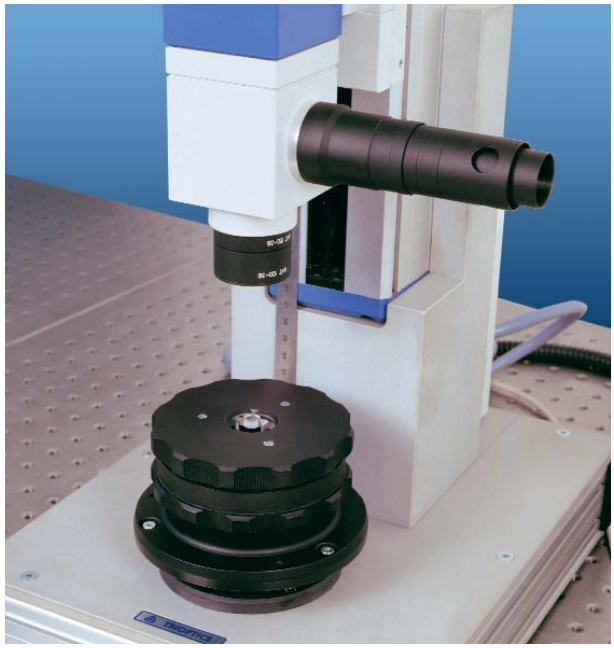


Measuring Centration in Transmission Mode

For centration measurement in Reflection, the autocollimating optical head (same used for BFL measurement) is mounted on the measuring unit instead of the standard optical head. The Autocollimating Optical Head is focussing in the center of curvature of the lens.
When rotating the lens under test - if centering errors are present - the image of the target formed on the CCD will move correspondingly. The size of the displacement is proportional with the centering error. In order to be rotated, the lens is positioned in a precision self-centering holder featuring four indexing stops at 90°and rotation over 360°.
During the holder rotation, measurement data are taken in any of the indexing stop positions. A special alghoritm allows for automatic calculation and display of the centering errors. The result of the measurement can be given as radius of the run out circle (in µm) with an accuracy of +/-0.5µm or as tilt of the surface or of the lens axis (in arcsec).



Measuring Centration in Reflection Mode



Measurement of centering errors in Reflection Mode with OPTOMATIC MICRO

MTF-Measurement

The set up for MTF measurement includes the standard optical head equiped with a high resolution relay lens. A narrow bandwidth interference filter is mounted into the illumination unit of the collimator.
Two basic measurement procedures are available: MTF-calculation based on the evaluation of the image of an edge target and a second procedure based on the analysis of the image of a slit target.
The edge image evaluation can be carried out with the standard collimator target i.e. a double slit, which is primarily used for EFL measurement. The advantage is the simplicity of the equipment and the simultaneous measurement of EFL and MTF.

Centration and MTF Measurement with OPTOMATIC MICRO

However, due to the measuring principle the accuracy is limited. This procedure is very cost effective and recommended for production quantities when relative measurements in comparison with a master are acceptable.
The slit evaluation requires a special slit target to be mounted in the collimator. The MTF calculated from the slit evaluation is more accurate, however, it requires expensive hardware. The OPTOMATIC system includes a special illumination unit with an electronic shutter. The electronic shutter is software controlled and opens alternatively the double slit for EFL measurement or the narrow slit for MTF-measurement.

Angle and Power of Wedges

The unique versatility of OPTOMATIC is underlined by the capability to measure not only parameters of lens systems but angles and power of wedges, windows, plane-parallel plates.A limited types of prisms (pentaprisms, 180°-prisms) can be measured as well.

The set up includes an ancillary lens positioned in the sample holder. A reference measurement of this lens is taken. The position of the focal plane of the ancillary lens and the position of the target image on the CCD is accurately determined and saved. Placing a wedge between the collimator and the ancillary lens causes a displacement of the target image on the linear CCD array. The displacement is measured and the deviation angle calculated and displayed with a resolution better than 1 arcsec. over a range of 1°-1.5°.

Aberrations of the transmitted wave front through the wedge or window under test will result in modifications of the EFL of the ancillary lens. Thus the power of wedges and prisms can be simultaneously determined with an accuracy better 0.002 dpt.

WIDESPREAD APPLICATIONS

OPTOMATIC has been design to measure a wide range of optical parameters related to almost all typical optical components and lens systems.
Virtually any existing lens systems ranging from high performance photographic lenses and microscope objectives to endoscope, ophtalmic lenses, singlets and doublets or molded plastic lenses can be accurately measured.
Further applications include the measurement of:

- high performance lenses
- cinematic and TV lenses
- enlarger and projection lenses
- copier and scanner lenses
- microlenses for CD and DVD applications

The capability to measure simultaneously the EFL and centration errors makes the OPTOMATIC an ideal measuring station for industrial and medical endoscope lenses.
A special application is the measurement of Intra Ocular Lenses. A dedicated version of OPTOMATIC MICRO measures fast and accurately the power, the MTF and the astigmatism of IOL's according to ISO 11979.

Not only high performance lenses can be accurately measured. Lenses with poor image quality (ex.:plastic lenses for proximity switches, aspheric molded lenses, molded condenser optics,etc) which can not be checked with visual instruments are measured fast and reliable with OPTOMATIC.

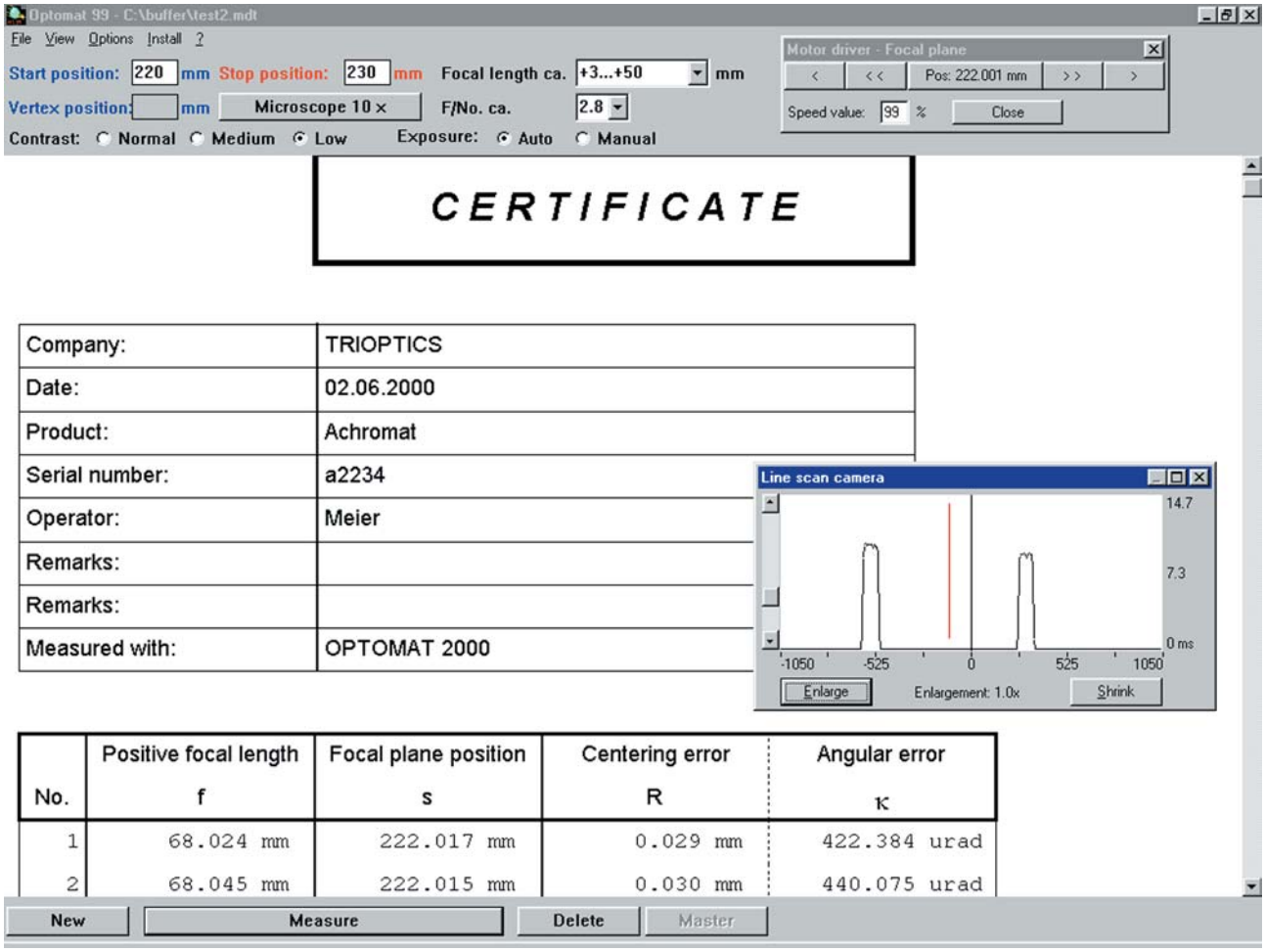
Since OPTOMATIC has a modular design, specific custom applications can be easily realised by adding optional modules. In this way is possible to meet different customer requirements as testing of lenses with rectangular shape or to extend the measurement capabilities in the NIR spectral range.

SOFTWARE

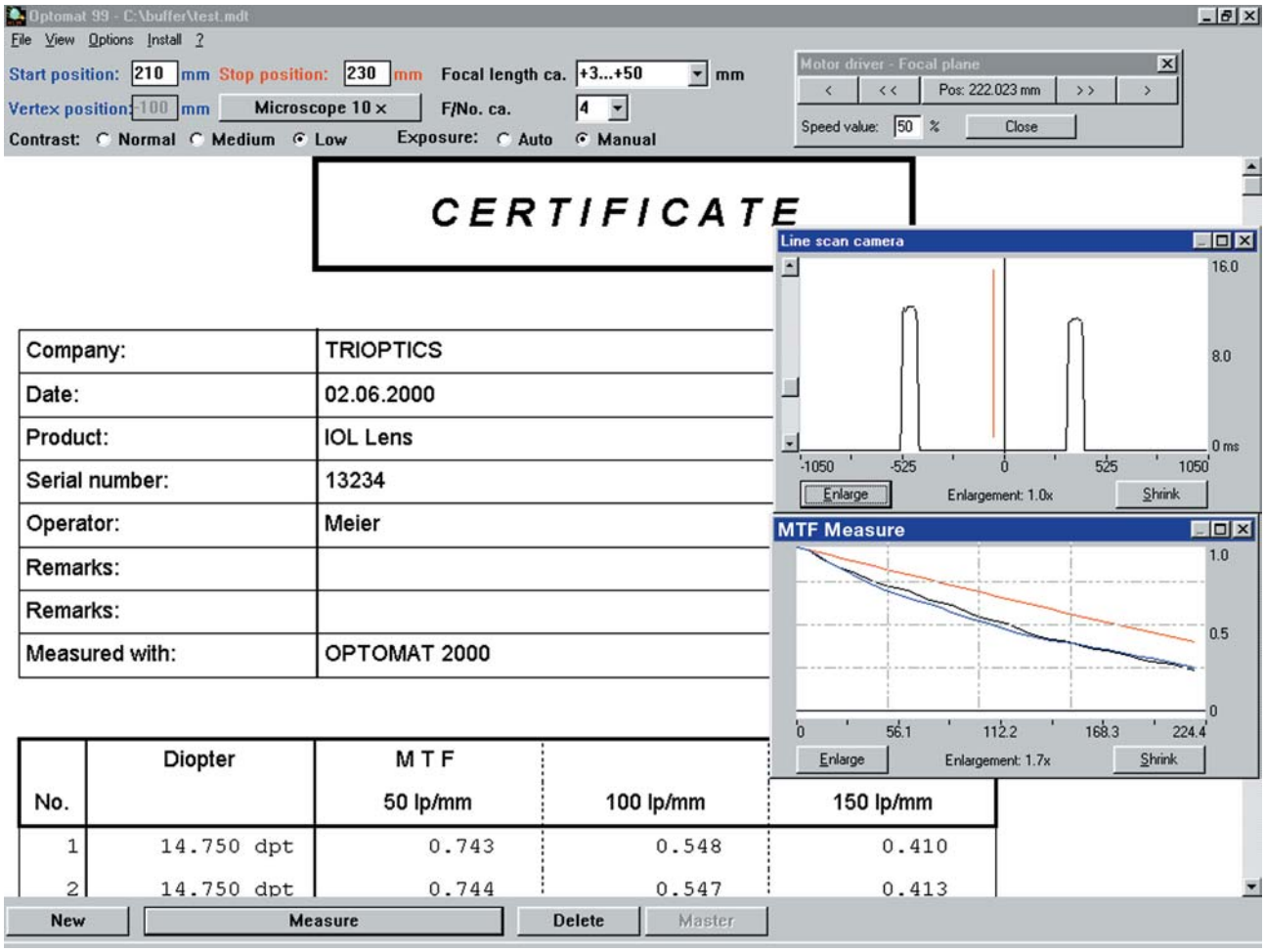
The advanced software is designed to work under Windows operating systems and fulfils the need of the optical shop for easy, intuitive operation and features a large number of options to accomodate a large variety of specific requirements:

- selection of different measurement routines for samples with different imaging quality. In this way even samples with lowest imaging performance can be easily tested.
- selection of rapid or accurate measurement routines offers highest operation flexibility
- to increase the efficiency in production process, the software has capabilities to save the optimized process parameter for future use.
- for production use the main functions can be transferred to a dedicated keyboard so that even unskilled operators can provide reliable measurement results.

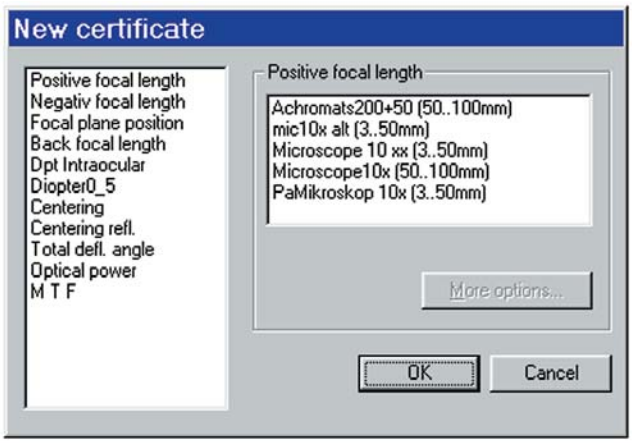
Since all the software modules used for measurement of different optical parameters are integrated into a main software program, the time necessary to change to another application is minimal. The measurement certificate includes besides the measurement data a statistical evaluation of the results.



Measuring EFL and Centration Errors



Measuring diopter power and MTF of IOL



INSTRUMENT SELECTION

The OPTOMATIC equipment line includes:

• OPTOMATIC - a versatile, horizontally set up instrument which is recommended when a large variety of samples should be tested and when flexibility and quickly changing measurement tasks are required.

OPTOMATIC is also the prefered instrument for measurement of longer focal length. However, due to the horizontal set-up the OPTOMATIC is less suited for centration measurement.

• OPTOMATIC MICRO - is vertically set-up and dedicated to the measurement of small lenses and shorter focal lengths.

OPTOMATIC MICRO

OPTOMATIC MICRO is recommended for testing of mass production quantities of IOL's or endoscopes lenses and for applications where centration measurement is main task (due to the vertical set up).

• OPTOMATIC 2000 - is vertically set up and specially designed for measurement of lenses of large diameter (up to 200 mm). Due to the

OPTOMATIC 2000

large aperture collimator with longer focal length OPTOMATIC 2000 is also the right choice for MTF measurement. All the basic models can be supplied in standard or customized versions to fulfill special requirements.

OPTOMATIC

ORDERING INFORMATION

Description	CODE		
BASIC INSTRUMENT	**OPTOMATIC**	**OPTOMATIC MICRO**	**OPTOMATIC 2000**
• Stand • Linear stage, stepper motor, stepper motor controller • Measuring head with high resolution linear CCD-array • High performance imaging head lenses • Image processing card for IBM-compatible PC • Target generator with collimating optics • Mount with self-centering holder. • Fiber optic illumination with long life cold light source 150W • Software for positive focal length (EFL+) • Aluminium case for storage and transportation	2-100-00	2-200-00	2-300-00
• Extension for measuring **negative focal length (EFL-)**	2-100-01	2-200-01	2-300-01
• Extension of measuring range for **positive / negative focal length**	2-100-12	2-200-12	
• Option for measurement of **back focal length(BFL+/BFL-)**	2-100-08	2-200-08	2-300-08
• Option for measuring **flange focal length** (FFL+/FFL-)	2-100-11	2-200-11	2-300-11
• Option for measurement of **centering errors in transmission**	2-100-05	2-200-05	2-300-05
• Option for measurement of **centering errors in reflection**	2-100-07	2-200-07	2-300-07
• Option for **angle measurement and power** of wedges, plan-paralell plates and 180°-prisms	2-100-03	2-200-03	2-300-03
• Option for **MTF-Measurement** on-axis in tangential plane. Edge evaluation	2- 100-06	2-200-06	2-300-06
• Option for **MTF-Measurement** on-axis in tangential plane. Special reticle pattern featuring a single slit/double slit. Electronic shutter. Slit evaluation	2-100-16	2-200-16	2-300-16

TECHNICAL SPECIFICATION

Considerations about accuracy

OPTOMATIC has been designed to cover a large measuring range and in this way to become a universal measuring tool. To enable this without sacrificing the accuracy, OPTOMATIC uses selected hardware components like high resolution CCD array, precision microscope objective or highly corrected achromats in order to accomodate to different samples and different optical parameters.
Moreover the software automatically adapts to different requirements when measuring under extreme conditions as too small or very long focal lengths, uncorrected lenses (poor image quality), poor contrast, etc.

The software also increases more than 20 times the resolution of the CCD, so that the measurement of the target image is made with a resolution smaller than 1µm.

The unavoidable inaccuracies of the system components are eliminated through individual calibration using high precision master lens certified by different national standard institutes. This sofisticated and costly calibration procedure assures the highest absolute accuracy of each instrument. The calibration values are stored in a special file and automatically used to correct the raw measurement data. The displayed measurement results are always corrected by means of calibration values specific to each instrument. The sofisticated calibration procedure is paying off in superior performance as well in increased repeatability.

On request Master lens calibrated by national standard institutes are supplied to customers for in-house checking of the calibration of the instrument or to be used when certification according ISO 9000 is required.

Features

- Fully automatic and computer controlled measuring process
- Menu driven software
- Calibration directly traceable to international standards
- Extremely short measurement time
- Advanced software running under all WINDOWS® operation systems

Technical Data

Effective Focal Length (EFL+/EFL-)	**OPTOMATIC**	**OPTOMATIC MICRO**	**OPTOMATIC 2000**
Standard measuring range:	+5...+750 mm - 5...- 550 mm	+1...+150 mm - 2...- 150 mm	+5...+1000 mm - 5...- 1000 mm
Extension of measuring range	+750...+1200 mm - 550...- 1200 mm	+150...+500 mm - 150...- 500 mm	
Lens Diameter	5 - 75 (100) mm	1 - 35 (75) mm	5 - 75 (200) mm
Repeatability	0.03...0.2%		
Measurement Accuracy	5...25 mm: 0.1%... 0.3% 25...500 mm: 0.03%...0.1% 500...800 mm: 0.05%...0.1% 800...1200 mm: 0.1%... 0.3%		
Measurement Time	First measurement: 5 - 8 sec Next measurement: 3 - 5 sec		

Flange Focal Length (FFL+/FFL-)			
Measuring range: (Extension on request)	+5...+500 mm - 5...- 500 mm	+5...+150 mm - 5...- 150 mm	+5...+500 mm - 5...- 500 mm
Lens Diameter	5 - 75 (100) mm	1 - 35 (75) mm	5 - 75 (200) mm
Repeatability	0.03...0.1%		
Measurement Accuracy	0.05%...0,2%		
Measurement Time	First measurement: 5 - 8 sec Next measurement: 3 - 5 sec		

Back Focal Length (BFL+/BFL-)	**OPTOMATIC**	**OPTOMATIC MICRO**	**OPTOMATIC 2000**
Measuring range: (Extension on request)	+5...+500 mm - 5...- 500 mm	+5...+150 mm - 5...- 150 mm	+5…+450 mm - 5…- 450 mm
Repeatability	0.1…0.3%		
Accuracy	0.2%…0,5%		
Measurement Time	10 - 25 sec		

Centering Errors in Transmission and Reflection			
Measurement Range (Extension on request)	+5...+500 mm - 5...- 500 mm	+5...+150 mm - 5...- 150 mm	+5…+450 mm - 5…- 450 mm
Repeatability	±0,5 µm or ±2 arcsec		
Accuracy	±1 µm or ±5 arcsec		
Measurement Time	5-15 Sec		

MTF-Measurement on-axis in tangential plane			
Measurement Range • absolute measurement: • relative measurement:	5...75 mm (EFL) 5-500 mm (EFL)	1...75 mm (EFL) 5-250 mm (EFL)	5...150 mm (EFL) 5-500 mm (EFL)
Test mode	automatic. on-axis		
Spatial frequency	0-150 lp/mm		
MTF-Measurement / Edge evaluation • Repeatability • Accuracy	 2 % 3 %		
MTF-Measurement / slit evaluation • Repeatability • Accuracy	 1 % 2 %		

Angle and power of wedges and plan-paralell plates	
Measurement Range	approx. 1°
Accuracy	±1 arcsec
Power (optical effect)	± 0.002 dpt
Measurement Time	1 sec

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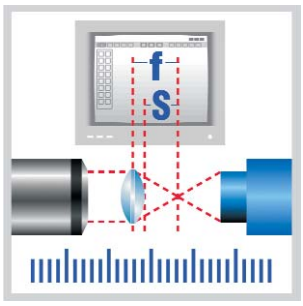
Optical Workstation

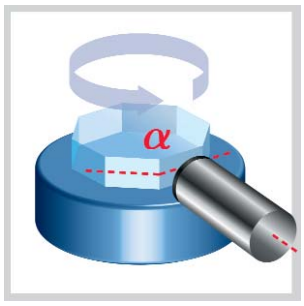
OPTOMATIC is modular and upgradeable to allow for custom configuration as test requirements change. All components of the instrument are individually calibrated. The calibration values are stored in a special file and automatically used to correct the measured values.This sofisticated calibration procedure is paying off in superior product performance and increased repeatability.
Being an automatic turnkey system OPTOMATIC is not operator-dependent. This not only reduce measurement time to a few seconds, but increases accuracy and reliability of the test. The measuring results can can be printed out or saved to file.

Dimensions and Weights

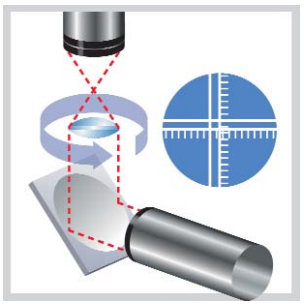
	Length X Width/Depth X Height (mm)	Weight (Kg)
OPTOMATIC	1250 X 200 X 300	20
OPTOMATIC MICRO	280 X 400 X 800	25
OPTOMATIC 2000	350 X 600 X 1150	40

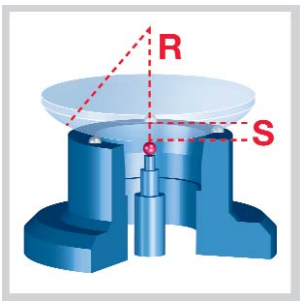


OPTICAL TEST STATIONS



GONIOMETERS


CENTRATION MEASUREMENT



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