

Form Talysurf PGI Optics

Aspherics measurement system



The measurement of aspherical surfaces

The three elements of a surface - dimension, form and texture - are inseparable in the function of a component. Therefore measuring one element without regard to the others can result in misleading or incorrect analysis.

What is dimension?

Dimensions (radius, distance and angle) are used to define the functional shape of a surface. Many objects, such as spherical or aspherical lenses, have engineered shapes.

What is form?

Form is deviation away from the intended nominal shape of the surface, ignoring variations due to texture. All objects have measurable deviations from the intended shape that can be caused by various factors:

- Inaccuracies of the slides or guide-ways in the machine tool
- Inadequate or improper stress relief of the component
- Thermal effects produced during machining

Deviations from intended shape will affect performance and may even render the component unsuitable for its task.

What is texture?

Texture is produced by the action of the cutting tool or polishing process usually resulting in process marks. Although excessive texture can be detrimental to function or cosmetic appearance, excessive processing is time consuming and expensive. Monitoring roughness and waviness helps to assure proper functionality within a cost effective process.

Optics production & inspection

The production of precision aspheric components, such as lenses and mirrors, follows a series of processes to arrive at the designed figure (form) and surface finish. After each stage of manufacturing such as diamond turning, grinding, polishing, etc., value is added to the component, and inspection is necessary.

Essential measurement tool

Launched in 1984, Form Talysurf was the first instrument ever to measure dimension, form and texture on curved surfaces. Ever since, it has been the instrument of choice for aspherics manufacturers.

The calibration procedure

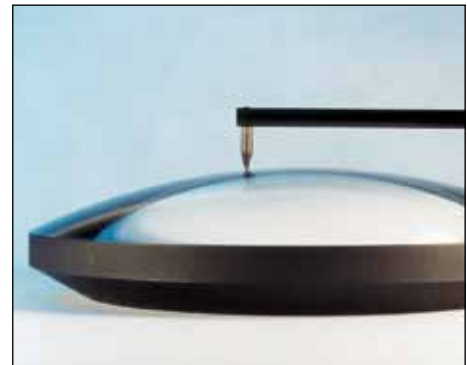
Like most instruments of this type, the Form Talysurf stylus moves in an arcuate manner. A method to linearize data measured in this way was pioneered by Taylor Hobson.

With this method a polynomial is applied to the readings from the gauge. To obtain the coefficients of the polynomial, Form Talysurf instruments are typically calibrated through the measurement of a high precision spherical artifact.

This method of calibration, patented by Taylor Hobson, is a true system calibration. All elements, including stylus tip geometry and gauge linearity, are checked and verified.



vertical gauge range is 12.5mm (expandable to 25 or 38mm) to handle optical components with large SAG or slope dimensions



horizontal measuring range is 200mm for single large components or multiple small ones using "step and repeat" program mode



0.8nm vertical and 0.125um horizontal resolution is essential for checking optical quality surface finish on curved components

Configured for optical precision

The Form Talysurf PGI 1240 is specifically designed for the optics industry and is supplied with everything necessary to measure precision optical components.

Standard equipment is as follows:

- 200mm traverse unit
- 12.5mm range PGI gauge
- Industrial grade PC
- ultra system software
- Aspherics Analysis software
- 60mm gauge arm with standard 2µm conisphere stylus
- 60mm gauge arm with 0.5mm radius ball stylus
- 120mm gauge arm with 0.5mm radius ball stylus
- Calibration artifact (80mm radius) including UKAS Certification
- 450mm motorized column
- Steel instrument support frame
- Pneumatic anti-vibration system
- Environmental enclosure and surround desk
- HP color DeskJet printer
- Computer desk
- Leveling and alignment stage
- Aspheric tilt and rotary stage

Accessories

A wide variety of positioning stages, workholding fixtures, alignment devices and other accessories are available to maximize performance of your Form Talysurf PGI 1240.

3D capability

Software and hardware options are available to provide topographical mapping of aspherical surfaces.

Significance of a straight line

Imperative to the measurement of form is the integrity of the reference to which the measured surface is compared. Form Talysurf PGI 1240 traverse units are designed and manufactured to exacting standards.

In addition, the Form Talysurf PGI 1240 can also be calibrated for horizontal straightness. In this procedure the stylus is traversed over an optical flat. A polynomial is applied to readings from the gauge to create, in effect, a perfectly straight reference datum.

The Form Talysurf traverse unit serves as an absolutely accurate reference for reproduction of the measured surface.

Typical applications:

- Digital Cameras
- Mobile phones
- Projection systems
- Contact lens molds
- Flat panel displays
- Diffractive optics
- IR Sensors
- Lasers

Industries served:

- Consumer electronics
- Optical telecoms
- Semiconductors
- Ophthalmics
- Bio-medical
- Automotive
- Defense
- Aerospace



the 80mm spherical calibration standard checks linearity over the entire gauge range and verifies that stylus tip geometry is correct



an optical flat is used to calibrate horizontal straightness of the 200mm traverse unit which serves as an absolute reference datum



Product features

Form Talysurf PGI 1240 is superior to interferometers for aspherical form measurement

For flat and spherical components, interferometers provide adequate measurements of surface finish and form. However, for the measurement of form on aspherical components, only Taylor Hobson technology gives a solution that meets research, product development and product manufacturing requirements.

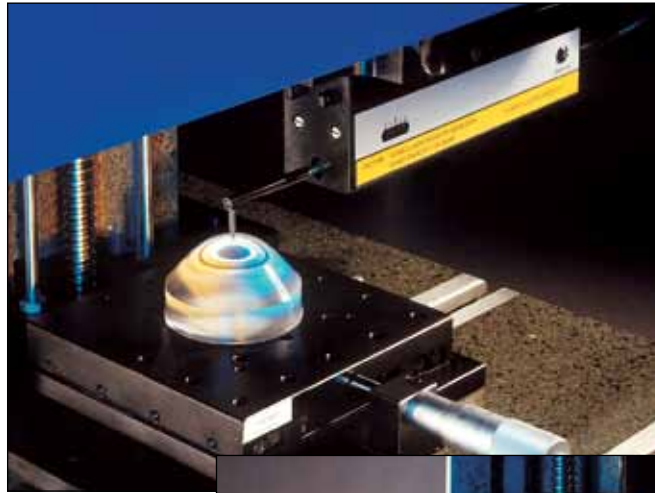
New stylus designs eliminate marking of optical components

The perception of contact metrology as increasing the risk of surface damage is an issue we have been aware of for some time. The high value materials used within the optics industry must be treated with care throughout the manufacturing process. Any scratches or marking which will affect the optical performance of the final component cannot be tolerated.

To address these concerns, Taylor Hobson engineers have developed a new series of stylus tips suitable for virtually all optical materials.

- Small diameter ball stylus for plastic optics and soft metal molds
- Extra small diamond stylus tips for steps and diffractive zones
- New material ball stylus for glass and germanium components

In addition, Taylor Hobson engineers have introduced new stylus arm materials and designs in order to improve the absolute stiffness of the stylus structure. For low and high SAG applications alike, PGI 1240 can deliver hitherto unachievable measurement accuracies.



contact of the stylus with the component can be centralized to the rigid, composite granite column for maximum stiffness of the measuring loop



stiffness of the extended length stylus arms makes possible expansion of the range to 25mm or 38mm (shown with 120mm arm for 25mm gauge range)

Mechanical features offer superior system performance	
Large component capacity	200mm horizontal traverse and 450mm vertical traverse for staging and measuring big production components
Wide gauge range	12.5mm vertical measuring range is ideal for curved surfaces; optional range of 25mm or 38mm also available
Unprecedented resolution	0.8nm gauge resolution effectively measures optical quality surface finish on curved or aspherical surfaces
Small asphere measurement	0.125µm data spacing in X and low traverse speed (0.1mm/s min) optimize the measurement of small aspherics, e.g. DVD lenses
Absolute confidence	Extremely low measurement uncertainty assures confidence in your measurement results and manufacturing process
Small feature measurement	Measurement noise is greatly reduced for checking coatings, steps, defects, etc. and for true verification of diamond turning systems
Increased productivity	Automated component set-up, via optics-specific fixturing and motorized translation stages, speeds the inspection process

Software

ultra System software

Reflecting the Taylor Hobson expertise at putting metrology to work in support of manufacturing, ultra takes charge of all operating functions. System performance is optimized by use of patented software routines and proprietary calibration techniques.

Although it is written using familiar Windows conventions, ultra has the look and feel of a machine tool interface. Commands are direct, purposeful and logic driven.

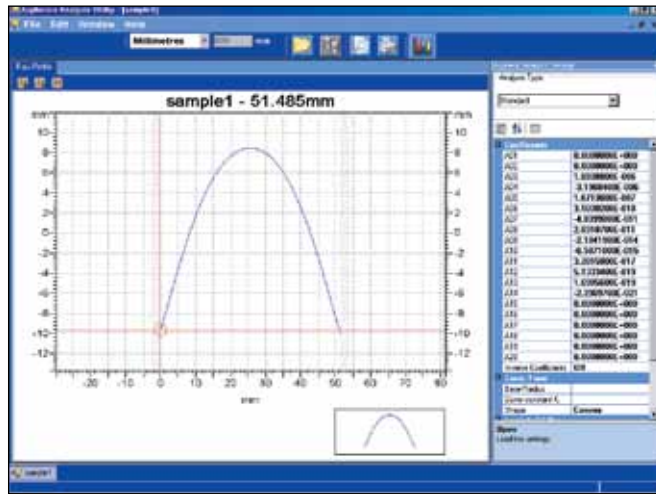
ultra provides everything important to the measurement of surface finish. Calibration history regarding operator, artifact and calibration date is stored automatically. All the standard form and texture parameters are included along with advanced analysis tools developed for specific applications.

Aspherics Analysis software

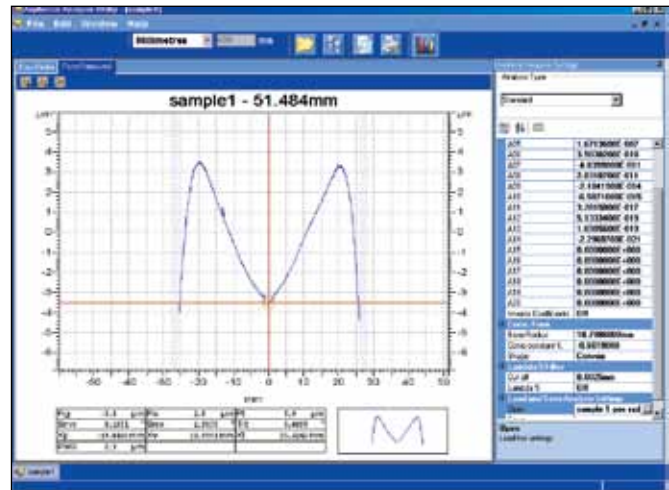
Developed in co-operation with pioneering manufacturers of optics, the Aspherics Analysis software module delivers advanced metrology using terminology and parameters familiar to all optics manufacturers.

A user simply enters the aspheric coefficients, conic constant and base radius. After the sample component has been measured, the form analysis is completed to show divergence of the actual from the nominal profile.

Data collected by the instrument is analysed in conformance to industry standards. Analysis results can then be documented via comprehensive reports. When necessary, corrective feedback to machine tools or polishers is also available.



the raw profile as measured over an aspherical shape



after form analysis has been completed, the modified profile and aspherics parameters are displayed

Software features provide real benefits

Profile comparison	Unique algorithms compute and display divergence of the actual (measured) to the nominal profile
Derived aspheric coefficients*	Calculate coefficients from real components to create drawings or test actual performance using optics design simulation software
SAG tables	Display profile data in a standard optics format; show actual Z and slope errors across the entire component
Astigmatism analysis	Monitor the rotational symmetry of aspherics with an automated measurement and analysis routine
Attributes storage	Save component details, analysis settings and reporting formats for common parts to reduce operator errors and increase productivity

* Optional accessory

Designed for accuracy

Built on a stable foundation

Precision measurement requires a stable environment to assure repeatability and reproducibility of results. Because operation in a clean room is not always practical or convenient, the PGI 1240 is constructed and approved for use in production areas.

Composite granite construction

This unique material has high damping characteristics and large thermal inertia. Both the column and the base are made of composite granite to provide stiffness throughout the measuring loop.

Large base

This massive base isolates the instrument from vibration and offers plenty of room for staging large components. Two tee slots, parallel to each other within 0.3mm (0.01in), are provided for precise mounting of accessories.

Motorized, programmable column

The column has fully motorized vertical movement for programmability and total automation.

- Absolute positional control - servo controlled motor drive and encoder for up/down movements is programmable for batch inspection. Maximum positioning speed is 10mm/second
- "Stop on contact" - automatically advances the stylus to the workpiece and stops on contact centered in the middle of the gauge range

Steel support frame

Welded steel frame for rigid support of granite instrument base and motorized column. Includes set of (4) pneumatic isolation pads to reduce measurement noise in shop environments.

Environmental enclosure

Clear polycarbonate panels set in a rigid aluminium frame completely surround the measuring station to suppress ambient noise, air currents and temperature fluctuations. Sliding panels front and rear of the enclosure provide access for loading components.

Nanometric measuring capability

Our meticulous attention to stability in this measuring instrument delivers an unprecedented combination of accuracy and precision.

With the launch of the Form Talysurf PGI 1240, Taylor Hobson has set a new standard for the measurement of aspheric optics.



motorized column and base shown with steel support frame



detail of pneumatic anti-vibration pad

Specification

Horizontal Performance		Environment
Traverse length - X Max / Min	200mm / 0.1mm (7.9in / 0.004in)	
Measuring / traverse speeds ¹	10mm/s max – 0.1mm/s, 0.25mm/s, 0.5mm/s & 1mm/s (0.39in/s max – 0.004in/s, 0.01in/s, 0.02in/s & 0.04in/s)	
Data sampling interval in X (length = measurement length)	0.125µm [0.1mm to 15mm length] (5µin [0.004in to 0.6in]) 0.25µm [15mm to 30mm length] (10µin [0.60in to 1.2in]) 1µm [30mm to 200mm length] (40µin [1.20in to 7.9in])	
Straightness error (Pt) (X = length) ²	0.11µm	
Vertical Performance		
Nominal measuring range (Z)	12.5mm [60mm stylus arm] (0.39in [2.36in]) 25mm [120mm stylus arm] (0.79in [4.72in]) 38mm [180mm stylus arm] (1.50in [7.10in])	
Resolution (Z) ³	0.8nm @ 12.5mm range (0.03µin @ 0.5in) range	
Range to resolution ratio	15,625,000 : 1	
Stylus arm length, tip size, force	60mm arm, 2µm radius conisphere diamond stylus, 1mN force 120mm arm, 0.5mm radius ball, 20mN force	
Z axis non-linearity, (Z = gauge displacement)	(0.07 + 0.03 Z [mm]) µm (3 + 30 Z [inches]) µin - after calibration ⁴	
Repeatability of Z axis indication ³	Flat surface - typically 0.025µm (1µin) ⁵ or 0.05µm (2µin) ⁶ Curved surface - typically 0.04µm (1.6µin) ⁷	
System Performance ³		
Form Error - Pt ⁸	Typically ≤ 0.1µm (4µin)	
System noise - RMS ⁹	Typically 1nm (0.4µin)	
Radius measurement uncertainty ¹⁰	0.1mm - 80mm (0.004in - 3.15in) = 1% - 0.005% of nominal 80mm - 1000mm (3.15in - 39.4in) = 0.005% - 0.1% of nominal 1000mm - 2000mm (39.4in - 78.7in) = 0.1% of nominal	
Inclination measurement uncertainty	0.5 arc minute uncertainty (+ / - 35° maximum range)	
Dimensions L x D x H (traverse unit)	470 x 130 x 225mm (18.5 x 5.2 x 8.9in)	
Weight (traverse unit)	15Kg (33lbs)	

Storage temperature
5°C to 40°C (41°F to 104°F)

Storage humidity
10% to 80% Relative, non condensing

Operating temperature
18°C to 22°C (64°F to 72°F)

Temperature gradient
< 2°C (< 3.6°F) per hour

Operating humidity
45% to 75% Relative, non condensing

Maximum RMS floor vibration
2.5µm/s (100µin/s) at < 50Hz
5.0µm/s (200µin/s) at > 50Hz

Electrical supply
Supply type
Alternating supply, singlephase with earth (3-wire system)

Instrument and computer voltage
90V - 130V or 200V-260V (switch selectable)

Frequency
47Hz to 63Hz

Supply voltage transients - width
Not less than 2µs, not greater than 20µs

Power consumption
500VA

Safety
EN 61010 - 1 : 2001

EMC
EN 61000 - 6 - 4 : 2001
EN 61000 - 6 - 1 : 2001

Laser classification
Class 1 product to EN 60825-1 (2001)
Continuous wavelength (CW) output < 1mW Max power for the laser
< 50µW Max power for the product

The above technical data is for measurements taken in a metrology laboratory controlled environment: 20°C ± 1°C (68°F ± 1.8°F), draft free, and isolated from low frequency floor borne vibration.

Uncertainties and maximum permissible errors (MPEs) are at 95% confidence in accordance with recommendations in the ISO Guide to the expression of uncertainty in measurement (GUM:1993). All errors are expressed as MPEs.

1 For surface texture measurements, speeds of 0.5mm/s (0.02in/s) and less are recommended.

2 Measured over a glass flat nominally parallel to the traverse datum using a 60mm arm with a diamond stylus (speed = 1mm/s, LS Line analysis, primary filter λs = 2.5mm).

3 Using a 60mm arm with a diamond stylus.

4 Measurements up and down a 35° angled slope over 80% of the gauge range, using a 60mm arm with a diamond stylus.

5 Repeated measurements over a glass flat that is nominally parallel to the datum (10mm traverse length, primary filter λs = 0.025mm).

6 Repeated measurements over a glass flat that is nominally parallel to the datum, (200mm traverse length, primary filter λs = 2.5mm).

7 Repeated measurements over an 80mm radius glass standard (primary filter λs = 0.25mm).

8 From a repeat measurement on the calibration artifact over 75% of the calibrated gauge range LS Arc analysis, primary filter λs = 0.25mm).

9 Measured over a glass flat nominally parallel to the traverse datum using a 60mm arm with a diamond stylus (speed = 0.1mm/s, Gaussian roughness filter, 0.08mm cut-off, 30:1 bandwidth).

10 Assumes a calibration artifact of perfect radius.

NOTE: Taylor Hobson pursues a policy of continual improvement due to technical developments. We therefore reserve the right to deviate from catalog specifications.

Serving a global market

Taylor Hobson is world renowned as a manufacturer of precision measuring instruments used for inspection in research and production facilities. Our equipment performs at nanometric levels of resolution and accuracy.

To complement our precision manufacturing capability we also offer a host of metrology support services to provide our customers with complete solutions to their measuring needs and total confidence in their results.

Contracted Services from Taylor Hobson

- **Inspection services**
measurement of your production parts by skilled technicians using industry leading instruments in accord with ISO standards
- **Metrology training**
practical, hands-on training courses for roundness and surface finish conducted by experienced metrologists
- **Operator training**
on-site instruction will lead to greater proficiency and higher productivity
- **UKAS Calibration and Testing**
certification for artifacts or instruments in our laboratory or at customer's site

For the above services, contact our Center of Excellence:
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- **Design engineering**
special purpose, dedicated metrology systems for demanding applications
- **Precision manufacturing**
contract machining services for high precision applications and industries
- **Preventative maintenance**
protect your metrology investment with a Tallycare service cover plan

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