
# Zygo's Guide to Typical

# Interferometer Setups

SURFACES | WINDOWS | LENS SYSTEMS

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# Welcome

# to the Interferometer Setups Guide

This booklet illustrates and discusses a number of the most common measurement setups for use with a Zygo interferometer. However, it is by no means a comprehensive collection of all the setups that are possible, partly because new and innovative setups are developed every day by users around the world.

Therein lies the beauty of Zygo's modular interferometer system; it is not limited to specific measurement setups that fit only specific measurement situations. It is dynamic, versatile, and limited only by the imagination and resourcefulness of the user.

With every technological advancement comes the challenge of finding a way to measure and quantify it, and an opportunity to use interferometry in a new way. Industries not previously considered to be likely candidates for interferometric testing are now utilizing this valuable tool to measure computer disks, diamond-turned surfaces, precision machined metal parts, highly polished metal surfaces, and so on.

All it takes is a little knowledge, some creativity, and a Zygo interferometer. We hope this booklet sparks your imagination.

# The Setups

Each setup example in this booklet shows a Mainframe, the part being tested, and the accessories required to make the setup work. The accompanying text explains how the setup is used. A GPI Mainframe is shown in the examples; however, any Zygo interferometer may be used with equal success.

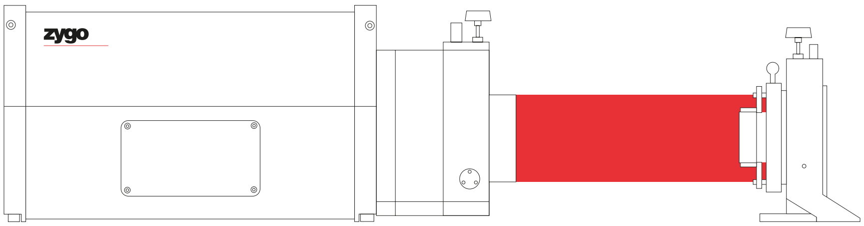
For many measurement situations, the Mainframe and the accessories may all sit on one vibration isolation table, with the measurement beam oriented horizontally. More elaborate arrangements are certainly possible, and may be required to suit particular measurement needs.

If you have questions about any of the setups, or you would like to discuss a setup not covered in this booklet, please contact Zygo Corporation for assistance. Our Support Team is ready to help you understand and explore interferometry.

## CONTENTS


| | |
|---|---|
| Surface Flatness | 4 |
| Plano Transmitted Wavefront | 4 |
| Parallelism (Wedge) | 5 |
| Prism and Corner Cube Testing | 5 |
| Transmission Sphere Selection | 6 |
| Concave Surface Figure | 6 |
| Convex Surface Figure | 7 |
| Two or More Simultaneous Measurement Channels | 7 |
| Slow Concave Surface Figure (Moderately-Long Radii) | 8 |
| Slow Convex Surface Figure (Moderately-Long Radii) | 8 |
| Noncontact Radius of Curvature and Figure | 9 |
| Lens/System Performance | 10 |
| Lens/System Performance Alternate Method) | 10 |
| Parabola Surface Figure | 11 |
| Hyperbola Surface Figure | 11 |
| Concave Elliptical Surface Figure | 11 |
| The Need for Various Aperture Diameters | 12 |
| Aperture Converters | 13 |

# Surface Flatness



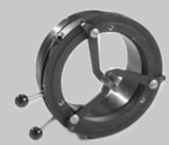

This setup is used for the measurement of surface flatness of plano elements such as mirrors, prisms, and windows. The test object must be held so that the surface under test can be aligned in two axes of tilt.

The Align Mode is used for rough alignment. The View Mode, using the Quick Fringe Acquisition System, is then used for fine alignment.

**SUGGESTED ACCESSORIES**

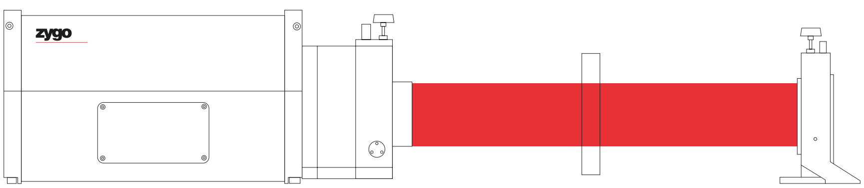
Transmission flat 4%

Mount, 2-axis



Self-centering element holder

# Plano Transmitted Wavefront




This setup is used to measure distortion of a plane wave transmitted through the element under test. It is typically used for windows, filters, and prisms. In addition, glass and other transparent raw material may be examined for homogeneity.

Software packages are available for material homogeneity evaluation. Since the measurement beam passes through the element under test, this element need only be placed nominally perpendicular to the optical axis of the test beam. No special mount or alignment is required.

**SUGGESTED ACCESSORIES**

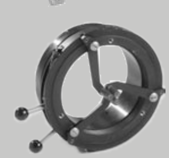
Transmission flat 4%

Reference flat, 4%

Mount, 2-axis

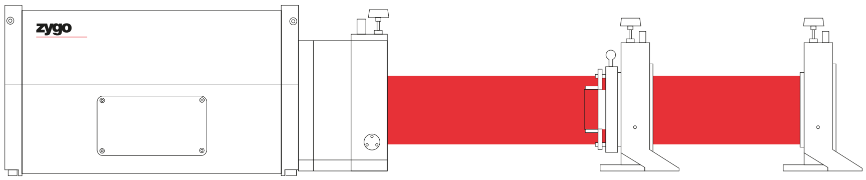
If needed, for test element:

Mount (2-axis)



Self-centering element holder

# Parallelism (Wedge)

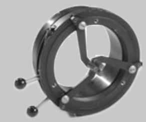


Parallelism (wedge) can be measured using the Mainframe. Measurement of very small wedges requires no auxiliary optics because interference is obtained between wavefronts reflected from the two surfaces of a transparent element. The element must only be placed nominally perpendicular to the Mainframe output beam. The optical and mechanical wedge can be calculated from the resulting interference pattern.

For medium wedges, the Plano Transmitted Wavefront setup can be used. This and other techniques, some with a fraction of an arc second resolution, can be used to measure wedge using a phase measuring Mainframe.

**SUGGESTED ACCESSORIES**

Mount, 2-axis



Self-centering element holder

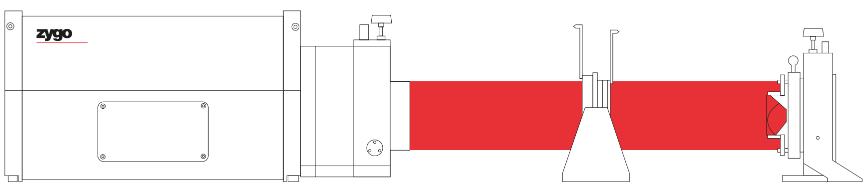
For medium wedges add:

Mount, 2-axis

Transmission flat, 4%*

Reference flat, 4%

# Prism and Corner Cube Testing



Many prisms and corner cubes can be measured as if they were a plano, that is, facing a transmission flat on the Mainframe.

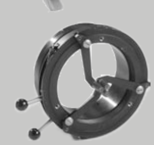
For pieces with high equivalent reflectivity (i.e. > 40%) an attenuation filter can be used as shown in the center of the setup, or a Dynaflect™ flat in place of the 4% transmission flat. Zygo's MetroPro™ software can calculate angle errors as well as transmitted wavefront errors.

**SUGGESTED ACCESSORIES**

Transmission flat, 4%*

Attenuation filter*

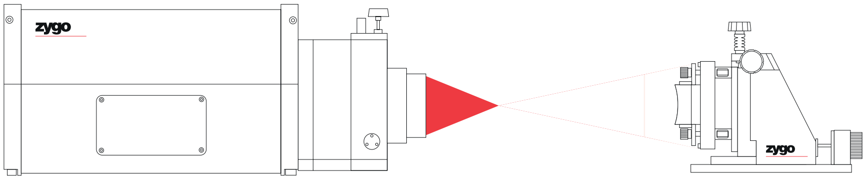
Mount, 2-axis



Self-centering element holder

**A Dynaflect™ transmission flat may be used instead of these two accesories for high reflectivity pieces.*

# Transmission Sphere Selection



Transmission spheres of various f/numbers are available as standard items, and others may be obtained on special order. In order to select the optimum transmission sphere f/number to fill the aperture of a concave or convex surface, the R/number of the surface to be measured is calculated using the following formula:

$$R/number = \frac{\text{Radius of curvature of surface under test}}{\text{Clear aperture of surface under test}}$$

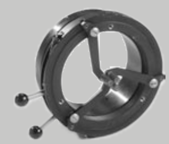
If the R/number of the surface under test does not match the f/number of the transmission sphere being used, one of two situations will occur. If the R/number is smaller than the f/number, the interferogram will not fully cover the entire aperture of the surface under test. If the R/number is larger than the f/number, the interferogram will be smaller than full size on the monitor, which can be compensated for by using the Mainframe's variable zoom.

A transmission sphere selection guide is available from Zygo to assist in choosing the correct f/number.

**SUGGESTED ACCESSORIES**

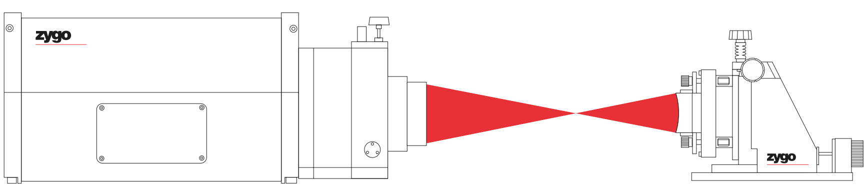
Transmission sphere

Mount, 3-axis or 5-axis



Self-centering element holder

# Concave Surface Figure



A transmission sphere transforms the Mainframe output beam into a precise spherical wavefront for the evaluation of spherical surfaces and lenses. A concave spherical surface is examined for surface figure and irregularity, i.e., the deviation from the best-fitting sphere, by placing its center of curvature coincident with the focus of the transmission sphere.

This usually difficult alignment is simple and takes only seconds using the Mainframe's Quick Fringe Acquisition System. Adjustment of the surface under test can be provided by a 3- or 5-axis mount. The 3-axis adjustment is necessary for spheres. However, the 5-axis mount is often chosen to be used with both spheres and flats (which need tilt adjustment).

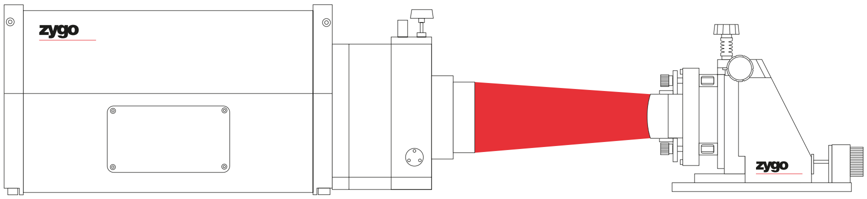
**SUGGESTED ACCESSORIES**

Transmission sphere

Mount, 3-axis or 5-axis

Self-centering element holder

# Convex Surface Figure




Convex spherical surfaces are examined for surface figure and irregularity using the setup shown. In order to select the optimum transmission sphere, two criteria must be met.

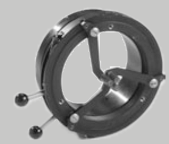
First, the radius of curvature of the convex surface under test must be less than the back focal length of the transmission sphere.

Second, the radius of curvature of the surface under test divided by the clear aperture, i.e., the R/number, should be less than or equal to the f/number of the transmission sphere. Both four-inch and six-inch diameter transmission spheres are available for these applications. Adjustment of the surface under test can be provided by either a 3-axis or 5-axis mount.

**SUGGESTED ACCESSORIES**

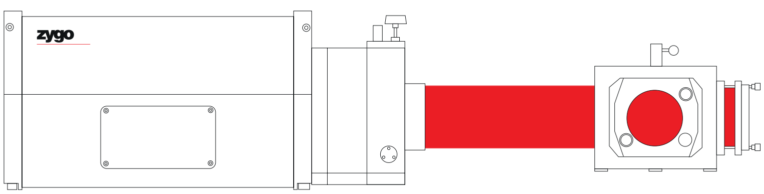
Transmission sphere

Mount, 3-axis or 5-axis



Self-centering element holder

# Two or More Simultaneous Measurement Channels




This illustration shows how two horizontal measurement channels are produced with a MUX (multiplexing) cube. Each channel can support its own measurement setup and has all of the Mainframe's features.

The transmission elements for each channel snap in the accessory receptacle on the MUX cube.

The two measurement channel feature is particularly useful because it significantly enhances the utilization of the Mainframe.

Two common use modes are:

Two operators can each use one of the measurement channels and thereby share one Mainframe.

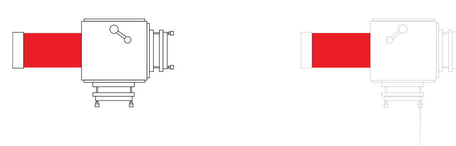
An operator can take measurements in one channel while the test setup in the second channel is coming to thermal equilibrium.

Very simply, the Mainframe can remain in use while a test setup comes to thermal equilibrium or while test setup is being put together in the other channel.

**SUGGESTED ACCESSORIES**

MUX Cube

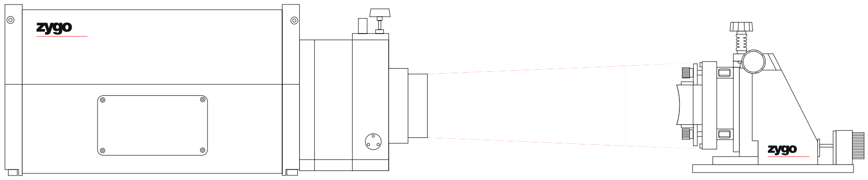
*Other accessories as required*




*Overhead view of each channel in use*

# Slow Concave Surface Figure

*(Moderately-Long Radii)*




Spherical surfaces with R/numbers in the range from 11 to 50 are best measured using the converger/diverger series of transmission spheres. The illustration depicts the measurement of a slow concave surface using a diverger.

Refer to the converger/diverger accessory sheet for the range of radii covered by each member of this series.

**SUGGESTED ACCESSORIES**

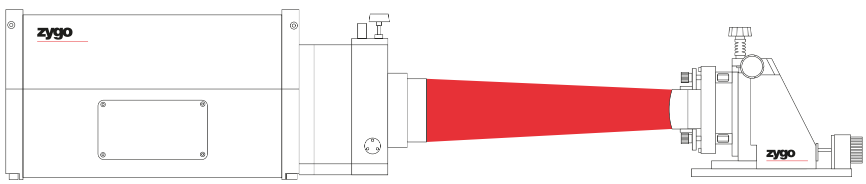
Transmission sphere, diverger

Mount, 3-axis or 5-axis

Self-centering element holder

# Slow Convex Surface Figure

*(Moderately-Long Radii)*

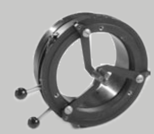



This illustration depicts the measurement of a slow convex surface using a converger.

**SUGGESTED ACCESSORIES**

Transmission sphere, converger

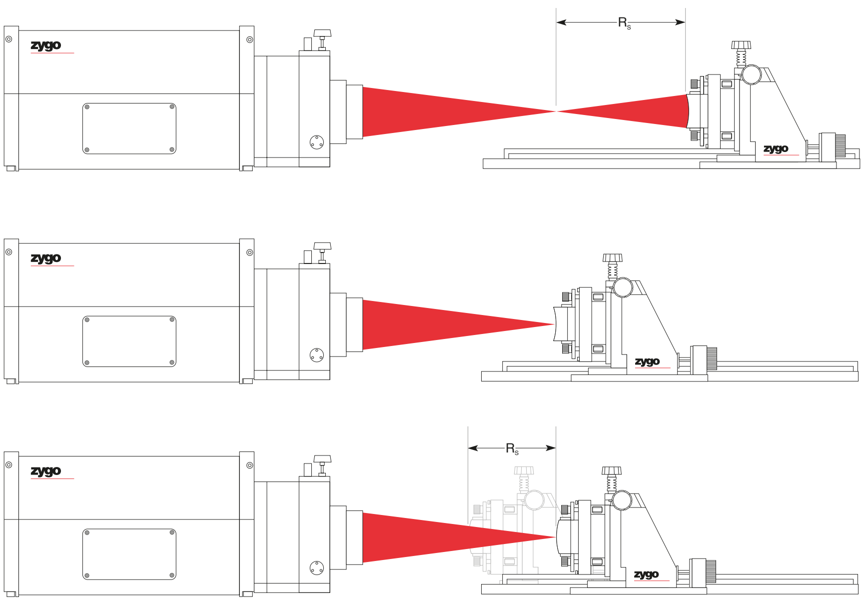
Mount, 3-axis or 5-axis



Self-centering element holder

*Note: For surfaces with very long concave or convex radii, contact Zygo Corporation for a quotation on a custom transmission sphere.*

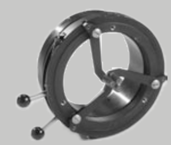
# Noncontact Radius of Curvature and Figure




**SUGGESTED ACCESSORIES**

Transmission sphere

Mount, 3-axis or 5-axis



Self-centering element holder

Digital Radius Slide

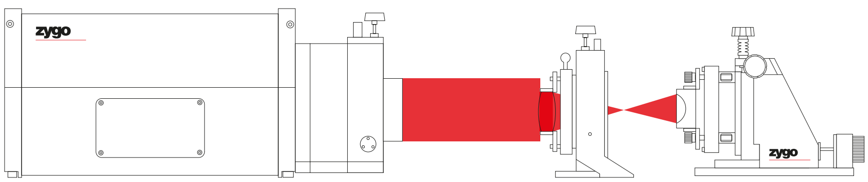
In addition to surface figure and irregularity, the radius of curvature of both concave and convex spherical surfaces can be measured. The center of curvature of the test surface is positioned to coincide with the focus of the spherical wave emanating from the transmission sphere. In this arrangement, shown in the first illustration, the fringe pattern provides information not only about the figure and irregularity of the surface under test, but also about the precise location of the center of curvature of the test surface with respect to the focus of the transmission sphere. The surface under test is then translated along the optical axis of the interferometer until the surface under test coincides with the transmission sphere focus, as shown in the second illustration. The fringe pattern again provides a very sensitive indicator of the point where the surface coincides with the focus. The distance that the surface under test is translated, Rs, is equal to the radius of curvature of the surface.

A digital radius slide provides a convenient read-out of the translated distance. Used with an encoder, this technique is accurate to 20 µm or 0.1%, whichever is larger. For cases where very high accuracy is required (1µm or 0.001%) an Interferometric Radius Slide is available. Both the encoder and the Interferometric Radius Slide can input these distance measurements directly to the interferometer's processor to correct for positioning errors.

The accuracy to which the radius of curvature of a high quality spherical or cylindrical surface can be determined is not just a function of the distance measurement accuracy. It is also a function of the R/number of the surface being measured, as well as the user's ability to judge fringe straightness (if the user does not choose to correct for positioning errors).

The third illustration shows the equivalent surface figure and irregularity and radius of curvature measurement setups for convex surfaces.

# Lens/System Performance



Lens or system quality can be measured by examining the distortion of the transmitted wavefront. For a lens or system focused for infinity, the lens can be placed in the collimated measurement beam and a high quality concave or convex sphere can be used to retroreflect the transmitted wavefront.

By rotating the optical axis of the lens under the test with respect to the axis of the measurement beam, performance at various field angles can be determined.

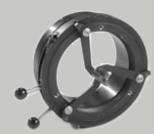
**SUGGESTED ACCESSORIES**

Transmission flat 4%

Mount, 2-axis

Mount, 3-axis or 5-axis


Reference sphere

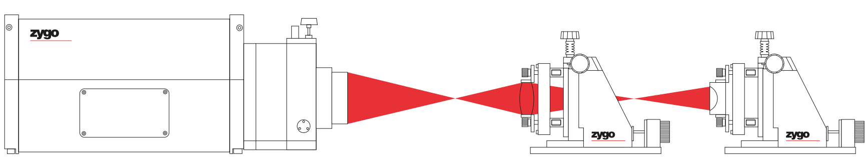


Self-centering element holders (2)

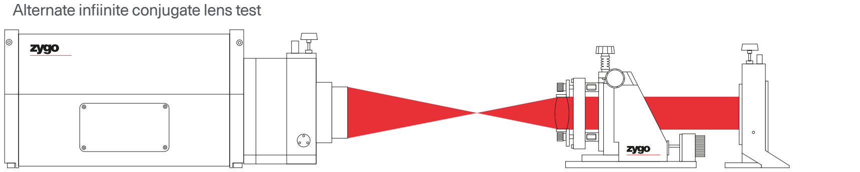
# Lens/System Performance

*(Alternate Method)*

Finite conjugate lens test



Alternate infiinite conjugate lens test



Particular situations may require an alternate lens/system setup. For lenses or systems with finite conjugates, a transmission sphere is necessary to form the "object" position in front of the lens under test.

For systems with apertures larger than the sample beam of the interferometer, or for systems with apertures much smaller than the sample beam of the interferometer, this alternate setup may be advantageous. The alignment of the elements, however, may be significantly more difficult, and errors due to misalignment may be introduced.

**SUGGESTED ACCESSORIES**

Transmission sphere

Mount, 3-axis or 5-axis

**For finite conjugate:**


Reference sphere

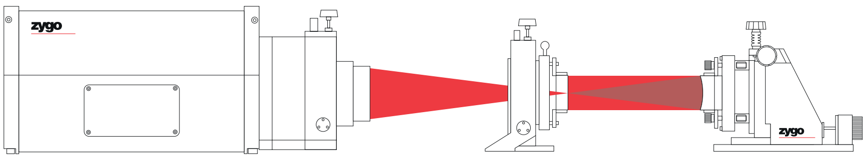
Mount, 3-axis or 5-axis

**For infinite conjugate:**

Reference flat

Mount, 2-axis

# Parabola Surface Figure



The surface figure and irregularity of a parabolic surface can be measured by employing a reference flat with a small central perforation, as shown in the illustration.

Misalignment of a parabola as well as any of the other conical surfaces discussed here will introduce alignment errors, so a 5-axis mount is recommended to align these parts.

**SUGGESTED ACCESSORIES**


Transmission sphere

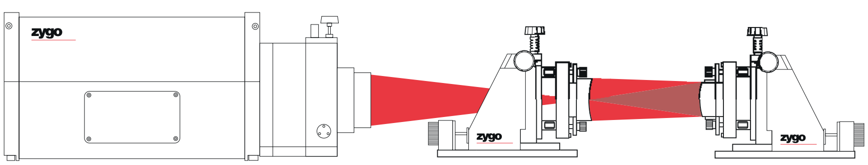

Mount, 2-axis


Perforated reference flat


Mount, 5-axis


Self-centering element holders (2)

# Hyperbola Surface Figure



For a hyperbolic surface, the surface figure and irregularity can be measured as shown by using a reference sphere with a small central perforation.

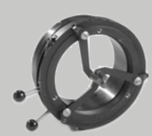
**SUGGESTED ACCESSORIES**


Transmission sphere

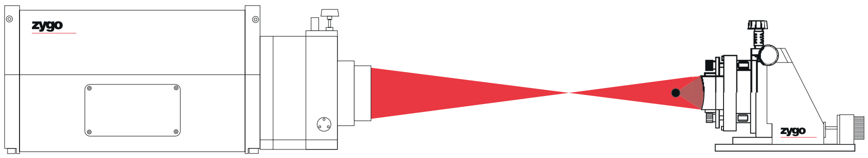

Mount, 5-axis


Mount, 3-axis

Perforated reference sphere


Self-centering element holders (2)

# Concave Elliptical Surface Figure



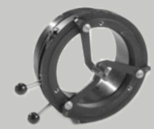

Concave elliptical surfaces are examined for surface figure and irregularity by positioning a glass retrosphere in the measurement beam as depicted in the illustration.

**SUGGESTED ACCESSORIES**

Transmission sphere

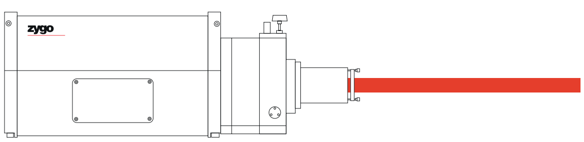
Mount, 3-axis, modified for this setup to hold a glass retrosphere

Mount, 5-axis

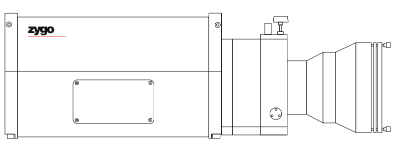


Self-centering element holders (2)

# The Need for Various Aperture Diameters




4 inch to 25 mm Aperture Converter




4 inch to 6 inch Aperture Converter

A number of situations may require the use of a different interferometer aperture diameter. For example, a single interferogram does not provide complete coverage when a plano surface, tested at normal incidence, is larger than the interferometer's aperture diameter. In this case, an interferometer aperture diameter at least equal to the test surface diameter is needed for full coverage with one interferogram.

Conversely, very small plano elements can produce interferograms too small to be useful. The Mainframe's 6X zoom obviates this problem until the elements become very small (< 15mm), at which point the 6X zoom is not enough for the interferogram to appear full size on the video monitor. For these parts, it is helpful to begin with a smaller interferometer aperture diameter.

Convex surfaces, which must be placed in a converging measurement beam, may require a larger interferometer aperture. For convex surfaces of large size and/or long radius, it may be necessary to begin with a larger aperture converging beam produced by the appropriate transmission sphere.

# Aperture Converters

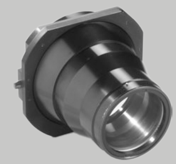
To meet the above needs, Zygo offers two different aperture converters, which can be inserted into the Mainframe accessory receptacle, to convert the 4 inch measurement beam to either a 25 mm or 6 inch diameter. The 25 mm aperture converter accepts both the 25 mm and the older 33 mm transmission elements. The 6 inch converter accepts all standard 6 inch transmission elements. By changing the size of the measurement beam, the aperture converters provide magnification in addition to the Mainframe's 6X zoom.

For example, using the 25 mm aperture converter in conjunction with the 6X zoom, a 4 mm diameter plano element will appear full size on the video monitor. A complement of accessories is available for both the 25 mm and the 6 inch aperture systems.

Zygo also offers larger fixed beam expanders for 12 inch, 18 inch, 24 inch and 32 inch apertures. These expanders are switched in using a MUX cube allowing alternate use of the 4 inch and expanded channel.

**SUGGESTED ACCESSORIES**

4˝ to 25 mm



4˝ to 6˝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