Autocollimators & Accessories

Measuring angle, straightness, flatness, squareness, and parallelism
The Autocollimator range
For measuring angle, straightness, flatness, squareness, and parallelism

Used extensively in workshop, tool rooms, inspection departments and quality control laboratories throughout the world, Taylor Hobson Autocollimators – developments of the renowned Hilger and Watts products – are sensitive optical instruments designed for the accurate measurement of small angular displacements.

There are five models in this comprehensive range, from the simple Minidekkor to the Ultra High Precision Autocollimator.

The principles of autocollimation

Light from an origin point $O$ is collimated (made parallel) by a high quality objective lens. If the collimated beam falls perpendicularly onto a plane reflecting surface, the light is reflected back along its original path and is brought to a focus at a point coincident with the origin point (as Figure A). If the reflector is tilted through an angle $\theta$, the reflected beam is deflected through an angle $2\theta$, and the image $I$ is displaced laterally from the origin $O$.

The amount of displacement is given by $d=2f\theta$ where $f$ is the focal length of the lens, and $\theta$ is in radians. Given that $f$ is a known constant for the Autocollimator, measurement of the displacement $d$ enables the tilt $\theta$ to be ascertained.

An illuminated target graticule is directed towards the objective by a beam splitter. After reflection by a mirror (workpiece) the light returns through the Autocollimator and passes through the beam splitter, forming an image of the target graticule in the plane of an eyepiece graticule.

The eyepiece graticule and the reflected image of the target graticule are viewed simultaneously through the eyepiece. Although the target graticule is always seen in focus and at constant magnification in the eyepiece.

At long working distances only a portion of the target graticule appears in the eyepiece, owing to the failure of obliquely returning rays to enter the Autocollimator. This can restrict the measuring range.

Figure 'A' Reflector square to beam
Figure 'B' Reflector tilted to beam
Figure 'C' Operating principle of Autocollimator
Autocollimation in practice: checking, measuring, indexing & monitoring

Taylor Hobson Autocollimators are used in conjunction with reflecting mirrors or surfaces for the accurate measurement of small angular deviations from a datum angle.

The main advantages of Taylor Hobson autocollimators are:

• High accuracy & wide range angle measurement
• Easy to set up and operate
• Calibration traceable to international standards
• Choice of Visual or Electronic systems
• Wide range of accessories and levels

Their main applications include:

• Checking straightness of machine tool slideways
• Checking dividing heads for their angular displacements
• Measuring very small angles
• Measuring small linear displacements
• Checking flatness of bed plates and surface tables
• Checking squareness of column to base
• Checking parallelism of twin slide rails
Visual autocollimators: flexible, affordable, easy-to-use and read

The visual autocollimators are extremely accurate instruments with a wide variety of applications.

They are normally supplied with the eyepiece positioned for straight through viewing, although the TA51 is available with the eyepiece positioned for right angle viewing if required. Measurements are made using a graticule in the eyepiece viewing system with or without micrometers.

The Taylor Hobson VA900 and TA51 Autocollimators incorporate a micrometer in the eyepiece viewing system for the precise measurements of angular displacement. The TA51 has two micrometers, one in each axis of measurement.

On single axis types, the instrument is rotated through 90 degrees to measure in a second plane.

The micrometer is used to move the eyepiece graticule across the field of view until it coincides with the reflected target graticule image. The angular displacement of the reflector can then be read directly from the micrometer scale.

The TA51 Autocollimator is normally supplied with a light field graticule. Only one setting line is used in instruments fitted with dark field graticules.

The VA900 and TA60 Minidekkor Autocollimators incorporate a micrometer in the eyepiece viewing system for the precise measurements of angular displacement. The VA900 and TA60 Minidekkor Autocollimators are normally fitted with dark field graticules as standard for a better visual contrast from low reflectivity surfaces or a small reflector. However, light field graticule variants can be supplied on request.

**TA60 Dual Axis Minidekkor**

code 142-10

- Affordable, lightweight and portable
- Wide range of measurement
- Can measure X and Y axes at the same time using a graticule
- Can measure components of low reflectivity or with small surface area

The TA60 Minidekkor is an inexpensive visual Autocollimator using a two axes graticule for general measuring duties in workshop and tool room. The standard Minidekkor is provided with a dark field graticule, forming an illuminated cross line image on a dark background. This offers the advantage of clear images being obtained from low reflectivity surfaces such as unsilvered glass, and from surfaces as small as 3mm (0.125in) in diameter.

With the addition of a microscope objective and linear measuring device, the Minidekkor can be used for measuring radius of curvature of a lens or mirror and, for example, the spacing of electrodes enclosed in a glass envelope.

This Autocollimator is supplied as standard without mounting fixtures. Therefore, when ordering it is important to consider the applications and select the appropriate mounting accessories.
VA900 Microptic Dual Axis Autocollimator  
**code 112-2208**

- Lightweight high accuracy instrument
- Ideal for precise measurement of angle of components such as prisms and for checking straightness, flatness and angular indexing
- Wide range using combination of graticule and micrometer

The VA900 Microptic Autocollimator is a dual axis, lightweight, highly accurate instrument. It is ideally suited for the precise measurement of angles or components such as prisms, for checking straightness, flatness or angular indexing. Measurement of the two axes is made using a combination of the instruments two axes graticule and single micrometer and is provided as standard with a dark field graticule.

This Autocollimator is supplied as standard without mounting fixtures. Therefore, when ordering, it is important to consider the application and select the appropriate mounting accessories.

TA51 Microptic Dual Axis Autocollimator  
**code 142-13**

- High Accuracy and Wide Angle  
- Ideal for checking machine slides for straightness and squareness  
- Checking flatness of surface tables  
- Checking angular indexing tables and polygons

The TA51 is supplied as standard with a light field graticule and comes complete with a levelling base as shown.

It is an extremely accurate and flexible system when used in conjunction with the wide variety of accessories shown in this brochure.
Ultra Series Digital Autocollimators

Machine tool slideways
The software's clear visual image and the sighting aid accessory make setting up fast and easy when carrying out simultaneous 2-axis straightness measurement on machine tool slideways.

Dual axis
Using the latest CCD technology the new Ultra Dual Axis Autocollimator is a highly versatile instrument offering high accuracy and stability over a range of applications.

Simple set-up
This wide range Autocollimator comes with a laser sighting aid for simple setup. Combine this with the clear visual display on the autocollimators tablet PC and set up is easy even over long distances or with small reflectors.

Clear results
The Ultra Autocollimator also includes as standard the Taylor Hobson dedicated Optical Analysis software which allows advanced measurement, calculation and analysis of a range of features.

Ultra Autocollimator
code 142-201-01

Key features
- Wide measurement range (1800 seconds)
- High accuracy (0.2 seconds)
- Simultaneous dual axis operation and display
- Laser sighting aid for easy set-up
- Simple touch-screen operation
- Clear software with full electro optics applications package

Applications include:
- Simultaneous 2 axis straightness measurement
- Alignment of optical systems
- Flatness measurement
- Lens centration
- Angles of optical components and prisms
- Checking, setting & measurement of angular indexing heads and tables

The laser sighting aid attachment and clear visual software in a range of languages ensure that measurement setup is quick and simple.
Straightness
This simple interactive icon driven software allows single or simultaneous 2 axis straightness of components such as machine tool slideways, shafting and rolls.

Twist
The twist program allows straightness measurements to be carried out on one guideway and then compared to the straightness of a second guideway (when using a Talyvel levelling system, see the brochure ‘Talyvel/Clinometers For Angular Measurement’).

Polygon
This program is designed specifically for the calibration of rotary devices and polygons with up to 72 faces, allowing single or bi-directional calibration with results of both angular indexing accuracy and pyramidal error.

Flatness
The Union Jack/Moody method for flatness measurement uses operator selected measuring steps to measure each generator line and calculate the overall flatness of the surface.

The Ultra Autocollimator combines a wide measurement range with high accuracy over its whole range.
Among the large number of applications possible with the Taylor Hobson Ultra Dual Axis Autocollimator, the most common is the simultaneous two axis straightness measurement of machine tool slideways.

Typically a ten metre slide can be checked in approximately five minutes — a considerable reduction in the amount of time taken compared with more conventional methods.

The supplied PC also has Taylor Hobson applications software pre-loaded at no extra cost, for computenced measurement of straightness, parallelism, squareness and twist with printouts of measured results available.

**Measuring procedure:**

Due to the high sensitivity of the autocollimator and the high accuracy with which measurements are made, the autocollimator is usually mounted directly onto the machine slideway.

This is best accomplished using a bracket, rigidly bolted to the end of the slide. If this is not possible the autocollimator can be placed directly on the slide.

The reflector to be used in conjunction with the autocollimator is mounted onto a carriage, specifically designed for dual axis measurement.

The steps along the slideway must be of equal distance therefore the number of steps to be taken will depend on the base length of the reflector carriage and the length of the slideway.

Any out-of-straightness in either of the two surfaces (side and top of the slide) will cause the carriage to change angle with respect to the autocollimator, and it is these changes which are measured and computed automatically to determine the error in straightness.

The out of straightness is the maximum peak to valley and can be calculated using either the ends zero, least squares or minimum zone method (selectable within the software).

In addition, the slope of the slideway with respect to the autocollimator is displayed as a gradient (ie mm per m or 0.001in per inch). This is derived from a least squares mean line calculated from the data. This slope can be particularly valuable when measuring parallelism and squareness between slideways.

A Talyvel Electronic Level is used in conjunction with the Ultra Autocollimator to measure the twist or roll of the slideway and an optical square is used for parallelism and squareness checks.
Application: parallelism of twin rails

This is a common application which can be solved by using an autocollimator together with an optical square and mirror.

Firstly the autocollimator is positioned and set up with the optical square to measure the first rail. The autocollimator can be mounted on trivets, tripods or heavy duty stands and the reflector is moved along the first rail and a series of straightness measurements can be taken and the slope value calculated (using the Taylor Hobson Electro Optics Analysis software).

Leaving the autocollimator in the same position, the optical square and reflector are then moved to the second rail and the measurements repeated.

Note: it is imperative that the autocollimator is not moved from the first rail position as this is the reference line. The out of squareness (parallelism) between the two rails is the difference in the individual slope values.

Application: checking indexing head and polygons

Modern machining systems use rotary tables for tilting and indexing the part. The rotary table’s positioning accuracy is an integral part of system accuracy.

When used to measure angular errors of rotary tables an autocollimator measures the deviation from nominal angle determined by the angular master. The angular master is usually a precision polygon mirror or an index table.

Uniquely the autocollimator’s accuracy is not influenced by breaking the light beam, making it a very practical device to use.

Polygon

Although polygons are available with as many as 72 faces, those used for rotary tables typically have 8, 12, or 16 faces. The polygons are regular; that is the angle between the faces is equal. Since polygons are not perfectly regular a list of deviations is supplied in the form of a calibration chart.

To ensure proper alignment, the polygon is mounted on the rotary table using the inside diameter of the polygon as a reference. The inside diameter centreline is parallel to the faces and square to the base. After alignment, one of the mirror faces on the polygon is rotated toward the autocollimator and zeroed; then the rotary table readout is zeroed.

During inspection the table is rotated until its readout is the nominal angle of the polygon (45 degree increments for an eight-sided polygon). This next face should be aligned to the autocollimator. If it isn’t, the error can be read on the autocollimator. The table should be rotated to each face of the polygon until all positions are inspected. At zero degrees, the table should return to zero deviation.

An alternative to the polygon is a precision indexing table. To use an index table, a plane mirror is placed on the centre of rotation and parallel to the axis of rotation. The index table is aligned in the same manner as a polygon. During inspection the rotary table is rotated to 23 degrees, for example, and the index table is counter-rotated 23 degrees. If the mirror isn’t aligned, again, the error can be read on the autocollimator.
Accessories

Levelling bases and stands

Levelling base (shown on item 1)  
code 142-76
Included as standard with Autocollimators TA51 and Ultra series.

The levelling base provides support for the Autocollimator, enabling the unit to be levelled and to bring its axis parallel to the surface being measured. It incorporates clamps to securely hold the Autocollimator without damage.

Three Lewis pads are included for use under the foot screws.

- Spacing between front and back foot screws: 205mm (8in)
- Spacing between the two back foot screws: 130mm (5in)
- Height of Autocollimator axis when base is resting on the pads: 76mm (3in)  
  without pads: 67mm (2.5in)
- Range of angular adjustments: approx ±3°
- Approximate weight: 3.4kg (7.5lb)

Adaptor Bushes code 112-2257
A set of two bushes to convert standard levelling bases 142-76 to 38mm (1.5in) diameter for use with VA900.

Azimuth Base code 112-4946
To give ½ degree fine adjustment of azimuth elevation on Ultra and TA51.
1. **Autocollimator**
   - Code: 112-3451-01 (TA60)
   - Code: 112-3450-01 (VA900)
   - On request (Ultra/TA51)

2. **Vertical Base with Adjusting Bracket**
   - TA60, 25.4mm (1in) dia clamp code 112-3451-01
   - VA900, 38mm (1.5in) dia clamp code 112-3450-01
   - A multipurpose stand of sturdy construction for general bench use, comprising epoxy granite surface plate, and ground cast iron column and bracket. The Autocollimator clamping bracket has independent clamping and rotational adjustments, enabling the bracket to be turned without disturbing the height adjustment.
     - Available for use with 25.4mm (1in), 38mm (1.5in) and 57mm (2.25in) diameter autocollimators.
     - Surface Plate Area: 220x150mm (8.7x5.9in)
     - Maximum Height Adjustment above Surface Plate: 200mm (8in)
     - Flatness of Surface: 5µm (0.0002in)
     - Approx Weight: 7.6kg (16.8lb)

3. **Tripods stands or trivets**
   - On request

4. **Unmounted 50mm glass reflector**
   - On request

5. **25mm Glass Cube Reflector**
   - Code: 142-25
   - Code: 142-24

6. **Large Glass Reflector**
   - Code: 142-26

7. **Box of Angle Gauges**
   - Code: 142-32

8. **12 sided Polygon (up to 72 sided polygons available on request)**
   - Code: 142-35

9. **Optical Square**
   - Code: 142-77

10. **Fixed Base**
    - On request

11. **Adjustable Base**
    - Code: 112-2316

12. **Side Feet**
    - Code: 137-1947

13. **Fixed Test Wedge**
    - Code: 137-1940
    - The fixed wedge can be used to quickly check the accuracy of any Autocollimator. It introduces a fixed angle of deviation nominally of 60 seconds by rotating the wedge from minimum to maximum deviation and comparing this with the readings on the Autocollimator. A UKAS certificate is optionally available.
      - Centre Height: 75mm (3in)
      - Weight: 1kg (2.25lb)
      - Working Diameter: 50mm (2in)

14. **Test equipment**

   **Fixed Test Wedge**
   - Code: 137-1940
   - The fixed wedge can be used to quickly check the accuracy of any Autocollimator. It introduces a fixed angle of deviation nominally of 60 seconds by rotating the wedge from minimum to maximum deviation and comparing this with the readings on the Autocollimator. A UKAS certificate is optionally available.
     - Centre Height: 75mm (3in)
     - Weight: 1kg (2.25lb)
     - Working Diameter: 50mm (2in)

   **TA48 Small Angle Generator**
   - Code: 137-1918
   - Autocollimators require periodic calibration to verify their capability for precise measurement. Users can calibrate their own Autocollimators using the Small Angle Generator. This device is also suitable for testing angle gauges, electronic levels, level vials used in block levels etc.
     - Total Measuring Range: 200 mins of arc
     - One Revolution of Micrometer Drum: 0.635mm (0.025in) moving the Autocollimator beam through 5 minutes of arc
     - Drum Graduations: 1 second of arc
     - Vernier Readings to: 0.1 second of arc

15. **Box of Angle Gauges**
    - Code: 142-32

16. **Large Glass Reflector**
    - Code: 142-26
### Straightness & flatness measurement

**Standard glass reflector**  
50mm (2 inch)  
Code 142-24 mounted  
A reflector is an integral part of any Autocollimator system. Successful autocollimation requires a reflector of adequate flatness, reflectivity and diameter; this reflector meets all of these requirements. Steel reflectors and unmounted versions can be supplied to special order.

- Diameter: 50mm (2.0in) nominal
- Faces Parallel to Within: 5 secs
- Faces Flat to Within: 0.08µm (3µin)
- Centre height of Mounted Reflector: 37mm (1.5in)
- Weight Unmounted: 130g (9oz)
- Mounted: 1.1kg (2.5lb)

**Large glass reflector mounted**  
100mm (4 inch)  
Code 142-26  
Offering a large reflective surface, this is normally used in conjunction with a reflector carriage and 142/24 mounted reflector for calibrating a surface plate. It enables several calibration lines to be traversed without the Autocollimator being moved, thereby saving setting up time.

**Adjustable base**  
Code 112-2316  
This accessory has a 200mm (8in) range of adjustment and can be set to the appropriate step interval length for flatness and straightness measurement. It provides a base for the reflector 142/24 with self aligning seating pads adjustable to a graduated scale. This base can also be used for mounting a Talyvel level unit.

Fixed bases can be supplied on request.

**Side feet**  
Code 137-1947  
For use with the Adjustable Base when measuring in two axes.

### Squareness & parallelism measurement

In addition to the items on the left, the following accessories are recommended:

**Optical square**  
Code 142-77  
- Aperture: 38mm (1.5in) 90° angle accurate to within ±1 sec

This square comprises a mounted pentagonal prism and is used to deviate the autocollimator beam through 90°. It may be used when checking the straightness of two surfaces which are at right angles to one another or when checking parallelism.

**Cube reflector**  
Code 142-25  
Can be used as general purpose reflector and for providing a 90° angle standard in three planes, for setting or checking perpendiculars.

- Size of Faces: 38mm (1.5in) square
- Reflector Faces: 3 (2 adjacent faces perpendicular to the base, 1 parallel to the base)
- Accuracy of 90° Angle: ±3 secs
- Weight: 0.43kg (1lb)

Other cubes can be supplied to required specifications to special order. For example, as above but with an accuracy of 90° ±1 sec or with four or five reflective faces.
Accessories

Indexing table, polygon & angle calibration

Polygon, 12 sided glass, nominal face angle 30°

code 142-35

The angle between the 0° datum face and any other face is within 5 seconds of the nominal values. A calibration chart is provided with each polygon, giving the actual angles to 0.1 second of arc to an accuracy of determination of 1 second.

Other polygons up to 72 sides and in steel or chrome carbide can be supplied to special order.

Angle Gauges (Set of 15)

code 142-32

• Gauge Angle – precision square, 45°, 30°, 15°, 5°, 3°, 1°, 30 min, 20 min, 5 min, 3 min, 1 min, 30 sec, 12 sec, 6 sec
• Accuracy of Angle: ±2 seconds

These gauges can be wrung together additively or subtractively to form most angles from 0° to 90° as a comparison standard. The faces themselves can be used as a reflector.

Software

Software Program

code 112-5105

A full applications software package is included with the Ultra Autocollimators. The package includes flatness measurement (Union Jack or Moody) straightness measurement (including twist and squareness) and the polygon angular indexing program. Users of older DA series Autocollimators can still use the previous windows software code 112-2337. Statistical filtering and edit facilities add to user confidence and flexibility of approach (Grid pattern flatness is also applicable to Talyvel systems).

• Flatness Program
• Straightness Program
• Polygon Program
• Twist Program

CCTV accessory

CCTV System code 137-1991

A miniature CCTV camera can be fitted to the eyepiece of the visual autocollimators when working in awkward locations or simply to reduce eye fatigue. By viewing the image on the laptop screen, the image can be magnified and a number of operators can view the image if required.

Twist measurement

Polygon measurement

Straightness measurement

Union Jack plot
Alignment & level product range

**Talyvel Electronic Level:**
Used for checking and setting for example:
- **Level:** (to gravity)
- **Straightness:** (of machine rails)
- **Flatness:** (of granite tables)
- **Setting horizontal references**

The Talyvel Electronic Level is universally accepted as the most accurate and stable level in the world with a resolution of 0.1 seconds.

**Precision Microptic Clinometers:**
Used for checking and setting for example:
- **Angle of machine vices**
- **Angle of helicopter blades**
- **Angle of guns**
- **Checking aircraft wing flaps**

The Taylor Hobson clinometers are simple and speedy instruments for checking and setting out angles from 0-360 degrees.

**Micro Alignment Telescope:**
Used for checking and setting for example:
- **Alignment:** (series of bores or bearings)
- **Squareness:** (column to a base)
- **Parallelism:** (series of rollers)
- **Level/Flatness:** (machine bed foundation)
- **Straightness:** (rails or guideways)

The Micro Alignment Telescope is a highly versatile alignment instrument that generates a straight line reference from zero to infinity. With its wide range of accessories it forms a unique and comprehensive system for solving problems in a wide variety of applications and industries.

**Laser Alignment System:**
The Micro Alignment Laser system is a laser measuring instrument equipped with the latest optical and electronic components for precise measurement of straightness, squareness and alignment. Typical applications include:
- **Dynamic checking of assembled machine tool slideways for straightness/squareness**
- **Parallelism measurements and adjustment of tracks and guide**
- **Monitoring of movement, deformation and deflection of structures**
The autocollimator range

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Specifications are subject to change without notice

**Flexibility to meet your measurement needs**

The flexible design of the Ultra Autocollimator allows wider measurement ranges and higher accuracies to be achieved according to your requirements – prices on application.

* Normally over a centre portion of the range for visual this is the central 60 seconds, for Ultra 800 seconds and for Ultra HP & LD central 100 seconds. Note: the best uncertainty that can be certified by UKAS is 0.5 seconds. Better uncertainty can be achieved by sending the unit to other international laboratories such as PTB.

** This excludes the outer 30 seconds of the range which can have some degradation.

*** Longer distances may be possible at proportionally reduced range.

**** Over 25m, estimated range ± 50 sec, accuracy ± 3 sec.

**NB:** All autocollimators are affected by the condition of the air path between the instrument and the reflector. To obtain maximum accuracy, this must be as short as possible and may need to be shielded from draughts and convection currents.

**UKAS Certificate**

Autocollimators and certain accessories can be supplied with a National Accreditation of Measurement and Sampling (UKAS) certificate which gives an independent and authoritative traceable guarantee of instrument performance and accuracy. Regular service and UKAS calibration will guarantee that the performance specification is traceable to International Standards.
Electro optical metrology

Taylor Hobson has been selling electro-optical metrology products since the late 1930s and the range includes Micro Alignment Telescopes (used for checking and setting straightness and alignment) Autocollimators (for accurate measurement of small angular displacements), clinometers and “Talyvel” electronic levels. Used in a range of applications in industries such as machine tools, aerospace, marine and steel rolling, the Taylor Hobson range combines high accuracy and repeatability with fast response and operational convenience.

To provide focused technical support to all its electro-optical metrology customers, Taylor Hobson has a dedicated technical support centre:

Spectrum Metrology

Electro-optical measurement customers often require advice on solving a specific manufacturing or calibration problem. With many years experience in electro-optical metrology, Spectrum Metrology provides rapid technical and application support via phone, e-mail or on-site visits. Full demonstration and training is available either on-site or in Spectrum Metrology’s demonstration room.

Spectrum Metrology is also the authorised repair agent to Taylor Hobson for the electro optical metrology range and holds a wide stock of ex-demonstration equipment for hire or sale.

Spectrum Metrology can be contacted on:

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