

# Portable laser measurement and calibration



## Machine tools and CMM

The ultimate tool for machine tool and CMM verification to international standards



## Motion systems

Unique dynamic performance for high speed, high resolution investigations



## Research and metrology

Traceable measurement for calibration and research laboratories



## From the world's leading laser measurement system manufacturer: the XL-80 laser system

Renishaw has been designing, manufacturing and supplying laser interferometer systems for over 20 years. Its ML10 laser system has become a globally recognised standard for accuracy and reliability in use.

The new XL-80 laser system offers greatly increased portability, system accuracy and improved dynamic measurement performance. It is quicker and easier to use, whilst retaining the benefits of a pure interferometry based system; a proven technology that has made Renishaw laser systems the preferred choice of companies worldwide.

XL-80 retains Renishaw's key virtues of accuracy, reliability and durability in day-to-day use, where it really matters.

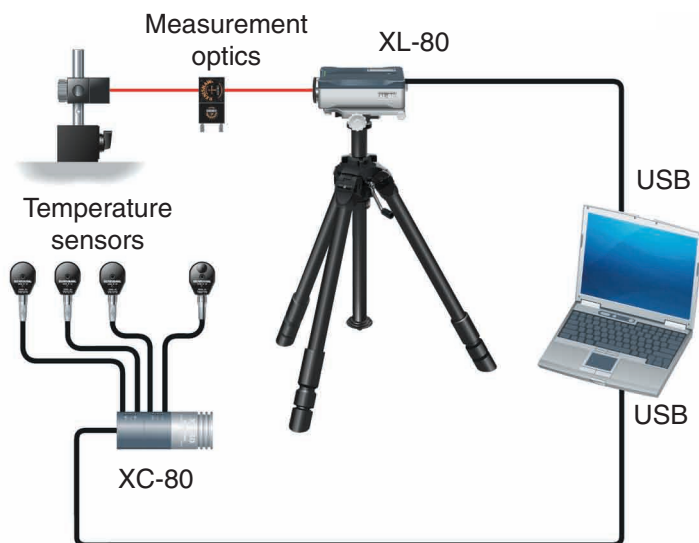


Increased performance from the XL laser measurement system widens your measurement options. Significantly smaller than existing systems, it delivers improved portability and ease of use, helping your business to stay ahead

XL-80 laser (with optional universal shutter) and XC-80 compensator

## XL system components

The basis of the new system is a compact laser head (XL-80) and an independent compensator system (XC-80)



### XL-80 laser

The XL-80 laser produces an extremely stable laser beam with a wavelength that is traceable back to national and international standards.

The laser frequency stability is specified as  $\pm 0.05$  ppm over 1 year and  $\pm 0.02$  ppm over 1 hour. This excellent performance is achieved by dynamic thermal control of the laser tube length to within a few nanometres.

Linear measurement accuracy is an assured  $\pm 0.5$  ppm over the whole environmental range i.e. from  $0\text{ }^{\circ}\text{C}$  -  $40\text{ }^{\circ}\text{C}$  ( $32\text{ }^{\circ}\text{F}$  -  $104\text{ }^{\circ}\text{F}$ ) and 650 mbar - 1150 mbar. Readings are taken at 50 kHz, with a maximum linear measurement speed of 4 m/s and a linear resolution of 1 nm; even at maximum speed.

As the XL system uses interferometry as the basis for all its measurement options (not just linear), you can have confidence in the accuracy of all your measurements.

With integrated USB there is no requirement for a separate laser-to-PC interface. The laser also features an auxiliary analogue signal output as standard, with quadrature output a factory option. The same socket also accepts a trigger signal input for data capture synchronisation.

LED status lights, indicating laser status and signal strength, provide back-up to the software's "on-screen" indicators. Together with a switchable long range mode (40 m - 80 m) and a warm-up time of less than 6 minutes, these features make the XL-80 quick and easy to use.

An external, switch mode power supply ensures 90 V - 264 V flexibility in input voltage.

## XL system components

### XC-80 compensator and sensors

The XC-80 compensator is a key factor in your XL system's measurement accuracy. Featuring 'intelligent sensors' that process the readings at source, the compensator very accurately measures air temperature, air pressure and relative humidity.

Like the XL-80 laser, the compensator is directly connected to your PC via a USB port which, for the XC unit, also supplies power (no separate power supply is required).

The XC-80 weighs only 490 g and together with the XL-80 weighs just over 3 kg (including connecting cables, XL power supply and sensors).

Both the air and material temperature sensors are 'intelligent'. Integral microprocessors analyse and process the sensors' output before sending digital temperature values to the XC-80 compensator. This offers more secure measurements and is a key reason why the XC-80 is so compact.

Up to three material temperature sensors can also be attached to the XC-80 compensator to allow linear measurements to be normalised to a standard material temperature of 20 °C.

Sensor cables are 5 m long and detachable for easy replacement. Multiple cables can be screwed together for extended lengths on longer machines.



It then modifies the nominal value of the of the laser wavelength to give a true value, used in calculations, which virtually eliminates any measurement errors resulting from these variations. This can be done automatically, every 7 seconds, as indicated by LED status lights on the XC-80 unit.

Each sensor 'shuts down' between readings to minimise heat dissipation; typical of the detail in the XC-80 design, which includes both temperature and pressure mapping of air pressure sensors and coefficient adjusted temperature sensors.



The design of the XC-80 and sensors ensures extremely accurate readings over the full range of operating conditions, from units that are built to withstand the daily handling that most systems will receive.

## XL system components

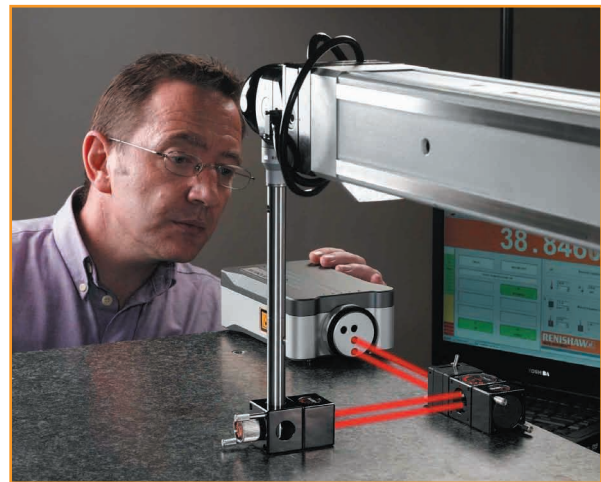
### Tripod and stage

Unless you are using a dedicated measurement rig, then you are likely to need a tripod and stage to adjust the laser's position relative to the desired measurement axis. A new universal tripod has been extensively tested to provide a stable adjustable base in a compact, lightweight unit.

The XL tripod stage allows for precise angular rotation and translation of the XL-80 and is designed to be left attached to the laser unit for easy storage and quick set-up.



A 'quick fit/release' mechanism enables rapid and secure fixing to the tripod. For those applications where tripod mounting is not convenient, e.g. for mounting directly on a machine tool table, the stage and laser can also be mounted on most standard magnetic bases, using an optional adapter with M8 thread.



Due to careful design, the XL-80 laser and optics can also be placed directly on a granite table (without tripod stage) for co-ordinate measuring machine (CMM) calibration.

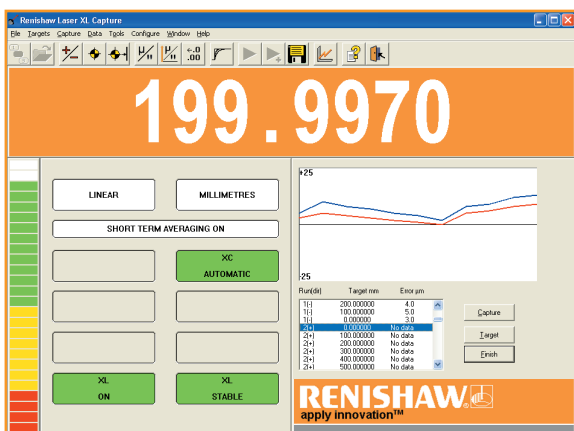
The tripod and tripod case together weigh just 6.2 kg, to complement the portability of the rest of the laser system.



## Dedicated software packages maximise your XL system performance and system benefits

### Software packages

Powerful software and clear but extensive support documentation are key to releasing the potential of the XL-80 system



LaserXL™ software

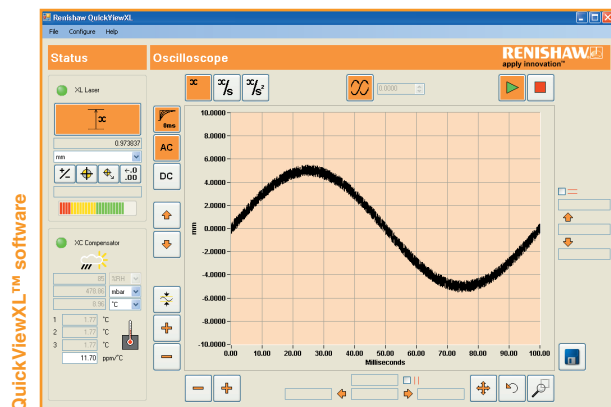
LaserXL™ software includes modules for linear, angular, rotary axis, flatness, straightness and squareness measurements, as well as dynamic measurement capability (see below). Users can select from English or a choice of several main languages for LaserXL™, QuickViewXL™ and system manual.

Standard report options conform to many international machine performance checking standards, such as ISO, ASME, VDI, JIS and GB, and include a comprehensive Renishaw analysis.

The dynamic measurement facility allows the collection of data at rates of 10 Hz to 50 kHz (at 12 preset values) and provides displacement, velocity and acceleration data. There's even an integrated FFT package for frequency analysis.

With optional linear error compensation packages, the data obtained from a LaserXL™ calibration can be used to create

compensation values for use in a CNC machine's controller. This can significantly improve a machine's positioning accuracy. Compensation packages are available to interface with many of today's machine controllers.



QuickViewXL™ software

Live, real-time display of laser measurement data for linear displacement, velocity and acceleration analysis. QuickViewXL™ provides the ideal tool for R&D, as it enables quick and easy investigation, review and characterisation of motion systems.

Both software packages are Windows® XP (SP2 and later) and Vista™ operating systems compatible (32-bit only).

Correct PC specification is vital for system performance. Please check with Renishaw for latest details.

### Support packages

A multi-lingual system manual is supplied on CD with each laser system. This contains written and illustrated set-up procedures for each measurement, calibration tips and analysis information.

It can be installed to your PC and accessed directly using the software Help button or used as a stand-alone reference.

Extra CDs are available free of charge.



## System benefits

### Performance

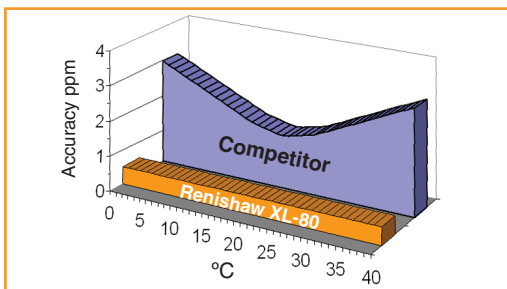


- ±0.5 ppm** certified linear measurement accuracy over the full range of environmental operating conditions
- 1 nm** linear resolution (even at max. velocity)
- 4 m/s** maximum travel velocity
- 7 seconds** between each automatically updated environmental compensation
- 50 kHz** dynamic capture rate
- 80 m** linear range as standard

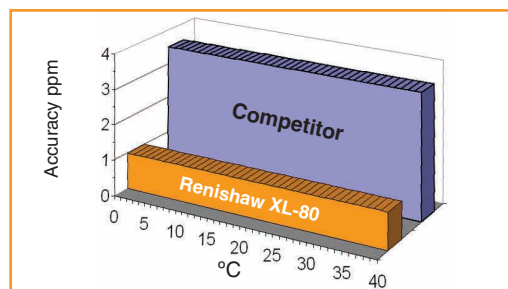
Without reliable and accurate wavelength compensation errors of 20 ppm - 30 ppm would be common

Great effort has been taken to ensure Renishaw's XC-80 compensation system and sensors are accurate across the entire operating range of the system. It is this that maintains ±0.5 ppm linear measurement accuracy from 0 °C - 40 °C (32 °F - 104 °F) and over the full air pressure range (see graph comparisons with competitor system below).

Performance specifications are verified to international procedures against a documented system error budget, with system accuracy quoted to 95% confidence level (k = 2). (see page 11, System performance).



System linear measurement accuracy vs. environmental temperature



Material normalisation accuracy @ 10 ppm/°C

## System benefits

### Ease of use

Easy to use and quick to set-up, the XL-80 allows users to reduce waiting time and increase available measurement time.

- Short preheat time (below six minutes)
- Laser and stage designed for combined storage
- Stage features quick release tripod mounting



- Reduced components and connections. Both laser and compensator connect to your PC via USB; no separate interface, and no complicated set-ups are required
- The XC-80 compensator is powered via its USB connection, so no external power supply is needed

#### Flexibility and ease of operation

- 'Switchable' between standard (40 m) and long (80 m) range modes
- An analogue I/O port allows for analogue and quadrature signal outputs (factory specified option) and a trigger signal input
- Easy to read LEDs for status and signal strength indication
- Uses standard or cordless mouse as trigger for remote manual data capture

### Portability and handling

The small size of the XL-80 laser and XC-80 compensator means that the whole system (less tripod) can now be packed into a truly portable "wheelie-case". A complete linear system in its case weighs around 12 kg. Even with the optional angular optics, accessories and a Renishaw QC10 ballbar kit (see page 10) it weighs just over 16 kg; a highly portable 'check and correct' system that others just can't match.



Base system (left) and full system (right) cases



System 'wheelie-case' and additional tripod case are truly portable

Base system case takes full linear and angular system





## Total confidence

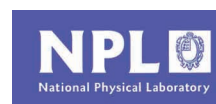
Quality in design, build and technical support are Renishaw hallmarks. That's vital, whether you're dealing in microinches or nanometres

### Design

Renishaw's laser design and manufacturing operations are accredited to ISO 9001:2008 and are subject to regular third party audits. Products are developed in line with rigorous in-house procedures and guidelines, with extensive checks and reviews at each stage.

The system design is based on extensive feedback from laser and non-laser users to design out current system limitations and design in expected future requirements. The XL-80 is designed to allow updates and developments as user requirements change in the future.

The performance of Renishaw laser systems has been independently verified by National Physical Laboratory (NPL), UK and Physikalisch-Technische Bundesanstalt (PTB), Germany.



### Build

Renishaw is big enough to produce nearly all components and assemblies in its own factories.

It has an extensive and modern machine shop, surface finishing and software departments. There's even a complete PCB design, build and test facility.

This in-house manufacture, together with design, gives Renishaw the capability to fully understand and control the design and build process, unlike suppliers who outsource these activities.



# Total confidence

## Test and certification

All XL-80 and XC-80 systems (including sensors) are delivered with comprehensive calibration certificates giving test data in both tabular and graphical format, as well as full details of calibration standards used and of traceability to international standards.

Separate laser and sensor certification allows you to interchange components whilst maintaining traceable accuracy.

## Support

Renishaw sales engineers are renowned for their pre and post sales support. We know that buying a laser system is a major investment for you and your company. Please ask us if you have any questions, we've nothing to hide and we want you to be sure you choose the right solution for your application.

To ensure ongoing performance, Renishaw offers a full in-house recalibration service for components and systems. Alternatively, third party calibration is available from various national standards laboratories including NPL, PTB and NIM (China).

**Product** XL-80 laser  
**Serial Number** H3742  
**Date of calibration** 3 November 2006

**Calibration certificate**

**Specification** Measure wavelength 633.00000770 µm (± 0.05 ppm)  
**Measured values and uncertainties of calibration**

**Results**

Parameter	Value (ppm)	Value (µm)
Wavelength of XL-80	±0.04 (0.02)	-
Laser frequency error	-0.7	0.001
Stability (one to ten)	1.0	0.004
Maximum laser frequency error	1.5	0.005
Uncertainty of measurement (k=2)	0.05	0.001

**Reference standards**

Reference standard	Model	SN/No	Certificate No.	Calibration date
Wavelength laser	DPF87-C1	197	LS00110402	28 January 2004
Frequency counter	99134A	0205	194176	18 November 2005
Reference laser	-	-	-	-

**Authorised Signature** **Signature** **Position** **Issue Date**  
 Jimmy Chalkindis Senior Test Engineer 9 November 2006

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**Calibration notes**

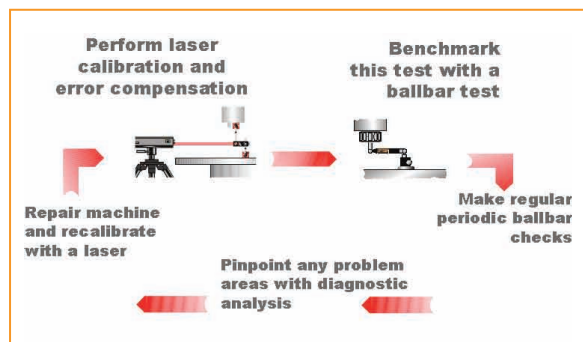
- Laser XL-80 and XC-80** are calibrated by comparison to a reference HeNe laser in a National Physical Laboratory (NPL) 1 µg class reference laser-stabilised HeNe laser. Reference lasers are routinely calibrated at NPL and are used to calibrate the laser under test. The laser under test and the reference laser are both checked onto an available standard by comparison to the laser under test. The laser under test is checked and calibrated using a 1000 frequency divider. The test is run for a period of one hour immediately following switching and stabilisation of the laser (the test period begins two hours after switch on for an XL-80).
- Compass sensors (XC and XC2)** The air pressure sensors are calibrated in a temperature-controlled oven by direct comparison with a reference pressure meter. The pressure is from 800 mbar to 1100 mbar in a range of 100 mbar and is held for 10 minutes at the reference pressure. The oven temperature is controlled to 0.1 °C and 0.1 °C. The reference accuracy (10 mbar) is achieved by comparison of the readings with those from a reference PRT probe with meter at a single applied humidity.
- All temperature sensors (XC and XC2)** are calibrated by direct comparison with transfer semi-standard reference temperature sensors in a temperature-controlled oven bath at various temperatures (0 °C, 10 °C, 20 °C, 30 °C and 40 °C). The transfer semi-standard PRTs are routinely calibrated against reference semi-standard PRTs.
- Motor temperature sensors (XC and XC2)** are calibrated by direct comparison with transfer semi-standard PRTs in a temperature-controlled oven bath at various temperatures of 0 °C, 10 °C, 20 °C, 30 °C, 40 °C and 50 °C. The transfer semi-standard PRTs are routinely calibrated against reference semi-standard PRTs.
- Ballbar transducers (DCH)** are calibrated using a reference HeNe laser interferometer system. The scale factor which should be entered into the Renishaw application software prior to use is calculated. New balls (nominal diameter: 12.7 mm, and sphericity: 0.25 µm) have been fitted and their sphericity is validated by the test manufacturer.
- Zenith® calibration** are calibrated by direct comparison with a reference Zenith® calibrator (calibrated by a national standards laboratory) using a reference QC10 ballbar as a transfer device. The measured values for the Zenith® calibrator should be entered into the Renishaw application software prior to use.
- Traceability** All the reference standards listed above used in these calibrations are traceable to international standards. In the UK this is either directly to NPL, or to NPL via a UKAS accredited calibration house. NPL is a signatory to the CIPM Mutual Recognition Agreement. At each of the NPL's standards and their calibration and measurement capabilities is recognised by all major national metrology institutes who have signed the agreement (e.g. UK, France, NIST, USA, PIR, Germany, NMI, Japan).
- Environment** The equipment used for calibration is in a facility between 18 °C and 22 °C.
- Uncertainty calculations** The uncertainty calculations have been carried out according to the European Cooperation for Accreditation document EA-02/02.
- Quality accreditation** All calibrations above are covered by Renishaw's EN ISO 9001:2000 quality management system. The system is also certified by a UKAS calibration agency. UKAS accreditation is recognised in many countries world-wide by the relevant national body in that country.
- Re-calibration** Customers may wish to confirm that systems are performing when published specifications over time. It is recommended that they should be periodically re-calibrated. Please refer to the appropriate system manual for further details.

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# Ballbar and laser, working together for maximum benefit

The Renishaw QC10 ballbar system is internationally recognised as the ideal solution to quickly check machine tools and is ideal for use in between scheduled laser calibrations.



## Your guarantee



With extensive in-house manufacturing and years of experience, Renishaw has the confidence to offer a 3 year system warranty as standard. An extension to 5 years is available for a small price premium (please ask for details).

Recognising this, both the XL system cases will accept an optional tray to securely hold all standard QC10 kit components.

This provides a portable 'check and correct' system that others just cannot match.




## XL-80 laser system: main specifications

<b>Laser head XL-80</b>	
Dimensions (weight)	214 mm x 120 mm x 70 mm (1.85 kg)
Power supply	External, 90 V AC - 264 V AC, auto sensing
System measurement capability	Linear, angular (and rotary), flatness, straightness and squareness
Laser output	
Interface	Integral USB comms, no separate interface
TPin (trigger signal)	Yes
Quadrature signal output	Yes (factory option)
Analogue voltage output	Yes
Signal strength LEDs	Yes

### Your XL laser is supplied as a kit including:


- XL laser unit (with standard shutter)
- USB cable
- Power supply and cables
- Aux I/O connector
- System manual (CD-ROM)

<b>System performance</b>		
Linear measurement range	80 m	
Linear measurement accuracy	±0.5 ppm	
Laser frequency accuracy	±0.05 ppm	
Resolution	1 nm	
Maximum travel velocity	4 m/s*	
Dynamic capture rate	10 Hz - 50 kHz**	
Preheat time	<6 minutes	
Specified accuracy range	0 °C - 40 °C	
Environmental sensors		
	Range	Accuracy
Material temperature	0 °C - 55 °C	±0.1 °C
Air temperature	0 °C - 40 °C	±0.2 °C
Air pressure	650 mbar - 1150 mbar	±1 mbar
Relative humidity (%)	0% - 95% non-condensing	±6% RH
* 1.6 m/s (80 nm quadrature); 0.2 m/s (10 nm quadrature)		
** 20 MHz in quadrature mode		

<b>Environmental compensator XC-80</b>	
Dimensions (weight)	135 mm x 58 mm x 52 mm (490 g)
Power supply	Powered via USB from PC
Internal sensors	Air pressure Relative humidity
Remote sensors	1 air temperature 1 - 3 material temperature
Interface	Integral USB comms, no separate interface

### Your XC compensator is supplied as a kit including:

- XC compensator unit
- Air temperature sensors kit
- Material temperature sensor kit
- USB cable
- System manual (CD-ROM)

<b>System cases and tripod</b>		
	Case 1 (base system)	Case 2 (full system)
Case dimensions (L x H x D)	560 mm x 351 mm x 229 mm	560 mm x 455 mm x 265 mm
QC10 ballbar kit provision*	Yes	Yes
System weight**	12 kg - 17 kg	16 kg - 25 kg
	Universal tripod base	
Dimensions folded with boss (weight)	Ø160 mm x 640 mm (3.9 kg)	
Working height range (to laser output beam)	Minimum: 540 mm Maximum: 1560 mm (column up)	
Tripod case	Armoured nylon bag**	
Case dimensions	670 mm x 170 mm x 170 mm	
* Optional lid inserts available to take standard QC10		
** System in case weight depends upon options specified Lower weights indicated are for: Case 1: Linear XL and XC system Case 2: Linear, angular and straightness XL and XC system		
*** Rigid tripod case available as an option		

<b>Other</b>	
Warranty	3 years (with 5 year option)
Certification	XL, XC, air and material temperature sensors. Certificates comply with requirements of ISO 17025.
Quality system	ISO 9001, BSI certified

## Measurement optics

The XL-80 system uses the same range of optics as Renishaw's ML10 system, covering linear, angular (including rotary axes), straightness, squareness and flatness measurements. All measurements are interferometric and therefore use the traceable international standard wavelength of laser light.



Other systems which use electronic targets to measure pitch, yaw and straightness errors, often compromise measurement accuracy and stability.



For rotary axis measurements the RX10 rotary axis kit is available. This high precision indexing table, when used with the XL-80 system and angular optics, gives fully automatic calibration of axes, with  $\pm 1$  arc sec accuracy.

## Optics accessories

### LS350 beam steerer

This unique patented optic provides easy angular adjustment of the laser beam in both horizontal and vertical planes, making laser alignment a simple one step process. The beam steerer speeds up linear, angular and straightness measurements, whether in-line or at  $90^\circ$ . The optic is also compatible with the linear/angular combination kit and swivel/ fixed turning mirrors. Clamping screws allow the beam steerer to be easily attached to measurement optics.



Specification	Metric	Imperial
Steering angle range	$\pm 35$ mm/m	$\pm 2^\circ$
Axial range	0 m – 10 m	0 ft – 33 ft

### Swivel mirror

This mirror can be used as an alignment aid for ANSI B5.54 diagonal measurements. It is also useful when measuring slant-bed lathes. Clamping screws allow the mirror to be easily attached to measurement optics.



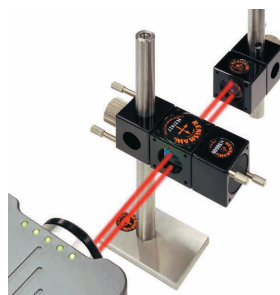
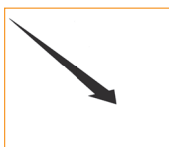
### Fixed turning mirror

This mirror reflects the laser beam through  $90^\circ$ . Like the swivel mirror, it can be attached to the measurement optics to aid optical set-up and is used primarily when there is restricted access to the required axis of measurement.



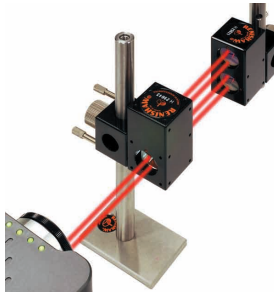
## Measurement specifications

### Linear



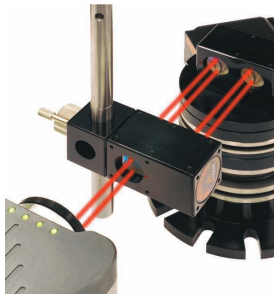
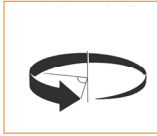
Specification	Metric	Imperial
Linear measurement range	0 m – 80 m	0 in – 3200 in
Measurement accuracy (with XC-80 compensator)	$\pm 0.5$ ppm (parts per million)	
Resolution	0.001 $\mu$ m	0.1 $\mu$ in
For measurements over 40 m it is recommended to use the long range linear accessory kit.		
Performance specifications for linear (above) and other measurement modes are quoted to 95% confidence level ( $k = 2$ ), and are valid across the full environmental operating range.		

## Angular



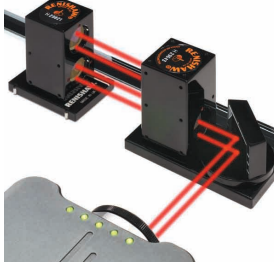
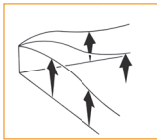
Specification	Metric	Imperial
Axial range	0 m - 15 m	0 in - 590 in
Angular measurement range	±175 mm/m	±10°
Angular accuracy	±0.2%* ±0.5 ±0.1M μm/m	±0.2%* ±0.1 ±0.007F arc sec
Resolution	0.1 μm/m	0.01 arc sec
Where M = measurement distance in metres; F = measurement distance in feet % = percentage of calculated angle * With high accuracy angular optics (± 0.6% with standard optics)		

## Rotary



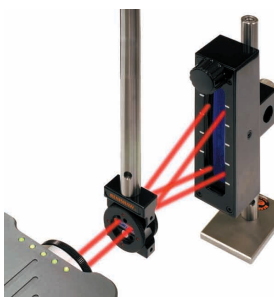
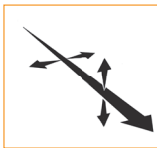
Specification	Metric	Imperial
Angular range	Unlimited	
Indexing accuracy (standard)	±5 μm/m	±1 arc sec
Repeatability	1 μm/m	0.2 arc sec
Mounting	Top or bottom faces for spindle or table location	
Axis of rotation	Vertical or horizontal	
Control	Automatic via RS232 to PC	
Maximum velocity of indexer table	30 rpm when the measurement step size is less than 10° 2 rpm when measurement step size is more than 10°	

## Flatness



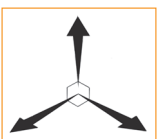
Specification	Metric	Imperial
Axial range	0 m - 15 m	0 in - 590 in
Flatness measurement range	±1.5 mm	±0.06 in
Accuracy	±0.6% ±0.02 M <sup>2</sup> μm	±0.6% ±0.08 F <sup>2</sup> μin
Resolution	0.01 μm	1 μin
Foot spacing	50 mm, 100 mm and 150 mm	2 in, 4 in and 6 in (approx)
Where M = length of the diagonal in metres; F = length of the diagonal in feet; % = percentage of calculated flatness		

## Straightness



Specification	Metric	Imperial
Axial range (short range)	0.1 m - 4.0 m	4 in - 160 in
(long range)	1 m - 30 m	40 in - 1200 in
Straightness measurement range	±2.5 mm	±0.1 in
Accuracy (short range)	±0.5% ±0.5 ±0.15 M <sup>2</sup> μm	±0.5% ± 20 ±0.5 F <sup>2</sup> μin
(long range)‡	±2.5% ±5 ±0.015 M <sup>2</sup> μm	±2.5% ±200 ±0.05 F <sup>2</sup> μin
Resolution (short range)	0.01 μm	1 μin
(long range)	0.1 μm	10 μin
Where M = measurement distance in metres; F = measurement distance in feet; % = percentage of displayed value ‡ subject to environmental conditions		

## Squareness



Specification	Metric	Imperial
Range	±3/M mm/m	±2000/F arc sec
Accuracy (short range)	±0.5% ±2.5 ±0.8 M μm/m	±0.5% ±0.5 ±0.05 F arc sec
(long range)	±0.5% ±2.5 ±0.08 M μm/m	±2.5% ±0.5 ±0.005 F arc sec
Resolution	0.01 μm/m	0.01 arc sec
Where M = measurement distance in metres of the longest axis; F = measurement distance in feet; % = percentage of displayed value		

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## About Renishaw

Renishaw is an established world leader in engineering technologies, with a strong history of innovation in product development and manufacturing. Since its formation in 1973, the company has supplied leading-edge products that increase process productivity, improve product quality and deliver cost-effective automation solutions.

A worldwide network of subsidiary companies and distributors provides exceptional service and support for its customers.

### Products include:

- **Dental CAD/CAM** scanning and milling systems
- **Encoder systems** for high accuracy linear, angle and rotary position feedback
- **Laser and ballbar systems** for performance measurement and calibration of machines
- **Medical devices** for neurosurgical applications
- **Probe systems and software** for job set-up, tool setting and inspection on CNC machine tools
- **Raman spectroscopy systems** for non-destructive material analysis
- **Sensor systems and software** for measurement on CMMs (co-ordinate measuring machines)
- **Styli** for CMM and machine tool probe applications

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