RENISHAW
apply innovation™

Accuracy at the point of contact

2.1



Accuracy at the point of contact

As industry has developed its requirement for increasingly diverse and complex manufactured parts, inspection systems have had to work hard to keep up. The use of co-ordinate measuring machines (CMMs) with probing systems and in-process inspection on machine tools are two of the solutions offered by Renishaw to help you maximise your productivity and maintain the highest quality.

Successful gauging depends very much on the ability of the probe's stylus to access a feature and then maintain accuracy at the point of contact. At Renishaw, we have used our expertise in probe and stylus design to develop a comprehensive range of CMM and machine tool styli to offer you the greatest possible precision.

These notes explain the critical features of every stylus type, helping you to choose the right design for each inspection need.

What is a stylus?

A stylus is that part of the measuring system which makes contact with the component, causing the probe's mechanism to displace. The generated signal enables a measurement to be taken. The feature to be inspected dictates the type and size of stylus used. In all cases, however, maximum rigidity of the stylus and perfect sphericity of the tip are vital.

To achieve this, Renishaw's stylus stems are produced on CNC machine tools to exacting standards. Great care is taken to ensure that location faces give maximum stiffness whilst stylus mass is optimised to suit Renishaw's range of probes.

Genuine Renishaw stylus balls are produced to the highest standards and are bonded to the stems in such a way as to ensure maximum joint integrity.

The performance of your gauging can easily be degraded if you use a stylus with poor ball roundness, poor ball location, bad thread fit or a compromised design that allows excessive bending during measurement. To ensure the integrity of the data you gather, make certain that you specify and use a stylus from the comprehensive range of genuine Renishaw styli.

What naming protocol do Renishaw use to describe their styli range?

Renishaw uses the following naming protocol to allow easy identification of styli by name and part number. The examples below show how this protocol is assigned and describe the abbreviations used:

Straight styli

M2 STY D2R L20 EWL14 d1.4SS

The above protocol describes an M2 threaded straight stylus fitted with a 2 mm diameter ruby ball. It has an overall length of 20 mm, has an effective working length (EWL) of 14 mm and has a 1.4 mm diameter stainless steel stem.

Star styli

M2 STR D2R L20 5BALL L19.5 S32

The above protocol describes an M2 threaded star stylus fitted with a 2 mm diameter ruby ball. It has 5 balls on the star and an overall length of 19.5 mm (from the centre of the ball to the rear of the star mounting face when assembled to a probe). The span of the star cluster is 32 mm.

Disc styli

M2 DSC SD18 SLVS T2.2 L2.6 BR-Y

The above protocol describes an M2 threaded disc stylus with a spherical diameter disc of 18 mm. It is made from silver steel with a disc thickness of 2.2 mm and a length of 2.6 mm. BR stands for balls/rollers followed by yes (Y) or no (N).

Cylinder styli

M2 CYL D3 SLVS L13 EWL4

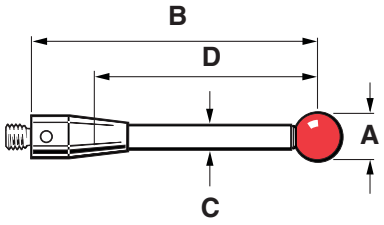
The above protocol describes an M2 threaded cylinder stylus with a critical measuring element diameter of 3 mm made from silver steel. It has an overall length of 13 mm and an EWL of 4 mm.

Extensions

M4 EXT L15 d7 SS

The above protocol describes an M4 threaded extension with a length of 15 mm diameter and a diameter of 7 mm. The extension is made from stainless steel.

Terminology



A Ball diameter
B Overall length
C Stem diameter
D Effective working length

Overall length

Renishaw uses a standard description of overall length, measuring from the rear mounting face of the stylus to the centre of the ball.

Effective working length (EWL)

This is measured from the centre of the ball to the point at which the stem will foul against the feature when measuring 'normal' to the part.

Choosing a stylus

To maintain accuracy at the point of contact we recommend that you:

Keep styli short

The more that a stylus bends or deflects, the lower the accuracy. Probing with the minimum stylus length for your application is the best option.

Minimise joints

Every time you join styli and extensions, you introduce potential bending and deflection points. Try, wherever possible, to keep to the minimum number of pieces for your application.

Keep the ball as large as possible

There are two reasons for this;

- firstly, it maximises your ball/stem clearance thereby reducing the chances for false triggers caused by 'shanking out' on the stylus stem
- secondly, the larger ball reduces the effect of the surface finish of the component being inspected.

The range of genuine Renishaw styli

Ball material

Ruby

The industry standard and the optimum stylus ball material for a vast majority of measurement applications, ruby is one of the hardest known materials. Synthetic ruby is 99% pure aluminium oxide which is grown into crystals (or “boules”) at 2000 °C using the Verneuil process.

The boules are then cut and gradually machined into a highly spherical form. Ruby balls are exceptionally smooth on the surface, have great compressive strength and a high resistance to mechanical corrosion.

Very few applications exists where ruby is not the preferred ball material, however there are two applications where balls manufactured from other materials are recommended.

The first is for heavy duty scanning applications on aluminium. Because the materials attract, a phenomenon known as ‘adhesive wear’ can occur which involves build up of aluminium from the surface onto the ball. A better ball material for such applications is silicon nitride.

The second is in heavy duty scanning applications on cast iron. Interaction between the two materials can result in ‘abrasive wear’ of the ruby ball surface. For such applications, Zirconia balls are recommended.

Silicon nitride

Silicon nitride possesses many similar properties to ruby. It is a very hard and wear-resistant ceramic which can be machined into very high precision spheres. It can also be polished to an extremely smooth surface finish. Silicon nitride does not have the attraction to aluminium and so does not exhibit the adhesive wear seen with ruby in similar applications. However, silicon nitride does show significant abrasive wear characteristics when scanning on steel surfaces and so its applications are best confined to aluminium.

Zirconia

Zirconia is a particularly tough ceramic material with hardness and wear characteristics approaching those of ruby. Its surface properties make it an ideal material for aggressive scanning applications on cast iron components.

Stem material

Steel

Stylus stems manufactured from stainless steel are used widely for styli with ball/tip diameters of 2 mm or greater and with lengths up to 30 mm. Within this range, one-piece steel stems offer the optimum stiffness to weight ratio, giving adequate ball/stem clearance without compromising stiffness with a joint between the stem and threaded body.

Please contact us if you require any styli with special ball materials. We can recommend the most suitable material for scanning different materials

Tungsten carbide

Tungsten carbide stems are best used for maximising stiffness with either small stem diameters required for ball diameters of 1 mm and below, or lengths up to 50 mm. Beyond this, weight can become a problem and stiffness is lost due to deflection at the stem to body joint.

Ceramic

For ball diameters greater than 3 mm, and lengths over 30 mm, ceramic stems offer stiffness comparable to steel but are significantly lighter than tungsten carbide. Ceramic stemmed styli can also offer additional crash protection to your probe as the stem will shatter in a collision.

Carbon fibre (Renishaw GF)

There are many grades of carbon fibre materials. However, Renishaw GF combines optimum stiffness characteristics, both longitudinally and in torsion (important in star constructions), with extremely low weight. Carbon fibre is inert and this, combined with a special resin matrix, provides excellent protection in the most hostile of machine tool environments.

Renishaw GF is ideal for maximising stiffness while giving very low mass for styli above 50 mm in length. It is the optimum stem material for high accuracy strain gauge technology probes with excellent vibration damping characteristics and negligible co-efficient of thermal expansion.

The genuine Renishaw stylus range comprises several types:

Straight styli



These are the simplest form of stylus, incorporating highly spherical industrial ruby balls and a choice of stem material.

Ruby is an extremely hard material and hence stylus wear is minimised. It is also of low density, keeping tip mass to a minimum, which avoids unwanted probe triggers caused by machine motion or vibration.

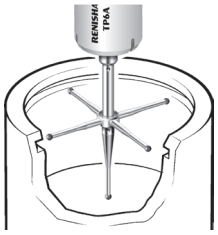
Mounted on stems made from a range of materials – stainless steel, tungsten carbide, ceramic and a specialised carbon fibre material, “Renishaw GF” – these simple ruby ball styli are suitable for most inspection applications.

Each stylus has an effective working length (EWL) which is the penetration that can be achieved by the ball before the stem fouls against the feature.

The size of the ball and the EWL of the stylus chosen are dictated by the size of the feature to be inspected. However, keeping the stylus ball as large as possible and the stem as short as possible will ensure maximum ball/stem clearance, whilst providing a greater yet still rigid EWL. Using larger ruby balls also reduces the effect of the surface finish of the component being inspected.

Probing with very long stylus/extension combinations is not recommended with standard kinematic touch trigger probes as the rigidity is reduced and accuracy lost due to stylus bending. This is not the case with other types of probe such as those with strain gauge technology, as their very low trigger forces permit the use of long stylus/extension combinations without a significant loss of accuracy.

Star styli



These stylus clusters provide you with multiple-tip probing of complex features and bores. Four or five ruby ball systems are mounted rigidly on a stainless steel centre. Three standard sizes are offered – alternatively, you can create custom-made star styli using a 5-way stylus centre and any of the genuine Renishaw stylus range.

Star styli can be used to inspect a variety of different features. Their use can reduce inspection cycle times by allowing multi-tip probing, minimising the need to move the probe to extreme points of internal features such as the sides or grooves in a bore. Using star styli also allows effective probing in the –Z (upwards) direction when using a 5-way probe, provided that the stylus tips extend beyond the diameter of the probe body. Each tip on a star stylus requires datuming (sometimes referred to as ‘qualifying’ or ‘calibrating’) in the same manner as a single-ball stylus. The 'span' of star styli is taken from ball centre to ball centre.

Disc styli



These styli are used to probe undercuts and grooves within bores which may be inaccessible to star styli. They are ‘sections’ of highly spherical balls and are available in various diameters and thicknesses. Full rotational adjustment and the ability to add a centre stylus are features of the Renishaw range of disc styli that make them particularly flexible and easy to use.

Probing with the 'spherical edge' of a simple disc is effectively the same as probing on or about the equator of a large stylus ball. However, only a small area of this ball surface is available for contact and hence thinner discs require careful angular alignment in order to ensure correct contact with the feature being probed.

A simple disc requires datuming for only one diameter (usually in a ring gauge), but limits effective probing to only X and Y directions.

Adding a 'radius end roller' allows you to datum and hence probe in the Z direction, provided that the centre of the 'radius end roller' extends beyond the diameter of the probe. The 'radius end roller' can be datumed on a sphere or a slip gauge. Rotating and locking the disc about its centre axis allows the 'radius end roller' to be positioned to suit the application.

Discs may also have a threaded centre to allow the fixing of a centre stylus, giving the additional flexibility of probing the bottom of deep bores (where access for the disc may be limited).

Styli for specialist applications

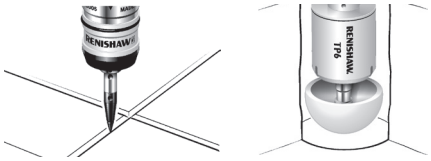
A range of specialist styli is available to enable probing of features such as thread form, thin sectioned material, tool setting and other specialist applications.

Cylinder styli



These are used for probing holes in thin sheet material. In addition, various threaded features can be probed and the centres of tapped holes located. Ball-ended cylinder styli allow full datuming and probing in X, Y and Z directions, thus allowing surface inspection to be performed.

Pointer and ceramic hollow ball styli



Pointer styli are designed for the inspection of thread forms, specific points and scribed lines (to lower accuracy). The use of a radius end pointer stylus allows more accurate datuming and probing of features as detailed above and can also be used to inspect the location of very small holes.

Ceramic hollow ball styli are ideal for probing deep features and bores in X, Y and Z directions, with the need to datum only one ball. There are two versions in the range, 18 and 30 mm diameter, specially designed for the TP2 / TP20 / TP200 and TP6 probes respectively. Probing with such a large diameter ball can average out the effects of very rough surfaces.

Tool setting styli



Typically, these are fitted with a square tip and can have threaded or plain shaft attachments. The tip faces are ground to ensure high squareness and parallelism. The TS27R tool setting probe for machining centres can also be fitted with a tungsten carbide disc stylus.

Crash protection devices



Renishaw's stylus crash protection devices are designed to break in the event of impact and protect the probe from damage.

Accessories and tools

A wide range of accessories including extensions, 4 and 5-way centres and stylus knuckles complement the genuine Renishaw stylus range to achieve fully flexible inspection.

Stylus centres



These provide maximum probing flexibility with a single probe. Taking up to five styli of the same mounting thread, this accessory allows you to build stylus configurations to your own specification.

Stylus knuckles



These give full adjustment about two axes, allowing the stylus to be orientated to probe angled features. This adjustment is especially useful when the probe cannot be correctly orientated by the probe head, or when access for the head is limited.

Stylus extensions



These provide additional probing penetration by extending the stylus away from the probe. However, using stylus extensions can reduce probe accuracy due to loss of rigidity. This is not the case with electronic probes, whose extremely low trigger forces render them less sensitive to this type of inaccuracy.

Stylus thread adaptors



These allow M2, M3, M4 and M5 threaded styli to be interchanged on the majority of touch trigger probes. They are particularly useful for adapting the extensive range of specialised application M2 styli for use on larger probes.

Stylus tools

Specifically designed for mounting styli correctly onto probes and for the construction of specialised stylus combinations, Renishaw's stylus tools protect your investment.

The S7 stylus tool



The stylus tool is used for tightening styli and accessories when connecting to one another or directly into the probe.
It is specifically designed to yield if excessive tightening force is applied, avoiding damage to the threads of stylus and probe.

A stylus crank



A stylus crank can allow access to features that are otherwise difficult to reach, and are often used in lathe inspection applications.

Renishaw stylus kits

Renishaw styli and accessories are available in a wide selection of kits, ranging from a small precision set of the most frequently used styli, to a comprehensive set to meet virtually every inspection need.

Some sets are housed in a quality wooden case for maximum protection and superb presentation. The styli are held in a wood insert, individually located in a nylon sleeve providing protection for the mounting threads. This type of box features a removable module which houses up to twelve ruby ball styli and contains a tray for discs, tools and accessories. This allows the stylus selection for a particular inspection task to be brought to the CMM's table. The sloping lid design of this kit provides easy access to styli, minimising handling of ruby balls and contact surfaces, thus aiding cleanliness.

Probing kits are also available to include a probe, probe head, extension bars and styli.

Custom design service

Renishaw's Styli division offers a unique service by providing customers with a total custom stylus solution for their probing needs for CMM, machine tool, Equator or scanning applications, where a standard stylus may not be suitable.

The division includes expertise in applications, design, engineering and manufacturing with extensive experience in providing tailor-made stylus product solutions to specific customer's requirements.

Our expertise allows us to develop a product that satisfies customer demand for accuracy, piece part feature inspection, delivery and cost. All of these aspects are considered within the design of a custom stylus, ensuring that the solution incorporates the ideal choice of ball & stem materials and optimises probe performance for your particular application.

Renishaw's Styli division has designed over 10,000 different custom styli for a wide range of probing applications worldwide ranging from aeronautical & automotive to high volume manufacturing, so the solution to your application problem may already exist.

For advice and further details, please contact your nearest Renishaw distributor.

We always recommend using Renishaw styli in order to maximise your quality & probing performance.

RENISHAW
apply innovation™

Custom stylus request form

2.7

Please complete the form and send it back to us. Our design team will review the supplied information and present you with a solution for your application.

Customer	_____	**Customer email**	_____
Company	_____	**Customer telephone**	_____

Stylus information

Type of stylus (please indicate on diagrams below) Other* ☐ * Please attach as much information as possible, including a sketch of the stylus.

Thread M2 ☐ M3 ☐ M4 ☐ M5 ☐ Other _____

Tip material Ruby ☐ Silicon nitride ☐ Stainless steel ☐ Tungsten carbide ☐ Zirconia ☐

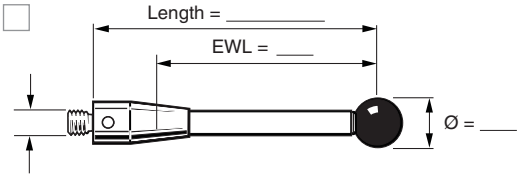
Stem material Carbon fibre ☐ Ceramic ☐ Stainless steel ☐ Tungsten carbide ☐

Quantity of styli required _____

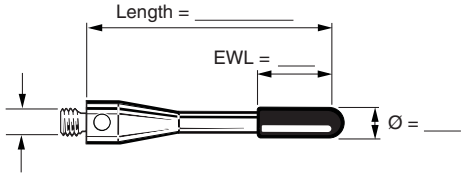
Type of stylus

Dimensions given are: Metric (mm) ☐ Imperial (in) ☐

A ☐



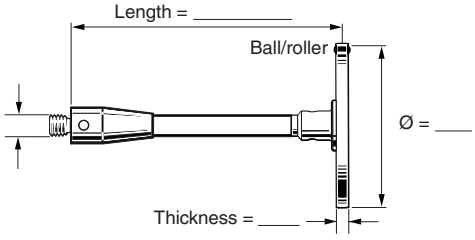
B ☐



C ☐

Is there a ball/roller? Yes ☐ No ☐

If yes, please specify height of ball/roller: _____



Probe information

Type of probe _____

Material being measured _____

Orientation Vertical ☐ Horizontal ☐

Application Scanning ☐ Inspection ☐

Additional information

Grade 3 high accuracy styli

With the increased use of very high accuracy CMMs, the specification of the stylus ball has become a significant factor when calculating error budgets. High precision measuring machines require precision styli. Renishaw offers grade 3 styli with a form deviation of ± 0.08 microns.

The sphericity of your stylus ball can affect your CMM measurements. To ensure the accuracy of your measurements, use a minimum of AFBMA 3290 / DIN 5401-11.1993 Grade 5 balls.

As standard, Renishaw uses Grade 5 stylus balls with a sphericity of 0.13 µm and not the lesser Grade 10 balls that most other manufacturers use.

Grade 3 balls, with a sphericity of 0.08 µm, are also available.

Grade 3 ball design considerations:

Investigations into the effect of the design and construction of styli using such a highly specified ball have indicated that the form of the ball can be degraded by machining a hole in it and through distortion from gluing it onto a spigot. Renishaw has researched ways to improve the design of the high accuracy Grade 3 ball styli.

All Grade 3 styli being produced by Renishaw are constructed using an undrilled ball bonded into a spherical cup. Measurements taken before and after assembly of this design have shown that the form of the ball remains well within specification throughout the process.

In order to easily identify a Grade 3 ball stylus, the stems are coated in Titanium Nitride, giving them a gold coloured finish.

Due to limits of measurement capability and bond strength, Grade 3 ball styli are only available with a minimum ball diameter of 1 mm. The styli are not serialised and are supplied with a certificate of roundness.

Contact your local Renishaw office for more details.