Brochure

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Discover RENGAGE™ technology – high-accuracy machine tool probes with market-leading performance

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The evolution of machine tool probing technology

Renishaw invented the touch-trigger probe for machine tools in the 1970s. The success of this innovation, based on a kinematic resistive principle, has contributed to Renishaw's status as a world leader in the design, manufacture and support of dimensional measurement products. The basis of this design continues to play a valuable role in part set-up, measurement and process control.

Decades of continuous investment in development enables Renishaw to provide high-quality products with leading-edge performance. This guide compares probes with RENGAGE™ technology with those of conventional probe design and illustrates RENGAGE technology's superior performance capabilities based upon 'real world' tests.

RENGAGE technology delivers exceptional three-dimensional (3D) measurement performance and sub-micron repeatability. Due to their innovative design and outstanding capability, Renishaw probes with RENGAGE technology outperform high-accuracy machine tool probes available from other manufacturers.

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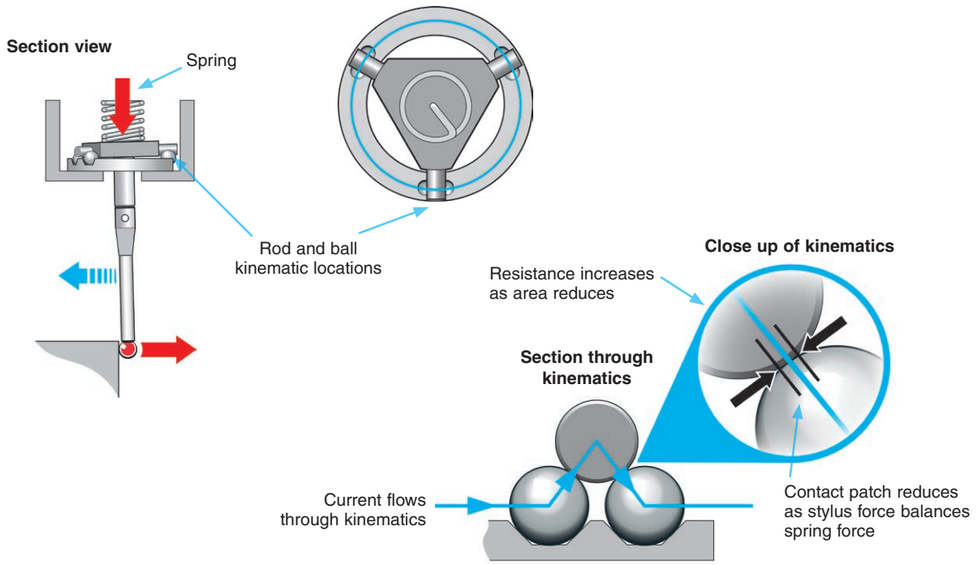
Conventional probe technology

Kinematic resistive probes

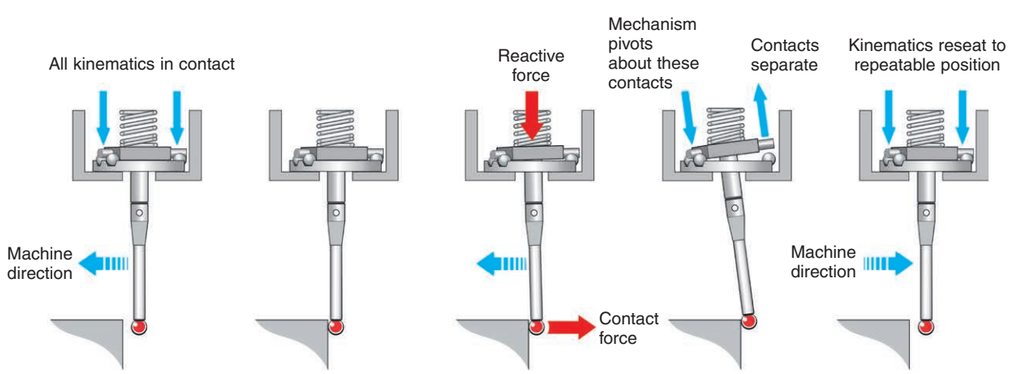
Inside a kinematic resistive probe, three equally-spaced rods rest on six tungsten carbide balls to provide six points of contact in a kinematic location. An electrical current flows between the balls and the rods.

A spring-loaded mechanism allows the probe stylus to deflect when it makes contact with the workpiece. Upon making contact with a workpiece, the force translated through the stylus moves the balls and rods apart, reducing the size of the contact patches and increasing their electrical resistance. The probe is triggered when a defined threshold is reached.

When the stylus is no longer in contact with the workpiece, the probe mechanism returns to its original position (reseats) to within 1 µm 2σ.

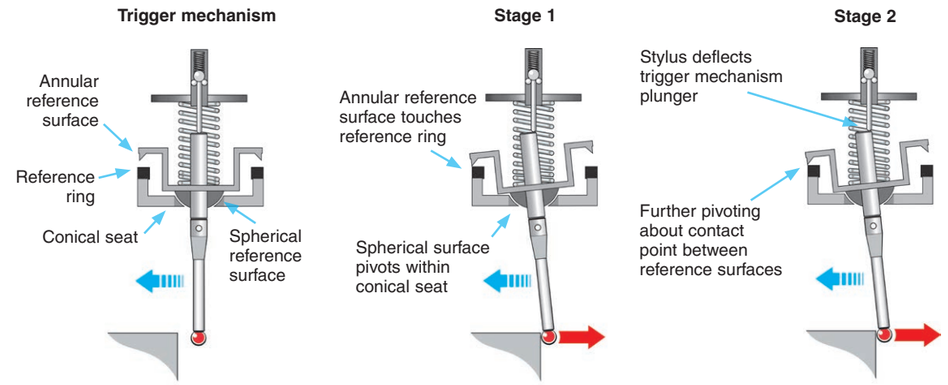


The stages in trigger generation for a kinematic resistive probe are shown below. Repeatable electrical triggering and mechanical reseating of the mechanism are fundamental to reliable metrology.



Other types of probes

Spherical seat or pivoting type probes are common alternative designs. Theory suggests that these designs provide uniform trigger force in the XY plane. However, the reality is very different because this is dependent upon the precision of the manufactured sphere and conical seat surfaces, and the relationship between the two. Therefore, in practice, trigger forces are highly variable.



The major drawbacks of this design are:

1. The stylus is not uniquely located because the relationship between the sphere and conical seat does not constrain all degrees of freedom. The mechanism can rotate and is not suitable for star-styli.
2. The free motion of the mechanism typically results in a significant stylus deflection before the probe triggers.
3. A high contact force between the stylus and the workpiece may mark the workpiece.

Probe lobing

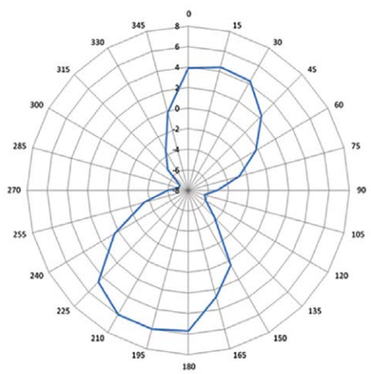
Lobing is a characteristic of all probes. It is caused by bending of the stylus and movement of the probe mechanism before the probe registers contact with a surface. It is therefore dependent upon:

- Length and stiffness of the stylus
- Force required to trigger the probe
- Direction of contact with the surface
- Design of the probe mechanism

All probes will therefore exhibit some lobing, which when plotted can resemble the irregular shape opposite.

For two axis measurement, potential errors are relatively easy to calibrate out. In three axis measurement however, lobing errors are greater and more complex to compensate for, particularly with some conventional probes.

These errors are significant and can adversely impact accuracy and repeatability in 3D measurement.



Example lobing plot (X-Y only) for conventional spherical seat type probe

RENGAGE™ technology

Engineered for over a decade and patented by Renishaw, probes with RENGAGE™ technology incorporate proven silicon strain gauge technology with ultra-compact electronics and precision mechanical design to achieve unparalleled performance and capabilities. Suitable for a wide range of machine tool applications and able to address the 3D performance limitations of many alternative probe designs, Renishaw's MP250, OMP400, RMP400, OMP600 and RMP600 models are the latest products to include this technology.

Strain gauges are positioned on carefully designed webs, forming part of the probe's structure, yet are separate from the kinematic mechanism. The strain gauges are arranged to sense strains in all axes and their outputs are electronically combined using patented algorithms.

On reaching a resistance threshold in any direction, a trigger signal is generated at forces that are much lower than those required to trigger conventional probes.

As sensing is completely independent of the probe mechanism, probes with RENGAGE technology feature low force, highly repeatable, and consistent trigger characteristics that are not typically achievable with conventional probe designs.

By using RENGAGE technology, it is possible to eliminate up to 90% of lobing errors.

For two-axis applications, strain gauge probes can eliminate the need for significant calibration. However, the benefits can really be seen when used in three-axis applications and during the measurement of complex geometry. It is in these applications that probes with RENGAGE technology are unique.

Probes with RENGAGE technology still use Renishaw's kinematic mechanism to reseat the stylus. This system, proven over 30 years, ensures a repeatable reseat and is fundamental to accurate metrology.

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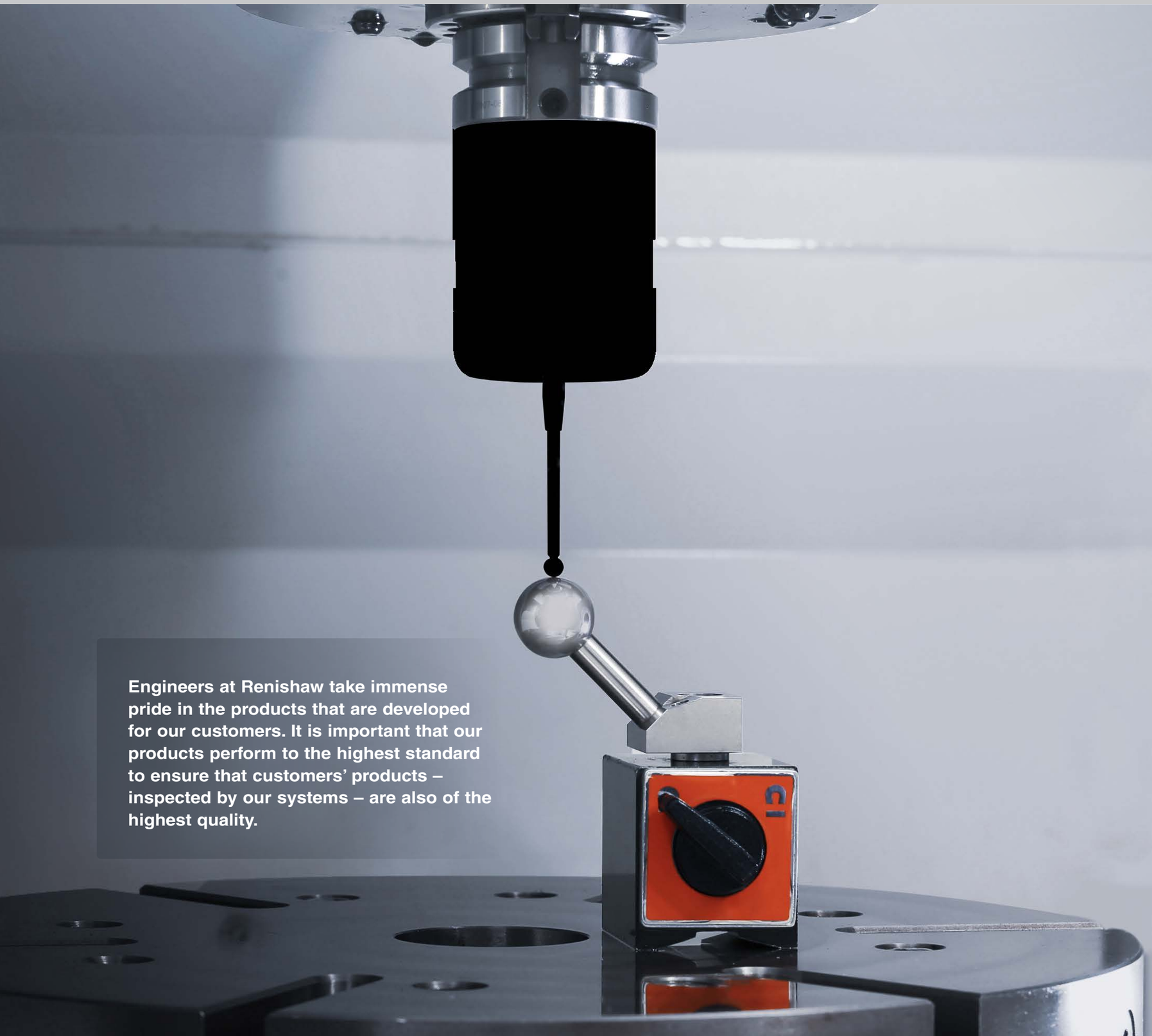

Engineers at Renishaw take immense pride in the products that are developed for our customers. It is important that our products perform to the highest standard to ensure that customers' products – inspected by our systems – are also of the highest quality.

Benchmarking RENGAGE™ technology

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Renishaw states that the performance of its high-precision machine tool probes with RENGAGE™ technology is "unrivalled". Transparency is as central to Renishaw's culture as the spirit of innovation, so to confirm the accuracy of these claims, Renishaw tested the OMP400 probe alongside five touch-trigger probes from other manufacturers – probes "A", "B", "C", "D" and "E". These probes are either low force versions of conventional probing systems or specially engineered high-accuracy probes.

To determine a realistic assessment of the performance of each probe, Renishaw ensured that each probe completed a thorough test programme – increasing dwell time and re-running the tests where necessary. This enabled each probe to provide results that can be used to benchmark performance.

Testing probe performance

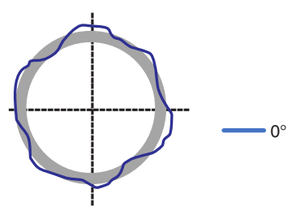
A consistent set of metrics is needed to compare the performance of the probes being tested. 2D form error, 3D form error and repeatability have been chosen, as these performance characteristics are critical in order to produce accurate components.

2D performance

The 2D performance is measured by finding the form error of a 2D feature.

In this test, the radius of a calibrated sphere was measured by taking points around its equator. The difference between the minimum and the maximum measured radius found by these points is the 2D form error.

Given that the dimensions of the sphere are known precisely, the form error must be generated by the probe. The lower the 2D form error of the probe, the better the 2D performance.



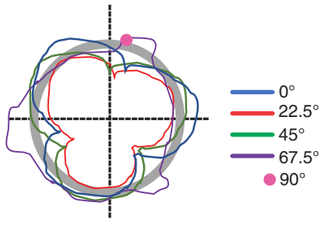
A 2D form plot

3D performance

With multi-axis machining now common place, 3D measurement performance is more important than ever.

3D performance is measured by finding the form error of a feature with X, Y and Z dimensions. The lower the 3D form error value, the better the probe's 3D performance.

To measure the 3D form error, the test measured the radius of a calibrated sphere by taking points at four different elevations and at the pole.
The difference between the minimum and the maximum measured radius is the 3D form error.



A 3D form plot

Repeatability

In this test, repeatability is a measure of how well a probe can reproduce a measurement under constant conditions. It is a metric that is frequently quoted on probe datasheets. The lower the value, the better the repeatability.

Repeatability is different from accuracy, as accuracy describes how close a measured value is from the true value.

Repeatable, but not accurate, measurements

The performance test measures a Ø25 mm calibrated sphere at a variety of angles and feedrates, with different styli, to obtain 2D form error, 3D form error and repeatability.

When performing the test, best practice – as defined in the ISO 230-10 standard – was followed. A medium-accuracy, mid-priced, 3-axis vertical machining centre (VMC) with a Siemens 828D control was used to conduct the test.

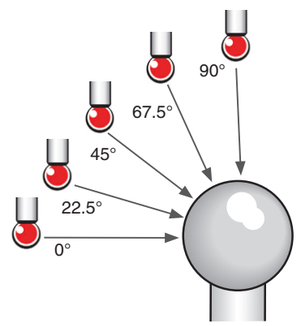
The test comprised the following aspects:

Points measured on a sphere

145 points at 2.5° increments were measured normal to the surface at 0°, 22.5°, 45° and 67.5° during the test. A point was also measured at the pole of the sphere.

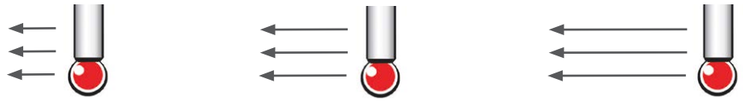
Points at 0° are used for calculation of 2D form error. When calculating 3D form error, all of the points are used.

To measure repeatability, each point was measured 25 times.



At a variety of feedrates

The test was run multiple times at 30 mm/min, 600 mm/min and 2000 mm/min.



30 mm/min | 600 mm/min | 2000 mm/min

With styli of different lengths

Each probe was fitted first with a 50 mm stylus, and then with a 200 mm stylus. Both styli were used to measure the points on the sphere at each feedrate.

According to specification documentation, all of the probes being tested can be used with a 50 mm stylus, but only the OMP400 and probe "A" are recommended for use with a 200 mm stylus. 200 mm is the longest stylus that is recommended for use with all machine tool probes with RENGAGE™ technology.

50 mm | 200 mm

In realistic machining conditions

All of the tests were run in wet conditions. The sphere was lubricated using coolant to represent the conditions found in a realistic machining scenario.

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Results of benchmarking tests

The results show that, for 2D form, 3D form and repeatability, the OMP400 probe with RENGAGE™ technology was the best overall performer.

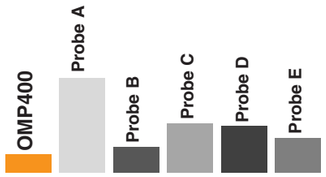
Although the OMP400 was the only model we tested with RENGAGE technology, due to the common design elements throughout the range, the results would be indicative for all high-accuracy probes with RENGAGE technology.

While the performance of other probes on the market was close to the OMP400 in some tests, when the results are viewed as a whole, only the Renishaw probe with RENGAGE technology consistently performs at a high level.

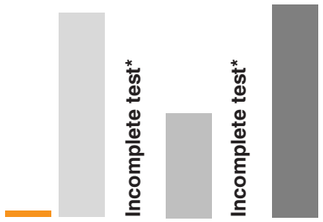
For exceptional performance at fast feedrates in all conditions, measuring both prismatic and free-form features with long or short styli, a Renishaw machine tool probe with RENGAGE technology is the logical and proven choice.

The results show that, for 2D form, 3D form and repeatability, the OMP400 probe with RENGAGE™ technology was the best overall performer.

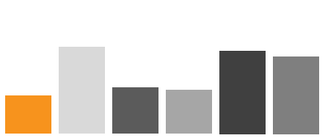
2D form error



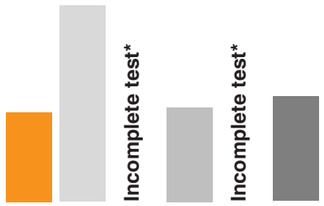
2D form error comparison at
30 mm/min with a 50 mm stylus



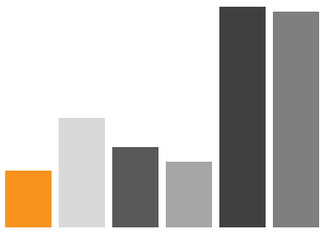
2D form error comparison at
30 mm/min with a 200 mm stylus



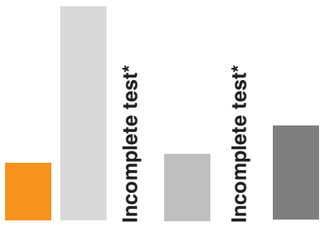
2D form error comparison at
600 mm/min with a 50 mm stylus



2D form error comparison at
600 mm/min with a 200 mm stylus



2D form error comparison at
2000 mm/min with a 50 mm stylus

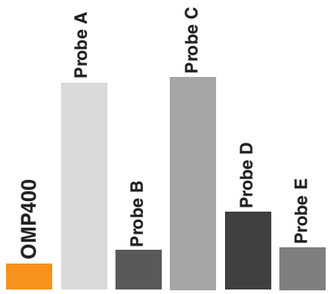


2D form error comparison at
2000 mm/min with a 200 mm stylus

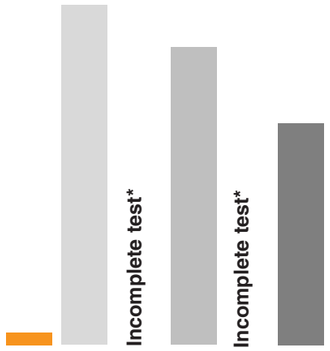
* Probes B and D failed to complete the test with a 200 mm stylus. However, neither of these probes are specified to work with a 200 mm stylus.

The Renishaw OMP400 probe with RENGAGE™ technology has the lowest 2D form error at all feedrates with both the 50 mm and 200 mm stylus.

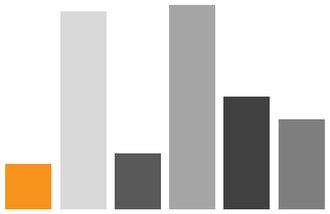
3D form error



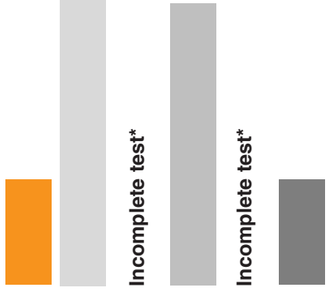
3D form error comparison at
30 mm/min with a 50 mm stylus



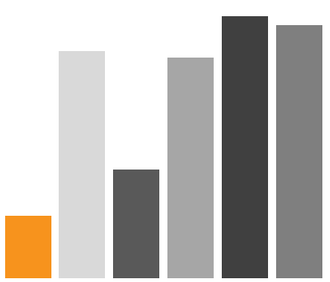
3D form error comparison at
30 mm/min with a 200 mm stylus



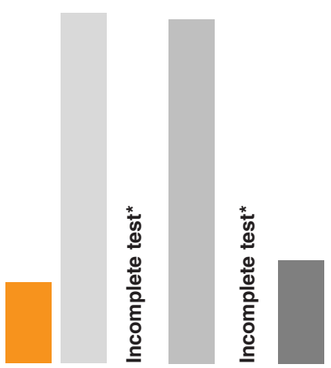
3D form error comparison at
600 mm/min with a 50 mm stylus



3D form error comparison at
600 mm/min with a 200 mm stylus



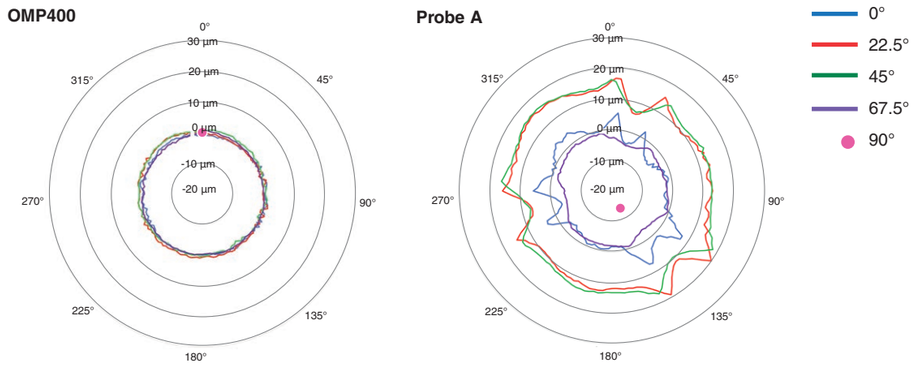
3D form error comparison at
2000 mm/min with a 50 mm stylus

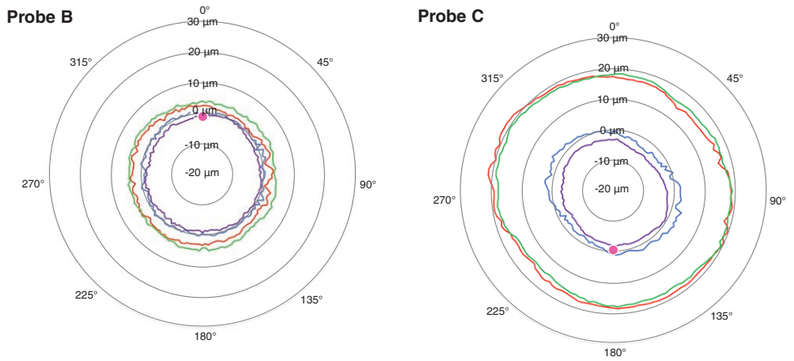


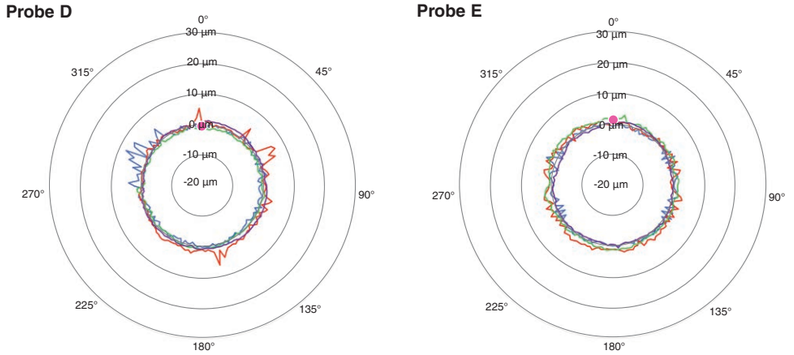
3D form error comparison at
2000 mm/min with a 200 mm stylus

* Probes B and D failed to complete the test with a 200 mm stylus. However, neither of these probes are specified to work with a 200 mm stylus.

The Renishaw OMP400 probe with RENGAGE™ technology has the lowest 3D form error at all feedrates with both the 50 mm and 200 mm stylus.

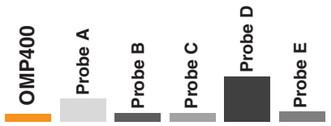




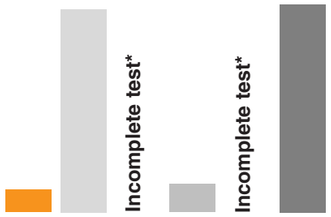


Repeatability

The repeatability of the Renishaw OMP400 probe with RENGAGE™ technology is better than or equal to other probes on the market at all feedrates with both the 50 mm and 200 mm stylus.

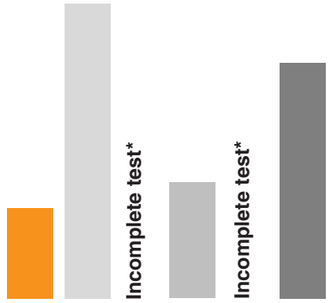


Repeatability comparison at
30 mm/min with 50 mm stylus

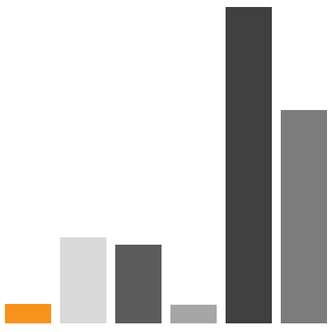


Repeatability comparison at
30 mm/min with 200 mm stylus

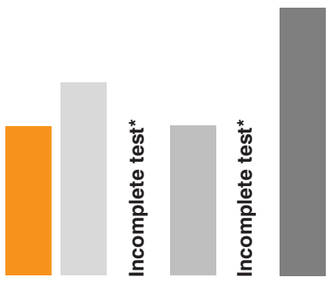
Repeatability comparison at
600 mm/min with 50 mm stylus



Repeatability comparison at
600 mm/min with 200 mm stylus



Repeatability comparison at
2000 mm/min with 50 mm stylus



Repeatability comparison at
2000 mm/min with 200 mm stylus

* Probes B and D failed to complete the test with a 200 mm stylus. However, neither of these probes are specified to work with a 200 mm stylus.

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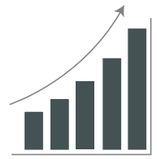
Probing pays with Renishaw

Optimise your cutting process



Ensure parts are machined "right first time".

Reduce scrap and rework

Set parts up to ten times faster than when using manual methods.

Save time and money

Produce more parts reliably and accurately.

> Meeting current and future performance requirements for our products demands manufacture of ever smaller and more intricate parts that are consistently accurate to within 1 µm. Reliable set-up and measurements are therefore critical to this process and form the basis of our decision to use RENGAGE™ technology.
>
> **Flann Microwave (UK)**

The Renishaw advantage

At Renishaw, we enjoy an excellent reputation for offering strong support to our customers through a network of over 70 service and support offices worldwide.

Technical assistance

We supply technical assistance to all our global customers.

Support and upgrades

We provide a variety of support agreements bespoke to your individual needs.

Training

We offer standard and bespoke training courses to meet your requirements.

Spares and accessories

Buy spares and accessories online or obtain quotes for Renishaw parts 24/7.

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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:

- Additive manufacturing and vacuum casting technologies for design, prototyping, and production applications
- Dental CAD/CAM scanning systems and supply of dental structures
- Encoder systems for high-accuracy linear, angle and rotary position feedback
- Fixturing for CMMs (co-ordinate measuring machines) and gauging systems
- Gauging systems for comparative measurement of machined parts
- High-speed laser measurement and surveying systems for use in extreme environments
- 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
- Styli for CMM and machine tool probe applications

For worldwide contact details, visit www.renishaw.com/contact

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