RENISHAW
apply innovation™

Explaining squareness measurement using the XK10 alignment laser system

Overview

The XK10 alignment laser system can measure the squareness deviation between two nominally square axes on a machine. This document aims to explain the differences between squareness measurements using traditional methods and the XK10 alignment laser system.

Squareness

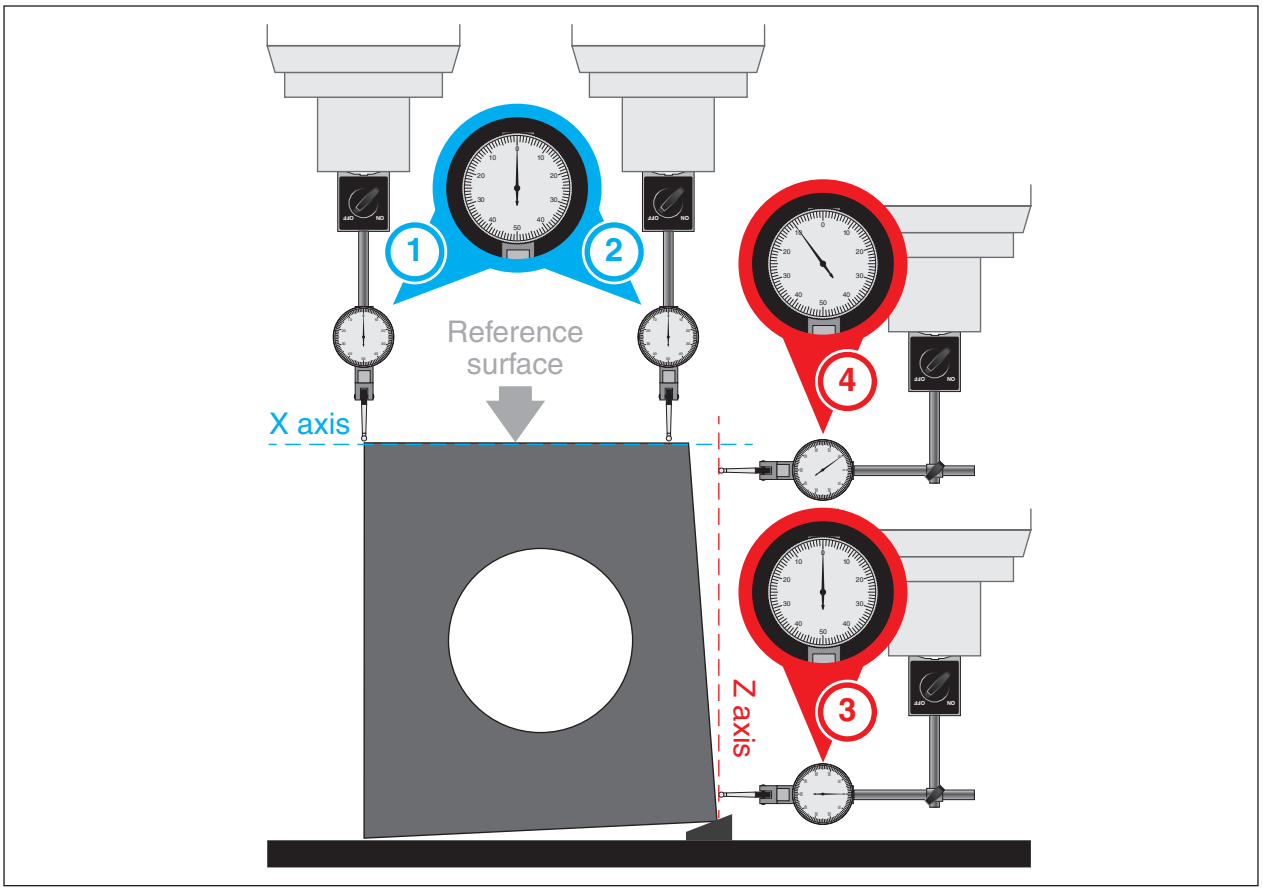
- In machine tool assembly and maintenance, squareness is defined as the angle between two nominally perpendicular axes.

Traditional methods

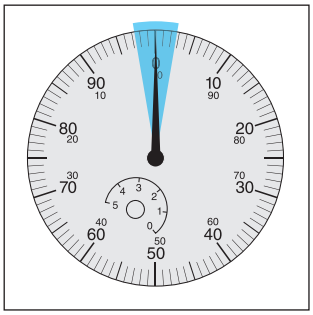
The traditional method for squareness is done by using a granite square in combination with a dial indicator. The process involves:

- aligning one reference surface of the square to one of the axes to be measured
- adjusting the square (sometimes with shims) until the indicator reads 0 at point 1 and 2
- reorienting and datuming the dial indicator at position 3

The reading at position 4 will be the squareness result between the axes.



Considerations



Dial indicators

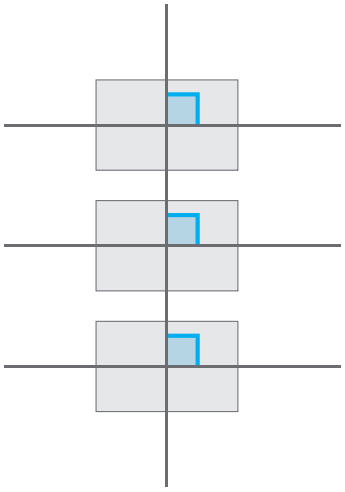
- Even the highest accuracy dial indicators have an uncertainty of about ±3 µm overall even if the repeatability is ±0.5 µm.
- This means that if a user sees a reading of 0 µm, the true error could be anywhere between -3 µm and +3 µm.

Granite square error

- The granite square error (α) is rarely removed from the final result by operators.
- The measurement of the granite square error (α) also has an uncertainty as it is measured using digital levels.

Alignment error

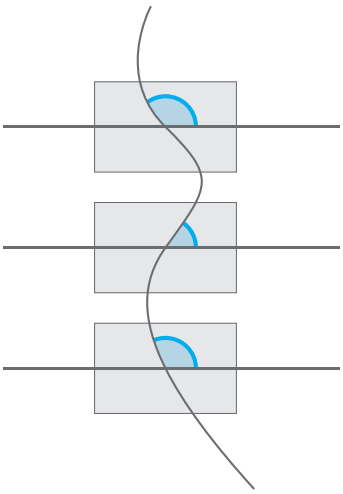
Initial alignment of reference surface to the reference axis needs to be perfect for results to be accurate. Due to the inaccuracies of the dial indicator and straightness variations along the reference surface this is not possible.



Perfectly straight X and Y axes giving consistent squareness across the machine.

Straightness error

The method of taking only two points along each axis ignores straightness errors in the machine along each axis and assumes that both are perfectly straight. In actuality there will be straightness errors which means that squareness is not constant along the axis so results will differ depending on where they are taken and the magnitude of the straightness errors.



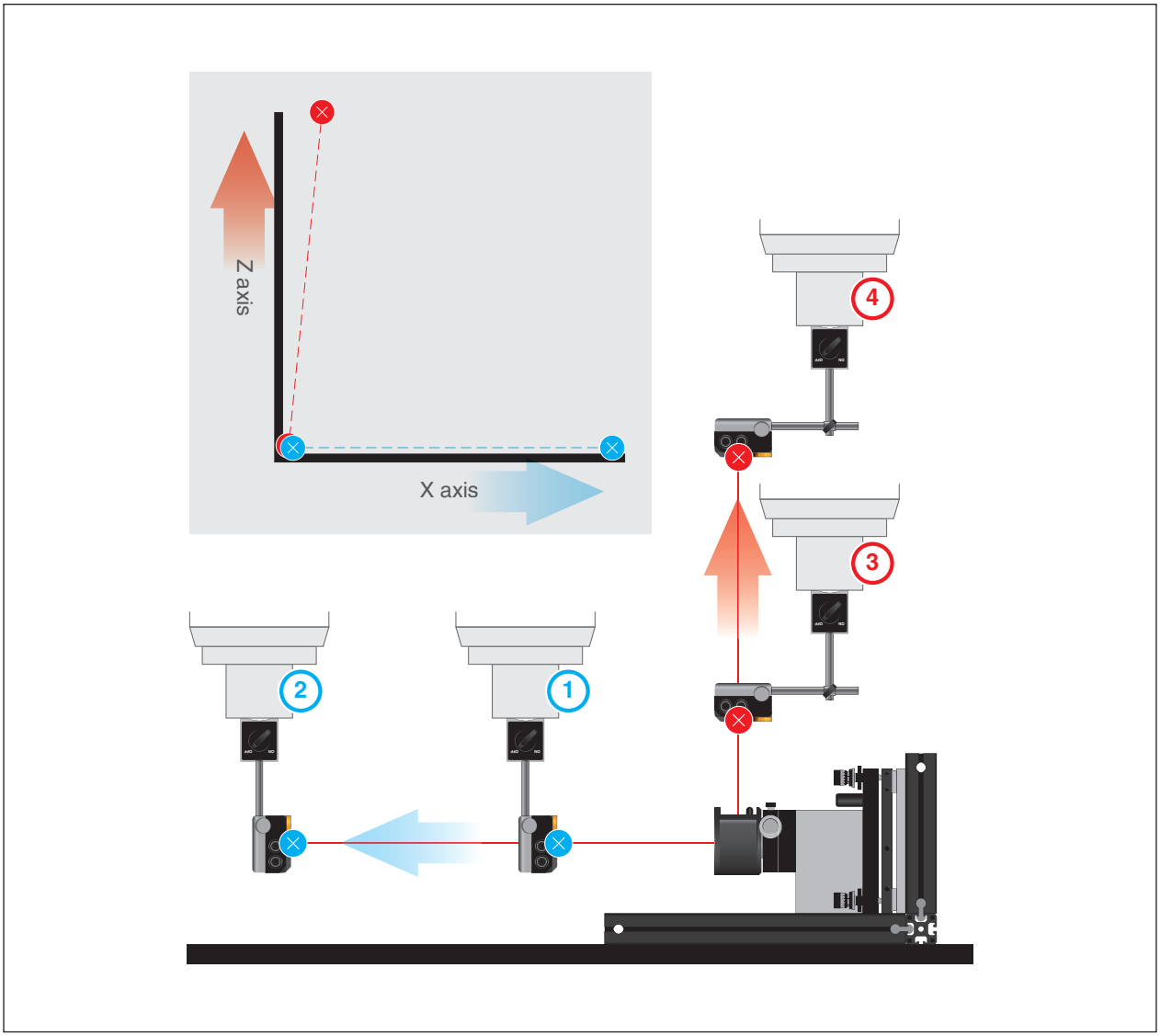
Straightness error along Y axis causing inconsistent squareness across the machine.

Squareness measurement using the XK10 alignment laser system

The XK10 alignment laser system measures squareness by remaining in one fixed position and moving the internal pentaprism into the main beam path to deflect it by 90°. All measurements are captured digitally.

4 point squareness

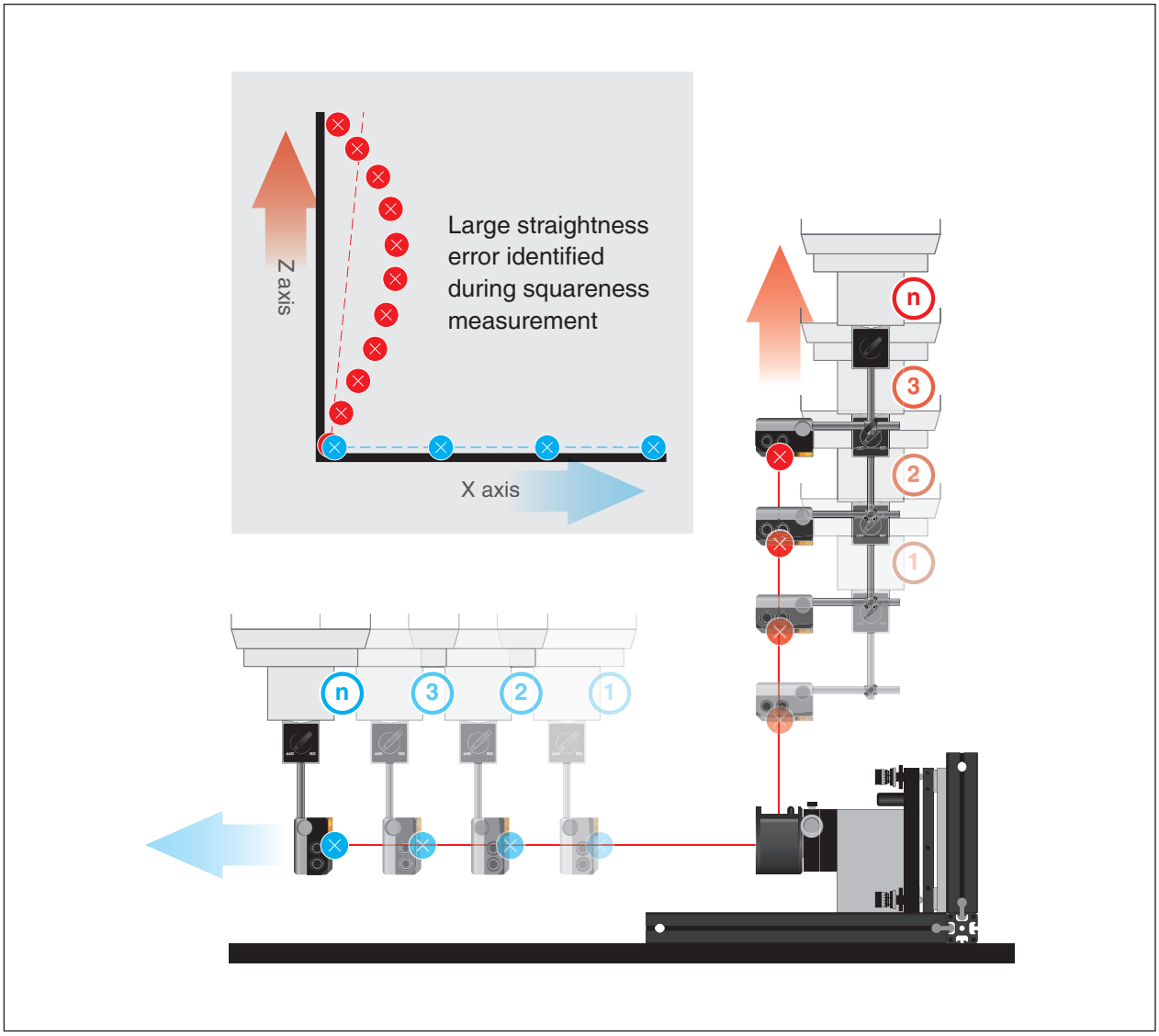
- Similar process to the traditional method with a few exceptions:
  - alignment to reference (1 and 2) axis is done with a laser beam
  - alignment with the laser is not as critical as alignment with a granite square



Squareness measurement using the XK10 alignment laser system

Multi-point squareness

- Takes multiple straightness readings along the axes and plots a best-fit line through the points to get a slope. The calculated slope for each axis is used to calculate the squareness.
- It is therefore possible to view the straightness errors along each of the axes and decide whether or not the straightness errors are a contributing factor to the squareness results.
- For example, if there is a large bow in one axis, the straightness needs to be addressed first as this will result in inconsistent squareness across the machine volume.



Analysis – squareness

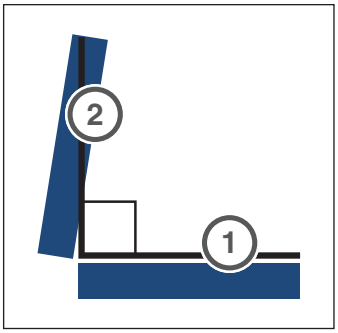
Extrapolation errors

The result should be output as µm/axis length (e.g µm/500 mm for 500 mm x 500 mm axes), otherwise the system will extrapolate the results and assume perfect straightness over larger distances.

Report – multi-point squareness

Test details and results

1. **Test details** – are set at the beginning of the measurements and should be as accurate as possible as the resulting angle is based on distance 1 and 2 as well as the measured angle.



Distances	
Distance 1	812 mm
Distance 2	812 mm
Number of points 1	15
Number of points 2	15

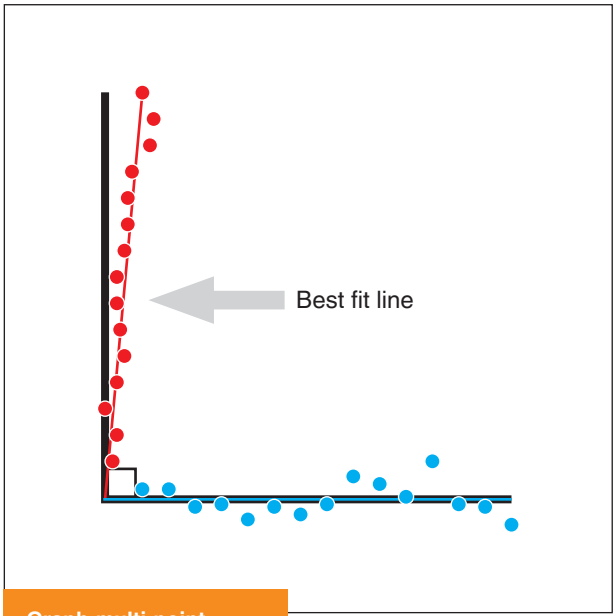
2. **Angle** – This is the calculated angle between both axes based on the distances measured.

Squareness result		
Angle	-0.014/1000 mm	within tolerance

3. **Tolerance** – This is the build tolerance set by the user, the default tolerance is the ISO tolerance for squareness.

Tolerance	
Custom tolerance	0.020/1000 mm

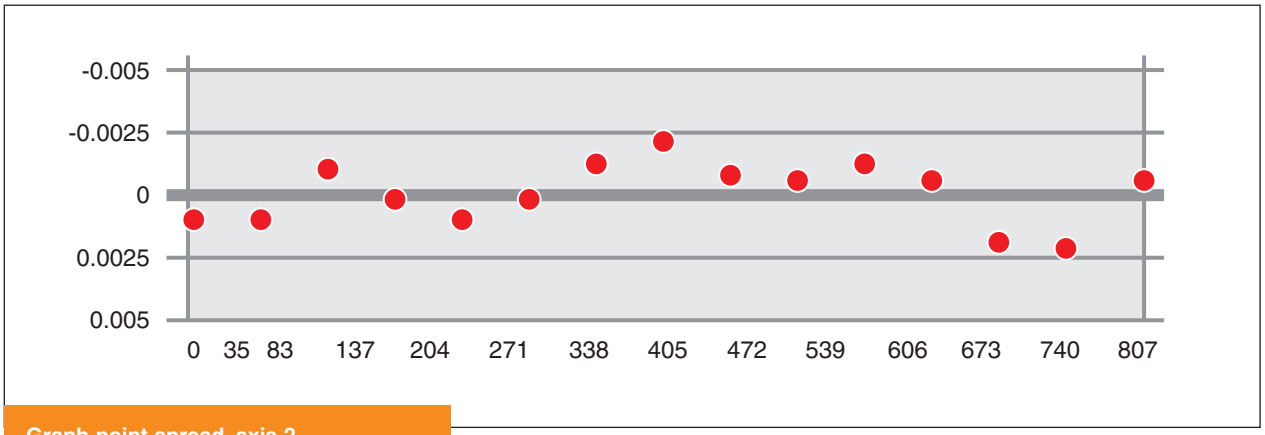
The graph shows the straightness result along the axes and the best fit line that has been used to calculate the angle.



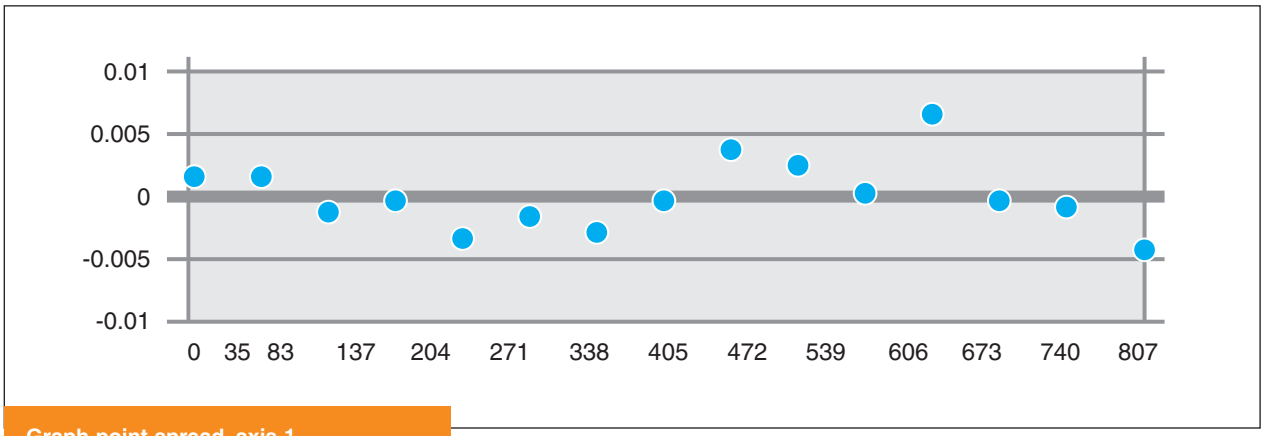
Graph multi-point

RENISHAW
apply innovation™

Report – multi-point squareness



Graph point spread, axis 2



Graph point spread, axis 1

The above graphs show the 'spread' along the best fit lines in the main graph (the slope has been removed). The purpose is to highlight any noise or any major straightness problems affecting the squareness result.

Note: Ideally straightness should be measured **before** squareness measurements.

Why might small differences occur between the XK10 alignment laser system and results generated by traditional methods?

- 4 points vs multi-point calculation
- Location of measurement in machine volume/ underlying straightness errors
- Dial indicator error
- Granite square error
- XK10 squareness error
- Air turbulence
- Extrapolation error

www.renishaw.com/xk10

#renishaw

+44 (0) 1453 524524 **uk@renishaw.com**

Part no.: H-9936-9091-02-A