RENISHAW
apply innovation™

XR20-W error budget and uncertainty calculations

Introduction

This document summarises the system measurement uncertainty calculations for a Renishaw XR20-W rotary axis calibrator. These calculations are used to confirm that the XR20-W rotary axis calibrator can measure angular position of a rotary axis, within the specified positional accuracy of ±1 arc sec when used with XL-80 and ±1.2 arc sec with an XM-system.

General information on the methodology used

The derivation of error budgets is a standard part of Renishaw's new product development process which is covered by the group's ISO 9001 compliant quality management system. ISO 9001:2008 is the internationally recognised standard for quality management systems and is verified at Renishaw by BSI management systems (UKAS accredited).

Error budgets are calculated following the guidance as outlined in EA-4/02 'Expression of the Uncertainty of Measurement in Calibration' and NIST technical note 1297. The contributory elements to the budget are derived from a combination of the validation of component specifications, experimental evidence of performance and theoretical calculations. The combination of these individual terms results in the system level specification. All specifications are published with 95% (k=2) confidence level. The error budgets are reviewed and signed off by qualified personnel. The first section outlines the uncertainty associated with the reference standards used, when calibrating an XR20-W. The second section outlines the sources of error associated with XR20-W, when in use.

Uncertainty of XR20-W calibration

Source of Uncertainty	***Uncertainty value (± arcsecs)***	***Probability Distribution***	***Uncertainty (k=1) (± arcsecs)***
Alignment errors	0.11	Normal (k=2)	0.06
Repeatability of measurement	0.39	Normal (k=2)	0.20
Thermal drift of angular reflector	0.20	Normal (k=2)	0.10
Other errors	0.10	Normal (k=2)	0.05
Combined Uncertainty (k=1)			**0.23**
Expanded Uncertainty (k=2)			**0.46**
Published Specification (k=2)			**0.46**

Application note

Uncertainty of XR20-W in use with XL-80

Source of Uncertainty	*Uncertainty value (± arcsecs)*	*Probability Distribution*	*Uncertainty (k=1) (± arcsecs)*
Uncertainty of calibration	0.46	Normal (k=2)	0.23
Acceptance limit	0.50	Normal (k=2)	0.25
Alignment errors	0.36	Normal (k=2)	0.18
Encoder ring resolution	0.10	Rectangular	0.06
Orientation	0.10	Normal (k=2)	0.05
Hysteresis	0.10	Normal (k=2)	0.05
Graduation error	0.40	Normal (k=2)	0.20
In-use drift	0.40	Normal (k=2)	0.20
Other errors	0.10	Normal (k=2)	0.05
Combined Uncertainty (k=1)			**0.49**
Expanded Uncertainty (k=2)			**0.98**
Published Specification (k=2)			**1.00**

Uncertainty of XR20-W in use with XM rotary

Source of Uncertainty	*Uncertainty value (± arcsecs)*	*Probability Distribution*	*Uncertainty (k=1) (± arcsecs)*
Uncertainty of calibration	0.46	Normal (k=2)	0.23
Acceptance limit	0.50	Normal (k=2)	0.25
Alignment errors	0.39	Normal (k=2)	0.19
Encoder ring resolution	0.10	Rectangular	0.06
Orientation	0.10	Normal (k=2)	0.05
Hysteresis	0.10	Normal (k=2)	0.05
Graduation error	0.40	Normal (k=2)	0.20
In-use drift	0.40	Normal (k=2)	0.20
Other errors	0.10	Normal (k=2)	0.05
Repeatability of measurement	0.41	Normal (k=2)	0.21
Combined Uncertainty (k=1)			**0.53**
Expanded Uncertainty (k=2)			**1.07**
Published Specification (k=2)			**1.20**

General notes for all tables:

- The first column lists the sources of the uncertainty errors considered.
- The second column gives the uncertainty value for the source of uncertainty in the appropriate units.
- The third column gives the probability distribution function for the source of the errors and the coverage factor used. This coverage factor is used to convert uncertainty values to k=1. An additional multiplier is applied to account for size of the sample data.
- The fourth column lists the uncertainties for the appropriate source of uncertainty.
- The individual values are combined using a 'root sum square' calculation to produce the total combined uncertainty.

This page is intentionally left blank

Renishaw plc

New Mills, Wotton-under-Edge
Gloucestershire, GL12 8JR
United Kingdom

T +44 (0) 1453 524524
F +44 (0) 1453 524901
E uk@renishaw.com

www.renishaw.com

RENISHAW
apply innovation™

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

H-9920-0437-03

Part no.: H-9920-0437-03-B
Issued: 04..2019