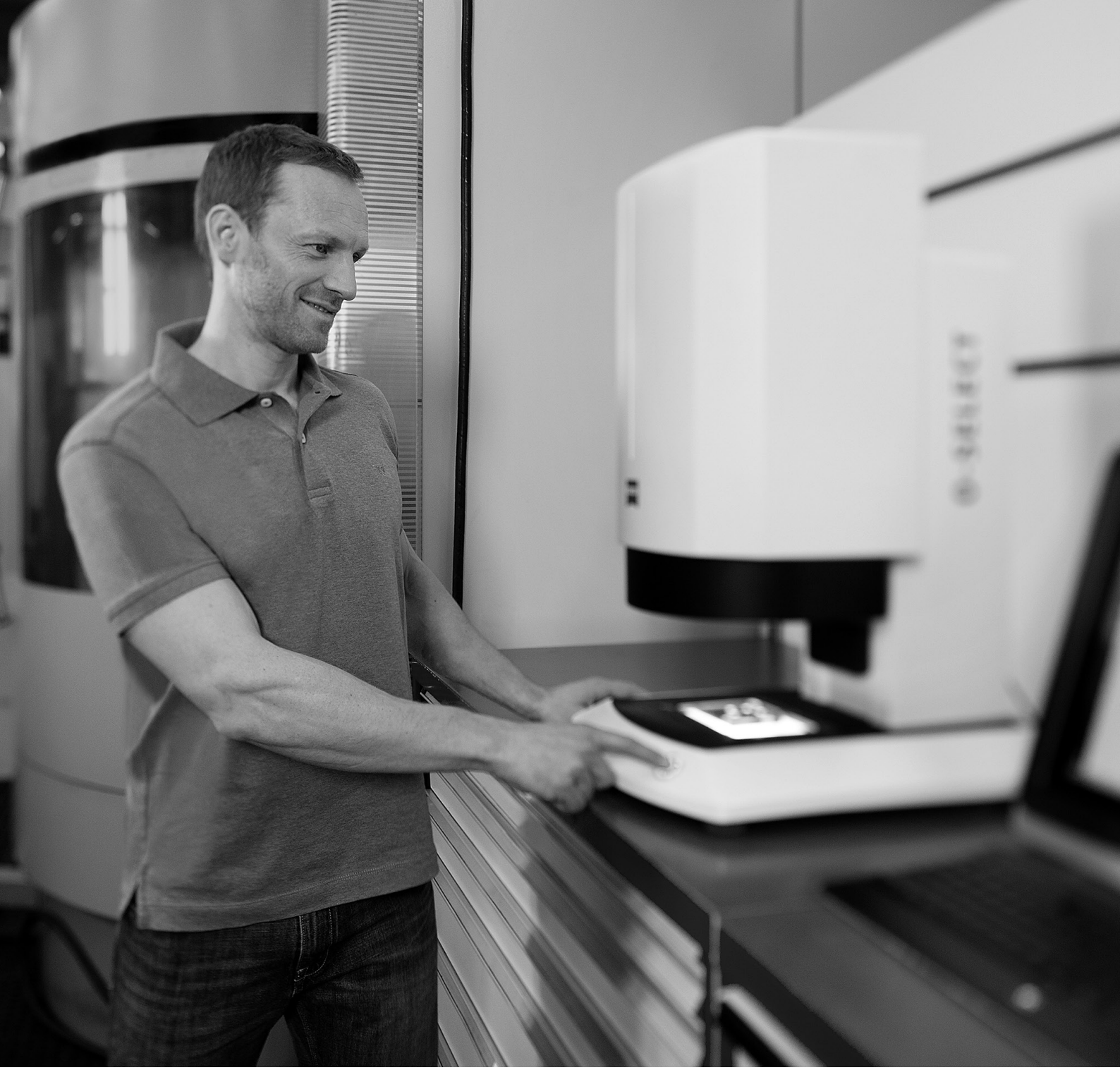


White Paper: ISO 10360-7

Guaranteeing precision
for quality measurements

ZEISS

ISO 10360-7

Guaranteeing precision for quality measurements

This white paper explains the main aspects of ISO 10360 and, in particular, ISO 10360-7, the standard for inspecting coordinate measuring machines with imaging probing systems. Learn why ZEISS chose this standard, how this standard benefits customers and what you need to keep in mind in the implementation.

Alessandro Gabbia, Product Manager for Measurement Standards at ZEISS IMT, discusses the benefits of ISO 10360.

What exactly is the ISO 10360-7 standard?

The ISO 10360 series of standards addresses the measuring precision of coordinate measuring systems. There are different parts: part 7 focuses in particular on coordinate measuring machines with an image probing system.

Are there alternatives?

There are many different standards, including B89.1.12M from the American Society of Mechanical Engineers, the CMMA standard, the British Standard BS6808, the Japanese Industrial Standard JIS B 7440 and the directive VDI/VDE 2617, which has long been dominant in Europe. All these standards are older and have become less important following the publication of the ISO.

Why did ZEISS choose ISO 10360-7?

ZEISS chose this standard early on when the standard was still quite new. ZEISS is one of the few manufacturers whose systems meet the specifications stipulated by this standard. This is particularly beneficial because, as this is an international standard, adhering to it ensures comparability worldwide. It is also the strictest standard, which is why there are still manufacturers who adhere to older standards. However, that will change because the market is forcing these manufacturers to either adopt this ISO standard or accept that they will not be as competitive.

How do customers benefit?

Customers can provide incontrovertible evidence that they perform their measurements with verifiable precision no matter where in the world they manufacture their products – as is the case in more and more industries. Measuring as per this standard is a requirement for being accepted as a supplier. When purchasing a coordinate measuring machine, the customer considers many different issues. However, the question whether or not the product meets the ISO standard should always be addressed at the beginning of the decision-making process.

ISO 10360-7
The details

The full name of the series of standards is:
Geometrical product specifications (GPS) – Acceptance and reverification tests for coordinate measuring machines (CMM)

ISO 10360 is published by the International Organization for Standardization, which was founded in 1947. ISO 10360 is valid globally. Its use is generally voluntary, as is true of other standards and directives, including CMMA, VDI/VDE 2617, ASME B89 and JIS. However, measuring machine manufacturers ultimately do not have a choice, because customers make their purchasing decisions based on whether or not a measuring machine meets the most stringent current standards. Thus ISO 10360 is clearly gaining in popularity and becoming the gold standard. It guarantees global comparability and is stricter than the other standards which are quickly becoming less important. ISO 10360 offers customers added value in terms of reliability and investment security. ZEISS was one of the first companies to ensure that its coordinate measuring machines were in line with this standard.

ISO 10360 only contains measuring specifications and evaluation methods. It does not contain any limit values for deviations. These are stipulated by the manufacturer and are part of the product features. The standard only ensures that these properties are observed in accordance with certain, verifiable acceptance processes.

ISO 10360 Part 7 (abbreviated as ISO 10360-7) was accepted by the European Committee for Standardization in 2011. It has been in effect for six years, making it a very recent standard. It regulates the calibration requirements for coordinate measuring machines with image probing systems that produce 2D measurements, i.e. machines that measure the projection of the object to be inspected on the image level. The language used in this part of the standard is not always optimal, because the procedures and evaluation criteria are taken from 3D contact coordinate measuring machines. Thus the norm also mentions "probing errors" with the relatively new optical systems even though, strictly speaking, no physical probing is performed. Nevertheless, the terms have been retained, and those experts familiar with the measuring machines know what is meant and how the terms can be applied to optical systems and optical measurements.

ISO 10360-7
The goals and the inspection method

The goals of ISO 10360-7

The tests stipulated in part 7 of ISO 10360 have two purposes:

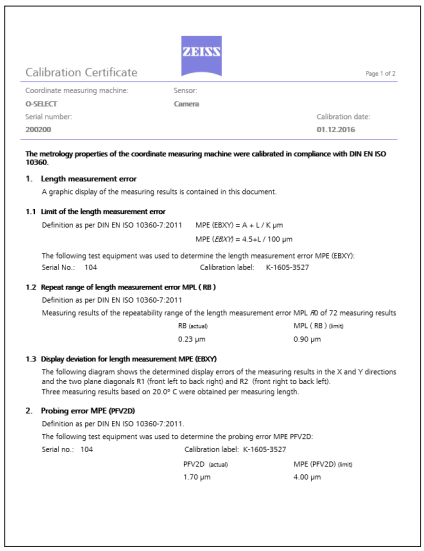
- To test for display errors for a calibrated inspection length with an imaging probing system.
- To test for image probing system errors.
- Performing the tests is beneficial because the measuring result can be traced back directly to the meter length unit. Moreover, the tests also provide information on how the coordinate measuring machine performs with similar length measurements.

Inspection as per ISO 10360-7

There are two tests as per ISO 10360-7:

- The acceptance test is the first machine test and is performed at the manufacturer's production facility. It ensures that the measuring system delivered to the customer adheres to the specified properties as concerns measuring accuracy. The acceptance test can also be repeated on the customer's premises.
- The certification test is performed by the operator at regular intervals. This ensures that the measuring machine maintains the required limit values over the long term. How often these tests are performed is not stipulated. The operator uses their own judgement to decide. They consider when precision and reproducibility requirements must be considered and draw on their experience of working with the system, such when confronted with ambient influences.

A reference standard (artefact) is used in both tests. The O-SELECT Check test piece is used for ZEISS coordinate measuring machines with optical image probing. The test standard is placed on the window, and the measuring machine automatically creates an image. Software analyzes the measurement points as per ISO 10360-7, and the operator receives a detailed measurement report documenting the errors. In the calibration certificate, a graph juxtaposes the measurement point errors for the length measurement in micrometers as a function of the measurement length in millimeters together with the error limits. The entire process only takes a few minutes.



Calibration Certificate

ZEISS

Page 1 of 2

Coordinate measuring machine: O-SELECT
Sensor: Camera
Serial number: 200200
Calibration date: 01.12.2016

The metrology properties of the coordinate measuring machine were calibrated in compliance with DIN EN ISO 10360.

1. Length measurement error

A graphic display of the measuring results is contained in this document.

1.1 Limit of the length measurement error

Definition as per DIN EN ISO 10360-7:2011 MPE (EBXY) = A + L / K µm
MPE (EBXY) = 4.5+L / 100 µm

The following test equipment was used to determine the length measurement error MPE (EBXY):
Serial No.: 104 Calibration label: K-1605-3527

1.2 Repeat range of length measurement error MPL (RB)

Definition as per DIN EN ISO 10360-7:2011
Measuring results of the repeatability range of the length measurement error MPL R0 of 72 measuring results

RB (actual)	MPL (RB) (limit)
0.23 µm	0.90 µm

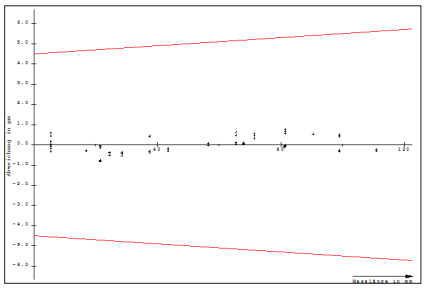
1.3 Display deviation for length measurement MPE (EBXY)

The following diagram shows the determined display errors of the measuring results in the X and Y directions and the two plane diagonals R1 (front left to back right) and R2 (front right to back left).
Three measuring results based on 20.0° C were obtained per measuring length.

2. Probing error MPE (PFV2D)

Definition as per DIN EN ISO 10360-7:2011.
The following test equipment was used to determine the probing error MPE PFV2D:
Serial no.: 104 Calibration label: K-1605-3527

PFV2D (actual)	MPE (PFV2D) (limit)
1.70 µm	4.00 µm



Acceptance and reverification test

ISO 10360-7
The measurement specifications

The standard requires three different evaluations:

- **Length measurement error:**
  Here the standard requires measurements in four different directions: – in the x and y directions of the measuring window and in the two diagonals. Moreover, it also provides parameters for the lengths of the inspection equipment. These lengths and distances should vary as much as possible in each direction. The longest length should cover at least two-thirds of the extension of the diagonal of the image field in order to capture errors in the outer edges of the measuring window.

- **Repeatability range:**
  The length measurements listed on page 5 are repeated three times. During this time, no contact is made with the test piece to ensure that no new sources of error affect the measurement. These are used to determine the three errors for the length measurement. The repeatability range is calculated using the difference between the longest and the shortest measured length in these three repeat measurements.

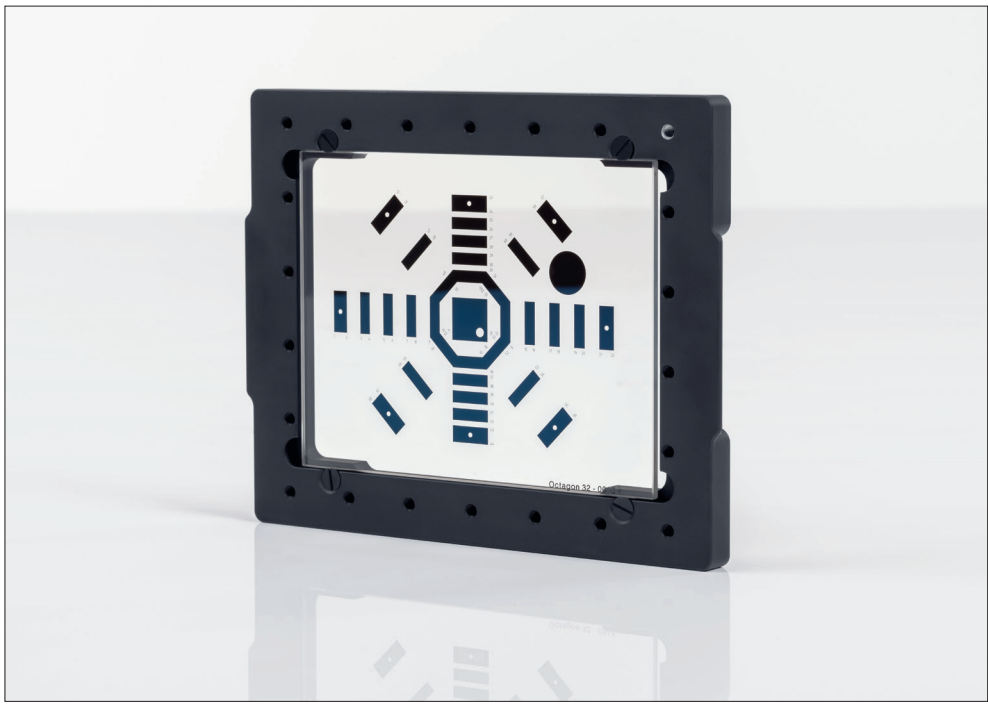
- **Probing error:**
  This is a term used for contact coordinate measuring machines and refers to moving the stylus along the artefact from different directions. This information is all compiled in one image for optical systems. The software then performs the calculation. The probing error also means that circles are measured with a small roundness error. As per the standard, the diameter of the test circle must be between 10 and 30 percent of the shortest length of the field of view. 25 points are evenly distributed along this circle and are used to calculate a Gaussian circle, i.e. a type of mean value for scattering more or fewer actual measurement values. The probing error is thus the span width of the distances of the measuring points to the Gaussian circle.

The artefact

For its acceptance tests, ZEISS uses the O-SELECT Check artefact. It comprises a Zerodur glass plate with a chromium coating.

O-SELECT Check has all the necessary measuring features in a single mount to meet the standard parameters. The test piece also has different-sized rectangles in the four required directions and a circle. The largest measuring length is significantly longer than the two-thirds of the measuring window length required in the standard, and the measuring objects are distributed evenly across the measuring window and cover the largest part of this area. The test piece features calibrated distances that are measured in the required four orientations with five different lengths. After three repeat measurements, 60 measuring results are available for length measurements.

The artefact is stable and durable. Nevertheless, a DAkkS calibration must be performed regularly to meet the standard.



O-SELECT Check artefact

Nomenclature for the measurement values as per ISO 10360

E = Error = Length measurement error
U = Uni-directional = Probing from one direction
B = Bi-directional = Probing from the opposite directions
XY = Evaluation plane
MPE = Maximum permissible error

Legend:

MPE (EBXY) = Maximum permissible error for a bi-directional length measurement on evaluation plane XY

MPE (PFV2D) = Maximum permissible probing error for the image probing system

The standard also defines numerous additional terms and abbreviations, such as error limits.

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