

Accuracy of Profile Projectors

This unit of the Metrology Fundamentals series was developed by the Mitutoyo Institute of Metrology, the educational department within Mitutoyo America Corporation. The Mitutoyo Institute of Metrology provides educational courses and free on-demand resources across a wide variety of measurement related topics including basic inspection techniques, principles of dimensional metrology, calibration methods, and GD&T. For more information on the educational opportunities available from Mitutoyo America Corporation, visit us at www.mitutoyo.com/education.

This technical bulletin addresses the accuracy and calibration of profile projectors, also known as optical comparators. No international or American national standard currently exists that addresses the specification of profile projectors. The technical basis for this document is the Japanese national standard on this topic, JIS B 7184:1999. This technical bulletin summarizes the most important technical issues; however, the JIS standard should be consulted for further information.

Accuracy Specifications

Table 1 shows the most important metrological characteristics and default specifications for profile projectors. The manufacturer or user may state different specifications. These characteristics are necessary for users to understand the accuracy of their measuring instruments and the possible errors in their measurements. In the calibration of profile projectors, these are the most important characteristics that should be properly calibrated and verified.

Table 1: Metrological Characteristics and Default Specifications

Characteristic	Metric (μm)	Inches (μin)	Inches (in)
Length accuracy (X & Y axis)	$\pm (6 + 0.04L) \mu\text{m}$	$\pm (240 + 40L) \mu\text{in}$	$\pm (0.00024 + 0.00004L) \text{in}$
Magnification accuracy (transmitted/contour illumination)	$\pm 0.15\%$ or $\pm 1.5L \mu\text{m}$	$\pm 0.15\%$ or $\pm 1500L \mu\text{in}$	$\pm 0.15\%$ or $\pm 0.0015L \text{in}$
Magnification accuracy (reflected/surface illumination)	$\pm 0.25\%$ or $\pm 2.5L \mu\text{m}$	$\pm 0.25\%$ or $\pm 2500L \mu\text{in}$	$\pm 0.25\%$ or $\pm 0.0025L \text{in}$
Squareness accuracy (X-Y axes)	$\pm (4.5 + 0.06L) \mu\text{m}$	$\pm (180 + 60L) \mu\text{in}$	$\pm (0.00018 + 0.00006L) \text{in}$

- For metric, L is length in mm. For inches, L is length in inches. The specifications in metric units are from JIS B 7184:1999. The inch units are converted with some minor rounding for convenience.
- For length accuracy, L is the measured length along the X or Y axis. For squareness accuracy, L is the maximum measuring range of the profile projector in either the X or Y axis. For magnification accuracy, L is the length of the feature being measured, not the length of the image on the screen.
- For magnification accuracy, the percentage shown is the percentage of nominal magnification.
- These specifications are from the Japanese national standard, JIS B 7184:1999, and not from Mitutoyo or any other manufacturer of profile projectors. Any manufacturer may specify alternative values for some of the characteristics. Being default specifications, these values apply if nothing else is stated by the manufacturer or agreed upon between the customer and supplier.
- All specifications apply at 20°C.

Magnification accuracy influences any measurements made across the measuring screen. Length accuracy (X & Y axis) impacts any measurements made using the measuring stage along either the X or Y axis. If the measuring stage is moved along both axes for a measurement, then the squareness accuracy also influences the measurement error.

The maintenance and calibration of a profile projector may include additional tests, as needed. These may include, for example, stage parallelism, screen eccentricity, screen cross-hair accuracy, and measuring accuracy of a rotating screen.

Calibration and Verification

There are many different types of profile projectors, and a suitable calibration method must be developed based on the specific configuration of the measuring instrument and the calibration goals of the user. Described below are examples of methods suitable for calibration; alternative methods may also be sufficient. In each case, to demonstrate conformity, the test values shall be within the accuracy specifications as stated in Table 1 or as otherwise stated or agreed upon.

Length Accuracy (X & Y axis)

Using a glass scale that covers the measuring range of the profile projector, separately calibrate the X and Y axis by taking a test point approximately every 25 mm or 1 inch. The glass scale should be positioned approximately in the center of the measuring stage. The measured test value (or error) is determined by the difference between the indicating reading and the calibrated value of the glass scale.

The Mitutoyo series 182 Working Standard Scales were specifically designed for this type of calibration. The Mitutoyo America Calibration Lab in Aurora, Illinois, offers ISO/IEC 17025 accredited calibrations for many types of glass scales.

Magnification Accuracy

For magnification accuracy, two different measurement standards are needed. A smaller standard, such as a short glass scale, is placed on the measuring table and its image on the screen is compared with a larger standard (the same glass scale used to check the X and Y length accuracy often works well). It is important to check the magnification in multiple places across the measuring range of the screen.

Squareness (X-Y axes)

The X-Y squareness error is calibrated using a precision square, such as a steel square or appropriate glass standard. The reference surface of the square is first aligned to either the X or Y axis, and then the squareness error is measured while moving along the other axis. Due to the small measuring range of profile projectors, it is usually sufficient to determine the squareness using only two test points – one each near the limits of stage travel. The squareness is calculated in length units and not in angle. The precision square must be appropriately calibrated at the necessary test points. The Mitutoyo America Calibration Lab in Aurora, Illinois, offers ISO/IEC 17025 accredited calibrations for many types of precision squares.

Calibration Services at Mitutoyo America Corporation

Mitutoyo America offers ISO/IEC 17025 accredited field calibrations of Mitutoyo profile projectors (A2LA 1643.01). Contact 888-MITUTOYO or email field.service@mitutoyo.com. In addition, the Mitutoyo Calibration Laboratory in Aurora, Illinois, offers accredited calibrations (A2LA 0750.01) of all the measurement standards needed to calibrate profile projectors, as well as almost any other make or model of dimensional measurement standard or measuring instrument. The Mitutoyo Calibration Laboratory is the premier dimensional calibration laboratory in the United States. Customers are welcome to visit and tour the Calibration Laboratory. Contact 888-MITUTOYO or email calibration@mitutoyo.com.



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