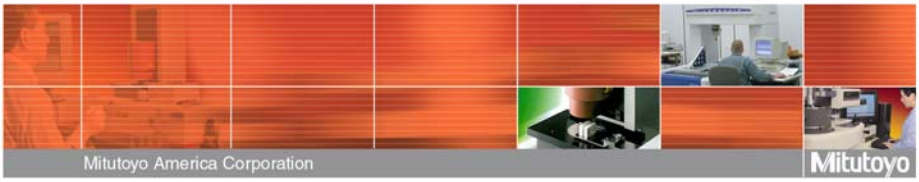

IMTS 2018

Reducing Calibration Risks in Your Measuring Systems: Leveraging Standards and Training

Jim Salsbury, Ph.D., General Manager, Corporate Metrology
Mitutoyo America Corporation

Mitutoyo

Mitutoyo America headquarters in Aurora, Illinois

New facility opened October 2013

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Mitutoyo Corporation

World's largest dimensional measuring instrument manufacturer

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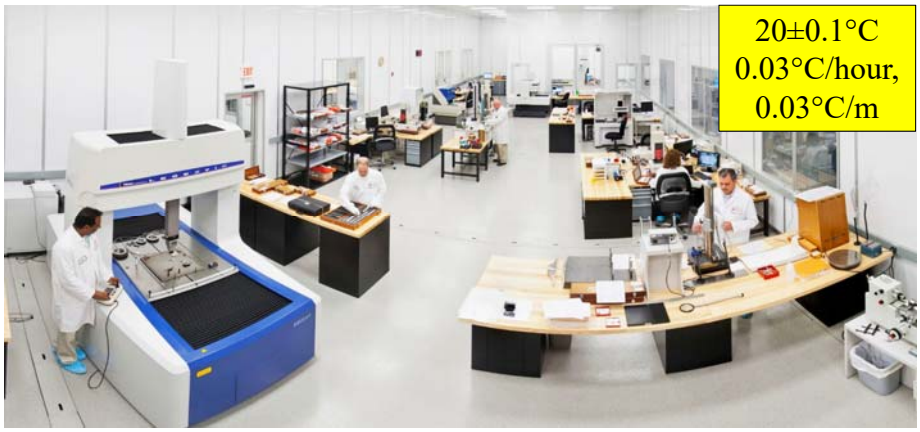
3

High Precision Calibration Lab



20±0.1°C
0.03°C/hour,
0.03°C/m

Mitutoyo America calibrates the masters for many organizations in the U.S., including other calibration laboratories.

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Mitutoyo Calibration Worldwide

Accredited laboratories and field service departments offering calibrations around the globe that are supported by international mutual recognition agreements.

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Mitutoyo Field Service Calibration

- Committed to serving the needs of our customers.
- A2LA accredited for almost all field calibrations since 2001.
- No extra cost for accredited calibrations.
- Strive to achieve at least a TUR of 4:1 for all calibrations.

ACCREDITED
CERTIFICATE #0750.01

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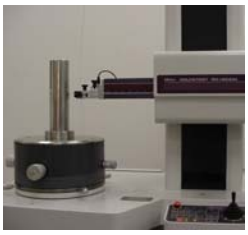
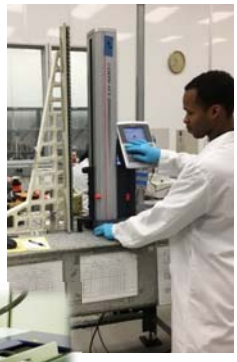
Lessons from True Calibration Stories

- There are some crazy practices happening every day in calibration.
- The goal of this presentation is to save you money and reduce your risks in calibration.





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Metrology Standards Work

- Mitutoyo is an active leader in the development of national and international metrology standards and practice.
- ASME B89 Dimensional Metrology
- ASME Y14 Dimensioning and Tolerancing.
- ISO/TC 213 Tolerancing and Metrology.
- NCSLI Dimensional Metrology Committee.

ASME

ISO

NCSL International

Mitutoyo

Educational Classes in Dimensional Metrology

Metrology Training Lab used primarily for teaching Hands-on "Gage Calibration" to customers

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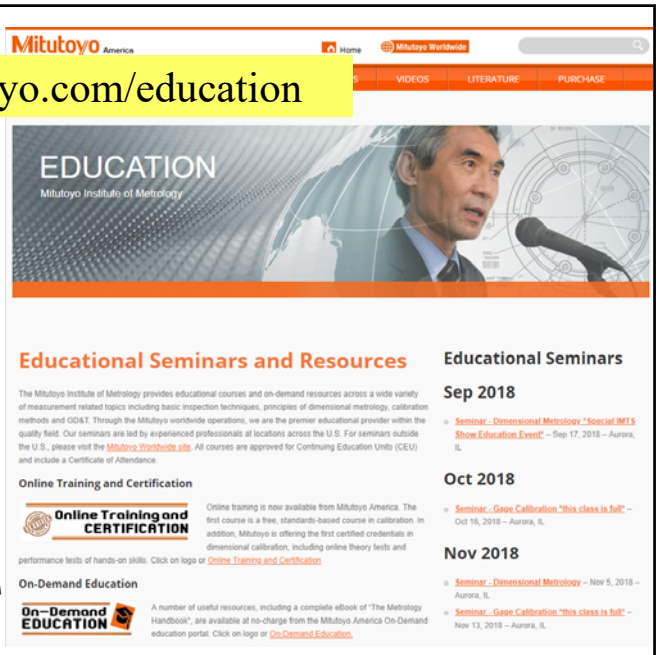
www.mitutoyo.com/education

Free On-Demand Metrology Educational Resources



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Main Lessons of this Presentation

- Don't waste money on unnecessary calibrations.
- Don't take on huge risks by not doing proper calibrations.
- Do realize calibration is your problem.
- Do understand there are some helpful resources.

Top in-house cal lab mistake: calibrating dial indicators with gage blocks. Just don't do it.

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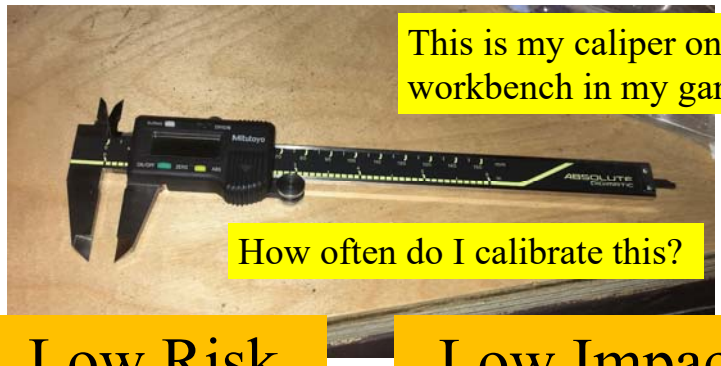
My Caliper



This is my caliper on my workbench in my garage

How often do I calibrate this?

Low Risk

Low Impact

It's been 20 years since the last calibration, and in this case, that is just fine for my needs.

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Linear Height, LH-600 Calibration

Accuracy < 0.0001” over 24”

Customer reported their 1-year old LH-600 was found out of tolerance.

We reviewed the cert from their 3rd party accredited calibration lab.

Uncertainty on cert ≈ 0.001”

The lab should not have accepted this work, but the customer had no idea.

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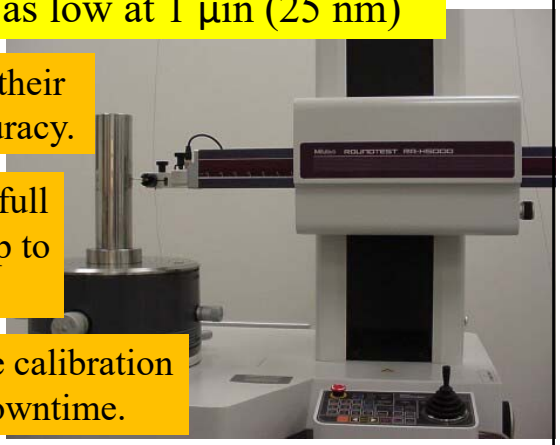
Roundness, RA-H5200, Calibration

Extreme accuracy as low at 1 µin (25 nm)



Customer bought it for their heavy parts, not for accuracy.

Due to high accuracy, full calibration may take up to two days.

We suggested alternative calibration to save money and downtime.

Customer was spending unnecessary money and resources on calibration.

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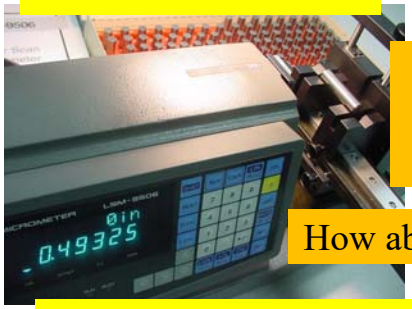
Pin Gage Calibration

Calibration with Laser Scan Micrometer



Customer said calibration costs more than buying new ones.

Customer suggested just buying new ones every year and throwing away the old ones.

How about just never calibrating them?

Every calibration cycle has a beginning and end. It is critical to do "as-found" readings to establish reliability. Even equipment that you never plan to use again needs to be recalibrated.

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CMM Calibration

ISO 10360-2:2009 standard
Length Measurement, E_0

- E_0 test run in 7 positions. In each position, 5 lengths and 3 repeats, for a total of 105 measurements.
  - Four space diagonals.
  - Parallel to X, Y, and Z axes.
- Comprehensive overall test of CMM structure, probe system, and repeatability.
  - Each measurement is a single point to single point distance which thoroughly tests the CMM.

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STA-Apex S Series

	Model No.	CRYSTA-Apex S 9106 / [9108]	CRYSTA-Apex S 9166 / [9168]	CRYSTA-Ape 9206 / [920
Measuring range	X axis	35.43"(900mm)		
	Y axis	39.36"(1000mm)	62.99"(1600mm)	78.3"(2000r
	Z axis	23.62"(600mm) / [31.49"(800mm)]		
Resolution		0.000004" (0.0001mm)		
Guide method		Air bearings on each axis		
Drive speed	*CNC mode* (Key selector: AUTO)	Max. moving speed = 519mm/s (20.4"/s) (3D) Max. measuring speed = 8mm/s		
	CNC mode (Key selector: MANUAL)	Max. moving speed = 239mm/s (9.4"/s) (3D) Max. measuring speed = 8mm/s		
Max. drive acceleration		2309mm/s² [1732mm/s²] (3D)		
Workpiece	Maximum height	31.49" (800mm) / [39.36" (1000mm)]		
	Maximum mass	2,645lbs.(1200kg)	3,306lbs. (1500kg)	3,968lbs. (180
Mass (including the control device and installation platform)		4,919lbs. (2231kg) [4,985lbs. (2261kg)]	6,322lbs. (2868kg) [6,389lbs. (2898kg)]	8,625lbs. (391 [8,691 lbs. (394
Air supply	Pressure	58 PSI (0.4MPa)		
	Consumption	2.11CFM (60L/min) under normal conditions		
	Air source	4.23CFM (120L/min)		

CRYSTA-Apex S900 Series Accuracy ISO 10360-2 unit:

Probe used	Maximum permissible error ($E_{0,MPE}$) ISO 10360-2:2009	Maximum permiss probing error (P_{FTU} ISO 10360-5:20
SP25M (Stylus: ø4 X 50mm)	1.7+3 L/1000 (temperature environment 1) 1.7+4 L/1000 (temperature environment 2)	1.7
TP200 (Stylus: ø4 X 10mm)	1.9+3 L/1000 (temperature environment 1) 1.9+4 L/1000 (temperature environment 2)	1.9
TP20 (Stylus: ø4 X 10mm)	2.2+3 L/1000 (temperature environment 1) 2.2+4 L/1000 (temperature environment 2)	2.2

* L = Selected measuring length (in mm)

When comparing CMM accuracy, only the guaranteed accuracy specifications really matter (and are warrantied).

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CMM Specifications and Calibration

- All CMMs are specified to ISO 10360 standards.
- All CMM OEMs calibrate to ISO 10360 standards.
- With such well-accepted standards, all CMM calibrations follow the standards, right?

Unfortunately not even close!

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CMM Calibration Practice in the U.S.

- Non-standard methods.
- No specifications.
- No pass/fail statements.
- No as-found readings.
- Every day accredited cal certs are issued and cal stickers applied to CMMs that are not in-tolerance.

Happy to reduce calibration costs, customers have no idea about quality risks they have brought to their organization.

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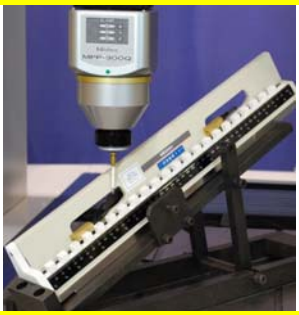
Impact of Calibration Risks

Mitutoyo Calibration Lab

Mitutoyo Field Calibration



If our lab releases bad data on Checkmasters, we would put at risk hundreds of CMMs and millions of measurements. That can never be allowed to happen.

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CALIBRATION

- **C**onformance to specification
  - Pass/fail statement? Decision rule?
  - Is uncertainty acceptable (less than tolerance, 4:1)?
- **A**djustments
  - Adjustments are often confused with calibration.
  - In any case, if you expect them, state it in advance.
- **L**imits – know your limits of acceptability
  - Define tolerance limits based on needs.
  - Look at manufacturer specs or standardized specs.

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CALIBRATION

- **I**dentify risks and impact
  - Level of accuracy. Likelihood of wear/drift.
  - What happens if out of tolerance occurs?
- **B**efore condition
  - Check the as-found condition, before service, before adjustment, before cleaning, before any repair.
- **R**equest what you need – not "calibrate this"
  - State specs, as-found, accredited, decision rule (4:1 TUR), conformance statement, adjustments.

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CALIBRATION

- **A**ccredited to ISO/IEC 17025
  - Traceability/competency.
- **T**echnique – method – procedure
  - Leverage the available documentary standards.
  - Look at manufacturer procedures.
- **I**ntervals – calibration intervals should be based on historical performance of the equipment.
  - The recommended calibration interval for a caliper is somewhere between 3 months and 25 years.

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CALIBRATION

- **O**ut of tolerance.
  - Are any out of tolerance conditions identified?
  - What is done when out of tolerance is found?
  - What can be done to limit future out of tolerance findings?
- **N**ew technology.
  - Be careful with new but similar looking technology.
  - More accurate and more capabilities may require different calibration methods.

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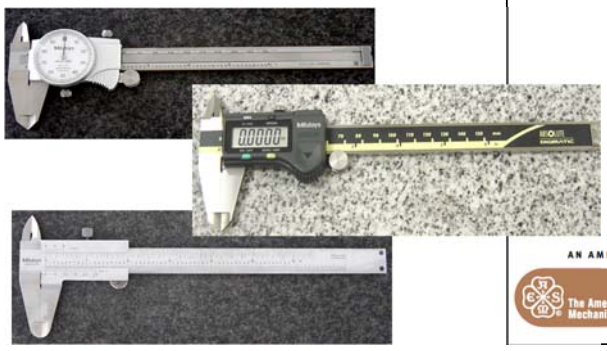
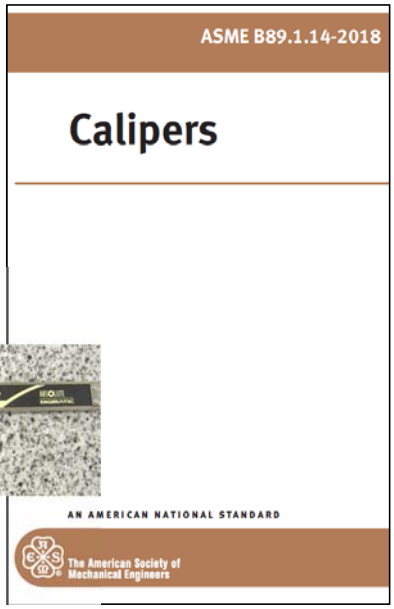
First American National Standard for Calipers

- ASME B89.1.14-2018
- Published May 2018





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American Society of Mechanical Engineers

- ASME B89 Dimensional Metrology
- Example American National Standards:
  - B89.1.9 Gage blocks
  - B89.1.10 Dial indicators
  - B89.1.13 Micrometers
  - B89.1.14 Calipers
  - B89.3.7 Granite surface plates
  - B89.7.3.1 Decision rules
  - B89.7.3.2 Measurement uncertainty
  - B89.7.5 Traceability

If you calibrate any of these, you should have the standard.

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Scope of ASME B89.1.14

- Design and metrological characteristics
- Default specification values
- Measurement uncertainty and decision rules
- Detailed test methods for calibration
  - Efficient yet sufficient – minimum expectations
  - Rules for setting zero, number of test points, etc.

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Selection of the default MPE Values

Measured Length, L		Digital Resolution of Caliper			
		0.0005 in.		0.01 mm	
mm	in.	E_{MPE}, in.	S_{MPE}, in.	E_{MPE}, mm	S_{MPE}, mm
$0 \le L \le 50$	$0 \le L \le 2$	± 0.0010	± 0.0010	± 0.02	± 0.03
$50 < L \le 150$	$2 < L \le 6$	± 0.0010	± 0.0020	± 0.03	± 0.05
$150 < L \le 200$	$6 < L \le 8$	± 0.0015	± 0.0020	± 0.03	± 0.05
$200 < L \le 300$	$8 < L \le 12$	± 0.0015	± 0.0025	± 0.04	± 0.06

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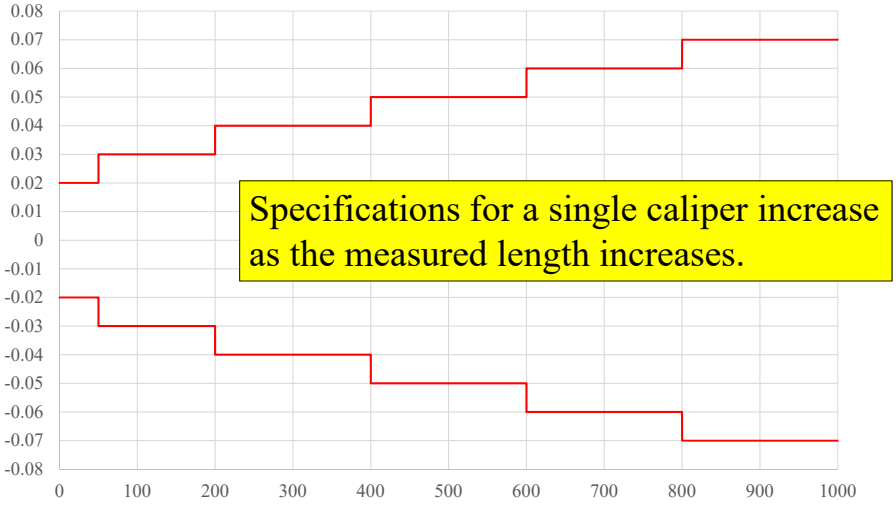
ASME B89.1.14 Caliper Specifications (mm)



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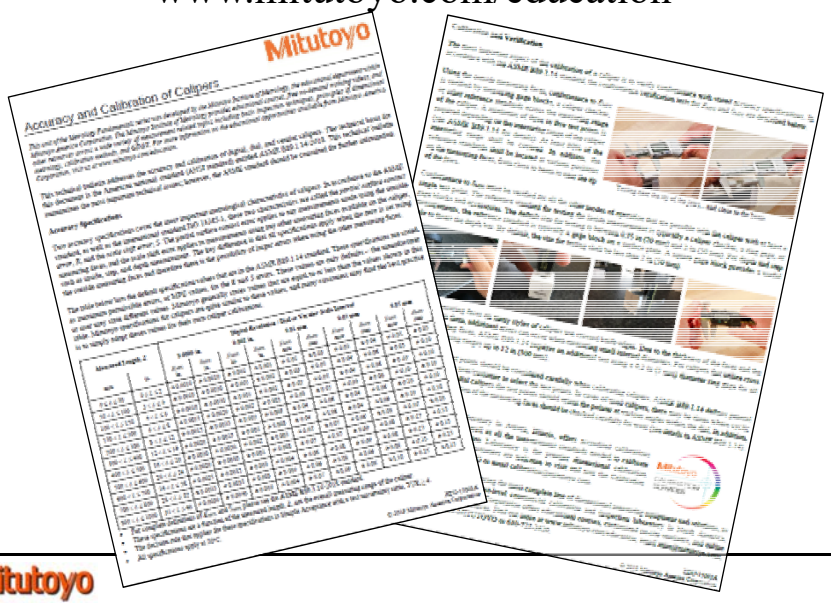
Free Technical Bulletin on ASME B89.1.14
www.mitutoyo.com/education



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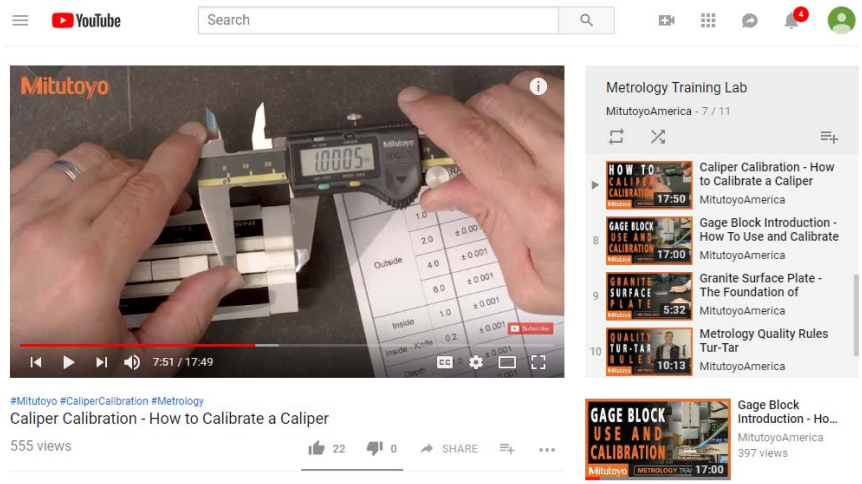
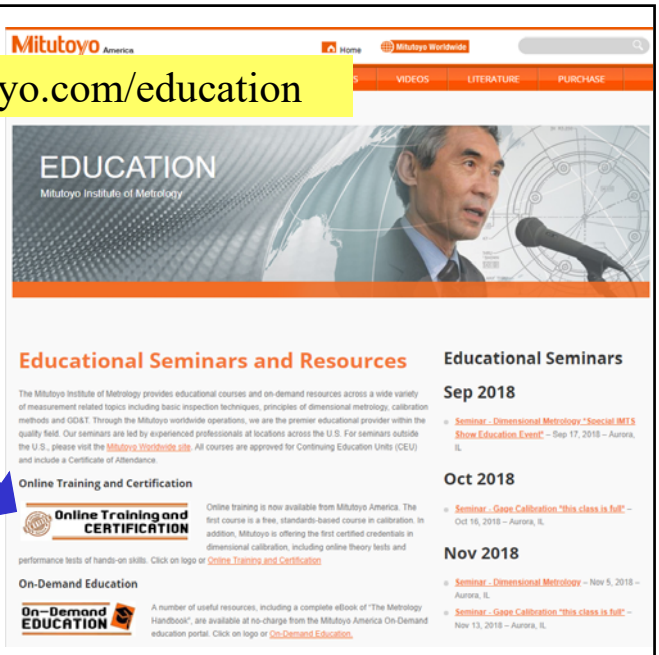
Free Online Training Videos Available



www.mitutoyo.com/education

Online Training and Certification



Online Training and Certification

- Free online video training for calibration concepts, calipers, and micrometer.
- Plan to add more in the future.
- Testing available to demonstrate your knowledge and hands-on performance and skills.

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Mitutoyo Institute of Metrology

Mitutoyo CALIBRATION SERVICES

Thank You

Dr. Jim Salsbury, GM, Corporate Metrology
630-723-3619, jim.salsbury@mitutoyo.com

www.mitutoyo.com/education

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