

Hi-precision Roundness/Cylindricity Measuring System **ROUNDTEST RA-H 5100** **SERIES**

Bulletin No. 1839

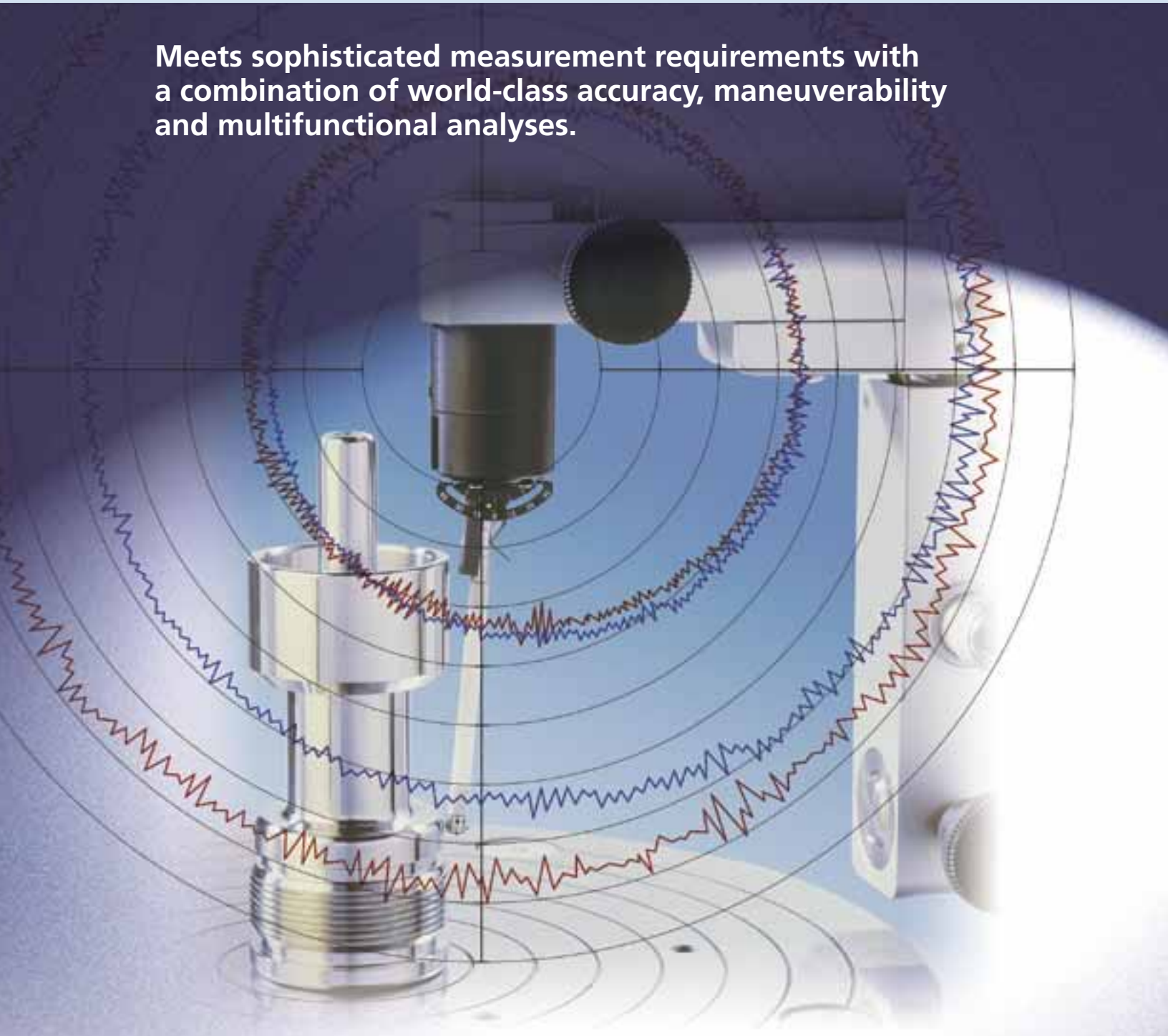


The Ultimate Roundness Tester

Mitutoyo

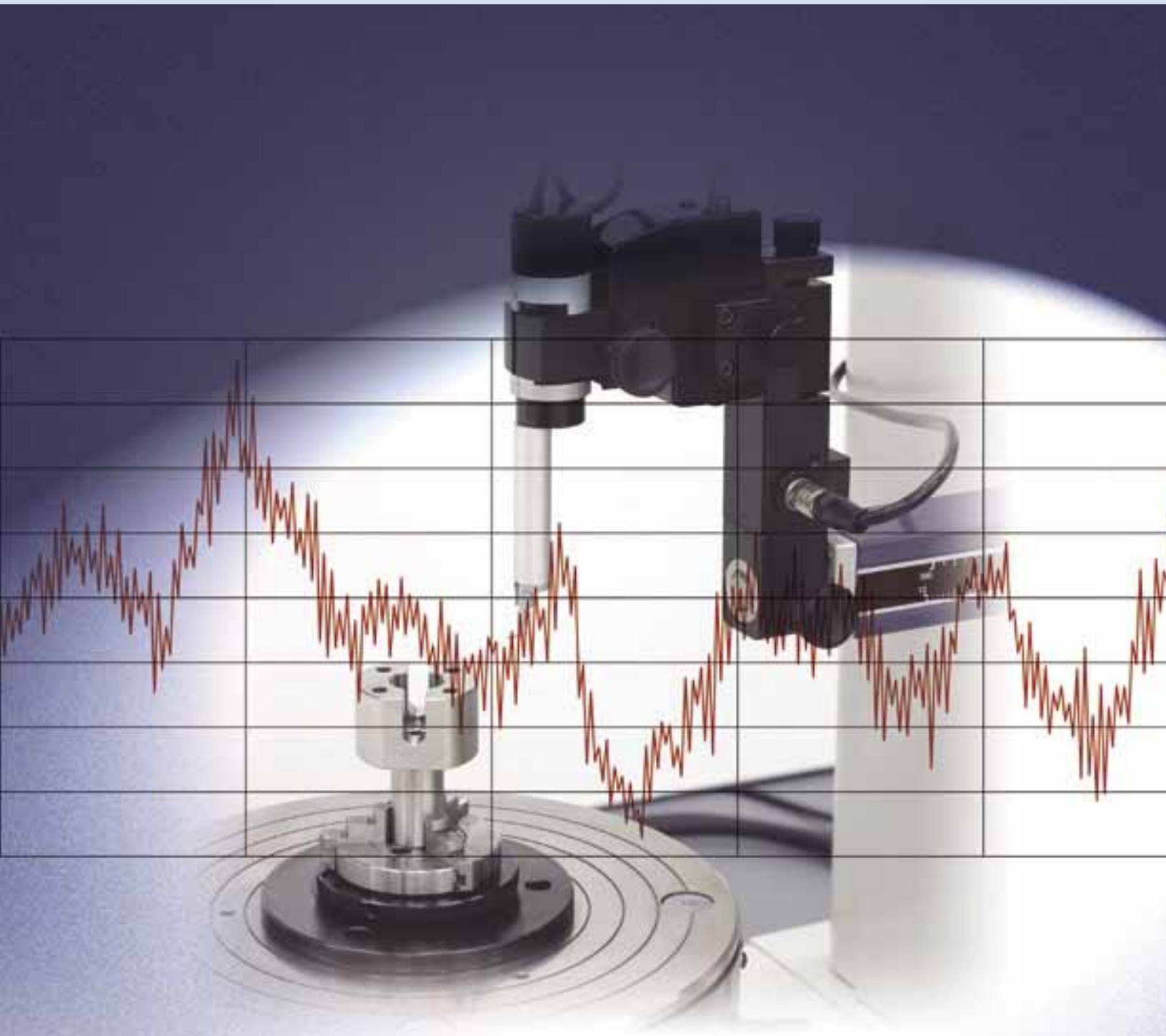
Enhances Product Quality, Reduces Time to Market, Reduces Costs, and Reduces Number of Defective Parts

Meets sophisticated measurement requirements with a combination of world-class accuracy, maneuverability and multifunctional analyses.



Greatly increases the total measurement throughput • Equipped with high-speed centering/leveling function • Fully automated operation from workpiece set-up to printing out measurement results • Measurement functions enhanced, including tracking measurement, automatic OD/ID measurement, etc.

Mitutoyo



Roundness and surface roughness measurements are both available from a single measuring system; workpiece set-up for roughness measurement is unnecessary. Roughness measurement is possible in the axial and circumferential directions.

ROUNDTEST EXTREME RA-H 5100 CNC SERIES

This CNC roundness measuring system greatly increases productivity and efficiency through a combination of high-accuracy and CNC automatic measurement functionality. It automatically performs high-speed, unattended measurement with automatic position control of the probe (in increments of 1 degree).



Position control of the holder-arm (vertical/horizontal)



Probe rotation mechanism

ROUNDTEST RA-H 5100 SERIES

This manual roundness/cylindricity measuring system was developed to combine world-class accuracy with easy maneuverability/high analysis capability. Enhanced measurement functions include a tracking measurement and automatic OD/ID measurement capabilities. It is also capable of roughness measurement (both in circumferential and axial directions).



BUILT FOR EXTREME PRECISION

High-accuracy automatic centering/leveling turntable

A highly accurate, highly rigid turntable allows measurement of critical components. Using a rotor and stator, in addition to an air-bearing incorporating a complex aperture that provides superior rigidity and uniform pressure distribution, gives rotational accuracy (radial) a world-class $(0.02 + 4H/10000)\mu\text{m}$.

The automatic centering/leveling mechanism incorporates a high-precision glass scale on each axis of the turntable. This allows feedback to be generated that prevents positioning errors from affecting centering/leveling adjustments. The high-speed, automatic, centering/leveling capability achieved greatly contributes to reducing the total measurement time from workpiece setting to workpiece measurement.

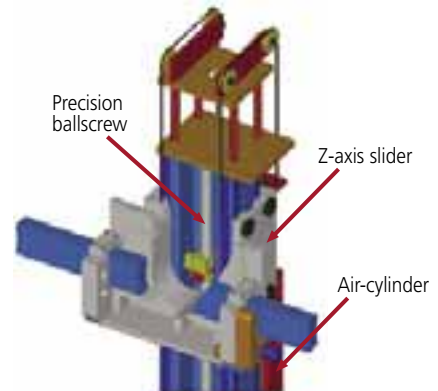


High-accuracy Z-axis column

The column guide, the heart of straightness in this machine, is tuned to extreme accuracy and uses precision ballscrews to drive the Z-axis slide movements in addition to a unique vibration damping mechanism to eliminate any vibration under power.

The precision ballscrews are arranged at the center of gravity of the Z-axis slide to prevent the slide's inertia from affecting traverse straightness while the slide is accelerating. To thoroughly eliminate vibrations, a long Z-axis slider and an air-balance type counterbalance are used.

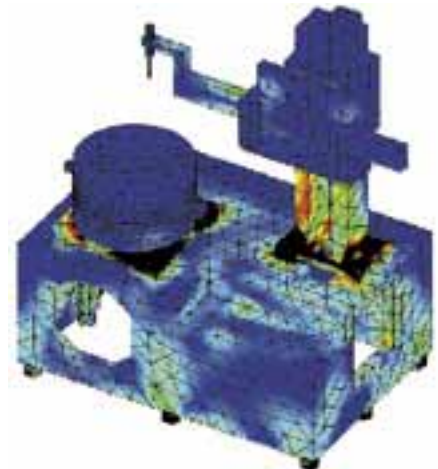
As a result, an ultra-high Z-axis drive straightness of $0.05\mu\text{m}/100\text{mm}$ (narrow range) is achieved.



High-rigidity machine base

The machine base is the foundation supporting the turntable, column, X-axis slide and the workpiece itself. It is essential that this foundation is highly rigid if the components are to function together as a highly accurate measuring system.

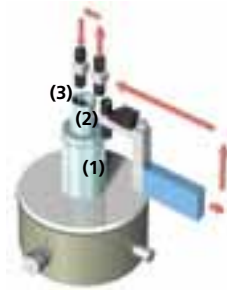
Leading-edge FEM structural analysis/simulation techniques were used in the design of the machine base, resulting in an exceptionally rigid construction that is virtually free of deformation due to load shift during measurement. Parallelism between the turntable and column axes is also maintained to a high order allowing stable, highly accurate measurements to be made.



INCREASED FUNCTIONALITY

Automatic continuous OD/ID measurement

Automatic measurement can be performed continuously from external diameter to internal diameter without having to change the probe position. This not only reduces measurement time but eliminates the error factors otherwise involved in changing the probe position, greatly facilitating high-accuracy measurement.



Continuous measurement is possible as shown in steps (1) through (3) on the figure at the left, without having to switch the probe direction.

(1) and (2): OD measurement
(3): ID measurement
→: Movement

X-axis tracking measurement

Thanks to the linear scale built into the X-axis (radial direction), measurement can be performed while tracking the workpiece. This function is effective for measuring a workpiece on which there is significant difference between diameters (such as a piston or a tapered shaft) that exceeds the detection range of the probe.

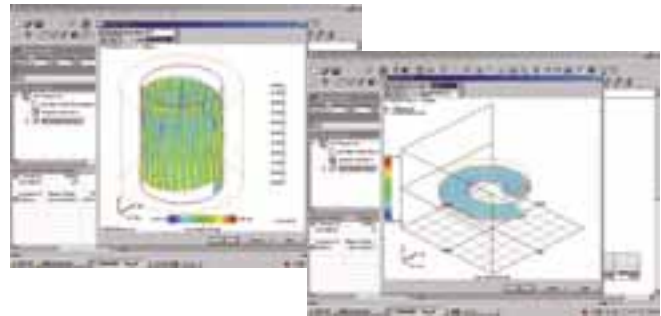


Measurement with tracking in X-axis

Because of the linear scale incorporated into the X-axis, measurement can be performed by tracking the workpiece surface. This function is effective for measuring a workpiece with a displacement that exceeds the detection range of the probe in measuring roundness/cylindricity or a taper that is determined with slider/column movement. (Tracking measurement range: $\pm 5\text{mm}$)

Spiral measurement function

Measurement and evaluation of cylindricity and flatness is possible with the spiral tracing method in which a workpiece is measured using a spiral motion of the probe. This method is free from intermittent movements of the probe and is therefore immune to the effect of hysteresis compared to the conventional discrete measurement method. It allows high accuracy and high-speed measurement/evaluation to be performed. This function is also effective for detecting flaws on workpiece circumference.

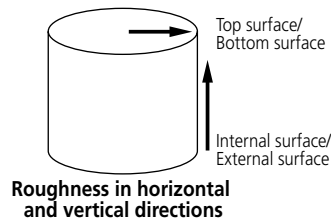
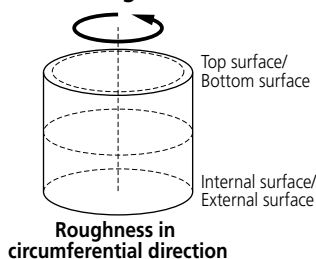


Surface roughness measurement function

(Roughness measurement unit: optional)

This is a multiple-sensor compatible system that is capable of accepting not only the roundness measuring system standard probe but also a surface roughness measuring detector. It permits verification of both geometric tolerancing on roundness or cylindricity and surface roughness to be performed with a single system.

Measuring direction



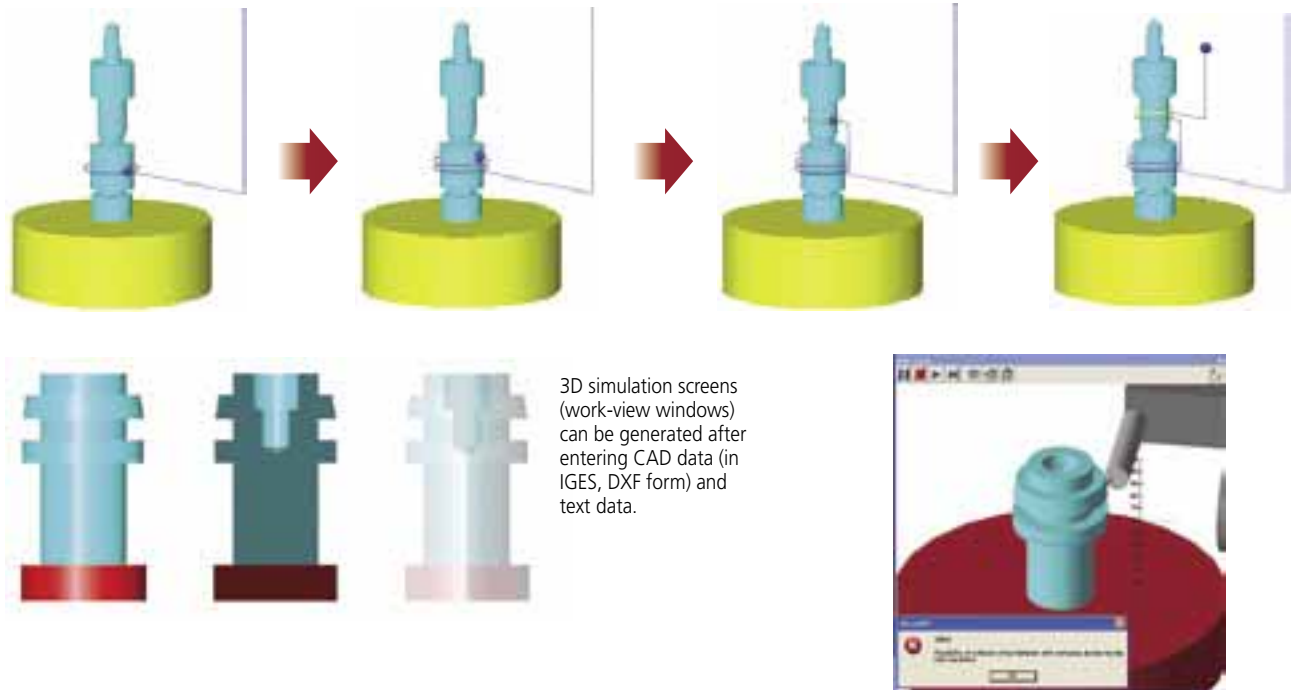
Roundness/cylindricity measurement/analysis software

ROUNDPAK®

Software for easy preliminary setup, measurement, analysis, and result output.

Off-line measurement procedure programming function

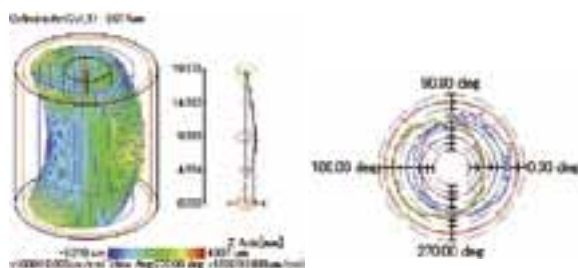
On-screen virtual 3D simulation measurements can be performed with the incorporated off-line teaching function that allows a part program (measurement procedure) to be created without a workpiece. The probe and the holder unit can be precisely represented with the Roundtest Extreme and an alarm can be issued to indicate that there is a risk of crash predicted during the simulation.



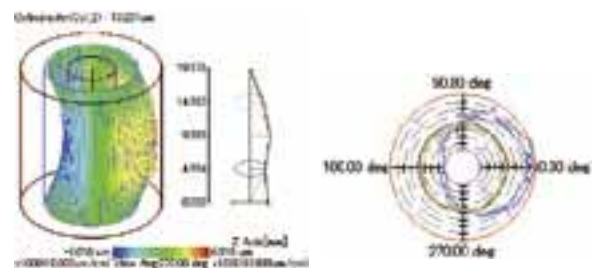
JIS B0021, ISO/DIS1101 based cylindricity evaluation

Cylindricity evaluation results obtained with the data analyzer of the conventional roundness/cylindricity measuring system differs from the results required by the relevant standard. This is due to the limited processing capability and calculation time of conventional systems, which simply select two arbitrary cross-sections to determine the reference axis as the line connecting the centers of the two sections for the calculation of cylindricity.

Cylindricity evaluation conforming to the relevant standards requires sophisticated algorithms and high data processing throughput to determine the reference axis of a cylinder. Mitutoyo ROUNDPAK offers a cylindricity evaluation function that complies with the established standard. Also, it is possible to perform cylindricity evaluation with the reference axis determined by using two arbitrary cross-sections if a correlation between cylindricity data accumulated on a conventional system and that obtained on a new one is required.



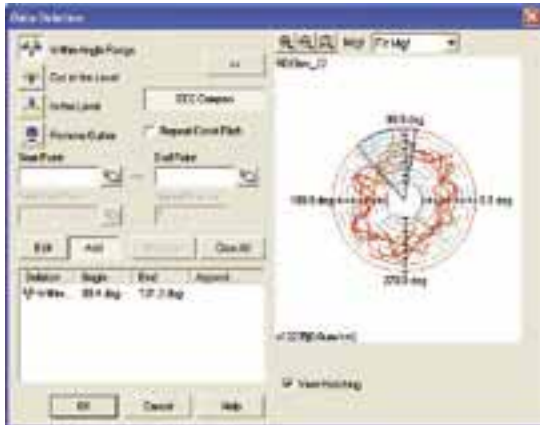
Cylindricity: .41" (10.541mm)
a. Standard-based cylindricity



Cylindricity: .78" (19.846mm)
b. Conventional system-based cylindricity

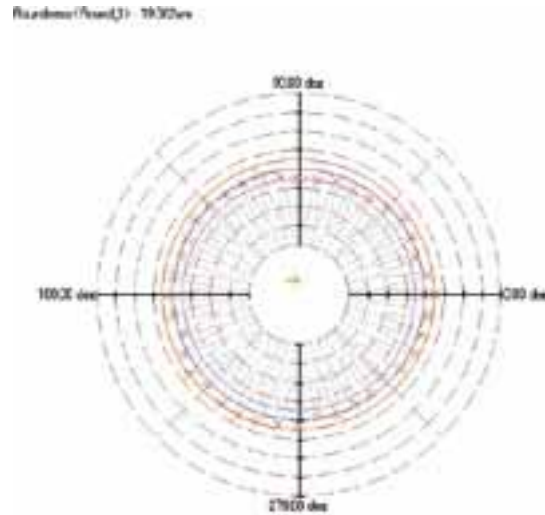
Data deletion function

This function allows calculation/analysis to be performed with only the remaining data after deleting unnecessary point data (from a notched section, or from an area outside the target area on the workpiece) from that obtained by measurement.



Feature points analysis

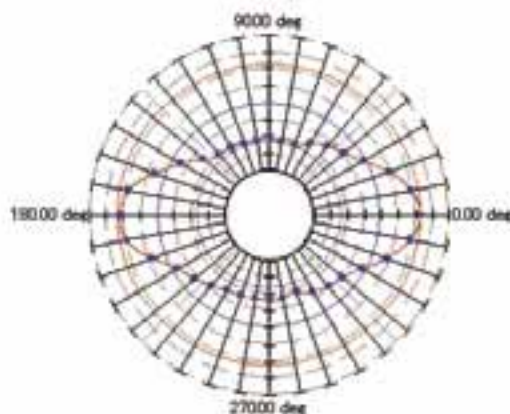
Analysis is possible with feature points (such as peak points or bottom points) extracted from the entire measurement data with the given conditions. This function is effective for analyses of roundness of tooth tips of a gear, etc.



Contour tolerancing function

The contour tolerancing function is provided to allow comparison between measured data and design data of a non-circular part, such as a piston, and to check the wear of a part by comparing measured data before and after use. Errors associated with workpiece setting can be offset by means of the best-fit function that allows a best-fit of the measured data and the master data by freely translating in the XY directions or rotating the data about the center.

Radial Contour(RCon_1) : 67.882um

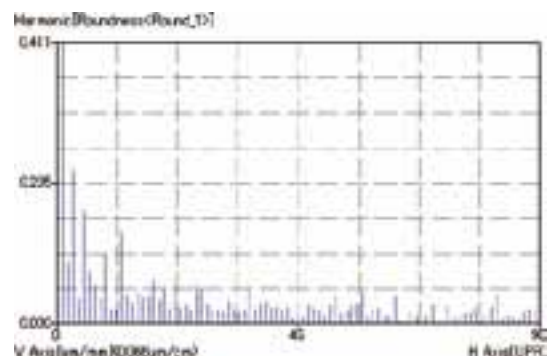


x200/50.000um/cm

Harmonic analysis

An effective function to analyze frequency components of measured data for the analysis of the process and processing method leading to workpiece deformation (by, for example, machine vibration and workpiece chucking) and for cause analysis of abnormal noise attributable to parts incorporated into a final product.

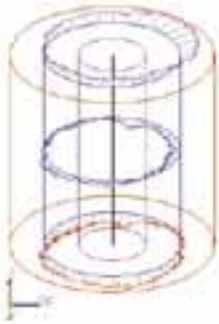
Harmonic [Table of Amplitude]										Amplitude [um]		
UPR	N=0	N=1	N=2	N=3	N=4	N=5	N=6	N=7	N=8	N=9		
PR0	0.00	0.41	0.00	0.20	0.04	0.17	0.00	0.00	0.04	0.10		
N=10	0.00	0.00	0.14	0.04	0.00	0.00	0.04	0.04	0.07	0.00		
N=20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
N=30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
N=40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
N=50	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
N=60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
N=70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
N=80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
N=90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		



ROUNDPAK®

Graphical display of results

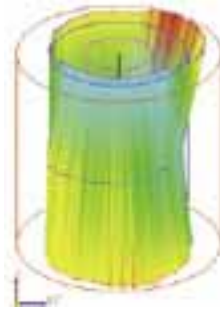
Results of analyses, such as for cylindricity or coaxiality, can be visually represented by a 3D graphical display. This 3D graphic can be pasted into a report, or into a software application through the clipboard.



Normal display



Wire-frame display



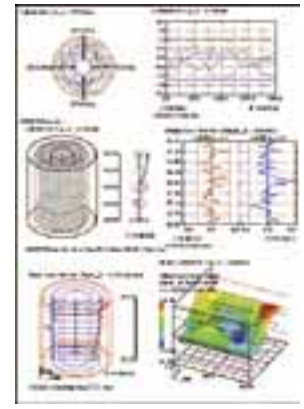
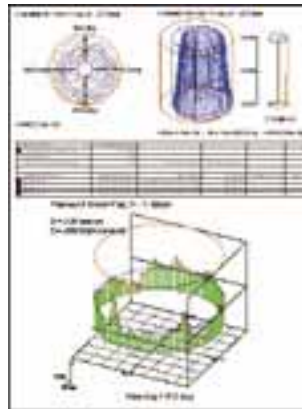
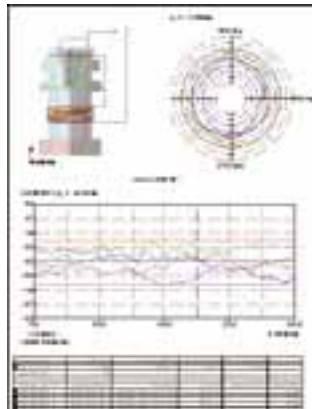
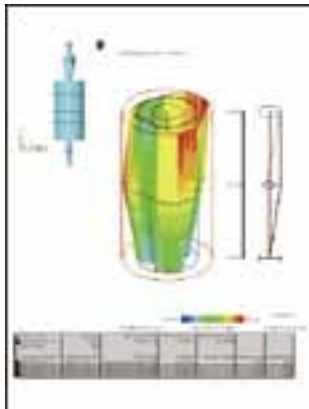
Surface map display



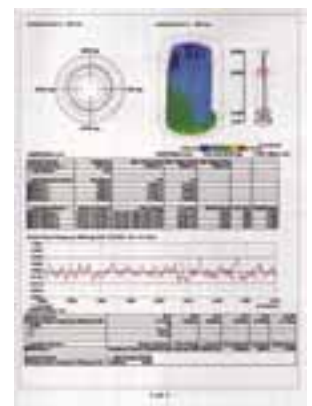
Shading display

Result output

Result output is possible in the customer's original format according to the layout prescribed for the location, size, etc., of the analysis results including graphics and drawings. The original layout, if saved, allows automatic operation from measurement to calculation (automatic saving, results display, and printing) just by pressing the measurement start button.





















Display examples of surface roughness measurement result reports



Analysis

Roundness measurement

Roundness		Roundness, mean roundness, narrow range roundness
Cylindricity		Cylindricity, mean cylindricity, spiral cylindricity, rectilinear motion cylindricity
Concentricity		
Coaxiality		Coaxiality (axis-axis), coaxiality (axis-element), spiral coaxiality (axis-axis), rectilinear motion coaxiality
Flatness		Flatness (1-element), flatness (N-element), spiral flatness, narrow range flatness
Parallelism		Parallelism (2-element), parallelism (N-element), rectilinear motion parallelism (IN/OUT), rectilinear motion parallelism (top/bottom)
Squareness		Squareness (axis-ref), squareness (plane-ref), rectilinear motion squareness, spiral squareness (axis-ref), spiral squareness (plane-ref)
Radius deviation		
Thickness deviation		
Runout		Runout (radial), runout (axial)
Total runout		Total runout (radial), total runout (axial), spiral total runout (radial), spiral total runout (axial)
Diameter measurement		
Straightness		Straightness (in/out), straightness (top/bottom)
		Inclination (in/out), inclination (top/bottom)
Taper		Taper (in/out), taper (top/bottom)
Radial contour tolerancing		
Rectilinear motion contour tolerancing		
Width measurement		Width measurement top/bottom (point-point), Width measurement top/bottom (plane-plane)

Roughness measurement

Sampling length	Arbitrary length (fixed with one sampling length)
Assessed profiles	Primary profile, roughness profile
Evaluation parameters	Ra1, Rp1, Rv1, Rz1, Rq1, RzJS, Rsm, Rmr(c), Pa1, Pp1, Pv1, Pz1, Pq1, PzJS, Psm, Pmr(c)
Cutoff length: λc inch(mm)	.01" (0.25), .03" (0.8), .10" (2.5), .31" (8), .98" (25), arbitrary value
Digital filter	Gaussian
Data compensation	Eccentricity compensation (rotational roughness measurement) Inclination compensation (rectilinear motion roughness measurement)

OPTIONAL ACCESSORIES

Interchangeable Styli for RA-H 5100S/H CNC

inch(metric)

Application/Type	Groove	Flat surface	General purpose	Notch
Order No.	12AAE310	12AAE302	12AAF150	12AAE309
Stylus tip	ø.06" (ø1.6) tungsten carbide	ø.06" (ø1.6) tungsten carbide	ø.06" (ø1.6) tungsten carbide	ø.06" (ø1.6) tungsten carbide
Dimensions inch(mm)				
Application/Type	ø.06" (ø1.6) ball	ø.03" (ø0.8) ball	ø.02" (ø0.5) ball	Deep groove
Order No.	12AAE303	12AAE304	12AAE305	12AAE308
Stylus tip	ø.06" (ø1.6) tungsten carbide	ø.03" (ø0.8) tungsten carbide	ø.02" (ø0.5) tungsten carbide	ø.06" (ø1.6) tungsten carbide
Dimensions inch(mm)				
Application/Type	Deep hole A		Deep hole B	
Order No.	12AAE306		12AAE307	
Stylus tip	ø.06" (ø1.6) tungsten carbide		ø.06" (ø1.6) tungsten carbide	
Dimensions inch(mm)				

Options common to the RA-H 5100S/H CNC, RA-H 5100AS/AH



Centering chuck
(key operated)

No. 211-014

Suitable for holding longer parts and those requiring a relatively powerful clamp.

- Holding capacity: Internal jaws, OD: .04"-1.38" (1-35mm) Internal jaws, ID: 1.30"-3.35" (33-85mm) External jaws, OD: 1.18"-3.15" (30-80mm)
- External dimensions: ø6.18" x 2.99" (ø157 x 76mm)
- Mass: 8.38 lbs. (3.8 kg)



Centering chuck
(ring operated)

No. 211-032

Suitable for holding small parts with easy-to-operate knurled-ring clamping.

- Holding capacity: Internal jaws, OD: .04"-1.42" (1-36mm) Internal jaws, ID: .55"-2.76" (14-70mm) External jaws, OD: .04"-2.95" (1-75mm)
- External dimensions: ø4.65" x 1.34" ø118 x 34mm
- Mass: 2.65 lbs. (1.2kg)



Micro-chuck
No. 211-031

Used for clamping a workpiece with a diameter less than .04" (1mm) that the centering chuck cannot handle.

- Holding capacity: up to ø.06" (ø1.5mm)
- External dimensions: ø4.65" x 1.91" (ø118 x 48.5mm)
- Mass: 1.76 lbs. (0.8kg)



Magnification calibration gage
No. 211-045

Used for normalizing detector magnification by calibrating detector travel against displacement of a micrometer spindle.

- Maximum calibration range: 400µm
- Graduation: 0.2µm
- External dimensions (WxDxH): 9.25" (max) x 7.28" x 2.76" (235(max) x 185 x 70mm)
- Mass: 8.82 lbs. (4kg)

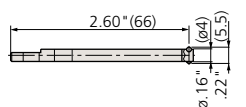
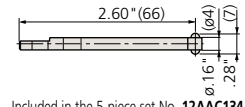
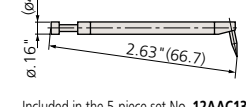
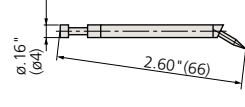
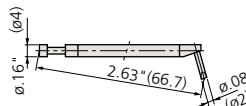
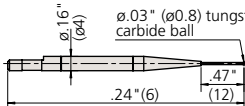
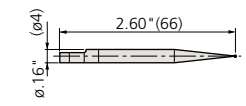
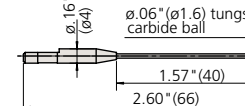
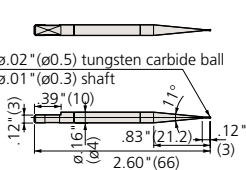
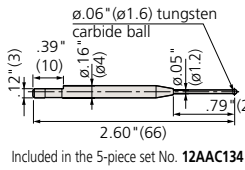
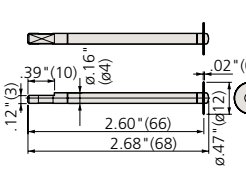
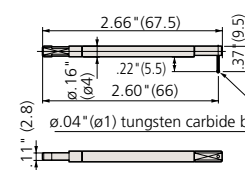
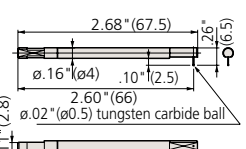
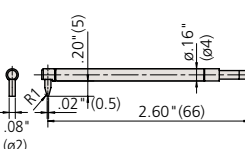
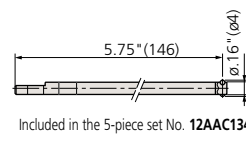
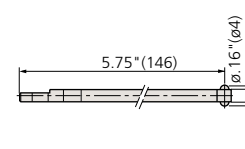
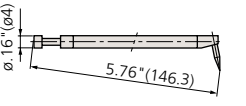
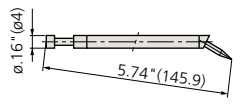
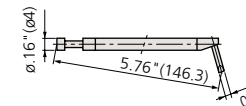
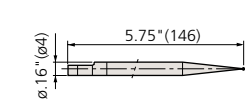
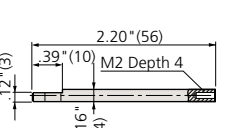
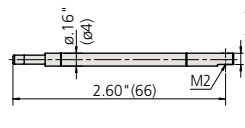
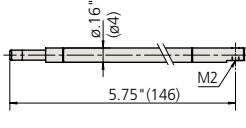
Cylindrical square
No. 350850

- Straightness: 0.5µm
- Cylindricity: 2µm
- External dimensions: ø2.76" x 9.84" (ø70 x 250mm)
- Mass: 16.53 lbs. (7.5kg)

Protective shield
No. 12AAB949

Interchangeable Styli for RA-H 5100AS/AH

Inch (Metric)

Application/Type	Standard type (supplied)	Notch	Deep groove	Corner
Order No.	12AAB681	12AAB682	12AAB683	12AAB684
Stylus tip	ø.06" (ø1.6) tungsten carbide	ø.12" (ø3) tungsten carbide	ø.01" (0.25) radius sapphire	ø.01" (0.25) radius sapphire
Dimensions inch (mm)		 Included in the 5-piece set No. 12AAC134	 Included in the 5-piece set No. 12AAC134	
Application/Type	Cutter mark	Small hole ø.03" (ø0.8)	Small hole	Small hole ø.06" (ø1.6)
Order No.	12AAB685	12AAE859	12AAB686	12AAE855
Stylus tip	.59" (15) radius tungsten carbide	ø.03" (ø0.8) tungsten carbide	ø.04" (ø1) tungsten carbide	ø.06" (ø1.6) tungsten carbide
Dimensions inch (mm)			 Included in the 5-piece set No. 12AAC134	
Application/Type	Extra small hole Depth: .12" (3)	ø.06" (ø1.6) ball	Disk	Crank tip: ø.02" (ø0.5)
Order No.	12AAB687	12AAB674	12AAB694	12AAB696
Stylus tip	ø.02" (ø0.5) tungsten carbide	ø.06" (ø1.6) tungsten carbide	ø.47" (ø12)	ø.06" (ø1.6) tungsten carbide Depth: .10" (2.5)
Dimensions inch (mm)		 Included in the 5-piece set No. 12AAC134		
Application/Type	Crank (tip: ø1 mm)	Flat surface	2X-long type*	2X-long type notch*
Order No.	12AAB695	12AAE856	12AAB688	12AAB689
Stylus tip	.04" (ø1) tungsten carbide Depth: .22" (5.5)	Tungsten carbide	ø.06" (ø1.6) tungsten carbide	ø.12" (ø3) tungsten carbide
Dimensions inch (mm)			 Included in the 5-piece set No. 12AAC134	
Application/Type	2X-long type deep groove*	2X-long type corner*	2X-long type cutter mark*	2X-long type small hole*
Order No.	12AAB690	12AAE691	12AAB692	12AAB693
Stylus tip	.01" (0.25) radius sapphire	ø.04" (ø1) tungsten carbide Sapphire	.59" (15) radius tungsten carbide	ø.04" (ø1) tungsten carbide
Dimensions inch (mm)				
Application/Type	Stylus shank	Stylus shank (standard groove)	Stylus shank (2X-long groove)	
Order No.	12AAB676	12AAE857	12AAE858	
Stylus tip	For mounting CMM stylus (mounting thread M2)			
Dimensions inch (mm)				

* Measuring is only in the vertical direction.

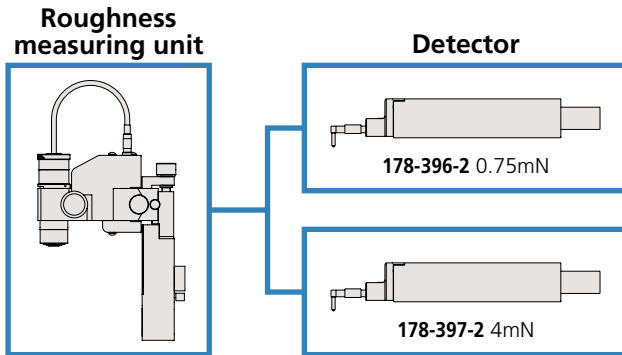
Measuring magnification of 20000X is available using the 2X-long stylus.

A set of five optional interchangeable styli is available including the most commonly used ones.

Customized special interchangeable styli are available on request. Please contact any Mitutoyo office for more information.

SPECIFICATIONS

Roughness measuring unit



Detectors matching the measurement method are also required in addition to the Roughness measuring unit.

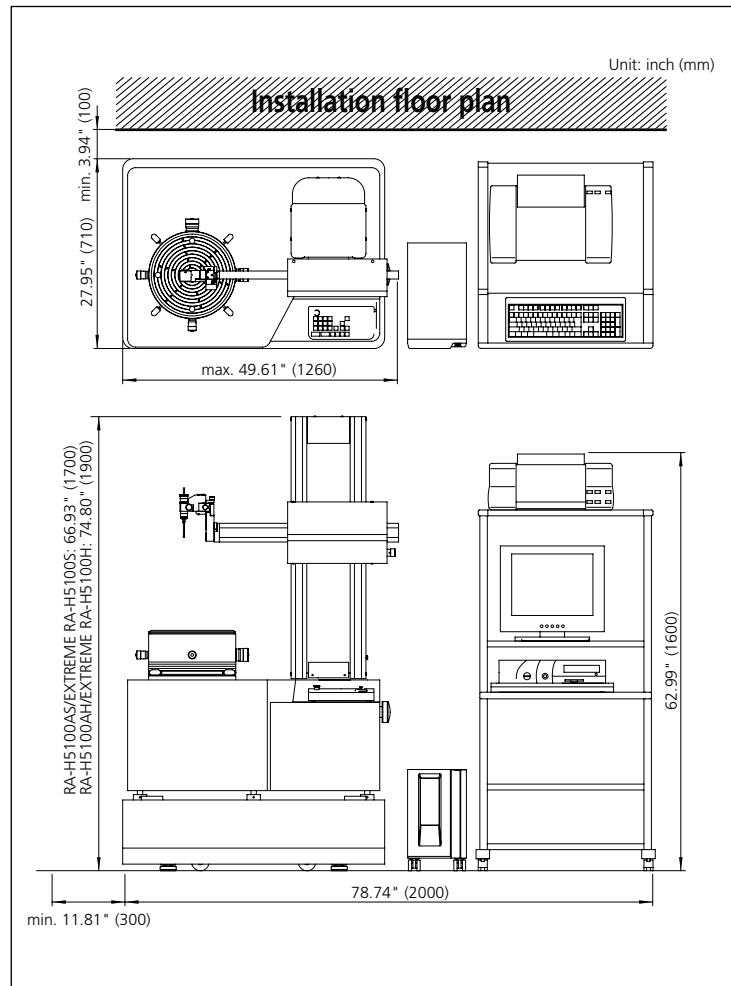
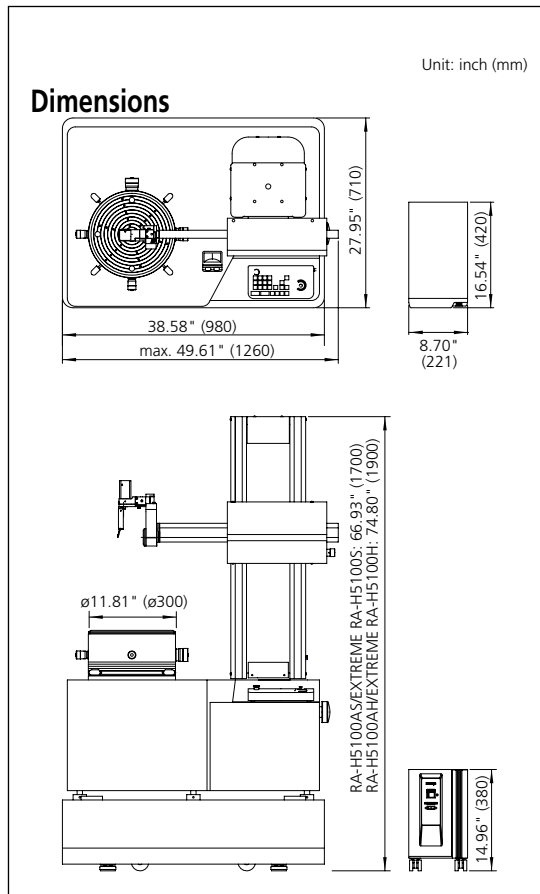
Specifications for roughness measurement

Model No.	RA-H 5100
Order No.	211-838
Direction of rotation	Clockwise
Measuring speed	Circumferential velocity .01"-.98"/s (0.25-25mm/s) (12 steps) (Table speed 0.5-2rpm)
Measuring range	ø.08"-ø14.29" (ø2 - ø363mm)*
Traverse linearity	Less than 1µm for both radial/axial directions

Maximum measurement diameter value in surface roughness measurement according to λc value

λc inch(mm)	λs inch(µm)	Maximum measurement value inch(mm)
.01" (0.25)	.10" (2.5)	ø3.77" (ø95.8)
.03" (0.8)	.10" (2.5)	ø3.77" (ø95.8)
.10" (2.5)	.31" (8)	ø14.29" (ø363mm)*
.31" (8)	.98" (25)	ø14.29" (ø363mm)*
.98" (25)	3.15" (80)	ø14.29" (ø363mm)*

* Above specifications apply to measurement with the detector No. **178-396-2** (0.75mN) or **178-397-2** (4mN) fitted with a standard stylus.



Specification

Inch (Metric)

Item		Model No.	RA-H 5100AS	RA-H 5100AH	EXTREME RA-H 5100S CNC	EXTREME RA-H 5100H CNC
Order No.	With machine stand		211-823	211-824	211-837	211-838
	With vibration isolating stand		211-823-2	211-824-2	211-837-2	211-838-2
Turntable	Rotational accuracy	Radial direction	(0.02+4H/10000) μ m H = probing height above turntable (mm)			
		Axial direction	(0.02+6X/10000) μ m X = distance from the turntable axis (mm)			
	Rotational speed	2,4,6,10rpm (in auto-centering: 20rpm)				
	Effective table diameter	ϕ 11.81" (ϕ 300mm)				
	Centering range	\pm .20" (\pm 5mm)				
	Leveling range	\pm 1 $^{\circ}$				
	Maximum table loading	176 lbs. (80kg) (in auto-centering: 143 lbs. (65kg))				
	Maximum measuring diameter	ϕ 15.75" (ϕ 400mm)		14.02" (ϕ 356mm)		
Maximum workpiece diameter	26.77" (ϕ 680mm)					
Vertical drive unit (Z-axis column unit)	Traverse straightness λ c. .10" (2.5)	Narrow range	0.05 μ m/100mm			
		Wide range	0.14 μ m/350mm	0.2 μ m/550mm	0.14 μ m/350mm	0.2 μ m/550mm
	Parallelism with turntable axis (generatrix base)	0.2 μ m/350mm	0.32 μ m/550mm	0.2 μ m/350mm	0.32 μ m/550mm	
	Traverse range	13.78" (350mm)	21.65" (550mm)	13.78" (350mm)	21.65" (550mm)	
	Traverse speed	2.36"/s (60mm/s) maximum for positioning; .02", .04", .08", .20"/s (0.5, 1, 2, 5mm/s) for measuring				
	Maximum probing height	for measuring OD	13.78" (350mm)	21.65" (550mm)	13.78" (350mm)	21.65" (550mm)
		for measuring ID	13.78" (350mm)	21.65" (550mm)	13.78" (350mm)	21.65" (550mm)
Maximum probing depth	3.94" (100mm)		ϕ .50"x1.02" (ϕ 12.7x26mm) (using the standard stylus) ϕ 1.26"x3.11" (ϕ 32x79mm) (using the standard stylus)			
Radial drive unit	Arm straightness λ c. .10" (2.5)	0.4 μ m/200mm				
	Perpendicularity to turntable axis (generatrix base)	0.5 μ m/200mm				
	Traverse range	8.86" (225mm)				
	Traverse speed	1.97"/s (50mm/s) maximum for positioning; .02", .04", .20"/s (0.5, 1, 5mm/s) for measuring				
Detector	Measuring force	7-50mN (changeable in 5 steps)		40mN		
	Stylus tip shape/material	ϕ .06" (ϕ 1.6mm) tungsten carbide ball				
	Range	Standard	\pm 400 μ m			
		Tracking	\pm .20" (\pm 5mm)			
Other	With stylus angle scale		Rotation mechanism (0 to 270 $^{\circ}$ in increments of 1 $^{\circ}$)			
Air Supply	Air pressure	390kPa				
	Air consumption	45L/min in standard condition (air supply of 120L/min or more)				
Mass	Main unit	1,433 lbs. (650kg)	1,477 lbs. (670kg)	1,433 lbs. (650kg)	1,477 lbs. (670kg)	
	Stand	With machine stand: 220 lbs. (100kg), with vibration isolating stand: 375 lbs. (170kg)				
Standard accessories		211-016 Reference hemisphere 356038 Thin workpiece stage 998382 Origin-point gage 12AAB681 Standard type styli 997090 Magnification calibration kit 996278 Air cleaner	211-016 Reference hemisphere 12AAE404 Thin workpiece stage 12AAD877 Origin-point gage for CNC 12AAF150 Standard type 12AAE302 Flat surface styli 997090 Magnification calibration kit 996278 Air cleaner			

Roundtest RA-H 5100 Series



Specifications are subject to change without notice.

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