FORMTRACER Avant S3000 Series
SERIES 178 — Surface Texture Measuring Instruments

FTA-S4S3000

- **FORMTRACER Avant S3000** Series are highly functional and user-friendly surface roughness measuring systems with innovative design features.
- **The FORMTRACER Avant S3000** Series includes models with inclined drive unit. Inclining the drive unit makes it easier to approach target surfaces and measure large workpieces.

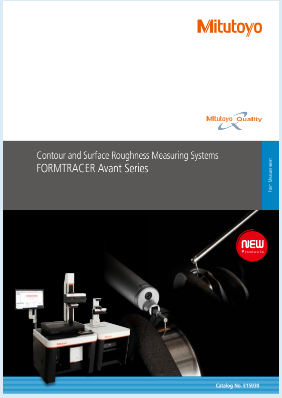
Inclined drive unit

- Equipped with an operability focused, new style remote box. The new part program key strongly supports manual part-programming.
- High throughput is achieved thanks to high drive speed (X axis: Max. 80 mm/s, Z2 axis: Max. 30 mm/s) and acceleration (X axis: 30 mm/s^2).
- All connecting cables are contained within the measuring instrument to eliminate any inconvenience during measurement.
- The Z1-axis detector is equipped with a built-in anti-collision safety device.
- A variety of detector holders (optional) are available.
- A detector for measuring contours can be retrofitted.

Large sized base models and high-column models are added to the line-up.

Remote box with user-friendly operability

Detector holder (optional)



Refer to the **FORMTRACER Avant** Series Brochure (**E15030**) for more details.

SPECIFICATIONS

Model No.		FTA-S4S3000	FTA-H4S3000	FTA-W4S3000	FTA-L4S3000	FTA-S8S3000	FTA-H8S3000	FTA-W8S3000	FTA-L8S3000
Measuring range	X axis	100 mm				200 mm			
	Z1 axis	800 µm, 80 µm, 8 µm							
Straightness (when the X axis is horizontal)		(0.05+0.001L) µm L = Measurement Length (mm)				(0.1+0.002L) µm L = Measurement Length (mm)			
X-axis inclination angle		±45° (Only for models with X-axis inclining drive unit)							
Z2-axis (column) travel range		300 mm	500 mm		700 mm	300 mm	500 mm		700 mm
Base size (W×D)		60×450 mm		1000×450 mm		600×450 mm		1000×450 mm	
Base material		Granite							

Note: While the appearance of the natural stone measuring table varies according to the source, the high stability for which this material is known can always be relied upon.

FORMTRACER Avant C3000/4000 Series
SERIES 218 — Surface Texture Measuring Instruments

- **FORMTRACER Avant C3000/4000** Series are highly functional and user-friendly contour measuring systems with innovative design features.
- **FORMTRACER Avant C3000/4000** Series comes with the inclined drive unit as standard, making approach to the target surface and measurement of large workpieces much easier.

Inclined drive unit

- Equipped with an operability focused, new style remote box. The new part program key strongly supports manual part-programming.
- High throughput is achieved thanks to high drive speed (X axis: Max. 80 mm/s, Z2 axis: Max. 30 mm/s) and acceleration (X axis: 30 mm/s²).
- All connecting cables are contained within the measuring instrument to eliminate any inconvenience during measurement.
- The Z1-axis detector is equipped with a built-in anti-collision safety device.
- A detector for measuring roughness can be retrofitted.
- The arm of the detector is a user-friendly, magnetic, one-touch, detachable mechanism.
- **C4000** type is a highly functional contour measuring system that has a wide-range digital detector (measuring range: 60 mm), top/bottom plane continuous measurement function, automatic variable measuring force function, and stylus drop detection function.

Refer to the **FORMTRACER Avant** Series Brochure (**E15030**) for more details.

FTA-S4C3000

FTA-S4C4000

Large sized base models and high-column models are added to the line-up.

Remote box with user-friendly operability

Detector

SPECIFICATIONS

Model No.			FTA-S4C3000 FTA-S4C4000	FTA-H4C3000 FTA-H4C4000	FTA-W4C3000 FTA-W4C4000	FTA-L4C3000 FTA-L4C4000	FTA-S8C3000 FTA-S8C4000	FTA-H8C3000 FTA-H8C4000	FTA-W8C3000 FTA-W8C4000	FTA-L8C3000 FTA-L8C4000
Measuring range		X axis	100 mm				200 mm			
		Z1 axis	60 mm (±30 mm in horizontal situation)							
Straightness (when the X axis is horizontal)			0.8 µm/100 mm				2 µm/200 mm			
Accuracy (20 °C)	C3000	X axis	(0.8+0.01L) µm L = Measurement Length (mm)				(0.8+0.015L) µm L = Measurement Length (mm)			
		Z1 axis (detector unit)	±(1.2+|2H|/100) µm H = Measurement height from the horizontal position (mm)							
	C4000	X axis	(0.8+0.01L) µm L = Measurement Length (mm)				(0.8+0.015L) µm L = Measurement Length (mm)			
		Z1 axis (detector unit)	±(0.8+|2H|/100) µm H = Measurement height from the horizontal position (mm)							
X-axis inclination angle			±45°							
Z2-axis (column) travel range			300 mm	500 mm		700 mm	300 mm	500 mm		700 mm
Base size (W×D)			600×450 mm		1000×450 mm		600×450 mm		1000×450 mm	
Base material			Granite							

Note: While the appearance of the natural stone measuring table varies according to the source, the high stability for which this material is known can always be relied upon.

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FORMTRACER Avant D3000/4000 Series
SERIES 525 — Surface Texture Measuring Instruments

FTA-S4D3000
(Detector for surface roughness measurement attaching example, Inclined drive unit, with monitor arm)

FTA-S4D3000
(Detector for form/contour measurement attaching example, Inclined drive unit, with monitor arm)

Large sized base models and high-column models are added to the line-up.

Inclined drive unit

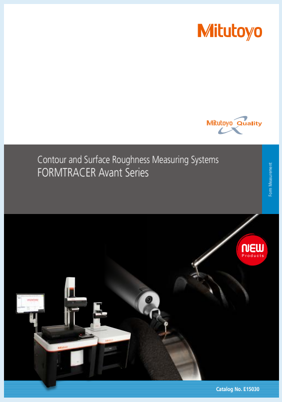
Connecting cables are contained within the measuring instrument.

Remote box with user-friendly operability

Detector holder (optional)

Detector

- **FORMTRACER Avant D3000/4000** Series are highly functional and user-friendly surface texture measuring systems with innovative design features. Both surface roughness measurement and contour measurement are available on a single system just by replacing the detector.
- The contour/roughness detector can be replaced without turning off the controller power and without using any tool. Furthermore, the detector is recognized automatically.
- **FORMTRACER Avant D** Series comes with the inclined drive unit as standard, making approach to the target surface and measurement of large workpieces much easier.
- Equipped with an operability focused, new style remote box. The new part program key strongly supports manual part-programming.
- High throughput is achieved thanks to high drive speed (X axis: Max. 80 mm/s, Z2 axis: Max. 30 mm/s) and acceleration (X axis: 30 mm/s^2).
- All connecting cables are contained within the measuring instrument to eliminate any inconvenience during measurement.
- The Z1-axis detector is equipped with a built-in anti-collision safety device.
- The arm of the detector for contour measurement is a magnetic, one-touch, detachable mechanism.
- **D4000** type is a highly functional contour measuring system with a digital detector (measuring range: 60 mm) that enables wide range measurement, top/bottom plane continuous measurement function, automatic variable measuring force function, and stylus drop detection function.



Refer to the **FORMTRACER Avant** Series Brochure (**E15030**) for more details.

SPECIFICATIONS

Model No.			FTA-S4D3000 FTA-S4D4000	FTA-H4D3000 FTA-H4D4000	FTA-W4D3000 FTA-W4D4000	FTA-L4D3000 FTA-L4D4000	FTA-S8D3000 FTA-S8D4000	FTA-H8D3000 FTA-H8D4000	FTA-W8D3000 FTA-W8D4000	FTA-L8D3000 FTA-L8D4000
Surface roughness measurement										
Measuring range		X axis	100 mm				200 mm			
		Z1 axis	800 µm, 80 µm, 8 µm							
Straightness (when the X axis is horizontal)			(0.05+0.001L) µm L = Measurement Length (mm)				(0.1+0.002L) µm L = Measurement Length (mm)			
Contour measurement										
Measuring range		X axis	100 mm				200 mm			
		Z1 axis	60 mm (±30 mm in horizontal situation)							
Straightness (when the X axis is horizontal)			0.8 µm/100 mm				2 µm/200 mm			
Accuracy (20 °C)	**D3000**	X axis	(0.8+0.01L) µm L = Measurement Length (mm)				(0.8+0.015L) µm L = Measurement Length (mm)			
		Z1 axis (detector unit)	±(1.2+|2H|/100) µm H = Measurement height from the horizontal position (mm)							
	D4000	X axis	(0.8+0.01L) µm L = Measurement Length (mm)				(0.8+0.015L) µm L = Measurement Length (mm)			
		Z1 axis (detector unit)	±(0.8+|2H|/100) µm H = Measurement height from the horizontal position (mm)							
Common specifications										
X-axis inclination angle			±45°							
Z2-axis (column) travel range			300 mm	500 mm		700 mm	300 mm	500 mm		700 mm
Base size (W×D)			600×450 mm		1000×450 mm		600×450 mm		1000×450 mm	
Base material			Granite							

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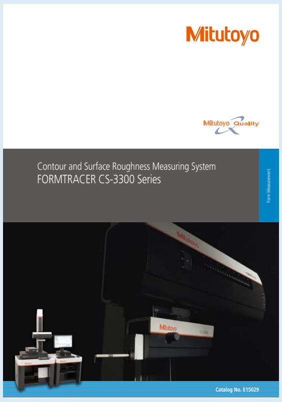
CS-3300 Series
SERIES 525 — Surface Texture Measuring Instruments

- **CS-3300** Series are highly functional and user-friendly surface texture measuring systems with innovative design features. They enable simultaneous measurement of both surface roughness and contour without changing the detector.
- Large sized base models and high-column models are newly added to the line-up.
- Equipped with a wide range and high resolution Z1-axis detector.
- **CS-3300** Series comes with the inclined drive unit as standard, making approach to the target surface and measurement of large workpieces much easier.
- Equipped with an operability focused, new style remote box. The new part program key strongly supports manual part-programming.
- High throughput is achieved thanks to high drive speed (X axis: Max. 80 mm/s, Z2 axis: Max. 30 mm/s).
- All connecting cables are contained within the measuring instrument to eliminate any inconvenience during measurement.
- The Z1-axis detector is equipped with a built-in anti-collision safety device.



Refer to the FORMTRACER **CS-3300** Series Brochure (**E15029**) for more details.

CS-3300H8

CS-3300H8
(With monitor arm)

Inclinable drive unit

Detector sliding mechanism

Connecting cables are contained within the measuring instrument.

SPECIFICATIONS

Model No.			CS-3300S4	CS-3300H4	CS-3300W4	CS-3300L4	CS-3300S8	CS-3300H8	CS-3300W8	CS-3300L8
Measuring range	X axis		100 mm				200 mm			
	Z1 axis		5 mm (±2.5 mm in horizontal situation)							
Straightness (when the X axis is horizontal)			0.2 µm/100 mm				0.6 µm/200 mm			
Accuracy (20 °C)	X axis		±(0.8+0.01L) µm L = Measurement Length (mm)				(0.8+0.015L) µm L = Measurement Length (mm)			
	Z1 axis (detector unit)		±(1.5+|2H|/100) µm H = Measurement height from the horizontal position (mm)							
Detector (Z1 axis)	Detection method		Differential inductance							
	Measuring force		0.75 mN							
	Stylus tip	Standard	Tip radius 2 µm, Tip angle 60°, Diamond (surface roughness/contour)							
		Cone	Tip radius 25 µm, Tip angle 30°, Sapphire (contour)							
	Stylus up/down		Available (stoppable at mid-stroke if required)							
X-axis inclination angle			±45°							
Z2-axis (column) travel range			300 mm	500 mm		700 mm	300 mm	500 mm		700 mm
Base size (W×D)			600×450 mm		1000×450 mm		600×450 mm		1000×450 mm	
Base material			Granite							

Note: While the appearance of the natural stone measuring table varies according to the source, the high stability for which this material is known can always be relied upon.

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PROPRIETARY INSPECTION CERTIFICATE

Formtracer Extreme
SV-C4500CNC/SV-C4500CNC HYBRID TYPE1
SERIES 525 — CNC Surface Roughness and Contour Measuring Systems

SV-C4500CNC (Contour detector shown mounted together with the inclinable drive unit and Y-axis table)

SV-C4500CNC HYBRID TYPE1
(Mounting example of non-contact detector)

SV-C4500CNC SPECIFICATIONS

Model No.			SV-C4500CNC
X1 axis (Drive unit)		Measuring range	200 mm
		Resolution	0.05 µm
		Scale type	Reflective-type linear encoder
	Contour	Straightness	2 µm/200 mm
		Accuracy (20 °C)	±(0.8+4L/200) µm L: Measuring length (mm)
	Surface roughness	Straightness	0.5 µm/200 mm
Z1 axis (Detector)	Contour	Measuring range	60 mm (±30 mm from the horizontal)
		Resolution	0.02 µm
		Scale type	Arc
		Accuracy (20 °C)	±(0.8+|2H|/100) µm H: Measuring height from horizontal position (mm)
	Surface roughness	Measuring range	800 µm, 80 µm, 8 µm
		Resolution	0.01 µm, 0.001 µm, 0.0001 µm
Z2 axis (Column)		Drive range	Specification is selectable from 300 mm or 500 mm.
		Resolution	0.05 µm

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SV-C4500CNC HYBRID TYPE1 SPECIFICATIONS

Model No.			SV-C4500CNC HYBRID TYPE1
X1 axis (Drive unit)		Measuring range	200 mm
		Resolution	0.05 µm
		Scale type	Reflective-type linear encoder
	Contour	Straightness (20 °C)	2 µm/200 mm
		Accuracy	±(0.8+4L/200) µm L: Measuring length (mm)
	Surface roughness	Straightness	0.5 µm/200 mm
	Non-contact type	Straightness	0.5 µm/200 mm
		Accuracy	±(0.8+4L/200) µm L: Measuring length (mm)
Y axis		Measuring range	200 mm
		Resolution	0.05 µm
		Maximum table loading	20 kg
Z1 axis	Contour	Measuring range	60 mm (±30 mm from the horizontal)
		Resolution	0.02 µm
		Scale type	Arc
		Accuracy (20 °C)	±(0.8+|2H|/100) µm H: Measuring height from horizontal position (mm)
	Surface roughness	Measuring range	800 µm, 80 µm, 8 µm
		Resolution	0.01 µm, 0.001 µm, 0.0001 µm
	Non-contact type detector **CPS2525***	Measuring range	1.2 mm
		Resolution	25 nm
	Non-contact type detector **CPS0517***	Measuring range	0.1 mm
		Resolution	5 nm
Z2 axis		Drive range	500 mm
		Resolution	0.05 µm

* Select either **CPS2525** or **CPS0517**.
Note: While the appearance of the natural stone measuring table varies according to the source, the high stability for which this material is known can always be relied upon.

SV-C4500CNC

- High-accuracy stylus type CNC Surface Roughness/Contour Measuring System that allows measurement of surface roughness and form/contour with one unit through detector replacement.
- For models with the α axis, it is possible to perform continuous measurement over horizontal and inclined surfaces by power-tilting the X1 axis. In addition, automatic measuring force adjustment function of Z1-axis detector for contour measurement enables automatic measurement with constant measuring force even with the X1-axis tilted.
- For models with the Y-axis table, it is possible to expand the measuring range for multiple workpieces through positioning in the Y-axis direction.
- Since the Z1-axis detector incorporates an anti-collision safety device, the machine will automatically stop if the detector touches a workpiece or jig.
- Optional external control function (Ext I/O) through bidirectional communication (RS-232C) with the PLC (programmable logic controller) is available.

SV-C4500CNC HYBRID TYPE1

- CNC Surface Roughness/Contour Measuring System equipped with a non-contact type detector as well as a contact type surface roughness contour measuring detector.
- Equipped with the Y-axis table, it is possible to expand the measuring range for multiple workpieces through positioning in the Y-axis direction.
- Since the Z1-axis detector incorporates an anti-collision safety device, the machine will automatically stop if the detector touches a workpiece or jig.
- Optional external control function (Ext I/O) through bidirectional communication (RS-232C) with the PLC (programmable logic controller) is available.

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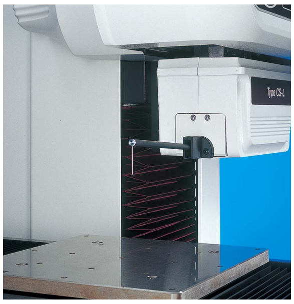
PROPRIETARY INSPECTION CERTIFICATE

Formtracer Extreme
CS-5000CNC/CS-H5000CNC
SERIES 525 — CNC Surface Roughness and Contour Measuring Systems

- High-accuracy stylus type CNC Surface Measuring System that allows batch measurement of surface roughness and form/contour.
- The X1 and Z2 axes have maximum drive speeds of 40 mm/s and 200 mm/s, respectively. This permits high-speed positioning that can potentially result in a large increase in the throughput of multiple-profile/multiple-workpiece measurement tasks.
- The high resolution linear encoder is incorporated in the X1 and Z1 axes so that high resolution is achieved and batch measurement of form/contour and surface roughness can be made.
- The active control method is employed for the Z1-axis detector to implement a wide-range measurement capability wherein the variation in dynamic measuring force is restricted.
- Since the Z1-axis detector incorporates an anti-collision safety device, the detector unit will automatically stop if it touches a workpiece or fixture.
- For models with the α axis, it is possible to perform continuous measurement over horizontal and inclined surfaces by power-tilting the X1 axis. (**CS-5000CNC** only)
- For models with the Y-axis table, it is possible to expand the measuring range for multiple workpieces through positioning in the Y-axis direction.
- Optional external control function (Ext I/O) through bidirectional communication (RS-232C) with the PLC (programmable logic controller) is available.

CS-H5000CNC
(with Y-axis table)



Wide-range detector employing active control technology

SPECIFICATIONS

<table>
<tr><th colspan="3">Model No.</th><th>CS-5000CNC</th><th>CS-H5000CNC</th></tr>
<tr><td rowspan="10">X1 axis</td><td colspan="2">Measuring range</td><td colspan="2">200 mm</td></tr>
<tr><td colspan="2">Resolution</td><td colspan="2">0.005 µm</td></tr>
<tr><td colspan="2">Scale type</td><td colspan="2">Transmission-type linear encoder</td></tr>
<tr><td rowspan="2">Drive speed</td><td>CNC mode</td><td colspan="2">Max. 40 mm/s</td></tr>
<tr><td>Joystick mode</td><td colspan="2">0 to 40 mm/s</td></tr>
<tr><td colspan="2">Measuring speed</td><td colspan="2">0.02, 0.05, 0.1, 0.2 mm/s (surface roughness), 0.02, 0.05, 0.1, 0.2, 0.5, 1.0, 2.0 mm/s (form/contour)</td></tr>
<tr><td colspan="2">Measuring direction</td><td colspan="2">Forward/backward</td></tr>
<tr><td rowspan="2">Straightness</td><td>with standard stylus</td><td>(0.1+0.0015L) µm L: traverse length (mm)</td><td>(0.05+0.0003L) µm L: traverse length (mm)</td></tr>
<tr><td>with 2X-long stylus</td><td>(0.2+0.0015L) µm L: traverse length (mm)</td><td>(0.1+0.0015L) µm L: traverse length (mm)</td></tr>
<tr><td colspan="2">Accuracy (20 °C)</td><td>±(0.3+0.002L) µm L: traverse length (mm)</td><td>±(0.16+0.001L) µm L: traverse length (mm)</td></tr>
<tr><td>α axis</td><td colspan="2">Inclination range</td><td>-45° (CCW), +10° (CW)</td><td>—</td></tr>
<tr><td rowspan="16">Z1 axis (Detector)</td><td rowspan="2">Measuring range</td><td>with standard stylus</td><td colspan="2">12 mm</td></tr>
<tr><td>with 2X-long stylus</td><td colspan="2">24 mm</td></tr>
<tr><td rowspan="2">Resolution</td><td>with standard stylus</td><td colspan="2">0.0008 µm</td></tr>
<tr><td>with 2X-long stylus</td><td colspan="2">0.0016 µm</td></tr>
<tr><td colspan="2">Vertical movement of the stylus</td><td colspan="2">Arc motion</td></tr>
<tr><td colspan="2">Scale type</td><td colspan="2">Transmission-type linear encoder</td></tr>
<tr><td colspan="2">Accuracy (20 °C)</td><td>±(0.3+|0.02H|) µm H: probing height (mm)</td><td>±(0.07+|0.02H|) µm H: probing height (mm)</td></tr>
<tr><td rowspan="2">Measuring force</td><td>with standard stylus</td><td colspan="2">4 mN (Fixed)</td></tr>
<tr><td>with 2X-long stylus</td><td colspan="2">0.75 mN (Fixed)</td></tr>
<tr><td colspan="2">Traceable angle</td><td colspan="2">Ascent: 60°, Descent: 60° (Depends on the surface texture.)</td></tr>
<tr><td rowspan="5">Stylus tip shape</td><td>Standard stylus</td><td colspan="2">Tip radius: 5 µm, Tip angle: 40°, Diamond</td></tr>
<tr><td>Standard ball stylus</td><td colspan="2">Tip ball radius: 0.25 mm, Sapphire</td></tr>
<tr><td>2X-long stylus</td><td colspan="2">Tip radius: 5 µm, Tip angle: 40°, Diamond</td></tr>
<tr><td>2X-long stylus</td><td>—</td><td>Tip radius: 2 µm, Tip angle: 60°, Diamond tip</td></tr>
<tr><td>2X-long ball stylus</td><td colspan="2">Tip ball radius: 0.25 mm, Sapphire</td></tr>
<tr><td colspan="2">Face of stylus</td><td colspan="2">Downward</td></tr>
<tr><td rowspan="6">Z2 axis (Column)</td><td rowspan="2">Travel range</td><td>Z2 axis (column, type S)</td><td colspan="2">300 mm</td></tr>
<tr><td>Z2 axis (column, type H)</td><td colspan="2">500 mm</td></tr>
<tr><td colspan="2">Resolution</td><td colspan="2">0.05 µm</td></tr>
<tr><td colspan="2">Scale type</td><td colspan="2">Reflective-type linear encoder</td></tr>
<tr><td rowspan="2">Drive speed</td><td>CNC mode</td><td colspan="2">Max. 200 mm/s</td></tr>
<tr><td>Joystick mode</td><td colspan="2">0 to 50 mm/s</td></tr>
<tr><td rowspan="2">Base</td><td colspan="2">Base size (W×D)</td><td colspan="2">750×600 mm</td></tr>
<tr><td colspan="2">Base material</td><td colspan="2">Granite</td></tr>
</table>

Note: While the appearance of the natural stone base varies according to the source, the high stability for which this material is known can always be relied upon.

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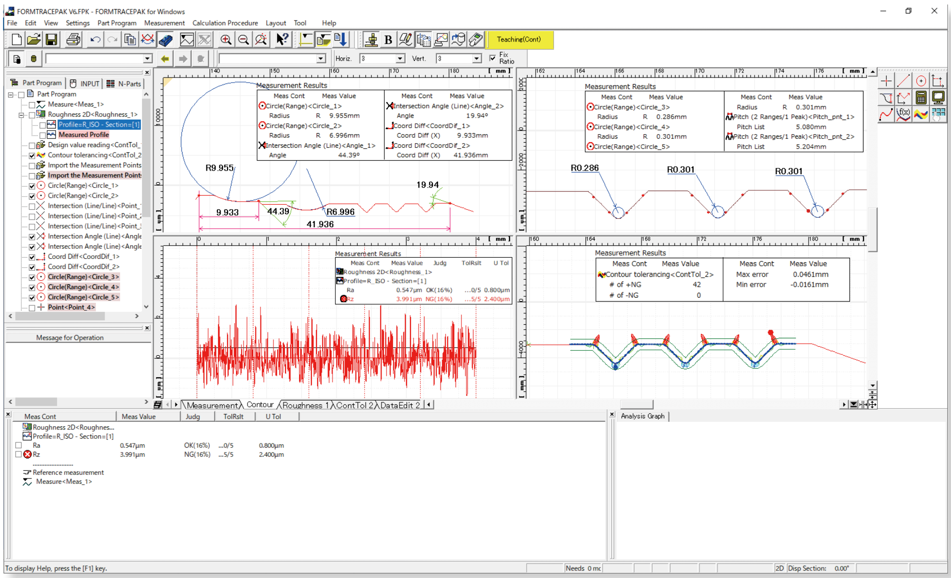
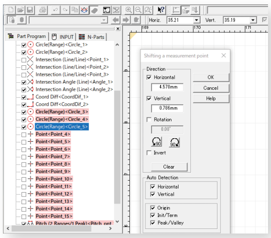
Surface Roughness/Contour Analysis Program FORMTRACEPAK



- **FORMTRACEPAK** functions offer total support for controlling the measurement system, surface roughness analysis, contour analysis, contour tolerancing, and inspection report creation.

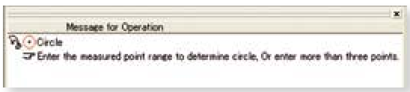
• Editing measurement procedures

The items displayed in the measurement procedure window can be directly modified. You can, for example, perform new analyses by modifying the evaluation setup or roughness standard.



• Operation messaging

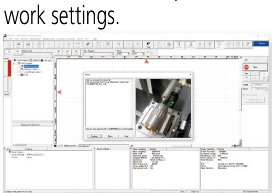
The operation message window for explaining the next step is incorporated.



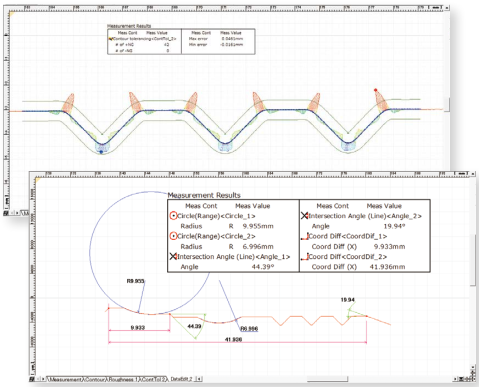
• Measurement control

To make only a single measurement, you can create a part program in the single mode. To measure multiple workpieces of an identical shape, you can use the teaching mode. Since you can embed the entire flow, from making measurement to printing a report, into a part program, you can efficiently make measurements, analyze data, and output a report. A function is also provided that enables you to insert comments accompanied with photographs at desired timings, enabling you to embed the roles described in a measurement procedure document that specifies important points such as work settings.

To make immediate measurements, you can use the pull-down menu to easily select and call up the desired operating procedure.



• Versatile graphics windowing for data and analysis

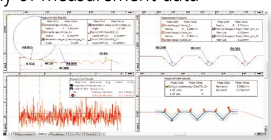


Tab-selection graphics window

Just select a tab to display the measurement data required, such as contour, roughness, or tolerancing results.

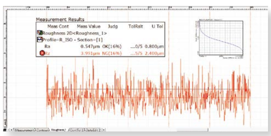
Dividing the screen into two or four windows

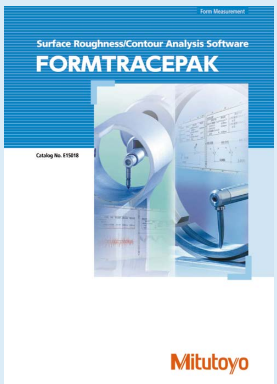
The screen can be divided into two, or four, windows for the convenient display of measurement data (for contour and roughness), analysis results, and contour tolerancing data, as required.



Displaying the results in the graphics window

You can paste the graphics obtained from measurements, as well as measurement values (including pass/fail results) and an analysis graph, into the graphics window. This enables you to check the graphics and measurement results at a glance using the graphics window alone.





Refer to the **FORMTRACEPAK** Brochure (**E15018**) for more details.

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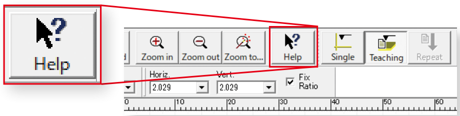
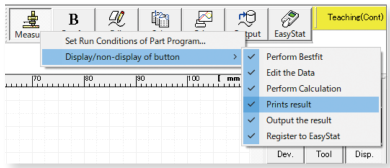
- **Online help functions**
Online help that can be viewed any time is incorporated into the software. In addition to index and keyword searches, a status-saving help button, which displays menus and Windows help with a click of the mouse, is provided.



- **Multiple language support (18 languages)**
You can switch the language to be used in the measurement, analysis, and layout windows.
After measurements have been made, you can switch to another language and create a report in that language. This function can be used worldwide.

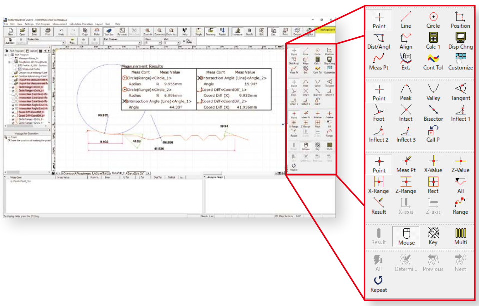
- **Button-editing function**
You can hide buttons that are not used frequently. For example, you can choose to display only those buttons that are used frequently and increase the size of the displayed graphics window, thereby customizing the window to suit your needs.



- **Simple statistical commands**
You can perform statistical calculations of roughness parameters and contour analysis results without using a separate program such as Excel.

Contour measurement

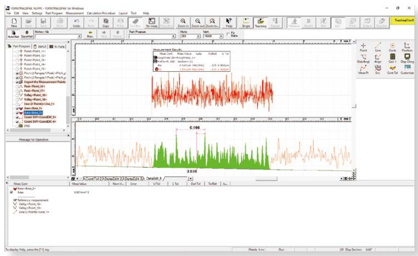
- **Contour analysis**
A wide variety of commands, which form the basic elements for analysis, are provided, including those for points (10 types), lines (6 types) and circles (6 types). A rich set of commands that combine these elements to calculate angles, pitches and distances as well as performing contour tolerancing and design value generation are also provided as standard features. These functions, combined with the function that enables you to customize the calculation command buttons by hiding less frequently used commands, help you to tailor the window according to the user's environment.



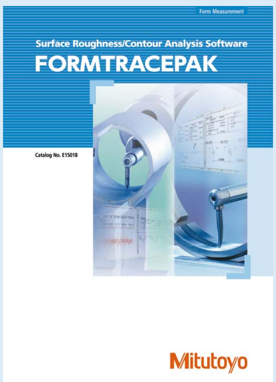
- **Contour-tolerancing as a standard feature**
- **Design value generation**
- **Data combination**
- **Simple pitch calculation**

Surface roughness measurement

- **Surface roughness analysis**
FORMTRACEPAK can perform surface roughness analyses that conform to various standards such as ISO, JIS, ANSI and VDA. For comparing measurement values with the tolerance limits, you can use the 16% rule or the maximum value rule. Furthermore, since **FORMTRACEPAK** comes with parameter calculation functions as well as a rich set of graphic analysis functions, it can be widely utilized for everything from routine quality control to R&D applications. It also includes many other functions such as the function for eliminating (compensating) shapes, such as slopes and radiused surfaces (R-surfaces), and data deletion.



- **Micro contour analysis**
- **Simple input using drawing symbols**
- **Multiple-point measurement**
- **Analysis using multiple-point measurements**
- **Reference length dialog box**
- **Analysis condition modification with preview**
- **R-surface automatic measurement**



Refer to the **FORMTRACEPAK** Brochure (**E15018**) for more details.

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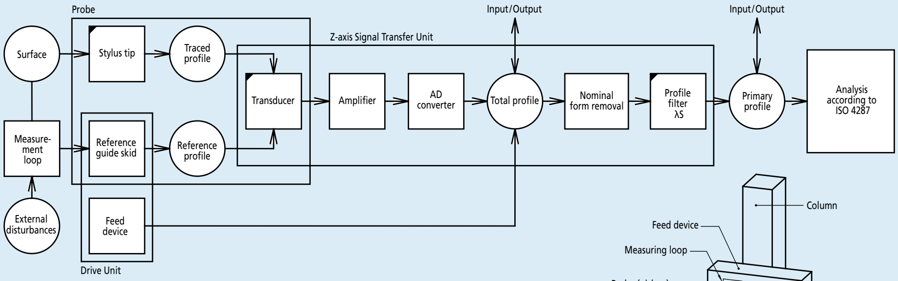
Quick Guide to Precision Measuring Instruments

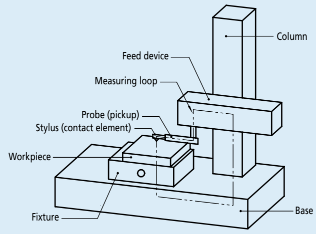
Surftest (Surface Roughness Testers)

ISO 4287: 1997 Geometrical Product Specifications (GPS) – Surface Texture: Profile method– Terms, definitions, and surface texture parameters
ISO 4288: 1996 Geometrical Product Specifications (GPS) – Surface Texture: Profile method– Rules and procedures for the assessment of surface texture
ISO 3274: 1996 Geometrical Product Specifications (GPS) – Surface Texture: Profile method– Nominal characteristics of contact (stylus) instruments
ISO 11562: 1996 Geometrical Product Specifications (GPS) – Surface texture: Profile method– Metrological characteristics of phase correct filters

Elements of Contact Type Surface Roughness Measuring Instruments

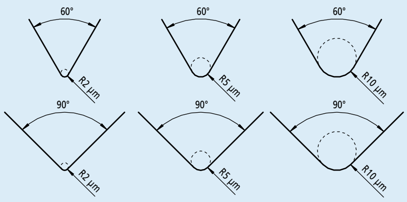
ISO 3274: 1996 (JIS B 0651: 2001)





Stylus Shape

A typical shape for a stylus end is conical with a spherical tip.
Tip radius: r_{tip} = 2 µm, 5 µm or 10 µm
Cone angle: 60°, 90°
In typical surface roughness testers, the conical angle of the stylus end is 60° unless otherwise specified.



Static Measuring Force

Nominal radius of curvature of stylus tip: µm	Static measuring force at the mean position of stylus: mN	Tolerance on static measuring force variations: mN/µm
2	0.75	0.035
5	0.75 (4.0) *	0.2
10		

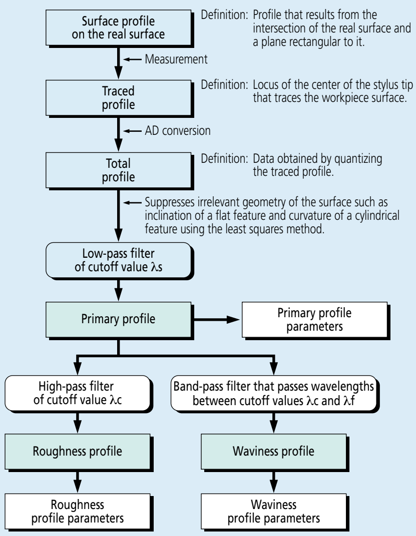
* The maximum value of static measuring force at the average position of a stylus is to be 4.0 mN for a probe with a special structure including a replaceable stylus.

Metrological Characterization of Phase Correct Filters

ISO 11562: 1996 (JIS B 0632: 2001)

A profile filter is a phase-correct filter without phase delay (cause of profile distortion dependent on wavelength).
The weight function of a phase-correct filter shows a normal (Gaussian) distribution in which the amplitude transmission is 50% at the cutoff wavelength.

Data Processing Flow



Relationship between Cutoff Value and Stylus Tip Radius

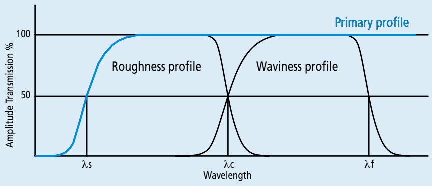
The following table lists the relationship between the roughness profile cutoff value λc, stylus tip radius r_{tip}, and cutoff ratio λc/λs.

λc mm	λs µm	λc/λs	Maximum r_{tip} µm	Maximum sampling length µm
0.08	2.5	30	2	0.5
0.25	2.5	100	2	0.5
0.8	2.5	300	2 *1	0.5
2.5	8	300	5 *2	1.5
8	25	300	10 *2	5

*1 For a surface with Ra>0.5 µm or Rz>3 µm, a significant error will not usually occur in a measurement even if r_{tip} = 5 µm.
*2 If a cutoff value λs is 2.5 µm or 8 µm, attenuation of the signal due to the mechanical filtering effect of a stylus with the recommended tip radius appears outside the roughness profile pass band. Therefore, a small error in stylus tip radius or shape does not affect parameter values calculated from measurements. If a specific cutoff ratio is required, the ratio must be defined.

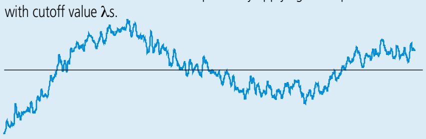
Surface Profiles

ISO 4287:1997 (JIS B 0601: 2013)



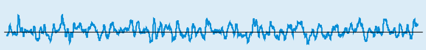
Primary Profile

Profile obtained from the measured profile by applying a low-pass filter with cutoff value λs.



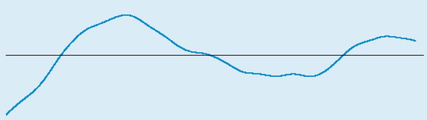
Roughness Profile

Profile obtained from the primary profile by suppressing the longer wavelength components using a high-pass filter of cutoff value λc.



Waviness Profile

Profile obtained by applying a band-pass filter to the primary profile to remove the longer wavelengths above λf and the shorter wavelengths below λc.



Roughness sampling length for non-periodic profiles

ISO 4288: 1996 (JIS B 0633: 2001)

Table 1: Sampling lengths for aperiodic profile roughness parameters (Ra, Rq, Rsk, Rku, $R\Delta q$), material ratio curve, probability density function, and related parameters

Ra µm	Sampling length lr mm	Evaluation length ln mm
(0.006)<Ra≤0.02	0.08	0.4
0.02 <Ra≤0.1	0.25	1.25
0.1 <Ra≤2	0.8	4
2 <Ra≤10	2.5	12.5
10 <Ra≤80	8	40

Table 2: Sampling lengths for aperiodic profile roughness parameters (Rz, Rv, Rp, Rc, Rt)

Rz $Rz1max.$ µm	Sampling length lr mm	Evaluation length ln mm
(0.025)<Rz, $Rz1max.$≤0.1	0.08	0.4
0.1 <Rz, $Rz1max.$≤0.5	0.25	1.25
0.5 <Rz, $Rz1max.$≤10	0.8	4
10 <Rz, $Rz1max.$≤50	2.5	12.5
50 <Rz, $Rz1max.$≤200	8	40

1) Rz is used for measurement of Rz, Rv, Rp, Rc, and Rt.
2) $Rz1max.$ only used for measurement of $Rz1max.$, $Rv1max.$, $Rp1max.$, and $Rc1max.$.

Table 3: Sampling lengths for measurement of periodic roughness profile roughness parameters and periodic or aperiodic profile parameter Rsm

Rsm mm	Sampling length lr mm	Evaluation length ln mm
0.013 <Rsm≤0.04	0.08	0.4
0.04 <Rsm≤0.13	0.25	1.25
0.13 <Rsm≤0.4	0.8	4
0.4 <Rsm≤1.3	2.5	12.5
1.3 <Rsm≤4	8	40

Procedure for determining a sampling length if it is not specified

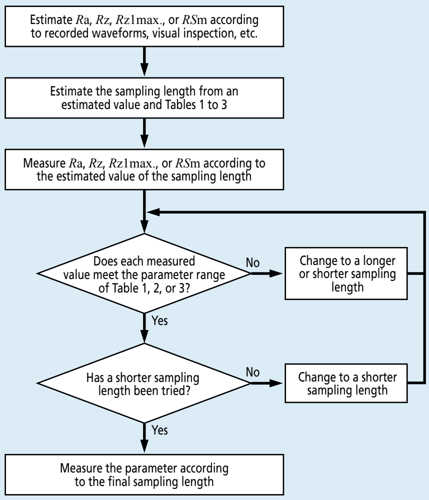


Fig.1 Procedure for determining the sampling length of an aperiodic profile if it is not specified.

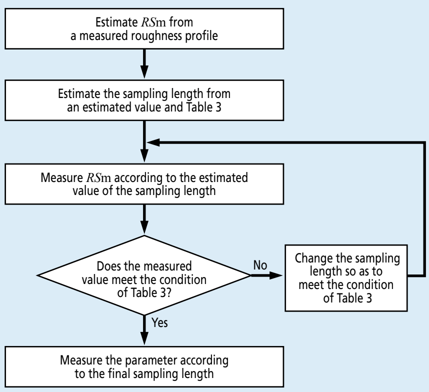


Fig.2 Procedure for determining the sampling length of a periodic profile if it is not specified.

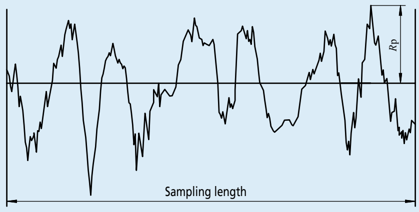
Definition of Parameters

ISO 4287: 1997, Amd. 1: 2009 (JIS B 0261: 2013)

Amplitude Parameters (peak and valley)

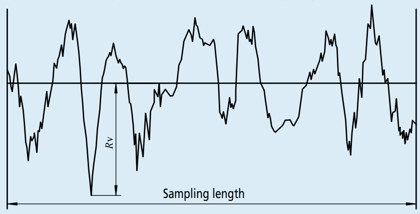
Maximum peak height of the primary profile *Pp*
Maximum peak height of the roughness profile *Rp*
Maximum peak height of the waviness profile *Wp*

Largest profile peak height *Zp* within a sampling length



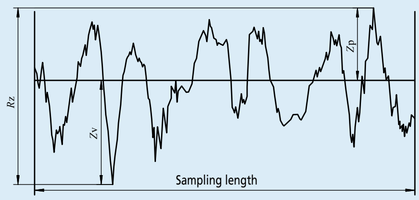
Maximum valley depth of the primary profile *Pv*
Maximum valley depth of the roughness profile *Rv*
Maximum valley depth of the waviness profile *Wv*

Largest profile valley depth *Zv* within a sampling length



Maximum height of the primary profile *Pz*
Maximum height of the roughness profile *Rz*
Maximum height of the waviness profile *Wz*

Sum of height of the largest profile peak height *Zp* and the largest profile valley depth *Zv* within a sampling length

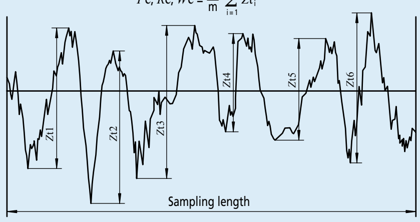


In the old JIS and ISO 4287-1: 1984, *Rz* was used to indicate the "ten point height of irregularities". Care must be taken because differences between results obtained according to the existing and old standards are not always negligibly small. (Be sure to check whether the drawing instructions conform to existing or old standards.)

Mean height of the primary profile elements *Pc*
Mean height of the roughness profile elements *Rc*
Mean height of the waviness profile elements *Wc*

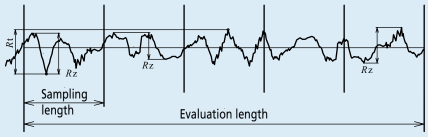
Mean value of the profile element heights *Zt* within a sampling length

$$Pc, Rc, Wc = \frac{1}{m}\sum_{i=1}^{m} Zt_i$$



Total height of the primary profile *Pt*
Total height of the roughness profile *Rt*
Total height of the waviness profile *Wt*

Sum of the height of the largest profile peak height *Zp* and the largest profile valley depth *Zv* within the evaluation length



Amplitude Parameters (average of ordinates)

Arithmetical mean deviation of the primary profile *Pa*
Arithmetical mean deviation of the roughness profile *Ra*
Arithmetical mean deviation of the waviness profile *Wa*

Arithmetic mean of the absolute ordinate values Z(x) within a sampling length

$$Pa, Ra, Wa = \frac{1}{l}\int_0^l |Z(x)|dx$$

with l as *lp*, *lr*, or *lw* according to the case.

Root mean square deviation of the primary profile *Pq*
Root mean square deviation of the roughness profile *Rq*
Root mean square deviation of the waviness profile *Wq*

Root mean square value of the ordinate values Z(x) within a sampling length

$$Pq, Rq, Wq = \sqrt{\frac{1}{l}\int_0^l Z^2(x)dx}$$

with l as *lp*, *lr*, or *lw* according to the case.

Skewness of the primary profile *Psk*
Skewness of the roughness profile *Rsk*
Skewness of the waviness profile *Wsk*

Quotient of the mean cube value of the ordinate values Z(x) and the cube of *Pq*, *Rq*, or *Wq* respectively, within a sampling length

$$Rsk = \frac{1}{Rq^3}\left[\frac{1}{lr}\int_0^{lr} Z^3(x)dx\right]$$

The above equation defines *Rsk*. *Psk* and *Wsk* are defined in a similar manner. *Psk*, *Rsk*, and *Wsk* are measures of the asymmetry of the probability density function of the ordinate values.

Kurtosis of the primary profile *Pku*
Kurtosis of the roughness profile *Rku*
Kurtosis of the waviness profile *Wku*

Quotient of the mean quartic value of the ordinate values Z(x) and the fourth power of *Pq*, *Rq*, or *Wq* respectively, within a sampling length

$$Rku = \frac{1}{Rq^4}\left[\frac{1}{lr}\int_0^{lr} Z^4(x)dx\right]$$

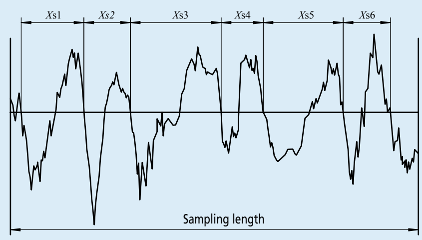
The above equation defines *Rku*. *Pku* and *Wku* are defined in a similar manner. *Pku*, *Rku*, and *Wku* are measures of the sharpness of the probability density function of the ordinate values.

Spacing Parameters

Mean width of the primary profile elements *PSm*
Mean width of the roughness profile elements *RSm*
Mean width of the waviness profile elements *WSm*

Mean value of the profile element widths *Xs* within a sampling length

$$PSm, RSm, WSm = \frac{1}{m}\sum_{i=1}^{m} Xs_i$$



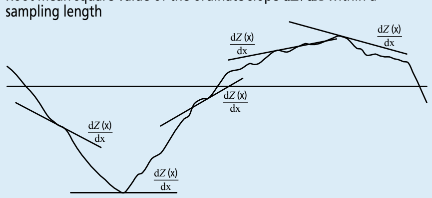
Peak count number based on the primary profile elements *PPc*
Peak count number based on the roughness profile elements *RPc*
Peak count number based on the waviness profile elements *WPc*

$$RPc = \frac{1}{RSm}$$

Hybrid Parameters

Root mean square slope of the primary profile *PΔq*
Root mean square slope of the roughness profile *RΔq*
Root mean square slope of the waviness profile *WΔq*

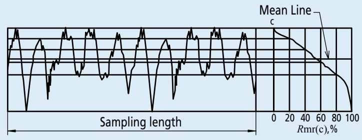
Root mean square value of the ordinate slope d*Z*/d*X* within a sampling length



Curves, Probability Density Function, and Related Parameters

Material ratio curve of the profile (Abbott-Firestone curve)

Curve representing the material ratio of the profile as a function of section level c



Material ratio of the primary profile *Pmr* (c)
Material ratio of the roughness profile *Rmr* (c)
Material ratio of the waviness profile *Wmr* (c)

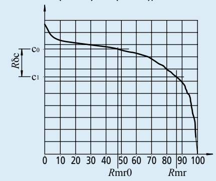
Ratio of the material length of the profile elements *Ml* (c) at a given level c to the evaluation length

$$Pmr(c), Rmr(c), Wmr(c) = \frac{Ml(c)}{ln}$$

Section height difference of the primary profile *Pδc*
Section height difference of the roughness profile *Rδc*
Section height difference of the waviness profile *Wδc*

Vertical distance between two section levels of a given material ratio

$$R\delta c = c(Rmr1) - c(Rmr2);\ Rmr1 < Rmr2$$



Relative material ratio of the primary profile *Pmr*
Relative material ratio of the roughness profile *Rmr*
Relative material ratio of the waviness profile *Wmr*

Material ratio determined at a profile section level *Rδc* related to the reference section level c_0

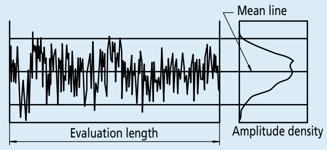
$$Pmr, Rmr, Wmr = Pmr(c_1), Rmr(c_1), Wmr(c_1)$$

where $c_1 = c_0 - R\delta c\ (P\delta c, W\delta c)$

$c_0 = c\ (Pm0, Rmr0, Wmr0)$

Probability density function
(profile height amplitude distribution curve)

Sample probability density function of the ordinate Z(x) within the evaluation length

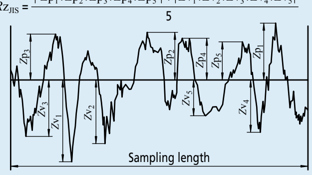


JIS Specific Parameters

Ten-point height of irregularities, Rz_{JIS}

Sum of the absolute mean height of the five highest profile peaks and the absolute mean depth of the five deepest profile valleys, measured from the mean line within the sampling length of a roughness profile. This profile is obtained from the primary profile using a phase-correct band-pass filter with cutoff values of lc and ls.

$$Rz_{JIS} = \frac{|Zp_1+Zp_2+Zp_3+Zp_4+Zp_5| + |Zv_1+Zv_2+Zv_3+Zv_4+Zv_5|}{5}$$



Symbol	Used profile
Rz_{JIS82}	Surface profile as measured
Rz_{JIS94}	Roughness profile derived from the primary profile using a phase-correct high-pass filter

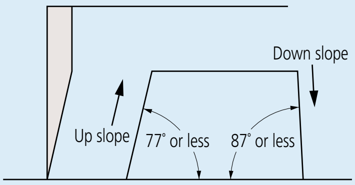
Arithmetic mean deviation of the profile Ra_{75}

Arithmetic mean of the absolute values of the profile deviations from the mean line within the sampling length of the roughness profile (75%). This profile is obtained from a measurement profile using an analog high-pass filter with an attenuation factor of 12db/octave and a cutoff value of λc.

$$Ra_{75} = \frac{1}{ln}\int_0^{ln} |Z(x)|dx$$

L

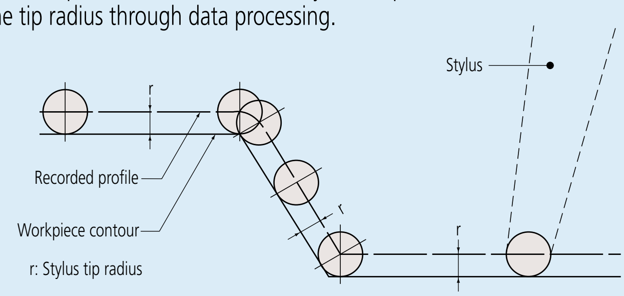
Traceable Angle



The maximum angle at which a stylus can trace upwards or downwards along the contour of a workpiece, in the stylus travel direction, is referred to as the traceable angle. A one-sided sharp stylus with a tip angle of 12° (as in the above figure) can trace a maximum 77° of up slope and a maximum 87° of down slope. For a conical stylus (30° cone), the traceable angle is smaller. An up slope with an angle of 77° or less overall may actually include an angle of more than 77° due to the effect of surface roughness. Surface roughness also affects the measuring force.

Compensating for Stylus Tip Radius

A recorded profile represents the locus of the center of the ball tip rolling on a workpiece surface. (A typical radius is 0.025 mm.) Obviously this is not the same as the true surface profile so, in order to obtain an accurate profile record, it is necessary to compensate for the effect of the tip radius through data processing.

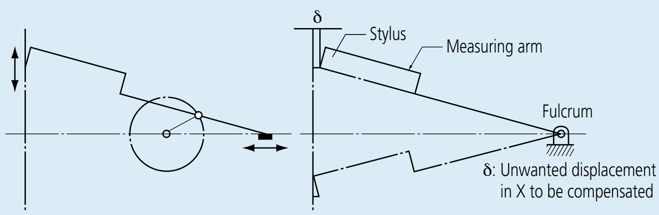


If a profile is read from the recorder through a template or scale, it is necessary to compensate for the stylus tip radius beforehand according to the applied measurement magnification.

Compensating for Arm Rotation

When the stylus traces through a circular-arc, error arises in the X-axis direction of the recorded profile. Possible methods for compensating for this effect are as follows:

1) Mechanical compensation
2) Electrical compensation



3) Software processing. To measure a workpiece contour that involves a large displacement in the vertical direction with high accuracy, one of these compensation methods needs to be implemented.

Accuracy

As the detector units of the X-and Z-axes incorporate scales, the magnification accuracy is displayed not as a percentage but as the linear displacement accuracy for each axis.

Overload Safety Cutout

If an excessive force (overload) is exerted on the stylus tip due, perhaps, to the tip encountering a too-steep slope on a workpiece feature, or a burr, for example, a safety device automatically stops operation and sounds an alarm buzzer. This type of instrument is commonly equipped with separate safety devices for the tracing direction (X axis) load and vertical direction (Z axis) load.

Circular-Arc / Linear Tracing

The locus traced by the stylus tip during vertical stylus movement can be a circular arc or a straight line. Ensuring a straight-line locus entails complex mechanics, while in the case of a circular-arc locus, if the amplitude of stylus displacement is large in the vertical direction, an error (δ) in the recorded profile in the horizontal direction arises. (See figure at lower left)

Z-axis Measurement Methods

Though the X-axis measurement method commonly adopted is by means of a digital scale, the Z-axis measurement divides into analog methods (using a differential transformer, for example) and digital scale methods.
Analog methods vary in Z-axis resolution depending on the measurement magnification and measuring range. Digital scale methods have fixed resolution.
Generally, a digital scale method provides higher accuracy than an analog method.

Contour analysis methods

You can analyze the contour with one of the following two methods after completing the measurement operation.

Data processing section and analysis program

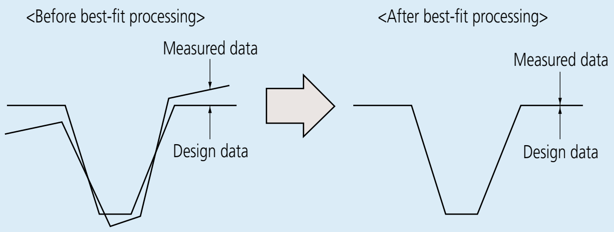
The measured contour is input into the data processing section in real time and a dedicated program performs the analysis using the mouse and/or keyboard. The angle, radius, step, pitch and other data are directly displayed as numerical values. Analysis combining coordinate systems can be easily performed. The graph that goes through stylus radius correction is output to the printer as the recorded profile.

Tolerancing with Design Data

Measured workpiece contour data can be compared with design data in terms of actual and designed shapes rather than just analysis of individual dimensions. In this technique each deviation of the measured contour from the intended contour is displayed and recorded. Also, data from one workpiece example can be processed so as to become the master design data to which other workpieces are compared. This function is particularly useful when the shape of a section greatly affects product performance, or when its shape has an influence on the relationship between mating or assembled parts.

Best-fitting

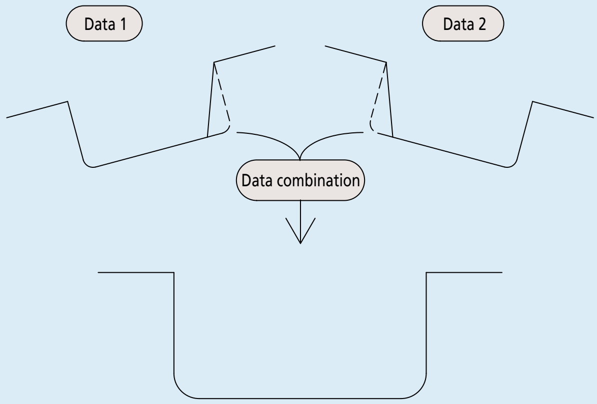
If there is a standard for surface profile data, tolerancing with design data is performed according to the standard. If there is no standard, or if tolerancing only with shape is desired, best-fitting between design data and measurement data can be performed.



The best-fit processing algorithm searches for deviations between both sets of data and derives a coordinate system in which the sum of squares of the deviations is a minimum when the measured data is overlaid on the design data.

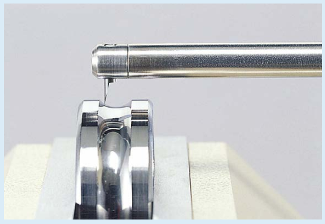
Data Combination

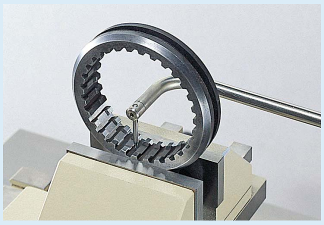
Conventionally, if tracing a complete contour is prevented by stylus traceable-angle restrictions then it has to be divided into several sections that are then measured and evaluated separately. This function avoids this undesirable situation by combining the separate sections into one contour by overlaying common elements (lines, points) onto each other. With this function the complete contour can be displayed and various analyses performed in the usual way.

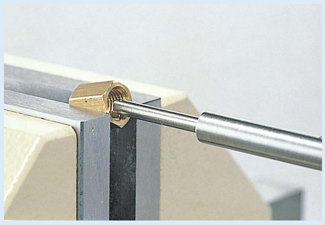


Measurement Examples

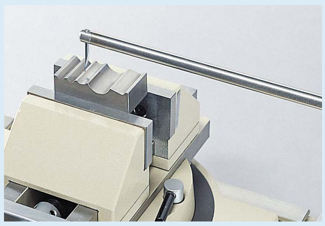

Aspheric lens contour


Inner/outer ring contour of a bearing


Internal gear teeth


Female thread form


Male thread form


Gage contour

L

Mitutoyo