

TP7M high accuracy touch trigger probe system



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Renishaw part no: H-1000-5010-05-B

Issued: 03 2006

TP7M

high accuracy touch-trigger probe system

user's guide



Care of equipment

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Patents

Features of Renishaw's TP7M probe and associated equipment are the subjects of the patents and patent applications listed below:

EP 0142373	JP 1556462	US 4462162
EP 0243766	JP 2,098,080	US 4651405
EP 0293036	JP 2,539,824	US 4813151
EP 0388993	JP 2,545,082	US 4817362
EP 242747 B	JP 2,647,881	US 4916339
EP 279828 B		

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1 Introduction

The TP7M and TP7M EP (enhanced performance) touch trigger probes provide superior measuring performance over kinematic switching probes throughout a wide range of gauging speeds. True 6-way sensing ($\pm X$, $\pm Y$, $\pm Z$) with any stylus offers greater flexibility of application. The extended operating life makes the TP7M and TP7M EP suitable for the most highly automated and demanding measuring tasks.

For applications requiring the highest possible accuracy, the TP7M EP version is specified for the smallest form measurement error.

The TP7M and TP7M EP are equipped with the Renishaw autojoint connector to enable repeatable, automatic probe changing when utilising the Renishaw autochange system. The probes may be mounted in the quill of the CMM, using a PH10M series motorised probe head, to provide automatic articulation. Alternatively, the PH6M fixed probe head may be used.

The TP7M and TP7M EP probes must be interfaced to the CMM controller using the dedicated PI 7-2 probe interface unit. The PI 7-2 automatically detects and interfaces with the Renishaw TP20, TP6 and other types of kinematic switching probe, so that the optimum probe type for the application can be easily used on the same machine.

2 Product description

2.1 Probe

The stylus is coupled to a strain sensing structure that is protected against excessive stylus displacement by a 6-way kinematic overtravel mechanism.

Silicon strain sensors, which detect the small gauging forces applied to the stylus tip, are connected directly to the PI 7-2 interface via the Renishaw autojoint connector, the probe head and associated wiring. The sensor signals are amplified and the resultant 'probe signals' proportional to the changes of strain, are compared with reference voltages to determine the status of the probe.



CAUTION: The TP7M is susceptible to damage if dropped. It must, therefore, be handled with care.

2.2 Probe dimensions

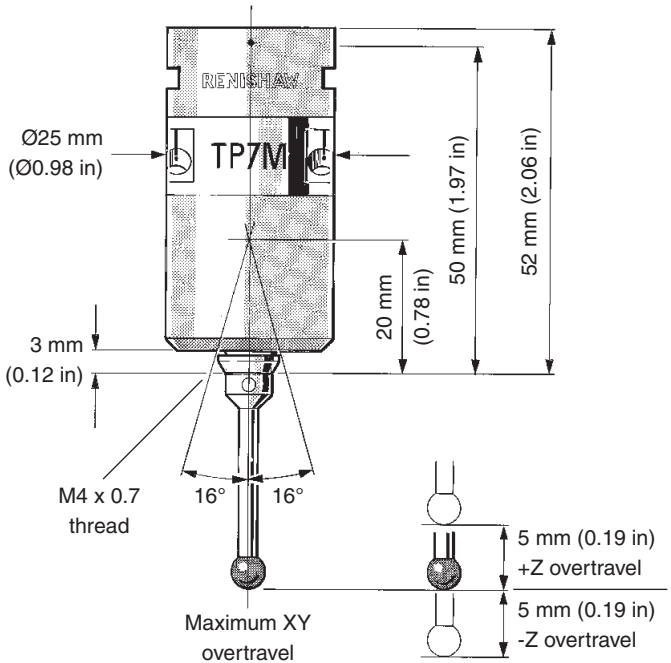


Figure 1 - Probe dimensions

2.3 Interface

The PI 7-2 is a dedicated signal conditioner for interfacing the TP7M and TP7M EP probes or kinematic switching probes (TP2, TP20 or TP6/TP6A) to the CMM controller. The recognition of the probe type is automatic.

The interface determines the probe status, which is either triggered or seated (armed), and transmits signals to the CMM controller. Status and control signals are passed between the PI 7-2 interface, other Renishaw equipment and the CMM controller via the product interconnection system (PICS) ports.

During high-speed position moves (fast traverse), it is necessary to reduce probe sensitivity to prevent vibration causing unwanted triggers. The CMM controller automatically switches the PI 7-2 into a low sensitivity mode, such that the vibration triggers are prevented, but a trigger is still issued to stop CMM motion if an unexpected collision occurs. This mode is known as “probe damped mode” and is indicated by an LED on the front panel.

NOTE: The probe cannot take accurate points when damped mode is selected.

The CMM manufacturer sets the configuration of the PI 7-2 and it should not be necessary for the user to make adjustments except to operate the reset button, as explained later in the handbook.

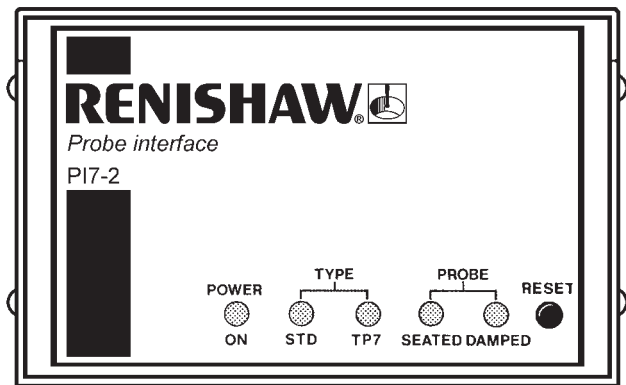


Figure 2 - PI 7-2

2.4 Part number summary

Part number	Description
A-1073-0121	TP7M probe kit
A-1073-0261	TP7M EP probe kit
A-1073-0122	TP7M probe and stylus kit
A-1073-0123	TP7M probe and stylus kit (including PS1-16R)
A-1073-0263	TP7M EP probe and stylus kit (including PS1-16R)
A-1073-0030	PI 7-2 interface

3 Specification

The following data is derived from test rig measurements and may not represent the performance achievable on a CMM. Please contact your CMM supplier for overall system accuracy information.

TP7M:

Sense directions	6-way: $\pm X \pm Y Z$
3D accuracy (test to ISO 10360 Pt 2)*	N/A
Unidirectional repeatability (2σ μm)	Trigger level 1: 0.25 μm (0.00001 in) Trigger level 2: 0.25 μm (0.00001 in)
XY (2D) form measurement deviation	Trigger level 1: ± 0.25 μm (0.00001 in) Trigger level 2: ± 0.50 μm (0.00002 in)
XYZ (3D) form measurement deviation	Trigger level 1: ± 0.50 μm (0.00002 in) Trigger level 2: ± 1.0 μm (0.00004 in)
Trigger force (at stylus tip)	XY plane: 0.02 N Z axis: 0.15 N
Overtravel force	XY plane: 0.78 N Z axis: 11.75 N
Weight	85 g (3.0 oz)
Maximum extension (on a PH10 series head)	200 mm (7.87 in)
Maximum recommended stylus length (M4 styli range)	150 mm (5.9 in) steel 180 mm (7.08 in) GF
Mounting method	Multi-wired autojoint
Suitable interface	PI 7-2
Automatic probe changing	Autochange rack
Operating temperature range	10 °C to 40 °C (50 °F to 104 °C)

TP7M EP (enhanced performance):

Sense directions	6-way: $\pm X \pm Y Z$
3D accuracy (test to ISO 10360 Pt 2)*	$<0.6 \mu\text{m}$ (0.000024 in)
Unidirectional repeatability ($2\sigma \mu\text{m}$)	Trigger level 1: $0.25 \mu\text{m}$ (0.00001 in) Trigger level 2: $0.25 \mu\text{m}$ (0.00001 in)
XY (2D) form measurement deviation	Trigger level 1: $\pm 0.25 \mu\text{m}$ (0.00001 in) Trigger level 2: $\pm 0.50 \mu\text{m}$ (0.00002 in)
XYZ (3D) form measurement deviation	Trigger level 1: $\pm 0.50 \mu\text{m}$ (0.00002 in) Trigger level 2: $\pm 1.0 \mu\text{m}$ (0.00004 in)
Trigger force (at stylus tip)	XY plane: 0.02 N Z axis: 0.15 N
Overtravel force	XY plane: 0.78 N Z axis: 11.75 N
Weight	85 g (3.0 oz)
Maximum extension (on a PH10 series head)	200 mm (7.87 in)
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Mounting method	Multi-wired autojoint
Suitable interface	PI 7-2
Automatic probe changing	Autochange rack
Operating temperature range	$10 \text{ }^\circ\text{C}$ to $40 \text{ }^\circ\text{C}$ $(50 \text{ }^\circ\text{F}$ to $104 \text{ }^\circ\text{C})$

The data on pages 10 and 11 applies for test conditions as follows:
Stylus length 50 mm (1.97 in) Stylus velocity 240 mm/min (1.57 ft/min)

* Test performed on a CMM specification $U^3 = 0.48 \mu\text{m} + L/1000$

3.1 3D measuring performance

To standard ASME B89.4.1 – 1997 for point to point measurement.

Typically, the 3D measuring performance (spherical characteristic) is better than 2 μm . This means that no matter from which direction the probe triggers, the maximum error will be less than 2 μm when standard qualification techniques have been employed using styli up to 50 mm long.

The 3D measuring performance of the probe considers the following sources of probe error:

- Unidirectional repeatability
- XYZ pretravel variation
- Stylus ball sphericity.

The table below only applies to TP7M with the additional styli:

Stylus configuration		Performance parameters	Sensitivity setting	
			Level 1	Level 2
Straight	100 mm long	Unidirectional repeatability	0.5 μm	0.5 μm
		2D form measurement deviation	$\pm 1.0 \mu\text{m}$	$\pm 2.0 \mu\text{m}$
		3D form measurement deviation	$\pm 1.5 \mu\text{m}$	$\pm 3.5 \mu\text{m}$
	150 mm long	Unidirectional repeatability	0.7 μm	0.7 μm
		2D form measurement deviation	$\pm 1.5 \mu\text{m}$	$\pm 2.5 \mu\text{m}$
		3D form measurement deviation	$\pm 2.5 \mu\text{m}$	$\pm 6.0 \mu\text{m}$
Offset	5 mm long, 50 mm offset	2D form measurement deviation	$\pm 0.4 \mu\text{m}$	$\pm 0.8 \mu\text{m}$
		3D form measurement deviation	$\pm 0.5 \mu\text{m}$	$\pm 1.0 \mu\text{m}$
	50 mm long, 50 mm offset	2D form measurement deviation	$\pm 0.7 \mu\text{m}$	$\pm 1.3 \mu\text{m}$
		3D form measurement deviation	$\pm 1.0 \mu\text{m}$	$\pm 1.8 \mu\text{m}$

3.2 Typical performance data for TP7M probe

The following information provides examples of the expected measuring performance of the TP7M when using M2, M3 and M4 styli in accordance with the stylus selection guidelines given earlier in this document.

In all cases, the 'contour' lines show probe performance figures using straight or right-angled stylus configurations.

For the configuration shown, where M2-M3-M4 adaptors and M2 styli are used, the expected measuring performance from the probing system would be within $\pm 1.5 \mu\text{m}$.

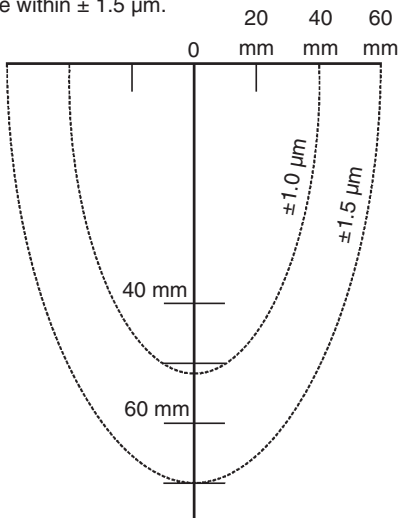


Figure 3 - TP7M using suitable M2, M3 and M4 adaptors and M2 styli

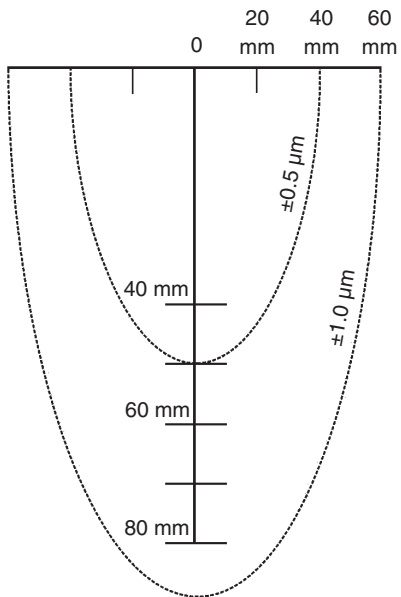


Figure 4 - TP7M using suitable M3 and M4 adaptors and M3 styli

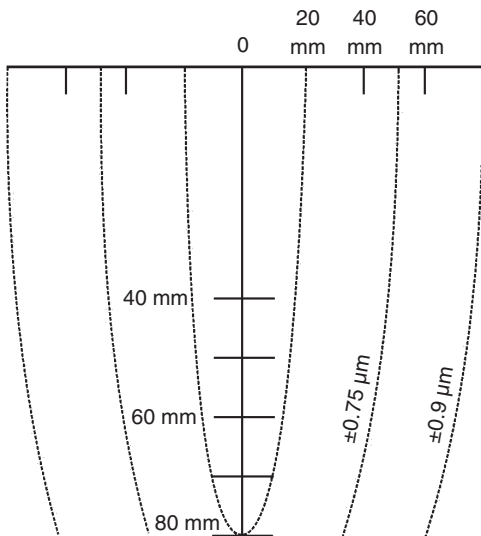


Figure 5 - TP7M using M4 styli

4 Installation procedure

4.1 Mounting the probe on the probe head



CAUTION: Great care must be taken not to drop the probe when installing.

Whenever practical, follow the instructions given later in this section to assemble the stylus to the probe before installing the probe on the probe head.

Locate the probe on the probe head, ensuring that the alignment dots on the head and probe are adjacent, and then lock the autojoint by clockwise rotation of the slotted actuator shaft using an S10 key (supplied).

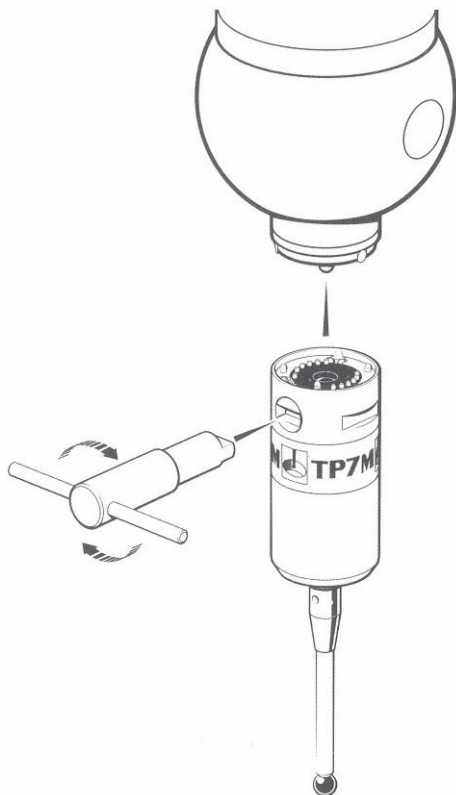


Figure 6 - Locating probe on probe head

4.2 Assembling a stylus to the probe

Screw the stylus into the threaded mount on the probe until finger tight. Fit the stylus tool (s) (supplied) into the stylus cross-hole and tighten using finger pressure. The stylus tool is designed to bend if over-tightened, preventing damage to the probe.

If the stylus has been assembled with the probe in-situ on the probe head, it may be necessary to reset the probe. Refer to section 4.3, 'Resetting the probe' on page 20.

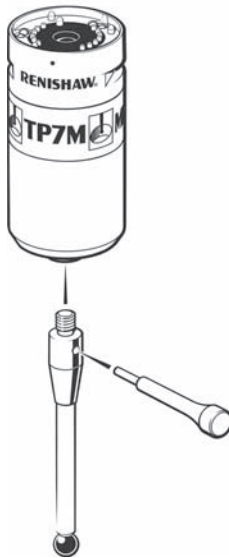
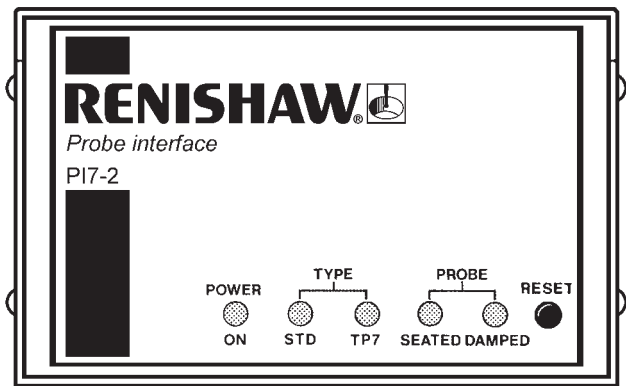


Figure 7 - Assembling a stylus to the probe

4.3 Resetting the probe

The probe will automatically reset to the armed state when the PI 7-2 is powered up or the TP7M is fitted to the probe head. It may sometimes be necessary to perform a manual reset, for example after fitting a new stylus. Press the RESET button on the front panel for 2 seconds to reset the probe to the armed (seated) state.



Indicator	Colour	Function
POWER ON	Green	Mains power in
TYPE STD	Green	Kinematic probe selected
TYPE TP7	Green	TP7M probe selected
PROBE SEATED	Green	ON Probe armed (seated) OFF Probe triggered or no probe connected
PROBE DAMPED	Yellow	PDAMP asserted



CAUTION: Pressing the reset button inhibits probe triggers. Prior to pressing the button the CMM must be stationary, in manual mode, with the stylus clear of the workpiece.

NOTE: The action of unlocking and locking the PH10 series motorised head will perform the same function as the RESET button.

5 Probe operation

The probe has 2 normal operating states, armed or triggered. The probe should be in the armed state except for the moments when the stylus is deflected against the workpiece.

5.1 Probe armed

When the probe is armed (sometimes called 'seated' or 'reset'), the following PI 7-2 front panel indicators will be ON:

- POWER ON
- TYPE: TP7M when a TP7M is fitted
STD when a TP2 is fitted
- PROBE: SEATED

Additionally, the probe head LED will be ON.

5.2 Probe triggered

Normally, when the stylus touches the workpiece, the SEATED LED on the PI 7-2 front panel will turn OFF. Also, the probe head LED will turn OFF.

The probe should be allowed to remain in the triggered state only for the minimum time necessary to reverse the CMM motion and back-off from the workpiece.

5.3 Speed of operation

The TP7M will work at touch speeds between 0.5 mm/s and 40 mm/s.

NOTE: For accurate measurement, it is essential that the moves used to qualify the probe and subsequent measurement moves are carried out at the same speed (to within $\pm 10\%$).

Use of touch speeds greater than 40 mm/s will result in significantly reduced measuring performance.

Use of touch speeds less than 0.5 mm/s (beware of glancing touches or joystick operations) will result in a possible corruption of the system's trigger and seated reference positions.

5.4 Pretravel variation

Pretravel is the distance the probe travels between the stylus touching the surface and a trigger signal being sent to the CMM.

Pretravel is compensated by the CMM computer by probe qualification. However, due to the design of standard probes and the changes in force required to trigger from different directions, there is a small variation in this pretravel. This is called pretravel variation.

On most CMMs using standard software and very long styli (i.e. up to 100 mm), pretravel variation can become a large factor in the probe's total margin of error. It is most evident in inspection routines requiring measurement of form (e.g. following contours or measuring roundness).

Many standard gauging practices, such as measurement of distance between bore centres, are largely unaffected by probe pretravel variation errors.

5.5 Stylus selection

To obtain the best performance, apply the following considerations when selecting and fitting a stylus:

- Use the shortest possible stylus length.
- Minimise the mass of the stylus by using the types with ceramic or GF stems where possible. Refer to the Renishaw stylus catalogue for further information.
- Work with the recommended stylus limits (see graph on opposite page).
- Ensure that stylus balls, threads and mating faces are kept clean.
- Tighten styli using only the tools provided.
- Always qualify the styli at the gauging speed set for the part measurement program. If the speed is changed re-qualify the stylus tip.
- Use the largest ball diameter to minimise surface finish effect on measurement.
- Whenever possible, use only styli from the M4 range. It is possible to adapt to the M3 or M2 styli, but this will result in reduced measuring accuracy and the user is advised to establish the suitability for the application.

5.6 Recommended stylus limits

The figure below shows the two parameters of a stylus configuration which, when plotted onto the graph used to determine stylus limits, determine whether or not the stylus is within the specified limits of operation. The stylus parameters shown below are the mass (M) and the length (L) from the stylus mounting to the centre of gravity of the stylus.

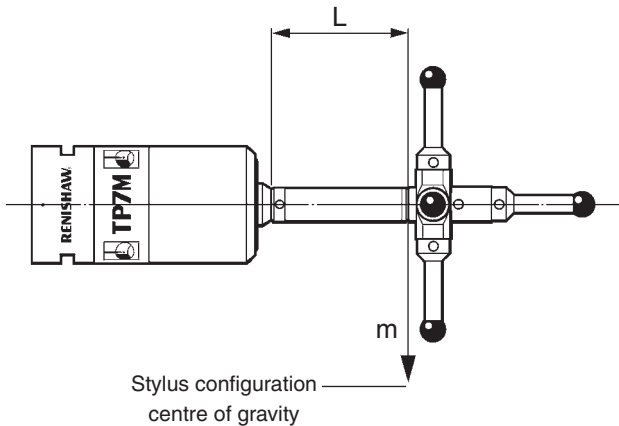


Figure 8 - Stylus limits

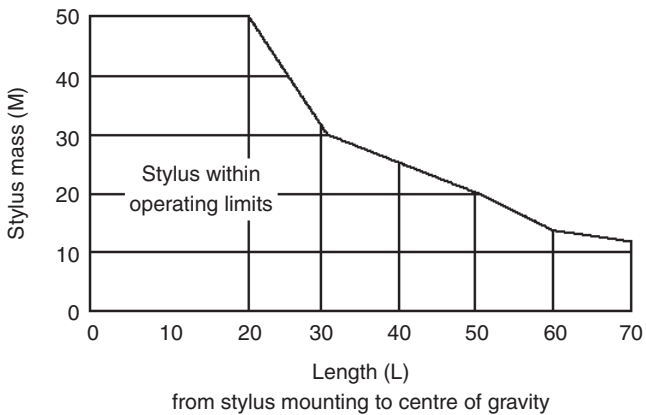


Figure 9 - Graph to determine stylus limits

5.7 Trigger level

Under certain conditions, vibration may cause false 'air' triggers during gauging and it may be necessary to reduce the probe sensitivity. False triggers may occur when large or heavy stylus arrangements are used, or when there is floor transmission from nearby machinery or vehicles:

- Trigger level 1 – the highest sensitivity mode, provides the best measuring accuracy
- Trigger level 2 – lower sensitivity to vibration, but with a small loss of measuring accuracy.

The trigger level is selected by switch number 9 on the rear panel of the PI 7-2 interface:

- Level 1 – switch 9 to right
- Level 2 – switch 9 to left.

NOTE: The sensitivity in probe damped mode is fixed and is not changed by the position of switch 9.

The stylus tip(s) must be re-qualified after changing the trigger level setting.

5.8 TP7M probing and overtravel forces

5.8.1 Probing force

This is the force required at the stylus tip to trigger the probe. The TP7M system is designed to trigger at very low forces to minimise distortion of the stylus, workpiece or CMM structure during measurement.

5.8.2 Overtravel forces

The ability to carry long or heavy stylus configurations requires the TP7M to have overtravel forces significantly higher than probing forces. Because these overtravel forces are experienced beyond the trigger point, but within the probe overtravel, measurement accuracy is not affected.

For measurement of very delicate components, or use of small styli ($\text{Ø}0.3$ mm or $\text{Ø}0.5$ mm), the overtravel forces may be sufficient to damage the surface or break the stylus. The forces experienced at the stylus tip can be reduced by either extending the stylus tip further away from the probe (as shown opposite), or minimising the probe overtravel within the touch cycle (as shown opposite).

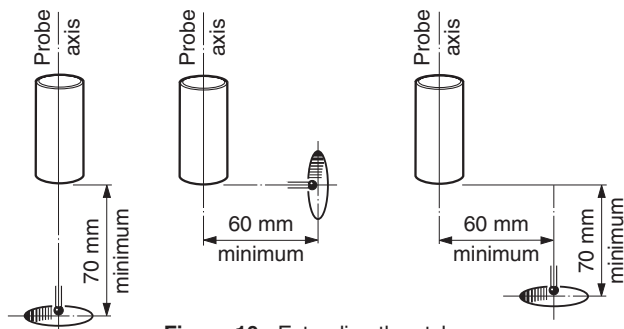


Figure 10 - Extending the stylus tip from the probe

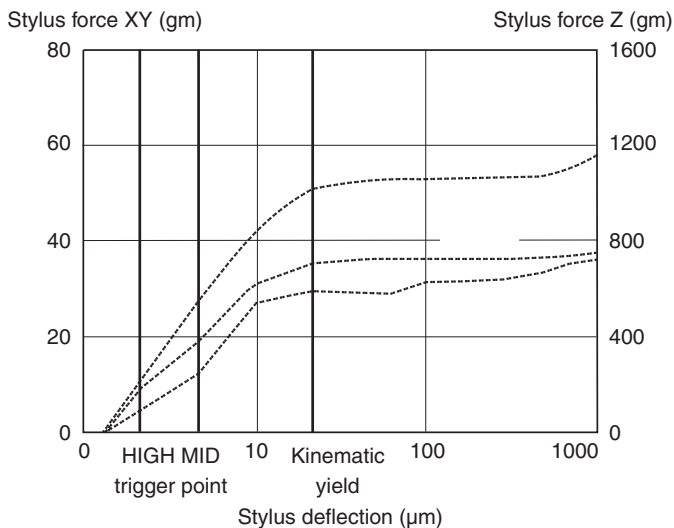


Figure 11 - TP7M force/deflection profiles

6 Fault finding

<p>The probe fails to trigger when the stylus touches the workpiece, but the probe operates normally when the stylus is deflected by hand</p>		
<p>PI 7-2 indicators</p>	<p>Possible causes</p>	<p>Remedy</p>
<p>'SEATED' LED ON</p>	<p>The trigger speed is too low.</p> <p>The stylus is too heavy.</p>	<p>Probe normally to the workpiece surface. Increase gauging speed.</p> <p>Refer to the section 'Stylus selection' for recommendations.</p>
<p>The probe will not arm or the probe does not stay armed after pressing the 'RESET' button</p>		
<p>'STD' LED ON</p>	<p>Probe sensor faulty.</p>	<p>Remove probe and test by substitution.</p>
<p>'SEATED' LED OFF</p>	<p>Probe connections open circuit.</p>	<p>Check wiring from probe to PI 7-2 interface.</p>
<p>The probe will not arm or the probe does not stay armed after pressing the reset button. The head LED is OFF.</p>		
<p>'TP7' LED ON</p> <p>'SEATED' LED OFF</p>	<p>Probe sensor faulty or damaged by collision.</p>	<p>Remove probe and test by substitution.</p>

False ('air') triggers occur while the CMM is stationary		
PI 7-2 indicators	Possible causes	Remedy
'TP7' LED ON	Probe sensor failure.	Remove probe and test by substitution.
'SEATED' LED operates normally	Faulty connection in autojoint, probe head or wiring. Excessive vibration from external source. Excessive vibration from CMM.	Inspect autojoint pins, check continuity of wiring from probe to interface. Eliminate source or isolate CMM. Check air supply. Maintain CMM.
False ('air') triggers occur at gauging speed		
'DAMPED' LED OFF	Stylus is too large or heavy	Use stylus arrangements within recommendations.
'SEATED' LED operates normally	Excessive vibration from CMM	Check CMM air supply. Maintain CMM air bearing system.
False ('air') triggers occur at fast traverse speed		
'DAMPED' LED ON	Stylus is too large or heavy	Use stylus arrangements within recommendations.
'SEATED' LED operates normally	Excessive vibration from CMM Traverse speed is too fast	Maintain CMM. Reduce traverse speed.

The probe does not rearm after taking a point		
PI 7-2 indicators	Possible causes	Remedy
'TP7' LED ON 'SEATED' LED OFF	The reset speed is too slow or the stylus has slowly deflected while moving off the workpiece surface.	Ensure that the direction of gauging and back-off is normal to the workpiece surface. Refer to the section 'Resetting the probe'.
There is an unexpected loss of accuracy		
'TP7' LED ON 'SEATED' LED operates normally 'DAMPED' LED is OFF at touch point	Stylus damaged or ball is dirty. Stylus is too large or heavy. The probe head is damaged or the mounting of the head to the CMM quill is faulty. The autojoint connector is damaged or dirty. The gauging speed has changed. The trigger level has changed.	Inspect and clean stylus ball or replace and requalify the stylus. Check that the stylus joints are tight. Use stylus arrangements within recommendations. Inspect and clean the autojoint connector. Refer to 'Maintenance' section. Requalify stylus tips.

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