K505/46

FORM TALYSURF

INTRA

Operator's Handbook

P.O. Box 36, New Star Road, Thurmaston Lane, Leicester LE4 9JQ England. .
Telephone +44 (0)116 2763771 Fax +44 (0)116 2741350
Website www.taylor-hobson.com

Publication K505/46 Issue 1.5, June 2002
Handbook revision applicable
to software Version 1 issue 5

CONTENTS

CONTENTS

SAFETY

WARNINGS

Battery Charging

Use **only** the batteries (249/36) and the battery charger (265/943) supplied by Taylor Hobson Limited, in accordance with the manufacturer's instructions. Using unsuitable battery charging equipment may result in an explosion and cause injury and damage.

Battery Short Circuit

Do not place a battery in a container that also has metal objects that may cause a short circuit. (e.g. do not carry a battery in a pocket that also contains coins or other metal objects). If the battery is short-circuited, an internal fuse will blow. This will render the battery useless.

Instrument Storage

If the instrument is to be unused or stored for more than one week, the batteries must be removed.

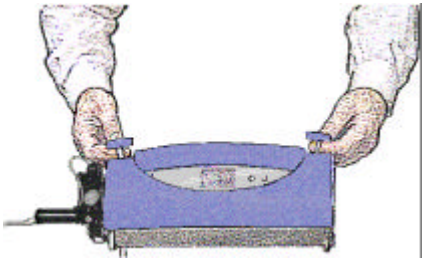
Disposal

Batteries can present an environmental hazard. Therefore:
Remove the batteries before disposing of a Traverse Unit or a Processor Control Module. The batteries can be returned to Taylor Hobson Limited for safe disposal.

SAFETY

CAUTIONS

1. The Traverse Unit **MUST** be carried by **BOTH** handles. Lifting by one handle only may damage the Traverse Unit.



2. The Processor Control Module **MUST NOT** be carried by the stand. This component is not designed for this purpose

.

SAFETY

ENVIRONMENT

The instrument is designed to be safe when, in addition to the electrical and environmental conditions described below, the following conditions also apply:

i The system is located indoors, in dry conditions.
ii Fluctuations in the mains supply voltage do not exceed ±10%.
iii The altitude does not exceed 2000m.

Electrical supply

This equipment is intended for installation category (overvoltage category) II, in accordance with IEC 1010 (1990) and EN 61010-1 (1993).

Voltage:	100 - 240Vac
Frequency:	50/60Hz.
Max. power requirement:	30VA

Environmental Conditions

Ambient temperature range

Operation:	15°C to 35°C
Storage:	0°C to 50°C
Ambient relative humidity:	10% to 80% non-condensing

Cleaning

The plastic cases of the instrument should be cleaned using a soft cloth moistened with a solution of water and a mild detergent. DO NOT attempt to use any other cleaning solvents or materials as these may damage the plastic.

The recommended cleaning product for the PCM touchscreen is a Lint free, quick drying, Isopropyl Alcohol surface wipes.
For the metallic components the product recommended should either be the Lint free, quick drying, Isopropyl Alcohol surface wipes, Ethyl Alcohol or Methyl Alcohol

SAFETY

SPECIFICATION

ANALYSIS

Form Removal:	None, Datum, LS line, MZ line, LS arc
Form Parameters:	Slope (LS line, MZ line) Radius (LS Arc and Absolute Arc)
Primary Analysis	
Filter:	Gaussian Cut offs (Ls). None, 0.0025mm to 0.8mm
Parameters:	Pa, Pq, Pv, Pt, Psk, Pp, Pku, Pz(JIS), PLamq, PDelq, PS, PSm, Pz, PDela, ln, PLo, Pc.
*Extended parameters:	Pvo, PPc, PHSC, Pmr, Pdc.
Roughness analysis	
Filter:	Gaussian, ISO 2CR, 2CR PC Cut offs (Lc). 0.08mm to 8.0mm Bandwidths: 30:1, 100:1, 300:1 (depending on cut off)
Parameters:	Ra, Rq, Rp, Rv, Rt, Rsk, Rku, Rz, Rz(JIS), Rz1max, R3y, R3z, RS, RSm, ln, RLo, Rc. RDela, RLamq, RDelq.
*Extended parameters:	Rvo, RPc, RHSC, Rmr, Rdc.
Waviness Analysis	
Filter:	Gaussian ISO 2CR, 2CR PC Cut offs (Lf). 0.025mm to 8.0mm
Parameters:	Wa, Wq, Wp, Wv, Wt, Wsk, Wku, Wz, WLamq, WDelq, WS, WSm, WDela, ln, WLo, Wc.
*Extended parameters:	Wvo, WPc, WHSC, Wmr, Wdc.

* The user may define 5 of each of these parameters for any single analysis

SPECIFICATION

Rk Analysis

Filter:	Gaussian Cut offs (Lc). 0.08mm to 8.0mm Bandwidths: 30:1, 100:1, 300:1 (depending on cut off)
Parameters:	Rk, Mr1, Mr2, Rpk, Rvk, A1, A2.

R&W Analysis

A and B cutoffs:	ISO standard values from for 0.02/0.1mm to 0.5/2.5mm and user entered values up to A=5mm, B=25mm.
Parameters:	Pt, R, AR, Rx, W, AW, Wx, Wte, SR, SAR, SW, SAW

INSTRUMENT (M112/2936)

Traverse (measuring) length:	0.1mm to 50mm (0.004in to 1.97in)
Run up distance required:	0.3mm (0.01in) max.

Straightness (using 1mm range conical diamond stylus):

Form best fit straight line:	0.3µm over 50mm (12µin over1.97in) 0.2 over any 20mm (0.78µin over any0.78in).
Inclination best fit straight line:	± 35 degrees (Range referred to straightness datum)
Accuracy of slope measurement:	within 3% of measured angle (Ra less than 0.1µm)
Form best fit circular arc (P+V):	0.25µm/9.5mm (10µin/0.37in) on calibration ball
Radius (min 1mm, max 1000mm):	within 2% at 1mm, 0.04% at 12.5-28mm 0.2% at 1000mm
Parameter measurement height:	within 2% +6nm (peak parameters only)

SPECIFICATION

Measurement speed:	1.0mm/sec (0.039in/sec)
Auto return speed and set-up speed:	Up to 10mm/sec (0.39in/sec) nominal
Removable media:	One PCMICA type II slot provided for use with optional PC Card

INDUCTIVE GAUGE

Nominal Gauge Range:	1mm (0.039in) nominal 0.2mm (0.008in) nominal
Gauge Resolution:	16nm with 1mm range (0.64µin with 0.039in range) 3.2nm with 0.2mm range
Stylus force:	0.7mN to 1mN
Stylus:	2µm radius conisphere
Gauge Body Diameter:	25mm
Length:	70mm
Weight approx.:	90g

DIMENSIONS AND WEIGHTS

Traverse unit length:	535mm retracted,
(incl stand. gauge and 60mm stylus)	585mm extended
Traverse unit depth:	116mm
Traverse unit height:	160mm
Processor Control Module length:	285mm
Processor Control Module depth:	200mm
Processor Control Module height:	80mm
Traverse Unit weight:	5.6kg (with batteries) 4.9kg (without batteries)
Processor Control Module weight:	1.9kg (with batteries) 1.5kg (without batteries)

POWER

Electrical supply:	110/220/240V 50/60Hz Via low voltage adaptor supplied
Power consumption:	10VA (Traverse Unit) 18VA (Processor Control Module)

SPECIFICATION

Batteries (optional):	6V NiMH rechargeable
Charger (optional):	For three batteries, charge time two hours
Battery life:	two hours

INFRA RED COMMUNICATION

Range:	1m
Angular range:	± 20°

CALIBRATION ARTEFACT

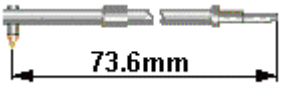
For use on 60mm long stylus arms:	Precision Tungsten Carbide ball nominally 25mm diameter
For use on 120mm long stylus arms:	Ball nominally 44mm diameter

Stylus details

1mm Range Stylus Arms.

Nominal effective arm length: 60mm

Actual arm length:



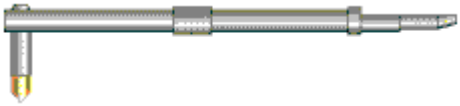
Standard Conical Diamond 112/2009

Range:	1mm (0.039in)
Tip Radius:	1.5 - 2.5µm
Stylus force over full range:	70-100mgf (0.7 - 1mN)
Enter 12mm bore to depth of:	12.7mm
Measurable depth of recess:	5mm

SPECIFICATION

Recess Conical Diamond 112/2011

Range:	1mm (0.039in)
Tip Radius:	1.5 - 2.5µm
Stylus force over full range:	70 - 100mgf (0.7 - 1mN)
Depth of recess measurable:	11mm

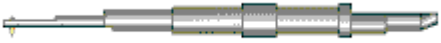


Small Bore Conical Diamond 112/2012

Range:	1mm (0.039in)
Tip Radius:	1.5 - 2.5µm
Stylus force over full range:	70 - 100mgf (0.7 - 1mN)

The stylus will enter:

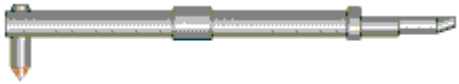
6.0mm bore to depth of:	12.5mm
2.0mm bore to a depth of:	5mm
2.5mm bore to a depth of:	11mm
1.4mm wide groove to depth of:	5mm
2.3mm wide groove to depth of:	11mm
3.0mm bore to depth of:	25mm



SPECIFICATION

Chisel Edge Diamond Stylus Arm 112/2013

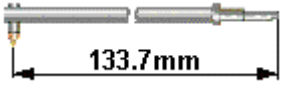
Range:	1mm (0.039in)
Chisel Edge Tip:	2.5µm x 0.9µm
Stylus force over full range:	70 - 100mgf (0.7 - 1mN)
The stylus will enter 12mm bore to a depth of:	12.7mm



2mm Range Arm With Sapphire Ball Stylus (Cannot be used with a Guard Nosepiece).

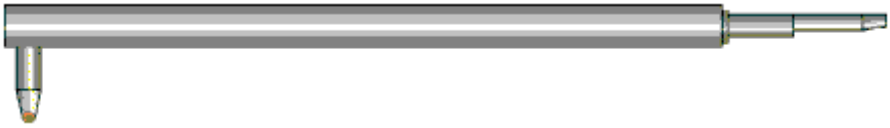
Nominal effective arm length: 120mm

Actual arm length:



Standard Ball Stylus 112/2010

Range:	2mm (0.078in)
Ball radius:	0.5mm ± 0.125µm
Stylus force over full range:	1.5 - 2.0 gf (15 – 20N)
Measurable depth of recess:	11mm



SETTING UP

SETTING UP THE INSTRUMENT

Unpacking the Instrument

Initial installation is carried out by a service engineer, or a representative, of Taylor Hobson Limited. PLEASE DO NOT UNPACK YOUR INSTRUMENT, OR ASSOCIATED PRODUCTS, UNLESS WITH PRIOR AGREEMENT WITH A SERVICE ENGINEER OR REPRESENTATIVE OF TAYLOR HOBSON LIMITED.

Siting the instrument

The overall accuracy of measurement results will be influenced by environmental conditions, particularly; draughts, vibration and the rate at which the ambient temperature changes. The choice of location depends on the application requirement. However, to ensure that the optimum performance is achieved, wherever possible, the instrument hardware should be installed with consideration given to the surroundings in which it will operate.

The following items must be considered when siting the instrument;

Draughts

Draughts and airborne vibration should be avoided particularly when measuring in the skidless mode. Avoid placing the instrument in draughts or directly under air conditioning vents.

For particularly critical applications it is often beneficial to cover the instrument to minimise the effects of air movement and airborne vibration.

Temperature Gradients

Avoid siting the instrument in areas that have a very rapid temperature gradient, as in the case of being near windows or skylights where sunlight may fall on the instrument.

Areas that experience temperature gradients of over 2°C/hour are not ideal for the measurement of precise form. For the measurement of surface texture parameters, a higher value can be tolerated (in the order of 5°C/hour).

Vibration

Vibration is particularly detrimental for the measurement of surface texture. It is essential that a good solid table, with anti-vibration mountings, is provided for applications in potentially "noisy" environments. The Taylor Hobson Instrument desk with anti-vibration mounts is recommended.

Power Supply-Mains Operation

It is important that a clean power supply should be provided to the instrument. If in doubt, many computer peripheral dealers can supply a suitable Un-interruptible Power Supply (U.P.S.). A complete U.P.S. system for the instrument can be obtained from Taylor Hobson Limited.

Hardware Installation

Table

A strong stable mounting, such as an instrument desk, is required to support the instrument (particularly when a column and stand is included). With the instrument desk in the required position, use the adjustable feet on the table to bring the table level. A bubble level should be used to assist the operation and check the result.

CAUTION

The base and column, together, weigh a maximum of 136 Kg (299 lbs). If the column and base are being used, the table must be capable of safely supporting this weight plus any other accessories.

SETTING UP

Granite Base 112/3046

Note: Initial installation is carried out by a service engineer, or a representative, of Taylor Hobson Limited.

Fit the four screw-in carrying handles, ensuring that they are screwed fully into the holes in the ends of the base (two handles at each end). Lift into position on the table. It is advisable to remove the handles after the base has been positioned. As the base weighs 100 Kg (220 lbs) the user must decide whether to use manual or mechanical lifting, depending on the environment and the distance to be moved.

WARNING: The threaded holes on the top of the base **MUST NOT** be used for lifting. The column must be removed from the base before attempting to lift the base.

Free Standing Base 112/3066

Installation information as for Granite Base except that the free standing base weighs 50kg (110lbs).

Column

Note: Initial installation and setting of the column to the base (112-3046 only) is carried out by a service engineer, or a representative, of Taylor Hobson Limited.

The column is delivered laying horizontally. It should be lifted in this position.

WARNING: The column weight is 36kg (79lb). **DO NOT** attempt to lift the column by the leadscrew or the handwheel.

Once one end of the column is positioned on the base, then the column can be raised from the horizontal to the vertical. It **MUST** immediately be moved across the base until the column slots align with the base holes. Bolt the column into place.

WARNING: DO NOT leave a column standing in the vertical position if it has not been bolted into place.

SETTING UP

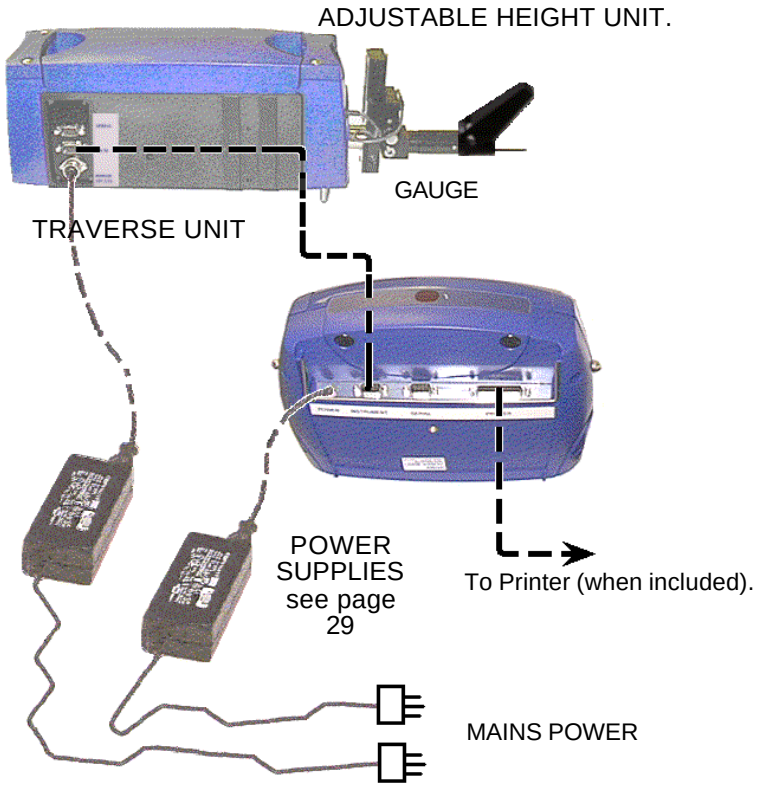
The user must decide whether to use manual or mechanical lifting, depending on the environment and the distance to be moved.

Interconnections

Connect the units as shown in the following diagram. Ensure that a good earth is available for the instrument when the power supply is connected. This is essential for both safety and correct operation.

Before assembling the Gauge with the Adjustable Height Unit, read the description of how to fit the Gauge, given on page 21.

Before attempting to fit a Stylus into the Gauge, read the description given on pages 24 and 25.

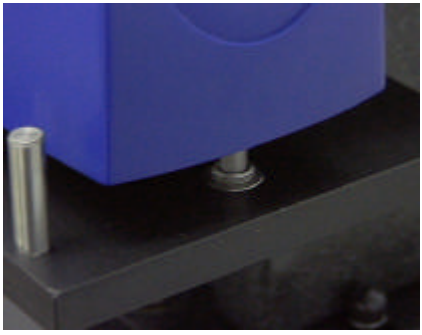


Mounting traverse unit onto column carriage

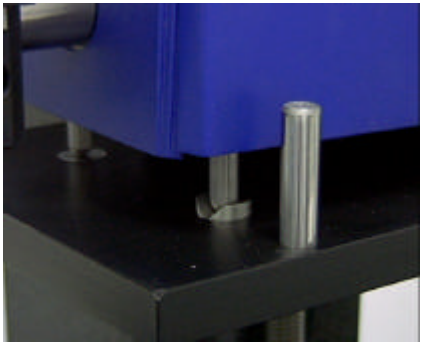
WARNING: Before placing the traverse unit on the carriage adaptor plate, ensure that the adaptor plate is firmly secured to the column carriage.

The traverse unit is mounted onto the carriage as shown. The rear foot must be located in the rear cup mounting on the carriage and the front left foot (viewed from the rear of the traverse unit) located in the vee mounting. Levelling of the traverse unit is achieved by adjustment of the screwed cone mount in the adaptor plate, located under the rear TU foot.

Rear foot location



Front feet location



Interconnections when mounted onto column and base

The electrical connections to the traverse unit when mounted on the column are identical. Care must be taken when positioning the traverse unit on the column carriage that the cables to the traverse unit are not or are not likely to be stretched during operation.

Upgrading software

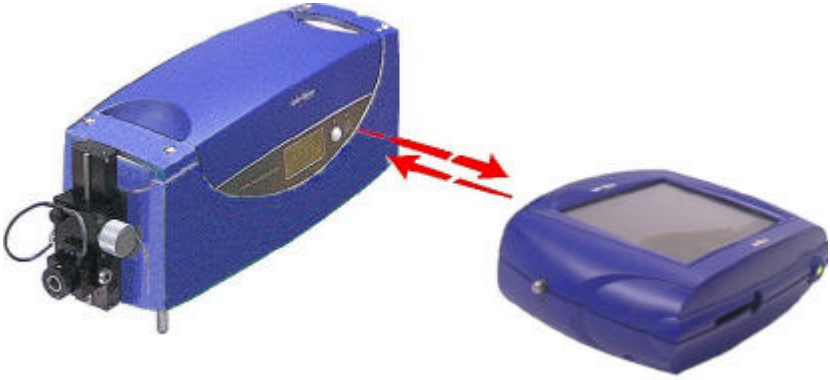
If the software is upgraded or the software on the PCM needs replacing then the software upgrade for the PCM is performed as follows:

- With the PCM switched on copy any measurement data files and PreSet files that need to be preserved from the Internal drive on to a spare PCMCIA card. This is done using the 'File' menu.
- Insert the PCMCIA card containing the software upgrade into the PCM.
- Switch the PCM off and on.
- A banner is displayed on the PCM screen along with information about reformatting the Internal drive. The file(s) are then copied from the PCMCIA card to the Internal drive.
- The PCM software is then automatically started and the first menu is displayed, e.g. Measure Menu.
- Remove the PCMCIA Card.

CONTENTS

INTRODUCTION

Form Talysurf Intra is a portable stylus type instrument for the measurement and analysis of surface texture and form. The instrument primarily consists of a 50mm Traverse Unit and a Processor Control Module. Both units can be battery powered or used in conjunction with a low voltage Power Supply Unit. Communication between the units is via an interconnecting lead or an infrared link



Designed to address a wide range of shop floor, production line and automated measurement applications, the instrument's accuracy and analysis capabilities also make it an invaluable addition to inspection and research laboratories (the instrument has a normal Gauge range of 1mm [0.039in] with a measurement resolution of 16 nanometres [0.63µin], but can have a reduced Gauge range of 200µm with a measurement resolution of 3.2nm).

The instrument can be used for a different measurement every time or can be pre-programmed to perform repetitive measurement sequences. For convenience, the PCM retains the last measurement settings after power off.

There is also an extensive range of accessories for work-holding and automated operation.

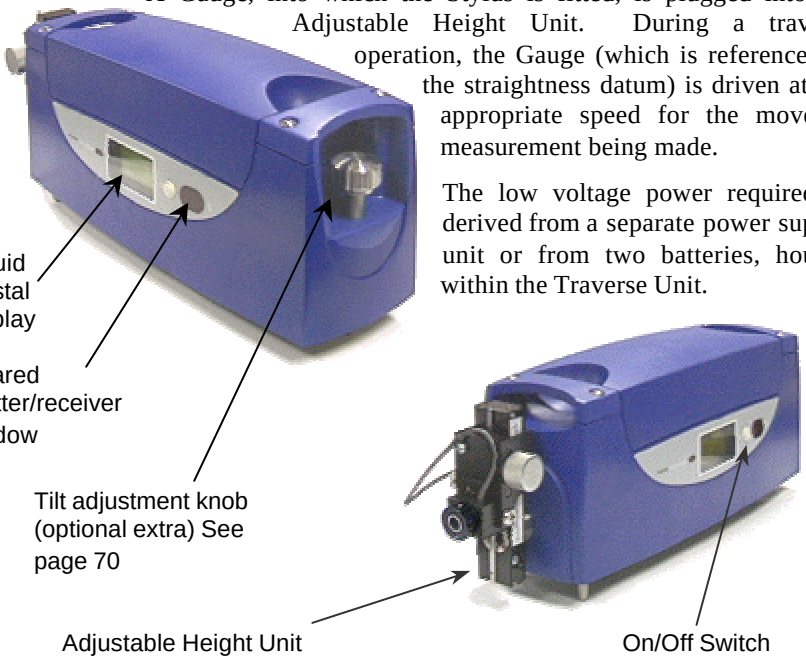
THE TRAVERSE UNIT

The traverse unit houses the motor, gearbox and associated circuits for traversing the stylus across the surface to be measured. Communication with the Processor Control Module is via an interconnecting lead or an infrared link. A straightness datum is incorporated, enabling measurements of up to 50mm long to be made without reference to an external straight-line datum. A tilt adjustment is available as an optional extra to enable the levelling of the traverse unit. This could be a requirement for long traverse measurements especially using gauge range 2.

The side panel carries the On/Off switch, an Infrared Emitter/Receiver Window and a Liquid Crystal Display. When the Traverse Unit is first switched on, the software revision number is displayed on the Liquid Crystal Display. During normal operation, the current positions of the Traverse Unit datum (X axis position) and the height of the Stylus (Z axis) are displayed.

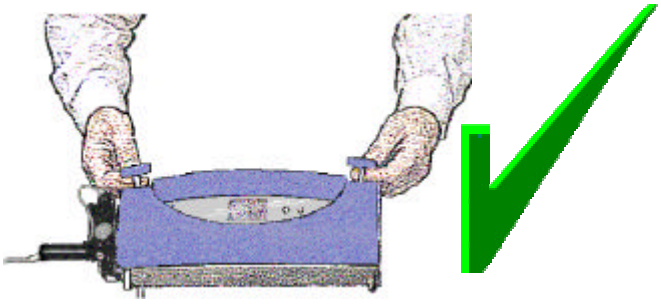
A Gauge, into which the Stylus is fitted, is plugged into the Adjustable Height Unit. During a traverse operation, the Gauge (which is referenced to the straightness datum) is driven at the appropriate speed for the move or measurement being made.

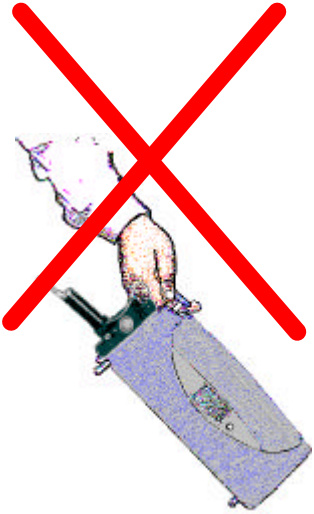
The low voltage power required is derived from a separate power supply unit or from two batteries, housed within the Traverse Unit.

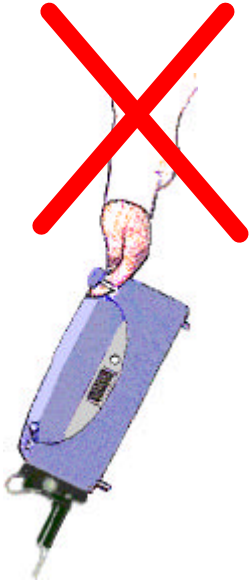


CAUTION

The Traverse Unit must be carried by both handles. Lifting by one handle only may damage the Traverse Unit.





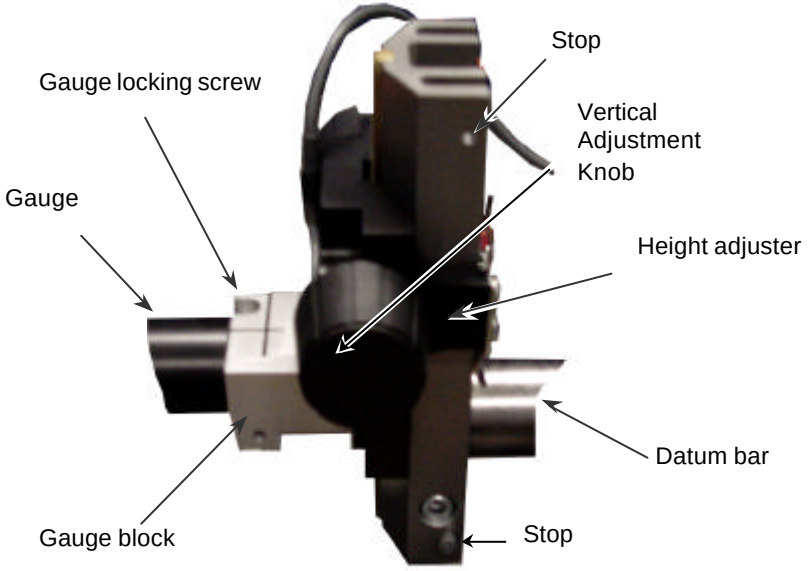


THE ADJUSTABLE HEIGHT UNIT

Mounted on the end of the Traverse Unit datum shaft is a Adjustable Height Unit.

The assembly, complete with gauge, can be raised and lowered by rotating the vertical adjustment knob on the side of the unit (clockwise to raise the pick-up, anti-clockwise to lower it). Stop screws at each end of the vertical traverse guide bar limit the travel of the height adjuster.

The range of vertical adjustment allows the stylus to be positioned between 70mm (nominal) above traverse unit base and 24mm (nominal) below traverse unit base.



Fitting the Gauge

The Gauge is mounted onto the Height Adjuster by carefully engaging the small diameter connector at the rear of the Gauge into the socket on the front of the Gauge Block. The Gauge Block is screwed onto the Height Adjuster. The Gauge Block socket houses a number of pins. These must align with the holes in the end of the Gauge connector. When the Gauge is fully engaged with the Gauge Block, turn the Gauge Locking Screw, on the top of the Gauge Block and gently clamp the Gauge.

The adjustable height unit enables the gauge to be used in both its normal position and at right angles according to how the gauge block is oriented. Page 21 shows the gauge block and the gauge in the normal position. By unscrewing the gauge block from the height adjuster it can then be screwed back onto the height adjuster oriented through 90^{o} to enable right angle use.

IMPORTANT

When using the adjustable height unit in right angle mode, the pick-up must first be calibrated in the normal in-line condition then, without disturbing the stylus, the pick-up should be removed from the gauge block. The gauge block is then refitted as stated above and the pick up carefully reinserted into the gauge block.

Note. When a right angle measurement is made, Right Angle Pick- up USED must be selected from the menu GAUGE SET UP options.

IMPORTANT

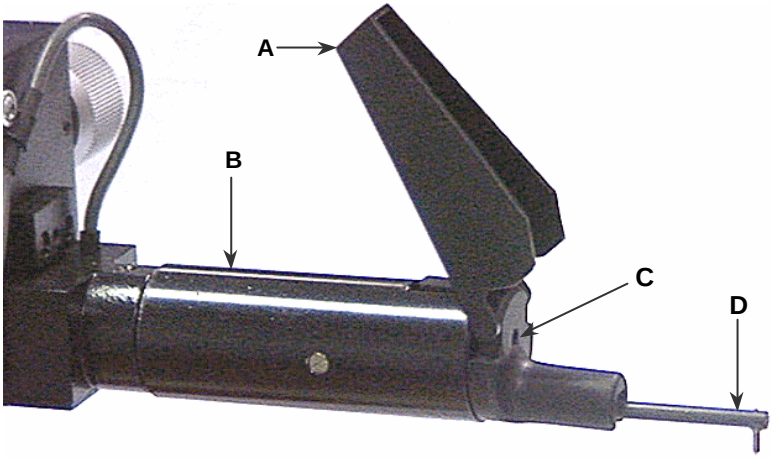
It is not practical to use a right angle attachment, in conjunction with the accessory column and stand as the stylus will overhang the edge of the base. However, should this arrangement be required, a suitable column and stand can be supplied on application to Taylor Hobson or its local agents.

There will be degradation in performance when using the right angle attachment with all gauges and styli.

Note. When the right angle attachment is required, the chisel styli should not be used.

THE GAUGE

The Gauge comprises a variable inductance transducer with a linear measuring range of 1mm. The Gauge is plugged into the Adjustable Height Unit of the Traverse Unit and can be used either with or without a Guard Nosepiece. A number of interchangeable Stylus Arms can be used with this Gauge.



A Guard Nosepiece **B** Gauge Body

C Guard Nosepiece Clamp Screw

D Stylus arm

When the cover of the Guard Nosepiece is closed over the stylus, the possibility of accidental damage to the stylus beam is minimized. The Guard Nosepiece can be used in conjunction with the Styli (112/2009, 112/2011, 112/2012 or 112/2013). Do not use when stylus 112/2010 is fitted.

THE STYLUS

The standard Stylus types available for use with the inductive Gauge are diamond tipped with an effective arm length of 60mm and Sapphire ball tipped with an effective arm length of 120mm. The measurement range is dependent on the length of the Stylus Arm i.e. a 60mm arm gives a range of 1mm, a 120mm arm gives a range of 2mm.

The type of assessment required determines the Stylus to be used. Surface texture assessments are only valid when a Diamond Tipped Stylus is fitted. Form assessment is available with all styli, the vertical range required to trace the component profile will determine the length of Stylus Arm to be used.

To fit or change a Stylus, pull out the Stylus that is fitted and gently push in the one required.

The end of the arm is shaped to fit the socket in the Gauge cartridge and must be fitted with the flat uppermost, when the Gauge is set for measurement on a surface below it.

CAUTION

The pivot of the Gauge is a delicate mechanism. Therefore, care must be taken when changing the stylus, not to force the beam into its socket or to impart a sideways or twisting movement.

Note The Stylus force is determined by balancing the arm with a small collar. When fitting or removing the Stylus, do not pull or push on this collar and disturb its position**.**

For details of the stylus types available, see Specifications.

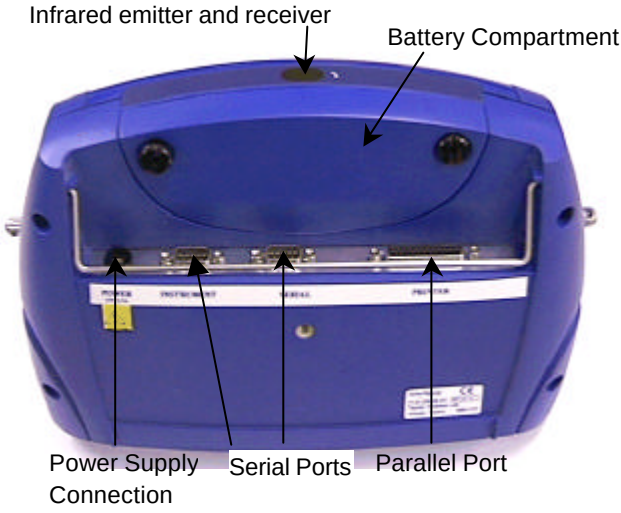
THE PROCESSOR CONTROL MODULE

The Processor Control Module provides the operator interface and data processing requirements for the instrument. It can be used either hand-held or desk mounted.

All instrument operation commands, analysis requirements and results displays are via a touch pad screen.

Instructions and data are passed between the Processor Control Module and a compatible Traverse Unit via an interconnecting lead or an infrared link. This enables the Processor Control Module to be used up to a distance of **1.0m** from the traverse unit (providing that there is an uninterrupted line of sight between the infrared emitters and receivers).
The low voltage power required is derived from a separate power supply unit, or from a battery, housed within the Unit.

Other features of the Processor Control Module are:



Sleep Mode (user selectable)

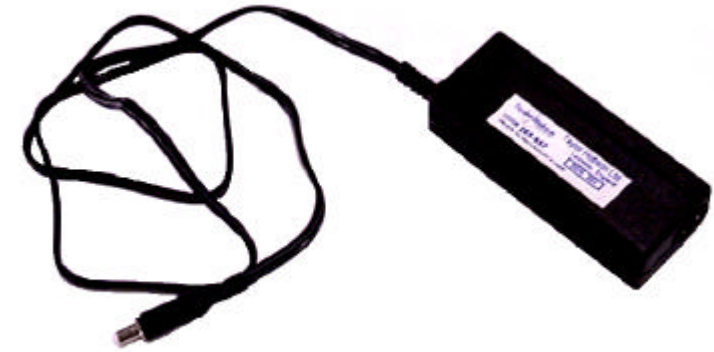
If the touch pad screen is not used for a period of time, then the power saving "Sleep Mode" is activated. In this mode, the screen back light is turned off and the processor clock speed is reduced. Any contact with the touch pad screen will restore the unit to the active mode

CAUTION

The Processor Control Module must **NOT** be carried by the stand. This component is not designed for this purpose.

THE POWER SUPPLY (part number 265-957)

Low voltage power for the Traverse Unit and the Processor Control Module is derived from separate Power Supply Units. The two power supply units are identical as shown.



The Power supply Unit accepts a mains power input of:

100-240V a.c. 50-60Hz 0.6-0.3A

and provides low voltage d.c output

+12V d.c. 2.5A 30W continuous.

BATTERIES

Use **only** the batteries supplied by Taylor Hobson Limited, part number 249/36. Allocate a particular battery for use in the Processor Control Module and the other two for use in the Traverse Unit. Ensure that they then remain only in use with their allocated units.

Do not use a partially charged battery with a fully charged battery in the traverse unit.

Battery Condition on Delivery
The instrument is delivered with the batteries in a discharged state. Before use, the batteries must be fully charged. Batteries must only be charged in the Taylor Hobson charger, part number 265/943.

Storage
If the instrument is to be unused or stored for more than one week, the batteries must be removed.

Disposal
Batteries can present an environmental hazard. Therefore:
Remove the batteries before disposing of a Traverse Unit or a Processor Control Module.

The batteries can be returned to Taylor Hobson Limited for safe disposal.

Battery Short Circuit
Do not place a battery in a container that also has metal objects that may cause a short circuit. (e.g. do not carry a battery in a pocket that also contains coins or other metal objects). If the battery is short-circuited, an internal fuse will blow. This will render the battery useless.

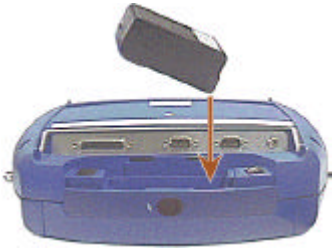
Note. If batteries are left in either unit when powered by the power supplies, it should be noted that there will still be a small current drawn from the batteries which will discharge the batteries over a period of time. If the either unit is to be powered by the power supply then the batteries should be removed.

BATTERIES IN THE PROCESSOR CONTROL MODULE

To access the battery, ensure that the unit is switched off. Turn the two fasteners, to release the cover to the battery compartment and lift off the cover.

To fit the battery:

Tilt the battery so that the end with the contacts is inserted first into the compartment in the PCM. Then push the battery into position until it is fully engaged.

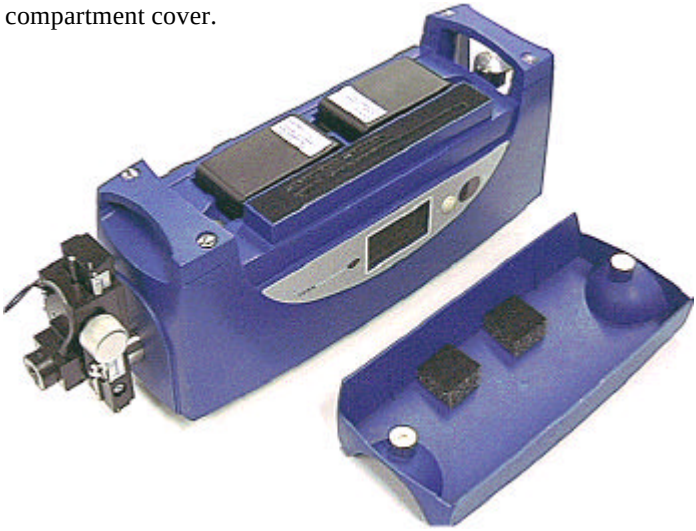


To remove the batteries:

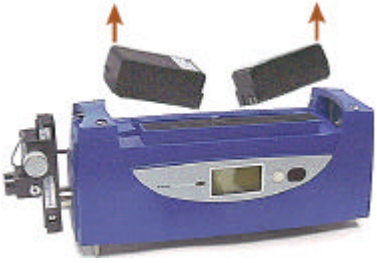
Pull on the end of the battery that is away from the contacts and lift the battery out of its compartment.

BATTERIES IN THE TRAVERSE UNIT

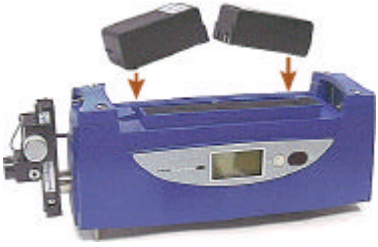
To access the batteries, ensure that the unit is switched off and lift off the battery compartment cover.



To remove a battery:
Pull on the end of the battery that is away from the contacts and lift the battery out of its compartment



To fit the batteries::
Place each battery into its compartment with the battery contacts to the centre of the Traverse Unit. The batteries are a tight fit in their compartments and to ease fitting, tilt each battery so that the end that is away from the contacts is inserted into the compartment first. Then push into position, until fully engaged.



CHARGING BATTERIES

Before charging a battery it must be removed from the Traverse Unit or Processor Control Module and placed into the charger supplied**..**

Recharging partially charged batteries

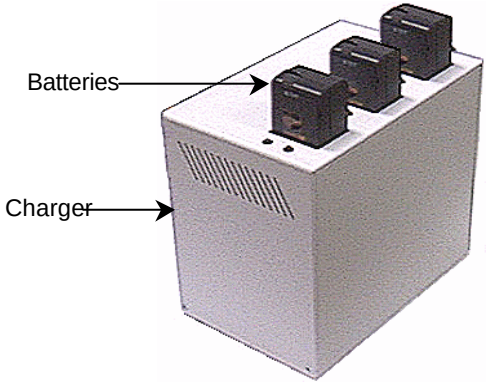
Unlike Nicad batteries, the batteries supplied with the instrument do not have a memory retention problem. Partially charged batteries may, therefore, be charged, as required. **Do not** attempt to discharge a battery by creating a short circuit (see WARNING below).

WARNING

Using unsuitable charging equipment may result in an explosion with associated injury and damage.

Use only the charger supplied, in accordance with the manufacturer's instructions. **A full charge will require up to 2 hours.**

Charger Operation



Charging Stages

The charging sequence consists of four stages. The soft start stage gradually increases current levels up to the fast charge rate during the first two minutes. The soft start stage is followed by the fast charge stage, which continues until termination. After termination, a two-hour topping charge is applied at a rate low enough to prevent cell heating but high enough to ensure a full charge. The topping charge is followed by a maintenance charge, which is intended to offset the natural self-discharge of the battery by keeping the cells primed at peak charge. The maintenance charge will continue as long as the battery is inserted in the bay.

The RED Charge Status indicator is activated continuously during soft start and fast charge. The GREEN Charge Status indicator is activated continuously during topping and maintenance charge.

Charge Termination Methods

The charger uses voltage slope, maximum temperature and charge timer methods to terminate fast charge. The maximum temperature and fast charge timer are used as a safety backup during the main charge cycle.

If the temperature of the battery exceeds the maximum limit during a charge cycle, the charger will shutdown and stop charging. The YELLOW Battery Temperature indicator will latch on indicating a Hot Battery condition. The user must remove the battery and manually reset the charger via the recessed push-button switch situated at the back of the unit. The battery must be allowed to cool before it can be reinserted and charged again.

Note: Repeated over temperature shutdowns indicates a potential fault condition and the battery must be removed from service immediately and returned to the supplier with details of the problem.

The charger uses a timer to limit the fast charge duration to 144 minutes. For safety, the fast charge timer is always enabled and cannot be disabled.

Note: *Powering-up, removing and re-inserting a battery, or manually resetting the charger using the push-button switch will reset the safety timer.*

Battery Detection

Upon power-up, removal of a battery, or manual reset after an over temperature shutdown condition, the charger enters the battery polling detect mode. To indicate this mode, the YELLOW indicator will flash continuously. Once a battery is installed in a charger bay, the YELLOW indicator will stop flashing and the charger will enter the soft start stage.

Cold Battery Charging

The charger checks for a cold battery before initiating fast charge. If a cold battery is present before fast charge begins, the charger begins a two hour topping charge cycle. If the battery is still cold after the two hour topping charge is complete, the charger begins a maintenance charge. The

maintenance charge will continue for as long as the battery remains cold. The charger checks the temperature every second to see if the battery has warmed up. If the battery warms up, the charger stops the topping or maintenance charge and begins the fast charge cycle.

The GREEN Charge Status indicator and the YELLOW Battery Temperature indicator will be active, indicating that a low current charge is being applied to the battery that is outside the specified temperature range for fast charging.

Safety Features

In the event of an accidental short circuit across the battery terminals inside the charger bay, the charger will automatically limit the internal current to 1.8A (normal fast charge current) to prevent damage to the electronics. The GREEN Charge Status indicator will flash and the YELLOW Battery Temperature indicator will turn on indicating the condition. *The user must immediately turn off system power and remove the short circuit obstruction from the charger bay*.

The input to each charger circuit is internally protected with a 3.15A fuse. *A blown fuse indicates a fault condition and must not be replaced by the user.*

Additionally, each battery pack includes a PTC fuse to protect against accidental short circuits across the battery pack terminals. The PTC should automatically reset itself when the short circuit condition is removed. *If the pack does not recover from the short circuit condition, the battery must be removed from service immediately and returned to the supplier with details of the problem.*

Please refer to the Operating and Safety Instructions for the Fast Charger System and Battery Packs supplied with the charger unit for additional safety information.

CALIBRATION STANDARD

There are two Calibration Standards; the Calibration Ball and the Three-Line Calibration Standard.

Calibration Ball

The standard comprises a highly polished Tungsten Carbide precision Ball, with housing and screw-on cap. The application of this standard is described in ***Calibration***.

The calibration standard used should be appropriate to the pick-up and stylus type.

For use on 60mm long stylus arms:	Precision Tungsten Carbide ball nominally 25mm diameter
For use on 120mm long stylus arms:	Ball nominally 44mm diameter

Note The calibrated size of each individual standard is shown on two labels. One label is located under the base of the standard and the other on the inside of the screw-on cap. Therefore, if more than one standard has been supplied, it is important to ensure that the screw-on caps are not interchanged. This could lead to the use of an incorrect radius when calibrating. In which case, subsequent measurement results would be invalid until the instrument was re-calibrated using the correct radius value.

Turning the Ball

If damage (e.g. scratches etc.) has occurred to the calibration ball and difficulty is experienced in obtaining a suitable calibration, then it is advisable to rotate the ball to present an undamaged surface area. This can be done as follows:

1. Ensure that the cap is firmly screwed in position.
2. Using a small screwdriver remove the plastic cover from the base of the housing to reveal three socket head screws (3mm).
3. Loosen the screws but do not remove them.
4. Gently lift up the black housing from its base to break the seal of the 'O' ring on the ball.
5. Turn the ball to a new, undamaged position.
6. Tighten the three socket head screws and replace the plastic cover.

Cleaning

The standard should be cleaned using a non-staining solvent such as Methanol AR (CH_3OH) on a lint free cloth or a lens tissue. Alternatively, any commercially available lens cleaning liquid can be used.

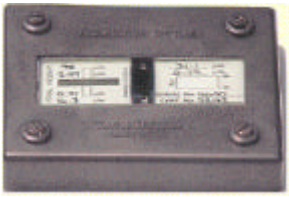
Caution. DO NOT use any form of abrasive cleaner.

Three Line Calibration Standard

The Three-Line Calibration Standard, for use with the Form Talysurf Intra instrument consists of a frame and base on which are mounted two glass plates.

The label below the left hand glass plate has a rectangle marked on it two rectangles. The rectangles denote the areas in which three lines (actually grooves) are located. These are nominally 2.5mm (100min) and 0.4mm (15min) deep. The label below the right hand glass plate has a single rectangle marked on it, this rectangle denotes the area in which a further three lines are located. These are nominally 0.025mm (1min) deep. The values of the middle line of each group are marked on the standard. The serial number of the NAMAS certificate for this standard is marked in this area when relevant.

Three Line and Ra Calibration Standard



The Three Line and Ra Calibration Standard, for use with the Form Talysurf Intra instrument consists of a frame and base on which are mounted two glass plates.

This standard is used for the calibration of the vertical displacement of the stylus and provides a confidence check for the Ra parameter. The label below the left hand glass plate has marked on it two rectangles separated by a black bar. The rectangles denote the areas in which three lines (actually grooves) are located. These are nominally 2.5mm (100min) and 0.40mm (16min) deep.

The value of the middle line is marked on the standard. The label below the right hand glass plate has marked on it a rectangle with two arrows. The rectangle denotes an area of the glass plate that is etched to a calibrated Ra value - nominally 0.8mm (31.5min) The arrows indicate the direction in which calibration measurements should made.

Cleaning of the three-line standard

The standard should be cleaned using a non-staining solvent such as Methanol AR * on a lint free cloth or a lens tissue. Alternatively, any commercially available lens cleaning liquid

THE SOFTWARE

Having switched on the Processor Control Module, the screen provides a menu driven operator interface for the control of the Traverse Unit and the analysis of measurement results.

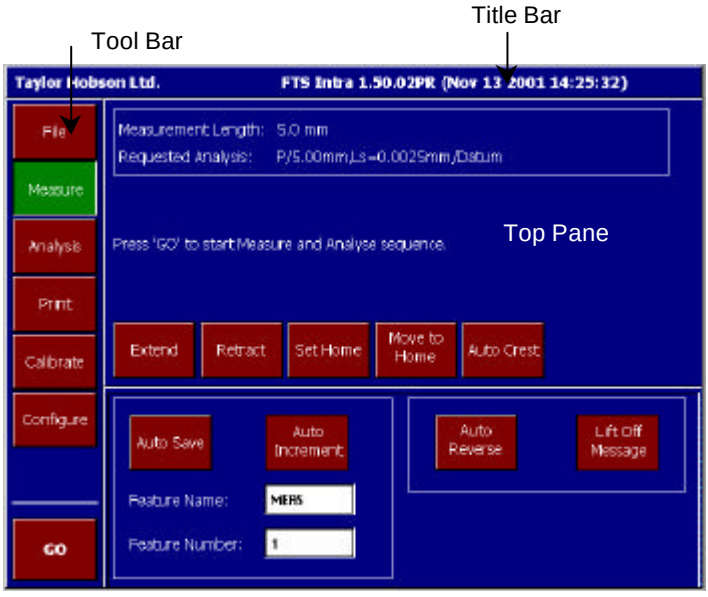
THE MAIN MENUS

The Main Menus consist of three panes and a title bar. The left-hand pane contains a toolbar of menu selection buttons and a "GO" button.

The rest of the screen is split horizontally into two panels. The upper panel contains menu option buttons for selecting the measurement and analysis conditions and, if appropriate, instrument control buttons. The lower panel contains further buttons or fields relating to the option selected from the upper panel.

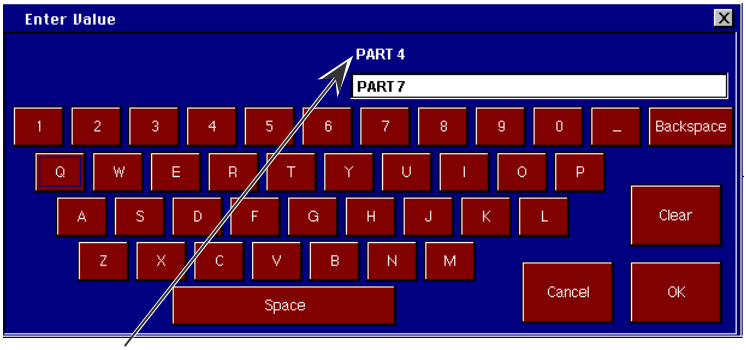
Selections are made by touching the buttons presented on the screen. The first touch in any pane will select that pane; thereafter, touching any button within that pane will activate that button.

Upon exiting a screen the settings for that menu are saved (a message is displayed upon exiting to that effect). If settings need to be saved before switching the system off, it is essential to exit the screen before switching off.

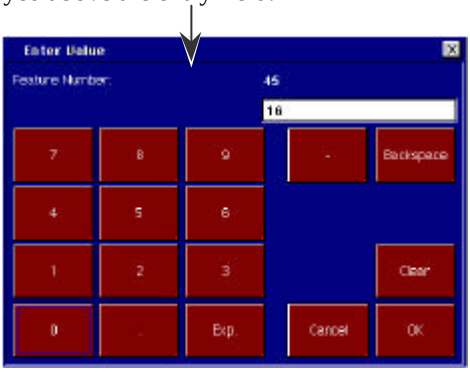


User inputs

There are occasions when the user is required to input information. When this is required, the software will present either a virtual keyboard or a number pad, as appropriate. To make an entry, press on the appropriate keys, then press the **OK** key



The currently saved entry is displayed above the entry field.



OK

Pressing this key will cause the contents of the entry field to be saved (except if the field is clear, in which case, the currently saved entry is retained).

Clear

Pressing this key will clear the entry field.

Exp.

The facility of entering numerical values in exponential form is available. This is done by entering a value, pressing the Exp key then entering the exponent. (e.g. 123 e –3 = 0.123).

Cancel

Pressing this key will abandon the current activity; the currently saved entry is retained.

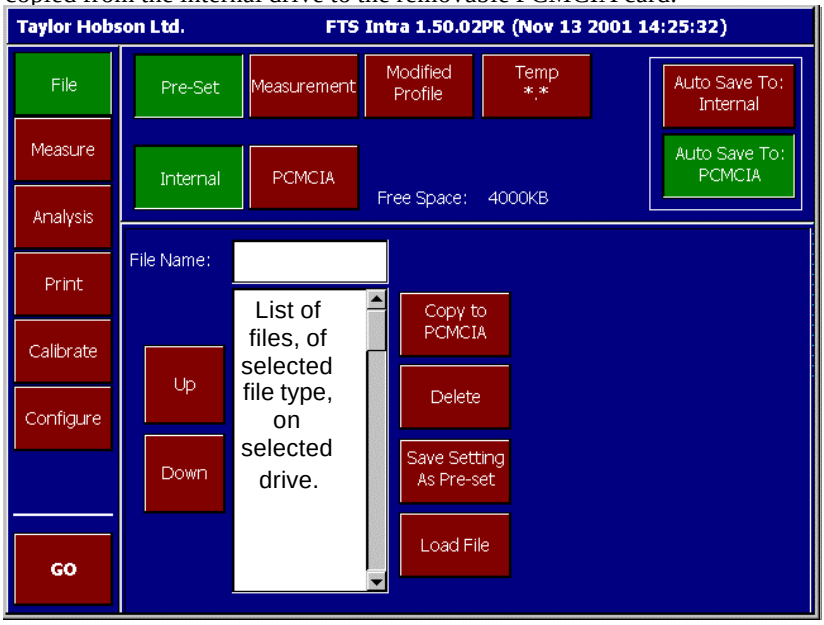
THE FILE MENU

This menu is displayed when the **File** menu button, on the toolbar, is pressed.

The function of this menu is to enable the user to save (and subsequently re-load) files of the **Pre-set, Measurement** and **Modified Profile** type.

> **Pre-set** type files contain menu options that the operator may wish to use repeatedly. Pre-set files include settings for the **Measure** menu, the **Analysis** Menu, the **Print** menu and some of the Gauge details from the **Calibrate** menu.
> **Measurement** type files contain raw measurement data only. These are stored in DEP v 2.0 format, which is described in the Appendix A at the back of this handbook.

Files can be saved to either the internal memory or a removable PCMCIA card. The saved files can then be re-loaded, as required. Files can also be copied from the internal drive to the removable PCMCIA card.



The toolbar **GO** button is not active with this menu.

The currently available space on the selected drive (Internal or PCMCIA) is displayed in the top pane. This is automatically updated.

THE FILE MENU
The options are as follows:

Pre-Set
This option causes the filing system to function only with files of the **Pre-set** type.

Measurement
This option causes the filing system to function only with files of the **Measurement** type.

Modified Profile
This option causes the filing system to function only with files of the **Modified Profile** type.

Note: When selected the option Load File in the bottom pane is not available.

Internal
Selecting this option causes the internal memory to be selected as the current drive for saving or loading files.

Note: Files in internal memory should be kept to an absolute minimum to ensure that analysis times are not impaired.

PCMCIA
Selecting this option causes the removable PCMCIA card to be selected as the current drive for saving or loading files.

Auto Save to internal/PCMCIA

The "Auto Save To" option specifies the drive destination, either Internal or PCMCIA, when the Measurement Auto Save option is used

File Name:
Use this field to enter a file name (up to 8 characters). Any file named in the **File Name** field will be used in any Copy, Delete, Save or Load operation. If the **File Name** field is empty, then the file that is highlighted in the File List will be used.

Note. Any name entered in the **File Name** field, is cleared when the **Up/Down** buttons are used.

A File List is located below the **File Name** field and provides a list of files of the selected type, on the selected drive.

Up / Down
Pressing these bottom pane buttons causes the highlight to be scrolled through the file names in the File List. By pressing the appropriate option button, the highlighted file can then be copied, deleted, saved or loaded.

Copy to PCMCIA, This bottom pane option is available only when the **Internal** drive is selected)
Selecting this option enables the currently active file (see **File Name**) to be copied from the Internal drive to the PCMCIA card.

Delete
Selecting this bottom pane option enables the currently active file (see **File Name**) to be deleted from the currently selected drive.

Save Setting As Pre-Set
This option is available only when the file type **Pre-set** is selected and enables the current Pre-Set values to be saved to a file (see **File Name**).

Save Measurement
This option is available only when the file types **Measurement** or **Modified Profile** are are selected and enables the current measured data to be saved to a file (see **File Name**).

Load File
Selecting this option enables the currently active file to be loaded (see **File Name**). This option is not available when **Modified Profile** is selected.

When a **Measurement** file is loaded, it will be automatically analysed using the current analysis settings. When a **Pre-set** file is loaded, the current Preset options are replaced.

Examples

The following examples can provide an insight into how each of the file types may be re-loaded and applied. These assume that a number of measurements, with different measurement and analysis conditions, have been made and files saved of both the **Measurement** and **Pre-set** type.

Measurement:
An application, of this file type, is to load previously saved measurement data and automatically analyse the data using the current **Analysis** Menu settings and display the results:

1. Select the **File** menu, and then select the **Measurement** option.
2. Use the **Up / Down** keys to move the highlight onto the required saved file. Select the **Load File** button.

Pre-set
An application, of this file type, is to assess measurement data to a number of different analysis conditions without repeatedly reconfiguring the **Analysis** Menu options. This is a useful application if it is required to frequently assess sets of different parts to different measurement and analysis conditions.

The data analysed can be from either the current measurement, a new measurement or from a previously saved **Measurement** type file.

The procedure is as follows:

1. Select the **File** menu, and then select the **Pre-set** option.
2. Use the **Up / Down** keys to move the highlight onto the required saved file. Select the **Load File** button. The settings for the **Measure** menu, the **Analysis** Menu, the **Print** menu and some of the Gauge details from the **Calibrate** menu are changed to those of the Pre-set file.
3. To start a new Measure and Analyse sequence, press the **Measure** menu button from the toolbar and then press the **GO** key. To just reanalyse the current measurement data, select the **Analysis** Menu and press the **GO** key.

THE MEASURE MENU

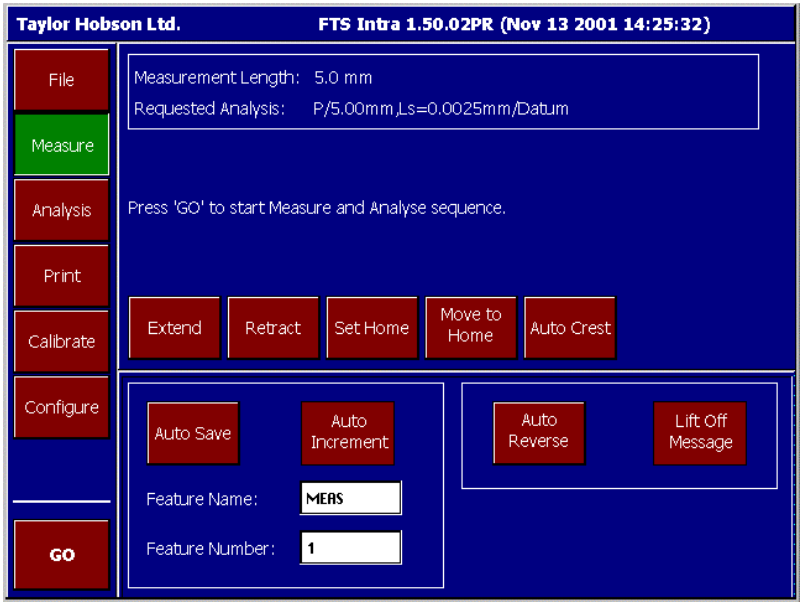
This menu is displayed when the software is first started and when the **Measure** button is pressed.

The function of this menu is to enable the user to:

Control the movement of the Traverse Unit in order to position the stylus ready for the start of the measurement.

Initiate a measurement sequence (with auto reverse, if required) with automatic analysis of results.

Specify feature names and feature numbers for the automatic saving of measurement data.



The current measurement length, analysis type, filters and reference line details are displayed in the top pane.

Pressing the **GO** button, from this menu, causes a measurement and analysis to be initiated, with automatic display of the results.

The control button and field functions are as follows:

Extend/ Retract
The **Extend** option causes the Gauge to be traversed away from the Traverse Unit. The **Retract** option causes the Gauge to be traversed towards the Traverse Unit.

A short press on these buttons causes the Gauge to be moved a small distance, typically 50µm. Holding a button down will cause the Gauge to start moving slowly, to allow set up, then accelerate up to the top speed. On releasing the button, the traverse is stopped.

Set Home
This option causes the current position of the Gauge to be defined as the Home position. The position display on the Traverse Unit will be set to zero.

Move to Home
This option causes the Gauge to move to the defined **Home** position (the zero position on the Traverse Unit display).

Auto Crest
Selecting this option causes the Auto-Crest routine to be run. This is a procedure that automatically finds the crown (or valley) of a convex (or concave) surface.

Auto Save
When selected, this option causes measurement data to be automatically saved after each measurement, to the filename specified by the Feature Name and Number. The Feature Number is automatically incremented after each save, when the Auto-increment option is selected.

The destination for the file, either **Internal** or **PCMCIA** drive, is set in the **File** menu.

Auto Increment/Overwrite
This button provides a toggle between the **Auto Increment** and **Overwrite** options and is only active when the **Auto Save** option is selected.

If **Overwrite** is selected, then when an **Auto Save** is made and a file with that name already exists, the existing file will be overwritten, without prompting the user. If the **Auto Increment** option is selected, then when an Auto increment exists, the user will be prompted with the option to overwrite or not (Ok/Cancel).

Feature Name

This field is used to enter a name of up to six characters only (see also **Feature Number**). The name may not include spaces, but may include the underscore (_) and numeric characters.

Feature Number

This field is used to enter a number between 0 and 99. This will be appended to the current Feature Name, to form a filename into which data from the next measurement will be saved.

Note After a measurement has been made the user always has the option of saving the data by using the **File Menu.**

Auto Reverse

This option causes the Gauge to be automatically returned to its starting position after a measurement has been made.

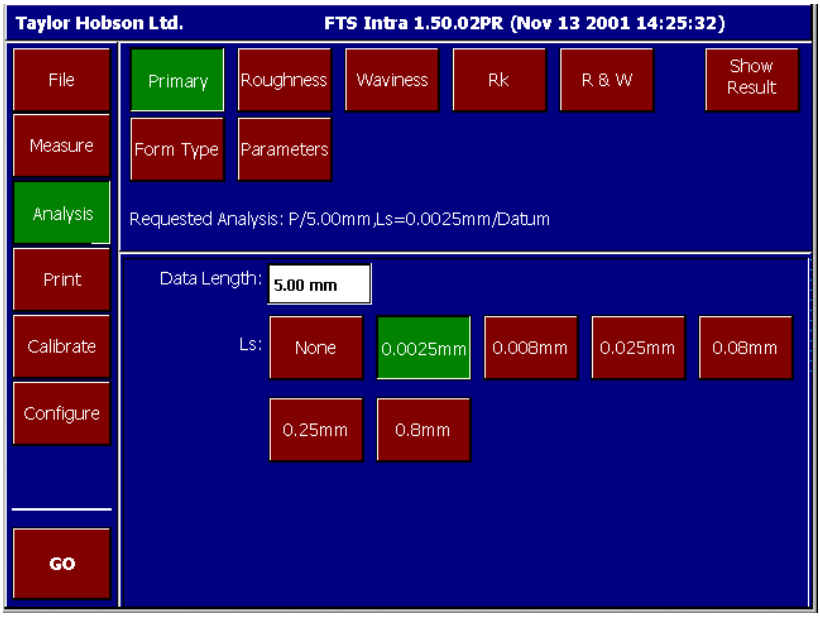
Lift off Message

This option is available when **Auto Reverse** is selected. If this option is selected then, after a measurement has been made, a message is displayed that prompts the user to lift the stylus before the auto reverse occurs. The message must be cleared before the auto reverse can take place.

THE ANALYSIS MENU

This menu is displayed when the **Analysis** menu button, on the toolbar, is pressed.

The function of this menu is to enable the user to select the parameters and conditions for the evaluation of measurement data.



Pressing the **GO** button, from this menu, causes the current measurement data to be re-analysed and displayed to the conditions currently selected. A summary of these details is given in the *Requested Analysis* summary, in the top pane.

Five types of analysis may be performed: Primary, Roughness, Waviness Rk and R&W. Press the required analysis button to display the menu for setting the conditions and parameter selections for that analysis.

The button and field functions are as follows:

Primary

This button must be pressed in order to select the conditions and parameters for the analysis of a primary filtered assessment of the measured data. With this button selected, the bottom pane displays buttons for selecting the cut-off length of the **Ls** filter and a field into which the required Data Length can be entered.

Roughness
This button must be pressed in order to select the conditions and parameters for the analysis of a roughness filtered assessment of the measured data.

With this button selected, the bottom pane displays buttons for selecting the type of filter, the cut-off lengths of the **Lc** and **Ls** filters and fields for entering the number of cutoffs or the Data Length required. (see **Inter-dependencies between options**, on the following page). The current Bandwidth value is displayed and automatically updated as values of **Lc** and **Ls** are changed.

Waviness
This button must be pressed in order to select the conditions and parameters for the analysis of a waviness filtered assessment of the measured data.

With this button selected, the bottom pane displays buttons for selecting the type of filter, the cut-off length of the **Lf** filter and fields for entering the number of cutoffs or the Data Length required. (see **Inter-dependencies between options**, on the following page).

Rk
This button must be pressed in order to select the conditions and parameters for the analysis of an Rk filtered assessment of the measured data.

With this button selected, the bottom pane displays buttons for selecting the cut-off lengths of the **Lc** and **Ls** filters and fields for selecting the number of cutoffs or the Data Length required. (see **Inter-dependencies between options**, on the following page). The current Bandwidth value is displayed and automatically updated as values of **Lc** and **Ls** are changed.

R&W
This button must be pressed in order to select the conditions and parameters for the analysis of an Rk filtered assessment of the measured data.

With this button pressed, the bottom pane displays buttons for selecting the cut-offs and Data lengths for the measurement. The cut-off and data length values can be one of three standard options or values entered by the user.

Show Result
Pressing this button causes the Results page from the current analysis to be displayed.

Form Type
Pressing this button, causes the reference line option buttons to be displayed and allows a new Form Type to be selected. The options available in the bottom pane are:

LS Line, this is positioned such that the sum of the squares of the deviations of the profile from the line is a minimum. The result is a reference line through the profile data.

MZ Line, this is defined by a pair of lines which just enclose the profile such that the distance between the lines is a minimum. The refernce line is the mean position between the two lines.

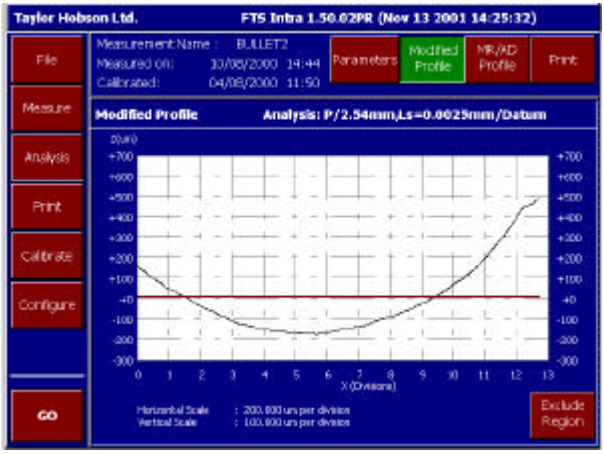
LS Arc, the radius of a measured surface is determined by fitting an arc to the measurement data. This is positioned such that the sum of the squares of the deviations of the profile from the line of arc is a minimum. The radius of the arc is then calculated.

Absolute Arc, with this option form errors are calculated with reference to a user specified radius. The user enters the reference radius in the Radius window which is visible when Absolute Arc is selected.

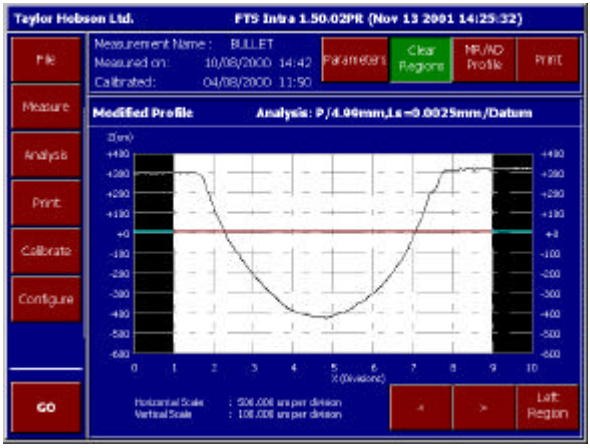
Datum, this is a line that is accurately parallel to the surface being measured enabling all of the surface irregularities to be measured and analysed with reference to the datum line.

None.

When the Analysis is performed with either Datum or None selected, an Exclude Region option is enabled when the Profile is displayed. Full details of the operation of the Exclude function is given in Analysis on Page 77.



The Exclude Region option allows portions of the profile at either end of the profile to be excluded from any subsequent analysis, particularly a LS Arc analysis. Pressing the Exclude Region button enables the function and allows the Left Hand side Exclude Region to be changed using the < or > buttons.



Pressing the Left Region button changes the Exclude Region function to the right-hand side of the profile. As with the left-hand side the Exclude Region is change dusing the < or > buttons. Once the region is defined the required analysis eg LS Arc can be initiated.

Parameters

Pressing this button causes the parameter option buttons to be displayed. The parameters available will be appropriate to the selected analysis type.

Inter-dependencies between options

To assist the user in selecting only valid combinations of filter type, Lc and Ls values, Bandwidth, number of Cutoffs and Data length, the option buttons in the bottom pane are arranged in priority order.

Selections made on the upper row of buttons have a higher priority than selections made on the lower row, and only selections that are compatible with the selection made on the upper row are available from the lower row.

Similarly, the numeric values for **Cutoffs** and **Data Length**, are automatically adjusted if higher priority items are changed.

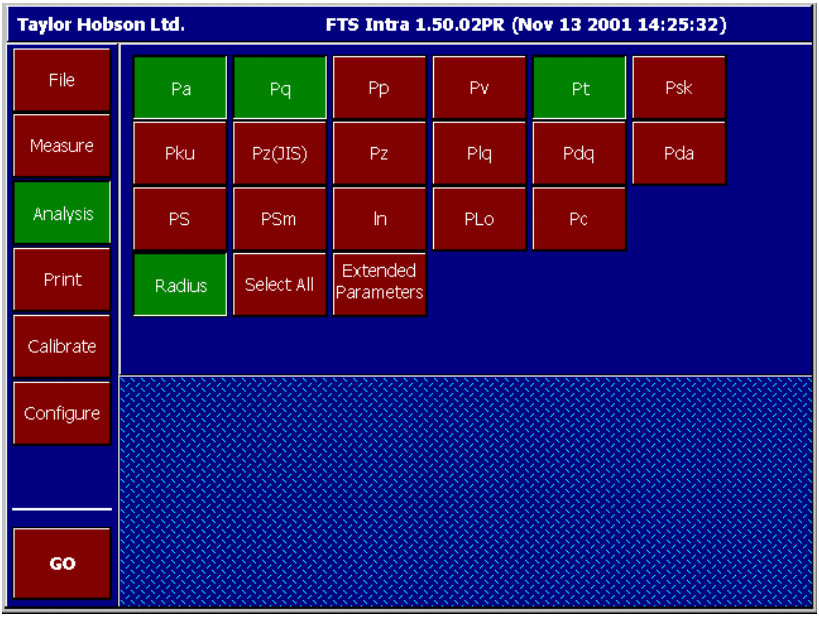
Examples (Roughness)

If the value of **Ls** is changed to **0.08mm** when **Lc** is set to **0.25mm** (giving a bandwidth of only 3:1 when the minimum is 30:1), then this action is disregarded and the previous selection is restored.
If the value of **Lc** is changed to **0.08 mm** when **Ls** is set to **0.008mm** (giving a bandwidth of only 10:1) then a lower value of **Ls** (e.g. 0.0025mm) will automatically be selected, so that the bandwidth is 30:1.

Parameter Selection

Note. Form parameters of Slope and Radius are selectable when applicable, ie slope available for LS Line and MZ Line and radius for LS Arc.

Having selected the required **Analysis** type from the **Analysis** menu and then pressed the **Parameters** option button, the **Parameters** menu relating to the selected analysis is displayed.



This menu consists of a button panel of normal parameter options, an **Extended Parameters** button (except on the Rk parameters menu) and a **Select All/ Select None** button. Parameters are selected for evaluation by pressing the relevant option buttons.

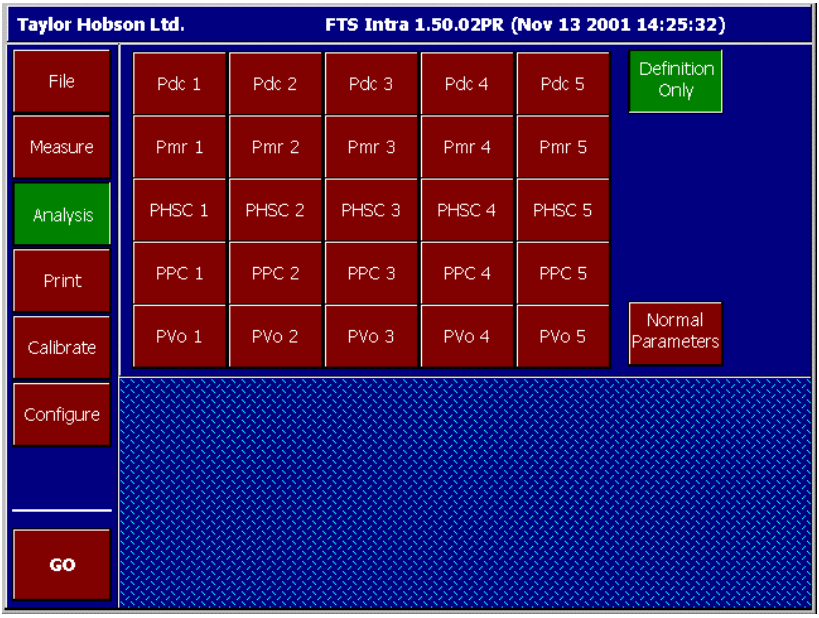
Pressing the **GO** button, from this menu, causes the current measurement data to be re-analysed and displayed to the conditions currently selected.

Select All/ Select None
To select or deselect all parameters, press the **Select All** button.

Extended Parameters

In addition to the normal parameter group, there is also a group of parameters that require additional information to be input in order to define the parameter fully.

These parameters are accessed by pressing the **Extended Parameters** button. The **Extended Parameters** menu relating to the selected analysis is then displayed.



Parameter options are selected from the upper pane of this menu. The lower pane provides facilities for the display and input of user definitions. Only those selected will appear in the Results displays and be available for printing.

Pressing the **GO** button, from this menu, causes the current measurement data to be re-analysed and displayed to the conditions currently selected.

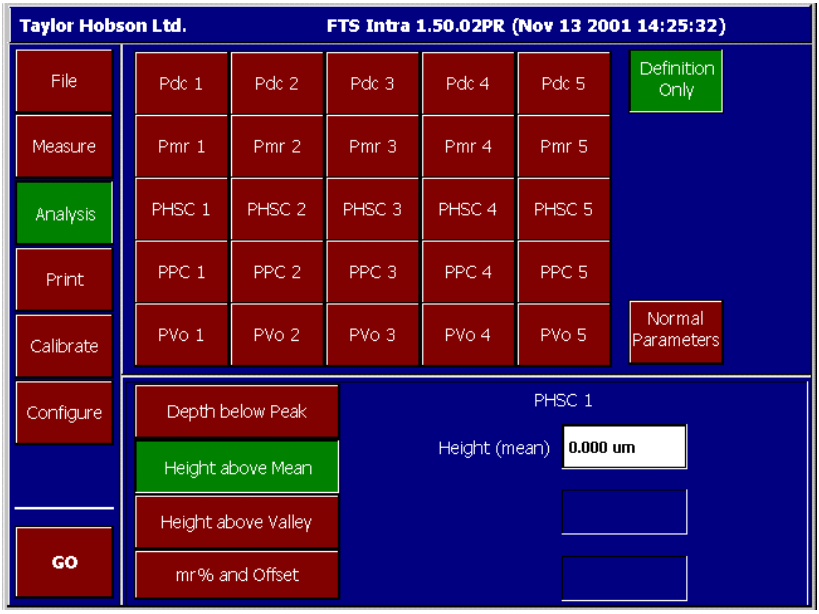
Normal Parameters

Pressing this button causes the normal parameter menu to be displayed.

Definition Only

This option controls the selection of extended parameters for evaluation and allows the user to input the required parameter definitions.

When the **Definition Only** option is selected and any extended parameter button is pressed, then the current definition details of that parameter are displayed in the bottom pane. Positioned to the left of the pane are the Definition Type options and to the right of the pane are the definition type value fields. Definition type values can be changed, as required, by selecting the definition type then pressing on its associated value field.



Notes

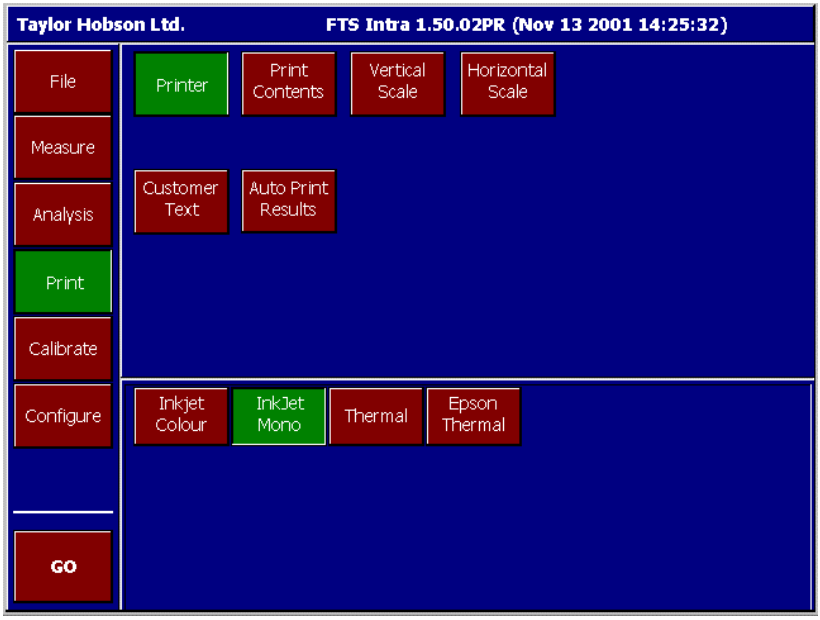
1. The actual content of the bottom pane will depend on the extended parameter that is currently selected (e.g. the parameter dc requires an upper and a lower mr% value, whereas the parameter PC requires a level value and a bandwidth).

2. Updating parameter definitions will **not** cause the parameters to be selected or de-selected for evaluation. This can be achieved only when the **Definition Only** option is **not** selected.

PRINT MENU

This menu is displayed when the **Print** menu button, on the toolbar, is pressed.

The function of this menu is to enable the user to select the content, conditions and presentation of printed results data.



Pressing the **GO** button, from this menu, causes the current analysis Results to be printed.

The control button and field functions are as follows:

Printer
Pressing this button causes the available printer buttons to be displayed, in the bottom pane. Select the required printer button.

Print Contents
Pressing this button causes the print content option buttons to be displayed, in the bottom pane. The options available are:

Header
When this option is selected, a header is included in any printouts. This includes the Taylor Hobson company name, instrument type, measurement date, calibration state, analysis details, measurement name and, if entered, any customer text.

Parameters
Selecting this option causes a list of the parameters that are selected for evaluation, with their calculated values to be included in the print-out.

Modified Profile
Selecting this option causes a graphical representation of the Modified profile data to be included in the print-out.

MR/AD
Selecting this option causes a graphical representation of the Material Ratio and the Amplitude Distribution curves to be included in the print-out.

Vertical Scale
Pressing this button causes the option buttons, for selecting the required vertical scale for graphical outputs to be displayed, in the bottom pane. The option buttons provide a range of fixed scale and an Automatic option (Automatic provides the best fit scale for the chart).

Note. The minimum selectable scale setting is 0.05µm/div, but if gauge range 1 is selected and a 60mm stylus arm is in use, then the minimum scale that will be printed out is 0.1µm/div. Also if gauge range 1 is selected and a 120mm stylus arm is in use, then the minimum scale that will be printed out is 0.2µm/div. Only if gauge range 2 is selected, with either the 60mm or the 120mm stylus arms, will 0.05µm/div scale settings be printed.

Horizontal Scale
Pressing this button causes the option buttons, for selecting the required horizontal scale of graphical outputs, to be displayed in the bottom pane. The option buttons provide a range of fixed scale and an Automatic option (Automatic provides the best fit scale for the chart).

Customer Text

Pressing this button causes a **Customer text** field to be displayed in the bottom pane. Text, of up to 40 characters can be entered in this field. This is included in any printout, when the **Header** option is selected.

Auto Print Results

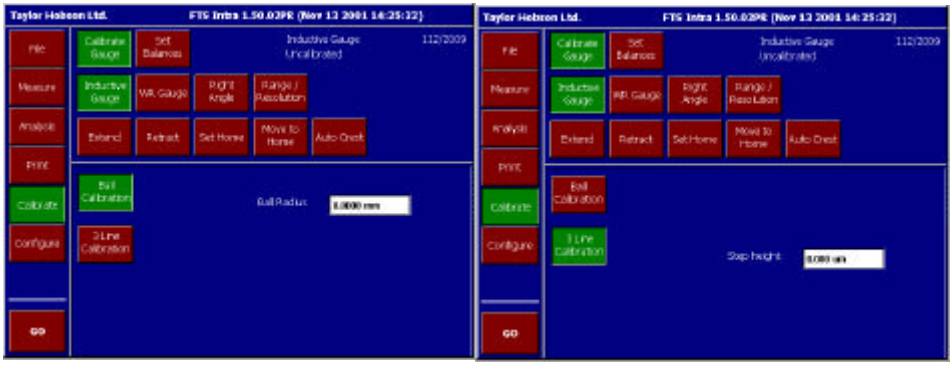
When this option is selected, results data is automatically printed after each data analysis.

THE CALIBRATE MENU

This menu is displayed when the **Calibrate** menu button, on the toolbar, is pressed. Additionally the instrument control buttons (see Measure Menu) are made available to allow the user to set up for calibrating the instrument

The function of this menu is to enable the user to:

- Calibrate the Gauge.
- Match the individual resistive and inductive characteristics of the Gauge to the system electronics.
- Select the Gauge Range/Resolution to be used.
- Set a Traverse Home position
- Cause the Traverse Unit to move the Gauge to the HOME position.
- Run the Auto Crest routine.
- Select the type of gauge and stylus to be used.
- Set stylus parameters for special styli.



The current Gauge type, Stylus number and the Gauge calibration state are displayed in the top pane.

Calibrate Gauge

When this option is selected, a **Ball Calibration** and a **3-line Calibration** button display in the bottom pane. Select the required option and enter the radius of the calibration ball or the step height, to which the instrument is to be calibrated, into the field displayed. When the **GO** button is pressed, a routine is run to calibrate the instrument. **(see Gauge Calibration-page 72).**

Set Balances
When this option is selected and the **GO** button is pressed, a routine is run to match the individual resistive and inductive characteristics of the Gauge to the system electronics. **(see Set Balances -page 69).**

Inductive Gauge
When this option is pressed and selected, then a list of available styli for the current Gauge and the details of the currently selected stylus are displayed in the bottom pane. The list of styli options includes **Special #1** and **Special #2**. These options enable the user to input details of their own special styli.

WR Gauge
When this option is pressed and selected, then a list of available styli for the current Gauge and the details of the currently selected stylus are displayed in the bottom pane. The list of styli options includes **Special #1** and **Special #2**. These options enable the user to input details of their own special styli.

Right Angle
This button MUST be pressed if the Right Angle Attachment is fitted, see Right Angle Attachment on Page 134.

There are a number of options available when the Calibrate Gauge and either the Inductive Gauge or the WR Gauge buttons are pressed. These options are detailed as follows:

Up / Down
Pressing these buttons causes the highlight to be scrolled through the list of Styli.

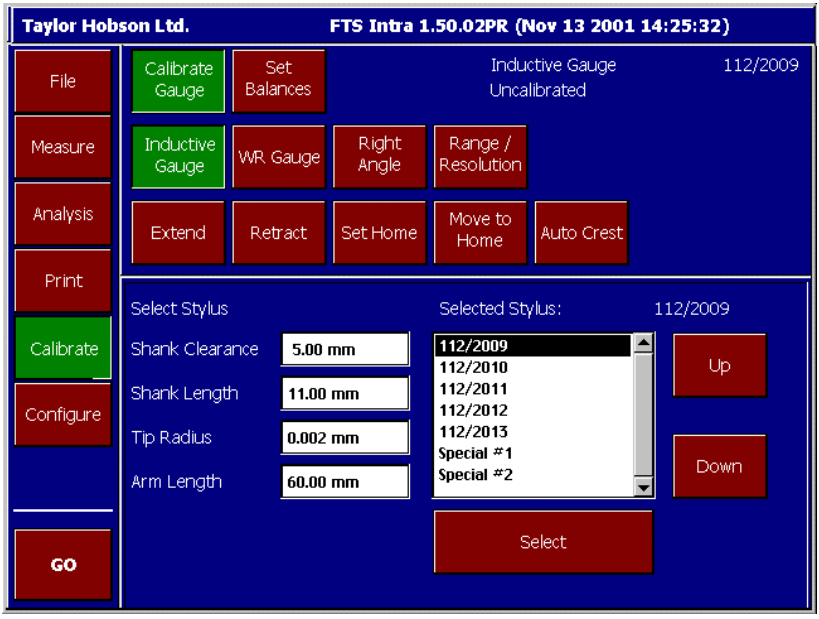
Select
Pressing this button causes the highlighted Stylus to be selected as the current stylus. Any details from a previous calibration for that stylus are installed and the displayed stylus dimensions are appropriately updated.

Entering Details of a Special Stylus

Using the Up / Down buttons move the highlight through the list of styli options, to highlight either Special #1 or Special #2, and press the Select button.

Press on each of the **Shank Clearance**, **Shank Length**, **Tip Radius** and **Arm Length** fields in turn and enter the details of the special stylus.

> **Note** If, after calibration, the details of a special stylus are changed, then the calibration is lost and the default calibration values are implemented.



Range/Resolution

When this option is selected, option buttons for selecting the required Gauge range and resolution are displayed in the bottom pane. One of the buttons is always selected. Selecting a non-selected button will change the current range and resolution setting and update the calibration details, from the calibration file.

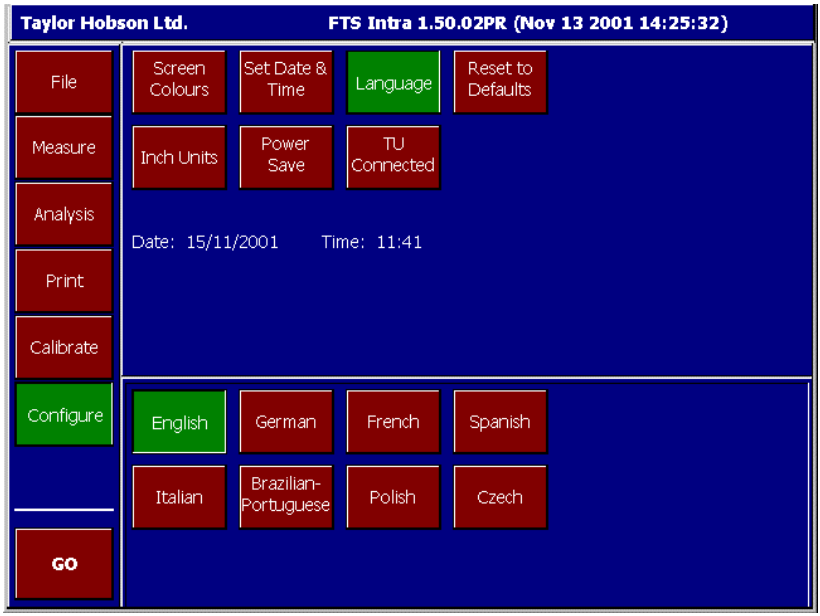
THE CONFIGURE MENU

This menu is displayed when the **Configure** menu button, on the toolbar, is pressed.

The function of this menu is to enable the user to set the Screen Colours, the Date and Time, the Language the information is presented in, the Units of measurement, the Power Save facility and select the Traverse Unit on or off line.

The settings made from this menu are saved in a system configuration file and are restored to the system when the PCM. is switched on. The toolbar **GO** button is not active with this menu.

The current Date and Time are displayed in the top pane.



The control button and field functions are as follows:

Screen Colours
Selecting this option causes the screen colour option buttons to be displayed in the bottom pane. Each option represents a pre-defined colour scheme such as light on dark or dark on light. When a selection is made the menu colour scheme is immediately changed.

Note The colour schemes also apply to the results displays

Set Date & Time
Selecting this option causes buttons for selecting the type of presentation and fields for updating the date and time to be displayed in the top pane.

Language
Pressing this button enables the user to select the language that the information is presented on the PCM in. The options available are given as a series of buttons located in the bottom pane. At present the languages available are **English, French, German, Italian, Spanish, Brazilian Portuguese, Polish and Czech.**

Reset to Defaults
Selecting this option causes the settings for the system configuration, Measurement, Analysis and Printer to revert to their default values. The calibration menu selections, including the current Gauge and Stylus, will also be reset, thereby putting the system into a known state.

As a consequence, the physical configuration of the system might no longer match the software configuration.

Inch Units
When this option is selected, all input and output values are in inch units. When not selected, all input and output values are in metric units.

Power Save
If, when this option is selected, no action is carried out on the PCM for more than ten minutes, then the LCD light is switched off and the processor is switched to minimum power mode. This condition will persist until the screen is touched. Full operation is then restored.

TU Connected
When this option is selected, communication with the Traverse Unit is attempted (e.g. to control movements, set units and gauge magnification and to start a measurement). When not selected no communications with the TU will be attempted.

Note. If prior to switching off the TU is not connected to the PCM and the 'TU not connected' button is not selected, then an error is generated. If analysis only is required when the PCM is switched on, then the error message may have to be cleared up to three times before data can be loaded for analysis

THE RESULTS PAGES

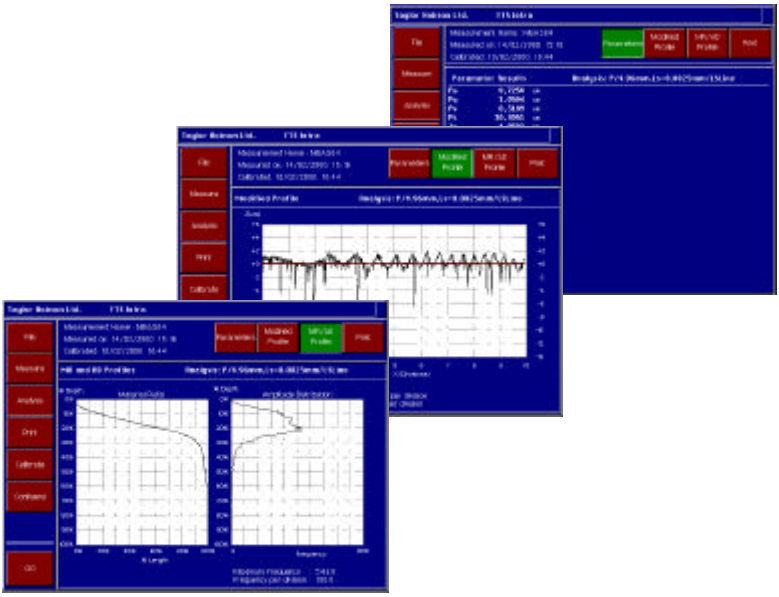
On completion of a measurement and data analysis, three pages of results are available. Buttons, for selecting the required page for display are included on the Results menu.

Parameters
Pressing this button causes a list of the currently selected parameters with their calculated values to be displayed.

Modified Profile
Pressing this button causes a display of the measured profile with the currently selected filtering and form removal applied.

MR/AD Profile
Pressing this button causes a display of the calculated graphs of Material Ratio and Amplitude Distribution.

Print
Pressing this button causes a print-out of all of the displays to be made (provided a printer is included and switched on). The information printed is selected in the Print Menu.



OPERATION

CONTENTS

SWITCHING ON

The Traverse Unit MUST be powered up before the Processor Control Module so that when the PCM is powered up it can detect the Traverse Unit. If the PCM is powered up first, an error is generated.

SETTING THE GAUGE BALANCES AND CALIBRATION

Setting the Gauge balances

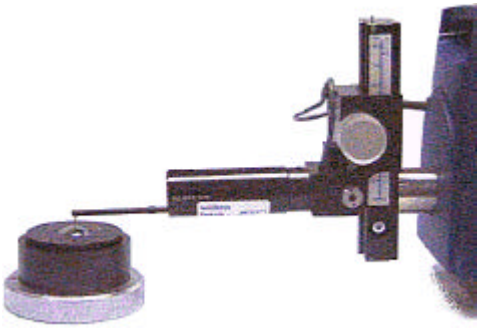
This is an automatic procedure that tests the electrical characteristics of the gauge and causes its individual resistive and inductive characteristics to be matched to the system electronics.

It is essential to carry out this procedure when the system has been newly installed, relocated, or when the gauge has been changed.

Note The instrument must be calibrated immediately after setting the balances.

Calibration

The computer makes corrections for the gain of the system electronics. In order that the corrections can be made, a series of constants whose values represent the characteristics of the individual stylus geometry are required. These values are automatically determined by running the **Calibrate Gauge** routine.



The system is normally factory set for use with the standard inductive gauge. When a Wide Range gauge is also supplied with a system, it is not possible to factory set for both gauge types. This results in the actual range of the Wide Range gauge deviating by up to 10% either way from the selected nominal range as shown by the software range/resolution buttons and wide range specification.

When using the right angle attachment, the pick-up must first be calibrated in the normal in-line condition, see Right -Angle attachment information for details.

SET BALANCES

The Set Balances procedure requires that the Stylus is traversed over a suitable radial surface. An appropriate surface is provided by the calibration ball and this is particularly convenient, as it is required that the gauge is re-calibrated after the balances are set.

The procedure is as follows:

On the PCM Unit, press the **Calibrate** button, on the toolbar, to display the **Calibrate** menu. Select either the **Inductive Gauge** or **WR Gauge** buttons depending upon which gauge is fitted and ensure that the details of the current Stylus are correctly entered in the bottom pane.

Before a Set Balances or Calibration routine can be carried out, the Ball standard must be placed below the stylus tip and crested in both the X and Y axes (this is to position the stylus exactly on the crest of the ball). Use the Extend or Retract key to extend the traverse unit to its approximate mid position and then centre the ball standard beneath the stylus tip.

For the Set Balance routine, nominal cresting is sufficient. However, for the Calibration routine, it is important to achieve crowning of the best accuracy possible.

As the instrument must be calibrated immediately after setting the balances, cresting must be carried out to the best accurately possible. For this reason it is preferred that the standard is mounted on a Y axis table. If a Y axis table is not available, then the standard can be carefully moved by hand.

The cresting procedure is as follows:

Using the Adjustable Height Unit, raise the stylus to provide the necessary clearance and position the crown of the ball approximately below the stylus tip. The stylus must now be crested on the ball, in both the Y and X-axes.

Y-axis cresting:

From the Calibrate Menu, select the widest range (1mm for Inductive Gauge with 112/2009 stylus). Lower the stylus into contact with the ball of the standard until the Traverse Unit display indicates that the gauge is approximately mid-range (gauge reading approximately zero).

Caution. When manually contacting a component with the stylus, the Traverse Unit display must be observed carefully as damage to the stylus may occur if the display changes to +*.**; this indicates a gauge out of range (high) position and at a small distance beyond this the mechanical end stop will be encountered.**

Turn the knob of the Y-axis table to move (or gently move by hand) the standard in the direction which causes the Z-axis gauge reading to rise. Continue moving the standard until the stylus position peaks and begins to fall.

Reverse the direction of movement of the standard and carefully watch the display for the point at which the rise changes to a fall. This position is the crest of the Ball in the Y direction.

X-axis Cresting

Having determined the crown position in the Y-axis and ensured that the stylus is within a few mm of the crown position in the x-axis, press the Auto Crest button. This will cause the X-axis Auto-Crest routine to be run. The stylus is traversed forward and backward over the ball, as a series of short measurements are made. This continues until the position of the crest is determined or a maximum number of attempts have been made. A message is displayed during the cresting procedure. This is removed when the crest position is successfully determined and the stylus is positioned on the crest of the ball.

Note. If the gauge is under range when auto crest is selected a message is generated informing of the under range condition. To clear, contact the stylus on the surface and either extend or retract the stylus before selecting auto crest. Failure to extend or retract the stylus will leave the message displayed and the auto cresting will not work.

Select the Set Balances option from the top pane of the PCM display and press the GO button. A message is displayed, instructing the user to ensure that the Stylus is crowned in both the X and Y axes and is set to a specific displacement.

Use the Adjustable Height Unit to adjust the height of the Gauge until the Traverse Unit display indicates a Stylus height reading of approximately the specified value. Do not disturb the position of the Stylus from the ball crown.

Select the OK option, from the displayed message panel. The balance setting procedure is then carried out.

The Gauge should now be calibrated.

Note. Calibration should be performed using the appropriate calibration artefact, see SPECIFICATION.

GAUGE CALIBRATION

Calibrating using the Ball Standard

Gauge Calibration should be performed on each gauge range to be used.

This is carried out as follows:

On the PCM Unit, press the **Calibrate** button, on the toolbar, to display the **Calibrate** menu.

Select either the **Inductive Gauge** or **WR Gauge** buttons depending upon which gauge is fitted and ensure that the details of the current Stylus are correctly entered in the bottom pane.

From the top pane, select the **Calibrate Gauge** option and then in the lower pane select **Ball Calibration**. Into the **Ball Radius** field, in the bottom pane, enter the radius of the calibration ball to which the instrument is to be calibrated.

The Calibration procedure is then, as follows:

Before the calibration measurement is made, the Ball standard must be placed below the stylus tip and crested, to the best accurately possible, in both the X and Y-axes. This procedure is the same as for **Setting the Balances** and is described on the previous page.

Having positioned the Stylus on the crest of the calibration ball, select the gauge range to be used and then select the **Calibrate Gauge** option from the top pane of the PCM display and press the **GO** button.

A message, instructing the user to ensure that the Stylus is crowned in both the X and Y axes and is set to a specific displacement.

Use the Adjustable Height Unit to adjust the height of the Gauge until the Traverse Unit display indicates a Stylus height reading of approximately the specified value. Do not disturb the position of the Stylus in the X and Y-axes. Press the **OK** button on the message.

The stylus is traversed forward and backward over the ball, as a series of short measurements is made. This process continues until the required surface data is obtained. The data is analysed and the calibration measurement results are displayed. This is overlaid with a message:

Press the **Continue** button.

The Calibration menu displays either the Calibration Constants or the Modified Profile. A button at the top of the top pane provides a toggle facility between these displays. If a printer is available, then a printout of the current display can be obtained.

Assess the results displays and either:

Press the **Accept** button, on the menu to save and use measured calibration data to a file, for future use.

Or press the **Reject** button, on the menu, to discard the calibration data and re-instate the previous calibration.

If neither button is pressed, but the menu is exited, all subsequent measurements will use the new calibration constants until either:

a) the system is switched off

b) a new calibration is performed

c) a stylus and range are reselected after a different stylus and range have been selected. This action results in the previously accepted calibration data for the stylus and range configuration being used.

Note. When calibrating the Wide Range gauge for the first time , two consecutive calibrations are necessary.

Assessing Calibration Results

Generally, the calibration measurement is acceptable when the measured form error, excluding spurious peaks or valleys, does not exceed the value given below, for the stylus type used.

Note. References in the following table are for the Inductive Gauge only.

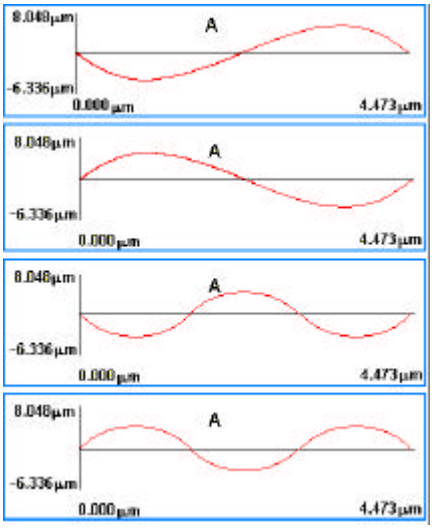
Stylus code	Stylus Type	Calibration Radius (mm)	Form error
112/2009	2µm Standard	12.5	≤0.25µm
112/2010	0.5mm ball	22	≤0.5µm
112/2011	2µm recess	12.5	≤0.25µm
112/2012	2µm Small bore	12.5	≤0.25µm
112/2013	Chisel edge	12.5	≤0.3µm

The following are some typical effects of incorrect Ball Standard calibration. In many instances, these effects can appear to be a genuine form error on the component. It is, therefore, worth noting these typical shapes, in order to avoid making a wrong assumption on the form of the component and attempting to take corrective action in the manufacturing process. Errors in calibration usually cause 'S', 'W', or 'M' shapes in the profile when measuring radii.

Errors are usually caused by:

- Lack of calibration.
- Change of stylus without re-calibration.
- Damaged stylus.
- Tracking errors on the stylus signal caused by sudden changes in displacement (e.g. when measuring over a step).

Typical Calibration Error Effects on Radius Measurement



A = Modified Profile

It is recommended that if any of the forms shown are exhibited on a component, that the instrument is re-calibrated. If the calibration is acceptable, then the component can be measured. If the results are the same, then it is likely that there is a genuine form error and not that of incorrect calibration.

Calibrating using the 3-Line Standard

Gauge Calibration should be performed on each gauge range to be used.

Calibrate using the 2.5µm (nominal) height lines on the 3- line standard.

Note. Before performing the calibration procedure, a check measurement should be made to ensure that:

a) the calibration traverse can be completed without the gauge going out of range,

b) all three lines are contained in the traverse,

c) the 3-line standard is nominally level (ie parallel to the traverse datum) and,

d) the line standard is in good condition (ie no scratches or dirt).

The calibration is carried out as follows:

On the PCM Unit, press the **Calibrate** button, on the toolbar, to display the **Calibrate** menu.

Select either the **Inductive Gauge** or **WR Gauge** buttons depending upon which gauge is fitted and ensure that the details of the current Stylus are correctly entered in the bottom pane.

From the top pane, select the **Calibrate Gauge** option and then in the lower pane select **3-Line Calibration**. Into the **Step Height** field, in the bottom pane, enter the height of the step on the 3-line calibration standard to which the instrument is to be calibrated.

The Calibration and check measurement procedure is then, as follows:

Place the calibration standard below the stylus, lower the stylus into contact with the standard at a point just in front of the marked rectangle which contains the three lines to be measured. The stylus should be positioned to bring the gauge reading to approximately its mid-position i.e. a reading of about zero.

Check that the calibration standard is nominally level with respect to the traverse unit. This can be done initially by eye and then by observing the gauge height position at the two ends of the proposed traverse (which is typically 4mm long). Perform a check measurement as follows:

Press the Analysis button to display the Analysis menu. Press the Primary button and in the bottom pane select None and a data length of 4mm. Press the Form Type button and in the bottom pane select None .

Press the Measure button followed by Go, but ensuring that the Auto Reverse button is enabled and the lift off message is disabled, to perform the measurement. If the above conditions are met perform the calibration as stated below. Return to the **Calibrate** menu and press **Go**. Follow the on-screen messages.

After traversing the 3-line standard, the Calibration menu displays either the Calibration Constants or the Modified Profile. A button at the top of the top pane provides a toggle facility between these displays. If a printer is available, then a printout of the current display can be obtained.

Assess the results displays (see note below) and either:

Press the **Accept** button, on the menu to save and use measured calibration data to a file, for future use.

Or press the **Reject** button, on the menu, to discard the calibration data and re-instate the previous calibration.

If neither button is pressed, but the menu is exited, all subsequent measurements will use the new calibration constants until either:

a) the system is switched off

b) a new calibration is performed

c) a stylus and range are reselected after a different stylus and range have been selected. This action results in the previously accepted calibration data for the stylus and range configuration being used.

Note. The calibration procedure compares the measured average distance from the adjacent ‘tops’ of the central line to the ‘bottom’ of that central line with the stated Step Height value and alters the gauge gain accordingly. From a calibration graph, if this average distance (not the Pt value) does not agree with the 4% tolerance, recalibrate the instrument. If there is a considerable difference between the stated and measured values, then perform the procedure for setting the balance and phase of the system before re-calibrating.

MAKING MEASUREMENTS

Making a measurement involves acquiring data from the surface of the component. This data is collected as many thousands of discrete points, to which the gauge calibration corrections are applied. The data is then processed and the results are displayed. The computer retains the unprocessed profile data, which can then be used for further analyses with different selections of filter, parameters and form etc.

Before making a measurement, there are a few general points of procedure that should be applied.

1. Ensure that the Set Balances routine has been recently run for the Gauge fitted and that the system has been correctly Calibrated (see the previous chapter- **SETTING THE GAUGE BALANCES AND CALIBRATION**).

2. Ensure that the Gauge Information is correct for the current gauge (see the **Calibrate** menu).

3. From the **Analysis** menu, select the required Parameters, Reference, Data Length and Filter, as appropriate.

4. Select the **Measure** menu. Set up the component with respect to the line of traverse of the stylus. The surface to be measured should generally be parallel to the line of traverse and when measuring along the length of a cylindrical component, the crest of the component must be directly under the stylus.

   If a curved component (convex or concave) is being measured, the component should be crested in both the X and Y as stated on page 64

   The smallest curved component that can be successfully crested is 1mm radius (Range 1) and 2mm (Range 2) for a diamond stylus (112/2009) and 3mm (Ranges 1 and 2) for a ball stylus (112/2010)

   The maximum curved component that can be successfully crested is 1000mm radius for both ball and diamond stylus tips.

5. Use the Adjustable Height Unit to bring the stylus into contact with the component. Adjust the height of the Gauge, so that during the measurement, the Stylus movement will remain within Gauge range over the entire measurement length.

   Do not lower the Stylus so that it is pressed hard against the component. This will cause damage to the stylus. **A Traverse operation cannot be made if the Gauge is over-range.** When manually contacting a component with the stylus, the Traverse Unit display must be observed carefully as damage to the stylus may occur if the display changes to +***.**; this indicates a gauge out of range (high) position and at a small distance beyond this the mechanical end stop will be encountered.

6. From the Measure menu, press the GO button. The measurement traverse is carried out and the results are displayed.

A measurement using the LS line and primary analysis will display the slope (or tilt) angle.

Tilt adjustment option

If the Traverse Unit has the optional tilt adjustment, the following table gives the relationship between tilt angle and turns of the tilt adjustment knob.

Tilt Angle	Turns of tilt adjustment knob
0.014º	0.1
0.035º	0.25
0.071º	0.5
0.141º	1
0.282º	2
0.705º	5
1.409º	10

ANALYSIS

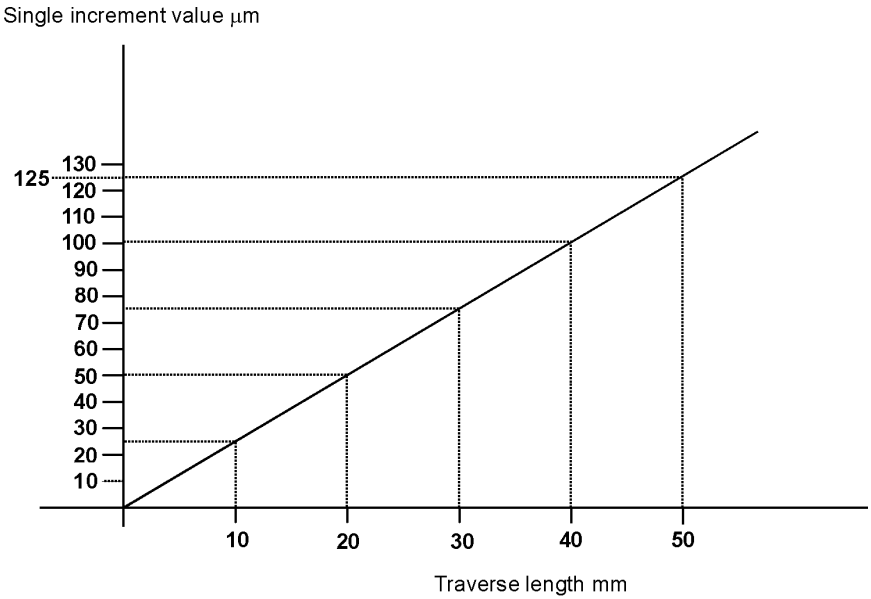
Raw data

The data acquired directly from a measurement is firstly corrected for stylus arm arcuate error by applying the calibration constants. The data is then further 'modified' by the application of the relevant form and filter options. Raw data is obtained when the form is set to none and the Primary filter Ls is set to none.

Exclude Option Features

This feature can be used for the analysis of any stored data or a current measurement.

1. The Primary filter (any Ls) and Form datum or none must be selected.
2. Using the Exclude Region button, select the region to be analysed. See figure below to determine the button's single increment distance for the appropriate profile length.



Note If the button is held down the increment size is equivalent to 5 single increments

3. To analyse the selected region, press the Analysis button and select Form Type and Filter required for the analysis. To ensure that the full included region is analysed the data length/number of cut-offs should be set to a value greater than or equal to the included region.

4. Press Go to perform the analysis.

If a different analysis is required the sequence from 1 to 4 must be repeated. If after following 1 and 2 the Go button is pressed the analysis will be performed over the selected region. If then 3 and 4 are performed the resultant analysis will be over the full region and not the selected region.

PARAMETERS AND DEFINITIONS

CONTENTS

What surface texture is and why it is necessary to measure it are subjects covered in the book Exploring Surface Texture, from Taylor Hobson. The user is advised to read this book to obtain background information on surface texture in general and on stylus-type measuring instruments in particular. It also gives useful information on parameters: their derivation and use.

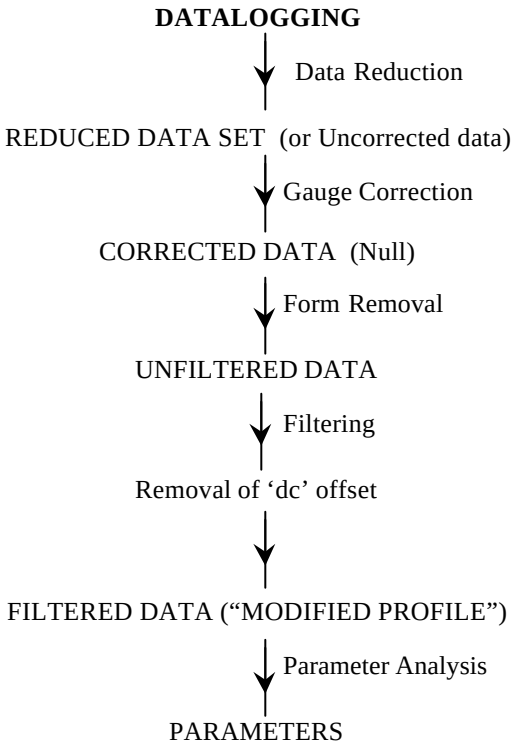
N.B. Some of these parameters are not applicable to your instrument

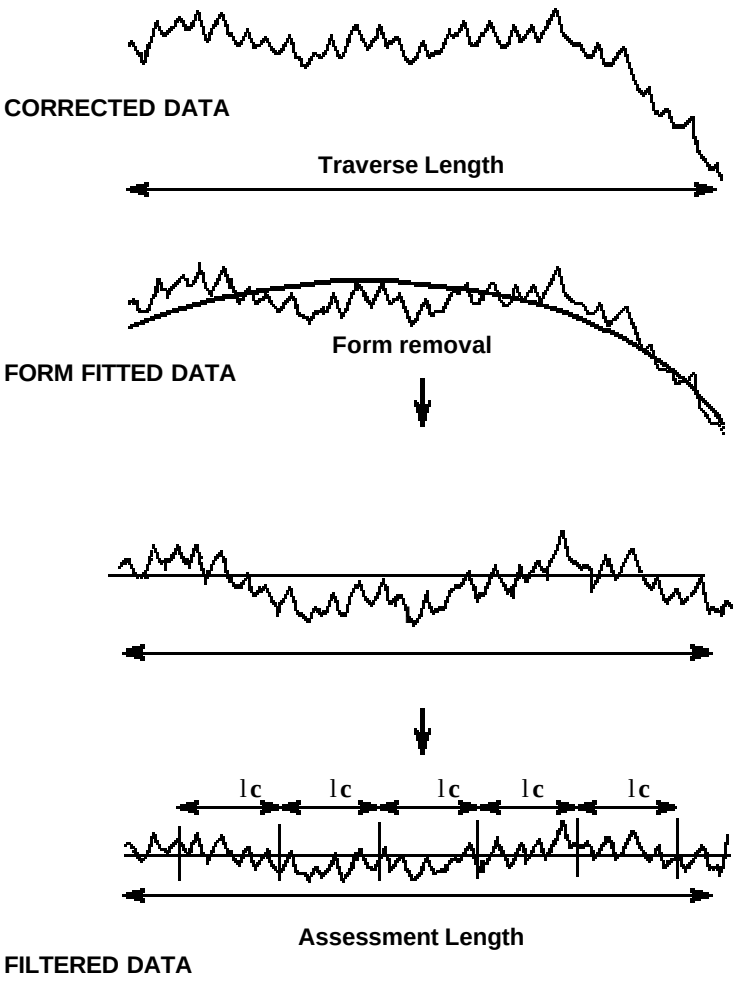
PARAMETERS AND DEFINITIONS

MEASURING SURFACE TEXTURE

Measurement methods

Surface Texture is generally measured by the following method:




CORRECTED DATA
Traverse Length
Form removal
FORM FITTED DATA
lc
lc
lc
lc
lc
Assessment Length
FILTERED DATA

DATALOGGING
Data is collected at regular intervals along the Surface, at a spacing of 0.5µm.

Generally, this large amount of data may be reduced to a smaller set to make the data more manageable and to speed up subsequent processing. This is performed using a weighted average method. A reduction ratio is chosen so that sufficient data density remains in order to allow the filters (see FILTERING) to achieve reasonable transmission characteristics, even for short wavelength filtering.

The data reduction process also performs the function of anti-aliasing.

DATA CORRECTION
The reduced data will be unscaled and contain distortion due to the systematic errors in the gauge. A scaling and correction is therefore applied, based on the Gauge Correction factors, that results in CORRECTED DATA.

FORM REMOVAL PROCESS
Form Removal is the elimination of the nominal shape of the component from the assessment of texture. This includes removal of slope or curvature. Form Removal may be applied either to access the form or to remove the form from subsequent surface analyses.

Form Removal, in general, fits a reference shape (Reference line) to the corrected data. A by-product of this process is the characteristics of the reference figure regarding slope or radius. The removal of form from the CORRECTED DATA results in the UNFILTERED DATA.

Individual options of Form Removal are defined later in this section.

FILTERING

Although the data at this point has been reduced, it is normally referred to as UNFILTERED. However, if required at this stage, filtering is carried out. There are many methods of filtering but all are intended to remove wavelengths from the data that are of no interest. This may be because of the intended function of the surface or in order to eliminate invalid data caused by extraneous noise etc.

Some filters result in discarding part of the data. The resulting data set after this stage, whether filtering has been applied or not, is known as the MODIFIED PROFILE.

Care should be taken if applying filters to data if FORM REMOVAL has been performed for the purposes of form measurement. Filters by definition distort this profile and are therefore best avoided unless restricted to filtering out wavelengths that are much shorter than those characteristic of component form.

Definitions and characteristics of the various standard filters are discussed later in this section.

PARAMETER CALCULATION

Mathematical parameters may be calculated from the MODIFIED PROFILE. There are many parameters dealing with the characteristics of the surface geometry, these are discussed later in this section.

Form removal

The purposes of form removal is to provide a reference line or figure to:-

a) Uniquely define the form and its position.
b) Provide a reference about which surface finish parameters may be calculated.

Possible form options are:

STRAIGHT LINE FITS

Least Squares Straight Line - This technique uses the method of least squares to derive a MEAN LINE such that the sum of the squares of the residual deviations are minimised. This mean line becomes the 'Reference line'.

Minimum Zone Lines - These lines are a geometric fit of two parallel lines enclosing the profile such that their separation is a minimum.
The bisecting line of the two MZ lines becomes the 'Reference line'.
Both straight line references inherently removes SLOPE from the data. SLOPE as measured to the instrument datum is a RESULT of these types of FORM REMOVAL. The convention is, SLOPES which indicate a rising stylus are positive and those indicating a falling stylus are negative.

ARCUATE FITS

Least Squares Arc - This is the best-fit arc such that the sum of the squares of the deviations from the arc are at a minimum.

Absolute Arc, This arc is calculated with reference to a specified radius.

This reference line also provides a radius result and the shape of the arc, either concave or convex.

DATUM & NULL REFERENCES

During the explanation of data correction, we explained that prior to the form fitting, the data was simply known as CORRECTED DATA. Whilst this data is now qualified by the calibration factors, the reference origin of the data remains as the gauge electrical zero.

Data represented in this form is known as NULL (Form type ‘None’), and in itself is useful since subsequent measurements can be compared by fixing the gauge zero.

FILTERS

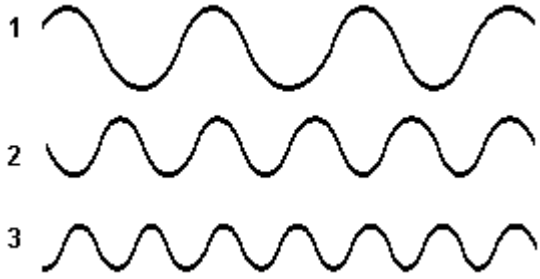
FILTERS may be required in the measurement of surfaces for several reasons. These, however, fall into two categories either because the property of the surface for which the measurement is being made is wavelength dependent or to eliminate false wavelengths that have been introduced during the measurement.

Before discussing these, it is necessary for the reader to understand the wave nature of profiles and the concept of Fourier or Harmonic analysis.

FOURIER PRINCIPLE

The concept is based on the idea that any continuous profile can be constructed from a series of sine waves or wavelengths that are multiples (harmonics) of the length of data analysed (fundamental). This concept is well known in music where the pitch of the note is determined by the fundamental which predominates, and the tone of the instrument is determined by the combination and proportion of the harmonics. This is what makes different instruments sound different even though they may be playing the same note. The illustration below shows how even complex shapes can be constructed using sine-wave harmonics.

For example if, in the diagram below, line 1 represents the predominant (fundamental) waveform and lines 2 and 3 represent other waveform components from which a note or a surface can be constructed.1



Then, when waveform 2 is superimposed onto the fundamental, the resulting form can be as shown below.

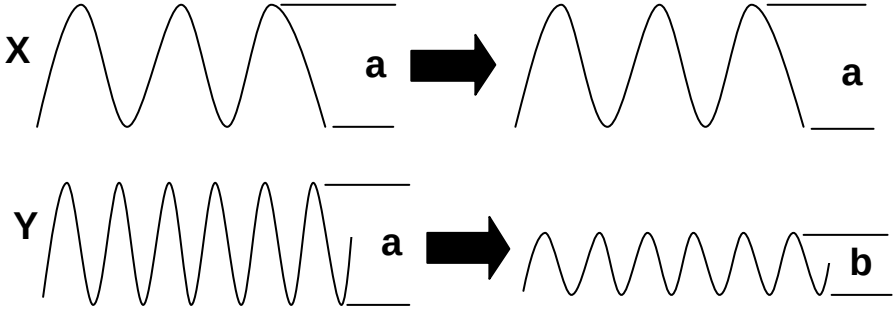
When waveform 3 is the superimposed onto the form generated from waveforms 1 and 2, then a resulting form can be as shown below.

Note that not all components are in step with each other i.e. we need to know not only the amplitude of the component but also its phase in relation to the fundamental.

APPLICATION TO INSTRUMENTATION-BANDWIDTH

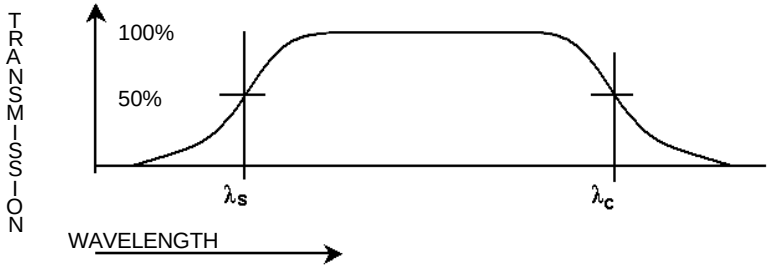
In measurement technology and electronics pure sine waves are welcomed because they are easy to handle and the response to processing can be readily predicted. In this way, if the instrument response can be defined for sine waves of specific wavelength, then because of the Fourier principle (and the assumption that the measuring instrument is a linear system) the response to any surface can be predicted by considering the surface as a group of sine wave components.

The problem is that all natural systems, be they electronic or mechanical, do not respond equally to signals of different wavelengths in the same way.



For instance, a signal X may be processed by a system to result in an unaltered waveform whereas a signal Y (of the same amplitude but different wavelength) may be reduced in amplitude to b.

The effect of a FILTER on a general waveform may therefore be predicted by a Response Curve which shows the percentage reduction in amplitude for each wavelength during transmission through the filter. For example, a Roughness Filter may look like this.



The above curve indicates that this filter will accept wavelengths from λc to λs, but attenuate other wavelengths. The width of this acceptance zone (λc to λs) is known as the TRANSMISSION BANDWIDTH and for surface finish measurements is usually expressed as a ratio of $\lambda c : \lambda s$.

On measuring instruments λc is set by the operator and is known as the CUT-OFF length. The actual transmission at λc depends on the FILTER TYPE but is 75% for ISO 2CR or PHASE CORRECTED FILTERS and 50% for GAUSSIAN type filters (the diagram shows λc = 50%).

All measurement systems have an equivalent to λs although problems arise when λs is limited by uncontrolled characteristics of the system rather than the applied filter. (such as the limitation of sampling rate, or display response and gauging bandwidth). However, if short wavelengths are present in the surface, standardisation of λs is a necessity for comparative measurement between instruments (λs is always expressed at 50%).

A summary of the reasons why a standardised bandwidth is of importance on multi-processed components is outlined following:

- Slope or Curvature related parameters are very sensitive to small wavelengths, and can be dominated by them. The use of a standardised bandwidth ensures that measurements made are 'Like for Like'.
- Conventional systems allow the stylus geometry to define the lower limit of the bandwidth. Since the geometry is not easily defined or controlled the use of a definable bandwidth is preferred.
- The use of selectable bandwidths allows a sensible correlation of measurements made over long assessment lengths.

ISO identifies standard CUT-OFF wavelengths in the series 0.025, 0.08, 0.25, 0.8, 2.5, 8 mm etc. which result in BANDWIDTHS of 100:1, 300:1, 1000:1, (these being the ratios of the above) with 300:1 as preference.

Establishment of l_s also has the dual purpose of providing ANTI-ALIASING of the data when in digital form.

WAVINESS (FILTERING)

Waviness filtering is essentially the same as for ROUGHNESS, except that the FILTER CUT-OFF is specified at the shorter wavelength end of the transmission curve (therefore, for waviness, l_s is not relevant). The longer wavelength end of the transmission curve is limited by the traverse length. The cut off is referred to as l_f.

In practice, the lower end of the response is so long that it may be taken to be close to infinity (i.e. straight line component). Therefore, bandwidth criteria are not currently generally used in waviness measurements.

ALIASING during WAVINESS measurement is not normally a problem provided l_f is 5 times larger than the sampling interval.

PRIMARY (FILTERING)

A primary filter may be applied instead of Roughness or Waviness filtering. The cutoff length is ls. This has the same effect as Waviness filtering, and is typically used with a short wavelength to filter out the high frequency (e.g. noise) elements from the measurement.

FILTERING OPTIONS

Filtering options allow the user to specify the cutoff length of the filtering and additionally for Roughness the bandwidth.

NOTE Unless this provision is deliberately made to limit the short wavelength (high frequency) response of an instrument, it would otherwise be determined by the stylus geometry, the electrical amplifier characteristics, or the sampling interval.

These factors would give rise to quite different filtering characteristics, and result in different parameter results when the same surface is measured on different types of instrument.

DATA POINTS AND FILTERING OPTIONS

Measurements are made with a data spacing of 0.5 um so that detailed information can be obtained about the surface finish. However, for longer cutoff lengths it is not necessary to use all of this data density and so the data is reduced using an anti-aliasing weighted-average filter. This helps to reduce the time to analyse the measurement data.

The selection of cutoff length (and bandwidth for Roughness filtering), is constrained by the following criteria:

1. At least 5 points must be available in each filter cutoff length. This applies to the Roughness low pass filter (ls), the Primary filter (ls) and the Waviness filter (lf). However, for Primary typically 10 points are used in each cutoff length, and for Waviness up to 500 points will be used.
2. The data reduction ratio must be a whole number.
3. The Roughness bandwidth is determined from a ratio between the standard cutoff lengths, with limits of about 30:1 to about 300:1.

Note For the accurate determination of the number of points per cut-off (and therefore, for accurate filtering), the following must be observed:

1. When measuring a flat surface, the component must be levelled prior to the measurement

2. When measuring an arc shaped component, the measurement should be made symmetrically about the turning point of the component profile.

BANDWIDTHS AVAILABLE AT 0.5µm RAW DATA SPACING

High-pass cutoff (mm) points)	Low-pass cutoff (mm) (points)	Bandwidth ratio	Reduction ratio	High-pass points/ Low-pass points/
0.08 (160)	0.0025 (5)	32:1	1	160 / 5
0.25 (500)	0.0025 (5)	100:1	1	500 / 5
0.8 (1600)	0.008 (16)	100:1	2	800 / 8
0.8 (1600)	0.0025 (5)	320:1	1	1600 / 5
2.5 (5000)	0.025 (50)	100:1	10	500 / 5
2.5 (5000)	0.008 (16)	312.5:1	2	2500 / 8
8.0 (16000)	0.08 (160)	100:1	32	500 / 5
8.0 (16000)	0.025 (50)	320:1	10	8000 / 8

Cutoff/filter types

The PROFILE FILTERS for the Roughness long wavelength cutoff, lc, and Waviness cutoff, lf, can be selected by the user from the following filter types:

ISO 2CR, 2CR PC (phase corrected), Gaussian filter.

The Primary filter and Roughness short wavelength cutoff, ls are implemented using the Gaussian filter.

These filters do not give a sharp cut in response to irregularities of widths greater than the cut-off length. Instead there is a gradual fall-off in response, as shown in the graphs on the following pages.

The 2CR filters (including 2CR PC) have been standardised to have a transmission of 75% at the selected CUT-OFF. This means that the amplitudes of the irregularities having a spacing equal to the CUT-OFF length are reduced to 75% of their true value. The amplitudes of shorter wavelength irregularities will be almost unchanged. The amplitudes of longer wavelength irregularities are progressively reduced.

However, Gaussian filters have a transmission of 50% at the cut-off wavelength. This means that the addition of the roughness filtered profile to the waviness filtered profile equals the original unfiltered profile. Coupled with the data discarding arrangement described later, this filter tends to provide a less distorted profile analysis.

The effects of a filter on a particular point depend on the data values of the previous or following adjacent points (or both dependent on the filter type). For this reason, filtered data cannot be calculated at the extreme ends of the data.

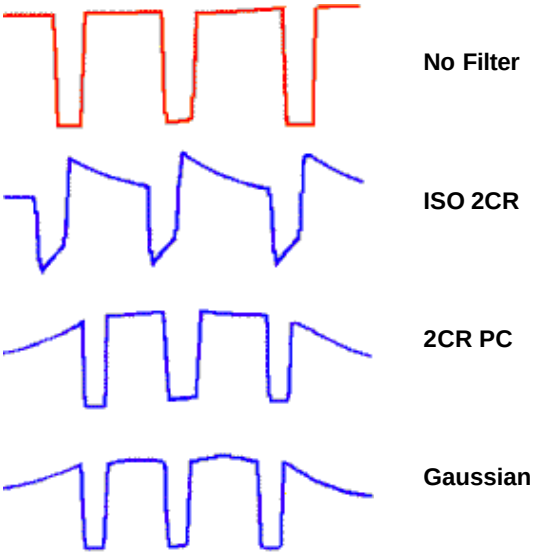
To minimise this problem, after filtering has taken place, some of the data collected from the ends of the traverse (particularly the start) is discarded. The amount of data discarded and its location, is dependent on the filter used, as follows:

ISO 2CR -The first two cut-offs are discarded.

2CR PC -The first and last cut-off are discarded.

Gaussian -Half of the first cut-off and half of the last cut-off are discarded.

The following profile graphs show the effect, in the extreme case on a vertical profile slope of using no filter, the ISO 2CR filter (which has a phase shift effect), the 2CR PC filter and the Gaussian filter (which is also phase corrected).



2CR FILTERS

Roughness Analysis

Filter details for ISO 2CR and 2CR PC filters are as follows:
Amplitude transmission ratio for a sinusoidal waveform:

$$\text{Amplitude transmission ratio: } = \frac{\text{output}}{\text{input}} = \frac{3}{3+\alpha^2}$$

Where α = l input/ l cutoff

There is a phase distortion effect (ϕ) dependent on a such that:

$$(\phi) = 2\left(\text{Tan}^{-1}\frac{\alpha}{\sqrt{3}}\right)$$

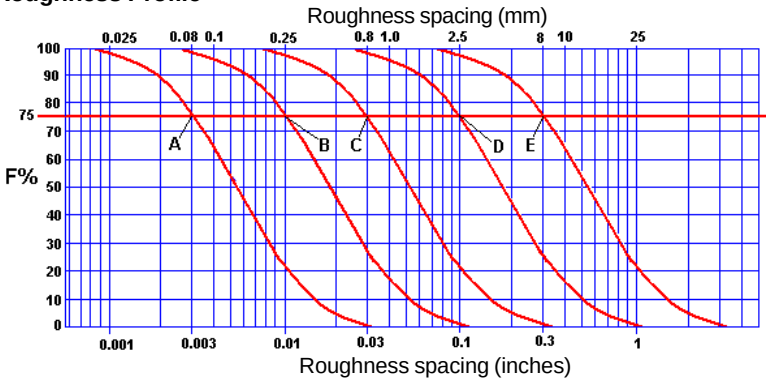
For 2CR PC filter there is no phase distortion: . $(\phi) = 0$

Waviness parameters are defined in the same manner as their roughness counterparts, but assessments are made using the surface data which has wavelengths greater than the cut-off selected, as shown below.

$$\text{Amplitude transmission ratio: } = \frac{\text{input}}{\text{output}} = \frac{3}{3 + ß^2} \quad \text{where } ß = \frac{\text{l cut-off}}{\text{l input}}$$

Filter Transmission Characteristics

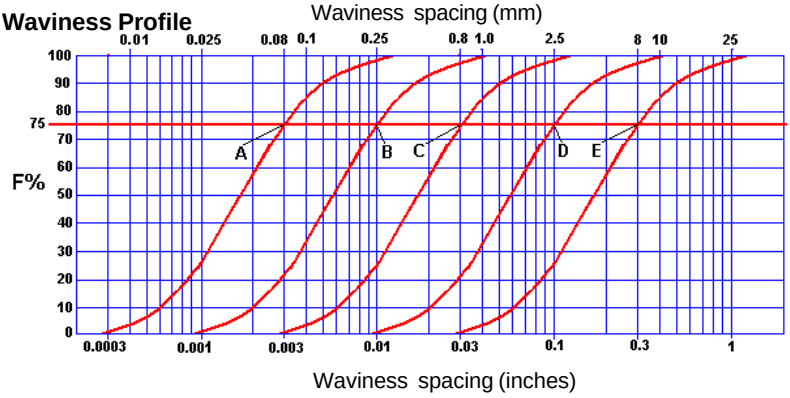
Roughness Profile



F% = Transmission %

Cut offs	mm	in
A	0.08	0.003
B	0.25	0.010
C	0.80	0.030
D	2.5	0.10
E	8.0	0.30

Waviness Profile



GAUSSIAN FILTERS

Gaussian filtering does not simulate a specific electronic filter, but is a mathematical function that is applied to the profile data. The filter is a weighted mean of the profile, where the weights have a Gaussian (bell) shape. Since this shape is symmetrical, the resulting filter is phase corrected.

A property of a Gaussian filter is the ability to take account of data before and after the effective stylus position. The response at the cut-off value is 50%.

The weighting function for the Gaussian filter has the equation of the Gaussian density function.

The transmission characteristics are made up of two components, these are: (a) the transmission characteristics of the mean line and (b) the transmission characteristics of the roughness profile.

a) Amplitude transmission ratio: $= \frac{\text{input}}{\text{output}} = e^{-\pi \left[\frac{\alpha \ lc}{\lambda} \right]^2}$

where $\alpha = \sqrt{\frac{\log_e 2}{\pi}} = 0.4697186\ldots$

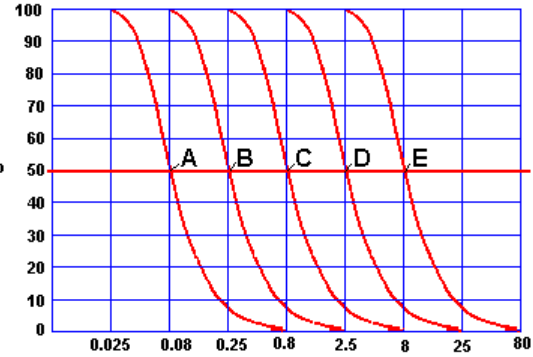
b) Amplitude transmission ratio: $= \frac{\text{input}}{\text{output}} = 1\text{-}e^{-\pi \left[\frac{\alpha \ lc}{l} \right]^2}$

where $\alpha = \sqrt{\frac{\log_e 2}{\pi}} = 0.4697186\ldots$

GAUSSIAN FILTER TRANSMISSION CHARACTERISTICS (Roughness Profile)

Cut offs	mm	in
A	0.08	0.003
B	0.25	0.010
C	0.80	0.030
D	2.5	0.10
E	8.0	0.30

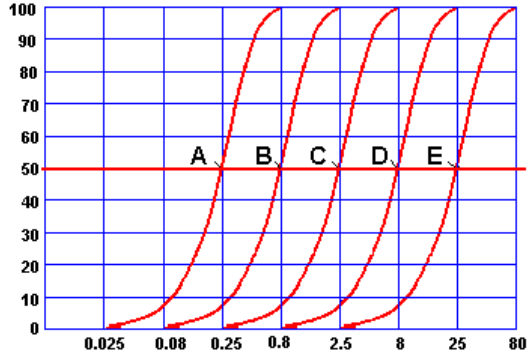
F% = Transmission %



GAUSSIAN FILTER TRANSMISSION CHARACTERISTICS (Waviness Profile)

Cut offs	mm	in
A	0.08	0.003
B	0.25	0.010
C	0.80	0.030
D	2.5	0.10
E	8.0	0.30

F% = Transmission %



RK FILTER

The filter applied for the evaluation of Rk is specific to this parameter and is described in the standard ISO 13565-1,2.

R&W FILTER

A specific filter is applied for the evaluation of the R & W parameters. This is described in the standard ISO 12085.

PARAMETERS

Surface texture is quantified by parameters which relate to certain characteristics of the texture. These parameters can be classified into three groups, according to the type of characteristic that they measure.

AMPLITUDE PARAMETERS

Are measures of the vertical displacements of the profile (z axis).

SPACING PARAMETERS

These are measures of irregularity spacings along the surface, irrespective of the amplitude of these irregularities (x axis).

HYBRID PARAMETERS

These relate to both the amplitude and spacing of the surface irregularities (z and x axis).

EXTENDED PARAMETERS

A number of parameters are not simply defined by the profile data only. These require further inputs or attributes to quantify the parameter. These parameters are dc, mr, HSC, PC, Vo.

TERMINOLOGY

Before discussing the various parameters available for assessment a number of terms relating to the length of data and its relationship to filters requires defining:-

There are four characteristic lengths associated with the numerical assessment of surface texture.

Cut-Off Wavelength
This is the wavelength of a sinusoidal profile of which only a certain percentage of its amplitude is transmitted by the profile filter. This percentage is 75% for ISO 2CR and 2CR PC filters and 50% for Gaussian filters.

Profile filters are identified by their cut-off wavelength values.

Sampling Length
This is the length of the reference line determined to be equal to the cut-off wavelength used in the Profile Filter in characterising the surface roughness. For primary filtering, this is equal to the evaluation length.

Evaluation Length (Assessment) - ln
The length of modified profile data measured along the reference line over which the values of surface finish parameters are calculated. Also known as the assessment length or data length (and referred to as ln). It may contain one or more sampling lengths.

Traverse Length
Nominal distance travelled by the traverse unit during data logging. However, any allowances for acceleration or stabilisation which may be made are not included. It can be greater than the evaluation length, due to the discarding of some data if filtering has been applied.

PARAMETER DEFINITIONS

ROUGHNESS, WAVINESS and PRIMARY PARAMETERS
This section contains definitions for the Roughness (R), Waviness (W) and Primary (P) parameters. Where the mathematical description for each of these filter modes is the same, only the Roughness parameter is described.

Parameter	Standard
ln	ISO 4287 1997
Rp, Wp, Pp	ISO 4287 1997
Rv, Wv, Pv	ISO 4287 1997
Rz, Wz, Pz	ISO 4287 1997
Rc, Wc, Pc	ISO 4287 1997
Rt, Wt, Pt	ISO 4287 1997
Rpm	ISO 4287 1997
Ra, Wa, Pa	ISO 4287 1997
Rq, Wq, Pq	ISO 4287 1997
Rsk, Wsk, Psk	ISO 4287 1997
Rku, Wku, Pku	ISO 4287 1997
RSm, WSm, PSm	ISO 4287 1997
Rdq, Wdq, Pdq	ISO 4287 1997
Pz (JIS)	TH Definition
Rz (JIS)	JIS B 0601 1994, 5.
R3y	TH Definition
R3z	TH Definition
Rlq, Wlq, Plq	ISO 4287 1984
RS, WS, PS	ISO 4287 1984
RLo, WLo, PLo	ISO 4287 1984
Rda, Wda, Pda	ISO 4287 1984
RHSC, WHSC, PHSC	TH Definition
Rdc, Wdc, Pdc	ISO 4287 1997
Rmr, Wmr, Pmr	ISO 4287 1997
Rmr(c), Wmr(c), Pmr(c)	ISO 4287 1997
RPc, WPc, PPc	TH Definition
RVo, WVo, PVo	TH Definition

Ra Wa Pa -Ra is the universally recognised, and most used, international parameter of roughness. It is the arithmetic mean of the departures of the profile from the mean line.

$$Ra = {}^{1}/_{L} \int_{0}^{L} \left| z(x) \right| \, dx$$

Rq Wq Pq - Root mean square (rms) of the ordinates

$$Rq = \sqrt{\frac{1}{L}\int_0^L |z^2(x)|\,dx}$$

Rt Wt Pt – Maximum sum of the largest peak and the largest valley of the profile in the evaluation length.

Rz Wz Rz - Sum of the largest peak and the largest valley of the profile within the sampling length.

Rc Wc Pc – This is the mean height of profile elements heights within a sampling length. A profile element is made up of a profile peak and an adjacent profile valley.

Rz (JIS) Pz (JIS) - also known as the ISO 10 point height parameter, is the average height difference between the five highest peaks and the five lowest valleys within the sampling length.

$$Rz\ (JIS) = \frac{1}{5}\left(\sum_{i=1}^{i=5} Z_{pi} - \sum_{i=1}^{i=5} Z_{vi} \right)$$

$$= \frac{(Zp1+Zp\,2+Zp\,3+Zp4+Zp5) - (Zp1+Zp\,2+Zp\,3+Zp4+Zp5)}{5}$$

Rv Wv Pv - The maximum depth of the profile below the mean line within the sampling length.

Rp Wp Pp - The maximum height of the profile above the mean line within the sampling length.

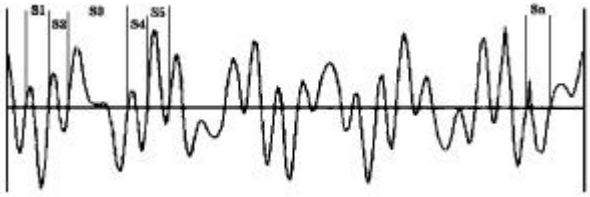
Rpm - The mean of Rp values obtained from all sampling lengths.

$$R_{pm} = \frac{1}{n}\sum_{i=1}^{i=n} R_{pi}$$

RS WS PS - The mean spacing of adjacent local peaks, measured over the evaluation length. (A local peak is the highest part of the profile measured between two adjacent minima, and is only included if the height between the peak and its preceding minima is at least 1% of the overall peak to valley of the profile).

$$RS = \frac{1}{n}\sum_{i=1}^{i=n} RS_i \qquad RS = \frac{(RS1 + RS2 + ...RSn)}{n}$$

S
Local peak spacing



RSm WSm PSm - The mean spacing between profile peaks at the mean line, measured over the evaluation length. (A profile peak is the highest part of the profile between an upwards and downwards crossing of the mean line). There is a 10% z height discrimination and 1% sampling length spacing discrimination.

$$RSm = \frac{1}{n}\sum_{i=1}^{i=n} RS_i \qquad RSm = \frac{(RS1 + RS2 + ...RSn)}{n}$$

RSm
Mean line peak spacing

Rdq Wdq Pdq – (?q) This is the rms slope of the profile throughout the evaluation length

$$\Delta q = \sqrt{{}^{1}/_{L}\int_{0}^{L} (\theta(x) - \bar{\theta})^{2}\, dx}$$

Where: $\theta = {}^{1}/_{L}\int_{0}^{L} \theta(x)\, dx$

and where θ is the slope of the profile at any given point θ = y'(x).

Rlq Wlq Plq -(lq) This is the rms measure of spatial wavelength content of the surface. Numerically:

$$R\,lq = \frac{2\pi Rq}{\Delta q}$$

R3z - This is the vertical mean from the third highest peak to the third lowest valley for each sample length.

$$R3z = \frac{1}{n}\sum_{i=1}^{i=n} R3zi \quad = \quad \frac{(R3z1 + R3z2 \,..R3zn)}{n}$$

Where R3zi is the deviation from the third highest peak to the third lowest valley in each sample length.

R3y -This is the largest of the R3zi values (see R3z).

Rda Wda Pda – (Δa) The mean of the absolute values of the rate of change of profile departures within the sampling length:

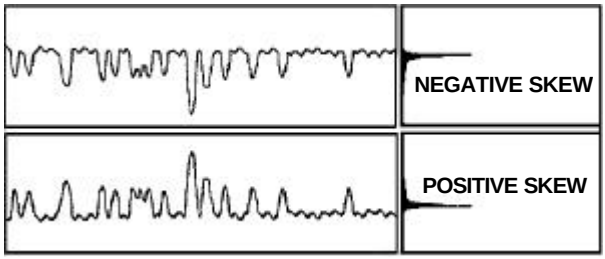
$$\Delta a = {}^{1}/_{L}\int_{0}^{L} \left|\frac{dy}{dx}\right| dx$$

Rlo Wlo PLo - This is the developed length of the profile.

ln - length in the direction of the x axis of the profile being evaluated.

Rsk Wsk Psk - Skewness is a measure of the symmetry of the amplitude distribution curve about the mean line.

Components with the same Ra but with +ve and -ve skew



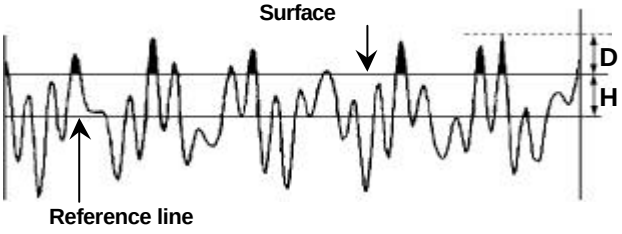
$$Rsk = {}^{1}/_{LRq^{3}} \int_{0}^{L} Z^{3}(x)dx$$

Rku Wku Pku - Kurtosis is a measure of shape (sharpness) of the amplitude distribution curve.

$$Rsk = {}^{1}/_{LRq^{4}} \int_{0}^{L} Z^{4}(x)dx$$

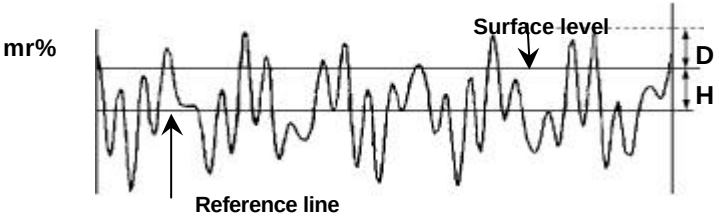
HSC The high spot count is the number of complete profile peaks (within the evaluation length) projecting above the reference line, the reference line being parallel to the mean line. The reference line can be set to a selected depth below the highest peak (D), at a selected distance above or below the mean line (H) or at a mr% height and offset.

High spot count



mr% - The material ratio is a measure of the length of surface (expressed as a percentage of the evaluation length), where the profile peaks have been cut off at a line which runs parallel to the mean line of the profile. It is typically used to measure bearing surface wear.

The line defining the surface, can be set at a selected depth below the highest peak (D) or at a selected distance above or below the mean line of the profile (H) or at a mr% height and offset. When this line is set to the depth of the largest profile valley, then mr is 100% because all the profile is above the line. By plotting the mr% value against depth below the highest profile peak (or distance from mean line) between the 0% and 100% limits, then the material ratio (or Abbott-Firestone) curve is obtained.



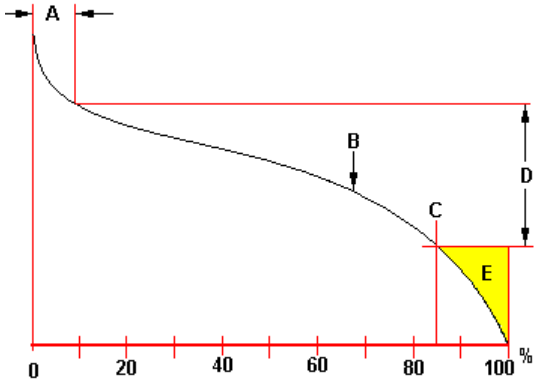
The addressed surface can be defined by specification of a base mr% (e.g. 5%) and a depth. This is useful in defining levels which are independent of initial wear of the upper parts of the surface.

dc - This is the distance between two mr% values.

Pc - The peak count is the number of peaks which project through a selectable band or "zonewidth" being parallel to the mean line. The zonewidth can be set to a selected depth below the highest peak, at a selected distance above or below the mean line or at mr% height and offset. The zonewidth value is selectable. The result is expressed as peaks/cm or peaks/inch

Vo - Volumetric Parameter. This parameter is used to determine the oil retention volume of a surface at a selected Material Ratio value and the results are given as the volume of oil retained per unit of surface area. Evaluation requires the determination of an area that is bounded by the Material Ratio curve. The portion of the Material Ratio curve that is to be evaluated can be specified by a depth, a distance above or below the mean line, or at a mr% height and offset.

A = Material Ratio% Reference Level. This data is excluded from the assessment
B = Material Ratio curve
C = Selected Material Ratio%
D = Bearing surface Depth
E = Oil reservoir (Vo) = mm^3/cm^2



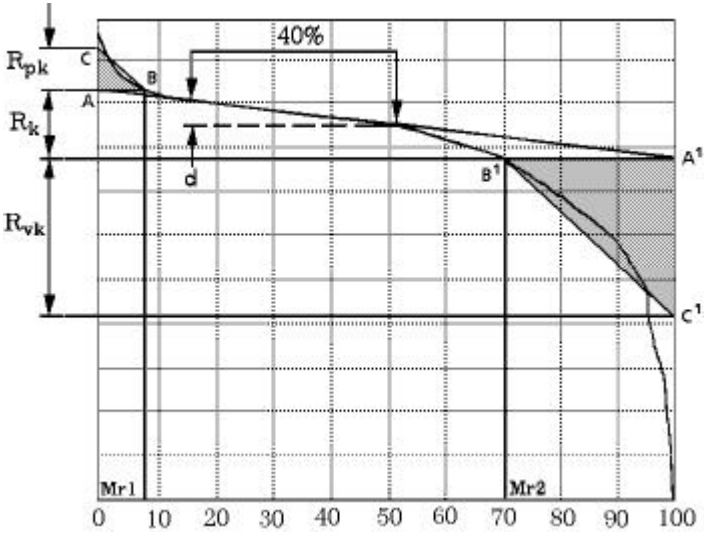
NOTE Results are given in mm^3 / cm^2 or min^3 / in^2.

Rk PARAMETERS

Rk associated parameters are a series of parameters designed specifically for the control of the potential wear in cylinder bores in the automotive manufacturing industry. It attempts to describe in numeric terms the form of the material ratio curve.

The filter used in Rk is a specific filter described in ISO 13565-1.

Derivation of the parameters are based on the division of the material ratio curve into three parts. The centre section (the "plateau") represents a 40% band on the mr% axis. This band is positioned such that the depth of the "plateau" (d) is a minimum.



The line A1 is then constructed through the ends of the "plateau". The interception of this line with the 0% and 100% ordinate gives rise to the Rk value as shown.

Two triangles are then constructed ABC (from which the parameter A1 is derived) and A1B1C1 (from which the parameter A2 is derived) on bases AB and A1B1, such that their areas are equal to the area above AB and under the curve, and the area below A1B1 and over the curve respectively, shown as shaded areas on the illustration.

a) The top portion of the surface (length AC) which will quickly be worn away when the engine begins to run. This is known as the Reduced Peak Height = Rpk. The actual volume of material which will be worn away (parameter A1) is determined from the triangle A1B1C1). Results are given in mm3 / cm2 or min3 / in2.

b) The long term running surface which will influence the performance and life of the cylinder. This is known as the kernal Roughness Depth = Rk (Rk = The depth of the Roughness Core Profile).

c) The oil retaining capability of the deep troughs which have been machined into the surface. This is known as the Reduced Valley Depth = Rvk. (length of A1 C1). Tha actual volume of oil retained (parameter A2) is determined from the triangle ABC.). Results are given in mm3 / cm2 or min3 / in2.

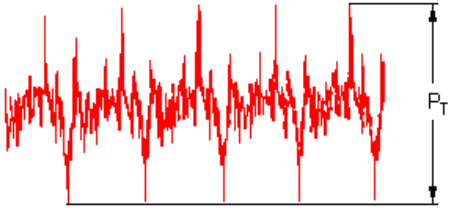
d) The Material Ratios Mr1 and Mr2 (in %) are determined from the line of intersection coinciding with the upper limit of the Roughness Core Profile.

R&W PARAMETERS

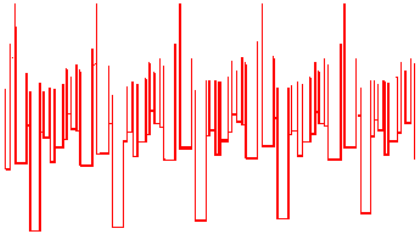
The method of filtering and analysis of R&W parameters is different and not directly comparable with other parameters. Details of this filtering is in document ISO 12 085.

Three profiles are used in the R&W analysis:

1. The unfiltered profile with slope correction (i.e. out of level has been removed with respect to a least squares straight line), gathered by traversing the stylus, skidless over the workpiece.



2. Roughness motifs.



3. Waviness motifs.

In addition to the slope of the profile, the standard parameters evaluated are:

Pt This is the maximum peak to minimum valley of the primary roughness motifs (i.e. the motifs before correction).

R The mean height of roughness steps, calculated from the roughness motifs.

AR The mean spacing between individual roughness motifs.

Rx The maximum peak to adjacent minimum valley (maximum individual motif) of the primary roughness motifs.

SR The standard deviation of R.

SAR The standard deviation of Ar.

SW The standard deviation of W.

SAW The standard deviation of Aw.

Wte The maximum peak to minimum peak of the corrected roughness envelope (in practice, calculated from the waviness motifs).

W The mean height of waviness motifs.

AW The mean spacing between individual waviness motifs. Waviness spacings greater than the waviness cut-off length are not considered for Aw calculations.

Wx The maximum individual motif of the waviness motifs.

METHOD OF CALCULATION

The sampling points collected from the measured slope corrected profile are subjected to a filtering process, from which the roughness motifs are constructed.

During this process, each peak contained within the data is detected and subjected to four tests. The peaks that fail these tests are eliminated from the envelope, the procedure being repeated until no further peaks can be eliminated. The residual motifs are designated the roughness motifs from which the Pt, Rx, AR and provisional R values are calculated.

Individual peaks are assessed once again for correction of amplitude (attenuation of isolated peak). When this is completed, the corrected roughness motifs are derived, from which the final value of R is calculated.

The peaks only of the corrected roughness motifs are then filtered again to form the waviness motifs, from which the W, Wx, WT and AW values are calculated.

Notes: As with all graphical methods, there are occasions when parameter calculation can fail. Two examples of this are described following:

1. Due to the algorithms method of peak elimination, it is possible to obtain slightly different parameter results from the same surface turned through 180 degrees. This is due to a different set of peaks and valleys being used for motif construction, based on the first peak encountered. This motif is then used for final parameter assessment which can show this condition, however, differences will be small.

2. If a surface is of periodic nature (i.e. Sinusoidal), some parameter results can be indeterminate, depending on the surface wavelength and the number of points used for calculation. If a purely periodic surface is measured with sufficient data points to represent that surface, all peaks will be in line leaving no waviness motif and hence no Waviness parameters. In this condition the results are shown as : Aw = ******

   If the number of data points is reduced causing an aliasing condition (See section on "Aliasing" further in this chapter) then a waviness profile may be created from the same data set. In this condition the Waviness parameter will be based on the sampled data criteria and not the surface undulations.

3. The surface should satisfy the criterion that the roughness peak to valley, PT, should not exceed 150 times the resolution of the gauge.

CALIBRATION (using the ball standard)

Because of the large range and high resolution the associated accuracy achievable, the calibration of the gauging system requires the inclusion of a number of sources of error which would normally be ignored by more conventional surface finish instruments. In addition to the gain correction, there are two main causes of non-linearity in the gauge:

1. First and most important, is the non-linearity, which is due to the arcuate movement of the stylus arm about the pivot. Ideally, as the gauge moves through the full measurement range, the stylus tip should move in a linear motion parallel to the Z axis. However, the stylus tip moves as a defined arc about a pivot thus introducing non-linearities in both X and Z co-ordinates.

2. Secondly, as the gauge moves through the full measurement range the transducer within the pick-up alters characteristics, introducing some minor non-linearities in the Z co-ordinates.

The nett effect of this is a non-linear relationship between the measured co-ordinates (x, z) and the actual co-ordinates (X, Z). These are related by the general formula;

$$Z = f(z)$$
$$X = x + g(Z)$$

where f () and g () are functions that can be determined empirically.

The two functions f () and g () are approximated by 3rd order polynomials. Thus the calibration formula becomes;

$$Z = z_1 z + z_2 z^2 + z_3 z^3$$
$$X = x + x_1 Z + x_2 Z^2 + x_3 Z^3$$

where $z_1, z_2, z_3, x_1, x_2, x_3$ are the calibration constants.

The calibration constants are related to the stylus geometry as well as the construction of the transducer of the pick-up. The exact relationship is not important since they all can be determined empirically via the automatic calibration routine provided in the instrument software.

.

This empirical determination is performed by measurement of a known controlled form (the calibration ball) which can be produced traceable to National and International Standards and provides an artifact that can be easily set-up on the instrument.

NOTE - The calibration of the instrument is valid only in that part of the vertical range over which the calibration of the instrument is carried out. Different stylus/calibration ball combinations produce different valid vertical calibration ranges of the instruments. Caution must be used when measuring outside this valid calibrated vertical range since the measurements may not be as accurate as those taken within the valid calibrated range. This is particularly so with the small bore styli which have a very limited valid calibration range.

Calibration Errors

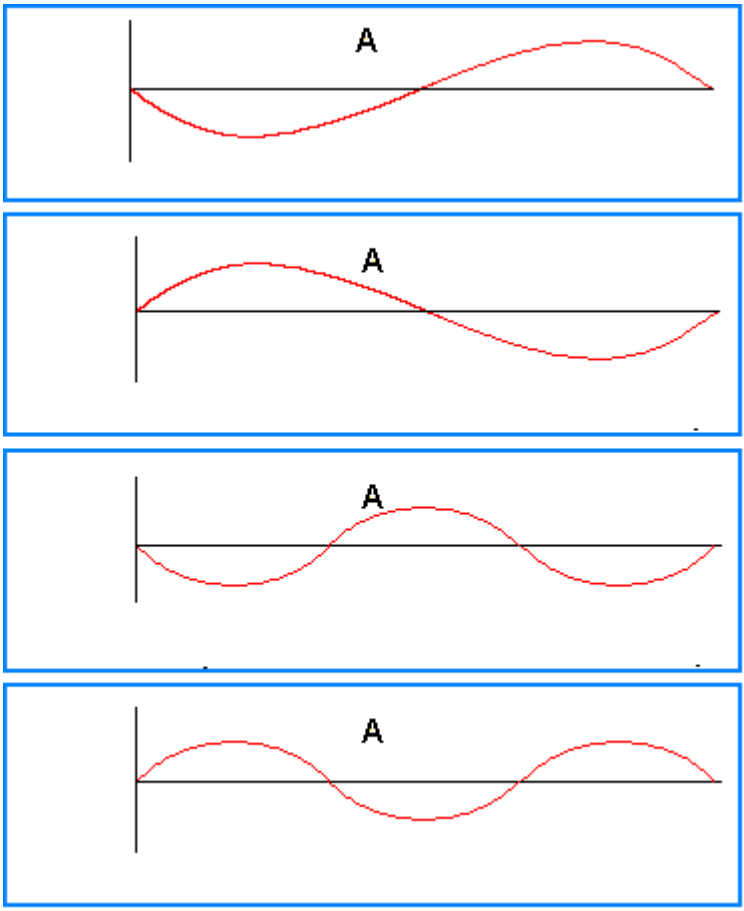
Outlined, on the next page, are some typical effects of incorrect calibration when measuring radii. In many instances these effects can appear to be a genuine form error on the component. It is, therefore, worth noting these typical shapes in order to avoid making a wrong assumption on the form of the component and attempting to take corrective action in the manufacturing process.

Errors in calibration usually cause 'S', 'W', or 'M' shapes in the profile when measuring radii, as shown in the following illustrations. The reasons for this include:

- Lack of calibration.
- Change of stylus without re-calibration.
- Damaged stylus and/or stylus arm pivots.
- 'Tracking' errors on the stylus signal caused by sudden changes in displacement (e.g. When measuring over a step).

It is recommended that if any of the forms shown in the following illustrations are exhibited on a component that the instrument is re-calibrated. If the calibration is acceptable then the component can be re-measured.

TYPICAL CALIBRATION ERROR EFFECTS ON RADIUS MEASUREMENT



A = Modified Profile

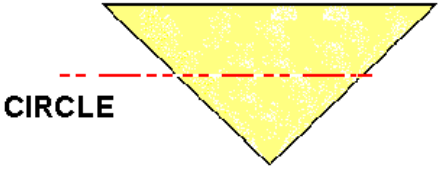
RADIUS
(MATHEMATICAL REFERENCE)

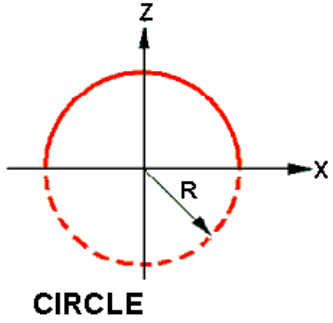
The evaluation of Radius is performed on a curve belonging to the conics group and is generated by the intersection of a plane on a cone (see illustration). The Circle is a plane parallel to the cone base.

The standard form of a circle is:

$$\frac{z^2}{R} + \frac{x^2}{R} = 1$$

where: R is the radius of the circle.





ACCURACY OF RADIUS MEASUREMENT

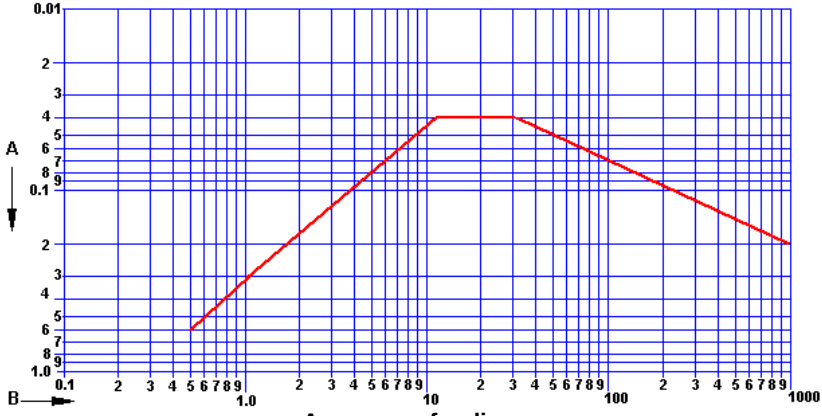
When measuring small radii, the surface roughness of the component and the value of the included angle have a major influence on the accuracy. For larger radii the accuracy depends more on the accuracy of calibration and traverse.

The best accuracy will normally occur in the 12.7mm to 25mm range (nominally around the calibration value), with an included angle of approx. 60°. For small values of radius with the requisite surface quality, an accuracy of 1% can be obtained with an included angle near to 60°. The accuracy for values of radii larger than 25mm is such that at the largest radius of 1000mm, an accuracy of 0.1% can be achieved with a minimum included angle of 5°.

Accuracy is always influenced by the following:

1) Accuracy of calibration
2) Condition of stylus
3) Component surface finish
4) Component form error
5) Included angle and its symmetry with respect to the vertical.
6) Accuracy of traverse

Any abnormal effects of these factors will degrade the accuracy further.



A = Accuracy % of nominal radius **B** = Nominal radius

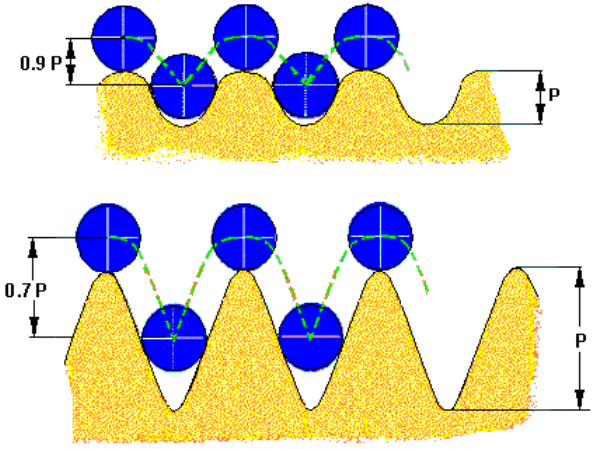
EFFECTS OF STYLUS GEOMETRY

Description

When the stylus tip radius is small compared with the curvature of the surface, the movement of the stylus will accurately follow the contours of the surface. As the curvature of the surface increases, there is a tendency for the stylus to bridge over any depressions with a small radius - reducing its sensitivity to short wavelength components

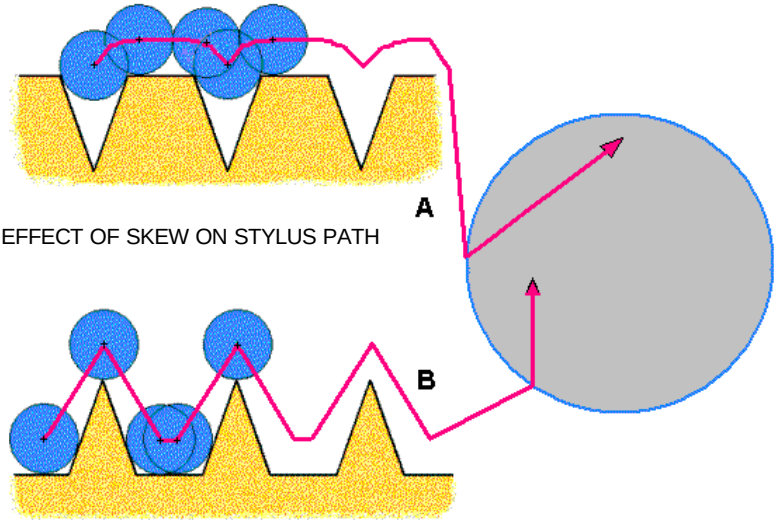
However this reduction is not simply dependent on wavelength, as with an electrical filter. The curvature of the surface is affected by both the height and the spacing of the surface features, and the filtering effect of the stylus tip radius can become less significant as the roughness of the surface is reduced. Although it must be noted that the above is true for surfaces of a constant wavelength, smoother surfaces usually also have a shorter wavelength and hence can often be more susceptible than rougher surfaces.

Each of the profiles shown has the same wavelength, but due to the amount of penetration of the stylus (or skid nosepiece) each would yield a different roughness value.



EFFECT OF MECHANICAL FILTERING ON ROUGHNESS

Although a stylus is not capable of fully entering a depression in the surface with a smaller radius of curvature than the stylus tip, it will be fully deflected by a similar shaped mound on the surface. The filtering effect of a stylus tip will therefore depend on the symmetry, or skew, of the surface profile. It is important, therefore that, when appropriate, the stylus is traversed squarely across the lay (the surface pattern caused by the machining process) of the component.



EFFECT OF SKEW ON STYLUS PATH

A = Stylus traversed obliquely across the lay of the surface

B = Stylus traversed at right angles to the lay of the surface

STYLUS FLANKING

There are certain conditions of stylus/component profile contact which can affect the validity of measurement results.

1. The effect of interference between the sides of the stylus tip and sloping or curved profile sections (stylus flanking) should be considered.

   This will occur when the stylus is traversed over a component profile which includes either a slope or a radiused section, any part of which

presents a tangential angle greater than 35° for a diamond tipped stylus or 55° for a ball tipped stylus.

The maximum traverse obtainable in a radiused section without stylus flanking occurring is given by:

T = 1.15 x R for a diamond tipped stylus,

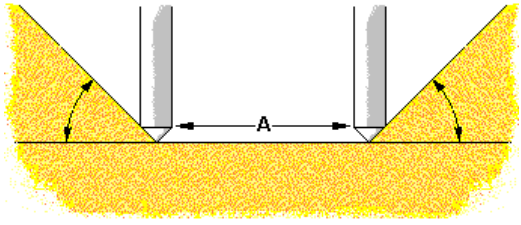
And

T = 1.6 x R for a ball tipped stylus

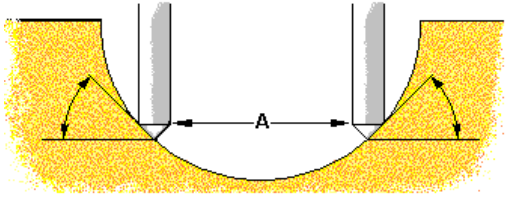
Where T = Traverse length and R = the profile radius.

2. When using a ball tipped stylus, the contact point of the ball with the profile being measured changes as the slopes of the profile contour changes.

The measured profile data is computed and results output with compensation for the stylus radius. However, dimensional data obtainable from the X and Z axis co-ordinates of the Data Selection displays is not compensated. Therefore, this effect should be taken into account when using these displays.



A =Stylus tip



SAMPLING INTERVAL THEORY

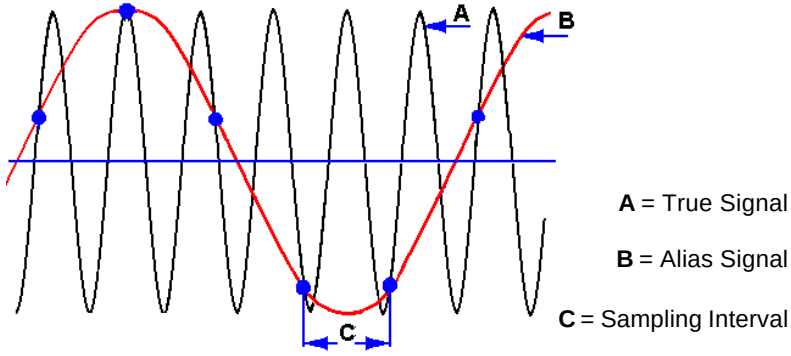
The use of digital computers to process profile data introduces another limitation to the high frequency response of the measuring system. Because the computer can only perform calculations with discrete numbers rather than a continuously changing electrical signal, the profile signal has to be sampled at regular intervals to provide a series of data values, each of which represents the surface height at one point on the surface. The spacing of these points along the surface determines the shortest surface wavelength which can be resolved.

Conventional sampling theory (Nyquist) requires that the sampling frequency should be at least twice the highest frequency contained in the signal. In terms of wavelength, this means that there should be at least two data points within the shortest surface wavelength contained in the profile. The speed and data capacity of the computer system impose a limit to the maximum sampling rate that can be used, and therefore to the shortest wavelength that the system is capable of measuring.

However, the Form Talysurf uses at least five points per cut-off wavelength to achieve a 1% transmission level of the Gaussian profile filter.

ALIASING

A further complication arises due to the phenomenon known as aliasing. When the profile contains a frequency which is greater than half of the sampling frequency, the sampling process can result in a much lower frequency being detected.



The detected frequency is the difference between the sampling and actual profile frequencies. If the sampled data were used to create a profile graph, the effect of aliasing would be to introduce long wavelength components into the profile, which were not present on the actual surface. To prevent this happening, it is usual to provide an electrical filter which removes any unwanted high frequencies from the profile data before it is sampled. Such a filter is commonly described as an anti-aliasing filter.

EFFECT ON RESULTS

With most manufactured surfaces, the longer wavelength components of the surface texture tend to have the greatest amplitudes. This is a natural consequence of most manufacturing processes. When the surface texture parameters of this type of surface are assessed, the short wavelength limit and bandwidth become much less significant than the long wavelength limit (cut-off), because it is mainly the long wavelengths which are contributing to the parameter values.

Very high precision surfaces, which have been subjected to a succession of machining operations, do not always show this same increase in amplitude with wavelength. The effect of the multiple machining is to remove the long wavelength components leaving only the short wavelengths. For these surfaces, the parameter values obtained after a measurement will be very sensitive to bandwidth and short wavelength limits. Not surprisingly, it is with this type of surface that most anomalies are found when measurements are made using different types of instrument.

AMPLIFIER CHARACTERISTICS

All electronic amplifier systems have a finite upper limit to their frequency range. Although it is possible to design amplifiers with very high upper frequency limits, and very large bandwidths, the frequency range is normally restricted in order to improve the noise performance.

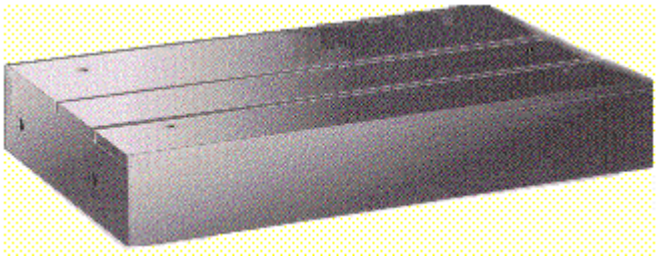
Both the transducer and the amplifier generate some electrical noise and this is then superimposed on the profile signal and effectively limits the resolution of the instrument. The amount of noise introduced is directly related to the bandwidth of the system and for high resolution, it is usual to design the amplifier with only the minimum bandwidth required.

The amplifier bandwidth is normally limited by the inclusion of electrical filtering networks. Although such filters may have a variety of different characteristics, their filtering effect is dependent only on frequency and is not affected by the amplitude of the signal or by the skew of the profile.

PARAMETERS AND DEFINITIONS

CONTENTS

Granite Base (112/2007-01)



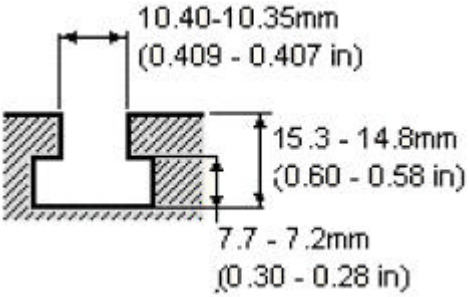
The base is of an epoxy granite construction on anti-vibration mounts, and provides a firm support for the column and workpieces. The isolation from vibration provided by the base enables the system to be used up to maximum performance level close to normal engineering environments (this does not include high energy activity such as forging, planing, shearing, bending etc). Two tee slots enables fixtures and base accessories to be secured to the surface.

WARNING: The threaded holes on the top of the base **MUST NOT** be used for lifting. The column must be removed from the base before attempting to lift the base.

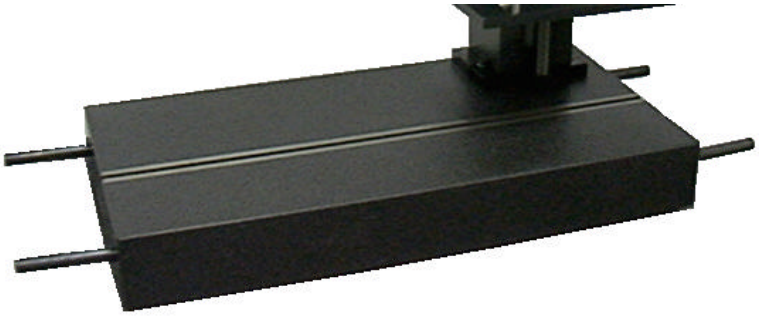
Four handles are provided for lifting the base, which weighs 100kg (220 lbs). These handles must be fully screwed into the threaded holes in the ends of the base (two handles at each end). The user must decide whether to use manual or mechanical lifting, depending on the environment and the distance to be moved

Specification

Material:	Epoxy Granite
Weight:	100kg (220 lbs)
WxDxH:	760 x 500 x 120mm
Location features:	2 Tee slot (for dimensions see sketch)



Granite Base (112/3046-01)



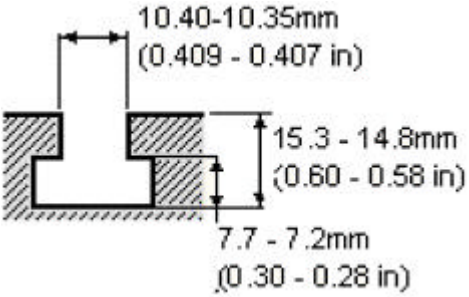
The base is of an epoxy granite construction on anti-vibration mounts, and provides a firm support for the column and workpieces. The isolation from vibration provided by the base enables the system to be used up to maximum performance level close to normal engineering environments (this does not include high energy activity such as forging, planing, shearing, bending etc). One tee slot enables fixtures and base accessories to be secured to the surface.

WARNING: The threaded holes on the top of the base **MUST NOT** be used for lifting. The column must be removed from the base before attempting to lift the base.

Four handles are provided for lifting the base, which weighs 100kg (220 lbs). These handles must be fully screwed into the threaded holes in the ends of the base (two handles at each end). The user must decide whether to use manual or mechanical lifting, depending on the environment and the distance to be moved

Specification

Material:	Granite
Weight:	100kg (220 lbs)
WxDxH:	800 x 400 x 100mm
Location features:	1 Tee slot (for dimensions see sketch)



Column (112/3117-01)

The column is used in conjunction with the epoxy Granite Base to provide a rigid stable mounting for the traverse unit. This enables the height of the traverse unit to be easily and precisely adjusted.

The height of the column carriage on which the traverse unit is mounted is adjusted by use of a handwheel located at the top of the column. Due to the isolation properties of the anti-vibration mounts located under the base, care should be taken when using the handwheel, not to cause the instrument and/or components to move.

The traverse unit can be attached to either a cradle adaptor plate via its feet or a fixed plate via the vertical dovetail adaptor

WARNING: Before placing the traverse unit on either of the carriage adaptor plates, ensure that it is firmly secured to the column carriage.

Cradle adaptor plate 112/3116

Ensure that the traverse unit is placed on the kinematic mounts, see page 15. Levelling of the traverse unit is achieved by adjustment of the screwed cone mount in the adaptor plate, located under the rear TU foot.

Fixed plate 112/3107

The fixed plate provides a more permanent location for the traverse unit and ensure a better noise performance as the traverse unit is directly attached to the carriage via a dovetail. The fixed plate is set to ensure the traverse unit axis is parallel to the base within 100µm/50mm. There is no allowance for tilt adjustments on the fixed plate.

A carriage clamp screw is provided to enable the carriage to be clamped to the column during sensitive measurements.

Specification

Material:	Epoxy Granite
Weight:	35kg
Height to top of handwheel:	810mm
Depth (including adaptor plate and clamp):	340mm
Width (including adaptor plate):	355mm
Minimum height of adaptor plate underside from base:	30mm
Maximum height of adaptor plate underside from base:	372mm
Range of movement on levelling screw: (only cradle adaptor plate)	Nominally ±4mm from level position

Column (112/3046-01)

The column is used in conjunction with the Granite Base to provide a rigid stable mounting for the traverse unit. This enables the height of the traverse unit to be easily and precisely adjusted.

The height of the column carriage on which the traverse unit is mounted is adjusted by use of a handwheel located at the top of the column. Due to the isolation properties of the anti-vibration mounts located under the base, care should be taken when using the handwheel, not to cause the instrument and/or components to move.

WARNING: Before placing the traverse unit on the carriage adaptor plate, ensure that it is firmly secured to the column carriage.

Ensure that the traverse unit is placed on the kinematic mounts, see page 15. Levelling of the traverse unit is achieved by adjustment of the screwed cone mount in the adaptor plate, located under the rear TU foot.

A carriage clamp screw is provided to enable the carriage to be clamped to the column during sensitive measurements.

Specification

Material:	Granite
Weight:	36kg
Height to top of handwheel:	522mm
Depth (including adaptor plate and clamp):	420mm
Width (including adaptor plate):	310mm
Minimum height of adaptor plate underside from base:	30mm
Maximum height of adaptor plate underside from base:	350mm
Range of movement on levelling screw:	Nominally $\pm$4mm from level position

Free Standing base (112/3066-01)

The base is a granite construction on anti-vibration mounts, and provides a firm support for the traverse unit and the various workpieces. The isolation from vibration provided by the base enables the system to be used up to maximum performance level close to normal engineering environments (this does not include high energy activity such as forging, planing, shearing, bending etc). One tee slot enables fixtures and base accessories to be secured to the surface.

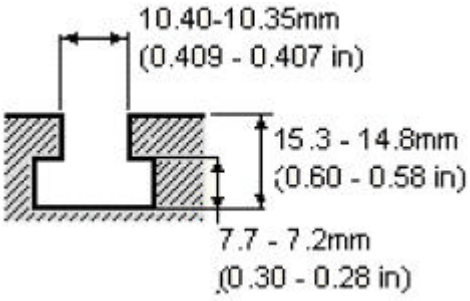
WARNING: The threaded holes on the top of the base **MUST NOT** be used for lifting..

Four handles are provided for lifting the base, which weighs 50kg (110 lbs). These handles must be fully screwed into the threaded holes in the ends of the base (two handles at each end). The user must decide whether to use manual or mechanical lifting, depending on the environment and the distance to be moved

Two pairs of additional blocks are provided as shown. These blocks locate on the base to raise the mounting for traverse unit to the required height

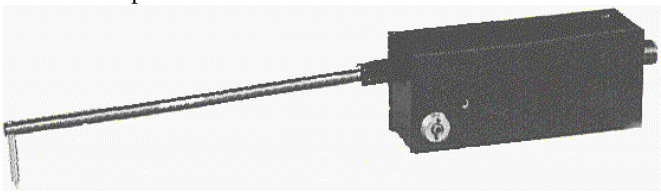
Specification

Material:	Granite
Weight:	50kg (110 lbs)
WxDxH:	750mm x 250 x 80mm
Location features:	1 Tee slot (for dimensions see sketch)
Block heights:	50mm and 100mm



The Wide range Pick-up 112/2628

This unit is a wide range inductive pick-up for profile measurement. Full arcuate compensation is obtained via the software.



The wide range pick-up is plugged into the hinge unit. The pick-up must be mounted with the stylus in the downward direction only. As this pick-up is used skidless, the hinged pick-up stem must be locked solid.

The stylus beam is a push fit into the anvil of the pick-up. A stop pin is fitted through the beam and this must fully engage with the recess in the anvil.

The pivot of the pick-up is a delicate mechanism. Therefore, care must be taken, when inserting and removing the stylus beam, not to force the beam into its socket or to impart a sideways or twisting movement.

The Stylus Stop When measuring workpieces which have interrupted surfaces, the stylus can drop into a hole or recess and cause the stylus to be damaged or the stylus arm to be disengaged from the pivot. To prevent this occurring, the movement of the stylus can be limited, by adjusting the stylus stop screw.

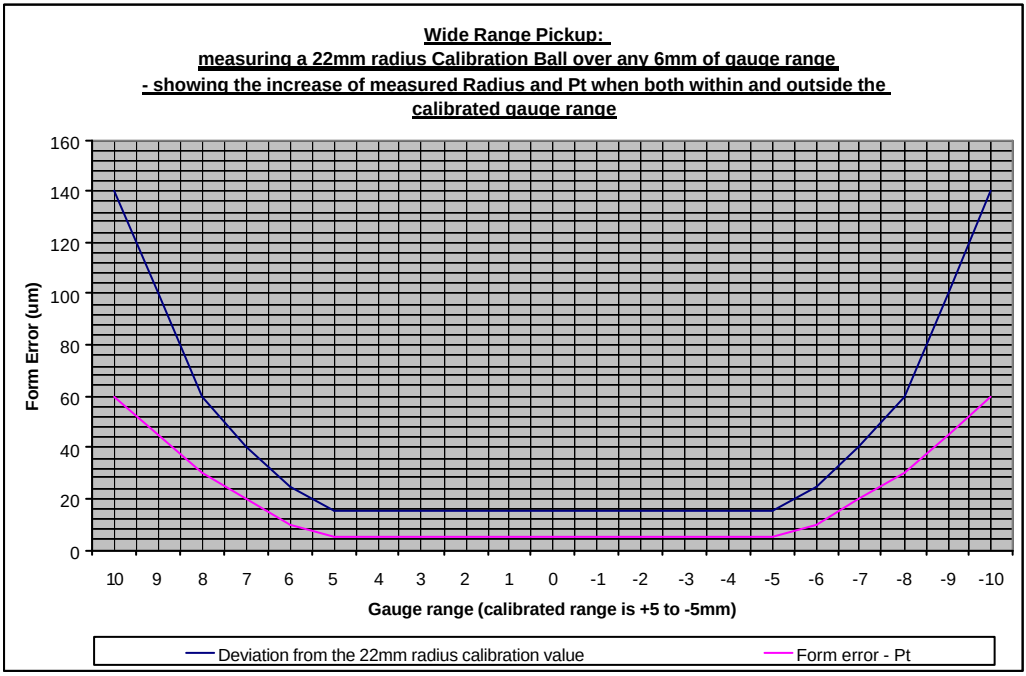
The stop screw is located by inserting an M3 hexagon key through the hole in the top plate of the pick-up. The screw should be adjusted so that the stylus is free to fully contact the surface to be measured but have only a limited drop into the interruption.

When non-interrupted surfaces are to be measured, the stop screw should not limit the movement of the stylus arm. This condition can be checked by allowing the stylus to hang freely and ensuring that the displayed stylus position indicates an out-of-range condition.

Specification

Pick-up type:	Wide range variable inductance
Calibrated Range:	Range 1: 29.5mm nominal (calibrated over the central 9mm), 450nm resolution.
	Range 2: 5.9mm nominal (calibrated over the full range), 90nm resolution.
	Range 3: 1.2mm nominal (calibrated over the full range), 18nm resolution.

The actual range is determined during the calibration routine and may deviate by 10% either way from the nominal range

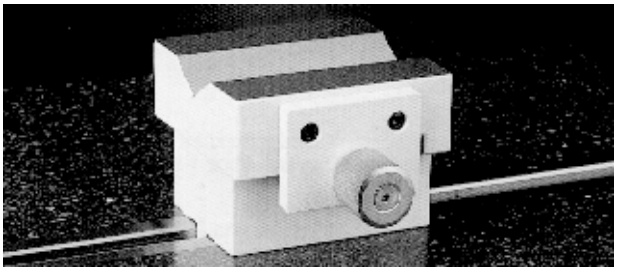


Dimensions	(W x D x H): 97mm, 30mm, 40mm (3.8 x 1.18 x 1.57in)
Weight:	230g
Interchangeable Styli	
Tungsten carbide 15° chisel tip- K501/1684:	20µm tip radius
Tungsten carbide 30° conical tip-K501/1685:	20µm tip radius
Sapphire Ball-K501/1686:	500µm tip radius
Resolution	850nm (83µin)
Stylus Force:	3gf (0.03N) nominal
Radius accuracy:	<0.5% *
Form best fit circular arc - P_t:	<5µm *
Calibration standard required	44mm diameter ball

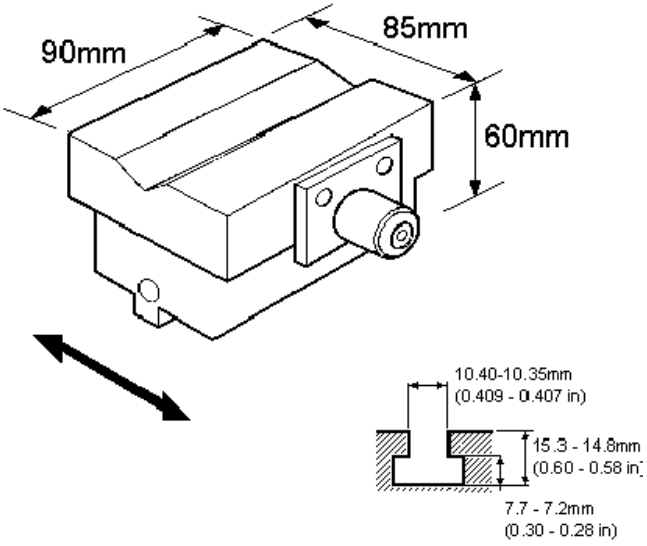
*Figures quoted are for measurements made within the calibrated range of the pick-up.

Note. Shank clearance, shank length and arm length (as stated in the Calibrate menu) are with respect to the gauge pivot point.

Adjustable Vee Block (112/1326)



Dimensions

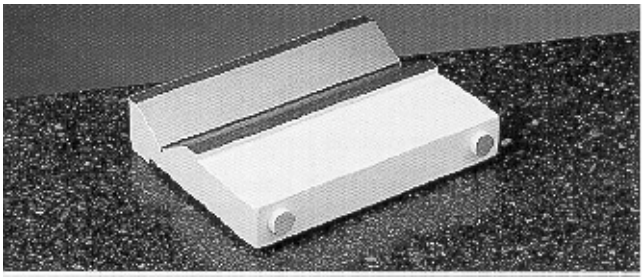


This accessory has 40mm (1.5in) of lateral adjustment and is particularly useful for bringing the crest of a cylindrical workpiece directly under the stylus and in line with the axis of the Gauge traverse.

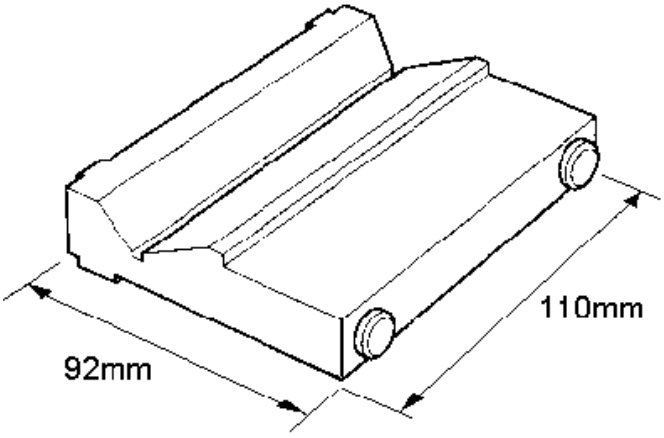
The vee block is designed to locate in the tee slot of the instrument base, or other specialised fixturing.

The tee slot dimensions are illustrated above.

Workholding, Vee Block, Plain (112/1283)



Dimensions

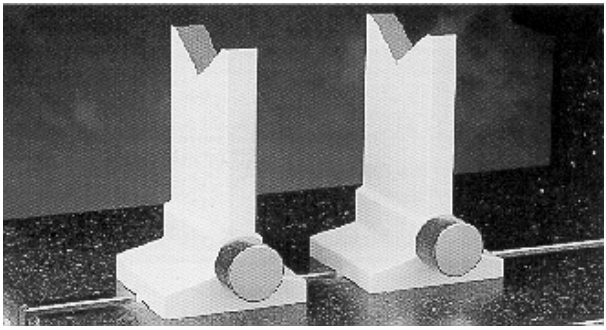


This provides a simple aid for rigidly supporting cylindrical components.

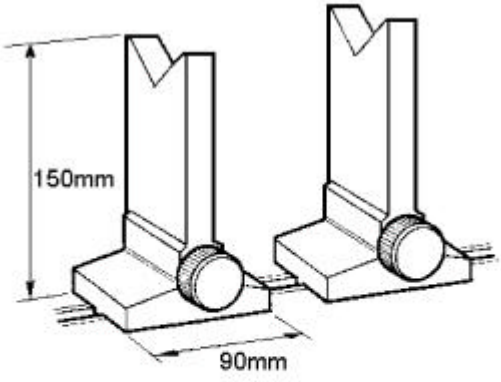
The vee is parallel with the faces of the two datum pads to assist with the alignment of the component to be measured, and is undercut to enable positive seating for the component.

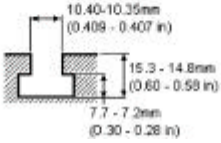
The vee block stands on three ground feet for maximum stability.

Workholding, Vee Block, 150mm (112/1645)



Dimensions





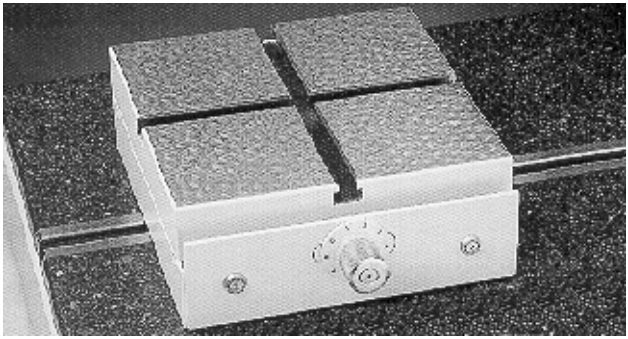
These vee blocks are provided as a pair and can be used to support components such as crankshafts, which cannot be easily supported on plain or adjustable vee blocks.

Each vee block can be locked into position in the tee slot.

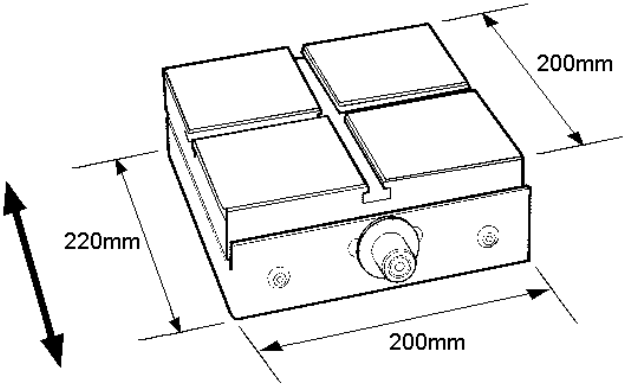
The vee block is designed to locate in the tee slot of the instrument base, or other specialised fixturing.

The tee slot dimensions are illustrated above .

Workholding, Worktable, 'Y' Axis (112/1826)



Dimensions



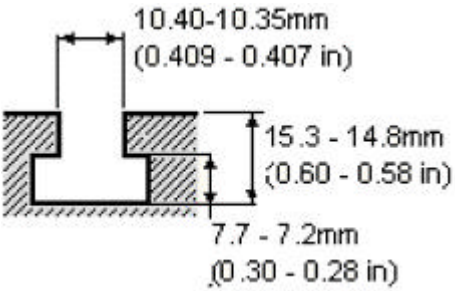
The 'Y' Axis worktable provides adjustment of the workpiece position at 90 degrees to the direction of gauge traverse. The worktable has a tee slot in both X and Y axes.

The total lateral adjustment of the table is 10mm (0.39in) minimum, indicated by a scaled knob. The table load capacity is 20kg (44lb).

This unit can be free standing or adapted for tee slot mounting.

This accessory can also be used with the adjustable vee block (112/1326) to position a cylindrical workpiece at right angles to the Gauge traverse.

The tee slot dimensions are:



Workholding, Universal

There are two options for the Universal workholding:

1. Complete assembly as shown. (112/3064)

Specification

Shift direction:		X, Y, Z, θ, T
Travel range:	X, Y	25mm
	Z	5mm
	θ	360^o
	T	10^o
Graduation:		0.01mm
Resolution		0.005mm
Load Capacity		1kg
Weight		0.6kg approx

X-Y Stage and Vee block only. (112/3067)

Specification

Shift direction:		X, Y
Travel range:	X, Y	25mm
Graduation:		0.01mm
Resolution		0.005mm
Load Capacity		1kg

Attaching both options to the base/free standing base

Both options are supplied with an Interface plate that fits into the tee slot of the base. Two screws can then be tightened to secure the interface plate and hence the workholding to which it is attached, in place on the base. A 4mm A/F Allen key is required to tighten the two screws.

Steatite Group

Data Sheet

Fast Charger
for NiMH 6V/3.6Ah batteries

Charger P/N: (265-943)
Battery P/N: (249-36)

27-06-2000

Taylor Hobson Fast Charger

General Description

The Fast Charger (265-943) is designed to charge the nickel-metal hydride (NiMH) 6V, 3.6Ah battery pack (249-36). The system comprises three independent chargers utilising a pulsed-current charging technique together with voltage slope and over temperature termination. Each of the three charger circuits employs a four-stage charge sequence that provides a complete recharge without overcharging.

The charger monitors for the presence of a battery and begins charging when a battery is installed in the charge bay. Voltage and temperature are measured to ensure that the battery is within fast charge conditions before charge is initiated.

Features

- Three independent charger bays with dedicated signal indicators.
- Multiple charge termination methods:
  - Voltage slope
  - Maximum temperature
  - Charge timer
- Four stage charge sequence:
  - Soft start charge
  - Fast charge
  - Topping charge
  - Maintenance charge
- Reverse-pulse charging in all charge stages.
- Fast charge time: < 2½ hours.
- Out-of-temperature range detection:
  - Hot battery: charger shutdown
  - Cold battery: low current charge
- Continuous polling mode for battery detection.

Charger Operation

Charging Stages

The charging sequence consists of four stages. The soft start stage gradually increases current levels up to the fast charge rate during the first two minutes. The soft start stage is followed by the fast charge stage, which continues until termination. After termination, a two-hour topping charge is applied at a rate low enough to prevent cell heating but high enough to ensure a full charge. The topping charge is followed by a maintenance charge, which is intended to offset the natural self-discharge of the battery by keeping the cells primed at peak charge. The maintenance charge will continue as long as the battery is inserted in the bay.

The RED Charge Status indicator is activated continuously during soft start and fast charge. The GREEN Charge Status indicator is activated continuously during topping and maintenance charge.

Charge Termination Methods

The charger uses voltage slope, maximum temperature and charge timer methods to terminate fast charge. The maximum temperature and fast charge timer are used as a safety backup during the main charge cycle.

If the temperature of the battery exceeds the maximum limit during a charge cycle, the charger will shutdown and stop charging. The YELLOW Battery Temperature indicator will latch on indicating a Hot Battery condition. The user must remove the battery and manually reset the charger via the recessed push-button switch situated at the back of the unit. The battery must be allowed to cool before it can be reinserted and charged again.

Note: *Repeated over temperature shutdowns indicates a potential fault condition and the battery must be removed from service immediately and returned to the supplier with details of the problem.*

The charger uses a timer to limit the fast charge duration to 144 minutes. For safety, the fast charge timer is always enabled and cannot be disabled.

Note: *Powering-up, removing and re-inserting a battery, or manually resetting the charger using the push-button switch will reset the safety timer.*

Battery Detection

Upon power-up, removal of a battery, or manual reset after an over temperature shutdown condition, the charger enters the battery polling detect mode. To indicate this mode, the YELLOW indicator will flash continuously. Once a battery is installed in a charger bay, the YELLOW indicator will stop flashing and the charger will enter the soft start stage.

Cold Battery Charging

The charger checks for a cold battery before initiating fast charge. If a cold battery is present before fast charge begins, the charger begins a two hour topping charge cycle. If the battery is still cold after the two hour topping charge is complete, the charger begins a maintenance charge. The maintenance charge will continue for as long as the battery remains cold. The charger checks the temperature every second to see if the battery has warmed up. If the battery warms up, the charger stops the topping or maintenance charge and begins the fast charge cycle.

The GREEN Charge Status indicator and the YELLOW Battery Temperature indicator will be active, indicating that a low current charge is being applied to the battery that is outside the specified temperature range for fast charging.

Safety Features

In the event of an accidental short circuit across the battery terminals inside the charger bay, the charger will automatically limit the internal current to 1.8A (normal fast charge current) to prevent damage to the electronics. The GREEN Charge Status indicator will flash and the YELLOW Battery Temperature indicator will turn on indicating the condition. *The user must immediately turn off system power and remove the short circuit obstruction from the charger bay*.

The input to each charger circuit is internally protected with a 3.15A fuse. *A blown fuse indicates a fault condition and must not be replaced by the user.*

Additionally, each battery pack includes a PTC fuse to protect against accidental short circuits across the battery pack terminals. The PTC should automatically reset itself when the short circuit condition is removed. *If the pack does not recover from the short circuit condition, the battery must be removed from service immediately and returned to the supplier with details of the problem.*

Please refer to the Operating and Safety Instructions for the Fast Charger System and Battery Packs supplied with the charger unit for additional safety information.

Electrical/Mechanical Specifications

Fast Charger

Parameter	Min.	Max.	Unit
Operating Temperature	0	+55	°C
Storage Temperature	0	+60	°C
Input Voltage Range	100 - 240		VAC
Line Frequency	47	63	Hz
Power Consumption		100	W
Input Receptacle	3-pin IEC (fitted with 5A quick blow fuse)		
Dimensions (L x W x H)	236 x 152 x 200		mm
Weight	2		Kg
Case Material	UL94HB HIPS		
LVD Approvals (LVD Safety Directive 73/23/EEC)	EN60335-2-29	Safety requirements for battery chargers.	
EMC Approvals (EMC directives 89/336/EEC amended by 92/31/EEC)	EN50081-1:1992	Generic Emission Standard: Residential, Commercial and Light Industry Environment	
	EN50082-1:1997	Generic Immunity Standard: Residential, Commercial and Light Industry Environment.	

Charging

Fast Charge Rate	C/2 (1.8A pulsed)
Topping Charge Rate	C/10 (2 hours)
Maintenance Charge Rate	C/40
Charge Termination	Voltage slope, maximum temperature, charge timer
Fast Charge Time	< 2½ hours

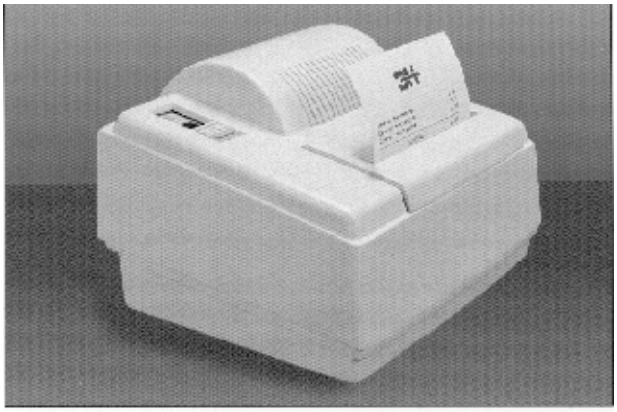
Signal Indicators

Charge Status LED	Battery Temperature LED	Description
Off	Flashing yellow	Insert Battery
Red	Off	Fast Charging
Green	Off	Topping/Maintenance Charge – Battery ready to use
Green	Yellow	Battery Cold – Trickle charge warm-up before fast charge (Charge Status LED green and Battery temperature LED yellow)
Off	Yellow	Battery Hot: Charger shutdown – 'Push-button reset' when cool (Repeated shutdowns indicate a fault condition)
Off	Off	No power to charger or open battery

Warning! Use only the 249-36 battery pack with the 265-943 Fast Charger. The use of any other battery types and fast charger systems will invalidate any approval or warranty applying to the charger and battery packs, and may be dangerous.

Steatite reserves the right to amend specifications without prior notice.

Printer (112/2762)



A typical printer is shown above. The printer can be used for producing hard copy of measurement results, parameter text and profile displays.

Specification

Resolution:	8 dots/mm (203 dots/in)
Speed:	30mm/sec (1.2in) maximum
Paper width:	108mm (4.4in)
Print width:	100mm (3.9in)
Dimensions	190mm x 175mm x 131mm (7.48in x 6.89in x 5.16in)
Weight	TBD
PSU	External

Epson Thermal

Epson printer TM-T88 IIP

Specification

Print Method	Thermal line printing.
Dimensions (mm)	W145 x D195 x H148
Weight approx.	1.8kg.
Print Speed	38 LPS (1/8" conversion) (120mm/sec).
Interface	RS-232C / bi-directional parallel / RS-485 (option).
Paper Dimensions	Thermal roll paper 79.5 +/- 0.5mm x dia. 83mm.
Power Supply	24VDC +/-7%.

Deskjet Printer 112/2902

Description
The Hewlett Packard Deskjet 950C printer can be supplied as an optional accessory and provides an alternative or addition to the printer 112/2762.

Results printouts are output to fit on A4 or Letter size paper.

Details of operation and specification are provided in the manufacturer's handbooks.

Versions are supplied appropriate to the country in which it is to be operated:

112/2902 E	for use in the U.K.
112/2902 F	for use in France
112/2902 G	for use in Germany
112/2902 I	for use in Italy
112/2902 S	for use in Spain
112/2902 U	for use in the U.S.A. and Canada.

Important

1. Do not load the printer driver software supplied with the Deskjet printer. The printer drivers required for use with Taylor Hobson equipment, are included and loaded with the instrument software.

2. Use only the lead supplied with the Taylor Hobson equipment to connect the printer to the parallel port of the computer. Do not use the lead supplied with the printer.

For further details on the printer, refer to the manufacturer's handbook supplied.

Laserjet Printer 112/2696

Description
The Hewlett Packard Laserjet printer can be supplied as an optional accessory and provides an alternative or addition to the printer 112/2762.

Results printouts are output to fit on A4 or Letter size paper.

Details of operation and specification are provided in the manufacturer's handbooks.

Versions are supplied appropriate to the country in which it is to be operated:

112/2696 E	for use in the U.K.
112/2696 F	for use in France
112/2696 G	for use in Germany
112/2696 I	for use in Italy
112/2696 S	for use in Spain
112/2696 U	for use in the U.S.A. and Canada.

Important

1. Do not load the printer driver software supplied with the Laserjet laser printer. The printer drivers required for use with Taylor Hobson equipment, are included and loaded with the instrument software.

3. Use only the lead supplied with the Taylor Hobson equipment to connect the printer to the parallel port of the computer. Do not use the lead supplied with the printer.

For further details on the laser printer, refer to the manufacturer's handbook supplied.

PCMCIA Card (112/3022)

The flash disk socket on the Intra PCM is designated as:

PCMCIA Type II

This specification covers the physical and electrical specifications of the interface.

The flash memory cards must conform to the following specification:

PC Card ATA

Specification

Removable media:	One PCMCIA Type II slot provided for use with optional PC Card ATA Flash Disks.

PCM Stand (112/3047)

A PCM stand is available to mount the PCM.

Flight case

The flight case provides the means to transport the traverse unit , PCM, power supplies, all required leads, gauge and Operator's manual.

This glossary contains descriptions of terms used in connection with the measurement and analysis of surface texture. Some terms relate to the functions and facilities of certain types of hardware or software and may not apply to your particular system.

A

A-D converter

Analogue to digital converter which is used on the **analogue** output of the **transducer** to create **Data Points.**

Amplitude Distribution

The distribution of frequency with which peaks of the same height occur in the measured profile data.

Analogue

Faithful representation of the changing states of something in the real world. The essence of analogue representation is that the measurement value is continuously variable, usually between known limits. The output from a **transducer** is analogue. An analogue signal is converted to digital in an **A-D converter**.

Analysis

Can refer to **Primary Analysis** or analysis of **roughness, waviness** etc. Analysis comprises form fit, form removal, filtering and parameters.

Arcuate Correction

The correction applied to the output from the **transducer** to compensate for the fact that the **stylus** (whose arm is pivoted) moves in an arc rather than a straight line.

Assessment Length

That part of the profile which remains after the various **filters** have removed **sampling lengths** (or parts thereof) from either end of the **data length**.

Auto Reverse

A facility to re-position the **stylus** at the start position automatically after a **data collection** pass. It does *not* automatically repeat the pass.

Axis

Unlike some other branches of mathematics and science, the y-axis is “front-to-back”, the z-axis is vertical and the x-axis is (as in the normal convention) horizontal. The term “z axis” is normally used to describe the column.

Axis Calibration

The action of specifying to the software the positions at which the traverse unit and column carriage are regarded as being located. This then provides a reference point on each **axis** for subsequent measurement or movement. The positions will normally be close to the physical positions (for example, the extreme left position of the traverse unit is nominally zero) but the reference will be precise; the physical position is not.

B

Balance

This term used to describe the resistive balance and phase characteristics that relate to inductive gauges only.

Bandwidth

The ratio between the wavelengths of the Lc Cut-off and Ls Cut-off values.

Specifies the ratio of the low pass cut-off to the high pass cut-off and represents the range of wavelengths that will remain after the filtering process

Bearing Ratio

Alternative term for **material ratio**.

C

Calibration

A generic term which, in terms of surface metrology embraces **axis calibration** and **gauge calibration**.

Calibration Constant

A numerical value that is required by the algorithms used to calculate the **parameters**. Typically, 6 such constants are computed during a calibration session. Used to minimise inaccuracies in the hardware.

Calibration Standard

A test surface having known values.

Coefficient

A mathematical term whose equivalent in the present context is **Calibration Constant**.

Constant

See Calibration Constant

Crowning (cresting)

For surface measurement, crowning (sometimes referred to as cresting) is the process of determining the highest point of a component that has a convex form, or the lowest point of a concave form. This is normally an iterative process in which the stylus is traversed over the component a number of times until the position of the turning point is established.

The stylus is then automatically positioned at this point on the component. The term Cresting is more properly applied to the alignment of the stylus to the axis of rotation of an instrument designed for the measurement of roundness

Cut-off

A portion of the profile, with length of **sampling length**, which is often regarded as a basic element in a specification of a surface measurement. The term is also used to refer to a wavelength but is ambiguous when used unqualified in this sense. In this sense, the qualified term **Lc Cut-off** or **Ls Cut-off** should be used instead.

Cut-off Length

A term often used to mean the same as **Sampling Length**.

D

Data Collection

The term used to describe the action of drawing the **stylus** across the **component**. (The term “measurement” can be ambiguous and is not normally used unqualified).

Data Length

The distance over which the stylus is drawn while data collection is taking place. Data Length does not include Run-up Length. The use of filters reduces data length down to assessment length. It is, arithmetically, the sampling length times the number of cut-offs used in the measurement. Also known as evaluation length and measurement length.

Data Point

A point on the analogue representation of the surface contour which has been sampled by the A-D converter and, consequently, had its position in space recorded by having co-ordinates allocated to it.

Datum

A fixed reference, to which the displacements of the stylus are referred. An independent straight datum is embodied in the Traverse Unit.

Desert Landscape

An analogy from nature which is often used to illustrate the concepts of **roughness**, **waviness** and **form**.

Device

An element which goes to form part of an **instrument**. Examples of elements would include the traverse unit, gauge, motorised y table, etc.

E

Evaluation Length
A term which means the same as **Data Length.**

Extend
Movement of the traverse unit to the left.

Extended Parameter
A surface finish parameter such as dc or HSC that requires one or more pieces of additional information to be specified for its calculation such as ‘height’.

F

Filter
A device for excluding unwanted, but closely specified, parts of the **raw data profile** from the **analysis**

Form
The overall “shape” of the object under test and the accuracy with which it conforms to a perfectly shaped conceptual model. In terms of the analogy with a **desert landscape**, form is the large undulations of hills and valleys.

Form Analysis
The calculation, carried out in the software, which creates a conceptual form fit (for example a straight line or an arc). It is the variation between this form fit and the real profile that enables parameters to be calculated.

Form Analysis

The calculation, carried out in the software, which creates a conceptual **form fit** (for example a straight line or an arc). It is the variation between this form fit and the real profile that enables **parameters** to be calculated.

Form Fit

A theoretical line or arc with which the real profile is compared.

G

Gauge

Mechanical assembly comprising the **transducer**, a pivoting mechanism to allow the **stylus** to move within its **stylus range** and an electrical connection.

Gauge Calibration

The measurement of an appropriate **calibration standard** (eg a radius) to enable the software to derive a set of **calibration constants** which are applicable to a the current gauge and gauge range.

Gauge Orientation

Whether the **stylus** is pressing UP or DOWN on the **component**. A gauge orientation of NORMAL is pressing DOWN, INVERTED is pressing UP. The gauge is constructed such that, when pressing UP, the stylus exerts the same force on the **component** as when pressing DOWN.

Gauge Range

The distance of vertical travel which the particular transducer permits the **stylus** to make. Normally in the range 0.5mm to 20.0mm.

Gauge Resolution

The smallest movement which the instrument can detect.

H

I

Inductive

The type of transducer that is housed within a gauge and converts the movements of the stylus into electrical signals. An inductive transducer employs the very small movements of the stylus to move an armature between two coils to change their relative electrical inductance. The amplitude and direction of these changes provide the output from the gauge.

J
K
L

Lc Cut-off

Used to specify the long wavelength limit for the Roughness bandpass filter. Wavelengths longer than this length will be removed by the filtering process.

See also Ls Cut-off and bandwidth.

Length

An ambiguous term when used unqualified. See Assessment Length, Cut-off Length, Data Length, Evaluation Length, Measurement Length, Sampling Length, Run-up Length, and Traverse Length.

Ls Cut-off

The short wavelength limit for the Roughness band pass filter and primary filter.

The Ls Cut-off specifies the low pass cut-off length for the selected filter. Wavelengths shorter than this length will be removed by the filter process.

See also Lc Cut-off and bandwidth.

Lf Cut-off

The short wavelength limit for the Waviness filter. Wavelengths shorter than this length will be removed by the filter process.

M

Material Ratio

The ratio expressed as a percentage, of the length of surface at any specified depth in the profile to the evaluation length.

Measurement Axis

The axis from which measurements are taken (x-axis) and used in the computation.

Measurement Length

A term which means the same as **Data Length.**

Measurement Loop

The physical connection between the structural elements of the instrument which provide the physical reference against which the movement of the stylus is measured. The measurement loop will typically comprise the transducer, stem, carriage, column, base, clamp and component and all the connections between them.

Measurement Speed

The speed at which the traverse unit moves during **data collection**. See also **Movement Speed**.

Modified Profile

The output from the analysis after form removal and filtering which is used in the further analysis of Primary, Roughness and Waviness surface finish.

N

O

Off-line

Used to indicate that the software is not to communicate with the instrument. Typically used when analyses use previously stored measurement data.

P

Parameter

The set of values used in surface metrology to describe the texture of a surface in quantitative terms. Phase Grating Interferometric transducer.

Primary Analysis

Analysis that takes **primary data** as its input carries out **form fit,** primary filtering and calculates **primary parameters**. The output from primary analysis is called the **Modified Profile**.

Primary Filter

The low pass filter used to reduce the number of **data points** from a **data collection**. It is an intelligent selection in that it takes account of the profile to reflect any significant feature that may be so narrow that **data density** selection might miss it.

Primary Parameters

Parameters which are produced by **primary analysis**

Profile

The trace of the **component**. It is stored digitally in terms **data points.**

Q

Qualifier

The optional variable(s) used in the calculation of a parameter.

R

Range

see Gauge Range

Raw Profile

A term often used which means broadly the same as **Primary Data**. Also known as Raw Data.

Resolution

see Gauge Resolution

Retracting

Stylus movement from left to right. Measurement must take place only while the stylus is retracting in order to avoid the effect of backlash in the mechanism and to prevent the stylus from digging in to the **component**. The opposite of retract is **extend**.

Roughness

The microscopic ridges by which the surface differs from a perfectly smooth line or plane. It is described in terms of the wavelength of the profile. In terms of the analogy with a **desert landscape**, roughness is the grains of sand.

Roughness Filter

A filter which removes longer wavelengths (that is, removes **waviness**).

Run-up Length

The amount of travel allowed for the traverse mechanism to stabilise before **data collection** begins.

S

Sampling Length

A term which has different meanings in different contexts. For a primary profile, it is equal to the **data length**. For **roughness** and **waviness** analysis, it is equal to the selected Lc Cut-off wavelength. Also known as **Cut-off Length**.

Stylus

The element which follows the contour of the **component**.

Surface Texture

See Texture

T

Texture

The generic terms which includes **roughness**, **waviness** and **form**. It is conveniently described by analogy with a **desert landscape**.

Transducer

The device which converts **stylus** movement to an electrical (**analogue**) signal. The analogue signal is converted to digital in an **A-D converter**.

Traverse Length

The full distance over which the **stylus** is drawn for a **data collection** operation. It includes **Run-up Length**. Arithmetically it is Data Length plus Run-up Length.

Traverse Unit

The drive unit which moves the **stylus** in the x-axis. **Data collection** must take place only while the traverse unit is **retracting**.

U

V

W

Waviness

Undulations which are larger than roughness but smaller than the shape called “form”. It is described in terms of the wavelength of the profile. In terms of the analogy with a **desert landscape**, waviness is the ripples in the sand.

Waviness Filter

A filter which removes shorter **wavelengths** (that is, removes roughness).

Wavelength

The distance between corresponding features of a substantially repetitive profile.

X

Y

Z

APPENDIX A

DATA EXCHANGE PROTOCOL CONVERSION

Description
The CONV_DEP program is a utility that enables the operator to transform measurement data files, from their original binary format into the ASCII format.

Note The CONV_DEP program is run from a Windows command prompt box.

File Conversion
The CONV_DEP program must be executed with three parameters, these are:

- The source path and filename.
- The type of output required (-A for ASCII format or -B for Binary format).
- The destination path and filename.

Typical examples of commands are:

CONV-DEP MEAS01.PRF -A MEAS01.TXT

The above command causes the data in raw profile file MEAS01.PRF to be converted into ASCII character format and output to the file MEAS01.TXT.

Restrictions and limitations
The Form Talysurf INTRA can only read data in a Binary format.

DATA EXCHANGE PROTOCOL (version 2.0)

Introduction
The 'DEP v2.0' file protocol enables Measurement data (Raw profile) information to be saved with sufficient detail for the reproduction of the data at a later date.

Raw profile data
To provide the facility of reloading a saved profile, independent of the current system configuration and parameters, information is stored relating to:

Number of data points.
- Data resolution.
- Spacing of data points.
- Measurement calibration coefficients.
- Radius of the stylus tip used for the measurement.
- Measurement date
- Calibration date

The protocol for the Raw profile is divided into three separate sections or records.

RECORD 1
The first record contains a fixed header declaring:
1) The format in which the file is stored.
2) The revision of the data exchange protocol used.
3) The feature name, number and extension of the stored feature.
4) The number of data points in the profile.
5) The scaling of the data points.

These are followed by a declaration of the axis resolution and the amount of information contained in the file.

RECORD 2
This may contain information that relates to :
1) The tip radius of the stylus,
2) The spacing of mapped or incremental axes.
3) The calibration correction coefficients.
4) User comments related to the feature.
5) Measurement date
6) Calibration date

RECORD 3
The Third record contains the measured axis data.

Each record is terminated by an 'EOR' command and the file terminated by 'EOF'.

APPENDIX A

Note. When measurement data is saved via the CONV-DEP utility, the file created is identified by the Feature name and Number of the original measurement. This information is included in the record 1 of the data file and is not changed by renaming the file.

Conventions
In the descriptions which follow:

- The Italic Text indicates mandatory text that appears at the start or end of the record.

DESCRIPTION OF SPECIFIC TERMS VALID IN RECORD 1

Field Name	Example / Options	Comment
'Data format'	:'0'	- Indication of binary file format.
	:'1'	- Indication of ASCII file format.
'Revision No.'	:'2'	- DEP Revision 2.00.
'<cr><lf>'	:	- Line Terminator
'Feature Name'	: 'RTH_'	- Name padded with spaces to 6 characters.
'Feature No.'	: 0.0e0	- Number in double precision floating point format.
'Feature Type'	: 'PRF'	- Raw PRoFile data.
'<cr><lf>'	:	- Line Terminator.
'Axis'	: 'CX'	- Cartesian X-axis data.
	: 'CZ'	- Cartesian Z-axis data.
'Data Type'	: 'M'	- Mapped data.
'No. Data Points'	: 4.003e3	- Number of data points (double precision float).
'Units'	: 'M'	- Metres.
	: 'MM'	
	: 'UM'	
	: 'NM'	
	: 'PM'	
	: 'IN'	- Inches.
	: 'MIN'	
	: 'UIN'	
	: 'NIN'	

Field Name	Example / Options	Comment
	: 'PIN'	
'Scale Value'	: 1.0e0	-Scale to indicated units.
'Axis Data Type'	: 'D'	- Double precision float.
'<cr><lf>'	:	- Line terminator.
'End Of Record'	: 'EOR'	- Record Terminator.
<cr><lf>'	:	- Line terminator.

DESCRIPTION OF SPECIFIC TERMS VALID IN RECORD 2

Field Name	Example / Options	Comment
'Stylus Tip Radius'	: 'STYLUS_RADIUS'	- Tip radius command.
'Value'	: 0.1234e05	- Double precision float.
'Units'	: 'M' to 'pm'	- Metric units.
	: 'IN' to 'pIN'	- Imperial units.
<cr><lf>	:	- Line terminator.
'Ordinate Spacing'	: 'SPACING'	- Spacing command.
'Axis'	: 'CX' -	Cartesian X axis data.
'Value'	: 0.123e04	- Double precision float.
'<cr><lf>'	: -	Line terminator
'Calibration'	: 'MAP'	- Mapping command.
'Map Type'	: 1.00e0	- Map type for CZ to CZ.
	: 2.00e0 -	- Map type for CZ to CX.
'Source Axis'	: 'CZ'	- Cartesian Z axis data.

Field Name	Example / Options	Comment
'Destination Axis'	: 'CX'	- Cartesian X axis data.
	: 'CZ'	- Cartesian Z axis data.
'Polynomial Order'	: 1.00e0	- One coeff only (A).
	: 3.00e0	-Three coeffs (E & F) [on CX]. $z_1, z_2, z_3, x_1, x_2, x_3$
'Values'	: 0.123e04	- Values for the calib coeffs.
.	:	- Repeated for each coeffs.
'Measurement date'	COMMENT MEAS_DATE.	- Measurement Date
'Values'	: 12345678	- seconds from 1/1/1970
'Calibration date'	COMMENT MEAS_DATE.	- Calibration Date
'Values'	: 12345678	- seconds from 1/1/1970
'<cr><lf>' :	- Line terminator.	
'Comments'	: 'COMMENT'	-Command.
'Comment Text'	: 'some text'	-Comments (60 characters max).
'<cr><lf>' :	-Line terminator.	
'End Of Record'	: 'EOR' -	Record terminator.
'<cr><lf>' :		- Line terminator.

APPENDIX A

DESCRIPTION OF SPECIFIC TERMS VALID IN RECORD 3

Field Name	**Example / Options**	**Comment**
'Value'	:	- Value of specified type.
'<cr><lf>'	:	- Line terminator.
.		
.	:	- Repeated for number of axis points.
.		
'End Of Record'	: 'EOR'	- Record terminator.
'<cr><lf>'	:	- Line terminator.
'End Of File'	: 'EOF'	- File terminator.
'<cr><lf>'	:	- Line terminator.

EXAMPLE

1 2<cr><lf>
MEAS_ 0.0e0 PRF<cr><lf>
CX M 4.003e3 MM 1.0e0 L<cr><lf>
CZ M 4.003e3 MM 1.6e-5 L<cr><lf>
EOR<cr><lf>
STYLUS_RADIUS 2.0e-3 MM<cr><lf>
SPACING CX 5.0e-4 <cr><lf>
MAP 1.0e0 CZ CZ 3.0e0 1.01e0 1.2e-02 2.3e-03 <cr><lf>
MAP 2.0e0 CZ CX 3.0e0 1.2e-2 2.3e-4<cr><lf>
COMMENT MEAS_DATE 42949967295
COMMENT CALIB_DATE 42949967295
COMMENT abcdefghijklmnopqrstuvwxyz 1234567890.<cr><lf>
COMMENT ABCD....XYZ !"œ$%^&**(<cr><lf>
EOR<cr><lf>
128<cr><lf>
133<cr><lf>
.
.
.
2345<cr><lf>
2643<cr><lf>
EOR<cr><lf>
EOF<cr><lf>

CUSTOMER SERVICES

Taylor Hobson Limited
P O Box 36
2 New Star Road
Leicester
LE4 9JQ
Technical Enquiries
Tel: +44 (0)116 276 3779
E-mail: helpdesk@taylor-hobson.com
Service Enquiries
Tel: +44 (0)116 246 3135
E-mail: service@taylor-hobson.com

Website Address: http://www.taylor-hobson.com

Taylor Hobson Inc
Suite 350, 2100 Golf Road
Rolling Meadows
Illinois 60008-4231
U.S.A.

Tel: (847) 290 8090
Fax: (847) 290 1430
e-mail:taylorhobson@csi.com

Taylor Hobson SA
6 Avenue de Norvege, Hightec 4
91953 Courtaboeuf Cedex
FRANCE

Tel: +33 160 92 14 14
Fax: +33 160 92 10 20
e-mail: contact@taylor-hobson.fr

Taylor Hobson KK
No. 31 Kowa Building 19-1,
3-Chome Shiroganedai
Minato-ku
Tokyo 108-0071
JAPAN

Tel: 3 3473 7001
Fax: 3 3473 7002
e-mail:mail-box@taylor-hobson.co.jp

Taylor Hobson GmbH
Postfach 4827
Kreuzberger Ring 6
65205 Wiesbaden
GERMANY

Tel:+49 611 973040
Fax:+49 611 97304600
e-mail: info@taylor-hobson.de

Taylor Hobson (China Office)
20/F,Delta House
3 On Yiu Street
Shatin,New Territories
HONG KONG

Tel:+852 2757 3033
Fax:+852 2757 1767
e-mail:talhobhk@netvigator.com

Taylor Hobson SPA
S.p.28 Vigentina 6,
20090 Opera
Milan
ITALY

Tel: 02 5760 6424
Fax: 02 5760 6740
e-mail: TaylorITA@compuserve.com

CUSTOMER SERVICES

Taylor Hobson Liaison Office
(Austria and Eastern Europe)
Amalienstrasse 68, A-1130 Vienna
AUSTRIA
Tel: 1 877557112
Fax: 1 877557116
e-mail: thp@vienna.at

Taylor Hobson
Parc Tecnologic Del Valles
08290 Cerdanyola
SPAIN
Tel: 343 582 0227
Fax: 343 582 4359
e-mail: taylorh@ptv.es

Taylor Hobson K Inc
#402, Hayan Bldg, 153-55
Samsung Dong, Kangam-Ku
Seoul 135-091
KOREA
Tel: (822) 564-0851
Fax: (822) 539-1708
e-mail: thseoul@kornet21.net

Taylor Hobson do Brasil Ltda
R. Carlos Petit, 161 - Conj 101
Vila Mariana - Sao Paulo
BRASIL 04110 - 000

Tel. (55 11) 5083 3846

e-mail: jpitman@taylorhobson.com.br