TENCOR® P-10
SURFACE PROFILER

REFERENCE

Tencor

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Software Version 3.1

Text **#412937-27 Rev. A** **9/96**

Text & Binder **#412929-27 For Use in Class 100 Clean Rooms**

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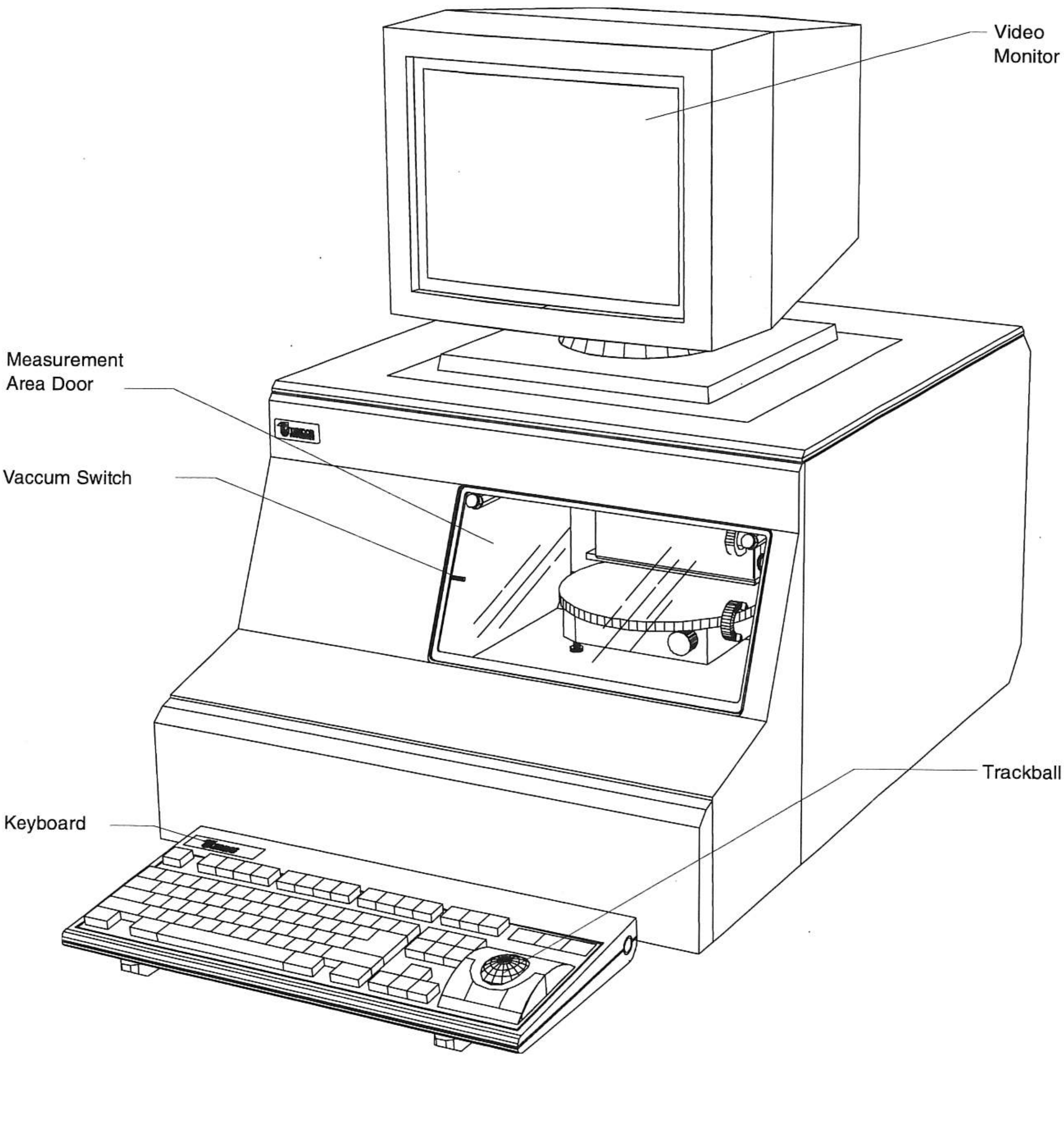
P-10 Surface Profiler



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1

INTRODUCTION

About this Manual

This manual is intended as a reference for individuals who use the Tencor P-10 Profiler to inspect and analyze sample surfaces, and as a general guide to configure and maintain the instrument.

This manual consists of the following chapters:

- Chapter 1, "Introduction," discusses how to use the manual and terminology used in this manual.
- Chapter 2, "Installation," details the procedures necessary for installation of the instrument.
- Chapter 3, "Theory of Operation," describes the principles behind the operation of the Tencor Profiler and information about the interpretation of data gathered with the instrument.
- Chapter 4, "Hardware Maintenance," discusses the Tencor Instruments service policy, troubleshooting, changing the stylus, and similar hardware issues.
- Chapter 5, "Software Maintenance," discusses troubleshooting, utility programs, backing up and recovering data, and similar software issues.
- Chapter 6, "MicroHead Measurement Head," provides information on the use of the MicroHead measurement heads.
- Chapter 7, "Desktop Program," describes the system requirements, software installation, and operation of the Desktop Program, which is compatible with data and recipes from the Tencor Profiler.
- Appendixes and an index are also provided at the end of this manual.

Related Manuals

Tencor Instruments also provides *Tencor P-10 Profiler Operations,* a manual describing the basic operation of the instrument and how to use it to collect data.

Conventions Used in this Manual

This manual uses typographic formatting and symbols to make your learning experience faster and easier. These conventions are introduced in the following sections. Keep these conventions in mind while reading this manual.

Typographic Formatting

Term	Meaning
abc...xyz	Italics are used to identify information you type using the computer keyboard.
CD D:\DATA	Messages and examples appear in bold text.
START	The keys or buttons you must press appear in small, capitalized letters.
ALT+S	When you see several keys divided by plus signs, hold down the first key while pressing the remaining key(s). For instance, hold down ALT while pressing S.
Configuration menu	Menus and windows are shown with initial capital letters.
Direction field	The term *field* is used to identify the location of areas on the screen into which you can enter data. Names of fields are shown with initial capital letters. The actual field name or description usually appears on the screen next to the location where you enter data. Some fields are for display purposes only and do not accept data.
[←] [→] [↑] [↓]	The arrow keys on the keyboard let you move the cursor around the display. To move the cursor in a specific direction, press the arrow key pointing in the desired direction. The trackball duplicates the actions of the arrow keys and allows diagonal cursor movement.
ENTER	To enter data means to type the words or data, then press the ENTER key.
NOTE	A note indicates that the information is vital to remember.
CAUTION	Contains information about a potential hazard that could result in damage to the instrument.
WARNING	Contains information about a potential hazard that could result in injury to personnel.

Arrow Keys

The four *arrow keys* are located on the operator keyboard. Each arrow key points in a specific direction. The arrow keys are used in many places throughout the Tencor Profiler software. For example, when you want to move the selection bar in menus, you press [∨] to move the bar downwards and [∧] to move the bar upwards. Use the [<] and [>] keys to move the measuring cursors in the Data Analysis window.

2

INSTALLATION

Operating Environment

The Tencor Profiler uses internal shock/isolator mounts to allow operation in a normal production-line environment. For highly sensitive measurements (that is, for artifacts below 500Å and above 1000Å or in excessively noisy areas),

Make sure that there is a minimum of 8 cm (5 in.) of space at the back of the instrument to accommodate cable connections. For service access, approximately 30 cm (12 in.) of air space on both sides and to the rear of the instrument is preferred. The computer and printer need approximately 8 cm (5 in.) of space behind them to accommodate cable connections.

CAUTION: The installation site must be free of sudden temperature changes or extreme drafts. Do not place the instrument directly in the airstream of an air-conditioning vent or heat outlet.

Facility Specifications

Vacuum	Required to hold down the samples: 6 mm (0.25 in.) nominal line providing a minimum of 500 mm (20 in.) mercury of vacuum at a flow of 27 liters/min. (1 cfm).
Dimensions	Instrument: 76 cm (30 in.) wide, 109 cm (43 in.) deep, 168 cm (66 in.) high. Computer: 18.4 (7.25 in.) wide, 40.6 cm (16 in.) deep, 34 cm (13.4 in.) high Monitor: approximately 35 cm (13.75 in.) wide, 38 cm (15 in.) deep, 34 cm (13.4 in.) high Printer (optional): approximately 46 cm (18 in.) wide, 38 cm (15 in.) deep, 20 cm (8 in.) high, requiring several inches of space in the back for cable connections.

Power	Two standard AC outlet (300V power supply operable on 90–130 VAC or 205–255 VAC 50/60 Hz), one for the instrument computer, the other for the printer, if purchased. UL, CSA, European-qualified. **Note**: If the power source is susceptible to radio-frequency interference, an isolation transformer may be necessary to provide additional filtering. Sensitive instrument computer components require a power source that is free from spikes, dips, and surges. **Note**: If power failure is a common occurrence, use an Uninterruptable Power Supply (UPS) device. A UPS device supplies power for 30 min. so that you can perform an orderly shutdown. See "Loss of Power" on page 27 for details.
Ambient Temperature	Specified operating range: 16°–26°C. Maximum rate of change: 2°C/hr.
Vibration	Floor vibration should be less than 250 µin./sec.

Installation

The following information is intended to supplement the Disk Profiler Preparation and Installation document provided with the instrument by the Tencor Instruments Service department

Note: *Save the shipping crate, shipping yoke, shipping turnbuckle, and shipping instructions in the event that the instrument is to be returned to Tencor Instruments. These items are essential and will have to be purchased from Tencor Instruments if they are needed again and are not available.*

Check the shipping crate very carefully at the time of receipt for any visible signs of possible damage. Each shipping container has Shockwatch and Tip-N-Tell monitors on the outside of the container to indicate possible damage to the instrument due to mishandling by the carrier. Descriptions of both types of monitors are provided below.

If there is any visible damage to the crate, or if the Shockwatch and Tip-N-Tell monitors indicate mishandling, make note in writing on the bill of lading before signing for the delivery. This must be done with the delivery person on site at the time of delivery.

In addition, contact Tencor Instruments Service department at 1-800-722-6775 if there is any indication of damage.

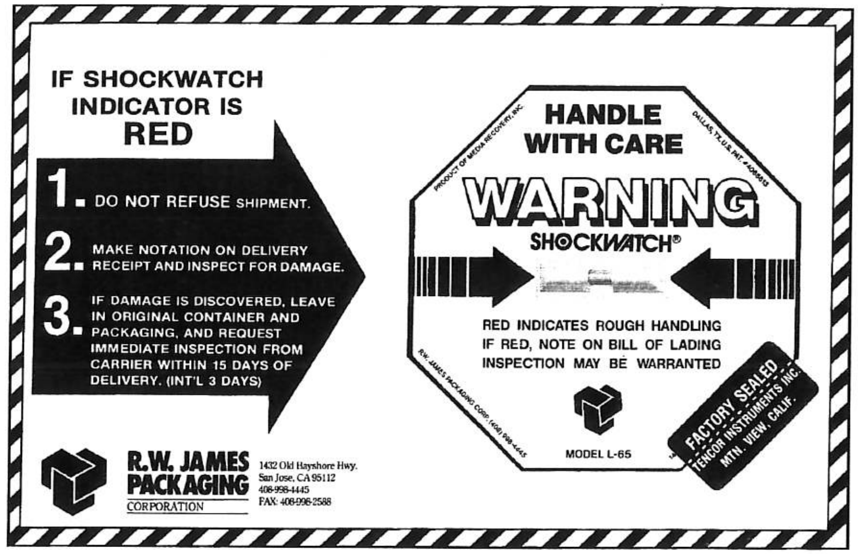
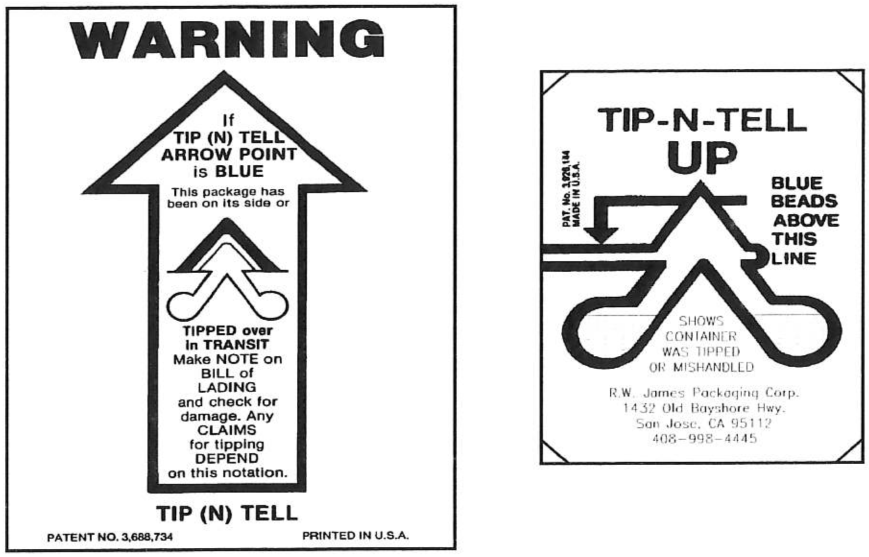


Figure 2-1. *Shockwatch Monitor*

If the indicator in the middle of a Shockwatch Monitor is red, the crate was not properly handled. Normal movements and acute angles during aircraft take-off and landing do not activate the indicator. If the instrument is damaged, notify the carrier and the service dispatcher at Tencor Instruments.

Also verify that the sticker "FACTORY SEALED, Tencor Instruments Inc., Mtn. View, Calif." on the Shockwatch Monitor is still intact. If the seal is not in place, the instrument could have been mishandled by the carrier. If the seal is missing or if it is not in place, make a note on the Service Report that the seal was missing. Check the instrument for damage and notify the carrier and the service dispatcher at Tencor Instruments in case of damage.

Figure 2-2. *Tip-n-Tell Monitor*



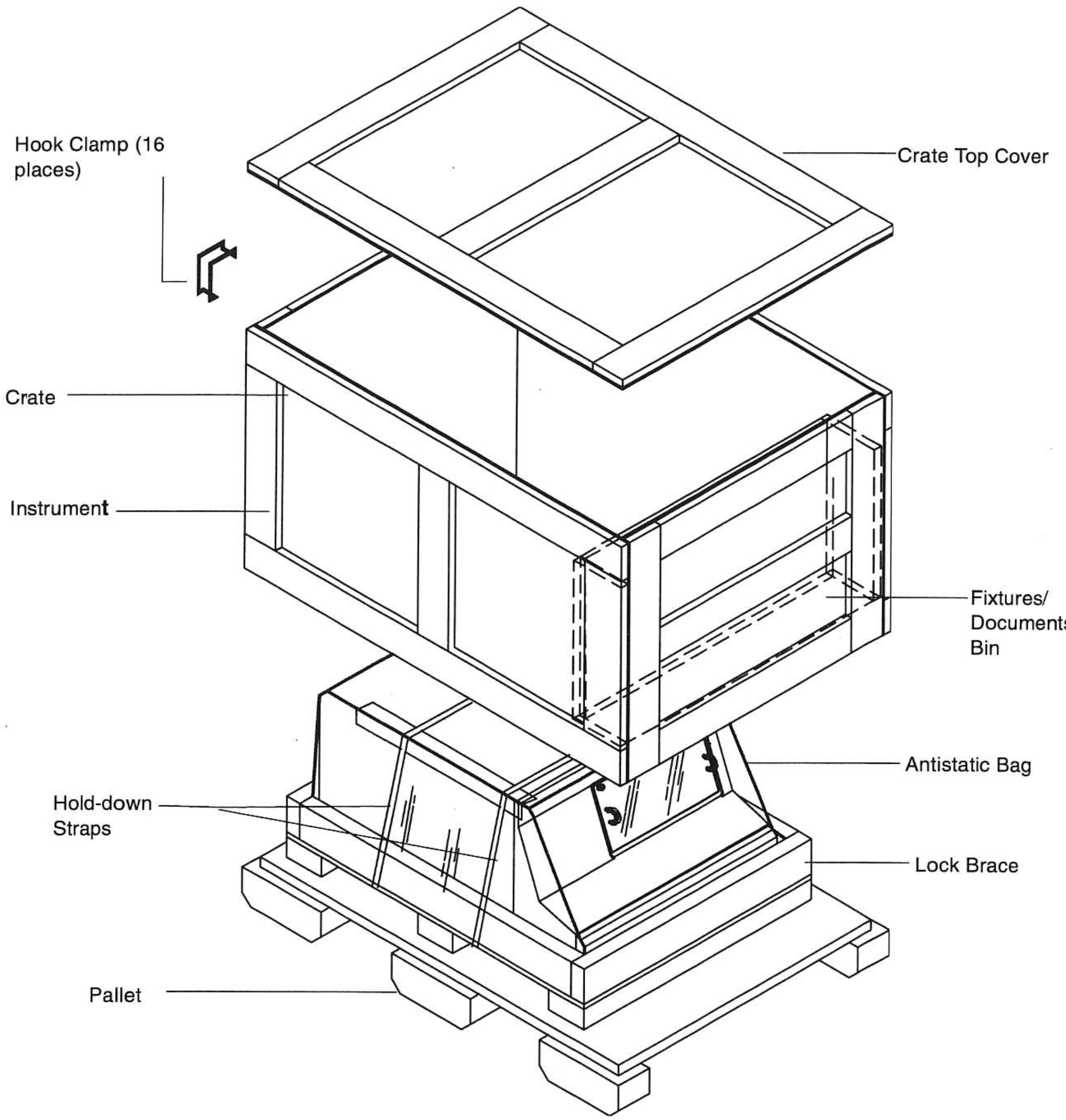
If there are blue beads above the black line (see Figure 2-2) or if the arrow point is blue, the crate was tipped or mishandled. If the blue beads indicate possible damage to the instrument, make a note on the bill of lading and the Service Report. Check the instrument carefully for damage and notify the carrier and the service dispatcher at Tencor Instruments in case of damage.

Uncrating Procedure

Uncrating the instrument requires

- A thick-blade screwdriver
- A sturdy, flat cart with locking wheels and a minimum surface area of 60 cm (24 in.) x 77 cm (30 in.), able to support 660 kg (around 300 lb).
- Two or more people to gently lift and transfer the instrument to the cart
- A forklift (optional)

Figure 2-3. *Uncrating the instrument.*



Refer to Figure throughout the following instructions.

To uncrate the instrument

1. Use the blade screwdriver to remove all the spring clamps from the front cover of the crate.

2. Lift the top cover from the crate and set it aside.
3. Remove the manuals and fixtures from the fixtures/documents bin within the shipping crate and put aside in a safe place.
4. Carefully lift the crate from the pallet to fully expose the instrument scanner section.
5. Release the web clamps on the two hold-down straps that secure the instrument to the pallet as follows:
   - Pull back on the quick release and hold.
   - Pull the handle up and over to a fully open flat position.
   - Pull the clamp up and loosen the strap.
6. Release the two brace clamps securing the lock brace in position. To release the brace clamp, rotate the lever on the clamp to extend the hold-down clamp.
7. Remove the lock brace from the pallet.
8. If a fork lift is not available:
   - Slide the instrument out until two or more strong people can comfortably get their hands under the bottom.
   - Lift the instrument carefully using proper lifting techniques for a weight of 170 lb.
   - If a fork lift is available:
   - Lift the pallet and instrument carefully until approximately level with the cart.
   - Place the wheeled cart against the pallet at the opening created by the removal of the lock brace.
   - Lock the wheels so that the cart will not roll, then slide the instrument out onto the top of the cart.
9. Unlock the cart's wheels and roll the instrument to its final location.

To unpack the computer and monitor

1. Transport the computer and monitor boxes to their final location.
2. Open the computer box carefully and remove the computer, cables and keyboard.
3. Open the monitor box carefully and remove the monitor.

Shipping Contents

The following items are shipped with the basic system.

- One set of Operations and Reference manuals
- One Tencor profiler program diskette set (total of five diskettes)
- One set Video Blaster SE video overlay software and manual
- One stylus, 5 µm, (installed)
- One stylus cleaning tool
- One vacuum fitting connector
- One power cord
- One shipping yoke

- One shipping turnbuckle
- One instrument computer
- One computer keyboard
- One computer monitor
- One set cables to connect the instrument to the computer
- One plastic forceps for stylus replacement

Check that all of the items in the above list were received. Contact Tencor Instruments if anything is missing.

Setting Up the Instrument and Computer

Setting up the instrument and computer involves

- Placing the instrument, computer, and monitor (Section , "Operating Environment")
- Connecting the vacuum line to the instrument (if required to hold down samples)
- Interconnecting the instrument, computer, keyboard, monitor, and printer (if any)

You will need

- A small blade screwdriver

Figure 2-4. *P-10 Rear View.*

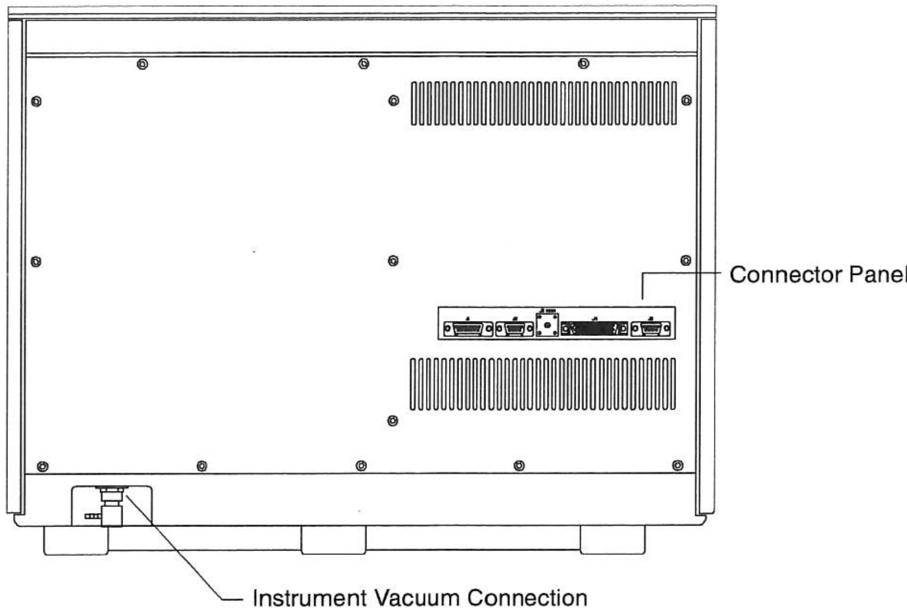
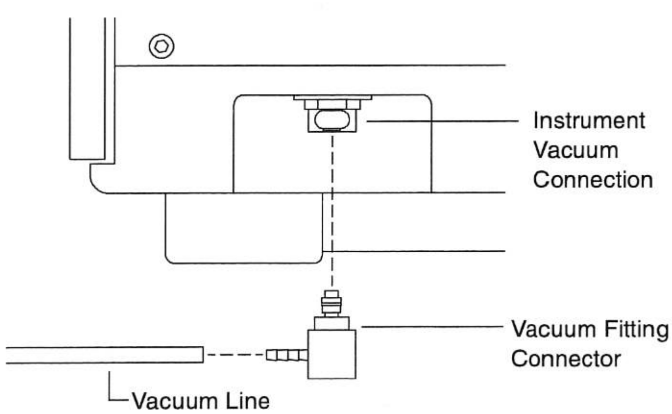


Figure 2-4 and Figure 2-5 show a rear view of the Tencor P-11 instrument with the locations of the vacuum connection and the electrical connections indicated.

Figure 2-5. *Vacuum Line Connection.*



To connect the instrument vacuum line

1. Connect the house vacuum line to the elbow-shaped vacuum fitting connector.
2. Insert the fitting connector into the back of the scanner unit.

The following instructions describe how to connect the instrument and the computer. If you are inexperienced with computer and electronic equipment and the various kinds of common connectors and cables, you should still have little or no difficulty if you read the brief description that follows before proceeding to the instructions on the next page.

Note: *If you are generally familiar with PCs, peripherals and the various kinds of common connectors and cables, you can skip the following paragraphs and go directly to the section "To connect the instrument and the computer" later in this section.*

On the inside of the computer there are several parallel slots, which allow peripheral devices to be interfaced to the computer. The interface electronics are provided in the form of standard circuit boards called *cards* that connect into slots and provide connections to outside devices at the back of the computer case. The Tencor P-10 computer has several cards that are referred to in the instructions below:

- The Universal Profiler Interface (UPI) card, which allows the computer to exchange data and instructions with the instrument, and provides power to the instrument
- The Video Blaster SE video overlay card, which takes image data from the instrument camera and allows it to be used in the computer and displayed on the monitor
- The VGA video display adapter, which provides the display data for the computer monitor

There are also other standard connections provided on the back of the computer:

- One or more parallel ports (labeled LPT1, LPT2,...)
- One or more serial ports (labeled COM1, COM2,...)
- A keyboard connector
- A connector for a standard line voltage power cord
- A connector for standard line voltage power out (used to power the monitor)

There are several different kinds of connectors used to interconnect the Tencor P-10 instrument and computer. These are:

- D connectors, so named because of the D-shaped metal shell that aligns the male and female connectors. These come in several varieties with different numbers of pins. There is usually a pair of small screws or thumbscrews that prevent the connectors from being dislodged.
- BNC connectors. The cable end has a round, knurled knob that fits over the connector on the instrument and turns into a locked position that prevents the connectors from being dislodged.
- RCA connectors. These are commonly used to connect consumer audio equipment. The female connector on the card is a short metal cylinder with a hole in the center. The male connector on the cable has a single pin concentric to three shorter cylinder sections. The central pin plugs straight into the center, and the three cylinder sections fit snugly over the outside of the female connector. The connection is maintained only by the snugness of the fit.

- DIN connectors. These are round connectors, notched to maintain pin alignment, that come in a variety of pin configurations. The cable from the computer keyboard has a 5-pin male connector that plugs straight into the 5-pin keyboard jack on the back of the computer. The connection is maintained only by the snugness of the fit.
- AC power cables. One end has the standard three-prong grounded AC plug for standard line voltage; the other end connects to a receptacle in the back of the computer. The connection is maintained only by the snugness of the fit. A similar cable extends from the VGA monitor and plugs into the back of the computer for power rather than a wall socket.
- Video Blaster interface cable. This is a special adapter that allows the Video Blaster SE overlay card to accept video and audio signals and interface to the VGA display card. It is a short cable with a single 15-pin D connector on one end and a cluster of connectors (a 15-pin D connector and 5 female RCA connectors) on the other end.

Refer to Figure 2-6 and Figure 2-7 throughout the following instructions.

Note: *Be sure to make all connections in the order described*

To connect the instrument and the computer

1. At the back of the instrument, gently plug the 15-pin instrument power cable to the leftmost connector, labeled “J1: Power.”

   Tighten the two screws on the sides of the plug so that the cable cannot be dislodged from the connector.
2. Connect the BNC end of the video cable to the connector labeled “J3: Video.”

   Gently turn the adapter clockwise until it is locked in the connector.
3. Plug the 50-pin data cable into the connector labeled “J4: Data.”

   Gently press the connector in until the spring-loaded clips on the side of the plug engage

Figure 2-6. *Rear View Detail of Connectors.*

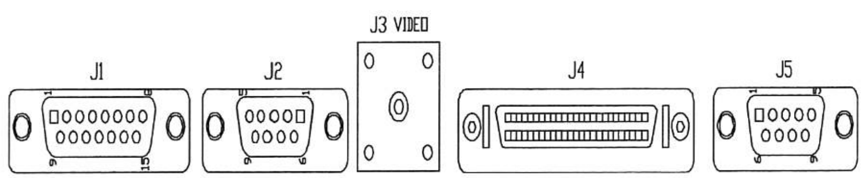
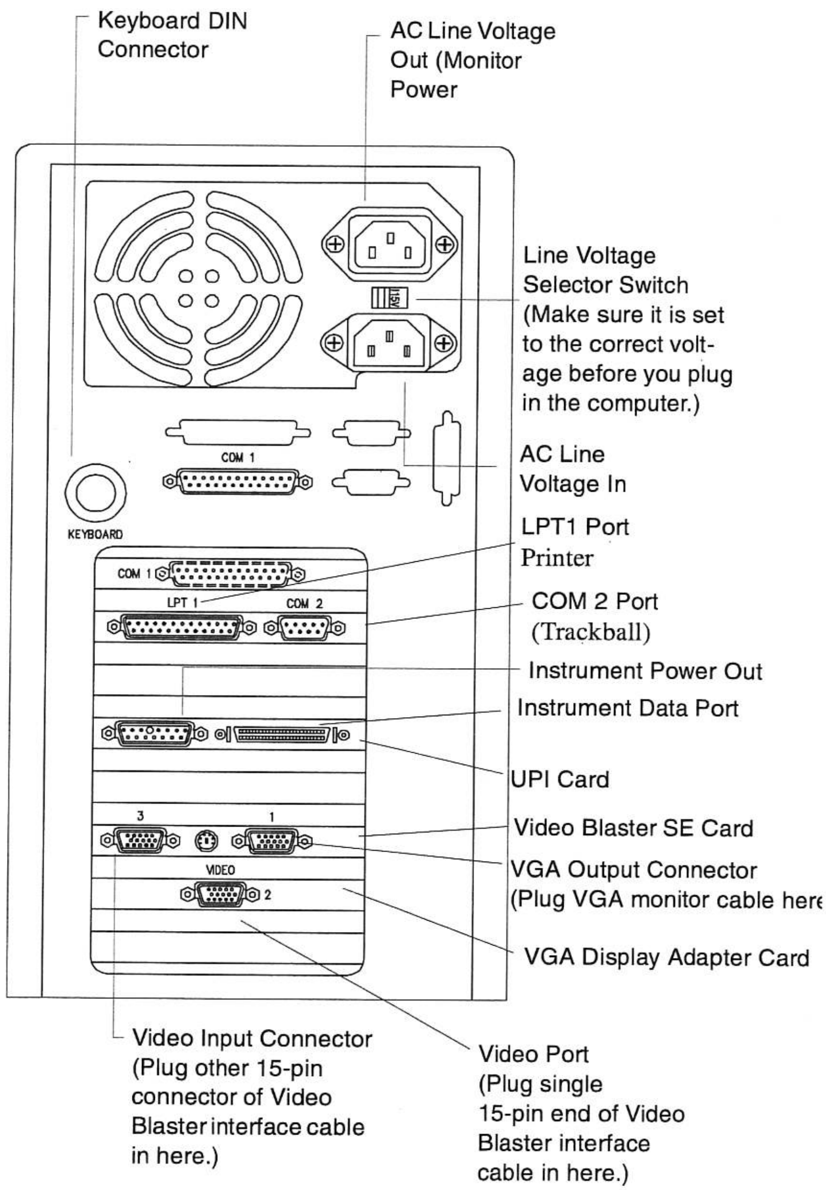


Figure 2-7. *Computer Rear View*



Make the following connections to the Video Blaster SE video overlay card on the back of the computer

1. Connect the 15-pin monitor cable to the VGA output connector. Tighten the two screws on the sides of the plug so that the cable cannot be dislodged from the connector.

> **CAUTION:** Be sure to make this connection first. It is difficult to plug in without trying to force it unless you plug it before the other connector. You can easily damage the connector pins trying to do this.

2. Connect the 15-pin D connector on the multiple-connector end of the short Video Blaster SE interface cable to the Video input connector. Tighten the two screws on the sides of the plug so that the cable cannot be dislodged from the connector.
3. Plug the RCA end of the video cable (from the J3 connector on the instrument) into the jack labeled Video 0 (the other jacks remain unconnected).
4. Connect the remaining 15-pin connector of the short interface cable to the VGA display adapter card. Tighten the two screws on the sides of the plug so that the cable cannot be dislodged from the connector.

Make the following connections to the UPI card

1. Connect the 15-pin instrument power cable (from the J1 connector on the instrument) to the Instrument Power Out connector. Tighten the two screws on the sides of the plug so that the cable cannot be dislodged from the connector.
2. Connect the 50-pin data cable (from the J4 connector on the instrument) to the Data Port connector. Gently press the connector in until the spring-loaded clips on the sides of the plug engage.
3. Plug the round DIN plug on the keyboard cable into the Keyboard DIN connector on the back of the computer.
4. Plug the 9-pin trackball cable into the serial port connector labeled COM2. Tighten the two screws on the sides of the plug so that the cable cannot be dislodged from the connector.
5. Plug the parallel cable from the printer (if any) to the parallel port labeled LPT1. Tighten the two screws on the sides of the plug so that the cable cannot be dislodged from the connector.
6. Check that the line voltage selector switch is set appropriately for the local standard line voltage (the switch will read 115V for 90–130V, or 230V for 180–240V). If not, be sure to change it to the correct setting.
7. Connect the male end of the monitor power cable to the AC Line Voltage Out connector on the back of the computer, and the other end to the line voltage in connector in the back of the monitor.
8. Connect the AC power cable to the AC Line Voltage In connector on the back of the computer.
9. Make sure that the power switch on the front of the computer is turned off, then plug the computer into a standard AC outlet.

Pre-Power Preparation

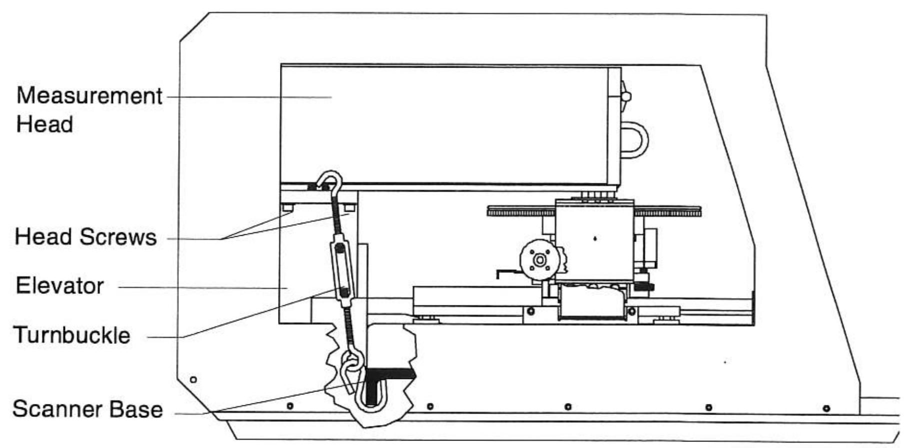
1. Open the measurement area door of the instrument. Support the left side panel

> **CAUTION:** Be sure to remove the shipping turnbuckle from the head assembly before turning on power to the computer.

   from the outside and unscrew the two thumbwheel knobs located at the inside upper corners.
2. After removing the thumbwheel knobs, press gently against the inside of the side panel and lift it away from the instrument.

   The shipping turnbuckle is located on the left side of the elevator assembly and hooks into a hole in the measurement head base and a hole in the scanner base (Figure 2-8).
3. Unscrew the turnbuckle, turning clockwise (looking downward), and remove it. Be careful not to pull the power cables off the Y-axis motor.
4. Store the turnbuckle in the shipping crate for possible future use.

Figure 2-8. *Removing the shipping turnbuckle.*



Powering Up

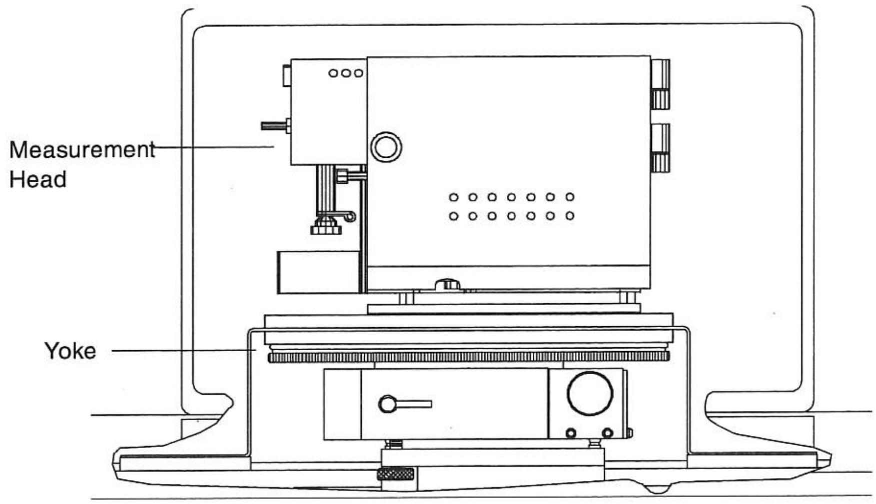
To power up the instrument

1. Press the power button on the front of the computer and the front panel of the monitor. The system boots and then displays the Windows start-up screen while initializing the Windows environment.
2. Double-click on the profiler icon in the Tencor program group. The profiler software begins initializing.
3. If you do not see anything on the monitor screen, first make sure that the monitor power switch is on and the power cord is firmly plugged in to the computer. Next, make sure that the connection from the monitor to the VideoBlaster card on

the computer has been made correctly and that the connectors are all seated and screwed in. Finally, try adjusting the Brightness and Intensity controls on the monitor. If you still do not see anything on the screen, call Tencor Service.

4. Remove the stylus protection plate by unscrewing the thumbnut screw.

Figure 2-9. *Removing the Shipping Yoke.*



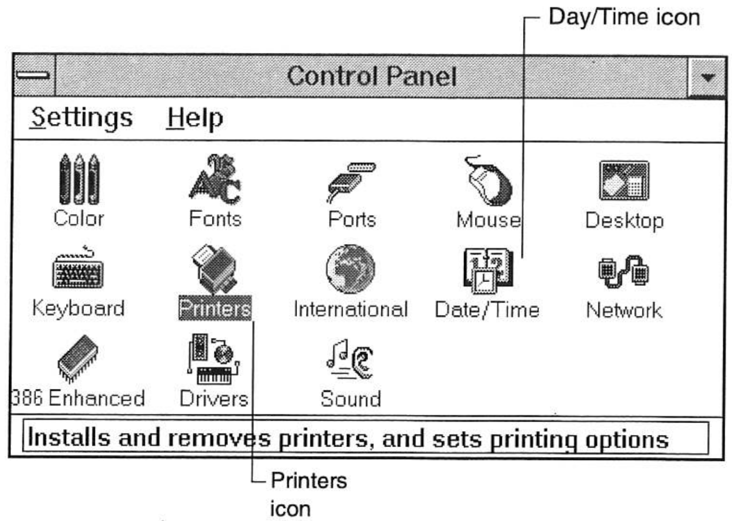
5. Close the front cover of the measurement head assembly and tighten the thumb-screw.
6. Replace the left and right side covers and secure them with the thumbwheel screws.

Setting the Date and Time

To set the date and time

1. In the Top Level menu, click on the minimize button to shrink the profiler software to an icon and reveal the underlying Windows desktop.
2. Double-click on the Control Panel icon.

Figure 2-10. *Windows Control Panel.*



3. From the Control Panel window, double-click on the Date/Time icon. The Date/Time dialog box appears, displaying the currently entered date, time, and time zone.
4. Highlight the part of the date or time (i.e., month, hour) that you want to change.
5. Type the new value.
6. Repeat for each new value you want to change.
7. Click **OK** to reset the system with the new date or time and to exit from the dialog box.
8. The instrument is now ready to use.

Installing a Precision Locator

A series of precision locators are available to enable exact positioning of a sample relative to a fixed reference point.

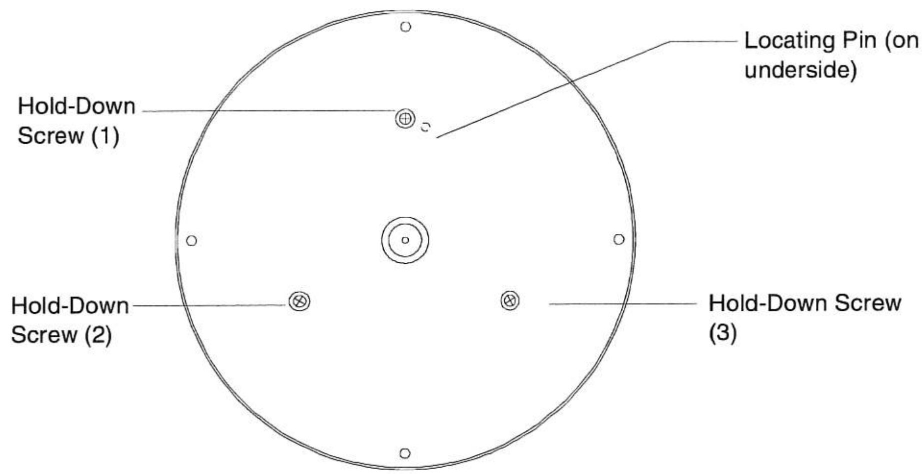
The stage table itself is removed and the precision locators bolt directly to the stage. Disk locators bolt directly to the stage table.

Note: *See Appendix E, "Precision Locators," for detailed information on precision locators.*

Standard Precision Locators

CAUTION: Recheck the setting for Lowest Elevator position when a precision locator is installed. The stylus can be damaged if the existing settings are incorrect.

Figure 2-11. *Lightweight Stage Table Top.*



9. Place the precision locator on the stage so that the three holes line up.

Disk Precision Locators

The lowest elevator position is set at the factory to allow the stylus to be nulled on the stage surface for the locator.

> **CAUTION:** It is very important to determine the correct lowest position for the elevator when a precision locator is installed. The stylus can be damaged if you leave the stage configuration with the existing setting

> **CAUTION:** When removing a precision locator, you must remove the hold-down screws (Figure 2-11) before removing the locator. Removing the locator without removing the screws could pull the stage assembly off its track.

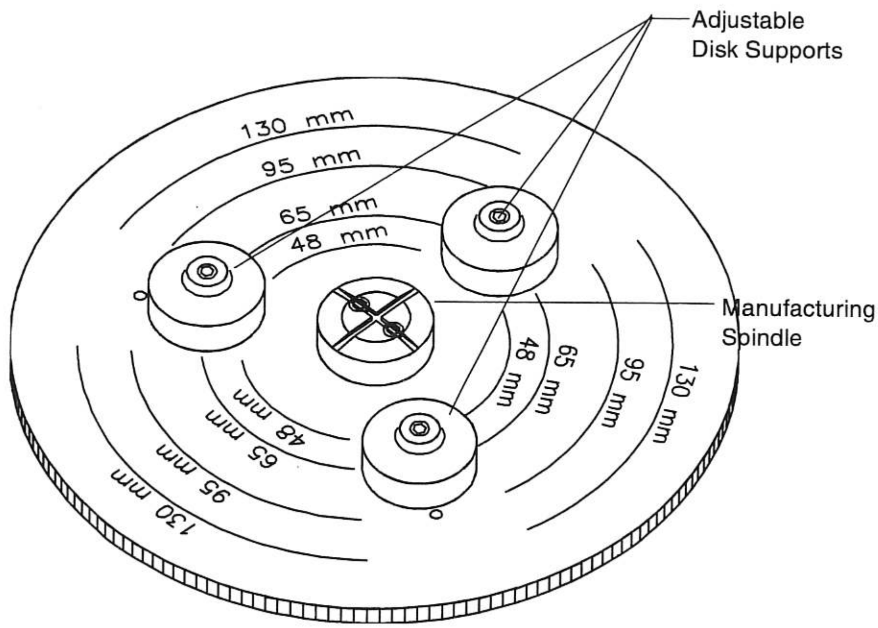
To install the 3-point disk locator

1. From the XY View window, raise the measurement head to the highest position to ease removal and avoid damaging the stylus.
2. Open the door. If the stage is not in the manual load position, click on the Manu-Load button in the tool bar to move the stage forward.

The 3-Point Disk Precision Locator

The disk locator for the Tencor P-12 profiler is shown in Figure 2-12.

Figure 2-12. *Disk Locator for Tencor Profilers.*



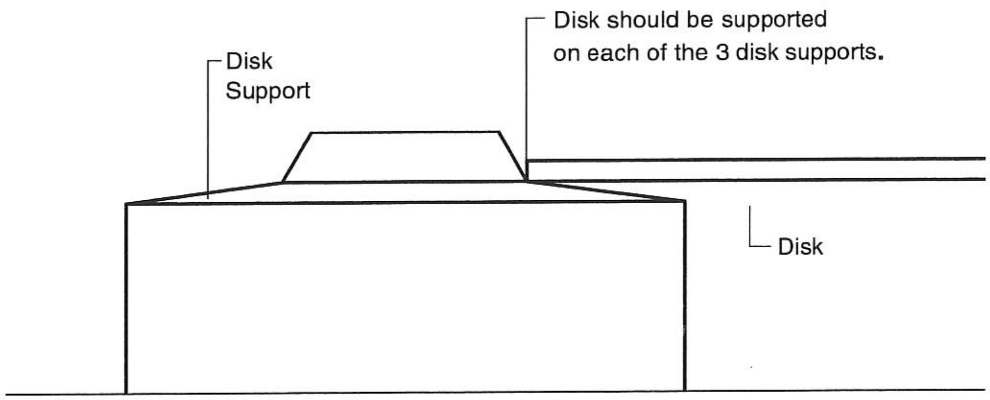
Three disk supports can be located in one of five positions to handle 48-mm, 65-mm, 84-mm, 95-mm, and 130-mm disks.

The lowest elevator position is set at the factory to allow the stylus to be nulled on the stage table top surface for the standard stage.

To adjust the disk size

1. Remove the screws (2-56 x 1/2 in.) holding each of the three disk supports.
2. Position each disk support to the desired position. The four disk sizes are identified by four concentric circles printed on the top of the locator. The circles pass through the centers of the disk support mounting holes.
3. Insert the screws and loosely tighten, so that there is still some play in the position of the three disk supports.
4. Place a representative disk on the supports and adjust them so that the disk is supported snugly between the three supports, as shown in Figure 2-13.

Figure 2-13. *Disk Support Adjustment.*



5. When the three disk supports are adjusted, tighten the three disk support screws and recheck the disk position. Leave enough clearance so that other disks this size can fit. Try to get the disk centered around the hub of the locator.

Installing a Custom Fixture

You can attach custom fixtures to the stage using three mounting holes with #8-32 hold-down screws on a 3.6-in. diameter bolt circle. Adjust it, If needed.

Setting Up Printers

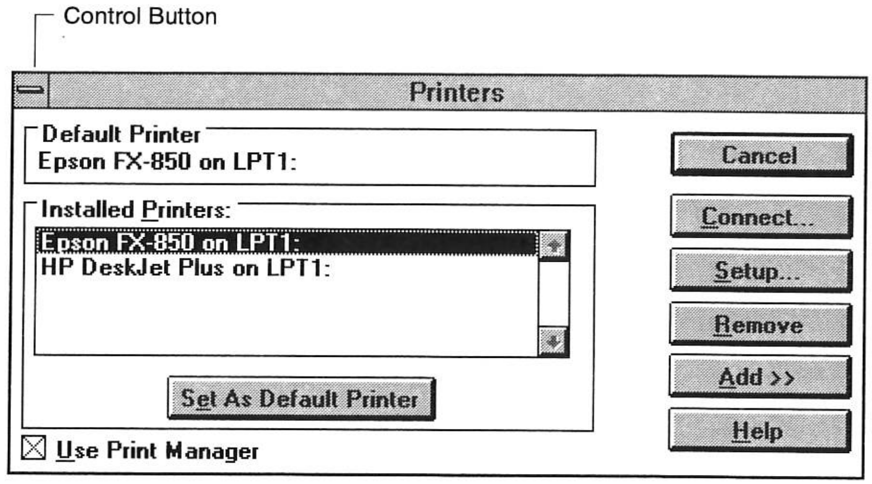
The Tencor Profiler supports virtually any printer supported by Microsoft Windows. If you have more than one printer installed, you can choose which one is active using the following procedure.

To select an available printer

1. In the Top Level menu, click on the **minimize** button to shrink the profiler software to an icon and reveal the underlying Windows desktop.
2. Double-click on the Control Panel icon.
3. In the Control Panel window, click on the Printers icon (Figure 2-10).

   The Printers dialog box appears with a listing of all loaded printer drivers:

Figure 2-14. *Printers Dialog Box.*



4. Select one of the available printers and click on **Connect**. If you want this printer to be the default printer (whenever Windows starts up), click on **Set As Default Printer**. You can also set printer options (if any) by clicking on the **Setup** button.
5. Click on the control button in the upper corner to close the Printers dialog box.

Printers are usually set up during installation of Windows 3.1. If you get a new printer of a different type, or an updated Windows driver for a previously installed printer, follow this procedure:

To add a new printer driver

1. Follow Steps 1–3 in the previous subsection, "To select an available printer."
2. Click on the **Add>>** button in the Printers dialog box. The Printers dialog box changes to include an extra list box and button (Figure 2-15).

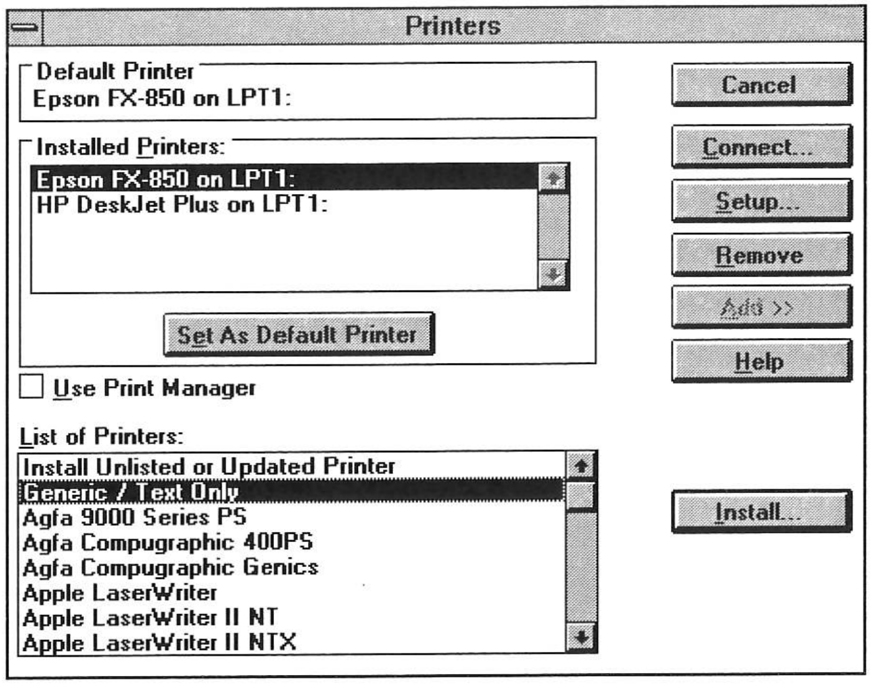


Figure 2-15. *Printers Dialog Box After Clicking Add>>.*

3. Uncheck the Use Print Manager box if it is checked.
4. Select Install Unlisted or Updated Printer from the dialog box if this is a new printer, then click on **Install**. The Install Driver dialog box appears:

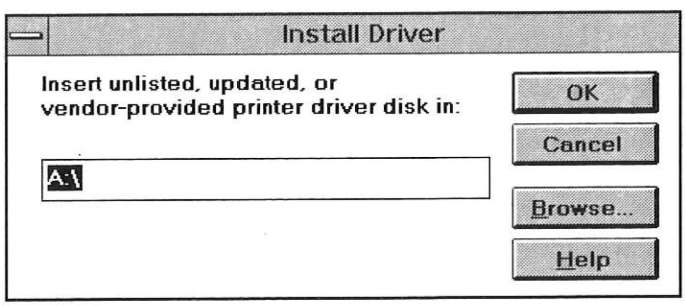


Figure 2-16. *Install Driver Dialog Box.*

5. Put the diskette with the printer driver into drive A: and click **OK**. A list of available drivers appears.
6. Choose the desired driver and click **OK**.

For more information about installing printer drivers and configuring printers, consult the Control Panel help system, your Windows documentation, and any documentation provided by the printer manufacturer.

Configuring Epson® FX-850 Switches

To enable the Epson FX-850 to print in both graphic and text modes, set the switches as follows:

SW1	1	On	SW2	1	On
	2	On		2	On
	3	On		3	On
	4	**Off**		4	On
	5	On			
	6	**Off**			
	7	**Off**			
	8	**Off**			

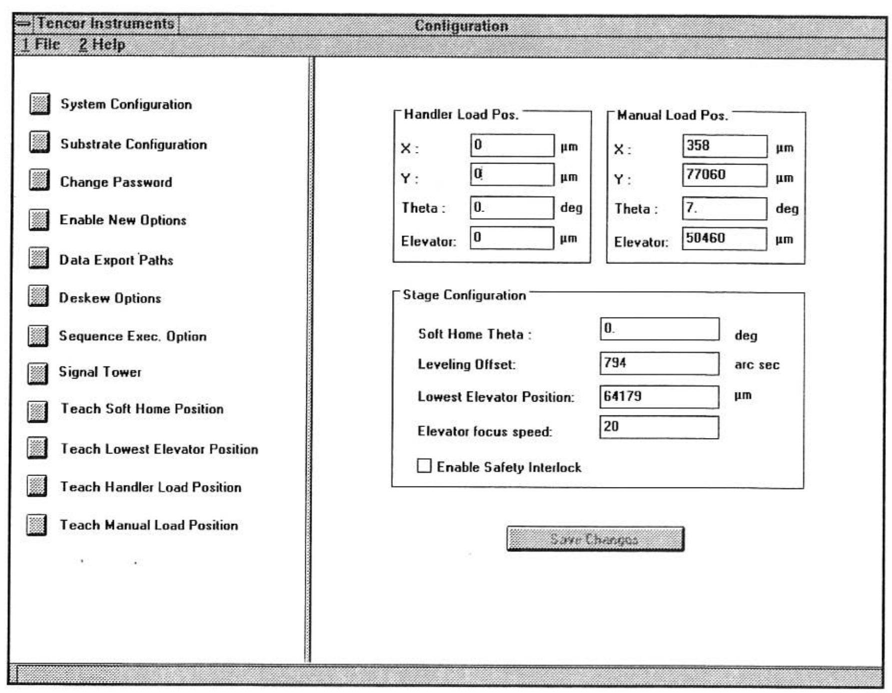
Configuration

The Tencor Profiler application software must have the correct information in its internal configuration files to properly run the instrument. This section covers checking and editing these configurations.

To view the Configurations window

Double-click on the Configuration icon in the Top Level menu. The Configuration window appears:

Figure 2-17. *Configuration window.*



The left side of the window contains a series of control buttons; the right side of the window shows the current settings.

The configuration routines are discussed in the following sections.

Machine Configuration

The Machine Configuration window contains settings that describe the instrument hardware. Typically these settings do not change unless you are reconfiguring the wafer handler, have changed sensor types, added a printer, or changed video display boards.

To edit the Machine Configuration

1. Click on the **System Configuration** button on the left side of the Configuration window (Figure 2-17). The following dialog box appears:

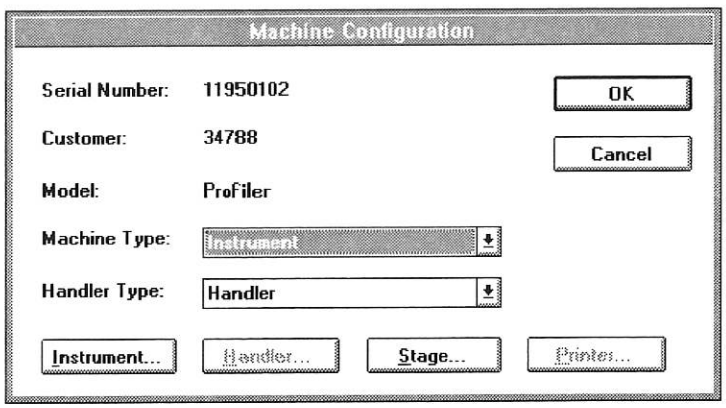


Figure 2-18. *Machine Configuration dialog box.*

2. Make any necessary changes.
3. Press ENTER or click **OK** to accept the changes, or **Cancel** to close this dialog box and return to the Configuration window with the original settings unchanged. A message box appears warning you to reboot the system if you have made any changes.
4. If you need to reboot the system, follow the instructions in "Turning Off or Resetting the Instrument" on page 28 to perform an orderly shutdown.

Substrate Configuration

The Substrate Configuration sets up the profiler to handle specific types of samples, if necessary. You can choose wafers or glass substrates. This configuration automatically sets up the X and Y travel limits and modifies the appearance of the Scan window and the Data Analysis window.

To set the Substrate Configuration

1. Click on the **Substrate Configuration** button on the left side of the Configuration window (Figure 2-17). The following dialog box appears:

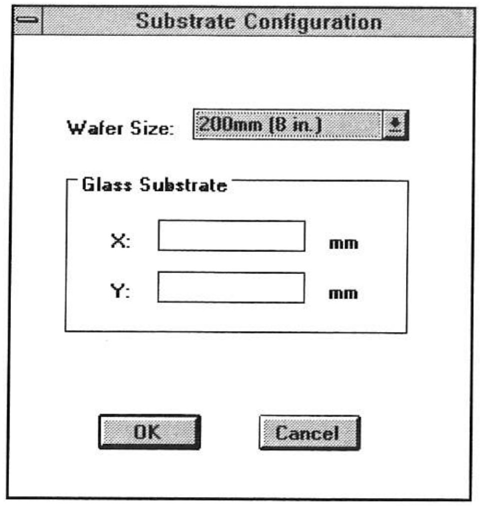


Figure 2-19. *Substrate Configuration dialog box.*

2. Choose a wafer size from the drop-down box, or enter X and Y dimensions for a glass substrate.
3. Click **OK** to save the new values, or **Cancel** to return to the Configuration window with settings unchanged.

Change Password

You can restrict access to data files and certain instrument settings by assigning a user password. With password access turned on, users must enter a password to access files in the database, change the instrument's configuration and calibration settings, and operate the optical zoom.

To assign or change a password

1. Click on the **Change Password** button on the left side of the Configuration window. The following dialog box appears:

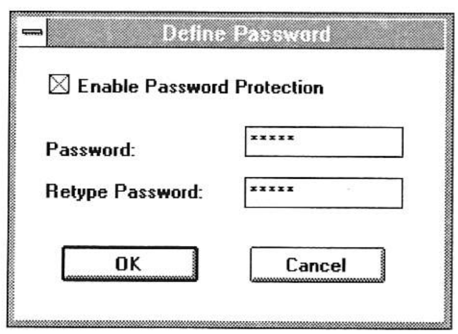


Figure 2-20. *Define Password dialog box.*

2. Check the Enable Password Protection box.
3. Press TAB to place the cursor in the Password entry field and type a password from one to 12 letters long.
4. Press TAB again and enter the password in the Retype Password field. If you have retyped the password correctly, the **OK** button, which was grayed out before, becomes active.

5. Click **OK** to enter the password and enable its use.

Enable New Options

In most cases, you can add options to an installed instrument without a special software or hardware installation. Only the Signal Tower with its dedicated hardware requires a Tencor Service installation. The Profiler software contains all the options. The options that are enabled and available for use are determined by the configuration code programmed into the Configuration Key at the factory. Using this dialog box and a code provided by your Tencor Sales representative, you can enable the options you want to add to your instrument.

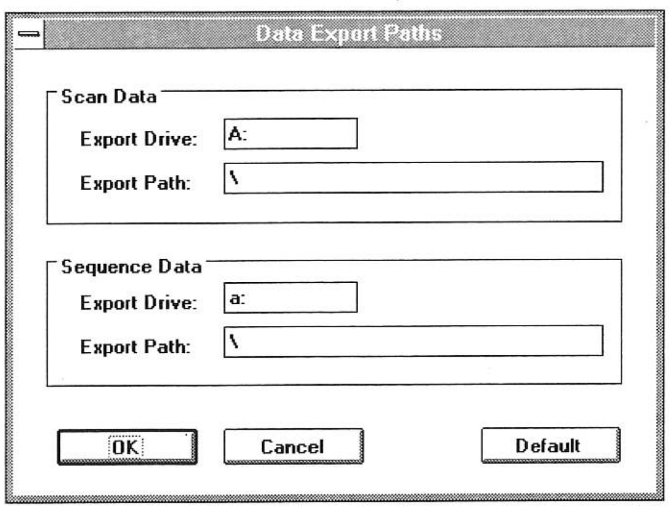
Data Export Paths

Data Export Paths allows you to set the default path for exporting scan and sequence data.

To set the Data Export Paths configuration

1. Click on the **Data Export Paths** button on the left side of the Configuration window (Figure 2-17). The following dialog box appears:

Figure 2-21. *Data Export Paths dialog box.*



2. For each type of data, enter the desired drive in the Drive field, and enter the desired directory path in the Path field.
3. Click **OK** to save the new values and return to the Configuration window, or **Cancel** to return to the Configuration window without changing the previous values.

De-skew Options

A second de-skew operation is sometimes necessary to improve the accuracy of pattern recognition de-skew in the Pattern Recognition Option. This configuration setting allows you to enable the second de-skew operation and set the parameters associated with it. For more information, see "De-skewing Twice to Align Theta" in the Operations Manual.

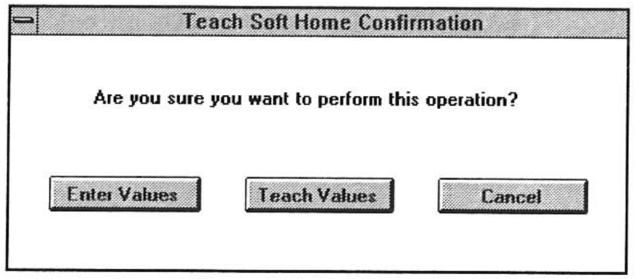
Teach Soft Home Position

You can change the Soft Home position by teaching the new position.

To teach the Soft Home position

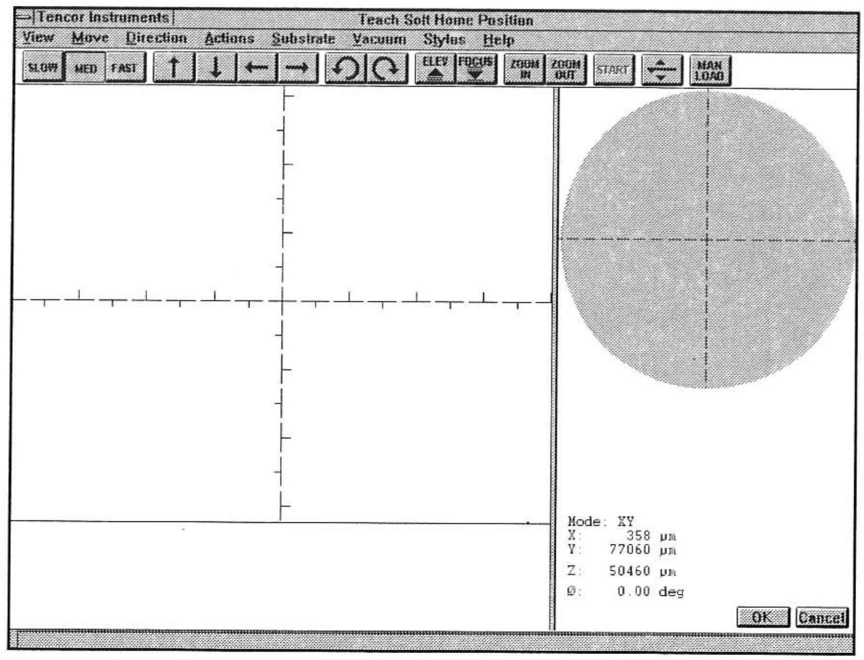
1. Click on the **Teach Soft Home Position** button on the left side of the Configuration window (Figure 2-17). The following message box appears:

Figure 2-22. *Machine Configuration dialog box.*



2. Click on the **Teach Values** button. The Teach Soft Home Position window appears:

Figure 2-23. *Teach Soft Home Position window.*



The stage rotates to the current Soft Home theta position.

3. Using the arrow buttons in the tool bar, move the sample to the desired new position. If necessary, use the rotation buttons to rotate the stage to the desired theta position.
4. Click on the video image to record the new position's coordinates.
5. Click **OK** to save the new position, or click **Cancel** to keep the original value and return to the Configuration window.

Teach Lowest Elevator Position

The Lowest Elevator Position allows you to restrict the range of vertical motion of the stage. You may wish to set a limit for the elevator so that the measurement head cannot descend past the level of the sample surface. This will prevent driving the head onto the sample surface in a case where the stylus drops into a hole or groove, or goes past the edge of a sample.

CAUTION: It is very important to determine the correct lowest elevator position when a precision locator is installed. The stylus can be damaged if you leave the stage configured with the original setting.

To teach the Lowest Elevator position

1. Click on the **Teach Lowest Elevator Position** button on the left side of the Configuration window (Figure 2-17). The following window appears:

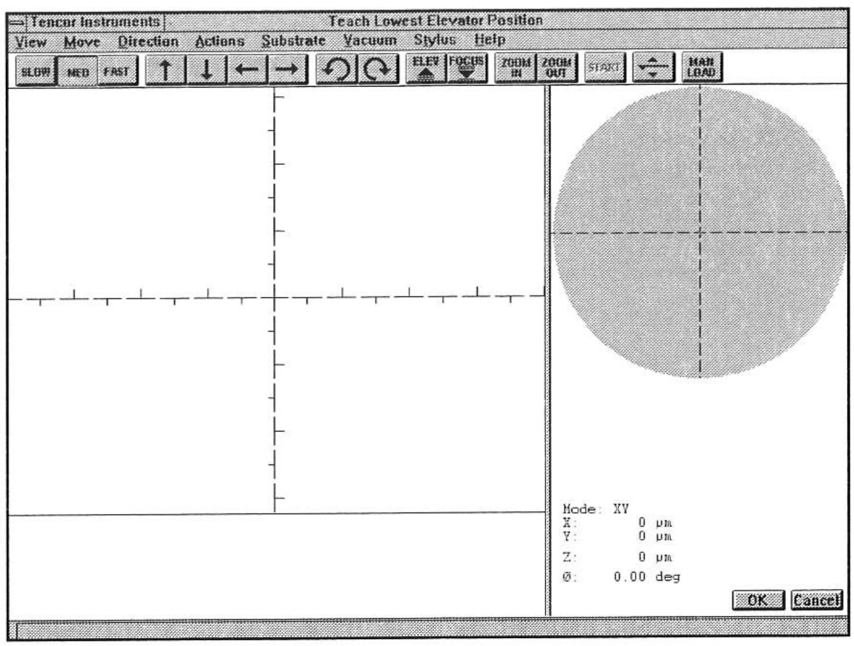


Figure 2-24. *Teach Lowest Elevator Position window.*

The stage moves to the current lowest elevator position.

2. Click on the **Focus** button in the tool bar to move the head down. When it has reached the desired height, click on the **Focus** button again to stop descent. You can click on the **Elev** button to move the head up if you lower it too far.
3. When you are satisfied with the Z coordinate, click **OK** to accept the new value. You can also click on **Cancel** to retain the original value and return to the Configuration window.

Teach Manual Load Position

The Manual Load position can be changed by teaching the new position.

CAUTION: When the instrument is turned on or reset, the stage moves to the Z coordinate of the Manual Load position. Be sure to set the Z coordinate high enough above the stage so that the measurement head does not contact the sample or other hardware that might be present. Incorrect teaching can damage the instrument.

To teach the Manual Load position

1. Click on the **Teach Manual Load Position** button on the left side of the Configuration window (Figure 2-17). The Teach Manual Load Position window appears:

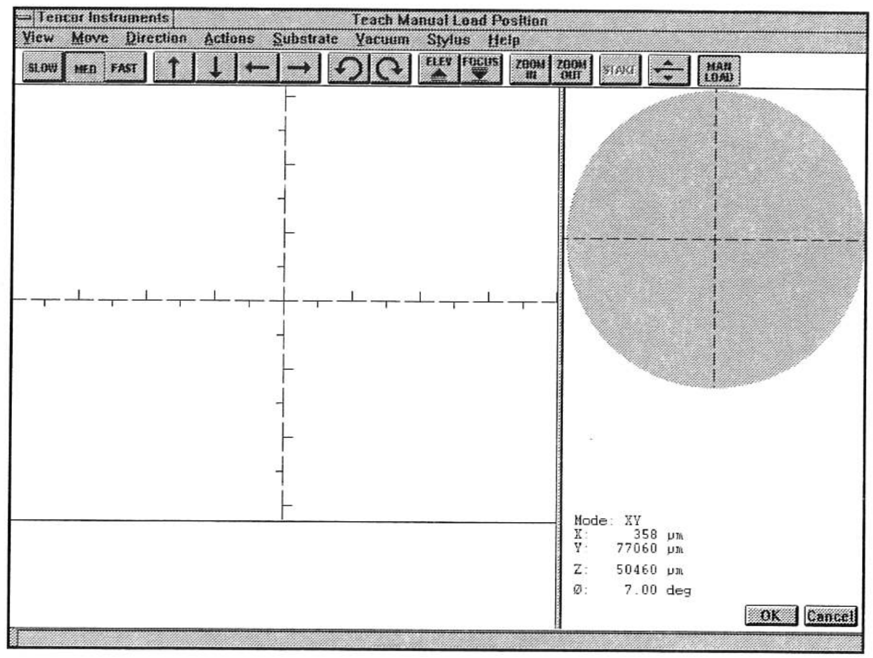


Figure 2-25. *Teach Manual Load Position window.*

   The stage moves to the current Manual Load position.

2. Using the arrow and rotation buttons on the tool bar, move the sample to the desired position and click on the video image to record its coordinates.
3. If desired, adjust the Z coordinate by raising the head with the **Elev** button in the tool bar.
4. Click **OK** to save the new position, or click **Cancel** to keep the original value and return to the Configuration window.

Loss of Power

The following aspects of loss of power on the Tencor Profiler should be kept in mind while operating the system.

- The head of the hard disk drive auto-parks at power loss so that the hard disk drive does not suffer damage. However, if power returns and cycles quickly on and off two or three times within 100 to 200 ms, there is a remote possibility of a head crash and permanent damage.
- If power failure is a common occurrence, use an Uninterruptable Power Supply (UPS) device that supplies power for 30 min. so that you can perform an orderly shutdown.

Turning Off or Resetting the Instrument

Before powering down the instrument, we recommend that you:

- Exit the Tencor Profiler software into the Windows desktop.
- Exit Windows.

> **CAUTION**: When the instrument is powered up or reset, the stage moves to the Z coordinate of the Manual Load position. If the Z coordinate is not high enough above the stage, the measurement head might contact any sample or other hardware that might be present. For more information, refer to the section entitled, "Manual Load Position," in the Operations Manual.

When powering down the instrument, use the following procedure to ensure against loss of data and recipes.

> **CAUTION**: *Never turn off the instrument* when the disk drive is in operation; otherwise, data, recipe, or program corruption can occur.

To exit to Windows

While holding down the SHIFT key, double-click on the **Log Off** button in the Top Level menu. The Tencor Profiler software closes and the screen reverts to the Windows desktop.

To quit Windows

1. Double-click on the Program Manager control button, or press ALT+F4. (If the Program Manager window is not open, double-click on its icon first.)

   The following message box appears:

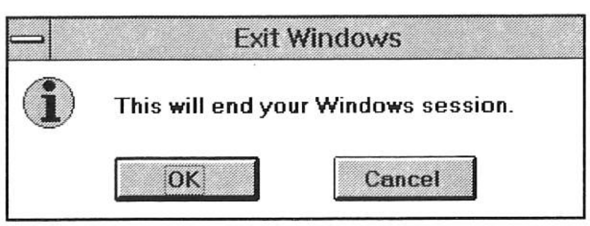


Figure 2-26. *Exit Windows Message Box.*

2. Click **OK** to exit, or **Cancel** to remain in Windows.

To turn off the Tencor Profiler

After exiting the profiler program and quitting Windows (above), press the instrument's power switch on the front of the computer.

3

THEORY OF OPERATION

Introduction

System Description

The Tencor P-10 characterizes a substrate by scanning it with a diamond stylus. The resulting trace represents a cross-sectional view with high vertical and spatial resolution. The P-10 can measure artifacts that are below 500Å and roughness below 10Å. It also can make a wide variety of analyses of the surface texture that allow optimization of the surface for particular applications.

The Tencor P-10 digitizes the data signal to permit easy and precise quantization of the results. In addition, the instrument's computer provides storage facilities for data and scan recipes. It also allows many data analysis functions and flexibility of use through its extended software.

The Tencor P-10 +has a capacitive sensor that registers the vertical motion of the stylus. The measurement stage rests on an optical flat reference that ensures smooth and stable movement across the scan length. The guide bar for the stage provides straight, directional movement of the stage beneath the stylus. Measurement noise from the instrument itself, which would distort the accurate analysis of surface roughness, is limited by decoupling the mechanisms of the scan motion from other motions within the instrument.

Environmental Effects

Uncontrolled influences of the environment can interfere with the fidelity of the output data. Environmental interferences can be mechanical, acoustical, thermal, and electrical. Loud noises and strong, pulsating air currents from air conditioning blowers also can generate nanometer-sized signals.

Air currents of varying temperatures or undulating velocities can cause differential heating or cooling of the profiler components. This can generate error signals or noise. Electrical interferences are always possible, although not likely, in modern designs.

To obtain optimum performance

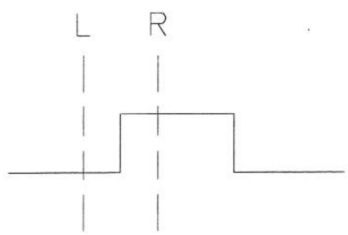
- Maintain floor vibration at less than 250 µin./sec.
- Maintain the ambient temperature within the following instrument specifications:
  - Range should be 16°–26°C.
  - Maximum rate of change is 2°C per hour.

Application

Step Height Measurements

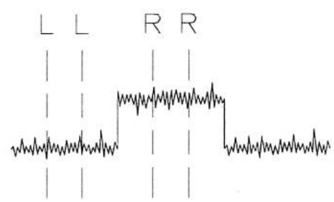
High accuracy measurements are easy to make on clean geometry and smooth surfaces, as shown in Figure 3-1. One quarter percent (0.25%) precision is attainable above 0.4 μm (16 μin.) step height. This precision can be reached by having a noise level that is small relative to the step height, negligible instrument drift, and calibration by an accurate height standard specimen.

Figure 3-1. *Step Height Measurement of a Smooth Surface.*



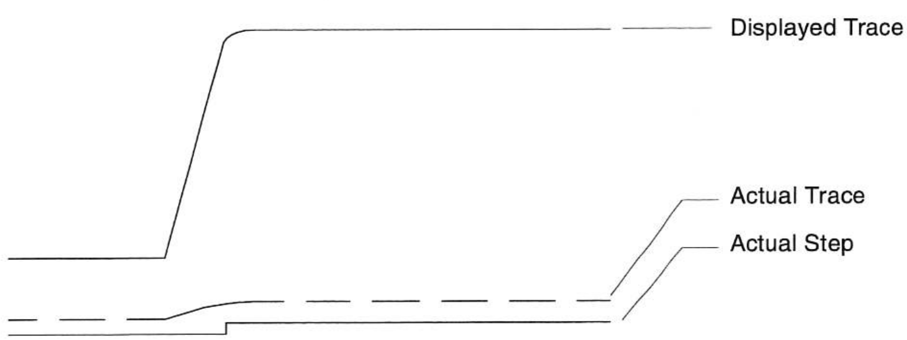
The Tencor Profiler has near zero electronic drift, is temperature-compensated, and offers a precise software calibration technique. When the surfaces are rough as in Figure 3-2, or the height of the step is small enough that noise becomes evident in the trace, each measurement cursor can be spread to average portions of the trace to preserve precision close to that of Figure 3-1. This technique is called Delta Averaging and is illustrated in Figure 3-2.

Figure 3-2. *Delta Averaging.*



A high resolution depiction of a trace shows distortion in the rise and fall of the trace. It does not show perfectly square corners and there is slope in the verticals, as seen in Figure 3-3. Three factors can contribute to this condition: the stylus geometry; input filtering that imposes a shortwave cutoff; and the effect of scan speed on the value of the shortwave cutoff wavelength.

Figure 3-3. *Travel Path of the Stylus.*

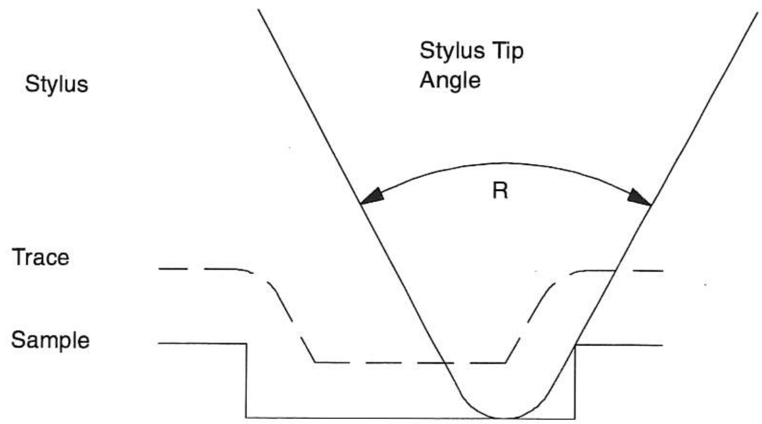


Stylus Geometry

The first factor contributing to the distortion of a step height is the size and shape of the stylus tip. The dotted lines in Figures 3-4 and 3-5 describe the travel path of the stylus radius. Under two worst-case scenarios, Figure 3-4 displays the case of a step significantly higher than the stylus radius, and Figure 3-5 displays the case of a groove width approximately equal to the stylus radius.

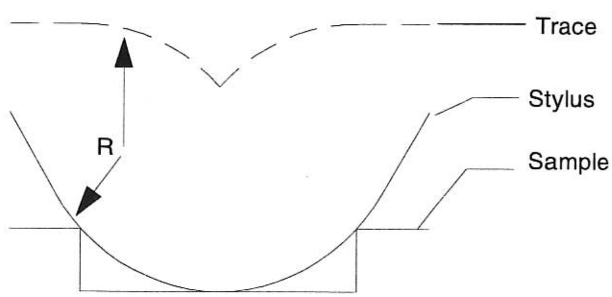
If a perfectly square step is assumed, the arcs in the trace are inverted replicas of the stylus radius while the slope of the trace in Figure 3-4 is a replica of the stylus tip angle (typically 60°). Note that the length of the trace of the groove is shorter than the actual length. The traces do not look like this on the instrument's display because the vertical dimensions are greatly exaggerated, perhaps 1000 times the horizontal dimensions, thereby minimizing any distortion.

Figure 3-4. *Effect of Stylus Radius and Stylus Tip Angle on a High Step.*



The distortion due to the stylus does not interfere with accurate measurement of step height. The only case in which an inaccuracy would occur is if the groove is too narrow for the stylus (Figure 3-5). As a result, even if the stylus reaches the bottom of the groove, there is not sufficient scan distance for optimal data collection, and a falsely low height measurement is recorded.

Figure 3-5. *Effect of Stylus Radius on a Narrow Groove.*



Groove width loss is defined as the length of the groove that is not traced (displayed) by the stylus. Figure 3-6 and Table 3-1 show a graph and table of groove depth versus groove width loss for different stylus radii. The significance of this table is that if groove width is to be measured, its width must be greater than the groove width loss.

Table 3-1. *Groove Width Loss for Different Radii and Groove Depths*

Stylus Radius (μm)	Groove Depth (μm)											
	.02	.05	.1	.2	.4	.8	1.6	2.5	5	10	20	25
12.5	1.4	2.2	3.2	4.5	6.3	8.8	12	15	20	26	38	43
5.0	.89	1.4	2.0	2.8	3.9	5.4	7.3	8.7	12	17	29	35
2.0	.56	.89	1.3	1.7	2.4	3.2	4.2	5.2	8.1	14	25	31
1.0	.40	.62	.87	1.2	1.6	2.1	3.0	4.0	6.9	13	24	30
0.4	.25	.39	.53	.69	.92	1.4	2.3	3.4	6.2	12	24	29
0.2	.17	.26	.35	.46	.69	1.2	2.1	3.1	6.0	12	23	29
0.0	.02	.06	.12	.23	.46	.92	1.9	2.9	5.8	12	23	29

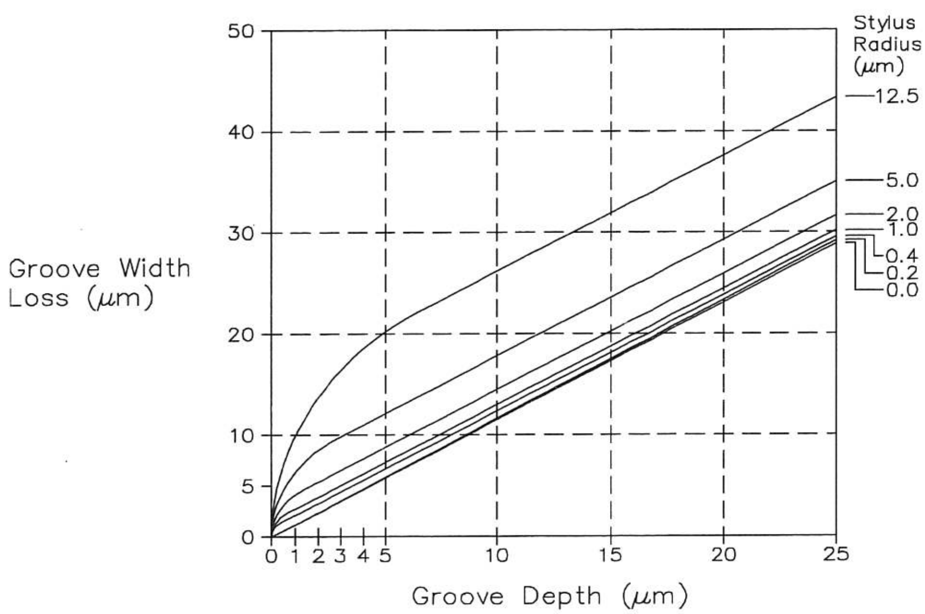


Figure 3-6. *Stylus Radius and Groove Width Loss Relation.*

The 0.0 entry for stylus radius in the above figure corresponds to the theoretical limit of a point stylus on a shank with 60° angle.

Filtering Effect of Scan Speed

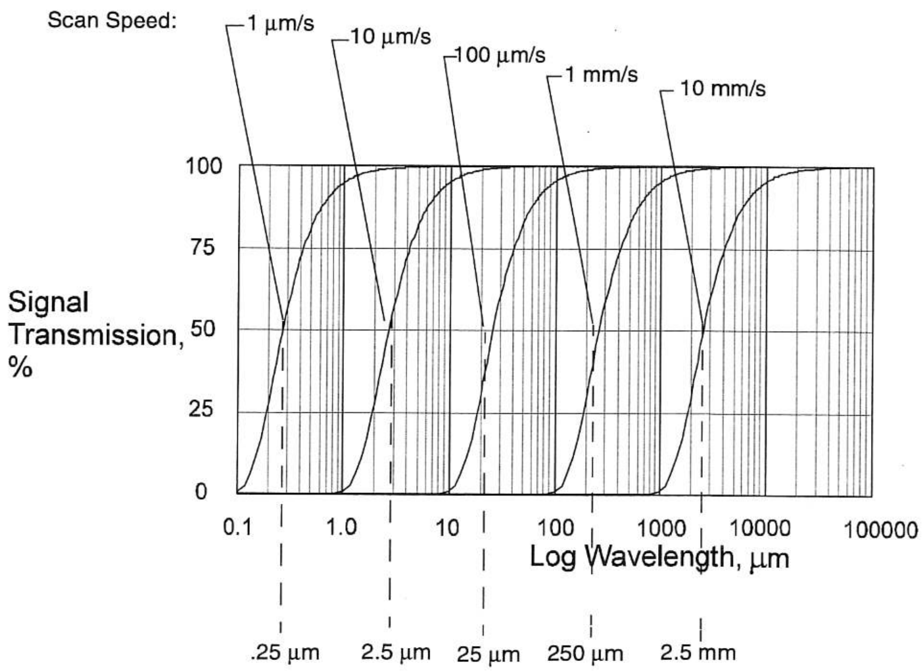
Another possible cause of height attenuation is the effect of the input filter. The Profiler contains both a Gaussian and an RC (Resistor/Capacitor) input filter. You can choose the desired filter (or none) using the **Filters/Cursors** button in the Recipe Editor window. The filters reduce noise and, in the case of digitized instruments, prevent aliasing effects in the A-to-D converter.

The cutoff frequency of the input filter is typically one-tenth the data input sampling rate. Note that it passes lower frequencies, which means longer wavelengths for profilers. Since the filter is fixed in frequency, the shortwave cutoff value varies with scan speed according to the following relationship:

$$\text{Short Wave Cutoff} = \frac{\text{Scan Speed}}{\text{Frequency of Cutoff}}$$

The shortwave cutoff curves for four decades of scan speed are shown in Figure 3-7. Since the Tencor Profiler speeds progress in the 1-2-5, 10-20-50, etc., step method, and the wavelength scale of the graph is logarithmic, the second and fifth steps can be plotted at 30% and 70% spacings, respectively, in the decade.

Figure 3-7. *short wavelength Cutoff Curves.*



The cutoff is specified at the point of 50% signal transmission for Gaussian filters, 75% for RC filters. The cutoffs in this case vary from 0.25 µm to 2.5 mm of wavelength as the scan speed progresses from 1 µm/s to 10 mm/s, respectively. Shortwave cutoff values corresponding to any scan speed can be computed using the above equation and 4.0 Hz as the cutoff frequency. In conclusion, *the short wavelength data is lost as the scan speed increases.*

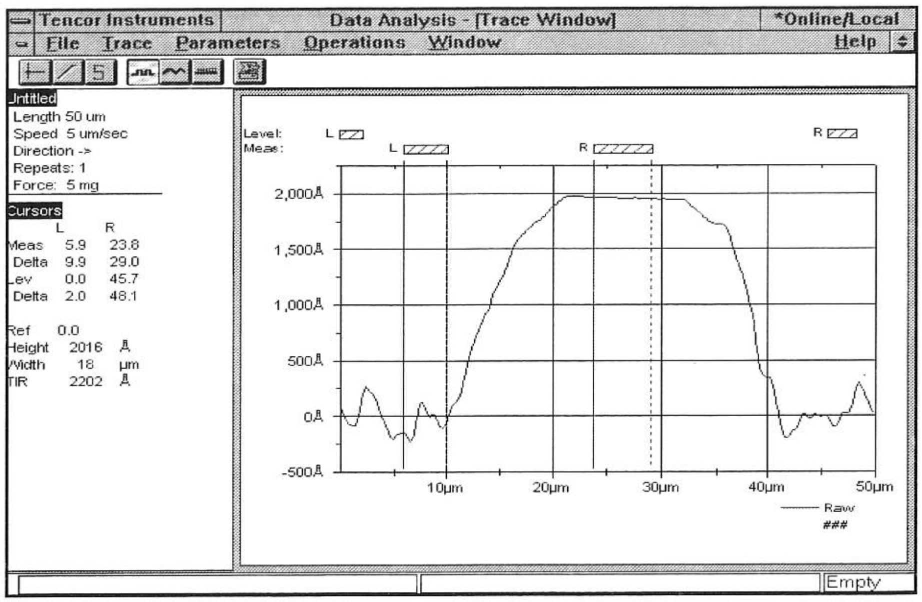
If a surface wave is sinusoidal and its wavelength is the same as the input filter cutoff, then its height is attenuated by 50% for Gaussian filters, 25% for RC filters. Note, however, that approximately 1% height loss would occur when the wavelength is five times the input filter cutoff. Non-sinusoidal waves are affected in more complicated ways.

The effects of changing shortwave cutoffs on a trace are shown in Figures 3-8 through 3-10. The sample consists of square bars and spaces 50 µm-wide, in oxide, which is 2200Å thick.

In these examples using the Gaussian filter option, the scan speed is increased from 5 µm/s to 50 µm/s, which causes the cutoff wavelength to vary from 1.25 µm to 12.5 µm.

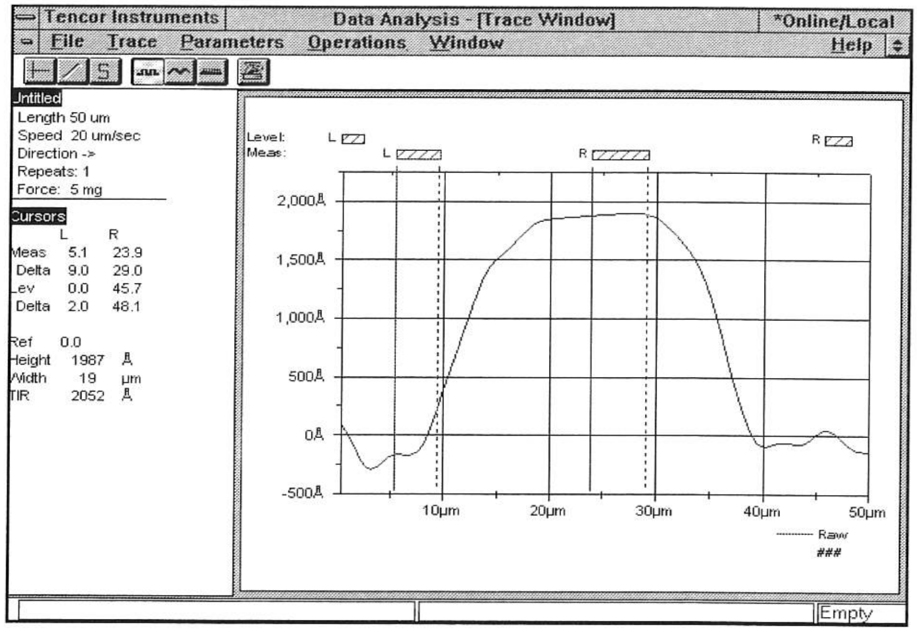
Figure 3-8 shows that at 5 µm/s the shape and height are faithfully reproduced.

Figure 3-8. *Trace at 5 µm/s Speed.*



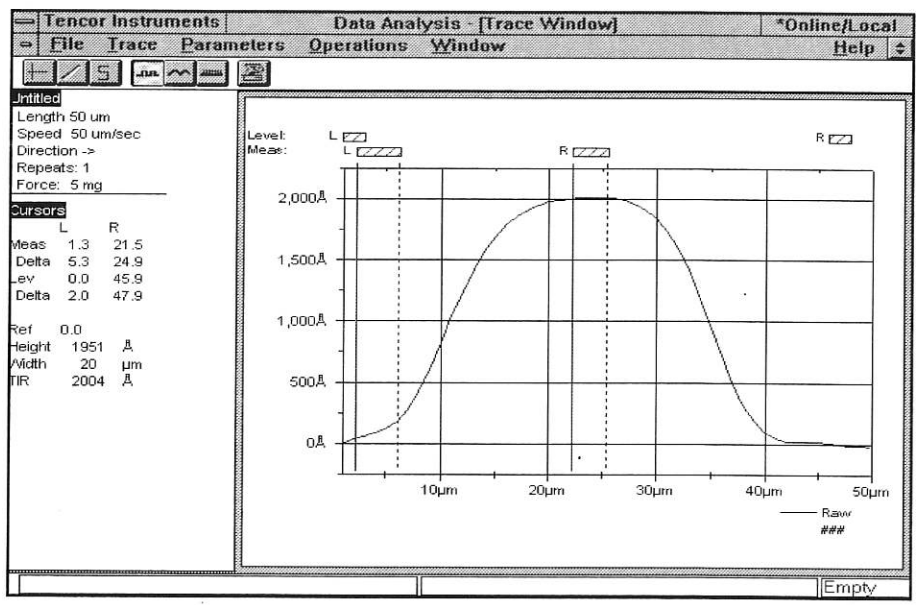
The filter cutoff value at 20 µm/s is 5.0 µm in Figure 3-9. This distorts the corners of the step and causes the center of the peak to shift to the right. Height is reduced by about 7%.

Figure 3-9. *Trace at 20 μm/s Speed.*



The trace at 50 μm/s in Figure 3-10 is even more rounded, with its height attenuated by about 9%.

Figure 3-10. *Trace at 50 μm/s Speed.*



Comparative figures for the RC filter would show:

- At 1 μm/s the shape and height are faithfully reproduced.
- The filter cutoff value at 5 μm/s is 1.25 μm, with severe distortion of the corners of the square wave. The center of the peak shifts to the right with height only slightly reduced.
- At 10 μm/s the trace becomes a sine wave with its height attenuated by 4%.

Surface Texture Analysis

The study and classification of surface texture have been underway for approximately 50 years. The subject is inherently complicated because of the large range of size and shape of surface artifacts as well as the great variety of surface generation methods.

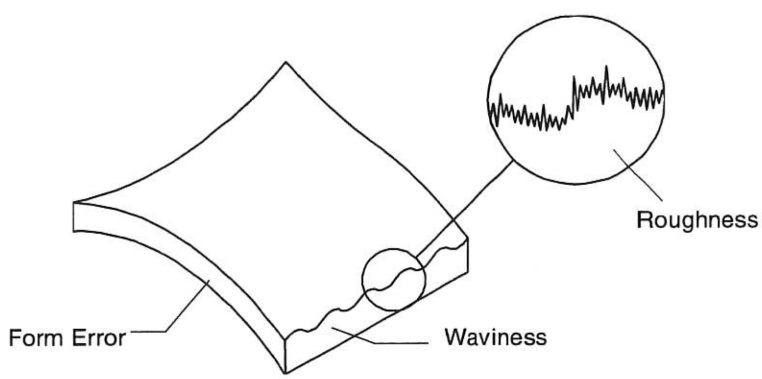
There is also a vast divergence of application interests. Researchers have generated many evaluation parameters and at least 24 national standards committees have been assigning names and definitions for the measurement parameters.

Surface Descriptions

Variations in surface topography can be divided into three general classes based on relative wavelengths of the variations: form error, waviness, and roughness (Figure 3-11).

Form error is a deviation from a perfect realization of a nominally specified shape. If a surface is nominally flat, its form error can be defined by the deviation from flatness. However, if the deviation from flatness has several waves, then the shape cannot be classified as form error. This error is called waviness. If there are many hundreds of thousands of randomly shaped undulations, this is called roughness.

Figure 3-11. *Three Classes of Surface Topography.*



The basic configuration of the Tencor Profiler can separate data into roughness, waviness, and raw data traces as shown in Figure 3-12. The cutoff filters allow further separation of intermediate wavelengths from standard roughness and waviness components (see "Using Cutoff Filters," in the Operations Manual for more information).

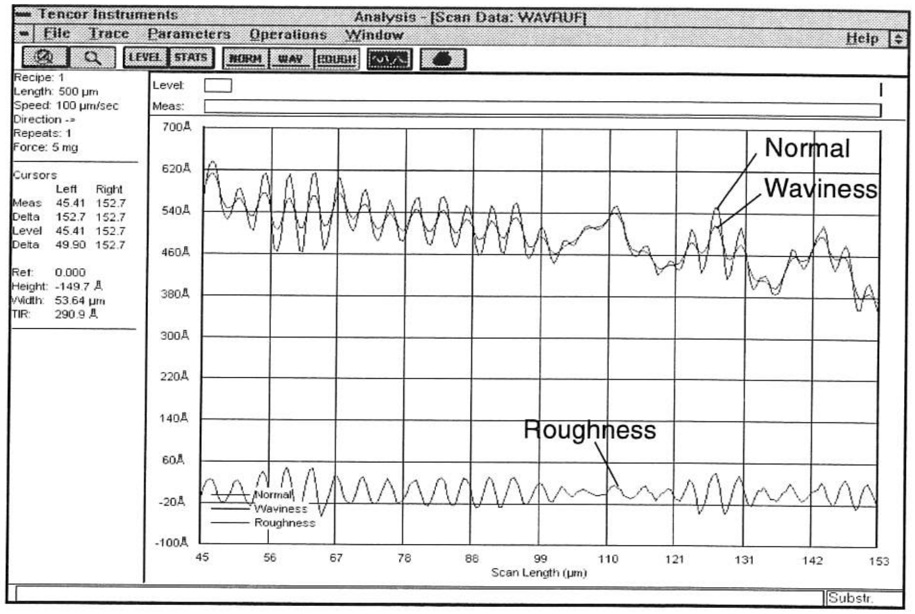


Figure 3-12. *Tencor Profiler Separates Surface Texture into Roughness and Waviness.*

These class divisions of surface variations are arbitrary in that the size of the wavelengths involved depends on the size of the sample being considered. No sharp divisions can be drawn between the categories. When wavebands of the categories are naturally well separated, it is easy to separate their outputs using filtering techniques for separate analyses. An example of this would be a form error = 1 to 3 waves, waviness = 25 to 80 waves, and roughness = 500 to 5000 waves.

When there is a continuum of wavelengths, there is no way of separating surface variation categories without significant data distortion. In this case, the user must have an application-specific method of data analysis that is effective in controlling surface quality.

Surface Characterization Parameters

Surface analysis is mostly concerned with the measurement of roughness. The earliest parameter to be developed was roughness average (R_a), which is the arithmetic average of the absolute values of the profile height deviations. These values are taken within the sampling length and are in reference to the graphical centerline. The R_a is defined by the following formula per the ANSI/ASME standard:

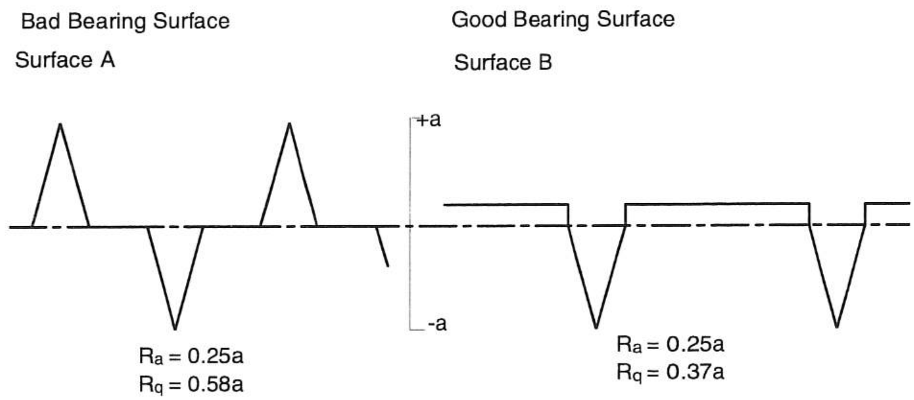
$$R_a = \frac{1}{L}\int_0^L |y|\,dx$$

where

R_a = Arithmetic average deviation from the centerline,
L = Sampling length, and
y = Ordinate height of the curve of the profile, relative to the centerline.

The R_a provides a good representation for a scale of roughness that is symmetrical about the centerline and has a Gaussian distribution of peak and valley heights. It contains little information about the nature of the roughness, however, and often fails in application correlation (see Figure 3-13).

Figure 3-13. *Same R_a for Different Surfaces.*



Surfaces A and B in the figure above produce the same R_a value even though surface A is obviously rougher and is a very bad bearing surface. On the other hand, surface B is an excellent bearing surface due to wear considerations and the ability to retain lubricant. A different roughness parameter, R_q, shows a 36% lower value for surface B because it is defined as the RMS average rather than the arithmetic average. The RMS (R_q) is defined per the ANSI/ASME standard as:

$$R_q = \left(\frac{1}{L}\int_0^L y^2 dx\right)^{1/2}$$

where

L = Sampling length, and
y = Ordinate height of the curve of the profile, relative to the centerline.

Squaring the y values gives emphasis to the large values of y versus the small values so that a distinction is made between surfaces A and B.

Many other parameters available with Tencor Profilers (Tables 3-2 through 3-4) have been developed to improve the correlation between a parameter value and a particular surface performance. For definitions of these parameters, see "General Parameters" and "Roughness/Waviness," in the Operations Manual.

Table 3-2 lists general surface analysis parameters of the Tencor Profiler.

Table 3-2. *General Surface Analysis Parameter Descriptions*

Parameter	Description
StpHt	Step Height
TIR	Total Indicator Run-out
Avg	Average Height
Slope	Slope
Rad	Radius
Area+	Area of Peaks
Area -	Area of Valleys
Area	Total Area of Peaks and Valleys
ProfL	Profile Length
MaxHt	Maximum Height
MinHt	Minimum Height
Edge	Distance to Edge (or Apex)
StpWd	Width of Step
StpN	Number of Steps
StpMn	Mean Step Height
StpSD	Standard Deviation in Step Height

Table 3-3 lists the roughness parameters of the Tencor Profiler.

Table 3-3. *Roughness Parameter Descriptions*

Parameter	Description
R_a	Average Roughness
Max R_a	Maximum of 19 Overlapping sections
R_q	Root-Mean-Square (RMS)
R_p	Maximum Roughness Height/Peak
R_v	Maximum Roughness Depth/Valley

Table 3-3. *Roughness Parameter Descriptions*

R_t	Maximum Peak-to-Valley Roughness
R_z	Ten-Point Height
$R3_z$	Six-Point Height
R_h	Height between two points
RPM	Mean Peak Height
D_q	Root-Mean-Square (RMS) Slope
L_q	Average RMS Wavelength
SD	Standard Deviation Heights
t_p	Bearing Length Ratio (at cutting depth)
CD	Cutting Depth (at bearing length ratio)
PC	Peak Count
HSC	High Spot Count
S_m	Mean Peak Spacing (associated with peak count or with high spot count)

Table 3-4 lists the waviness parameters of the Tencor Profiler.

Table 3-4. *Waviness Parameter Descriptions*

Parameter	Description
W_a	Arithmetic Average
W_q	Root-Mean-Square
W_p	Maximum Height/Peak
W_v	Maximum Depth/Valley
W_t	Maximum Peak-to-Valley
W_h	Waviness Height

Stylus Geometry and Scan Speed

The stylus geometry can also affect the roughness data. If the wavelengths on the surface are short relative to the stylus radius, they do not register on the trace or greatly attenuate in height. The stylus radius should be small enough to penetrate the bottom of the wave satisfactorily.

As with step height, the horizontal resolution decreases as the speed increases. The scan speed chosen should be consistent with the wavelengths to be measured.

Long-Wave Cutoff Filters

Filtering is employed to separate the roughness data from the waviness and form error data. The American Roughness Standard ANSI B46.1-1985 specifies the long-wave filter characteristic to be that of a two-pole RC network whose cutoff wavelength is at 75% transmission.

See Figure 3-7 for transmission curves and cutoff values. Tencor Instruments has added intermediate and extended range values to increase the available list of long-wave cutoff filters. Table 3-5 lists these values in both metric and English units.

Table 3-5. *Additional Intermediate and Extended Long-Wave Cutoff Filters*

Long-Wave Cutoff Filter Lengths					
μm	mil	μm	mil	mm	mil
4.5	0.18	140	5.6	4.5	180
8.0	0.30	250[1]	10.0[1]	8.01	300[1]
14	0.56	450	18.0	14.0	560
25	1.0	800[1]	30.0[1]	25.0	1000
45	1.8	1.4	56	45.0	1800
80[1]	3.01	2.5	100[1]	–	–

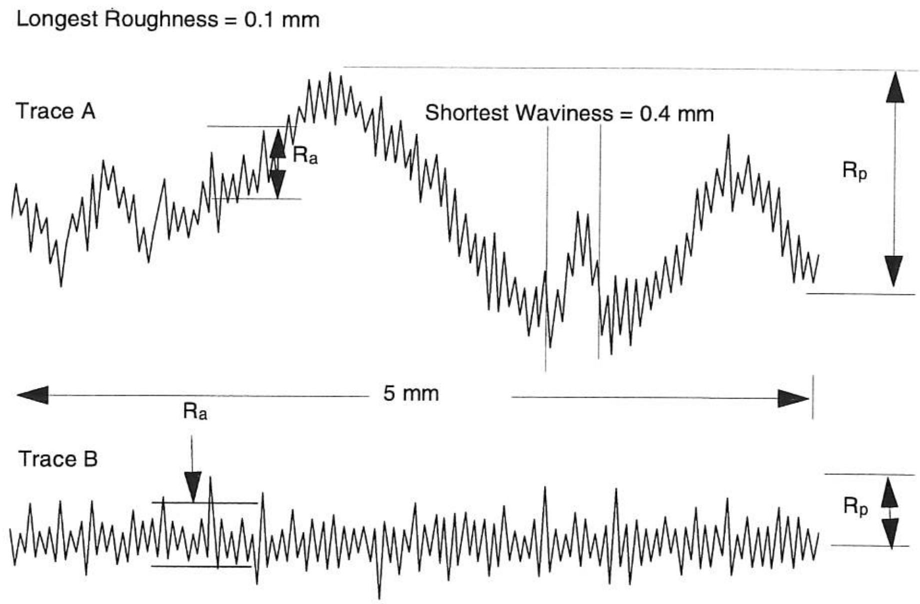
[1] These values are specified in ANSI B46.1-1985.

To separate roughness data from waviness data, the cutoff wavelength should be equidistant between the shortest waviness lengths and the longest roughness lengths. The cutoff wavelength also should be less than one-third of the total scan length (unaffected by zooming the data). A good rule of thumb is to start with one-fifth (20%) of the total scan length.

In the example in Figure 3-14, 0.25 mm would be the proper choice for the cutoff wavelength, because it is the closest standard length available between the longest roughness (0.1 mm) and the shortest wavelength (0.4 mm). If there is more than a decade of wavelength clearance between roughness and waviness, there should be no problem in finding an appropriate cutoff.

There are occasions when one cutoff does not completely remove waviness and the next lower value attenuates the roughness reading. The user must then make a choice based on the requirements of the application.

Figure 3-14. *Cutoff Wavelength.*



In trace A, calculations of R_p and R_a include the waviness. When the waviness is filtered out as in trace B, the lower values of R_p and R_a better reflect the fine grain structure of the surface texture.

Roughness Analysis Method

The Tencor Profiler calculates roughness and waviness from digitized data points using the Finite Impulse Response (FIR) technique. The FIR technique filters by convoluting the trace data with the impulse response of the filter specification as defined by the ANSI/ASME standard. The impulse response is obtained by taking the inverse fast Fourier transform of the filter specification. According to the ANSI/ ASME standard, the percent transmission of the transfer function for the shortwave cutoff is as follows:

$$\frac{100}{1 + 0.33\left(\frac{Short\ Wave\ Cutoff}{Wavelength}\right)^2}$$

For the longwave cutoff, the percent transmission of the transfer function is as follows:

$$\frac{100}{1 + 0.33\left(\frac{Wavelength}{Long\ Wave\ Cutoff}\right)^2}$$

To calculate roughness, the centerline of the surface wave is found. This centerline is approximately equal to the waviness trace. The roughness data is produced by subtracting the centerline from the raw data. This data is then used to determine parameter values according to their mathematical definitions. This method has advantages of precision, a lack of phase distortion, and a reduced requirement of only three cutoff lengths of trace for full fidelity. Also, if less than three cutoff lengths of trace are available, error probability is reduced by an assumption of continuity of the surface wave before and after the actual trace.

Conclusion

There are many factors that contribute to profiling a surface. Environmental interference as well as stylus geometry and filtering can affect data. Also, as the scan speed increases, the distance between data points increases. These factors must be taken into consideration when determining an application for step height measurement, surface roughness, or waviness.

4

Hardware Maintenance

Troubleshooting

Service Information

The Tencor Instruments Service Organization is available to you in the United States, Europe, and Japan. We also have representatives in Taiwan, Singapore, and Korea.

Our commitment is to provide a technical response by telephone within 24 hours, often within the same business day. Our commitment for on-site repair is 48 hours.

In the United States we handle all service requests through a central number located in California. Call (800) 722-6775 Monday through Friday between 6:00 A.M. and 6:00 P.M., Pacific Standard Time, to arrange for service or repair work or to order replacement parts.

Standard on-site service hours are Monday through Friday, 8 A.M. to 5 P.M., Pacific Standard Time. You can arrange for other hours through a customized service contract.

We provide service beyond the original warranty period of one year as needed. Repair work that is done after the original warranty expires is guaranteed for 3 months. Full service contracts extend the warranty period and can be customized to your specific requirements.

We encourage you to attend a maintenance and repair training course for your instrument. In general, we find that better trained customers experience greater instrument up-time and make better use of our service resources. Your sales or service engineer can provide you with the course and fee schedule.

Diagnostic Scans

In the course of troubleshooting, Tencor Service personnel may ask you to run one or more of the diagnostic scans provided in the Scan Recipe Editor.

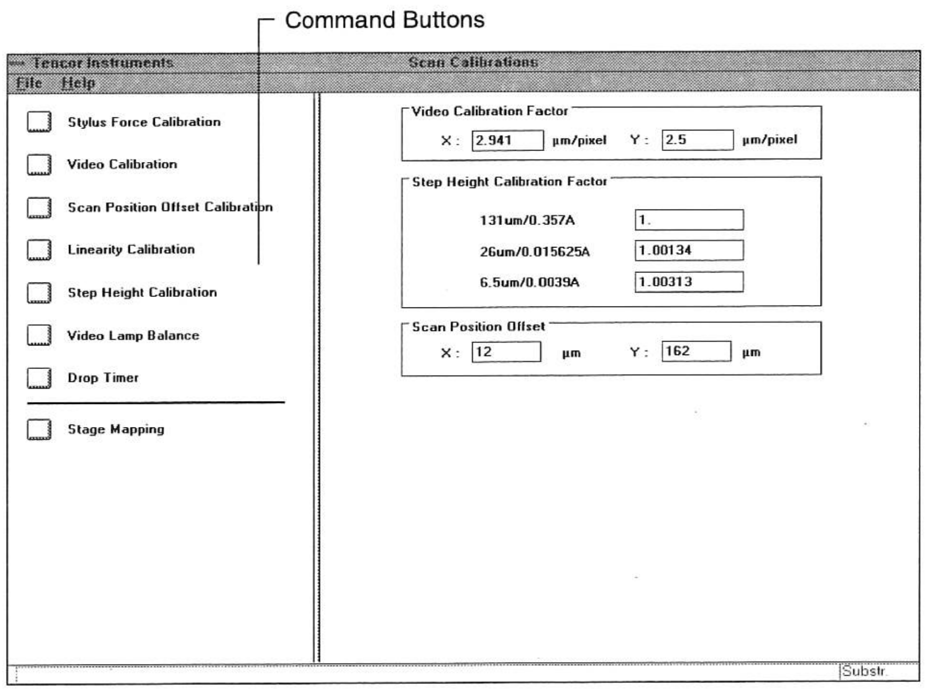
> **CAUTION:** Do not attempt to run a diagnostic scan without advice and instruction from Tencor Service.

Calibration

The Scan Calibrations window gives you access to the calibration functions you need to obtain consistently accurate data. Manually calibrating the instrument serves mainly as a diagnostic tool and an accuracy check of the calibration settings.

If you experience any problems, or have any questions about the performance of the MicroHead, check the calibration settings by following the procedures described here. If recalibrating does not eliminate the problem, or if you cannot obtain reasonable calibration settings, you will need to contact Tencor Service for assistance.

Figure 4-1. *Scan Calibrations window.*



The Scan Calibration window consists of command buttons, a Video Calibration field, Step Height Calibration field, and a Scan Position Offset field. The calibration procedures using these buttons and fields follow.

Stylus Force Calibration

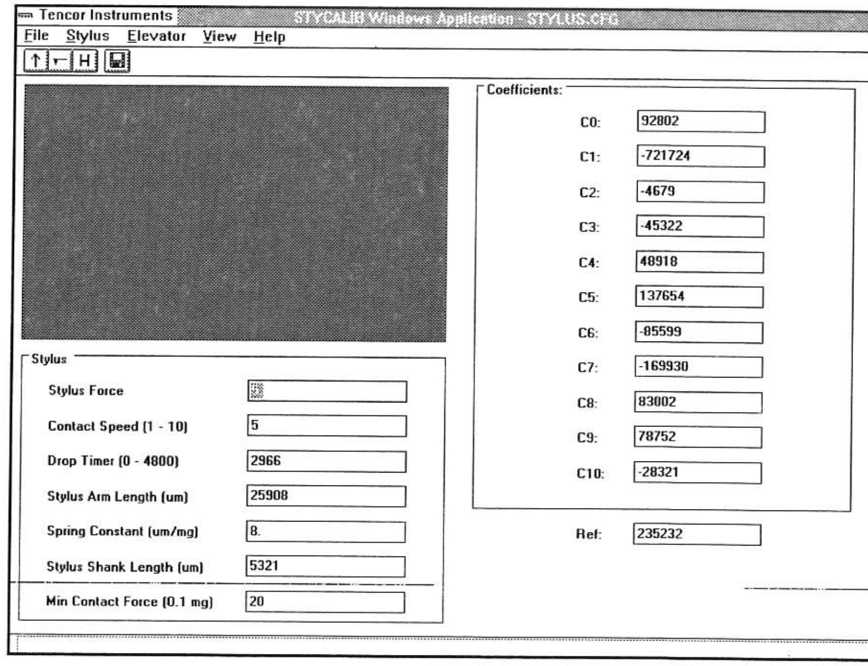
Stylus force is the force on the stylus tip when the stylus is in contact with the substrate. Mechanical changes in the stylus arm can affect calibration settings.

Note: *Recalibrate the stylus force each time the stylus is changed, especially when operating below 10 mg.*

To check the stylus force setup

1. Click on the **Stylus Force Calibration** button in the Scan Calibrations window. The Stylus Force Calibration window appears:

Figure 4-2. *Stylus Force Calibration window.*



If the stylus is near a sample surface, select Move Up 500 µm or Move To Soft Home from the Elevator menu.

2. Select Calibrate Force Coefficients from the Stylus menu. The stylus force response is calculated and the coefficients C0 to C10 are displayed (Figure 4-2). Call Tencor Service if:
   - all the coefficients are 0, or
   - the number 8388608 (or -8388608) appears for any coefficient
3. If neither of the above circumstances apply, choose Save from the File menu to save the new values.

Video Calibration

Note: *When performing the Video Calibration at higher magnifications, be sure to select Move Speeds from the Move menu and set the Move Extent for the Slow speed to 1 µm.*

The Video Calibration relates screen coordinates to stage coordinates, which allows accurate teaching of scan lengths and sequence scan locations. The Video Calibration must be performed each time you change the optic magnification (zoom) in an XY View window. To perform the calibration, you need a sample with some clearly distinguishable features, such as a step height standard.

To perform the Video Calibration

1. Load the sample on the stage and locate it beneath the measurement head.
2. From the Scan Calibrations window, click on the **Video Calibration** control button. The Video Calibration window appears:

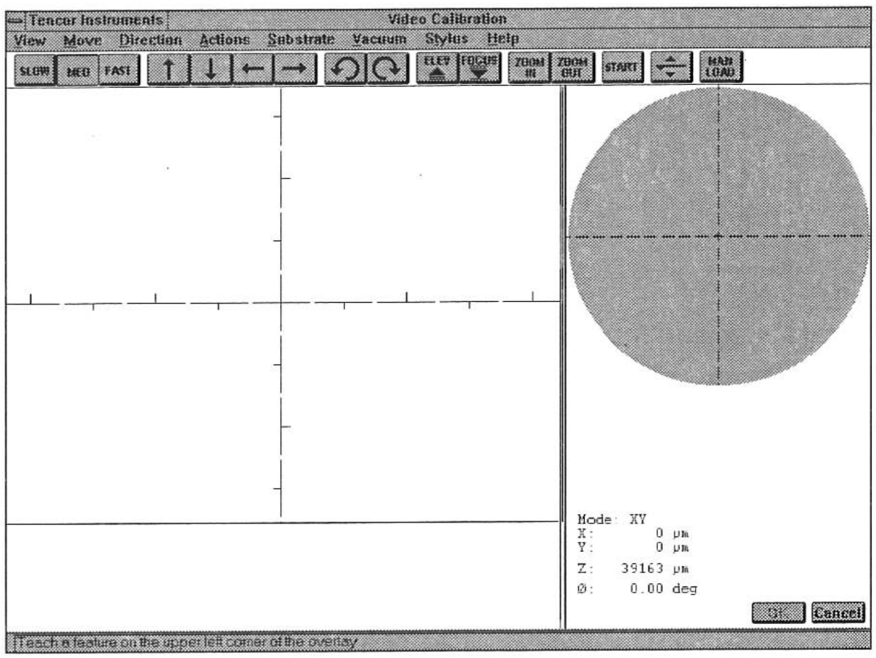


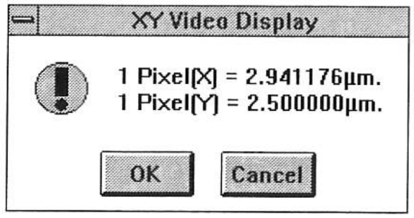
Figure 4-3. *Video Calibration Main window.*

3. Click on the **Focus** button in the tool bar. The stylus nulls on the sample surface and the image comes into focus.
4. Choose a feature in the upper lefthand corner of the screen to use to teach the calibration. The corner of a rectangle is ideal. *Avoid choosing something that is identical or very similar in appearance to other features nearby.*
5. Move the cursor, which appears as cross hairs, over the chosen corner and click. The stage moves slightly in the X and Y directions, and the prompt changes to

   Teach the same feature again.

6. Move the cursor over the chosen corner in its new position and click. The following message box appears:

Figure 4-4. *XY Video Display Window.*



The values in the message box are the calculated ratios of vertical and horizontal screen units (called pixels) to X and Y stage coordinates in microns.

7. Click **OK**. The Scan Calibration window reappears.

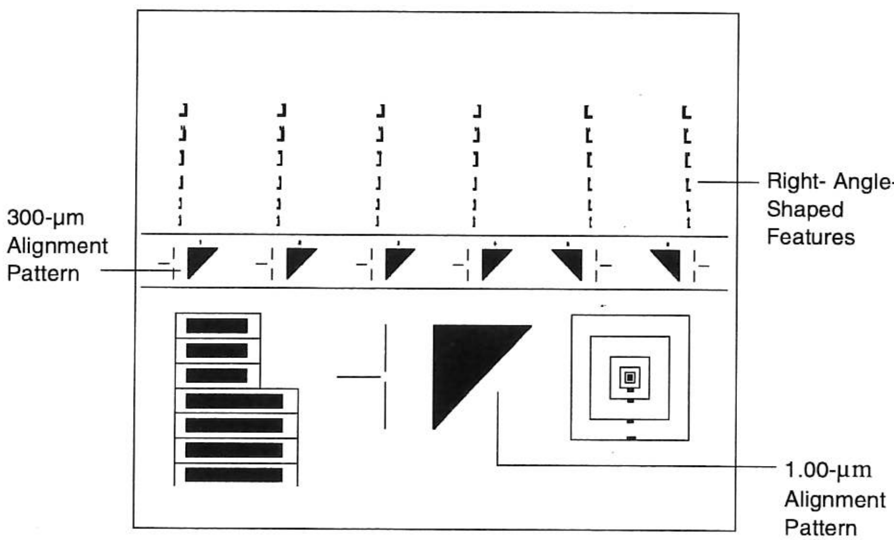
Scan Position Offset Calibration

Use the Tencor Stylus Alignment Tool (Tencor Part No. 219517) to determine the distance that the stylus tip is offset from the cross-hairs overlay in the XY View window.

Perform the stylus offset calibration

- whenever you change the stylus, or
- if you change zoom settings in order to scan a small feature.

Figure 4-5. *Tencor Stylus Alignment Tool.*



To calibrate the Scan Position Offset

> **IMPORTANT:** Before performing the Scan Position Offset Calibrations, make sure that the optical magnification is at the maximum setting (click on the **Zoom-In** button in the window's tool bar, then release when no further change occurs in the image), and finally perform a Video Calibration as described in the previous section. Note that while the scan takes place at high magnification, the stylus completely blocks the field of view.

1. Load the Stylus Alignment Tool in the instrument so that the alignment patterns are square to the stage X- and Y-axes.
2. Turn on the vacuum.
3. Click on the **Scan Position Offset Calibration** button in the Scan Calibrations window. The Scan Position Offset Calibration Options dialog box (Figure 4-6) appears in the center of the window:

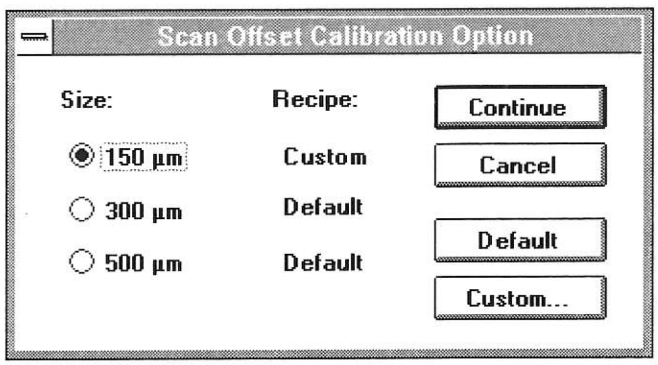


Figure 4-6. *Scan Position Offset Calibration Options dialog box.*

4. Click on the radio button next to 150 µm to select the 150 µm calibration option.
5. Select the recipe desired. The profiler provides both default and customizable calibration recipes for each of the three ranges. The recipe that will be applied automatically—Default or Custom—is indicated in the Recipe column to the right of the Size column (see Figure 4-6). (Filenames for custom calibration recipes are automatically provided and are identified by an initial underscore; for example, _OFF150 is the filename for the 150-µm range custom offset recipe.)
   - To use the recipe indicated to the right of the size, click on the **Continue** button to proceed with the calibration.
   - To apply the default recipe when "custom" is indicated, click on **Default**. The message, "Copy default to custom recipe?" appears. Clicking on **Yes** replaces the parameters in the custom recipe with default values.
   - To apply a custom recipe when "default" is indicated or when you want to modify the custom recipe that is indicated, click on **Custom**. The Recipe Editor opens, displaying the parameters for the custom recipe. Make changes as desired and proceed as if taking a scan.
6. Click **OK** to proceed. The Scan Position Offset Calibration window appears (similar to Figure 4-3 on page 4).

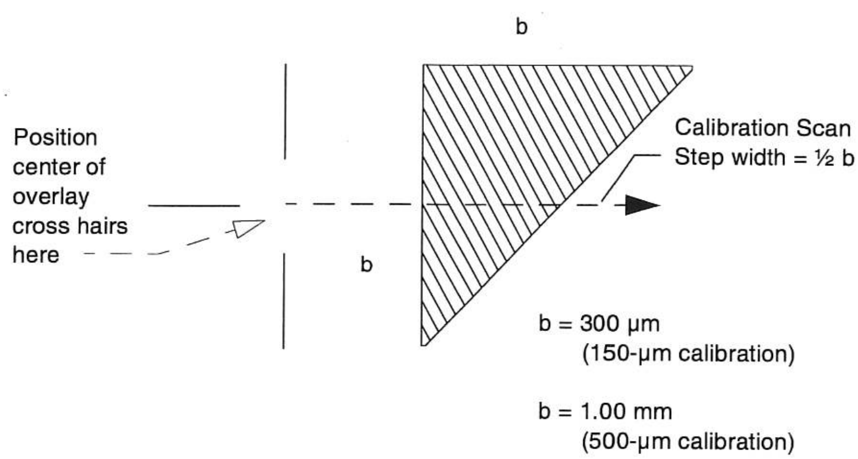
7. Click on **Focus** in the tool bar to lower the measurement head until the sample surface is visible and the stylus nulls on the surface.
8. Locate one of the 150-µm cross-hairs alignment patterns (Figure 4-7).

   There are two different-sized alignment patterns for the Scan Offset Calibration on the Stylus Alignment Tool (see Figure 4-5). Both have right triangles with two equal sides; one has 300-µm sides (for the 150-µm calibration option), the other has 1.00-mm sides (500-µm calibration option). There are six of the smaller patterns, and one of the larger.

   Use one of the 300-µm patterns with the 150-µm calibration first. If the stylus offset is too great, the calibration scan will miss the triangle. In that case, try the 1.00-mm pattern using the 500-µm calibration option, then repeat the 150-µm calibration.

   If the calibration scan misses the 500-µm triangle, the stylus needs to be physically realigned by an authorized Tencor Instruments service representative.
9. Align the cross hairs of the video overlay with those of the pattern so that center matches center, producing a trace path as illustrated by the dotted line in Figure 4-7.

Figure 4-7. *Cross Hairs Alignment Pattern.*



Note: *If precision alignment for sequence operation (features 1 10 µm) is required, the optical magnification must be at maximum zoom, and the Video Calibration must be performed, or the Scan Offset Calibration cannot be accurate.*

10. Click on the **Start** button in the tool bar. The stylus lowers and the instrument scans the triangle at the point where the step width equals half the length of the sides—150 µm for the 300-µm triangle and 500 µm for the 1.00-mm triangle.
11. When the scan is completed, the following Data Analysis window, in this case for a 150-µm calibration, appears:

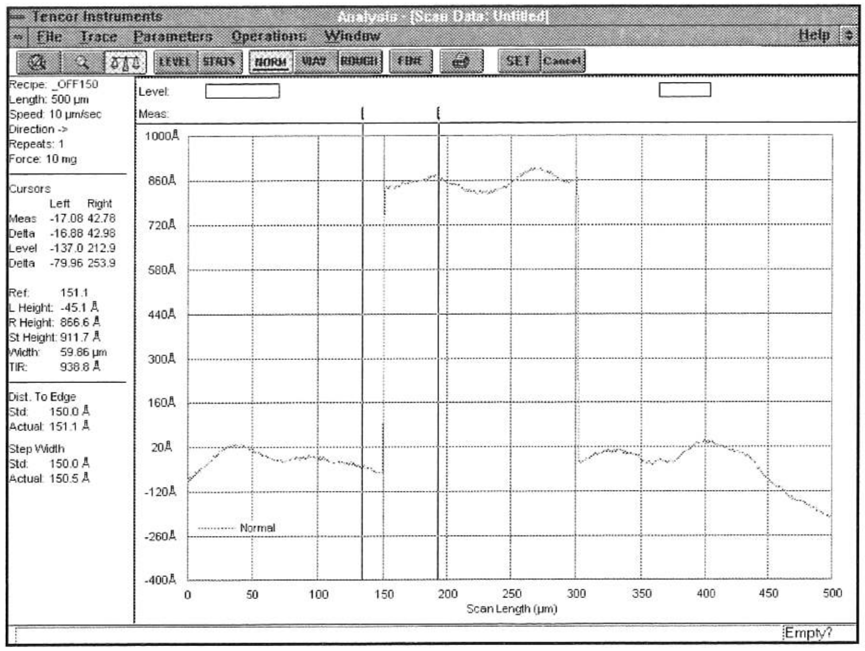


Figure 4-8. *Scan Offset Calibration Data Analysis window.*

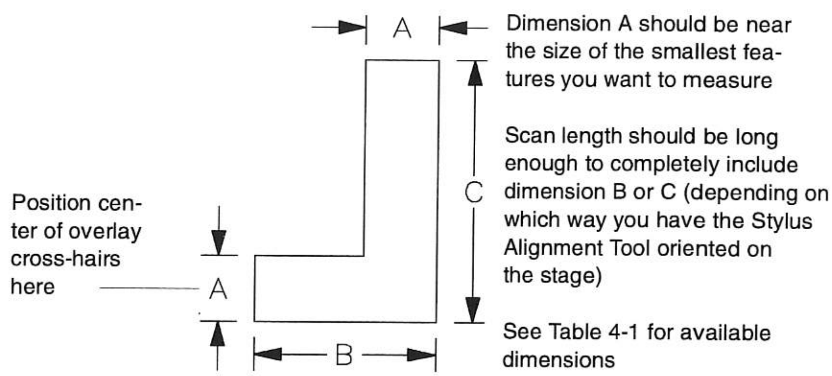
If the actual values for Distance to Edge and Step Width (bottom portion of the Information Area) are within 2 µm of their standard values, click on the **Cancel** button in the tool bar to keep the existing offset values.

If the actual distance and width are more than 2 µm from the standard values, but still relatively close, click the **Set** button in the tool bar to accept the new offset calculation. Then repeat the scan until the distance and width values fall within the 2-µm acceptable range.

If the actual distance and width values are substantially different, the current offset is too great to allow recalibration using the 150-µm calibration option. Click the **Cancel** button in the tool bar and return to step 3. In Step 5, choose the 500-µm calibration option and repeat the scan on the 1.00-mm alignment pattern.

Note that it is difficult to verify the accuracy in the Y dimension. Check your calibration before proceeding to scan samples. The Stylus Alignment Tool provides a set of right-angle-shaped features (Figures 4-5 and 4-9) of varying dimensions that are useful for checking the calibration. Use the feature that has dimensions on the order of the smallest features you intend to measure.

Figure 4-9. *Right-Angle-Shaped Feature.*



To check the Scan Offset Calibration

1. Locate one of the right-angle-shaped features (Figure 4-5) with the center of the cross hairs and perform a scan (see Table 4-1 for available dimensions). The scan length you choose should allow you to completely scan across the feature.

Table 4-1. *Available Dimensions for Figure 4-9*

A (µm)	B (µm)	C (µm)
4	16	50
6	24	60
8	32	80
10	40	100
14	56	100
18	72	100

2. If the stylus sets down above or below the bottom of the L, the calibration should be repeated. (If above, the step width is approximately A instead of B; if below, no step appears.)

Step Height Calibration

Note: *You must calibrate all vertical ranges, and you must calibrate each range independently.*

The vertical sensing transducers in profilers are not absolute devices and, therefore, require calibration. The calibration factors for the available vertical ranges are tuned to approximately 1.00 at the factory.

The most precise calibration comes from precision techniques carefully repeated. To promote uniformity in results, the Step Height Calibration routine is automated for routine calibration of each range. The recipes are written for use with VLSI Standards Inc. step height calibration standards. We recommend that you perform the step height calibration monthly.

To perform the Step Height Calibration

1. Click on the **Step Height Calibration** button in the Scan Calibrations window.The Step Height Calibration Options dialog box appears in the center of the window:

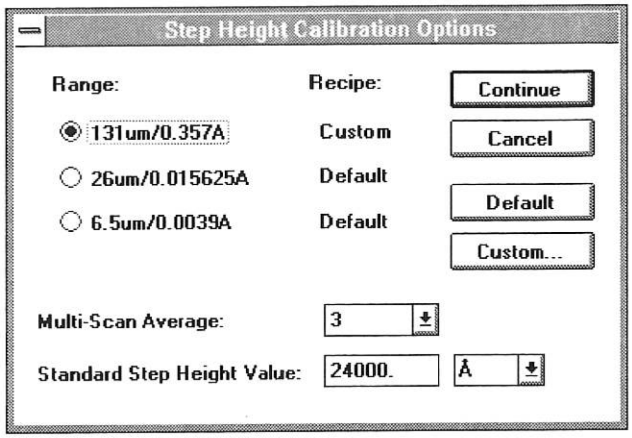


Figure 4-10. *Step Height Calibration Options Dialog Box.*

2. *Range*: Select the calibration range appropriate for the step height standard you are using and click on its radio button.
3. *Multi-Scan Average*: Choose a value for Multi-Scan Average by clicking on the drop-down button and selecting from the list. This number determines how many times the profiler will repeat the scan. Results from each scan are automatically averaged.
4. *Standard Step Height Value:* Enter the nominal step height of the standard you are using into the Standard Step Height Value field, and select the correct units from those available in the drop-down list to the right.

Note: *Units in Å correspond to recipes for VLSI Thin File standards; units in µm correspond to the longer scan of VLSI Standards Thick Film standards.*

5. *Recipe:*

   The profiler provides both default and customizable calibration recipes for each of the three ranges. The recipe that will be applied automatically—Default or Custom—is indicated in the Recipe column to the right of the Range column (see Figure 4-10). (Filenames for custom calibration recipes are automatically provided and are identified by an initial underscore; for example, _STEPHTH is the filename for the high-range custom step height recipe.)

   - To use the recipe indicated to the right of the range, click on the **Continue** button to proceed with the calibration.
   - To apply the default recipe when "custom" is indicated, click on **Default.** The message, "Copy default to custom recipe?" appears. Clicking on **Yes** replaces the parameters in the custom recipe with default values.
   - To apply a custom recipe when "default" is indicated or when you want to modify the custom recipe that is indicated, click on **Custom**. The Recipe Editor opens, displaying the parameters for the custom recipe. Make changes as desired and proceed as if taking a scan.

   The Step Height Calibration window appears (similar to Figure 4-3 on page 4)

6. Locate the calibration step on the standard, just as you would position any other sample for scanning.

7. Position the cross hairs about 200 µm from the right side of the step height and click **OK** or on the **Start** button in the tool bar. The instrument performs as many scans as you indicated in Step 3. Upon completion, the calibration factor is calculated and displayed in the bottom portion of the Information Area of the Data Analysis window (Figure 4-11).

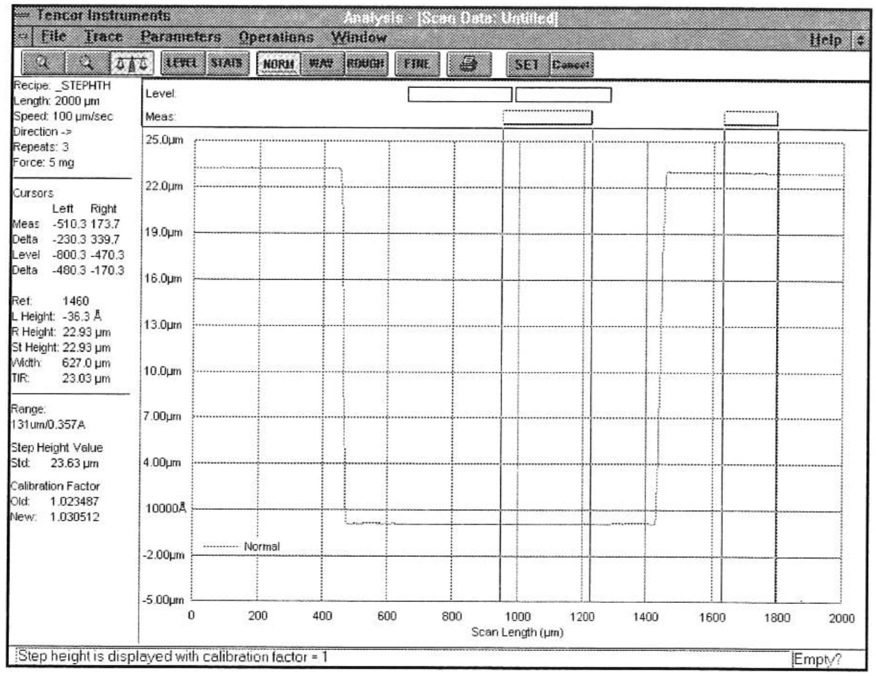


Figure 4-11. *Step Height Calibration Data Analysis window.*

8. Click on the **Set** button in the tool bar to save the calibration factor, or the **Cancel** button to keep the original value and return to the Scan Calibrations window.

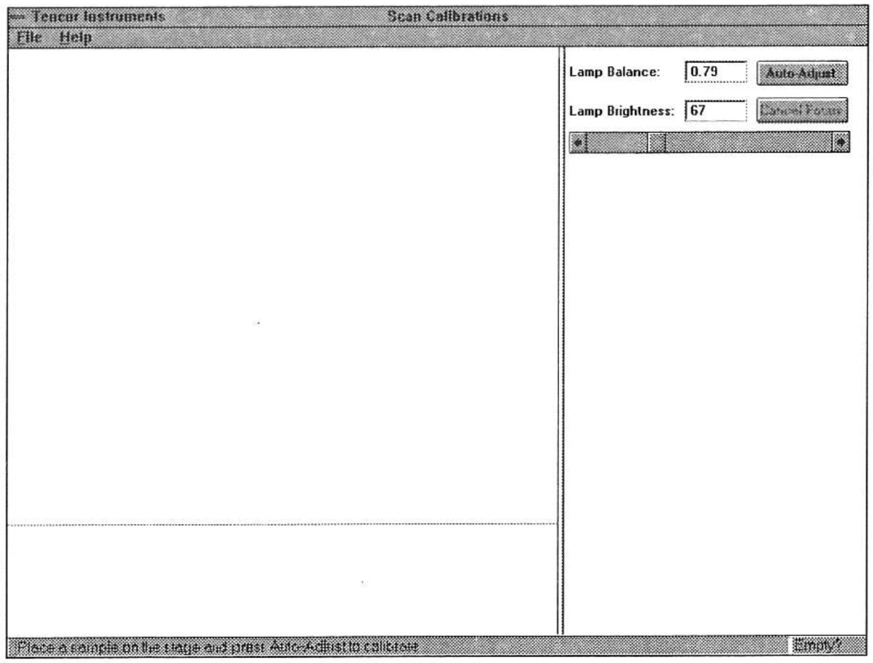
Video Lamp Balance

The Video Lamp Balance for dual-view optics allows you to optimize your view of a particular sample surface. You can vary the total illumination on the sample plus adjust the relative brightness of the two video lamps.

To adjust the total illumination

1. Place a sample on the stage.
2. Click on the Calibrations icon in the Top Level menu. The main Scan Calibrations window appears.
3. Click on the **Video Lamp Balance** button to open its window (Figure 4-12).

Figure 4-12. *Video Lamp Balance window.*



4. Click and drag on the slide bar to adjust total illumination. The value in the Lamp Brightness entry field changes accordingly.
5. Click on **Auto-Adjust**. The stylus lowers to the sample surface twice, first to measure the illumination from the top-view bulb, then again for the side-view bulb.

   The profiler automatically adjusts the output of the two lamps so that the top-view lamp supplies most of the illumination (lamp balance approximately 0.80 to 0.90). With very low or very high outputs, the top-view lamp supplies almost all of the illumination (lamp balance approaches 1.00).

To change lamp balance

1. Follow steps 1 through 3 in the preceding instructions to open the lamp balance window.
2. Click on the Lamp Balance entry field to highlight the current value.
3. Type the desired value as a decimal fraction less than 1.
4. Choose Exit from the File menu. A message, "Save changes to EEPROM?" appears, indicating that the value you have entered will be stored in memory until you change it again.
5. Click on **Yes** to enter the new balance. The screen returns to the main Scan Calibrations window.

Stylus Drop Timer

The Stylus Drop Timer function is a diagnostic tool to be used only under supervision of Tencor Service personnel.

Lubrication

Your instrument uses Tri-Flow™ (Tencor Part No. 069213) and Braycote® (Tencor Part No. 177555) lubricants for servicing the reference flat and leadscrews. The proper lubricant to use is specified on the labels affixed to each lubrication point. *Do not use any other than the specified lubricant.* Follow the warnings on the Tri-Flow or Braycote bottle.

Lubricating X-, Y-, Z-Axis Leadscrews and Reference Flat

The X-, Y-, and Z-axis leadscrews have lubrication wicks to extend the service life and to allow long periods between preventive maintenance.

To lubricate the X- and Y-axis leadscrews and the reference flat

Note: *Be very careful not to bump the stylus or the sensor assembly when lubricating the leadscrew or the reference flat. You may want to install the stylus protection plate for added protection of the stylus. For details on installing the stylus protection plate, see "Removing the Head Assembly" on page 6-14.*

Note: *Do not use solvent to clean the reference flat unless essential.*

Lubricate the X- and Y-axis leadscrews and the reference flat every 12 months based on average use in a relatively clean environment.

1. Remove the left side panel. Each side panel is held by two thumbwheel knobs on the inside upper corners. Support the side panel from the outside and unscrew the thumbwheel knobs, then gently lift the side panel away from the instrument.
2. Use a cleanroom wipe to remove any dirt or excess lubricant on the leadscrews. Move the stage around using the trackball to clean the entire length.
3. Put several drops of Braycote lubricant on the leadscrews and move the stage around to distribute the lubricant and recharge the wick. Continue adding the lubricant and moving the stage until about 10 drops of the lubricant have been added to each screw.
4. Take a fresh clean-room wipe and carefully wipe all lubricant and dirt from the reference glass flat. Move the stage back and forth to clean the entire surface, and also remove any dirt that might have collected on the feet. Add approximately 10 to 20 drops of Tri-Flow lubricant to the flat and rub it in using a clean, dry clean-room wipe. Wipe off any excess with a fresh clean-room wipe. *The lubricant must be evenly spread over the entire surface of the reference flat.*

To lubricate the Z-axis

Lubricate the Z-axis leadscrew every 12 months based on average use in a relatively clean environment.

1. Remove the left side panel. Each side panel is held by two thumbwheel knobs on the inside upper corners. Support the side panel from the outside and unscrew the thumbwheel knobs, then gently lift the side panel away from the instrument.
2. Raise the elevator to the top. The Z-axis leadscrew is lubricated through the hole in the left side of the elevator post near the center.

   You also can access the lubrication hole in the elevator post through the measurement area door. Be very careful not to bump the stylus or the sensor assembly. You may want to install the stylus protection plate for added protection of the stylus. See step 3 in "Removing the Head Assembly" on page 6-14 for details on installing the stylus protection plate.

3. Add two drops of lubricant into the lubrication hole and move the elevator up and down. Repeat until 10 drops of lubricant are added.

Motorized Level and Rotation Stage

Lubricate the Motorized Level and Rotation stage once every 12 months. Use Tri-Flow or Braycote only, as specified on the labels affixed to each lubrication point of your instrument.

To lubricate the Level Adjust Leadscrew

1. Make a note of the level position so that you can return the stage to its original level position after lubrication. To note the level position:

   Double-click on the Configuration icon in the Top Level menu. The Configuration window opens. The Level position is listed in the Stage Configuration box under Leveling Offset.
2. Wipe away any dirt on the leadscrew with a fresh, dry cleanroom wipe.
3. Add two drops of lubricant to the level adjust screw. Manually move the screw to spread the lubricant evenly.
4. Return the table level motor to or near the original Mechanical Level Angle.

To lubricate the Theta Rotation Gear

To lubricate the Theta Rotation gear, use only the lubricant (Tri-Flow or Braycote) specified on the labels affixed to each lubrication point of your instrument. Lubricate the gear every 12 months.

1. Remove the front sheet-metal plate.
   - Loosen the two 4-40 screws holding the plate.
   - Lift the plate away.

> **CAUTION:** Be very careful not to bump the stylus or the sensor assembly when removing the table top. You may want to install the stylus protection plate for added protection of the stylus. See “Removing the Head Assembly” on page 6-14 for details on installing the stylus protection plate.

2. Wipe off any dirt on the Theta Rotation gear using a fresh clean-room wipe. Rotate the Theta Rotation gear by clicking and holding on one of the theta rotation buttons in the tool bar.
3. Remove the rechargeable wick. To reuse the wick, clean it using a clean-room wipe. You also can replace the wick if it is excessively dirty.
4. Add approximately 25 drops of lubricant to a new wick or add approximately 10 drops to the cleaned wick until it is evenly saturated without dripping.
5. Install the wick. The wick should not drip when touching the theta gear.
6. Rotate the Theta Rotation gear to evenly distribute the lubricant. Also, wipe up any drips.
7. Install the front sheet-metal plate.

5

SOFTWARE MAINTENANCE

This chapter is intended for users who have extensive experience using PCs in an MS-DOS environment. This chapter includes:

- Procedures for checking available memory on the computer's hard disk.
- Procedures to recover system files and the database if you get error messages indicating database corruption.

Checking Space Available on the Hard Disk

> **CAUTION:** Avoid overloading the hard disk. If you get a message such as "Insufficient space on drive" or "Out of disk space," your database can become corrupted. Periodically check the amount of space left on the hard drive (see below). When the drive is more than 90% full, stop storing data and delete some files.

To check the space available on the hard disk

In the Windows File Manager, click on the C: drive icon to highlight it. The C: drive's total capacity and the space still available (with Windows running) appears in the status bar at the bottom of the File Manager window.

Deleting Files from the Database

You can delete Scan and Sequence recipes and data from the appropriate catalog.

To delete a database item

1. Double-click on the Export/Import icon in the Top Level menu. The main Database window opens with the Scan Recipe Catalog active.
2. Display the desired catalog by clicking on the appropriate command button on the left side of the window.
3. Select the item you wish to delete by clicking on it or by scrolling with the arrow keys.
4. Click on the **Delete** button below the catalog list, or on the Delete icon in the tool bar. The Delete Recipe dialog box appears.
5. Click **OK** to delete, or **Cancel** to leave the selected item in the catalog.

Backing Up Files

Hard disk corruption is one of the most serious problems that can occur and is the major purpose for periodic backups of critical files on the hard disk. The DOS CHKDSK utility provides an initial check of file system integrity and catches most problems. Other commercially available utilities perform much more extensive tests on disks to help isolate as well as prevent problems caused by defective media.

If you encounter serious corruption of Tencor Profiler system or data files, restore them from the last backup. If you get error messages involving only a few specific items, try deleting those items only and then save all the other items that have not been backed up.

CAUTION: If the hard disk has been reformatted due to database corruption, do not restore backups that were made during the corruption period; otherwise, corruption can occur again.

All the following operations must be performed from the DOS prompt. Sometimes, you must go to a specific DOS directory to perform an operation; in such cases, directions to do so are provided. If you are in the main program, exit to DOS as follows.

To exit to DOS

1. From the Top Level Menu, hold down the Shift key and double-click on the **Log Off** icon. A message box appears with the prompt

   This will end your Windows session.

2. Press ENTER, or click **OK** to close down Windows. The current directory is C:\ORCA.

Backing Up System Files

To back up the calibration and configuration settings

1. Insert a blank, formatted floppy disk into drive A. Use the diskette labeled BAKUPCAL that is provided with the instrument.
2. At the DOS prompt, type *cd c:\orca\cfg* to make C:\ORCA\CFG the active directory.
3. Type *copy *.* a:* to copy the contents of this directory to the floppy disk.

Backing Up the Database

To back up the database

1. Insert another blank, formatted floppy disk into drive A.
2. At the DOS prompt, type *cd c:\orca\db* to make C:\ORCA\DB the active directory.
3. Type *copy *.* a:* to copy the contents of this directory to the floppy disk.
4. Label the diskette to identify it as the one with the recipes and sequences.

To back up De-skew image files

1. Insert another blank, formatted floppy disk into drive A.
2. At the DOS prompt, type *cd c:\orca\dskw_img* to make C:\ORCA\DSKW_IMG the active directory.
3. Type *copy *.* a:* to copy the contents of this directory to the floppy disk.
4. Label the diskette to identify it as the one with the de-skew image files.

Purging Old Files

If the database becomes corrupted, you may need to purge all the old software before rebuilding the system. This step is rarely necessary.

To purge the old software

1. First exit from the profiler software and then from Windows.
2. At the DOS prompt, type *cd* and press ENTER to get to the root directory.
3. Type *deltree\windows* and press ENTER to delete the entire contents of the WINDOWS directory.
4. Similarly, execute the command *deltree\orca* to delete the contents of the profiler directory, ORCA.
5. Verify that you have MS-DOS version 6.2 or higher by typing *ver*. Call Tencor Technical Support if the response is anything lower than MS-DOS version 6.2.

Restoring System Files

Note: *A diskette containing initial CFG settings (BAKUPCAL) is shipped with the instrument. Also, a copy of the CFG directory is created automatically in the BACKUP directory during installation so that you will have a CFG directory that was valid at the time of the last software installation.*

To restore the calibration and configuration settings

1. At the DOS prompt, type *cd c:\orca\cfg* to make C:\ORCA\CFG the current directory.
2. Insert the appropriate floppy disk into drive A.
3. Type *copy a:*.** to copy the contents of this directory to the current directory.
4. When the copy is finished, remove the floppy disk.

To reinstall the profiler software from the installation disks, refer to Appendix B, "Installing Tencor Profiler Software."

Restoring the Database

Note: *These procedures assume that a single floppy disk suffices to hold all the files in a single directory. If the contents of any of the directories are too large to be contained in a single floppy disk, use the DOS backup/ restore utility MSBACKUP as detailed in the Microsoft DOS 6.x User's Guide.*

To restore the scan recipes and sequences

1. At the DOS prompt, type *cd c:\orca\db* to make C:\ORCA\DB the current directory.
2. Insert the appropriate floppy disk into drive A.
3. Type *copy a:*.** to copy the contents of this directory to the current directory.
4. When the copy is finished, remove the floppy disk.

To restore De-skew image files

1. At the DOS prompt, type *cd c:\orca\dskw_img* to make C:\ORCA\DSKW_IMG the current directory.
2. Insert the appropriate floppy disk into drive A.
3. Type *copy a:*.** to copy the contents of this directory to the current directory.
4. When the copy is finished, remove the floppy disk.

6

MicroHead Measurement Head

Tencor's advanced, low moment MicroHead enables the P-10 Profiler to precisely measure the surface topography of finely textured surfaces at sub-angstrom vertical resolution, while preserving the sample's true surface condition. The MicroHead offers accurate measurement of the features of a variety of surfaces with excellent vertical repeatability and reproducibility.

Features of the low moment MicroHead include

- Innovative stylus arm, offering an extremely low moment of inertia, which reduces sensitivity to environmental noise
- Advanced digital signal processing (DSP), improving control and accuracy with up to 1-kHz sampling rates for faster scans
- Constant stylus force control throughout the entire vertical sensor range, achieved by incorporating an intelligent sensor to determine surface topography
- Ultra-low stylus force down to 0.05 mg (Low Force MicroHead II), measuring accurate profiles of roughness below 10Å and features less than 100Å
- Dual-view optical design (optional), providing a top-down view of an image for stylus positioning, as well as a side-angle view for checking the stylus tip and measured features
- Color camera (optional), simplifying identification of ultra-thin or color features
- Automatic positioning of the stylus on the sample surface for enhanced roll-off measurement repeatability
- Extremely low noise characteristics, enabling measurement of step heights with a repeatability of 8Å maximum in the 6.5 mm (±3.2) range (Low Force MicroHead II)
- High-resolution 3D imaging of areas more than 500 x 500 µm, utilizing the low-drift sensor of the head
- Proximity detector to allow fast descent until near the sample

See Appendix A, "Specifications," for more details.

You will need a standard set of metric and Allen (hex) wrenches to perform some of the procedures in this chapter.

MicroHead Components

Figure 6-1 shows the major components of the MicroHead.

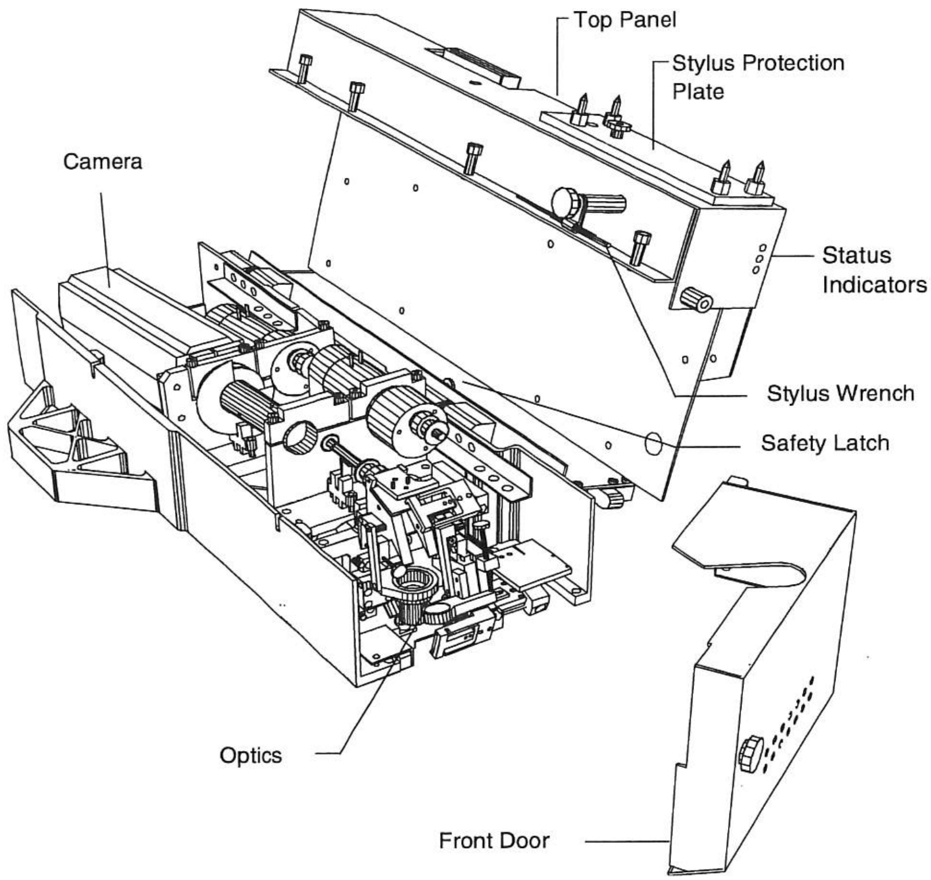


Figure 6-1. *MicroHead Measurement Head.*

Front Door

You must remove the door before raising the top panel of the MicroHead.

Top Panel

The top panel of the MicroHead contains the measurement head electronics. This door is also removable and contains a safety latch to prevent it from slipping off when it is open.

Measurement Head

The measurement head contains the optics used in the MicroHead, the sensor assembly, and the motor to lower the sensor to the measurement position.

Status Indicators

The three status indicators are visible through the top panel of the MicroHead. These lights are controlled by the digital signal processor (DSP) in the scanner unit. When the DSP is reset, all Status indicators are on. When the DSP software is running, the DSP controls the state of the indicators as follows:

- The green indicator flashes at about 3.8 Hz while the DSP code is running. This is the normal state during instrument operation.
- The red indicator turns on when the computer is acquiring data. This light is normally off except during scans.
- The yellow indicator turns on if the stylus is above the null position; it turns off if the stylus is below the null position.

Electrostatic Effects and Low Stylus Forces

It is possible for a large electrostatic force to develop between a highly charged sample surface and the MicroHead stylus. This can make operation at low stylus forces impossible. If you need to profile a non-conductive substrate such as a glass flat, remove any electrostatic charge before taking a measurement, or use a stylus force setting of at least 0.6 mg.

MicroHead Vertical Ranges

The following table shows vertical ranges for Tencor MicroHead. The accompanying resolution values are based on the MicroHead's performance and software characteristics; actual values depend on the level of environmental noise and on the sample's surface characteristics as it is scanned.

Table 6-1. *MicroHead Vertical Ranges*

Measurement Head	Vertical Range (μm)	Resolution (Å)
Low Force MicroHead II	±3.2	0.004
	±13	0.016
	131	0.08
Extended MicroHead *xr*	±6.5	0.008
	±6.5	0.08
	1000	0.6
MicroHead *sr*	±6.5	0.008
	±32.5	0.04
	327	0.2

Changing the Stylus

Styli are color-coded to indicate radius. Check the color band on the stylus arm against the following table for the stylus radius.

Table 6-2. *Available L-Stylus Radius*

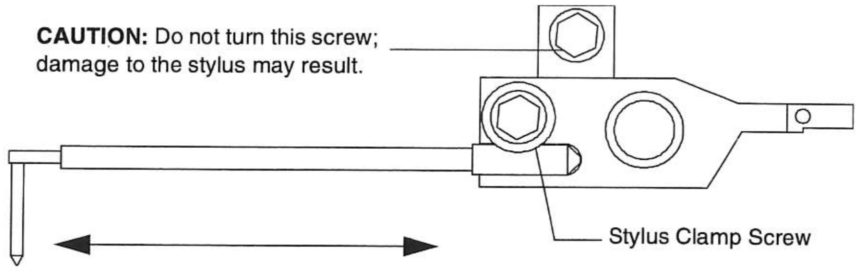
Color Code Band	Stylus Radius (μm)	Shank Angle (Deg.)
Red	12.5	60
Yellow	5.0	60
Green	2.0	60
Black[a]	0.3–0.8	70
Black[a]	0.1–0.2	70

a. For radius values, refer to the SEM documents provided with the stylus.

Low Force MicroHead II and MicroHead *sr*

The MicroHead includes a stylus wrench, located on the left side of the head. To avoid losing the stylus, should you accidentally drop it, place a piece of paper, a clean-room wipe, or a small container on the stage beneath the stylus before proceeding.

Figure 6-2. *Replacing the Stylus, Low Force MicroHead II.*



To remove the stylus

1. Raise the measurement head and then open the door.
2. Loosen the thumbscrew holding the stylus wrench on the side of the head and slide the wrench from its holder (see Figure 6-1, "MicroHead Measurement Head.," on page 2).
3. The head of the stylus clamp screw is visible when you face the instrument. Loosen the screw by inserting the stylus wrench and turning the wrench counter-clockwise 1/2 turn. Be careful to apply turning torque only, and do not press inward any harder than necessary to seat the wrench. Do not remove the screw.
4. Pull the stylus gently to the left and remove it from the stylus arm.

To replace the stylus

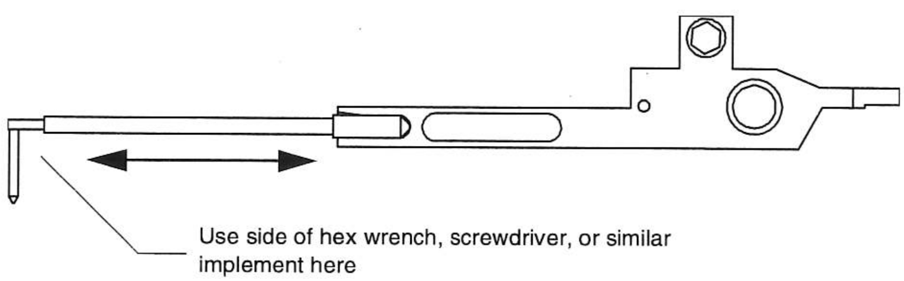
Note: *After changing the stylus, be sure to perform the Scan Position Offset Calibration, as described in "Scan Position Offset Calibration" on page 4-5. Also be sure to perform a stylus force calibration, "Stylus Force Calibration" on page 4-2.*

1. Insert the long arm of the stylus into the groove in the stylus arm with the tip pointing downward toward the stage. Gently maneuver it until it is fully inserted into its slot.
2. Gently tighten the clamp screw to hold the stylus in place. Do not tighten it too much or you can damage the stylus arm pivot.
3. Remove the stylus wrench from the stylus clamp screw, return it to its storage clip, and tighten the retaining thumbscrew.
4. Close the measurement head door.

Extended Range MicroHead *xr*

The Extended Range MicroHead *xr* stylus uses a spring clip to secure the stylus in place and simplify replacement. To avoid losing the stylus, should you accidentally drop it, place a sheet of cardboard or paper or a small container on the stage beneath the stylus before proceeding.

Figure 6-3. *Replacing the MicroHead xr stylus.*



To remove the stylus

1. Raise the measurement head to the top and open the door.
2. Locate the stylus. With the side of a small hex wrench or similar implement, reach behind the bend in the L (Figure 6-3) and press gently towards the left. Be careful to apply force only to the left along the line of the stylus shaft. The stylus slides out of its slot and drops.

To replace the stylus

Note: *After changing the stylus, be sure to perform the Scan Position Offset Calibration, as described in "Scan Position Offset Calibration" on page 4-5 Also be sure to perform a stylus force calibration, "Stylus Force Calibration" on page 4-2.*

1. Using your fingers, gently insert the long side of the L-stylus into the groove in the stylus arm with the tip pointing down toward the stage. Be careful to align the flattened back side of the stylus to the rear wall of the groove.
2. Gently slide the stylus into the groove until it is fully inserted.
3. Close the measurement head door.

Changing the MicroHead Objective Lens

Two lenses are available for the Tencor MicroHead top view options, offering a range of magnifications. Table 6-3 lists the magnification ranges and field widths for the available lenses.

Table 6-3. *Available Objective Lenses for the MicroHead*

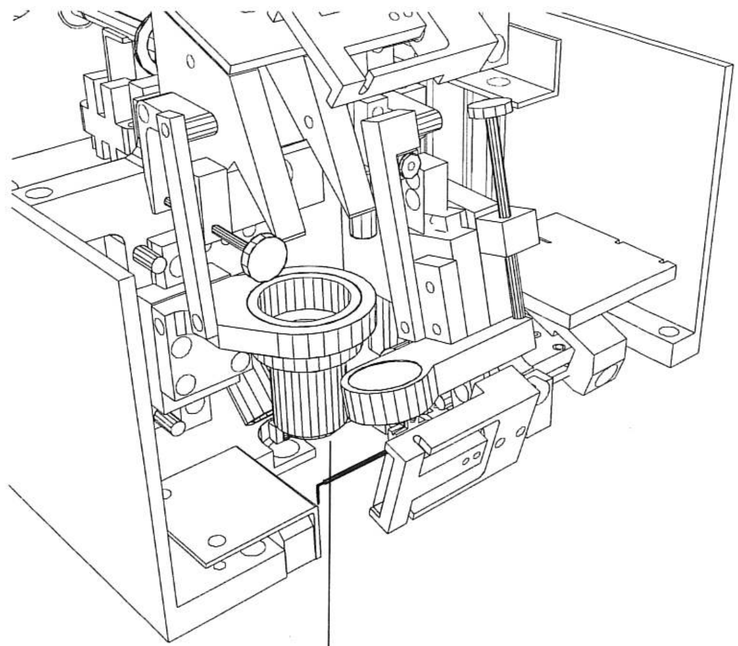
Lens	Magnification Range		Field Width (mm)
	90° (Top View)	45° (Side View)	
4.0x	115–465x	95–410x	1.60–0.40
6.3x	185–750x	95–410x	1.0–0.25

Note: *Remove the stylus before changing the lens to eliminate the possibility of damaging the stylus by dropping the lens. See "Changing the Stylus" on page 6-4 for details.*

To change the objective lens

1. Raise the measurement head so that the stylus tip cannot contact any surface.
2. Open the measurement head door.
3. Reach in using both hands, and unscrew the objective lens. Using both hands assures you won't drop the lens onto the stylus arm.
4. Lift the lens out carefully.

Figure 6-4. *Changing the Objective Lens.*



5. Screw in the replacement lens in the same manner.

> **CAUTION**: Be careful not to drop the objective lens when removing it from the measurement head.

6. Close the measurement head door.

Replacing the MicroHead Sample Illumination Bulbs

The illumination bulbs for the optic lens are located in the back of the optics block, as shown in Figure 6-5.

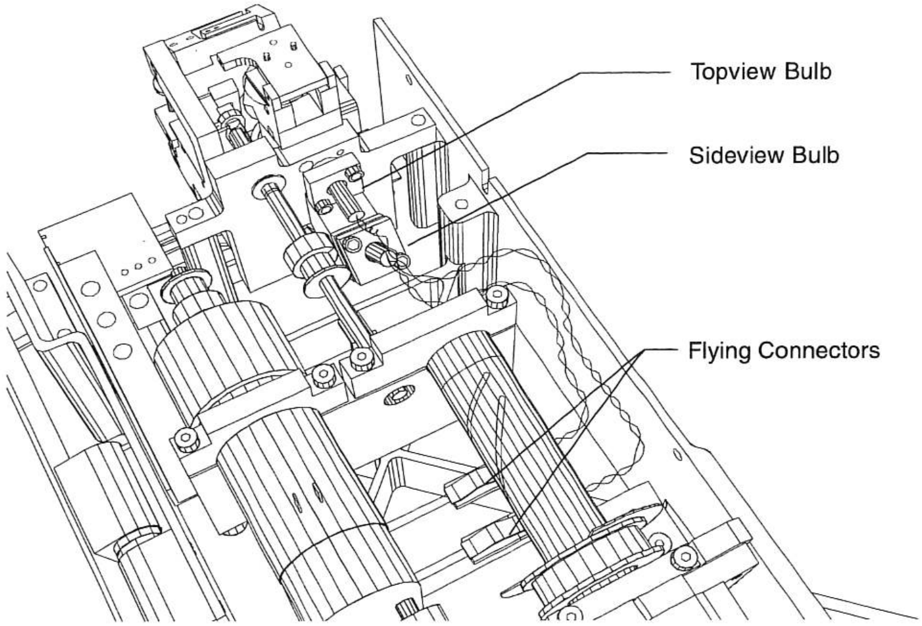


Figure 6-5. *MicroHead Illumination Bulbs.*

The standard optical design provides a side-angle view for checking the stylus tip and measured features. However, the optional optical design provides a top-down view of an image for stylus positioning, as well as the side-angle view.

To replace the illumination bulbs

1. Remove the instrument's left and right side panels. Each side panel is held by two large thumbwheel knobs on the inside upper corners. Support each panel from the outside and unscrew each of the thumbwheel knobs, then gently lift the panel away from the instrument.
2. Use the 3/32-in. hex wrench to remove the instrument top panel. The top panel is held by ten button-head screws, five along each side. Lift the top panel vertically away from the instrument.
3. Lower the measurement head and null the stylus on a patterned substrate.
4. Remove the front door of the measurement head.
5. Loosen the three button-head screws on the left side of the measurement head top panel, then tilt the top panel vertically.
6. Locate the pair of intertwined wires from the illumination bulb at the back of the optics block.
7. Follow the wires to where they are plugged into another cable at flying connectors (see Figure 6-5). Unplug the connectors.
8. Follow the wires to the optics block. The illumination bulb is mounted on a collet that is held down by a collet clamp plate with two No. 4 cap-head screws.
9. Use a hex wrench (3/32 in.) to carefully loosen the two cap-head screws on the collet clamp plate, just enough to slide the lamp out of the collet. Hold the lamp by the side of the collet—*do not pull on the wires!*
10. Insert a new illumination bulb. Try not to touch the bulb with your fingers. Do not tighten the cap-head screws yet.

11. Plug the wires of the bulb into the same connector into which the previous bulb's wires were plugged.
12. Look at the projected light on the sample surface. Adjust the position of the (optional) topview bulb until the projected light forms a bright, nearly perfect circle.
13. Adjust the sideview bulb by observing the video image on the computer screen.
14. For either bulb, check the video image with the zoom magnification set to minimum for acceptable quality.
15. Hold the bulb in this position and tighten the cap-head screws on the collet clamp plate.

MicroHead Setup

To set up the measurement head software

1. Turn on the instrument.
2. Double-click on the Calibration icon in the Top Level menu. The Scan Calibrations window appears.
3. Click on the **Stylus Force Calibration** button. The Stylus Force Calibration window appears (Figure 4-2).
4. Perform the Stylus Force Calibration as described on page 4-2.
5. Store the stylus protection plate for possible future use.

Stylus Tip Radius Measurement

This procedure describes a method of inspecting the tip of a stylus to measure its radius or determine if it has been broken. This is done by profiling an apex with a radius much smaller than the radius of the stylus tip itself. The Tencor Stylus Radius Measurement Tool (Tencor Part No. 205958) consists of a razor edge mounted in a rectangular fixture, as shown in Figure 6-6.

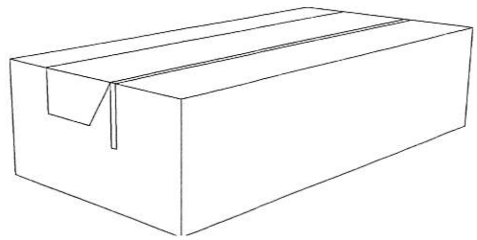


Figure 6-6. *Tencor Stylus Radius Measurement Tool.*

> **WARNING**: Do not touch the razor edge on the Stylus Radius Measurement Tool. To protect the razor edge from any contact with objects other than a stylus, return the tool to its storage case promptly after use. The method of stylus radius determination used is based on the assumption that the razor edge has a radius much smaller than the stylus radius. Dulling of the edge invalidates this assumption.

To measure a stylus tip radius using the Stylus Radius Measurement tool

1. From the Top Level menu click the Scan icon.

   The Scan Recipe Catalog window appears.

2. Click the **View/Modify** button at the bottom of the screen.

   The Recipe Editor screen appears.

3. Enter the following 2D recipe:

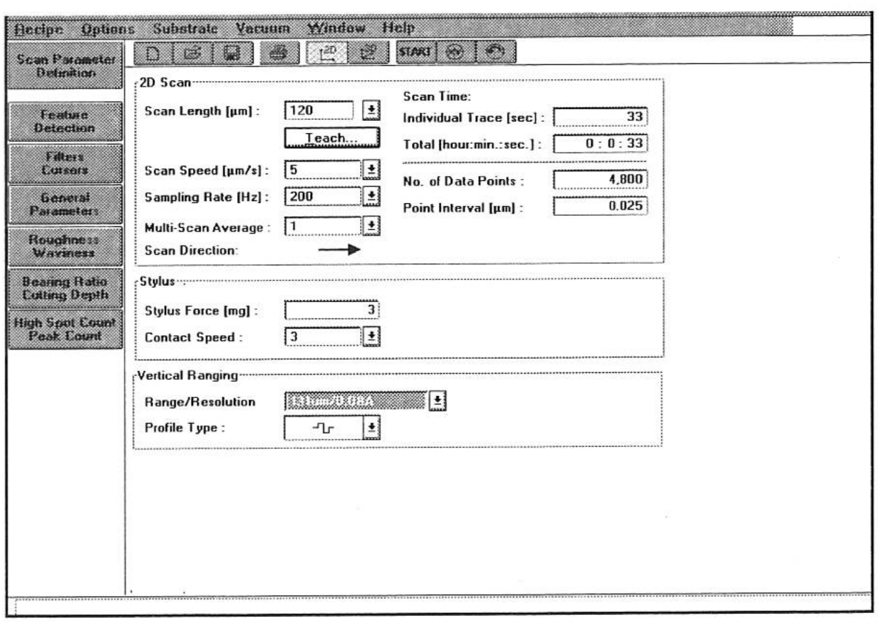


Figure 6-7. *Recipe Editor window for Determining Stylus Radius.*

4. Enter the highest Range/Resolution value available.

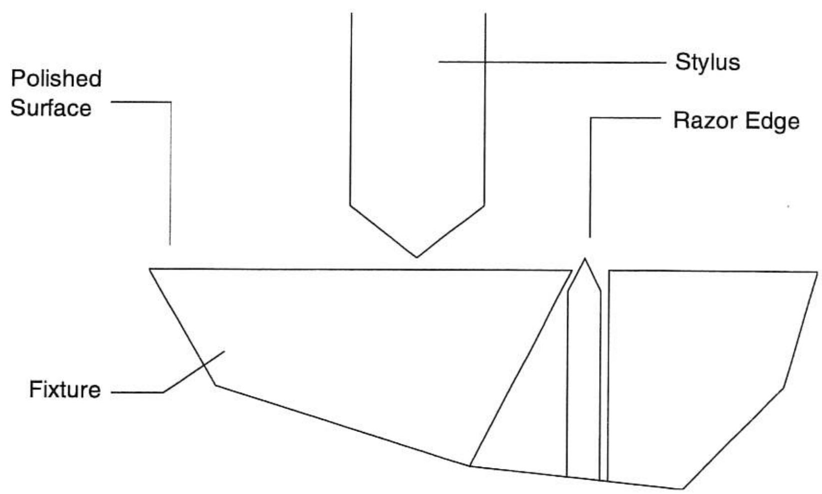
5. Make sure that you set the positions of the L and R leveling cursors to 0 to disable leveling, and that the measurement cursors have a preset position. In the General Parameters dialog box, check the Radius and the Distance to Edge parameters so they will display.

   If a scan length of 120 µm is too short to effectively make the scan, try:
   Scan length: 240 µm
   Scan speed: 5 µm/s
   Samp. Rate: 100 Hz

6. Click on the **XY** button to display the XY View screen.

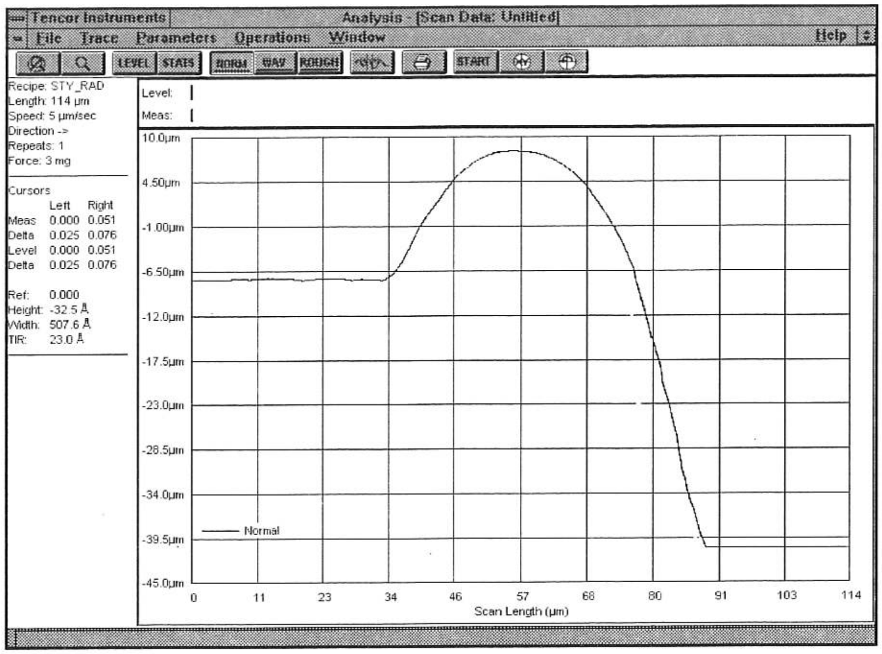
7. Position the stylus about 50–60 µm from the edge of the blade, as shown in Figure 6-8. If you cannot accurately determine the position of the edge, take a longer scan to locate the edge, then adjust the start position accordingly, and finally return to the shorter scan length.

Figure 6-8. *Positioning to Start Scan.*



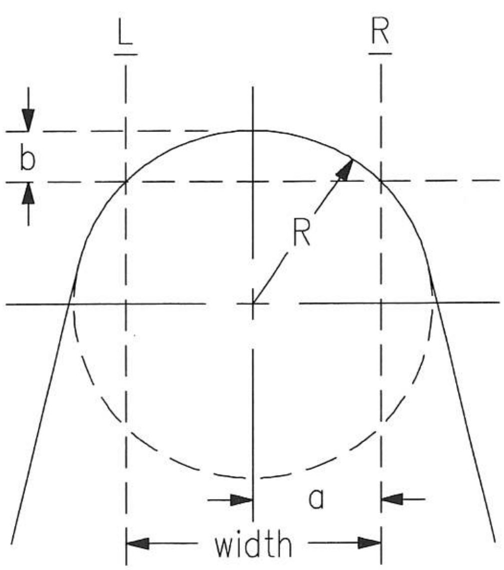
8. Null the stylus, then start the scan. Figure 6-9 shows a typical profile.

Figure 6-9. *Typical Data From Scanning Stylus Radius Measurement Tool.*



9. Zoom the trace to the area near the apex and position the measurement cursors on either side (Figure 6-10) such that
   - The cursors clearly intersect the trace *on the curved portion* of the apex, not further away where the trace straightens out
   - The difference between the cursor heights is as close to 0 as possible. The height difference should be less than 3% of the measurement width. If you want to adjust the measurement cursors manually, be sure that you have zoomed in the Data screen as much as possible on the region of the apex.

Figure 6-10. *Cursor Positioning for Radius Determination.*



10. Read the radius value from the Trace Information box in the Data Analysis window.

Stylus tips are not perfectly spherical; typically, the radius varies, being smallest at the tip and larger as the curve flattens out into the shaft. For smaller features, the effective radius of the stylus at the area where the tip contacts the sample surface is smaller than it is for larger features. If the value of *b* in Figure 6-10 can be chosen as the TIR value of a typical measurement, then the actual effective radius of the stylus at that scale can be more precisely stated.

During a scan, the stylus moves in a circular arc around the stylus arm pivot instead of a pure vertical motion. Turning on *arc* correction compensates for the distortion this would otherwise cause.

If the arc at the apex of the trace is noticeably flattened or misshapen, this could indicate a dull spot in the razor edge or a broken or misshapen stylus. Try taking the scan at a few other locations along the razor edge. If the apex of the trace appears much the same regardless of location along the razor edge, the stylus may be flawed.

The Thin Film Step Height Standards, listed in Appendix D, "Ordering Information," have two stylus integrity test tracks that allow diagnostic checks of the stylus condition (symmetry and cleanliness). For more information, see the VLSI Standards Application Note, "Thin Film Step Height Standard," provided with the Step Height Standards.

Focusing the Optics

To refocus the optics—topview measurement head

1. Raise the measurement head, and then open its front door (Figure 6-1).
2. Use the **Focus** button to null the stylus on the sample (a patterned sample with easily defined features works well).
3. Turn the Focus knob to focus the view.

To refocus the optics—dual-view measurement head

1. Raise the measurement head, and then open its front door (Figure 6-1).
2. Use the **Focus** button to null the stylus on the sample (a patterned sample with easily defined features works well).
3. Turn the topview Focus knob to focus the topview (Figure 6-11).
4. Lower the stylus on the sample, then use the sideview Focus knob to focus the side view.

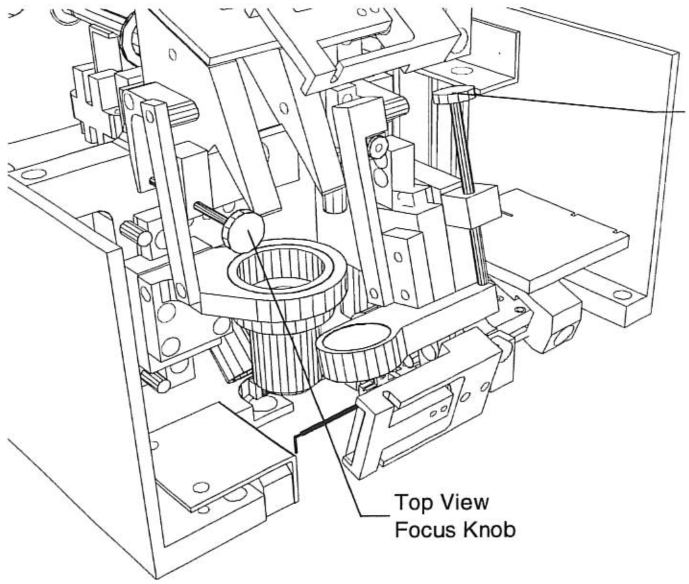


Figure 6-11. *Focusing the Optics (Dual-View Optics).*

Removing and Installing the Head Assembly

The modular design of the Tencor Profiler head assembly enables a user with no special mechanical aptitude or training to change the head using the following instructions. Important points to keep in mind while changing the head:

- Do not discard the special boxes and packaging used to ship the replacement head. Use them to return the damaged head to the factory. If the head is not shipped in the special protective boxes, Tencor Instruments is not responsible for any damage to the head during shipment.
- Do not remove the stylus protection plate (Figure 6-12) on the replacement head until you are instructed to do so.
- The head weighs 11 lbs and should be held carefully with both hands when removed from or inserted into the instrument.

You need the following to replace a damaged head:

- 3/16-in. hex wrench
- 30 to 40 min. to remove and replace the head

Removing the Head Assembly

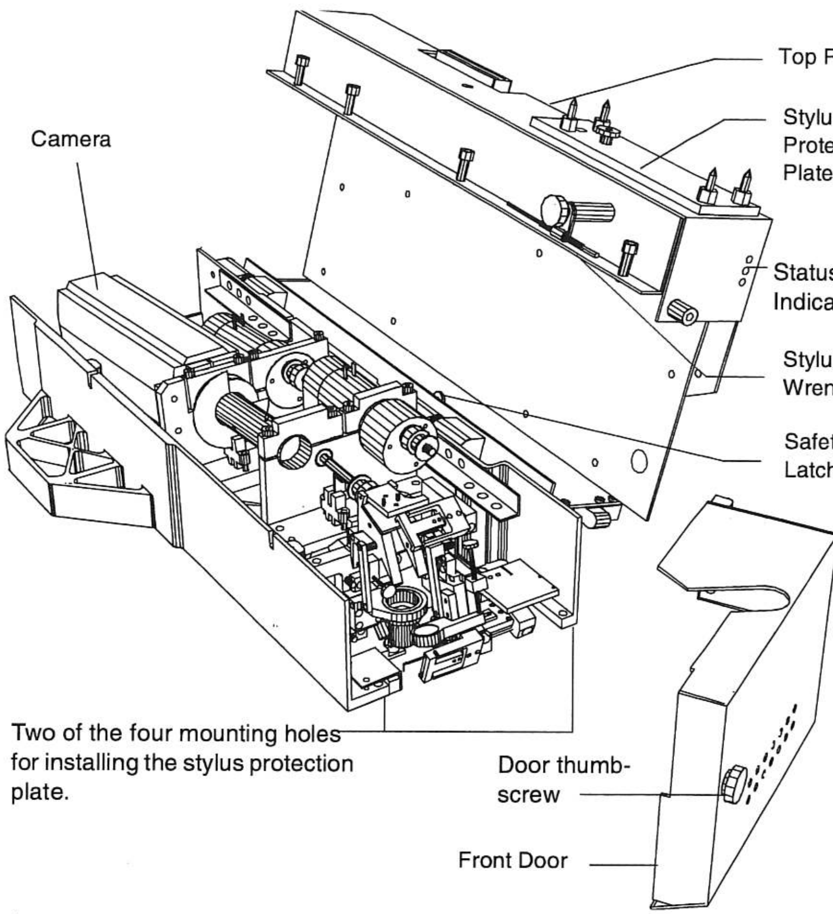
We recommend that you read the following instructions before beginning the removal procedure and that you follow each step in sequence.

To remove the head assembly

1. Open the instrument front door. Remove both the left and right side instrument panels. Each panel is held on by two knobs located inside the instrument near the top front and rear corners.
2. Open the measurement head front door by loosening the thumbscrew. This enables you to see the location for installing the stylus protection plate.

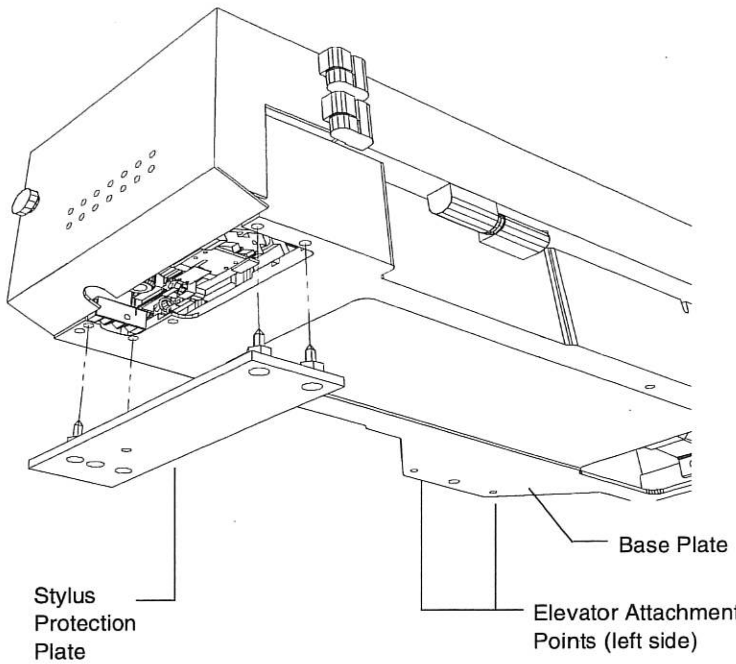
Remove the top of the instrument by loosening the ten button headscrews along the top left and right edges. Use a 3/32-in. hex wrench.

Figure 6-12. *Removing the Head Assembly.*



3. Install the stylus protection plate as follows:
   - Remove the Stylus Protection Plate from the Top Panel by removing the thumbscrew (see Figure 6-12).
   - Hold the stylus protection plate with the guide pins facing up (See Figure 6-13, "Installing the Stylus Protection Plate.," on page 16).
   - Insert the guide pins into the holes on the left and right sides of the base plate below the stylus.

Figure 6-13. *Installing the Stylus Protection Plate.*



4. Close the front door and tighten the thumbscrew.
5. Lower the measurement head until the head or the stylus protection plate almost touches the stage table. Note that if the head is damaged, you might not be able to lower the head but you can still remove it.
6. Turn the power off and disconnect the flat cable connected to the head assembly on the left side.
7. The head is attached to the elevator by four 1/4-20 screws, two on each side of the elevator (Figure 6-13). You can access these screws through the side panels.

To free the head

- Use a 3/16-in. hex wrench to loosen all four screws by a half-turn.
- Remove three of the screws. Don't remove the rear screw, on the side from which you will lift out the head. This screw will hold the head until you are ready to lift it out of the instrument.

8. When you are ready to lift the head out, place one hand below the base plate (Figure 6-13) to support the head and remove the last rear screw.

CAUTION: When lifting the head, support it with both hands.

9. Lift the head out of the instrument. On some instruments, you need to disconnect the camera BNC cable in the back.
10. Install the new head using the instructions in the following section, "Installing the Head Assembly."
11. Return the damaged head to the factory using the same boxes and packaging used to ship the replacement head.

Installing the Head Assembly

We recommend that you read the following instructions before beginning the installation procedure.

To install the head assembly

1. Unpack the replacement head carefully from its boxes and packaging.

   Do not discard the special protective shipment boxes and packaging. The damaged head must be shipped in the same boxes and packaging used for the replacement head; otherwise, Tencor Instruments is not responsible for any damage to the head during shipment.
2. Open the instrument front door. Remove both the left and right side instrument panels. Each panel is held on by two knobs located inside the instrument near the top front and rear corners.
3. Remove the top of the instrument by loosening the ten button headscrews along the top left and right edges. Use a 3/32-in. hex wrench.

CAUTION: When lifting the head, support it with both hands.

4. Lift the head assembly by its base plate, carefully insert it into the instrument, and place it over the elevator.
   - The head assembly should fit snugly over two head assembly locating pins on the top of the elevator.
   - Use the head alignment labels on either side of the head and elevator to guide the head assembly into its correct position.
   - Use a 3/16-in. hex wrench to replace the two 1/4-20 screws on each side of the elevator. Tighten the screws to approximately 8 ft-lb.
5. Plug the flat cable into the socket on the left side of the head assembly. Attach the camera BNC connector if necessary.
6. Remove the stylus protection plate:
   - The stylus protection plate is a white plate stored below the stylus. Gently apply downward pressure to both ends of the protection plate and remove it.
   - Store the stylus protection plate for possible future use.

7. Reinstall the side panels. Place each side panel against the instrument body, support the side panel from the outside, and screw on each thumbwheel screw on the inner side. Each panel is held by two thumbwheel screws on the inner side.
8. Turn on the instrument and recheck the calibrations for Scan Position Offset, Stylus Force, Video, and Step Height. Recalibrate if necessary.

Shipping the Damaged Head

Return the damaged head to the factory. Pack the damaged head in the special protective boxes and packaging used to ship the replacement head. The shipping container displays the following label.

Figure 6-14. *Measurement Head Shipping Label.*

FRAGILE!

TENCOR® INSTRUMENTS

PROFILER MEASUREMENT HEAD SHIPPING CONTAINER

DO NOT DISCARD OR DAMAGE THIS BOX AND ITS PROTECTIVE FOAM INSIDE

MEASUREMENT HEAD MUST BE RETURNED TO TENCOR IN THIS SHIPPING CONTAINER TO AVOID RESPONSIBILITY OF REPAIR CHARGE IN CASE OF SHIPPING DAMAGE

SHIPPING CONTAINER KIT: EXTERNAL BOX + 6 FOAM CUSHIONS
INTERNAL BOX + 2 FOAM END CAPS
ANTI-STATIC BAG FOR THE MEASUREMENT HEAD

CAUTION: If the head is not shipped in the special protective boxes, Tencor Instruments is not responsible for any damage to the head during shipping.

7

Desktop Program

You can load the Profiler program into a desktop or laptop computer for analyzing and manipulating data obtained with the instrument. Instead of performing detailed analysis on the production floor, you can conveniently transfer data to an office environment and free the instrument for measurement tasks.

This option lets you view and manipulate measurement data using the standard and the band pass filters. You can do stress calculations and display three-dimensional data. You also can selectively retrieve data using the Database Manager and download or upload to another host using the SECS interface.

This section covers

- System requirements
- Software installation
- Desktop program operation

System Requirements

- PC-compatible 486 or higher
- DOS 6.2 or higher
- 20-MB minimum free disk space for the program itself; additional space needed for recipes and scan data
- 16 MB minimum of RAM
- Windows 3.1 or higher (not Windows 95™ or Windows NT™)
- Disk drive able to read high-density 3.5-inch disks
- Parallel port set to LPT1 for the Configuration Key
- VGA monitor with 800 x 600 resolution; 256 colors (or more)
- Windows virtual memory swap file, 20 MB or more

Installing Software Version 3.x on a Desktop System

Following the steps below minimizes changes to your system's AUTOEXEC.BAT and CONFIG.SYS files. Proper desktop installation requires:

- changing the path statement in AUTOEXEC.BAT
- changing the Files= statement in CONFIG.SYS

> **IMPORTANT:** This procedure applies only to installation on desktop or laptop computers. *Do not use it to install the software on the instrument.*

To prepare for installation

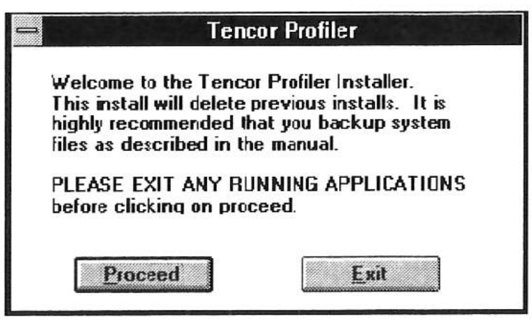
1. As a precaution, make a copy of your system's AUTOEXEC.BAT and CONFIG.SYS files (located on the C:\ directory) on a disk.
2. Double-click on the Control Panel icon of the Windows Program Manager and then double-click on the Color icon. Note the specified color scheme. (Installation resets the color scheme; you may want to change it back to the previous scheme after installation.)
3. If you are installing the software on a laptop, double-click on the Enhanced icon (386 chip) in the Control Panel. In the Enhanced dialog box, click on the **Virtual Memory** button, then on the **Change >>** button. Increase Swap File size to at least 20,000 KB if available.
4. Turn off the computer.
5. Insert the Configuration Key into your computer's parallel printer port. If you had a printer connected here, you can reconnect it to the Configuration Key.

To install Profiler Software Version 3.x

1. Turn on the computer and restart Windows.
2. Close all other applications, then insert the first of the six installation disks in your A drive.
3. In the Windows File Manager, click on File, then on Run. The Run dialog box appears.
4. In the command line text box, type *a:setup* and click **OK**.

   The Welcome Message dialog box appears

Figure 7-1. *Welcome Message Box.*



5. Click on the **Proceed** button. The Configuration Options dialog box appears:

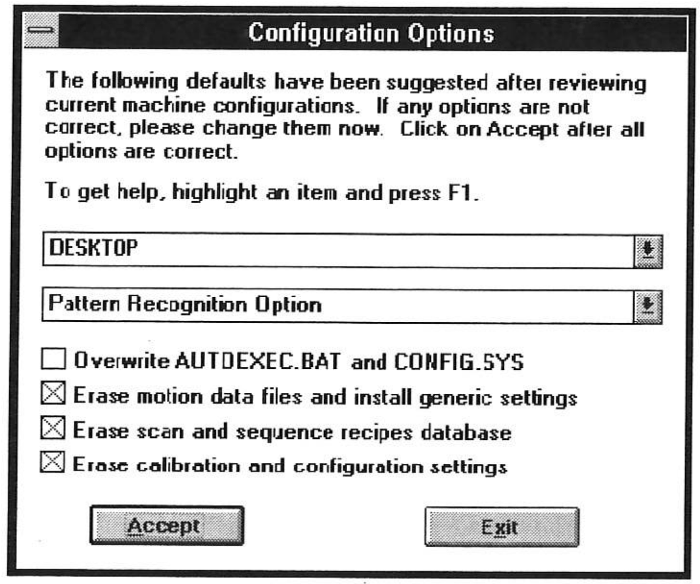


Figure 7-2. *Configuration Options Dialog Box.*

6. Click on the Instrument Type list box and choose "Desktop."
7. In the same manner, choose "Pattern Recognition Option" in the Video Option list box.
8. Make sure the *Overwrite AUTOEXEC.BAT and CONFIG.SYS* box is not checked.
9. Check the other three boxes:
   - *Erase motion data files and install generic settings,*
   - *Erase scan and sequence recipes database,* and
   - *Erase calibration and configuration settings.*
10. Click on the **Accept** button to continue installation, following instructions as prompted by the installation program.
11. When the last disk has been read, remove it from the drive and click **OK**. The system restarts. If the computer does not reboot automatically, reboot it manually.

Note: *Step 8 is critical to minimizing changes to your systems AUTOEXEC.BAT.*

To edit the AUTOEXEC.BAT and CONFIG.SYS files

1. After the system reboots, open CONFIG.SYS (c:\ directory) from the Windows Notepad or another text editor.
2. Change the number in the FILES= statement to 30 or greater (Files=30 is the correct syntax) and save the file.
3. Open AUTOEXEC.BAT (c:\ directory).
4. Immediately after the existing Path= statement, type the following:

   path=%path%;c:\orca\exe;c:\orca\dll

5. Save the file and close the editor.
6. Reboot the system. Version 3.x is now installed.

If Problems Occur

Although the setup program automatically saves the existing AUTOEXEC.BAT and CONFIG.SYS files, it is possible to overwrite these backup files if you install the software more than once. If your other applications do not work properly after installation, you can retrieve these files from the C:\ORCA\BACKUP directory after the first installation, or from your backup disks from step 1 if you have installed the software a second or third time.

To obtain top performance, verify that your system's swap file is at least 20 MB. You can access the Swap File size through the Enhanced icon in the Windows Control Panel.

Running the Desktop Software

For best performance, close all other applications before running the Profiler program on your desktop.

Conflict with Norton AntiVirus™

If you use Norton AntiVirus, you may find that its Autoprotect feature conflicts with the Profiler Memory Manager. You can turn off the Memory Manager by editing the Windows SYSTEM.INI statement,

drivers=mmsystem.dll winmm16.dll c:\orca\dll\fxlmbdll.dll

to

drivers=mmsystem.dll winmm16.dll

If you have no conflicts, we suggest that you simply minimize Memory Manager for optimal performance.

A

Specifications

Measurements

Roughness	R_a, Arithmetic Average Max R_a, Maximum of 19 overlapping sections R_q, Root-Mean-Square (RMS) R_p, Maximum Height R_v, Maximum Depth R_t, Maximum Peak-to-Valley R_z, Ten-Point Height R_{3z}, Six-Point Height R_h, Height between two points
Waviness	W_a, Arithmetic Average W_q, Root-Mean-Square W_p, Maximum Height W_v, Maximum Depth W_t, Maximum Peak-to-Valley W_h, Height between two points
Topography	
TIR	Total Indicator Run-out
Height	Height between two points (Step Height)
Average Height	Average height of all data points between the measurement cursors relative to the leveled baseline (Delta Averaging)
Slope	Rate of change of the profile between two points
Radius	Distance from center of curvature of profile arc to the profile
Area of Peaks	Total area bounded by the leveled baseline and the profile above the baseline
Area of Valleys	Total area bounded by the leveled baseline and the profile below the baseline

Total Area	Sum of Area of Peaks and Area of Valleys
Profile Length	Length obtained from drawing out the profile into a straight line
Maximum Height	Maximum height of trace between the measurement cursors relative to the zero line
Minimum Height	Minimum height of trace between the measurement cursors relative to the zero line
Edge	Distance to rising or falling edge or apex from start of profile
Step Width	Width of profile step
Number of Steps	Number of steps between the measurement cursors
Mean Step Height	Mean value of all the steps between the measurement cursors
Std. Dev. Step Height	Standard deviation of all the steps between the measurement cursors
Mean Peak Height	Mean value of peak heights
RMS Slope	Root-mean-square value of slopes
Average RMS Wavelegth	2π times ratio of RMS deviation of R_q to the RMS slope
Standard Deviation Heights	Standard deviation of peak heights
Bearing Length Ratio	Ratio of bearing length to sampling length at chosen value of Cutting Depth
Cutting Depth	Distance below highest peak to reference line giving chosen value of Bearing Ratio
Peak Count	Number of peak/valley pairs per unit length projecting through a band of chosen width centered about mean line
High Spot Count	Number of profile peaks per unit length projecting through a chosen reference line
Mean Peak Spacing	Mean value of the local peak spacing, where peaks are defined as in Peak Count

Table A-1. *Long-Wave Cutoff Filter Wavelengths*

mm	in.	mm	in.	mm	in.
0.0045	0.0002	0.14	0.006	4.5	0.18
0.008	0.0003	0.25	0.01	8.0	0.3
0.014	0.0006	0.45	0.018	14	0.55
0.025	0.001	0.8	0.03	25	1.0
0.045	0.002	1.4	0.055		
0.08	0.003	2.5	0.1		

Table A-2. *Short-Wave Cutoff Filter Wavelengths*

mm	in.	mm	in.	mm	in.
Default[1]		0.014	0.00056	1.4	0.056
0.00025	0.00001	0.025	0.0010	2.5	0.10
0.00045	0.00002	0.045	0.0018	4.5	0.18
0.00080	0.00003	0.08	0.0030	8.0	0.30
0.0014	0.00006	0.14	0.0056	14	0.56
0.0025	0.00010	0.25	0.010	25	1.0
0.0045	0.00018	0.45	0.018		
0.008	0.00030	0.80	0.030		

[1] Default cutoff filter values differ depending on scan speed and sampling rate. See Table A-3.

Microhead Measurement Heads

Table A-3. *MicroHead II Low Moment Measurement Heads (Stylus Force: 0.05—50 mg)*

Scan Method	Moving stage, stationary stylus	
	Metric	**English**
Scan Length	150 mm	6 in. maximum

Table A-3. *MicroHead II Low Moment Measurement Heads (Stylus Force: 0.05—50 mg) (Continued)*

	Metric	English
Scan Speed	1 µm/sec. to 25 mm/sec.	0.04 mil/sec. to 1 in./sec.
Sampling Rate	50, 100, 200, 500, and 1000 Hz nominal	
Vertical Range:		
Low Force MicroHead II		
At 0.004Å (0.004 µin.) Resolution	±3.2 µm	±0.13 mil max.
At 0.016Å (0.008 µin.) Resolution	±13 µm	±0.5 mil max.
At 0.8Å (0.008 µin.) Resolution	±13 µm	±0.5 mil max.
At 0.5Å (0.04 µin.) Resolution	131 µm	5.2 mil max.
MicroHead *xr*		
At 0.008Å Resolution	±6.5 µm	±0.26 mil max.
At 0.8Å Resolution	±65 µm	±0.2.6 mil max.
At 0.6Å Resolution	1000 µm	±39.4 mil max.
MicroHead *sr*		
At 0.008Å Resolution	±6.5 µm	±0.26 mil max.
At 0.04Å Resolution	±32.5 µm	
At 0.2Å Resolution	327 µm	
Vertical Linearity, below 2000Å	10Å	0.04 µin
Vertical Linearity, above 2000Å	±0.5%	±0.5%
Because the instrument linearity guarantee is significantly smaller than the uncertainty of the step height standards available in the range of typical use of the instrument, step height standards cannot be used to verify the linearity of the instrument		
Horizontal Resolution At 1 µm/sec. scan speed	0.01 µm (100Å)	0.4 µin

Table A-3. *MicroHead II Low Moment Measurement Heads (Stylus Force: 0.05—50 mg) (Continued)*

Stylus Control	Programmable Force: Range 0.05—50 mg Resolution 0.05 mg Full retract between scans Programmable descent rate
Variable Sample Image Magnification Sideview optic Topview optic (include with optional dual-view optics)	 150—600 x 183—750 x and 300—1200 x (with user interchangeable lens)

Table A-4. *Default Short-Wave Cutoff Filter Wavelengths*

Speed (µm/s)	Sampling Rate (Hz)	Short-Wave Cutoff Frequency (Hz)	Short-Wave Cutoff Wavelength (µm)
1	50	4	0.25
	100	7.5	0.13
	200	15	0.07
	500	37.5	0.03
	1000	Not Available	Not Available
2	50	4	0.5
	100	7.5	0.27
	200	15	0.13
	500	37.5	0.05
	1000	75	0.03
5	50	4	1.3
	100	7.5	0.67
	200	15	0.33
	500	37.5	0.13
	1000	75	0.07

Table A-4. *Default Short-Wave Cutoff Filter Wavelengths (Continued)*

Speed (µm/s)	Sampling Rate (Hz)	Short-Wave Cutoff Frequency (Hz)	Short-Wave Cutoff Wavelength (µm)
10	50	4	2.5
	100	7.5	1.3
	200	15	0.67
	500	37.5	0.27
	1000	75	0.13
20	50	4	5.0
	100	7.5	2.7
	200	15	1.3
	500	37.5	0.53
	1000	75	0.26
50	50	4	13
	100	7.5	6.7
	200	15	3.3
	500	37.5	1.3
	1000	75	0.67
100	50	4	25
	100	7.5	13
	200	15	6.7
	500	37.5	2.7
	1000	75	1.3
200	50	4	50
	100	7.5	27
	200	15	13
	500	37.5	5.3
	1000	75	2.6

Table A-4. *Default Short-Wave Cutoff Filter Wavelengths (Continued)*

Speed (µm/s)	Sampling Rate (Hz)	Short-Wave Cutoff Frequency (Hz)	Short-Wave Cutoff Wavelength (µm)
400	50	4	100
	100	7.5	53
	200	15	27
	500	37.5	11
	1000	75	5.3
1000	50	4	250
	100	7.5	130
	200	15	67
	500	37.5	27
	1000	75	13

Sample Handling

Wafer Sizes	50 mm, 75 mm, 100 mm, 125 mm, 150 mm, and 200 mm	
X-Y	Unlimited programmable locations	
Manual Control	Use trackball or keyboard	
	Metric	**English**
Maximum Sample Size	254 x 254 mm	10 x 10 in.
	Note: 355 x 355 mm (14 x 14 in.) with side panel removed..Stylus can access any part of a 150-mm (8.2-in.) round sample without sample repositioning.	
Maximum Sample Weight	2.2 kg.	5 lb.
Throat Depth	228 mm	9 in.
Throat Height, incl. Rotary Stage	63.5 mm	2.12 in.
X,Y Maximum Travel	150 mm	6 in.
X,Y Positioning Speed	Variable up to 25 mm/sec.	1 in./sec.
Motorized Stage Rotation		
Angle Resolution	0.001°	
Leveling	Electronic leveling of traces is standard. Automatic mechanical leveling of sample with Motorized Level and Rotation Option.	
Vacuum Hold-Down of Sample	Standard	
Custom Fixturing Interface	Three 8-32 UNC 2B threaded holes on 3.16-in. diameter circle, 90° apart	

Measurement Control

Manual/Single Scan Mode	Continuous or segmented scan, from recipe
Repeat and Average Mode	Scan repeated up to ten times and averaged

Data Storage

Hard Disk	850 MB. Stores over 20,000 scans at 1000 points each.
Diskette	1.44 MB, 3.5 in. Data storage limited to approximately 100 recipes and 200 scans at 1000 points each. (300 scans per diskette dedicated to data.)
Storage Requirements	DOS Operating System: approx. 6 KB
(estimates only)	Microsoft Windows program: approx. 10 MB
	Tencor Profiler program: approx. 11 KB
	Recipe: 215 bytes
	Single-scan data: 652 bytes plus trace data
	Trace data: Trace data storage requirements are added to that for the scan data.
	2D trace data: minimum 2K bytes for the first 505 data points plus 4 times the number of data points thereafter
	3D trace data: 2122 bytes minimum plus 2048-byte increments
	32 bytes per trace (range 1 to 210 inclusive)
	4 bytes per data point
	Approximate number of data points = number of traces × scan length × sampling rate/scan speed

Data Analysis

Interactive Graph	Two-cursor read-out. Cursors move independently or in tandem.
Measurement or Leveling	Each cursor is expandable into a region for measurement.
Zoom Box Data Expansion	Portion of a graph can be magnified.
Data Catalog	Immediate data retrieval and display from catalog

Equipment Specifications

Processor	80486,33 MHz microprocessor (subject to change). Runs MS-DOS version 6.22.
RAM	16 MB
Monitor	15 in. SVGA Displays magnified image of the sample or output data. Initial data trace or cross-hair identification of stylus location relative to stage can be superimposed on sample image. High resolution Color data display, user-selectable colors
Standard Keyboard	Enhanced 101 AT with trackball
Real-Time Clock	Battery-backed clock provides date and time of day.

Physical Specifications

	Metric	English
Dimensions		
Width	57 cm	23 in.
Height	46 cm	17.5 in.
Depth	84 cm	34 in.
Weight		
Instrument	68 kg	150 lb
Shipping Weight	127 kg	280 lb
Electrical	90– 110V, 50/60 Hz 110–130 V, 50/60 Hz 180–260 V, 50/60 Hz	
Power controller rating	150 VA	
Current usage	15 A (120V) 30 A (230V)	

B

INSTALLING TENCOR PROFILER SOFTWARE

It may be necessary to reinstall the Profiler software in the course of maintenance or troubleshooting. This appendix contains step-by-step instructions for the following installation procedures:

- Backing up and purging files
- Installing the Profiler Software Version 3.x
- Restoring files (if necessary)

> **IMPORTANT**: Use this procedure only for installing profiler software in the instrument. Profiler software may be installed on a desktop PC but requires a different procedure that safeguards existing files. Refer to Appendix C for desktop installation instructions.

Backing Up and Purging Files

It is recommended that you back up critical files before installation.

Backing Up Files

You should back up the files containing system configuration and calibration settings, recipes, sequences, and De-skew image files before installing the profiler software. After installation, you can restore these backup files to the appropriate directories.

The following directories contain the files you should back up:

- The C:\ORCA\CFG directory contains system configuration and calibration setting files.
- The C:\ORCA\DB directory contains database files.
- The C:\ORCA\DSKW_IMG directory contains De-skew image files.

To back up files

Note: *This procedure assumes that the files in a single directory can be copied to one 1.44-MB disk. If the contents of any of the directories are too large to be copied to a single disk, use the DOS MSBACKUP command as described in the Microsoft DOS manual.*

1. Make sure you have three blank, formatted, high-density (1.44 MB) disks.
2. Close all applications and exit Windows.
3. Label one of the blank disks to identify it as containing calibration and configuration backup files, and then insert the disk into drive A.
4. The upgrade package contains a disk labeled BACKUPCAL, which you can use to save the calibration and configuration backup files. You can also save the handler NUM settings to this disk.
5. At the DOS prompt, type *cd c:\orca\cfg* to make C:\ORCA\CFG the active directory.

6. Type *copy *.* a:* to copy the contents of the directory to the disk, and then remove the disk from the drive and set the tab to "read only."
7. Label another blank disk to identify it as containing recipe and sequence backup files, and then insert the disk into drive A.
8. At the DOS prompt, type *cd c:\orca\db* to make C:\ORCA\DB the active directory.
9. Type *copy *.* a:* to copy the contents of this directory to the floppy disk, and then remove the disk from the drive and set the tab to "read only."
10. Label the last blank diskette to identify it as containing De-skew image backup files, and then insert the disk into drive A.
11. At the DOS prompt, type *cd c:\orca\dskw_img* to make C:\ORCA\DSKW_IMG the active directory.
12. Type *copy *.* a:* to copy the contents of this directory to the floppy disk.
13. Remove the disk from the drive, set the tab to "read only," and store the three backup disks in a safe place.

Purging Old Files

If the database is corrupted, you may need to purge all the old software before reinstalling the profiler application software. Purging the system is rarely necessary, so if you are not sure you need to, call Tencor Technical Support before proceeding.

To purge old files

1. Close all applications and exit Windows.
2. At the DOS prompt, type *ver* to verify that you have MS-DOS version 6.2 or higher. If the version number is lower than 6.2, call Tencor Technical Support before proceeding.
3. At the DOS prompt, type *cd* and press ENTER to get to the root directory.
4. To delete the profiler application directory, type *deltree\orca* at the DOS prompt and press ENTER to delete the entire contents of the ORCA directory.

Installing Profiler Software Version 3.x

To install the software

1. Turn on the system.
2. With the currently installed software version running, double-click on Configuration in the Top Level menu to display the Video Option of the current installation.
3. Make a note of the video configuration.
4. Close all applications except the Windows Program Manager.

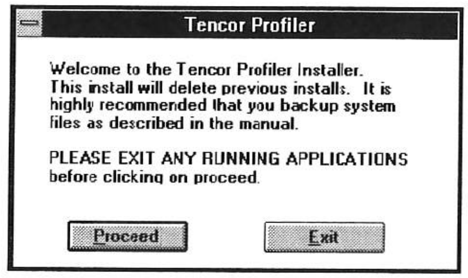
   Make sure MEMMGR is also closed.

Note: *It is important that you write down the video configuration; you will need it when you install the new software.*

5. Insert the first disk, labeled #1 of 6, in the disk drive.
6. From Program Manager, choose Run from the File drop-down menu. The Run dialog box appears.
7. In the Command Line text box, type `A:\SETUP` and click **OK**.

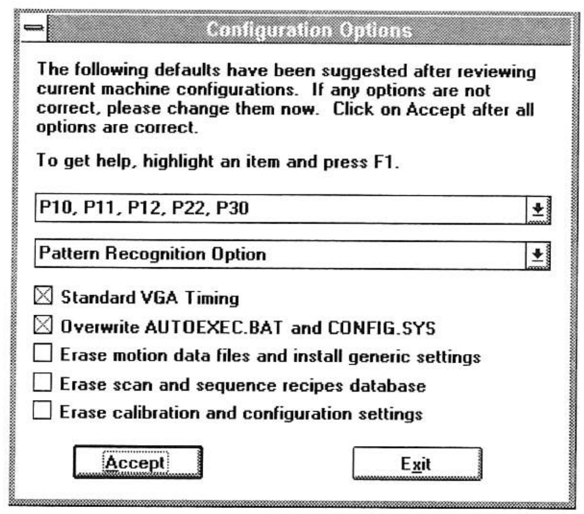
The profiler installation begins loading the configuration information of the instrument. The following message is displayed before the files are copied from the diskettes.

Figure B-1. *Welcome message box.*



8. Click on the **Proceed** button. The Configuration Option dialog box appears.

Figure B-2. *Configuration dialog box.*



The two list boxes in the upper portion of the dialog box show the Profiler model type and video options. The model type information is read from the Configuration Key, and the video option setting is read from the installed hardware and/or configuration files. The lower region of this dialog box contains the installation option check boxes.

9. Verify that the model type and video option information is correct. If necessary, select the correct settings. Note that if the model type is set to 'Desktop', any video option may be used.
10. Make sure the *Standard VGA Timing* option is checked by default for the first installation.
11. Make sure the *Overwrite AUTOEXEC.BAT and CONFIG.SYS* option is checked.

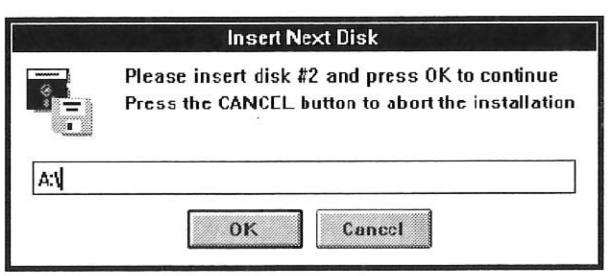
The AUTOEXEC.BAT and CONFIG.SYS files contain the environment setup for the installed software. Always install the new AUTOEXEC.BAT and CONFIG.SYS. You should always back up your old AUTOEXEC.BAT and CONFIG.SYS files if you have set your own environment as, for instance, in a DESKTOP installation.

12. Check or uncheck the *Erase motion data files and install generic settings* box based on one of the following:
    - If you are upgrading from 2.*x* software, it is not necessary to reinstall the motion data files; therefore, leave the box unchecked.
    - Place a check in the box if 2.x or 3.x software was not previously installed on the instrument.
13. Check or uncheck the *Erase scan and sequence recipes database* box based on one of the following:
    - Leave the box unchecked if you are upgrading from 2.*x* software and want to keep the old database contents.
    - Place a check in the box
        - if the instrument's hard drive was reformatted
        - if you want to clear all of the database contents and all scan and sequence recipes
        - if the previous software version is 1.*x*
        - if the previous 2.*x* or 3.x version software was not installed correctly
14. Check or uncheck the *Erase calibration and configuration settings* box based on one of the following:
    - Leave the box unchecked if you are upgrading from 2.*x*.

      Checking this item is **not** recommended, unless you decide to redo all the configurations and calibrations.
    - Place a check in the box
        - if the instrument's hard disk was reformatted
        - if the current calibration configuration values cannot be used
        - if the previous software version is 1.*x*
        - if a 2.*x* or 3.x version software was not installed correctly
15. Click on the **Accept** button to begin installation.

    Message boxes will appear, prompting you to insert another diskette.

Figure B-3. *Insert Next Disk message box.*



When installation is complete, a message box appears, indicating Windows will be restarted.

16. Remove the last installation diskette from the disk drive, and click **OK**.

    The system restarts. (If Windows does not restart automatically, restart it manually.) Version 3.x is now installed.

Restoring Files

After the profiler application software has been installed, you can restore files as needed.

Note: *If you are restoring scan and sequence recipes from version 2.2, you must first run the 2.2 to 2.3 Upgrade program before using the instrument.*

To restore calibration and files

1. Close all applications and exit Windows.
2. At the DOS prompt, type *cd c:\orca\cfg* to make C:\ORCA\CFG the current directory.
3. Insert the disk containing the calibration and configuration backup files into drive A, and type *copy a:*.** to copy the contents to the current directory.
4. Remove the floppy disk, and insert the disk containing the scan recipe and sequence backup files.
5. At the DOS prompt, type *cd c:\orca\db* to make C:\ORCA\DB the current directory.
6. Type *copy a:*.** to copy the files to the current directory.
7. Remove the floppy disk, and insert the disk containing the De-skew image backup files.
8. At the DOS prompt, type *cd c:\orca\dskw_img* to make C:\ORCA\DSKW_IMG the current directory.
9. Type *copy a:*.** to copy the files to the current directory.
10. Remove the disk.

C

EXPORT/IMPORT FILE FORMATS

This appendix describes the scan and sequence data file formats for the Tencor Profiler. See the sections, "Exporting Data," and "Importing Data," in the Operations Manual for information on using the Tencor Profiler database to export and import data files.

Data files can be exported in either binary format (files with the extension.DAT) or ASCII format (files with extension.TXT). Data files can only be imported in binary format.

This section describes in detail the format of the binary data files. The format description is organized into tables, grouped in the following sections:

- *Recipe information.* The information that appears in the Recipe Info dialog box of the Recipe Editor (170 bytes)
- *Scan recipe parameters.* The settings in the Scan Parameter Definition form of the Recipe Editor (132 bytes)
- *Scan parameters.* Actual scan speed, hardware sampling rate, and so on (22 bytes).
- *Post-processing parameter settings.* The settings in the rest of the Recipe Editor forms (2458 bytes)
- *Results of parameter calculations* (4062 bytes)
- *Trace data* 4+20*n* bytes, where *n* is the number of data points

Recipe Information

The first 170 bytes contain the recipe information that is set by the operator in the Recipe Info dialog box of the Recipe Editor window.

Table C-1. *Scan Data Format—Recipe Information*

Field	Index	Size	Name/Description
1	0	17	Name, character string
2	17	17	Author, character string
3	34	4	Access code, long integer
4	38	4	Time modified, long integer
5	42	128	Comments, 128 characters

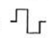
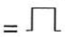
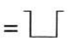
Scan Recipe Parameters

Bytes 171–302 contain the information that the operator sets in the Scan Parameter Definition form of the Recipe Editor window.

Table C-2. *Scan Data Format—Scan Recipe Parameters*

Field	Index	Size	Name/Description
6	170	2	Scan Type, unsigned short integer 0 = 2D scan 1 = 3D scan 2 = Segmented scan
7	172	4	Diagnostic Scan Flag, unsigned long integer 8 least significant bits are used; rest are unused Bit 1 = No-motion scan Bit 2 = No nulling Bit 3= No backscan Bit 4= Do not apply linearity table Bit 5= Do not apply cal factor to raw data Bit 6= Do not perform noise filtering Bit 7= Do not perform leveling Bit 8= Do not check; scan goes out of bounds
8	176	4	Scan Length, long
9	180	2	Scan Length Display Unit, unsigned short 0 = µm 1 = mm 2 = µin. 3 = mil 4 = in.
10	182	2	Sampling Rate, unsigned short
11	184	2	Scan Direction, unsigned short 0 = Scan left to right 1 = Scan right to left 2 = Default direction (left to right)
12	186	2	Multiscan Average, unsigned short
13	188	16	Reserved1, 8 unsigned shorts
14	204	2	Number of Traces, unsigned short (3D)
15	206	4	Spacing, long (3D)
16	210	8	Reserved2, 4 unsigned shorts (3D)
12	218	4	Stylus Force in mg, float

Table C-2. *Scan Data Format—Scan Recipe Parameters (Continued)*

Field	Index	Size	Name/Description
13	222	2	Contact Speed, unsigned short
14	224	8	Reserved3, 4 unsigned shorts
15	232	2	Profile Type, unsigned short 0 =  1 =  2 = 
16	236	2	Range, unsigned short 0 = High range 1 = Medium range 2 = Low range
17	234	64	Reserved4, 32 unsigned shorts

Scanning Parameters

Bytes 301–322 contain information that describes physical parameters relating to the scan. These are not set by the operator, but depend on the settings in the Scan Parameter Definitions form in the Recipe Editor window and hardware characteristics of the instrument.

Table C-3. *Scan Data Format—Scanning Parameters*

Field	Index	Size	Name/Description
18	300	4	Actual Points, long
19	304	8	Horizontal resolution, double
20	312	2	Hardware sampling rate, unsigned short
21	314	4	Analog cutoff frequency, float
22	318	4	Actual scan speed, float

Post-Processing Parameter Settings

Bytes 323–2780 contain the information that the operator sets in the Feature Detection, Filters/Cursors, General Parameters, Roughness/Waviness, Bearing Ratio/Cutting Depth, and High Spot Count/Peak Count forms of the Recipe Editor window.

Table C-4. *Scan Data Format—Post-Processing Parameter Settings*

Field	Index	Size	Name/Description
Noise Filter (Short-Wave Filter) Information			
23	322	2	Filter index, unsigned short, used by software
24	324	2	Flag, unsigned short 0 =Use default noise filter cutoff 1 =Use cutoff defined
25	326	4	Cutoff, float 14, 25, 45, 80, or 140
Long-Wave Filter Information			
26	330	2	Filter index, unsigned short, used by software
27	332	2	Flag, unsigned short 0 = Use default noise filter cutoff 1 = Use cutoff defined
28	334	4	Cutoff, float 80, 140, 250, or 450
Bearing Ratio Parameter Options (3)			
29	338	2	Check flag 1, 16-bit Boolean 0 = Off 1 = On
30	340	4	Depth 1, float
31	344	2	Unit 1, unsigned short
32	346	2	Check flag 2, 16-bit Boolean 0 = Off 1 = On
33	348	4	Depth 2, float
34	352	2	Unit 2, unsigned short
35	354	2	Check flag 3, 16-bit Boolean 0 = Off 1 = On

Table C-4. *Scan Data Format—Post-Processing Parameter Settings (Continued)*

Field	Index	Size	Name/Description
Bearing Ratio Parameter Options (continued)			
36	356	4	Depth 3, float
37	360	2	Unit 3, unsigned short
Cutting Depth Parameter Options (3)			
38	362	2	Check flag 1, 16-bit Boolean 0 = Off 1 = On
39	364	4	Ratio 1, float
40	368	2	Check flag 2, 16-bit Boolean 0 = Off 1 = On
41	370	4	Ratio 2, float
42	374	2	Check flag 3, 16-bit Boolean 0 = Off 1 = On
43	376	4	Ratio 3, float
Peak Count Parameter Options (3)			
44	380	2	Check flag 1, 16-bit Boolean 0 = Off 1 = On
45	382	4	Band 1, float
46	386	2	Unit 1, unsigned short
47	388	2	Check flag 2, 16-bit Boolean 0 = Off 1 = On
48	390	4	Band 2, float
49	394	2	Unit 2, unsigned short
50	396	2	Check flag 3, 16-bit Boolean 0 = Off 1 = On

Table C-4. *Scan Data Format—Post-Processing Parameter Settings (Continued)*

Field	Index	Size	Name/Description
Peak Count Parameter Options (continued)			
51	398	4	Band 3, float
52	402	2	Unit 3, unsigned short
Sm Peak Count Parameter Options (3)			
53	404	2	Check flag 1, 16-bit Boolean 0 = Off 1 = On
54	406	4	Band 1, float
55	410	2	Unit 1, unsigned short
56	412	2	Check flag 2, 16-bit Boolean 0 =Off 1 = On
57	414	4	Band 2, float
58	418	2	Unit 2, unsigned short
59	420	2	Check flag 3, 16-bit Boolean 0 =Off 1 =On
60	422	4	Band 3, float
61	426	2	Unit 3, unsigned short
High Spot Count Parameter Options (3)			
62	428	2	Check flag 1, 16-bit Boolean 0 =Off 1 =On
63	430	4	Height 1, float
64	434	2	Unit 1, unsigned short
65	436	2	Check flag 2, 16-bit Boolean 0 =Off 1 =On
66	438	4	Height 2, float
67	442	2	Unit 2, unsigned short

Table C-4. *Scan Data Format—Post-Processing Parameter Settings (Continued)*

Field	Index	Size	Name/Description
High Spot Count Parameter Options (continued)			
68	444	2	Check flag 3, char 0 =Off 1 =On
69	446	4	Height 3, float
70	450	2	Unit 3, unsigned short
Sm High Spot Count Parameter Options (3)			
71	452	2	Check flag 1, 16-bit Boolean 0 =Off 1 =On
72	454	4	Band 1, float
73	458	2	Unit 1, unsigned short
74	460	2	Check flag 2, 16-bit Boolean 0 =Off 1 =On
75	462	4	Band 2, float
76	466	2	Unit 2, unsigned short
77	468	2	Check flag 3, 16-bit Boolean 0 =Off 1 =On
78	470	4	Band 3, float
79	474	2	Unit 3, unsigned short
Feature Detection Parameters			
80	476	256	Reserved, 128 unsigned shorts
81	732	2	Type, unsigned short 0 =No feature 1 =UpEdge 2 =UpBase 3 =DownEdge 4 =DownBase 5 =Convex 6 =Concave

Table C-4. *Scan Data Format—Post-Processing Parameter Settings (Continued)*

Field	Index	Size	Name/Description
Feature Detection Parameters (continued)			
82	734	2	Number, unsigned short
83	736	4	Slope threshold, float
84	740	4	Plateau threshold, float
85	744	4	Min. plateau width, float
86	748	32	Reserved, 16 unsigned shorts
Fit & Level and Cursor Parameters			
87	780	2	Fit and Level flag, 16-bit Boolean 0 =Off 1 =On
88	782	8	Left leveling cursor, double
89	790	8	Left delta leveling cursor, double
90	798	8	Right leveling cursor, double
91	806	8	Right delta leveling cursor, double
92	814	8	Leveling cursor reference, double
93	822	8	Left measurement cursor, double
94	830	8	Left delta measurement cursor, double
95	838	8	Right measurement cursor, double
96	846	8	Right delta measurement cursor, double
97	854	8	Measurement cursor reference, double

Table C-4. *Scan Data Format—Post-Processing Parameter Settings (Continued)*

Field	Index	Size	Name/Description
General Parameter Flags			
98	862	2	Step Height, 16-bit Boolean 0 = Off 1 = On
99	864	2	TIR, 16-bit Boolean 0 = Off 1 = On
100	866	2	Average, 16-bit Boolean 0 = Off 1 = On
101	868	2	Slope, 16-bit Boolean 0 = Off 1 = On
102	870	2	Radius, 16-bit Boolean 0 = Off 1 = On
103	872	2	Area of Peaks, 16-bit Boolean 0 = Off 1 = On
104	874	2	Area of Valleys, 16-bit Boolean 0 = Off 1 = On
105	876	2	Total Area, 16-bit Boolean 0 = Off 1 = On
106	878	2	Profile Length, 16-bit Boolean 0 = Off 1 = On
107	880	2	Edge, 16-bit Boolean 0 = Off 1 = On

Table C-4. *Scan Data Format—Post-Processing Parameter Settings (Continued)*

Field	Index	Size	Name/Description
General Parameter Flags (continued)			
108	882	2	Step Width, 16-bit Boolean 0 = Off 1 = On
109	884	32	Reserved, 32 characters 0 = Off 1 = On
Roughness Parameter Flags			
110	916	2	R_a, 16-bit Boolean 0 = Off 1 = On
111	918	2	Max R_a, 16-bit Boolean 0 = Off 1 = On
112	920	2	R_q, 16-bit Boolean 0 = Off 1 = On
113	922	2	R_p, 16-bit Boolean 0 = Off 1 = On
114	924	2	R_v, 16-bit Boolean 0 = Off 1 = On
115	926	2	R_t, 16-bit Boolean 0 = Off 1 = On
116	928	2	R_z, 16-bit Boolean 0 = Off 1 = On
117	930	2	R_{3z}, 16-bit Boolean 0 = Off 1 = On
118	932	2	R_h, 16-bit Boolean 0 = Off 1 = On

Table C-4. *Scan Data Format—Post-Processing Parameter Settings (Continued)*

Field	Index	Size	Name/Description
Roughness Parameter Flags (continued)			
119	934	2	Rpm, 16-bit Boolean 0 = Off 1 = On
120	936	2	D_q, 16-bit Boolean 0 = Off 1 = On
121	938	2	L_q, 16-bit Boolean 0 = Off 1 = On
122	940	2	SD, 16-bit Boolean 0 = Off 1 = On
123	942	32	Reserved, 32 characters
Waviness Parameter Flags			
124	974	2	W_a, 16-bit Boolean 0 = Off 1 = On
125	976	2	W_q, 16-bit Boolean 0 = Off 1 = On
126	978	2	W_p, 16-bit Boolean 0 = Off 1 = On
127	980	2	W_v, 16-bit Boolean 0 = Off 1 = On
128	982	2	W_t, 16-bit Boolean 0 = Off 1 = On
129	984	2	W_h, 16-bit Boolean 0 = Off 1 = On
130	986	32	Reserved, 32 characters

Table C-4. *Scan Data Format—Post-Processing Parameter Settings (Continued)*

Field	Index	Size	Name/Description
Reserved			
131	1018	256	Reserved, 128 unsigned shorts
132	1274	1506	Reserved, 753 unsigned shorts

Results of Parameter Calculations

Bytes 2781–6842 contain the results of parameter calculations based on the scan data and the cursor settings.

Table C-5. *Scan Data Format–Results of Parameter Calculations*

Field	Index	Size	Name/Description
133	2780	2	Version, short
134	2782	2	Params total, short
Edge Detection Results			
135	2784	2	If exists flag, 16-bit Boolean
136	2786	8	Dist to UpEdge, double
137	2794	8	Dist to DownEdge, double
138	2802	8	Dist to Apex, double
139	2810	8	Step Width, double
140	2818	200	UpEdges found, 25 doubles
141	3018	2	Number of UpEdges found, unsigned short
142	3020	200	DownEdges found, 25 doubles
143	3220	2	Number of DownEdges found, unsigned short
Scan Parameters			
144	3222	8	Level Angle, double
145	3230	8	Actual Scan Length, double
146	3238	4	Actual number of points, long integer

Table C-5. *Scan Data Format–Results of Parameter Calculations (Continued)*

Field	Index	Size	Name/Description
Result Parameters (83 used, 117 reserved); see Table C-6			
147	3242	18	Height
148	3260	18	TIR
149	3278	18	Avg
150	3296	18	Width
151	3314	18	ProfL
152	3332	18	Area+
153	3350	18	Area-
154	3368	18	Area
155	3386	18	Radius
156	3404	18	Slope
157	3422	18	Edge+
158	3440	18	Edge-
159	3458	18	Apex
160	3476	18	SWidth
161	3494	18	BandWidth
162	3512	18	Reserved
163	3530	18	Reserved
164	3548	18	Reserved
165	3566	18	Reserved
166	3584	18	Reserved
167	3602	18	R_a
168	3620	18	Max R_a
169	3638	18	R_q
170	3656	18	R_p
171	3674	18	R_v
172	3692	18	R_t

Table C-5. *Scan Data Format–Results of Parameter Calculations (Continued)*

Field	Index	Size	Name/Description
Result Parameters, continued; see Table C-6			
173	3710	18	R_z
174	3728	18	R_{3z}
175	3746	18	Rpm
176	3764	18	SD
177	3782	18	Reserved
178	3800	18	Reserved
179	3818	18	Reserved
180	3836	18	Reserved
181	3854	18	Reserved
182	3872	18	Reserved
183	3890	18	Reserved
184	3908	18	Reserved
185	3926	18	Reserved
186	3944	18	Reserved
187	3962	18	W_a
188	3980	18	Max W_a
189	3998	18	W_q
190	4016	18	W_p
191	4034	18	W_v
192	4052	18	W_t
193	4070	18	Reserved
194	4088	18	Reserved
195	4106	18	Reserved
196	4124	18	Reserved
197	4142	18	Reserved
198	4160	18	Reserved

Table C-5. *Scan Data Format–Results of Parameter Calculations (Continued)*

Field	Index	Size	Name/Description
Result Parameters, continued; see Table C-6			
199	4178	18	Reserved
200	4196	18	Reserved
201	4214	18	Reserved
202	4232	18	Reserved
203	4250	18	Reserved
204	4268	18	Reserved
205	4286	18	Reserved
206	4304	18	Reserved
207	4322	18	Sm_PC
208	4340	18	Sm_HSC
209	4358	18	HSC
210	4376	18	PC
211	4394	18	t_p
212	4412	18	CD
213	4430	18	L_q
214	4448	18	Sk
215	4466	18	K
216	4484	18	D_a
217	4502	18	D_q
218	4520	18	Reserved
219	4538	18	Reserved
220	4556	18	Reserved
221	4574	18	Reserved
222	4592	18	Reserved
223	4610	18	Reserved
224	4628	18	Reserved
225	4646	18	Reserved

Table C-5. *Scan Data Format–Results of Parameter Calculations (Continued)*

Field	Index	Size	Name/Description
Result Parameters, continued (83 used, 117 reserved); see Table C-6			
226	4664	18	Reserved
227	4682	18	Hm
228	4700	18	MedianHeight
229	4718	18	Volume
230–347	4736	2106	Reserved, 118 result parameter structures

Format of Result Parameters

Each of the result parameters in Table C-5 consists of the following fields:

Table C-6. *Result Parameter Format*

Field	Size	Name/Description
1	2	ParamId, short
2	8	Value, double
3	4	Argument, float
4	2	Source, short 0 =2D 1 =3D 2 =Raw Trace 3 =Leveled Raw Trace 4 =Normal Trace 5 =Roughness Trace 6 =Waviness Trace 7 =Option 8 =Installed 9 =No display
5	2	Parameter flag, for internal use 0 =Parameter needs to be updated 1 =Parameter has been updated 2 =Parameter is not available

Scan Data

Following the result parameter fields are the fields containing the individual points of the scan trace in five forms: the raw trace, leveled raw trace, normal trace, roughness trace, and waviness trace.

The data format is described in Table C-5. The number of data points *n* is stored in a long starting at byte 6843. The raw trace data begins at byte 6847. The size and index for each trace that follows depends on the number *n*.

Table C-7. *Data Format*

Field	Index	Size	Name/Description
348	6842	4	*n*, Actual Number of data points, long
349	6846	4**n*	Raw Trace, *n* floats
		4**n*	Leveled Raw Trace, *n* floats
		4**n*	Normal Trace, *n* floats
		4**n*	Roughness Trace, *n* floats
		4**n*	Waviness Trace, *n* floats

Scan Data Format Tables for ASCII Data

ASCII-format export files are designed to print a data table. They contain table header strings, the data file name, the recipe name, total number of points, and raw trace, leveled raw trace, normal trace, roughness trace, and waviness trace values for each data point.

The following section from a sample file shows the ASCII format.

Sample ASCII Format Data File

Data		AAAA			
Recipe		test1			
Points		71			
	Raw	RawLevel	Normal	Rough	Wavi
1	-35950.3	-35950.3	-24.8789	0	0
2	-35912.5	-35913.1	-2.51953	0	0
3	-35879.3	-35880.5	21.0859	0	0
4	-35844.8	-35846.6	42.8789	0	0
5	-35821.3	-35823.8	58.9219	0	0
6	-35804.5	-35807.6	65.7578	0	0
7	-35792.6	-35796.3	61.5586	0	0
8	-35816.4	-35820.7	47.3516	0	0
9	-35878.3	-35883.2	27.5742	0	0
10	-35934.8	-35940.4	9.06641	0	0
11	-35963.9	-35970	-1.60938	0	0
12	-35948.8	-35955.6	-1.22266	0	0
13	-35909.3	-35916.7	8.46875	0	0
14	-35861.7	-35869.7	21.5469	0	0
15	-35813.1	-35821.7	30.9219	0	0
16	-35811	-35820.3	31.9961	0	0
17	-35859.8	-35869.6	25.0273	0	0
18	-35914.6	-35925	14.6602	0	0
19	-35936.4	-35947.5	6.97656	0	0
20	-35928.9	-35940.6	5.80859	0	0
21	-35903.3	-35915.6	10.5078	0	0
22	-35859.7	-35872.6	16.293	0	0
23	-35826.2	-35839.7	16.9375	0	0
24	-35828.9	-35843	8.28906	0	0
25	-35890.6	-35905.3	-9.29297	0	0

D

ORDERING INFORMATION

Software Options

Part No.	Description
401250	Interactive 3D Software Option
404209	Desktop Program -Includes: Program disks, Configuration key and Manual set. System requirements are: PC-compatible 486 or higher DOS 6.2 or higher at least 20 MB of free disk space at least 16 MB of RAM Windows 3.1 or higher (not Windows 95 or NT) 3.5-in. floppy disk drive parallel port set to LPT1 for Configuration key VGA, 800x600 resolution, 256 colors or greater-virtual memory swap file, 20 MB or more

Hardware Options

Part No.	Description
401994	MicroHead sr Exchangeable Measurement Head -Topview optics (115 - 465x and 185 - 750x with user interchangeable lenses). -Vertical range: 0-300 µm -Stylus force: 1-50 mg -Constant stylus force control -Black and white camera -Stylus to Cross-Hair Alignment Tool -5.0 µm radius stylus
401986	MicroHead II Low Force Measurement Head -Dual view optics (sideview: 95 -410), (topview: 115 - 465x and 185 - 750x with user interchangeable lenses) includes stylus to cross-hair alignment tool. -Vertical Range: 0-130 µm -Stylus Force: 0.05-50 mg -Constant stylus force control

	-Black and white camera -Stylus to Cross-Hair Alignment Tool -2μm radius stylus
402001	MicroHead *xr* Extended Range Measurement Head -Dual view optics (sideview: 95 -410), (topview: 115 - 465x and 185 - 750x with user interchangeable lenses) includes stylus to cross-hair alignment tool. -Vertical Range: 0-1000 μm -Stylus Force: 0.05-50 mg -Constant stylus force control -Black and white camera -Stylus to Cross-Hair Alignment Tool -5 μm radius stylus
241164	Motorized Level and Rotation (Factory Installed)
301485	Dual view Optics
331716	Hewlett Packard DeskJet 660C Printer, w/ Cable (110V US only)
239739	Color Camera (factory installed)
129909	Printer, black and white OEM Warranty (110V, US only)
219517	Stylus to Cross-Hair Alignment Tool

Precision Sample Locators

206814	Stage Table Top
155764*	50 mm Wafer (Flat or Sq. Substrates)
143049*	75 mm Wafer (Flat or Sq. Substrates)
206709	100 mm Wafer (Flat or Sq. Substrates)
216186	100 mm Wafer w/notch
206717	125 mm Wafer (Flat or Sq. Substrates)
216194	125 mm Wafer w/notch
206725	150 mm Wafer (Flat or Sq. Substrates)

237450	150 mm Wafer w/notch
181714*	200 mm Wafer (Flat or Sq. Substrates)
206733	200 mm Wafer w/notch
	***Requires Stage Table Top (P/N 206814)**

Precision Sample Stress Locators*

155756	50mm Wafer Stress (flat or sq. substrates)
143030	75mm Wafer Stress (flat or sq. substrates)
134902	100mm Wafer Stress (flat or sq. substrates)
134899	125mm Wafer Stress (flat or sq. substrates)
134872	150mm Wafer Stress (flat or sq. substrates)
183741	200mm Wafer Stress (flat or sq. substrates)
	***Requires Stage Table Top (P/N 206814)**

Most Common Replacement Styli

217212	L-Stylus, 0.1-0.2µm radius, 70°
217247	L-Stylus, 0.3-0.8µm radius, 70°
270741	L-Stylus, 2±0.5µm radius, 45°
217182	L-Stylus, 2µm radius, 60°
217190	L-Stylus, 5µm radius, 60°
240532	L-Stylus, 12.5µm radius, 60°

Recommended Calibration Standards

P0006	Step Height/Roughness Set (6) -Step 880Å, 4500Å, 9400Å -Roughness: 220Å, 440Å, 2250Å

P0005	Step Height/Roughness Set (5) -Step: 1.8µm, 8 µm, 24 µm -Roughness: 2250Å, 4700Å
SHS-0004A	Step Height Set (4) 440Å, 880Å, 4500Å, 9400Å
SHS-180A	Step Height, 9400Å
SHS-9400A	Step Height, 9400Å
248509-27	P-10 Reference Drawings, CleanRoom
248509	P-10 Reference Drawings
412660-27	P-10 Operations Manual, CleanRoom
412929-27	P-10 Reference Manual, CleanRoom

Services

248517	Installation
248525	Additional Operator Training

NOTE: All Ground transportation for this equipment requires electronic air ride van. Shipment will be effected accordingly unless we hear otherwise.

The P-10 is user-installed.

E

Precision Locators

Precision locators are fixtures that allow you to exactly position a sample relative to a fixed reference point. Tencor Instruments provides the following types of precision locators:

- *Standard Precision Locators.* These locators allow positioning of square substrates and wafers with flats, or notched wafers. Instruments are shipped with a choice of the standard stage table or one of the locators in this list.
- *Optional Precision Locators.* These locators allow positioning of less common sizes of square substrates and wafers. They bolt on top of the standard stage table. Note: These locators have to be purchased separately.
- *Disk Precision Locators.* These locators are used for holding hard disk samples to the stage. They bolt on top of the standard stage table. Note: These locators have to be purchased separately.

Instructions for installing precision locators can be found in Section 2.4, "Installing a Precision Locator."

The following sections list the available locators. See Appendix D, "Ordering Information," for model numbers to order locators.

Standard Precision Locators

Standard precision locators for instruments include (see Figs. E-1 through E-6)

- 4-in. for Wafer with Flat/Square Substrate
- 4-in. for Wafer with Notch
- 5-in. for Wafer with Flat/Square Substrate
- 5-in. for Wafer with Notch
- 6-in. for Wafer with Flat/Square Substrate
- 6-in. for Wafer with Notch

Optional Precision Locators

Optional precision locators for instruments include (See Figs. E-7 through E-18)

- 2-in. for Wafer with Flat/Square Substrate
- 3-in. for Wafer with Flat/Square Substrate
- 82-mm for Wafer with Notch
- 4-in. for Wafer with Flat/Square Substrate
- 5-in. for Wafer with Flat/Square Substrate
- 5-in. for Wafer with Notch
- 48-mm for Disk
- 65-mm for Disk

- 95-mm for Disk
- Adjustable (48-, 65-, 95-, and 130-mm) for Disk

Standard Precision Locators

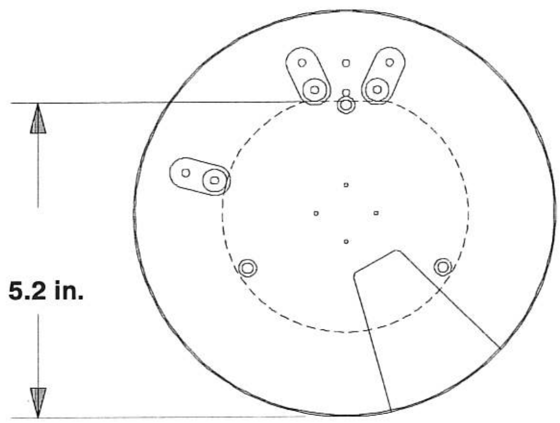


Figure E-1 Locator for 4-in. Wafer with Flat or Square Substrate

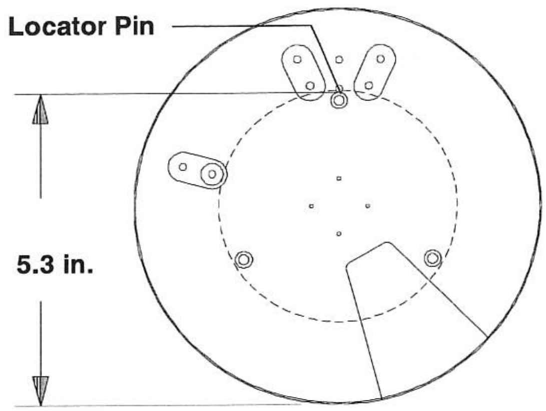


Figure E-2 Locator for 4-in. Wafer with Notch

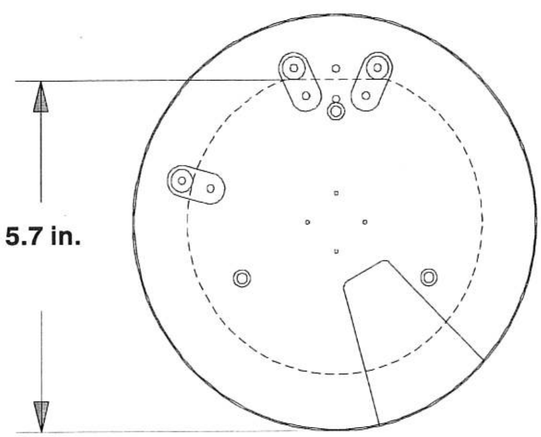


Figure E-3 Locator for 5-in. Wafer with Flat or

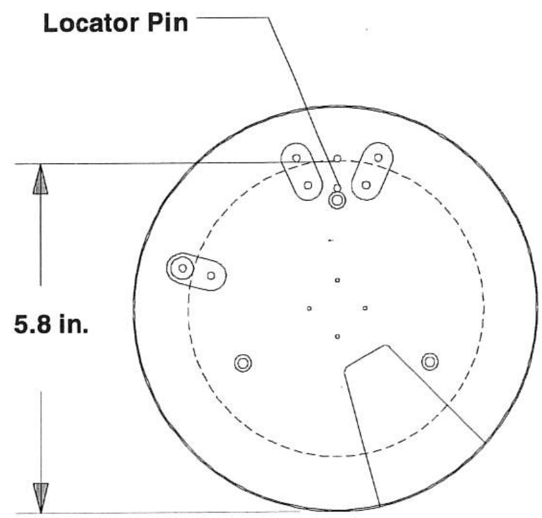


Figure E-4 Locator for 5-in. Wafer with Notch

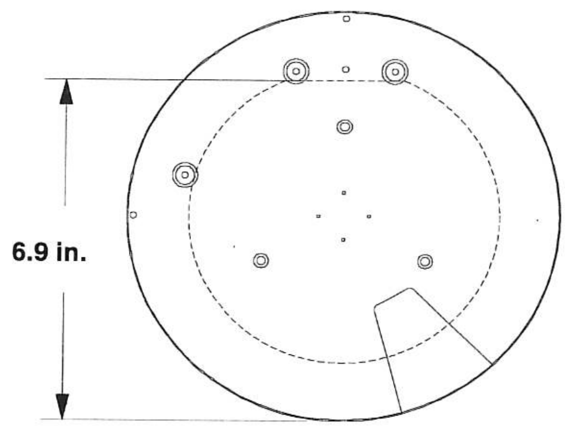


Figure E-5 Locator for 6-in. Wafer with Flat or Square Substrate

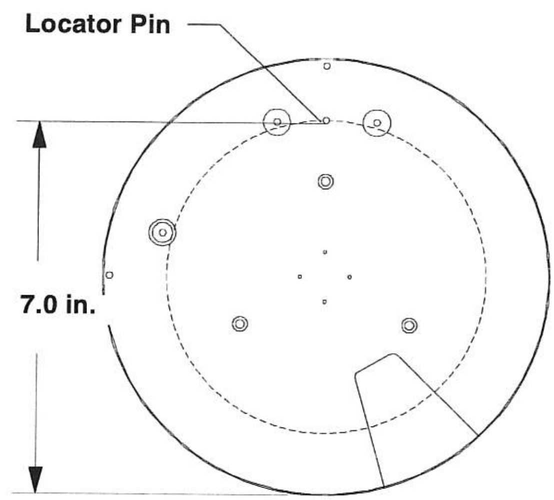


Figure E-6 Locator for 6-in. Wafer with Notch

Optional Precision Locators

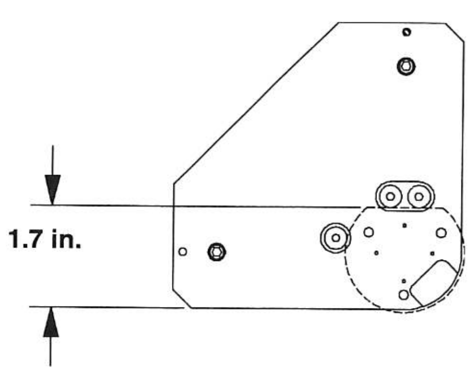


Figure E-7 Locator for 2-in. Wafer with Flat or Square Substrate

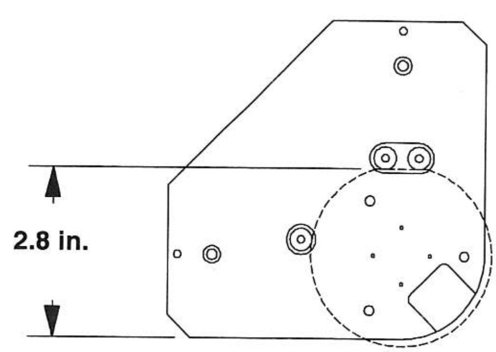


Figure E-8 Locator for 3-in. Wafer with Flat or Square Substrate

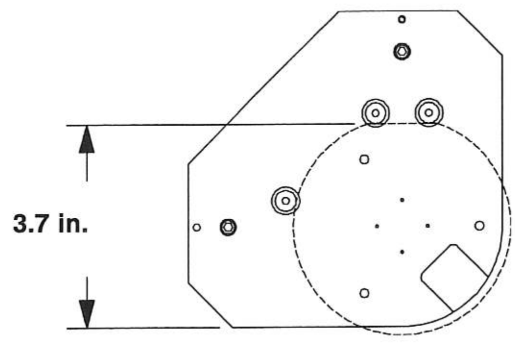


Figure E-9 Locator for 4-in. Wafer with Flat or Square Substrate

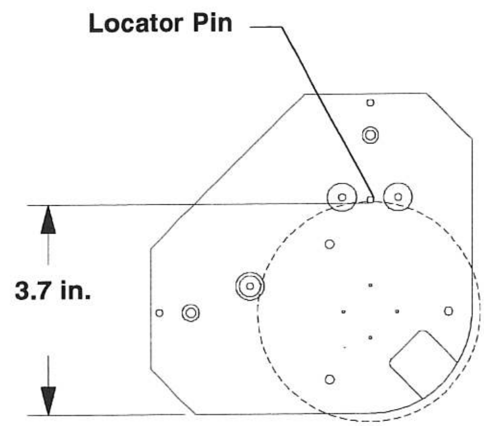


Figure E-10 Locator for 4-in. Wafer with Notch

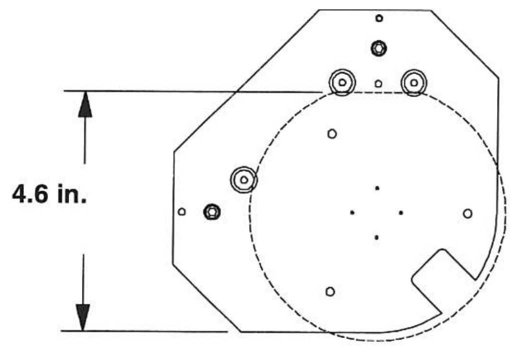


Figure E-11 Locator for 5-in. Wafer with Flat or Square Substrate

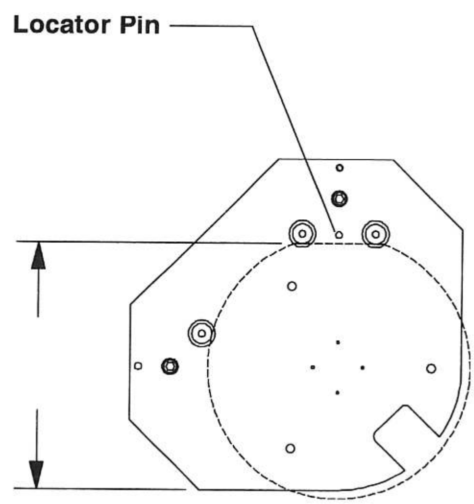


Figure E-12 Locator for 5-in. Wafer with Notch

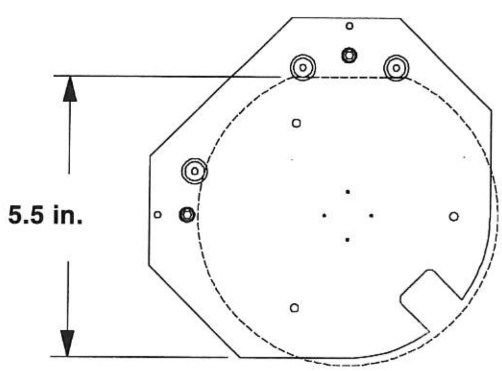


Figure E-13 Locator for 6-in. Wafer with Flat or Square Substrate

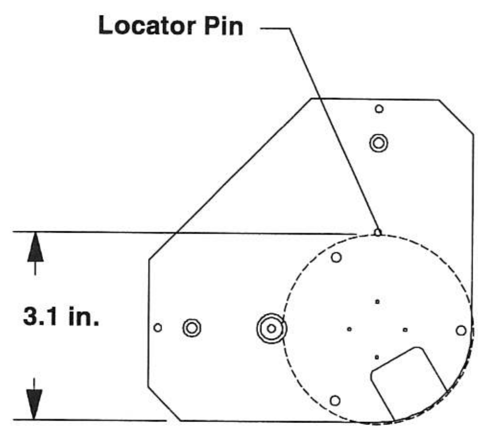


Figure E-14 Locator for 82-mm Wafer with Notch

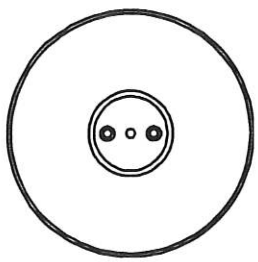


Figure E-15 48-mm Disk Locator

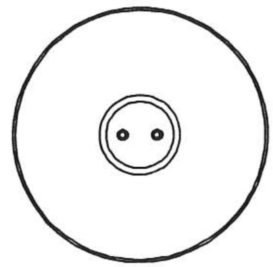


Figure E-16 65-mm Disk Locator

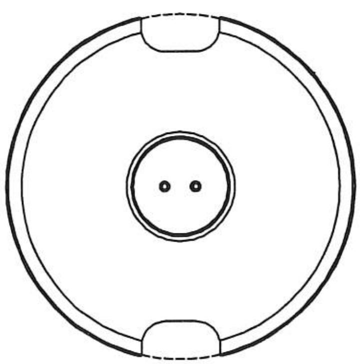


Figure E-17 95-mm Disk Locator

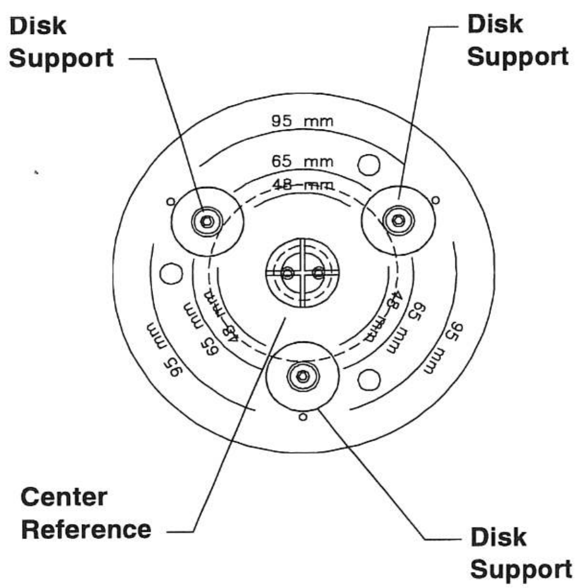


Figure E-18 Adjustable Disk Locator for 48-, 65-, 95-, and 130-mm Disks

GLOSSARY

2D Data: Two-dimensional data.

3D Data: Three-dimensional data.

ASCII Data: ASCII (American Standard Code for Information Exchange) codes are used to represent characters for storage in a computer's memory.

Application: A software program such as the Tencor Profiler Scan application.

Application icon: Graphic symbol representing a software application. The Tencor Profiler Top Level menu displays application icons.

Application window: The main window opened by an application.

Area: *See* Total Area.

Area+: *See* Area of Peaks.

Area-: *See* Area of Valleys.

Area of Peaks (Area+): Total area bounded by the leveled baseline and the profile above the baseline.

Area of Valleys (Area-): Total area bounded by the leveled baseline and the profile below the baseline.

Arrow keys: The arrow keys on the operator keypad. These keys can be used to highlight a menu item or dialog box option or to move a text or graphics cursor.

Average Height (Avg): The average height of all data points between the measurement cursors relative to the leveled baseline.

Avg: *See* Average Height.

Back up: To save data from the Tencor Profiler hard disk to diskettes or a network drive (if available). The data can be restored at a later time.

Base: Used (with prefix Up- or Down-) to identify the bottom of the sloping side of a step, to distinguish it from the top of the slope, called the *edge*. See UpBase, DownBase.

Bearing Ratio (t_p): A reference line is drawn parallel to the mean line and at a preselected or predetermined distance (cutting depth) below the highest peak of the roughness trace within the sampling length. This reference line intersects the roughness trace in one or more subtended lengths. The bearing length is the sum of these subtended lengths. The bearing ratio is the ratio of the bearing length to the sampling length. Also called Bearing Length Ratio.

Centerline: The center-line divides the profiles such that all areas above it are equal to all areas below it.

Choose: To pick a menu item or other item that starts an action. You can choose an item using the mouse or keypad.

Click: Pressing and releasing the left or right mouse button without moving the mouse. Clicking the left button on a menu title, on an icon, on a dialog box option or command button, or in a window selects the item. Left and right buttons have different functions when clicking. *Compare to* double-click.

Concave: Describes an arc that curves inward from a level reference plane; a valley-like arc.

Contact Speed: Contact speed defines the stylus drop speed at contact with the substrate.

Convex: Describes an arc that curves outward from a level reference plane; a hill-like arc.

Cursor: An object on the screen that can be moved with the mouse or arrow keys and that allows the user to locate or edit data. *See* limit cursor, particle cursor, and text cursor.

CutDp: *See* Cutting Depth.

Cutoff Length: The cutoff length is the wavelength on the filter transmission curve that corresponds to 75% transmission. According to the ANSI B46.1-1985 standard, 800 µm is the preferred cutoff for most surfaces.

Cutting Depth (CutDp): A preselected or predetermined distance below the highest peak of a sample. *See* Bearing Ratio.

D_q: *See* Root-Mean-Square Slope.

Database: A collection of data organized by records. The Tencor Profiler database can contain data summaries, maps, user IDs, system log records, recipe records, and other data.

Deskew: Deskew is a feature of the Tencor Profiler that compensates for any translational or rotational errors between different substrates by allowing you to select manually two fixed reference points to be used for calculating stage coordinate values.

Dialog box: A rectangular box on the screen that can contain a combination of lists, options, data entry fields, and command buttons. A dialog box appears when the instrument needs more information before performing an operation.

Disk space: The total amount of space available on the hard disk. Free disk space is the amount of disk space unused.

Directory: Computer files are stored on the computer's hard disk in directories. The directory name identifies the location where the files are stored. *See* Path.

Download: Importing a recipe from a remote host through the GEM/SECS Option.

DOS: Disk Operating System, also called MS-DOS. The central program used to control and manage the computer system.

Double-click: The mouse action performed when you press and release the mouse button twice in rapid succession. The first click selects the item and the second click performs the action associated with the item. When you double-click the left button on an application icon, the application starts. Left and right buttons have different functions when double-clicking. *Compare to* click.

DownBase: The bottom of the sloping side of a trough-like feature, or downward step.

DownEdge: The top of the sloping side of a trough-like feature, or downward step.

Drag: The mouse action performed when you hold down the mouse button and move the mouse. Dragging can be used to choose a menu item and to move a graphics cursor.

Drive (disk): The disk drive identifier. A single character followed by a colon. For example, C: refers to drive C.

Edge: The distance to the first rising or falling edge of a step (or the apex of a peak) from the beginning of the profile. Also used (with prefix Up- or Down-) to identify the top of the sloping side of a step, to distinguish it from the bottom of the slope, called the *base*. *See* UpEdge, DownEdge.

Export: To save selected data, such as recipes, wafer summaries, and wafer maps, to diskette. Exported data can be imported into another Tencor Profiler system. *See* Import.

Field: A rectangle in a dialog box used for entering data. The text cursor (a vertical bar) generally appears in the first field in a dialog box.

Finite Impulse Response (FIR): The Tencor Profiler uses the Finite Impulse Response technique to calculate roughness and waviness from digitized data points.

Form Error: Form error is a deviation from a perfect realization of a nominally specified shape. For example, for a flat surface the form error would be the deviation from flatness. If the deviation is periodic (that is, has waves), the error is termed waviness. If there are many hundreds or thousands of randomly shaped undulations without a discernible pattern, the error is called roughness. The difference between form error, roughness, and waviness is not precisely defined; it is more a qualitative distinction. See Waviness and Roughness.

GEM: Acronym for *G*eneric *E*quipment *M*odel.

Graphics cursor: Graphics cursors appear as vertical bars in histogram windows and can be used to change defect bin splits.

HSC: *See* High Spot Count.

Height: The difference in height between two points on the sample surface defined by the positions of the measurement cursors.

High Spot Count (HSC): The number of profile peaks per unit length projecting through a reference line parallel to and at a given height above a line drawn through the lowest point of the roughness trace, parallel to the mean line. See Peak Count.

Import: To load data previously saved in an export file. *See* Export.

Keylock: The keylock limits operator access to Scan recipes and Sequence programs for operational security.

L_q: *See* Root-Mean-Square Wavelength.

Locator: The plate upon which a cassette rests when on the handler. The locator must be changed for different cassette sizes.

Log Off: Sign off from the Tencor Profiler by choosing the Log Off icon from the To Level menu.

Manual/Single Scan Mode: The user programs the parameters for a scan into a recipe using a menu. The scan can be specified to be continuous or segmented into sections of equal length.

Maximum Height (MaxHt): The maximum height of a trace relative to the zero line within the sampling length.

Max R_a: *See* Maximum Average Roughness.

Maximum Average Roughness (Max R_a): The trace within the cursors is divided into 19 overlapping sections. Each section is one-tenth of the sampling length. The average roughness (R_a) of each section is calculated and the maximum is displayed.

Maximum Stress: Maximum stress is the maximum of 13 overlapping sections of one-third the length and offset across the total profile.

Mean Peak Height (Rpm): The mean value of the local peak heights of the roughness trace within the sampling length.

Mean Peak Spacing (S_m): The mean value of the local peak spacing of the roughness trace within the sampling length, where the peaks are defined by the criteria of the Peak Count parameter. *See* Peak Count.

Menu: A list of commands. Two types of menus are supported — icon-based menus and drop-down menus. Full-screen menus such as the Top Level Menu display application icons. You can start an application by double-clicking the left button on its icon. A menu in the menu bar opens when clicked:

Menu bars are displayed at the top of application windows and list menu titles. You can open a menu listed in the menu bar by clicking on its title. You can choose from the menu by clicking on an item.

Microsoft Windows: A graphical user environment developed by Microsoft Corporation that uses windows to present information and a pointing device, usually a mouse, for user interaction.

Minimum Height (Min Ht): The minimum height of a trace relative to the zero line within the sampling length.

Multiscan Average Mode: A scan is repeated up to ten times and the average is calculated automatically.

PC: *See* Peak Count.

Parameters: Measurement attributes such as length, speed, and direction are the parameters used in the Tencor Profiler software.

Path (to file): The location of a file or directory. A complete path consists of a drive identifier (A:, for example) followed by the directory and subdirectory names. The directory and subdirectory names are separated with the backslash character (\). In C:\DATA\TEMP\TEST.DAT, the path to the TEST.DAT file is C:\DATA\TEMP.

Peak: The distance between the mean line and the highest peak of the roughness trace or waviness trace within the sampling length.

Peak Count (PC): The number of peak/valley pairs in the roughness trace per unit length, projecting through a band of width b, and centered about the mean line. Projecting through means that the profile curve climbs above and then falls below the band. Thus, if the profile rises above the band more than once without falling below the band, multiple peaks are not identified. *See* High Spot Count.

Peak/Valley: The vertical distance between the highest peak and the lowest valley of the roughness or waviness trace, leveled on the mean line. Also known as R_{max} or W_{max}, Maximum Peak-to-Valley Roughness or Waviness.

Profile Length (ProfL): The length that would be obtained from drawing out the profile in a straight line within the sampling length.

ProfL: *See* Profile Length.

Profile: If you intersect a surface with a plane, the curve formed is a *profile*. The Tencor Profiler measures a profile by scanning a surface with a stylus. As the stylus moves up and down, the instrument records the variation along the length measured. The word *scan* or *trace* is sometimes used interchangeably with profile.

Prompt: An indication from the computer that it is waiting for information or instructions from the user.

R_{3z}: *See* Six-point Height.

R_a: *See* Roughness Average.

R_h: *See* Roughness Height.

R_p: *See* Peak.

R_q: *See* Root-Mean-Square Roughness.

R_t (P/V): *See* Peak/Valley.

R_v: *See* Valley.

R_z: *See* Ten-Point Height.

RMS: *See* Root-Mean-Square.

Rpm: *See* Mean Peak Height.

RRWG: Acronym for raw scan, roughness, waviness, and grid. The RRWG colors represent the individual color options for the graph and grid lines.

Radius: The distance from the center of curvature of the profile arc (assuming a circular profile within the sampling length) to the profile. The measurement cursors define two points of a circular arc. A least squares fit is performed on the points between the cursors.

Recipe: The Tencor Profiler takes a scan based on the settings selected by the user in the *recipe*. A recipe is a list of scan parameters such as scan length, stylus force, and vertical range/resolution. A recipe also contains instructions for the analysis of the data collected in the scan.

Recipe ID: The Recipe ID is the name of the generating recipe.

Restore: To return data previously saved by a backup operation.

Root-Mean-Square Roughness (R_q): The root-mean-square or geometric average deviation of the roughness profile from the mean line measured in the sampling length.

Root-Mean-Square (RMS): The square *root* of the arithmetic *mean* of the *squares* of a set of numbers.

Root-Mean-Square Slope (D_q): The root-mean-square or geometric average deviation of the slope of the roughness trace.

Root-Mean-Square Wavelength (L_q): 2π times the ratio of the root-mean-square deviation of the profile (R_q) to the root-mean-square slope of the profile (D_q). L_q is a measure of the spacing of local peaks and local valleys, taking into account their relative amplitudes and individual spatial frequencies.

Root-Mean-Square Waviness (W_q): The root-mean-square or geometric average deviation of the waviness profile from the mean line measured in the sampling length.

Roughness: A surface is said to be rough when the surface's deviation from flatness has many hundreds or thousands of randomly shaped undulations. *See* Form Error and Waviness.

Roughness Average (R_a): The arithmetic average deviation of the absolute values of the roughness profile from the mean line or centerline. Also known as Centerline Average Roughness. *See* Centerline.

Roughness Height (R_h): The difference in height in the roughness profile between the values at the left and right cursor positions of the profile.

Scan: Action performed when the Tencor Profiler measures a sample surface. Also used interchangeably with *profile* or *trace* to describe the plotted data that results from the scan.

SD: *See* Std Dev Heights.

SECS Interface: The Semiconductor Equipment Controller Standard (SECS) Interface provided on the Tencor Profiler defines a computer-to-computer communications interface between the Tencor Profiler and a host computer.

S_m: *See* Mean Peak Spacing.

Sampling Length: The length of trace between the cursors.

SECS: Acronym for *S*emiconductor *E*quipment *C*ommunication *S*tandard.

Segmented Scan: The scan is divided into segments of equal length and no data is taken between the segments. Using this method, roughness can be measured over several short lengths spaced equally along a straight line.

Selection bar: The highlighted bar or dotted rectangle appearing in a dialog box that indicates the option or command button that is selected if you press the ENTER key.

Sequence: The Tencor Profiler allows you to write a *sequence*, which programs the instrument to take a series of scans rather than taking them all manually, one by one. A sequence is like a script that links specific locations on a sample (or on a number of samples) with specific scan recipes to be performed at each location.

Sequence Identifier: The Sequence ID is the name of the generating sequence program.

Six-Point Height (R_{3z}): The average height difference between the three highest peaks and the three deepest valleys within the cursors measured from a line parallel to the mean line and not crossing the profile.

Slope: The ratio of the difference in vertical positions to the difference in horizontal positions of the measurement cursors. The slope is reported as an angle in degrees.

Spatial resolution: Spatial resolution is a measure of a profiler's capability to resolve the smallest vertical or horizontal feature on a surface. Four primary factors determine spatial resolution: stylus radius, short wave filtering, vertical resolution, and horizontal resolution. In practice, stylus radius and short wave filtering are the two factors that limit spatial resolution.

Std Dev Heights (SD): The standard deviation of the local peak heights of the roughness trace about the mean peak height within the sampling length.

StpWt: *See* Width of Step.

Stylus Force: The force of the stylus tip when the stylus is in contact with the substrate.

t_p: *See* Bearing Ratio.

TIR: *See* Total Indicator Runout.

Ten-Point Height (Rz): The average height difference between the five highest peaks and the five deepest valleys within the cursors measured from a line parallel to the mean line.

Text cursor: The vertical straight line appearing in fields. The text cursor marks the location where characters appear when typed.

Title bar: Each application displays a title bar at the top of the application window. The title bar shows the application name, current recipe in parentheses, communication mode—Local or Remote—and window control buttons.

Top Level Menu: The Tencor Profiler Top Level menu displays icons of the applications available to the user.

Total Indicator Runout (TIR): The difference in height between the highest and the lowest points within the surface bracketed by the cursors.

Trace: The plotted data that results from a scan. The word *profile* or *scan* is sometimes used interchangeably with trace.

Type: Type identifies the type of data that can be saved, recalled, restored, or deleted in a sequence. The following six preset values are available: raw trace data, point data, sequence results, 3D data, and any data. Statistics data is supplied within sequence results.

UpBase: The bottom of the sloping side of a step-like feature, or upward step.

UpEdge: The top of the sloping side of a step-like feature, or upward step.

Upload: Exporting a recipe or data set to a remote host through the GEM/SECS Option.

Valley: The distance between the mean line and the lowest valley of the roughness or waviness trace within the sampling length.

W_a: *See* Waviness Average.

W_h: *See* Waviness Height.

W_p: *See* Peak.

W_q: *See* Root-Mean-Square Waviness.

W_t: *See* Peak/Valley.

W_v: *See* Valley.

Waviness: Waviness of a surface is a periodic deviation from flatness, where the wavelengths generally range from 30 to more than 100 times the average wavelength of the roughness. *See* Form Error and Roughness.

Waviness Average (W_a): The arithmetic average deviation of the absolute values of the waviness profile from the mean line or centerline. Also known as Centerline Average Waviness. *See* Centerline.

Waviness Height (W_h): The difference in height in the waviness profile between the values at the left and right cursor positions of the profile.

Width of Step (StpWt): The distance between the first rising edge and the next falling edge of a step height plateau.

Window: Rectangular area for displaying and running an application program. The Scan application displays the Scan window.

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