CMI 700 Series

Users Guide

Version 4.3 Rev. I

P/N 51-98-2090-00020

OXFORD INSTRUMENTS

1 Introduction

CAUTION: GROUND BEFORE OPERATING
THIS INSTRUMENT MUST BE PROPERLY GROUNDED WITH THE 3-WIRE GROUND CORD PROVIDED. FAILURE TO DO SO MAY RESULT IN ELECTRICAL SHOCK HAZARD

CAUTION: SERVICE BY QUALIFIED ELECTRONIC TECHNICIAN ONLY
THIS INSTRUMENT CONTAINS VOLTAGES THAT ARE HAZARDOUS. ALL SERVICING MUST BE DONE BY A QUALIFIED ELECTRONIC TECHNICIAN.

1.1 Purpose of the Equipment

The CMI 700 Series is a modular, non-destructive coating thickness measurement instrument. It is designed to precisely measure various coatings and/or plating on different substrates. The CMI 700 Series can be configured with any combination of three measurement modules: Micro resistance (MRX); Beta backscatter (BMX); Eddy current and magnetic induction (EMX). The EMX module can be configured for any combination of magnetic, eddy current or nickel measurement disciplines.

1.2 Location of the Equipment

The CMI 700 Series is a laboratory quality, precision instrument with a rugged, state of the art microprocessor based design that can be used in a shop environment. A stable, reasonably level table of adequate size should be available for the instrument with sufficient room for storage of inspected and in-process materials.

1.3 Electrical Supply Connections

The CMI 700 requires a low voltage power pack for the electrical source of supply. The supply must be capable of providing up to 1.6 Amp at 16 VAC, 60 or 50 Hz. The frequency of the unit must be set to match the frequency of the incoming supply voltage. Refer to Section 5.5 System Options Screen for a description of how to set the unit operating frequency.

2 Setup

2.1.1 Unpacking

Carefully unpack and inspect all boxes. Remove all items and place on a large stable surface for setup. Notify Oxford Instruments Measurement Systems and/or the carrier immediately in case of any damage to the unit.

2.1.2 Cable Connections

All of the cables used to interconnect the various components of the system are unique to prevent an incorrect connection. All connections are made at the panel at the rear of the unit, where each connector is identified. Connections should be made in the following sequence.

2.1.3 Main Unit

1. If provided, the footswitch is connected to the connector labeled "FOOTSWITCH".

2. Nickel probes are connected to the connector labeled "NIP."

3. Eddy current probes are connected to the connector labeled "ECP."

4. Magnetic probes are connected to the connector labeled "SMP."

5. Beta probes are connected to the connector labeled “BMX”.

6. Serial cables are connected to the connector labeled "RS-232." Connect the other end to the serial port connection of an IBM compatible PC or other device requiring serial data.

7. Connect the 16 Volt AC source of electrical supply to the connector marked " 16 VAC 1.6 AMP."

2.1.4 Printer (Optional)

1. The CMI 700 will operate with Ink-Jet and laser printers that are compatible with the HP-PCL4 standard and with dot matrix printers that are compatible with the Epson Esc P specification with IBM PC line drawing characters. It will also accommodate the DPU 411 thermal printer and any ASCII plain text printer.

2. Connect the cable from a compatible, parallel printer to the connector labeled "PARALLEL PRINTER."

3. Connect the printer power cord to an appropriate electrical source of supply.

2.1.5 Probes

EMX Module

Depending on the unit configuration, three types of probes, magnetic, eddy current and nickel can be used with the EMX module of the CMI 700. Each eddy current probe must be tuned before using it with the instrument for the first time. Refer Section 5.7 Calibration and Tuning Screen for a description of probe tuning and to Section 11 Specifications for module specifications.

MRX Module

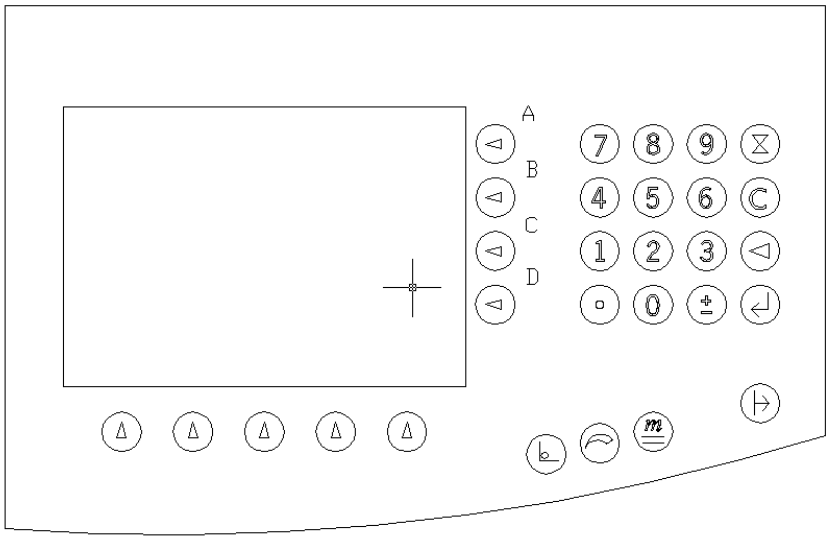
Depending on the unit configuration, three types of probes, TRP, surface (SRP-1 and SRP-3), and ETP can be used with the MRX module of the CMI 700. Refer to Section 5.7 Calibration and Tuning Screen for a description of calibrating TRP for auto size (Cal LVDT) and calibrating the ETP probe. Refer to the Specifications section for module specifications.

BMX Module

Depending on the unit configuration, three types of Oxford Instruments supplied isotopes; Promethium-147, Thallium-204 and Strontium/Yttrium-90 can be used with the BMX module of the CMI 700. Additionally, customer supplied isotopes C14, Ra and CD-109 are also supported. Refer to Section 8.2 BMX Calibration and Section 14 GM-1 and GM-2 Probes for additional information.

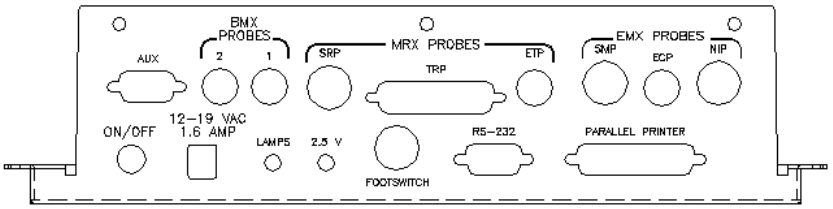
3 Instrument Configuration

3.1 Front Panel



The above illustration is a front view of the instrument. There are five softkeys below the display and four to the right. The functions of the softkeys and the other operational keys are described in Section 3.3 Keyboard.

3.2 Rear Panel



The above is an illustration of the rear panel. All connections to the instrument are made at this panel. Connectors are labeled with the name of the probe, accessory, parallel printer, or serial output RS-232 for which it is intended. Connectors are polarized to prevent possible misconnection. The jack for the external 16 V power supply and the ON/OFF switch are also located on the panel.

3.3 Keyboard

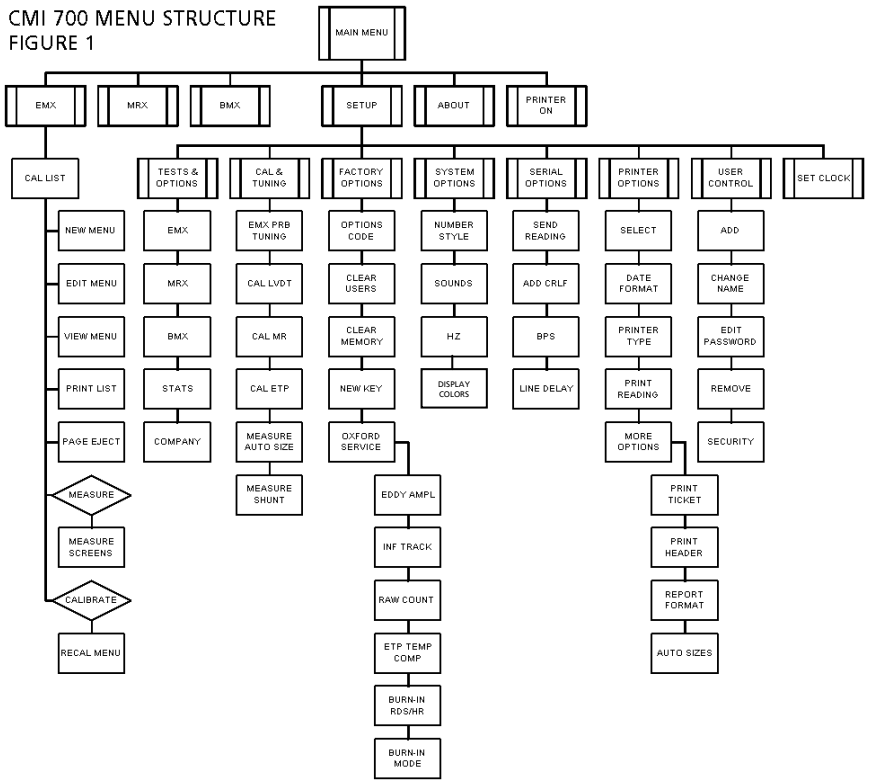
The following is a description of each of the keys and the functions or operations that it performs.

KEY	NAME	FUNCTION
	SOFTKEYS	Accesses the menu or performs the software function displayed adjacent to that key. Function(s) displayed will change dependent on which menu is accessed.
		
	SETUP	Accesses the Edit Calibration Menu sequence when pressed from the Measure Screen.
	CALIBRATE	Opens the Recalibration Menu if an existing calibration is selected. Also opens the Recalibration Menu when pressed from the Measure Screen.
	MEASURE	Opens the Measure screen with the selected calibration. This key is active only from the Calibration List Menu.
	GO	Makes a measurement when in Manual mode and accepts the last reading taken in Continuous mode. Also opens the Measure screen with the calibration selected in the Calibration List Menu.
	CANCEL	Cancels the operation in process and returns to the previous operation or screen.
	CLEAR	Clears the present entry or clears the last reading taken in the Measure Screen.
	BACKSPACE	Moves the cursor back a character and erases the previous character.
	ENTER	Stores the present entry or accepts the present selection. If pressed twice, opens the Measure screen with the calibration selected in the Calibration List Menu.
	PLUS/MINUS	Changes the scrolling direction for the time/day/date settings in the Set Clock Sub-menu. From the Measure Screen changes the time interval between readings taken in the Continuous mode.
0 - 9	NUMERIC	Enters the numeric value when entering data for calibrations and setup functions.
	DECIMAL POINT	Enters a decimal point when entering numeric data

3.4 Menu Structure

Figure 1, CMI 700 Menu Structure, displays the menu structure of the CMI 700. Menus are accessed by pressing the softkey adjacent to the menu name shown on the display screen. The Recalibration screen and the Measure screen are accessed by pressing their respective function keys. The following describes the warm up period softkeys and the Main Menu softkeys.

CMI 700 MENU STRUCTURE
FIGURE 1



3.4.1 BYPASS

This softkey will appear only during the warm-up period when the instrument is first powered up. Pressing this softkey will bypass the warm-up period and allow immediate access to the instrument. This should not be done unless the instrument has been in use and was momentarily switched OFF.

3.4.2 LANGUAGE

This softkey will appear only during the warm-up period when the instrument is first powered up and display the second language available. Pressing this softkey allows the choice between English or a second language (factory configured).

3.4.3 PRINTER ON/OFF

This function is used to enable/disable the external printer by pressing the softkey adjacent to it on the display. The softkey displays the status of the printer; I.e. "Printer On."

3.4.4 ABOUT SCREEN

Displays information about your unit's hardware configuration and software version. It also displays a five-digit code that is used by Technical Support for providing an emergency temporary password to access the system, if the user passwords are lost or forgotten.

3.4.5 SETUP MENU

Used to access the SETUP submenus shown below. These submenus are used for entering or defining system attributes such as: time/date, passwords, printer settings, serial output specifications, number convention, security levels, service options, for tuning eddy current probes and for entry of a company name to print on a header or ticket.

3.4.6 EMX/MRX/BMX MODULE MENU

Provides access to the Calibration and Measure Menus of the eddy current/magnetic induction module (EMX), micro resistance module(MRX) or the beta backscatter module (BMX). Press the EMX, MRX or BMX softkey to access the corresponding Calibration List screen. The Calibration List screen is used make new calibrations or modify existing ones. The Measure Screen is used to take measurements.

4 Getting Started

The steps outlined below identify the sequence of operations that must be performed when using your instrument for the first time. Once the system characteristics have been setup and calibrations are entered, you need only select the desired calibration to make measurements. Each eddy current probe must be tuned before its initial use with the instrument. It does not require re-tuning, as long as the same probe is used.

A calibration is a means of correlating the readings of your instrument with known, certified standards. Calibrations must be made for each type of coating and base material that you intend to measure.

4.1 Setup System Characteristics

From the Main Menu, access the Setup submenus by pressing the SETUP softkey.

Not all of the submenus will require modification. For example, if you will not be uploading data you do not need to edit the Serial Options submenu.

Determine which of the submenus you wish to modify.

Press the appropriate softkey to access that menu.

Refer to Section 5 Setup Menu for complete details on editing all of the setup functions.

4.2 Enter Calibrations

From the Calibration List Screen press the NEW softkey and follow the screen prompts to complete the calibration.

The calibration can now be used to make measurements.

Refer to Sections 6.2 EMX Calibration, 7.2 MRX Calibration and 8.2 BMX Calibration for complete details on making a calibration.

4.3 Make Measurements

1. From the Calibration List Menu, select a calibration of the same type as the coating thickness you wish to measure to advance to the Measurement Screen.

2. This is accomplished by either of the following key sequences;

    a. Use the Up and Down arrow keys to highlight the number of the calibration to select. Press the MEASURE, GO or ENTER function keys followed by the ENTER key.

    b. Press the MEASURE, GO or ENTER functions keys followed by the number of the calibration to select, then press the ENTER key.

3. Verify that you are using the probe type specified in the calibration.

4. Use the Mode softkey in the Measure screen to select the mode of measurement: AUTOMATIC, MANUAL, SCAN or CONTINUOUS. Not all of the modes are available in every application.

5. Using the Chart Select softkey in the Measure Screen select the display format, either charts or readings.

6. Place probe on the sample to make a measurement.

Refer to Section 9 Measurement for details on making measurements

4.4 Printing

Individual readings, statistical calculations, calibration information, calibration list, header, ticket, X-Bar & R charts, trend charts, or a histogram can be printed. When the printer type selected is "Plain Text - 80 col.", the charts and histogram will not print. Refer to the Printing section for details.

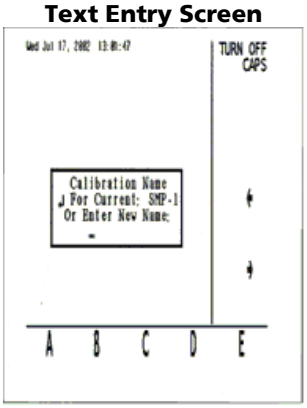
From the Measure screen press the PRINT CONTROL softkey to access the Print Control Screen from which ticket, header, stats, readings, or report can be printed.

From the Calibration List screen press PRINT LIST softkey to print the calibration list. From this screen press VIEW softkey to have access to PRINT CAL and PRINT READINGS softkeys. Press PRINT CAL to print calibration parameters. Press PRINT READINGS to print all saved readings for the calibration.

4.5 Entry Screens

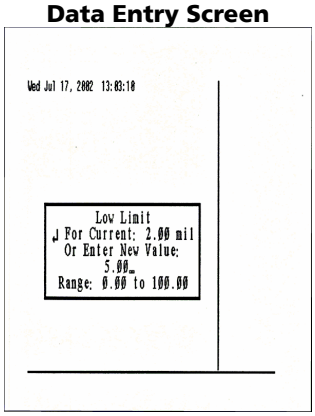
Information may be entered as text or as numerical data. For example, text is used when entering items such as a calibration name or a company name for a header. Numerical data is used in a variety of places such as when entering values for calibration limits or number of decimal places or number of readings to save. The following two screens describe how to enter text or numerical data.

Text Entry Screen



Text is added one letter or character at a time until the desired name or legend is spelled out on the display. If the item is being renamed, the current name is displayed.
Use the arrow softkeys to scroll through the letters and other characters. To select a character press the softkey adjacent to it.
Change to upper or lower case by pressing TURN ON CAPS/TURN OFF CAPS softkey.
Four function keys can also be used:
ENTER Key
Accepts current entry.
BACKSPACE Key
Moves the cursor back one character.
CLEAR Key
Clears the screen.
CANCEL Key
Aborts the present operation and returns to the previous screen.
When finished, press the ENTER function key to save the entry.

Data Entry Screen



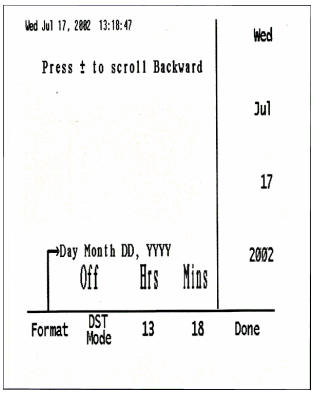
When an item is selected in which data is to be entered or edited, a data entry box will appear. The actual information in the box will vary dependent on the specific item selected, but the format is the same.
First Line
Identifies the item selected.
Second Line
Displays the current value. Press ENTER key to accept.
Third Line
Prompts user to enter value on line below
Fourth Line
User entered value.
Fifth Line
Specifies the acceptable range for the selected item.
Cursor
Displayed as an underscore, locates the next character to be entered

5 Setup Menu

The screens shown in this section are used for entering, editing or selecting system characteristics. Refer to Figure 1, CMI 700 Menu Structure, for an overview of the menu structure. Access the Setup menu from the Main menu by pressing the SETUP softkey. The individual screens are accessed from the Setup screen by pressing the softkey adjacent to the name on the display. Each screen provides access to a specific set of characteristics. These characteristics are applied globally to all of the measurement modules provided with the instrument.

5.1 Set Clock Screen

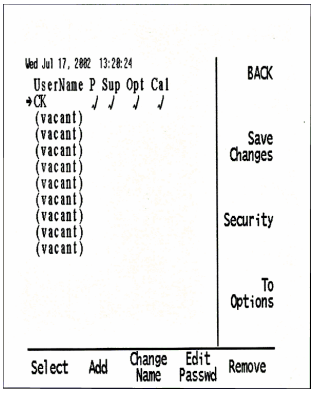
Use this screen to edit all of the day, date, and time settings for the system clock.



KEY INPUT	RESULT
Day/Month/Date	Located to the right of the display. Scrolls the day, month, or date each time
Softkeys	the softkey adjacent to the item is pressed.
Format	Scrolls through the day\month\year arrangements
DST Mode	Turns ON/OFF the automatic daylight savings time adjustment to the system clock. Adjustment is based on US rules for daylight savings time only.
Time	Scroll through the hours or minutes time setting, depending on which softkey is pressed.
Done	Press this softkey to save the day\date\time settings entered and return to the Setup Menu. CAUTION: If you exit without pressing this key, your changes will not be saved.
+- key	Changes the direction of scrolling when a softkey is pressed.

5.2 User Control Screen

This feature is accessible only for Supervisor (Sup) level user. Use this screen for entering and editing all users, passwords, and security levels. The presence of a checkmark (√) indicates an option has been assigned to the user.

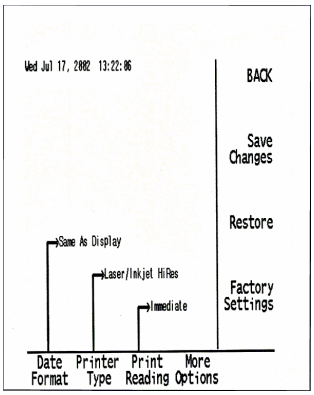


KEY INPUT	RESULT
Select	Scrolls the select arrow through the list of assigned user names. Selects the user name to be edited.
Add	Prompts for entry of a new user name. Enter the new user name, character by character, by pressing the softkey adjacent to the displayed letter. Scroll through the letters by pressing the softkey arrows. Change to upper or lower case by pressing TURN ON CAPS/TURN OFF CAPS softkey. Press the ENTER function key when completed.
Change Name	Prompts for entry of a new name for the selected user. Follow procedure for entry of a new user name described above.
Edit Passwd	Prompts for entry of a password for a new user, or for entry of a different password for the selected user. When a password is entered, a checkmark will appear under the "P" heading at the top of the screen. Follow new user entry procedure described above.
Remove	Press this softkey to remove the selected user. CAUTION: Verify that the user name selected is the one you wish to remove, as you will not be prompted a second time.
To Options/ To Names	Displays the OPTIONS softkeys of SUPER, OPTS, and CAL. **SUPER** Grants the user supervisor status, which allows access to, and editing of all features of the system. **OPTS** Grants the user the ability to edit all options except for the User Control, Factory Options, Cal & Tuning, and Tests & Options in the setup screen. **CAL** Grants the user the ability to edit and make Calibrations. Select which of these options you wish to assign to the user and press the TO NAMES softkey to return to the User Control menu.
Security	This feature is accessible only if you have a Supervisor level password. Select the level of system security from the following options. **NO RESTRICTIONS** Any user can access all features of the system.

	RESTRICT OPTIONS A Supervisor level password is required to access the Setup menu. Anyone can make or edit calibrations.
	RESTRICT CALIBRATIONS Calibrations can only be selected and used for measurements. Making or editing calibrations requires a Supervisor level password.
	RESTRICT ALL Instrument can only be used for making measurements, changes to options or calibrations are not allowed. Supervisor level password is required to access the Setup menu and to make or edit calibrations.
	MULTI-USER MODE Requires all users to Login in with their name and password. Access to system features is controlled by the configuration of the individual profile setup in the user control menu.
Save Changes	Saves the changes made to all of the items. Press this softkey before exiting the User Control menu or your changes will not be saved.
Back	Returns to the previous menu.

5.3 Printer Options Screen

Use this screen to specify the type of printer to be used, and to edit the other printing options. Readings can be printed in a standard format or a long format. In standard format, a reading and a sequence number are printed. In long format, the date and time that a reading was taken are added to the standard format. See the Printing section of the manual for printing details, additional Printer Control options and samples of a header and ticket.

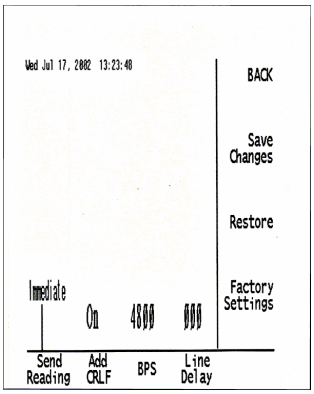


KEY INPUT	RESULT
Date Format	Allows for selecting how the date will print. Select either to print the "Same As Display" or from the various day/date formats available.
Printer Type	The CMI 700 will operate with ink jet or laser printers that are compatible with the HP PCL4 standard and dot matrix printers that conform to the Epson Esc P specification with IBM PC line drawing characters. Select which of the following list of generic types of printers best describes the printer you wish to use: Laser/Inkjet Hi Res, Laser/Inkjet LoRes, Plain Text 80 Col, 9 or 24 Pin Dot Matrix or the DPU 411 thermal printer.
Print Readings	Selects when the readings are to be printed. Select from the following options: **NEVER** Readings are not printed. **IMMEDIATE** Readings will print automatically when taken. **DELAYED** Readings will print, when a subsequent reading is taken. **IMMEDIATE LONG** Same as IMMEDIATE except a long format is printed. **DELAYED LONG** Same as DELAYED, except a long format is printed.
More Options	This is a submenu of the Printer Options screen. **PRINT TICKET** NEVER, ALWAYS, or IF ASKED before entering the measure screen. **PRINT HEADER** NEVER, ALWAYS, or IF ASKED before entering the measure screen. **REPORT FORMAT** - This is a submenu of the More Options screen. A full report consists of the printing of the ticket, header, stats, readings, trend

	chart, X & R chart, and histogram. Only items with a check mark next to them will be printed in the report. Use the up or down arrow to scroll to an item. To toggle (on or off) the check mark, press the 'Select' softkey. To clear readings after printing the report, check 'Clear Readings, Exit'.
Factory Settings	Restores the Date Format, Printer Type, and Print Reading selections to the default factory settings.
Restore	Restores the original settings of the items that have been changed.
Save Changes	Saves the changes made to all of the items.
Back	Returns to the previous menu.

5.4 Serial Options Screen

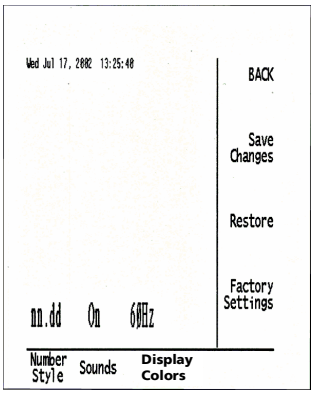
Use this screen to set the parameters for the serial output of data from the CMI 700 to a PC or other device requiring serial data.



KEY INPUT	RESULT
Send Readings	Specify when readings are to output from the CMI 700. Select from: **IMMEDIATE** Data is output when a reading is taken **DELAYED** Data is output when the next reading is taken. **NEVER** Data is never output.
Add CRLF	Change to On or Off if you are experiencing problems with the printer correctly spacing readings. When ON, it adds a Carriage Return and a Line Feed to each reading.
BPS	Sets the output rate of transmission in Bits Per Second. The default value is 4800. Consult the manual of the device you are connecting to for the correct setting.
Line Delay	Change the value by pressing the softkey, if you are experiencing problems synchronizing the printer.
Factory Settings	Press this softkey to restore the factory settings for all of the printer options.
Restore	Restores the original settings of the items that have been changed.
Save Changes	Saves the changes made to all of the items.
Back	Returns to the previous menu.

5.5 System Options Screen

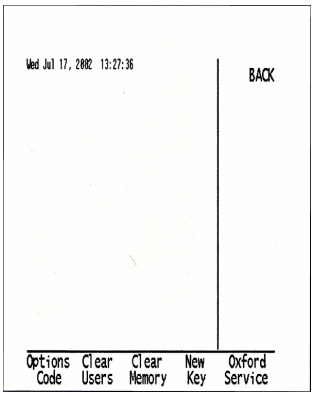
Use this screen to select the number format, power supply frequency selection and keystroke sounds.



KEY INPUT	RESULT
Number Style	Selects the number format for the system. Select either American (00.00) or European (00,00) convention for the use of periods and commas.
Sounds	Select ON for an audible tone at each keystroke, select OFF for none.
HZ	Toggles between 60 and 50. Select the value that matches the frequency of the line voltage. Active ONLY when no calibrations have been made and stored.
Display Colors	Submenu of the Systems Options Screen. **Backgnd Color** **Font color** (Includes color of all graphics and text) Select Red, Green, Blue, Magenta, Yellow, Cyan, White, Black or Custom. Select Custom to open submenu to create a color by selecting: **Red Level** Select 0 to 63 (greater is brighter) for intensity of the red component. **Green Level** Select 0 to 63 (greater is brighter) for intensity of the green component. **Blue Level** Select 0 to 63 (greater is brighter) for intensity of the blue component.
Factory Settings	Press this softkey to restore the factory settings for all of the System Options.
Restore	Restores the original settings of the items that have been changed.
Save Changes	Saves the changes made to all of the items. Press this softkey before exiting the System Options menu or your changes will not be saved.
Back	Returns to the previous menu.

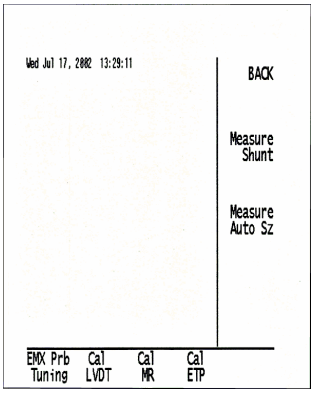
5.6 Factory Options Screen

This screen is for diagnostic use under the supervision of Technical Support, or for a technician. There are no user-related options in this menu.



5.7 Calibration and Tuning Screen

Use this screen for tuning each eddy current probe before using it with the instrument for the first time. The Cal & Tuning screen contains five other screens, which are for the MRX module. These softkey options will only appear if the MRX module option has been installed.

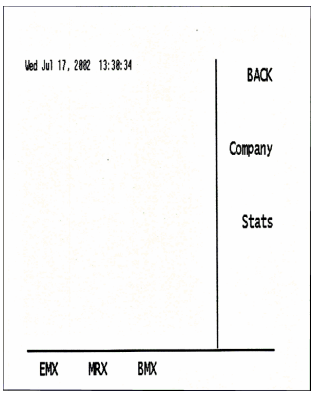


KEY INPUT	RESULT
EMX Prb Tuning	This selection presents the Probe Select screen, select the probe you wish to tune by pressing the number key that corresponds to the probe type. Then press the number key next to the method you wish to use in tuning the probe. 1: AUTOMATIC Tunes probe to factory specifications and is the recommended method.

	Automatically samples the probe and enter the correct frequency. Follow the on-screen prompt to place the probe on the bare copper standard and then press the "GO" function key. Hold the probe in contact with the copper until the tuning prompt disappears from the screen and is replaced with the Probe Select Menu. 2: MANUAL Select this method if you wish to manually enter a frequency for the probe. Enter the desired frequency from the keyboard and press the "ENTER" key to accept the entry. . Consult with Technical Support if you wish to manually enter the probe frequency or adjust it 3: TEST This selection allows for adjusting the probe frequency by fixed increments of plus or minus 1% and plus or minus 0.1%. Press the softkey adjacent to the percent adjustment you wish to make. Press the SAVE CHANGES softkey before exiting the menu to save and record your changes. Press the BACK softkey to exit without saving the changes
Cal LVDT	This selection is used to calibrate the auto size feature for the TRP probe for the MRX module. The unit must be calibrated upon receipt and must be recalibrated if any of the following occurs: Changes to measuring heads Damage to measuring head Internal battery dies Select standard head. The standard head is capable of reading holes 20 mils in diameter or greater. Choose the number of measurements per standard. Place standard #1 under the probe and press the GO function key. A message will appear displaying the measured values and asking if they are correct. If No is selected, the unit will prompt to remeasure standard. If Yes is selected, the unit will accept these values as correct. Enter the board thickness using the numeric keys and press ENTER function key. Enter the hole size using the numeric keys and press ENTER function key. Repeat above steps for the measurement of standard #2. This will allow the unit to calculate the correct calibration curve and will complete the calibration of the auto size feature.
Cal MR	This selection is only used by technicians in production to calibrate and verify the accuracy of the unit.
Cal ETP	This selection is used to calibrate the ETP probe which must be calibrated before use.
Measure Auto Sz	After calibrating the unit using Cal LVDT, this selection is used to verify the calibration. A standard of known board thickness and hole diameter is measured and the results are compared to the standard information to determine if the unit is calibrated correctly. Enter units. Select standard. The standard head is capable of reading holes 20 mils in diameter or greater Place standard under probe and press GO function key. The board thickness and hole size will be displayed. If the values are incorrect, repeat measurement to confirm that measurement was taken correctly. If values are still incorrect, proceed to Cal LVDT (described above) to recalibrate the unit.
Measure Shunt	This selection is only used by technicians in production to verify the unit is working correctly by testing the resistance measuring feature.
Back	Returns to the previous menu.

5.8 Tests and Options Screen

This screen is used to enter a company name or other designator. The name entered will appear on Headers and Tickets, if these options have been enabled in the Printer Options/More Options Screen.



KEY INPUT	RESULT
Company	Pressing this softkey enables the entering of letters and/or characters for a company name, or other designator, which will appear on Headers and Tickets. A maximum of 38 characters is allowed. Refer to the Text Entry screen for details on how to enter letters and characters.
Stats	Pressing this softkey displays the amount of free space for measurement readings.
BMX	This selection is only used by technicians in production to verify the unit is working correctly.
MRX	This selection is only used by technicians in production to verify the unit is working correctly.
EMX	This selection is only used by technicians in production to verify the unit is working correctly.
Back	Returns to the previous menu.

6 EMX Module Menus

The following sections describe the Measurement and Calibration procedures that pertain specifically to the EMX module. These menus are accessed by pressing the EMX softkey.

6.1 Principle of Operation

The CMI 700 EMX is a dedicated, non-destructive combination eddy current, magnetic, and nickel thickness tester. It is designed to precisely measure various plating/coatings on different substrates.

The CMI 700 EMX utilizes eddy current and magnetic induction principles. The general applications of the various principles are shown below.

Applications of Measurement Principles		
Measurement Principle	Coating	Substrate
Eddy Current	Non-Conductive Zinc Cadmium Nickel Copper Copper	Metallic (non-magnetic) Steel Steel Steel Steel Non-metallic
Magnetic	Non-magnetic	Magnetic
Magnetic	Magnetic Nickel (Sulfamate, Sulfate Bright)	Non-magnetic

6.2 EMX Calibration

Calibrations are a means of correlating the instrument's readings to known, certified standards. To perform a calibration, measurements are taken on a sample of a base material, two or more standards of known thickness, and an infinity reading. Calibrations must be performed for each type of coating and base material that is to be measured.

6.2.1 Calibration Procedure

To make a new calibration, press NEW softkey in the Calibration List or if no calibrations have been made, answer "yes" to the question that appears after pressing EMX softkey from the Main Menu. You will then be prompted through the following (for the meaning of each option see Edit/Change Calibration Screens #1 through #3 below):

1. Probe Type.

2. Calibration Number.

3. Calibration Name.
4. Calibration Identity.
5. Application.
6. Probe Model.
7. Units.
8. Precision.
9. Measurements Per Reading.
10. High Limit.
11. Low Limit.
12. Maximum Saved Readings.
13. X & R Group Size.
14. Clear Stats + Charts Before Measure.
15. Offset.
16. Conductivity Factor.
17. Scan Time.
18. Number of Standards.
19. You will now be prompted to calibrate on standards. Press any key.
20. The prompt to measure the base material will appear on the screen.
21. Place the probe on the standard base material.
22. Hold the probe on the base material and press the GO function key on the front panel.
23. The prompt to obtain an infinity reading will appear on the screen.
24. If shims are being used to make the calibration, hold the probe in air, at least 6" away from any object.
25. If hard plated standards are being used to make the calibration, place and hold the probe on the infinity standard provided with the set.
26. Press the GO key on the front panel.

27. The prompt to measure the first required standard will appear on the screen. If the calibration parameters were set to require more than one measurement per standard the specified number of readings will be taken.

28. Place the probe on the standard, hold in place and press the GO key.

29. The probe can be removed from the standard when the "Enter Thickness" menu appears.

30. Enter the value of the standard using the numeric keys.

31. Review the entered amount on the display and if correct press the ENTER function key. If incorrect, press the CLEAR function key and re-enter the value of the standard.

32. The prompt to measure the second required standard will appear on the screen.

33. Place the probe on the second standard, hold in place and press the GO key.

34. The probe can be removed from the standard when the "Enter Thickness" menu appears.

35. Enter the value of the standard using the numeric keys.

36. Review the entered amount on the display and if correct press the ENTER key. If incorrect, press the CLEAR key and re-enter the value of the standard.

37. If additional standards are required, follow the on-screen prompts and use the same procedure as described in Steps 32 through 36.

38. If there is no prompt for an additional standard, the calibration is complete and ready for use.

6.2.2 EMX Calibration List Screen

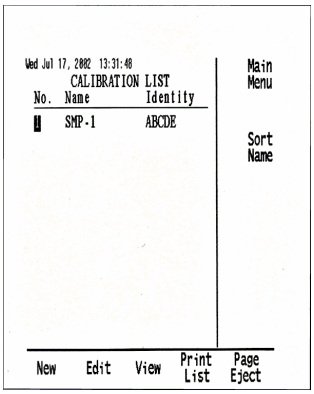
This screen is accessed by pressing the EMX softkey from the Main menu, and is used to add, change, copy, view, print and remove calibrations. It lists all calibration names and identities that are entered in the system. Press the SORT IDENTITY softkey to toggle between sorting the listing by name, number or by identity.

To select a calibration and advance to the measure screen perform either one of the following key sequences;

1. Use the Up and Down arrow softkeys to highlight an item in the list to select. The selected calibration number will be highlighted in reverse video. Then press the MEASURE, GO or ENTER function keys followed by the ENTER key.

2. Press the MEASURE, GO or ENTER function keys followed by the number of the calibration to select, then press the ENTER key.

Some of the listed calibrations may not have had calibration measurements performed, and therefore cannot be used to make measurements. If selected to make measurements, their use will be denied. For these press the Calibrate function key to begin calibration measurements.



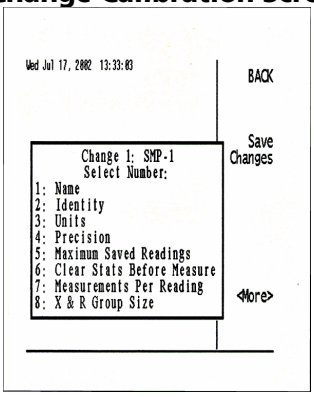
KEY INPUT	RESULT
New	Allows creation of a new calibration. Follow the screen prompts.
Edit	Allows modification of an existing calibration. Follow the screen prompts. **Copy** Allows the selected calibration parameters to be copied to a new calibration. Scroll through the characters and enter a name and identity for the calibration into which the parameters are to be copied. **Delete** Removes the selected calibration. **Change** Allows editing of the selected calibration's parameters. See Edit/Change calibration menu below.
View	Displays the calibration parameters and the last 100 saved readings taken with the selected calibration. The following softkeys appear when in this menu. **PRINT CAL** Prints the calibration parameters. **PRINT READINGS** Prints the saved readings. **SCROLL** Use the up or down arrow to scroll through the calibration parameters and the saved readings. **PAGE EJECT** Ejects printer page.
Print List	Prints Calibration List.
Page Eject	Ejects printer page.
Main Menu	Returns to the Main Menu.

6.2.3 EMX Edit/Change Calibration Screens

The following three screens are part of the Edit/Change Calibration menu. They are accessed by pressing the EDIT softkey in the Calibration List Screen followed by pressing Enter for the highlighted calibration or the number of the calibration to change followed by the Enter function key, then select 3 (Change). Select a calibration and use these menus to change the parameters. The following softkeys appear on the right side of each of the screens.

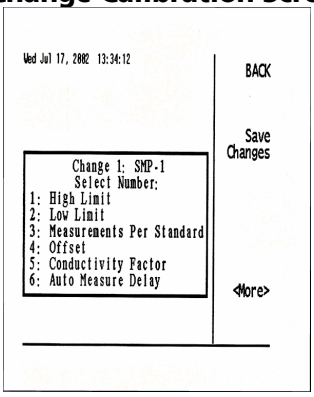
KEY INPUT	RESULT
Back	Returns to the previous menu.
Save Changes	Saves changes made to the parameters. "Save Your Changes?" will appear on the display if you exit without saving the changes. If NO is pressed you will exit the menu without saving the changes. If YES is pressed changes will be saved.
More	Advances to the next Edit screen.

EMX Change Calibration Screen #1



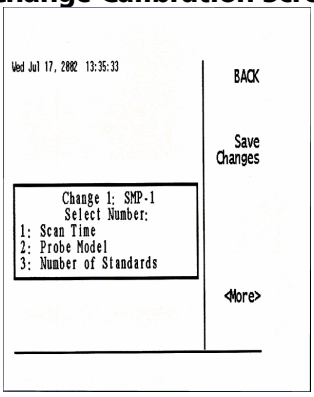
KEY INPUT	RESULT
1: Name	Displays the name entered from the New menu. Change if desired.
2: Identity	Displays the identity entered from the New menu. Change if desired.
3: Units	Specify the unit of measure. Select from mil, µm, µin, mm, in, or %. Displays the unit of measure currently specified.
4: Precision	Defines the number of decimal places used when performing calculations, or printing, or displaying readings. The current value is displayed. Enter a number between 0 and 6.
5: Maximum Saved Readings	Memory is allocated in units of ten readings. A maximum of 1000 readings can be assigned to each calibration. Memory capacity for the instrument is 10,000 readings maximum. A warning first appears indicating that all collected stats (readings) will be lost if changes are made. Press the YES softkey to continue, or NO to exit. If YES, a menu appears indicating the current memory allocation for this calibration. Enter a new value for the number of readings. The value entered is multiplied by 10 for the total amount of readings saved. Statistical calculations, such as S.D., Mean, etc., are made on an ongoing basis from the measurements that are taken, and are independent of the number of readings saved.
6: Clear Stats Before Measure	Specify when readings are to be cleared. Select from the following options: **Never** Readings are cleared only when the CLEAR SESSION or CLEAR SAVED softkey is pressed. When memory is full, the oldest reading is removed when a new reading is taken. **Always** Readings are cleared when entering the Measure menu. **If Asked** Prompts to clear stats (Yes or No) upon entering the Measure screen.
7: Measurements per Reading	Specify the number of readings to be taken per measurement. A maximum of 20 readings can be specified. The average of the readings is used for the value of the measurement. Scan Mode will not be accessible if more than one reading per measurement is specified.
8: X & R Group Size	Specify the statistical group size used for the X Bar & R charts.

EMX Change Calibration Screen #2



KEY INPUT	RESULT
1: High Limit	Specify a value for the high limit. Readings that exceed the limit will be noted on the display and you will be prompted to either accept or reject them.
2: Low Limit	Specify a value for the low limit. Readings that are less than the limit will be noted on the display and you will be prompted to either accept or reject them.
3: Measurements Per Standard	Enter a value, between 1 and 20, for the number of measurements to be taken on each standard used in making the calibration.
4: Offset	An offset is used to compensate for differences between the base material of the sample to be measured and the base material that was used in making the calibration. It is either added to or subtracted from the thickness measured on the base material used in the calibration. Enter a value within the range of -20.00 to 20.00. The number of decimal places shown is determined by the value specified in the Precision selection made in Screen #1. The current offset is displayed. An offset of 0.00 indicates that no correction will be made.
5: Conductivity Factor	A conductivity correction factor is used to compensate for differences in the method of plating used on the sample to be measured. It is a multiplier that is applied to all measurements made with the calibration. Select a value between 0.5 to 4.0. A correction factor of 1.0 means no change will be made.
6: Auto Measure Delay	In the Auto measure Mode this is the time between when the probe is placed on the surface and the measurement is initiated. The range for this value is 0.0 to 5.0 seconds.

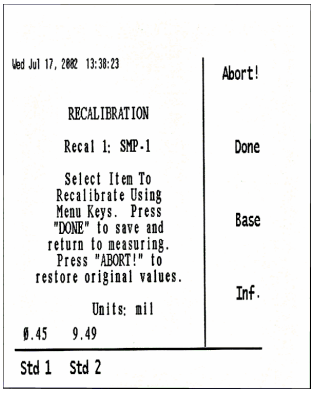
EMX Change Calibration Screen #3



KEY INPUT	RESULT
1. Scan Time	The time in seconds during which readings will be taken, at a rate of 2 readings per second. Range is 1 - 10 seconds. An entry of 0 disables Scan Mode.
2: Probe Model	Used to change the probe model specified in the calibration. For magnetic and eddy current calibrations, a different selection can be made within the family of probes displayed for each measurement discipline. You can select a different magnetic probe only for a magnetic calibration. You can also select a different eddy current probe for an eddy current calibration. The probe cannot be changed for nickel calibrations.
3: Number of Standards	Specify the number of standards that are required to be measured when making a calibration. Select a value of from 2 to 4 standards. The default value is two standards.

6.2.4 EMX Recalibration Screen

This screen is used to re-enter some or all of the measurements made for an existing calibration. The screen shown below is for a calibration that requires two standards. The number of softkeys displayed will depend on the number of standards used in the calibration. Displayed above each standard softkey is the value measured in the original calibration. The units selected for the calibration are also displayed.



KEY INPUT	RESULT
Std 1	Press this softkey if you wish to re-measure Standard #1. Begins the following sequence for measuring the standard and entering the value. Follow the on-screen prompts. Place the probe on the standard and press the GO key. Remove the probe when the "Enter Thickness" menu appears. Enter the value of the standard using the numeric keys. Review the entered amount and press the ENTER key if correct. If incorrect press the CLEAR key and re-enter the value of the standard.
Std 2	Press this softkey and repeat the above process if you wish to re-measure the second standard.
Inf.	Press this softkey and follow the on-screen prompts if you wish to take another infinity reading. Hold the probe in air if shims are being used, or hold the probe on the infinity standard if hard plated standards are being used.
Base	Press this softkey if you wish to either re-measure the base material or if you wish to measure a different base material for this calibration.
Done	Press this key when you are finished making measurements. It will save the measurements and return you to the Calibration List screen.
Abort!	Press this key to abandon all measurements made and return to the Calibration List menu.

7 MRX Module Menus

The following sections describe the Measurement and Calibration procedures that pertain specifically to the MRX module. These menus are accessed by pressing the MRX softkey.

7.1 Principle of Operation

The MRX series is a dedicated non-destructive plating thickness tester. It is designed to precisely measure surface copper thickness or plated thru-hole copper thickness in printed circuit boards and to determine hole quality through the detection of cracks, voids, and non-uniform plating.

7.2 MRX Calibration

7.2.1 Calibration Procedure

7.2.1.1 Surface Probe

Calibrations are a means of correlating the instrument's readings to known, certified standards. To perform a calibration measurements are taken on two standards of known thickness.

To make a new calibration for the Surface probe, press NEW softkey in the Calibration List or if no calibrations have been made, answer "yes" to the question that appears after pressing MRX softkey from the Main Menu. You will then be prompted through the following (for the meaning of each option see Edit/Change Calibration Screens #1 through #3 below) assuming MRX Surface was entered for probe type:

1. Calibration Number
2. Calibration Name
3. Calibration Identity
4. Probe Model
5. Units
6. Precision
7. Measurements Per Reading
8. Measurements Per Standard
9. High Limit
10. Low Limit
11. Measure Fine Lines

12. Maximum Saved Readings
13. X & R Group Size
14. Clear Stats + Charts Before Measure
15. Offset
16. Conductivity Factor
17. You will now be prompted to calibrate on standards. Press any key.
18. The prompt to measure the first required standard will appear on the screen. If the calibration parameters were set to require more than one measurement per standard the specified number of readings will be taken.
19. Place the probe on the standard, hold in place and press the GO key.
20. The probe can be removed from the standard when the "Enter Thickness" menu appears.
21. Enter the value of the standard using the numeric keys.
22. Review the entered amount on the display and if correct press the ENTER function key. If incorrect, press the CLEAR function key and re-enter the value of the standard.
23. The prompt to measure the second required standard will appear on the screen.
24. Place the probe on the second standard, hold in place and press the GO key.
25. The probe can be removed from the standard when the "Enter Thickness" menu appears.
26. Enter the value of the standard using the numeric keys.
27. Review the entered amount on the display and if correct press the ENTER key. If incorrect, press the CLEAR key and re-enter the value of the standard.

7.2.1.2 TRP Probe

To make a new calibration for the TRP probe, press NEW softkey in the Calibration List or if no calibrations have been made, answer "yes" to the question that appears after pressing MRX softkey from the Main Menu. You will then be prompted through the following (for the meaning of each option see Edit/Change Calibration Screens #1 through #3 below) assuming MRX TRP was entered for probe type:

1. Calibration Number.
2. Calibration Name.
3. Calibration Identity.
4. Units.
5. Precision.
6. Measurements Per Reading.
7. High Limit.
8. Low Limit.
9. Head Type.
10. Hole Mode.
11. Board Thickness.
12. Hole Size.
13. Head Type.
14. Maximum Saved Readings.
15. X & R Group Size.
16. Clear Stats + Charts Before Measure.
17. Offset.
18. Conductivity Factor.
19. Multilayer Board?

If Auto Size is chosen for Hole Mode (10 above), an LVDT calibration must be performed before measurement is allowed. See 5.7 Calibration and Tuning Screen, LVDT.

7.2.1.3 ETP Probe

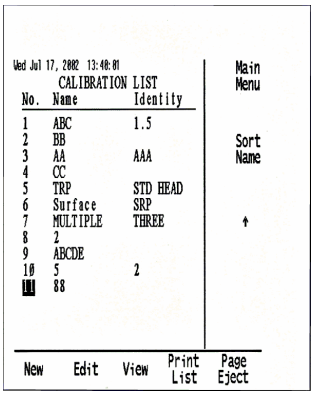
To make a new calibration for the ETP probe, press NEW softkey in the Calibration List or if no calibrations have been made, answer "yes" to the question that appears after pressing MRX softkey from the Main Menu. You will then be prompted through the following (for the meaning of each option see Edit/Change Calibration Screens #1 through #3 below) assuming MRX ETP was entered for probe type:

1. Calibration Number.
2. Calibration Name.
3. Calibration Identity.
4. Units.
5. Precision.
6. Measurements Per Reading.
7. High Limit.
8. Low Limit.
9. Board Thickness.
10. Copper Weight.
11. Etched?
12. Maximum Saved Readings.
13. X & R Group Size.
14. Clear Stats + Charts Before Measure.
15. Offset.
16. Conductivity Factor.

Before measurement with the ETP probe is allowed, a calibration on a standard needs to be performed. See Cal & Tuning Screen/Cal ETP.

7.2.2 MRX Calibration List Screen

This screen is accessed by pressing the MRX softkey from the Main menu. See EMX Calibration List Screen above for functions, key inputs and results.

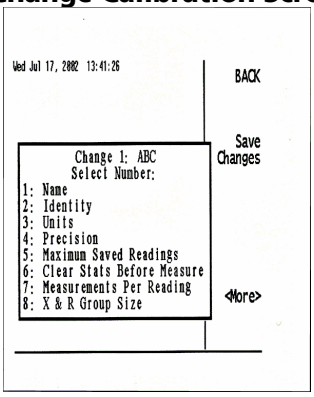


7.2.3 MRX Edit/Change List Screen

The following three screens are part of the Edit/Change Calibration menu. They are accessed by pressing the EDIT softkey in the Calibration List Screen followed by pressing Enter for the highlighted calibration to change followed by enter, then press 3 (Change). Select a calibration and use these menus to change the parameters. The following softkeys appear on the right side of each of the screens.

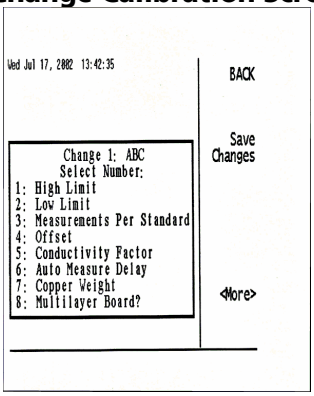
KEY INPUT	RESULT
Back	Returns to the previous menu.
Save Changes	Saves changes made to the parameters. "Save Your Changes?" will appear on the display if you exit without saving the changes. If NO is pressed you will exit the menu without saving the changes. If YES is pressed changes will be saved.
More	Advances to the next Edit screen.

MRX Change Calibration Screen #1



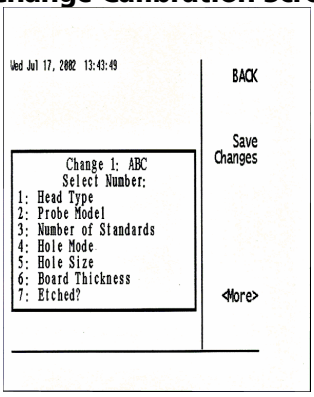
KEY INPUT	RESULT
1: Name	Displays the name entered from the New menu. Change if desired.
2: Identity	Displays the identity entered from the New menu. Change if desired.
3: Units	Specify the unit of measure. Select from mil, µm, µin, mm, in, or %. Displays the unit of measure currently specified.
4: Precision	Defines the number of decimal places used when performing calculations, or printing, or displaying readings. The current value is displayed. Enter a number between 0 and 6.
5: Maximum Saved Readings	Memory is allocated in units of ten readings. A maximum of 1000 readings can be assigned to each calibration. Memory capacity for the instrument is 10,000 readings maximum. A warning first appears indicating that all collected stats (readings) will be lost if changes are made. Press the YES softkey to continue, or NO to exit. If YES, a menu appears indicating the current memory allocation for this calibration. Enter a new value for the number of readings. The value entered is multiplied by 10 for the total amount of readings saved. Statistical calculations, such as S.D., Mean, etc., are made on an ongoing basis from the measurements that are taken, and are independent of the number of readings saved.
6: Clear Stats Before Measure	Specify when readings are to be cleared. Select from the following options: Never - Readings are cleared only when the CLEAR STATS softkey is pressed. When memory is full, the oldest reading is removed when a new reading is taken. Always - Readings are cleared when exiting the Measure menu. If Asked - Prompts to clear stats (Yes or No) upon entering the Measure menu.
7: Measurements Per Reading	Specify the number of readings to be taken per measurement. A maximum of 20 readings can be specified. The average of the readings is used for the value of the measurement. Scan Mode will not be accessible if more than one reading per measurement is specified.
8: X & R Group Size	Specify the statistical group size used for the X Bar & R charts.

MRX Change Calibration Screen #2



KEY INPUT	RESULT
1: High Limit	Specify a value for the high limit. Readings that exceed the limit will be noted on the display and you will be prompted to either accept or reject them.
2: Low Limit	Specify a value for the low limit. Readings that are less than the limit will be noted on the display and you will be prompted to either accept or reject them.
3: Measurements Per Standard	Enter a value, between 1 and 20, for the number of measurements to be taken on each standard used in making the calibration.
4: Offset	An offset is used to compensate for differences between the base material of the sample to be measured and the base material that was used in making the calibration. It is either added to or subtracted from the thickness measured on the base material used in the calibration. Enter a value within the range of -20.00 to 20.00. The number of decimal places shown is determined by the value specified in the Precision selection made in Screen #1. The current offset is displayed. An offset of 0.00 indicates that no correction will be made.
5: Conductivity Factor	A conductivity correction factor is used to compensate for differences in the method of plating used on the sample to be measured. It is a multiplier that is applied to all measurements made with the calibration. Select a value between 0.5 to 4.0. A correction factor of 1.0 means no change will be made.
6: Auto Measure Delay	In Auto Measure Mode, this is the time between the probe being placed on the surface and the measurement is initiated. The Range is 0.0 to 5.0 seconds. This is applicable to the surface probe only.
7: Copper Weight	Choose between 0.5 oz., 1.0 oz., or 2.0 oz. surface copper weight. Applicable to ETP probe only.
8: Multilayer Board?	Answer yes or no to the question of whether the board has multiple layers. Applicable to TRP probe only.

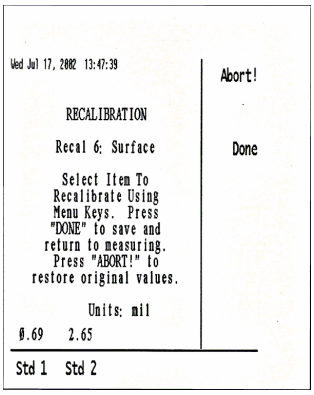
MRX Change Calibration Screen #3



KEY INPUT	RESULT
1. Head Type	Choose between Standard or Micro Head. The Standard Head is capable of reading holes 20 mils in diameter or greater. The Micro Head is used on holes 40 mils in diameter or less. Applicable to TRP probe only.
2: Probe Model	Choose between SRP-1, SPR-2, SRP-3, or SRP-4 type. Applicable to surface probes only.
3: Number of Standards	Specify the number of standards that are required to be measured when making a calibration. Select a value of from 2 to 4 standards. The default value is two standards.
4. Hole Mode	Choose between Fixed Size or Auto Size. Use Fixed Size if hole diameter and board thickness are known. Use Auto Size if these values are not known and you want the unit to calculate them. Auto Size requires that a LVDT calibration has been performed. Applicable to TRP only.
5. Hole Size	Size of hole to be measured. Applicable to TRP probe using Fixed Size option only.
6. Board Thickness	Board thickness to be measured. Applicable to TRP probe using Fixed Size option or ETP probe.
7. Etched?	Answer yes or no to the question of whether the hole to be measured is in an etched or unetched board. Applicable to ETP probe only.
8. Measure Fine Lines	Turn Fine Line Measure Mode On or Off. If On, enter numeric trace width value. Applicable to SRP probes only. (*This feature, not pictured above)

7.2.4 MRX Recalibration Screen

This screen is applicable only to the MRX Surface probe and is used to recalibrate on one or both standards. Displayed above each standard softkey is the value measured in the original calibration. The units selected for the calibration are also displayed.

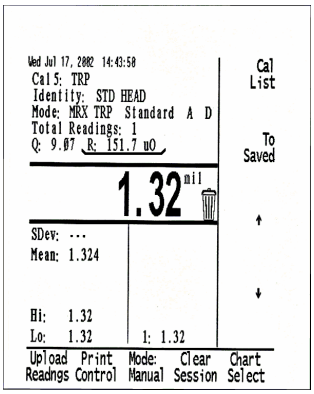


KEY INPUT	RESULT
Std 1	Press this softkey if you wish to re-measure Standard #1. Begins the following sequence for measuring the standard and entering the value. Follow the on-screen prompts. Place the probe on the standard and press the GO key. Remove the probe when the "Enter Thickness" menu appears. Enter the value of the standard using the numeric keys. Review the entered amount and press the ENTER key if correct. If incorrect press the CLEAR key and re-enter the value of the standard.
Std 2	Press this softkey and repeat the above process if you wish to re-measure the second standard.
Done	Press this key when you are finished making measurements. It will save the measurements and return you to the previous screen.
Abort!	Press this key to abandon all measurements made and return to the previous screen.

7.2.5 Using the Quick Check Board

With every TRP probe a Quick Check Board is included to check the operation of the probe. To check the TRP operation for these steps.

1. Create a New TRP calibration.
2. Measure 1 or more holes on the Quick Check board.
3. Refer to the figure to retrieve the resistance (R) value.



The difference between the measured R value and the labeled value should be within ± 10 %. If these vary by more than 10%, please contact Oxford Instruments Technical Support.

8 BMX Module Menus

The following sections describe the Measurement and Calibration procedures that pertain specifically to the BMX module. These menus are accessed by pressing the BMX softkey

8.1 Principle of Operation

The BMX utilizes the properties resulting from the interaction between high speed electrons (beta particles) emitted from a radioactive source, and atoms in the target material(s).

When beta particles collide with atoms from the target material, a fraction of the beta particles will be reflected or backscattered. The number of reflected beta particles increases as the atomic number of the target material increases. The total number of backscattered beta particles will also increase with increasing thickness of the target material, up to a specified thickness. This specified thickness is termed the saturation or infinite thickness. The total number of backscattered beta particles will no longer increase for a given isotope once the saturation thickness has been reached.

Because of this, the intensity of the backscattered radiation (measured in counts per minute) for a beam of beta particles striking a coating/base combination will be dependent on the coating thickness as long as:

1. The base material thickness is not varied (in practice the base material thickness is usually greater than the saturation thickness).

2. The thickness of the coating material is less than its own infinite or saturation thickness for the isotope in use.

3. The atomic number of the base material and coating material differs by at least five.

The preceding is the principle behind coating thickness measurement using the beta particle backscatter principle. The actual relationship between the coating thickness and the measured backscattered intensity, or counts per minute, is not linear. A four or more point calibration must be performed prior to measurement so that the instrument can convert the measured counts per minute to the appropriate thickness.

An exception to this four point calibration is the measurement of percent composition of alloys. The relationship between backscattered intensity and percentage composition is linear and a two-point calibration is sufficient

8.2 BMX Calibration

Calibrations are a means of correlating the instrument's readings to known, certified standards. To perform a calibration, measurements are taken on a sample of a base material, two or more standards of known thickness, and an infinity reading. Calibrations must be performed for each type of coating and base material that is to be measured.

8.2.1 Calibration Procedure

To make a new calibration, press NEW softkey in the Calibration List or if no calibrations have been made, answer "yes" to the question that appears after pressing BMX softkey from the Main Menu. You will then be prompted through the following (for the meaning of each option see Edit/Change Calibration Screens #1 through #3 below):

1. Calibration Number.
2. Calibration Name.
3. Calibration Identity.
4. Probe Port.
5. Probe Model.
6. Base Material.
7. Coating Material.
8. Coating Density Factor.
9. Measurement Units.
10. Precision.
11. Aperture Size.
12. Measurements per Reading.
13. Measurements per Standard.
14. Measurement Time.
15. High Limit.
16. Low Limit.
17. Maximum Saved Readings.
18. X & R Group Size.
19. Clear Stats and Charts before Measure.
20. Offset.
21. Linear Curve.
22. Number of Standards.

23. Once all items are inputted you will be prompted to calibrate on standards, press any key.

24. The prompt to measure the Base Material will appear on the screen. Place the probe on the Base Material. Press the GO function key to start the measurement.

25. The prompt to measure the coating infinity material will appear on the screen. Place the probe on the Infinite material. Press the GO function key to start the measurement.

26. The prompt to measure Standard 1 will appear on the screen. Place the probe on Standard 1. Press the GO function key to start the measurement. After the measurement is completed, a prompt to enter the thickness of Standard 1 will appear. Enter the thickness value for Standard 1 and press Enter to continue.

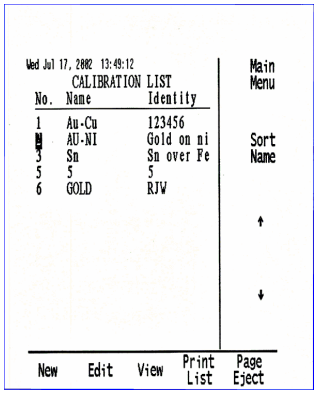
27. The prompt to measure Standard 2 will appear on the screen. Place the probe on Standard 2. Press the GO function key to start the measurement. After the measurement is completed, a prompt to enter the thickness of Standard 2 will appear. Enter the thickness value for Standard and press Enter to continue.

28. If there are more that two standards repeat step 27 above.

29. Once the calibration is complete, press any key to save the calibration and continue.

8.2.2 BMX Calibration List Screen

This screen is accessed by pressing the BMX softkey from the Main menu. See the EMX Calibration List Screen above for functions, key inputs and results.

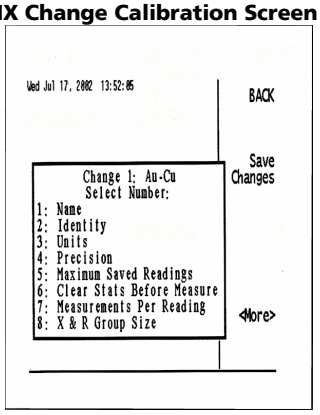


8.2.3 BMX Edit/Change Calibration Screens

The following three screens are part of the Edit/Change Calibration menu. They are accessed by pressing the EDIT softkey in the Calibration List Screen followed by pressing Enter for the highlighted calibration to change followed by enter, then press 3 (Change). Select a calibration and use these menus to change the parameters. The following softkeys appear on the right side of each of the screens.

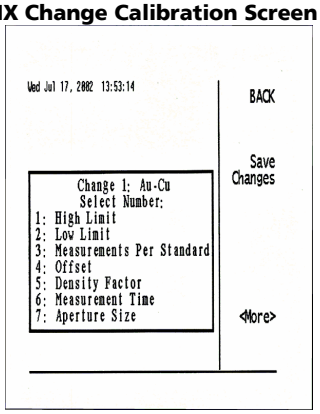
KEY INPUT	RESULT
Back	Returns to the previous menu.
Save Changes	Saves changes made to the parameters. "Save Your Changes?" will appear on the display if you exit without saving the changes. If NO is pressed you will exit the menu without saving the changes. If YES is pressed changes will be saved.
More	Advances to the next Edit screen.

BMX Change Calibration Screen #1



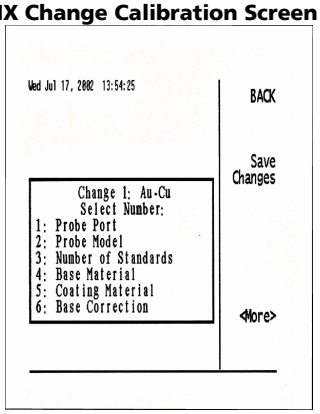
KEY INPUT	RESULT
1: Name	Displays the name entered from the New menu. Change if desired.
2: Identity	Displays the identity entered from the New menu. Change if desired.
3: Units	Specify the unit of measure. Select from mil, µm, µin, mm, in, or %. Displays the unit of measure currently specified.
4: Precision	Defines the number of decimal places used when performing calculations, or printing, or displaying readings. The current value is displayed. Enter a number between 0 and 6.
5: Maximum Saved Readings	Memory is allocated in units of ten readings. A maximum of 1000 readings can be assigned to each calibration. Memory capacity for the instrument is 10,000 readings maximum. A warning first appears indicating that all collected stats (readings) will be lost if changes are made. Press the YES softkey to continue, or NO to exit. If YES, a menu appears indicating the current memory allocation for this calibration. Enter a new value for the number of readings. The value entered is multiplied by 10 for the total amount of readings saved. Statistical calculations, such as S.D., Mean, etc., are made on an ongoing basis from the measurements that are taken, and are independent of the number of readings saved.
6: Clear Stats before Measure	Specify when readings are to be cleared. Select from the following options: Never - Readings are cleared only when the CLEAR STATS softkey is pressed. When memory is full, the oldest reading is removed when a new reading is taken. Always - Readings are cleared when exiting the Measure menu. If Asked - Prompts to clear stats (Yes or No) upon entering the Measure menu.
7: Measurements per Reading	Specify the number of readings to be taken per measurement. A maximum of 20 readings can be specified. The average of the readings is used for the value of the measurement. Scan Mode will not be accessible if more than one reading per measurement is specified.
8: X & R Group Size	Specify the statistical group size used for the X Bar & R charts.

BMX Change Calibration Screen #2



KEY INPUT	RESULT
1: High Limit	Specify a value for the high limit. Readings that exceed the limit will be noted on the display and you will be prompted to either accept or reject them.
2: Low Limit	Specify a value for the low limit. Readings that are less than the limit will be noted on the display and you will be prompted to either accept or reject them.
3: Measurements per Standard	Enter a value, between 1 and 20, for the number of measurements to be taken on each standard used in making the calibration. Displays the current setting.
4: Offset	An offset is used to compensate for differences between the base material of the sample to be measured and the base material that was used in making the calibration. It is either added to or subtracted from the thickness measured on the base material used in the calibration. Enter a value within the range of -20.00 to 20.00. The number of decimal places shown is determined by the value specified in the Precision selection made in Screen #1. The current offset is displayed. An offset of 0.00 indicates that no correction will be made.
5: Density Factor	A density factor is used to compensate to the differences in standard coating and sample coating densities. If the density of the coating on the sample is equal to the density of the coating on the standard, the density factor will remain 1.00. If the density of the coating on the sample is not equal to the density of the coating on the standard the following formula is used to calculate the density factor. Select a value between 0.001 and 10.000. Density Factor = (Sample Density) / (Standard Density)
6: Measurement Time	The Measurement time in seconds will be used to measure each sample. The default measurement time of 15 seconds may be changed to suit the particular coating application. Select a value between 1 and 120.
7: Aperture Size	The ideal aperture choice is the one with the largest opening that will completely cover or be covered by the part being measured. If the opening is too large, beta particles will escape into the air instead of being backscattered into the Geiger tube. If the opening is too small, the counts being backscattered will be reduced, affecting the repeatability of the readings. The aperture size can be found on the probe. Enter a value between 0.000 and 9.999 for the Aperture size.

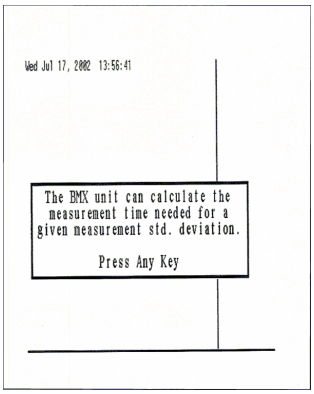
BMX Change Calibration Screen #3



KEY INPUT	RESULT
1: Probe Port	Select the desired probe port. The CMI 700 has two probe ports; BMX Port 1 and BMX Port 2. Select the appropriate Probe Port to use. If the selected probe is not connected to the BMX Port, no counts will be measured and an error message will appear when attempting to use the calibration in Measure Mode..
2: Probe Model	Select the probe type being used. Select the number next to the probe model you wish to use. The probe type selection is recorded only for the printing of the header. This selection does not affect the numerical calculation or output of the unit.
3: Number of Standards	Specify the number of standards that are required to be measured when making a calibration. Select a value of from 2 to 4 standards. The default value is two standards.
4: Base Material	Select the number that corresponds to the base material of the standards and samples being measured. There are two screens of base Materials, selecting <More> toggles between the two lists.
5: Coating Material	Select the number that corresponds to the coating material of the standards and samples to be measured. There are two screens of coating materials, selecting <More> toggles between the two lists.
6: Base Correction	Base correction allows you to correct for differences between the bare standard and the bare part. If a base correction is not required, select OFF. If base correction is desired, select ON. If base correction has previously been calibrated, a message will appear asking if you desire to change the base correction setting. To calibrate the base correction, put probe on the bare part as directed, and press **GO**.

8.2.4 BMX Recalibration Screen

This screen is used to re-enter some or all of the measurements made for an existing calibration. When the CALIBRATE function key is pressed from the Calibration List screen or the Measure screen the following message will appear;



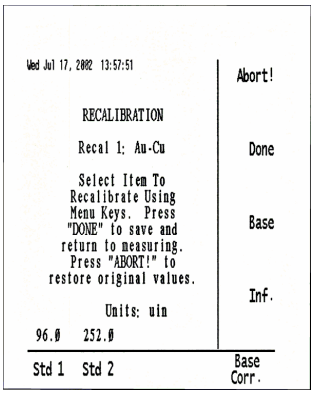
This feature allows you to let the unit determine the measuring time required to yield a given standard deviation. If YES is selected for the 'Automatic Time Calculation' prompt, enter the desired standard deviation in % as prompted and press ENTER. Place the probe on the part or plated standard, as prompted and press start. When the measurement is complete, the calculated measuring time will be displayed. The calculated measurement time can be accepted or rejected. To accept the measurement time select YES. To reject the measurement time select NO, enter the new measurement time and press ENTER. If the calculated measurement time is greater than the measurement time used when measuring the standards, the following message will appear.

THE NEW MEASUREMENT TIME IS GREATER THAN BEFORE. FOR MAXIMUM ACCURACY RECALIBRATE USING ALL STANDARDS. PRESS ANY KEY

If this occurs, recalibrate the standards using the calculated measuring time. This will insure that the highest degree of accuracy is maintained.

Base Correction

The base correction selection allows you to correct for differences between the bare standard and the bare part. If base correction is not required, select OFF. If base correction is desired, select ON.



KEY INPUT	RESULT
Std 1	Press this softkey if you wish to re-measure Standard #1. This Begins the following sequence for measuring the standard and entering the value. Follow the on-screen prompts. Place the probe on the standard and press the GO key. Remove the probe when the "Enter Thickness" menu appears. Enter the value of the standard using the numeric keys. Review the entered amount and press the ENTER key if correct. If incorrect press the CLEAR key and re-enter the value of the standard
Std2	Press this softkey and repeat the above process if you wish to re-measure the second standard.
Base Corr.	Press this softkey if you wish to perform Base Correction. After pressing this softkey you are prompted to turn ON or OFF Base Correction. If you elect to turn ON Base Correction, you will be prompted to measure a bare part.
Inf.	Press this softkey if you wish to re-measure the infinite standard.
Base	Press this softkey if you wish to re-measure the base standard.
Done	Press this key when you are finished making measurements. It will save the measurements and return you to the previous screen.
Abort!	Press this key to abandon all measurements made and return to the previous screen.

9 Measurement

9.1 Measurement Modes

The Measure screen is accessed by either of the following key sequences.

1. Use the Up and Down arrow keys to highlight the number of the calibration to select. Press the MEASURE, GO or ENTER function keys followed by the ENTER key.

2. Press the MEASURE, GO or ENTER functions keys followed by the number of the calibration to select, then press the ENTER key.

All measurements are made from this screen, statistics options (saved or session) are selected, the format of the display can be selected, and readings or charts can be printed. Measurements are made using one of the following four methods. Not all of the methods are available for every application.

1) Automatic Mode - Readings are taken automatically.

   a) Place the probe in contact with the sample to be measured.

   b) Hold the probe in contact with the sample until a beep is heard and the reading is displayed on the screen. The reading is now stored in memory.

   c) Press the CLEAR key to delete the reading and remove it from memory, if desired.

2) Manual Mode - Readings are taken when the GO function key is pressed.

   a) Place the probe in contact with the sample to be measured.

   b) Press the GO function key to make a measurement and store it in memory.

   c) Press the CLEAR key to delete the reading and remove it from memory, if desired.

3) Continuous Mode - Readings are taken continuously and displayed.

   a) Place the probe in contact with the sample to be measured.

   b) Readings will continuously be displayed on the screen.

   c) Press the GO function key to store the last reading displayed in memory.

   d) If the probe is held in air, the display will show six dashes indicating an out of range reading, when using calibrations made with shims. A meaningless number will display if hard plated standards were used in the calibration.

4) Scan Mode - Readings are taken over an area on the sample and the average is displayed.

   a) Scan mode will not be accessible if more than one reading per measurement is specified in the calibration to be used for the measurement.

   b) Place the probe in contact with the sample, maintain contact, and move it around the area of the sample that you wish to scan.

   c) Scan times can be set from 0 - 10 seconds. If 0 is specified the Scan Mode will not be enabled. The default value for all new calibrations is 0 and must be changed, if Scan Mode is to be used.

   d) Two readings per second are taken for the length of time specified in the "Scan Time" parameter of the calibration in use.

   e) When scanning, the display will count down the number of readings remaining to be taken.

   f) If the probe is lifted from the surface before the scan time is completed, the scan sequence will be aborted.

   g) Upon completion, all readings taken are averaged and the result is displayed. Readings outside the limits are accepted and calculated into the overall average.

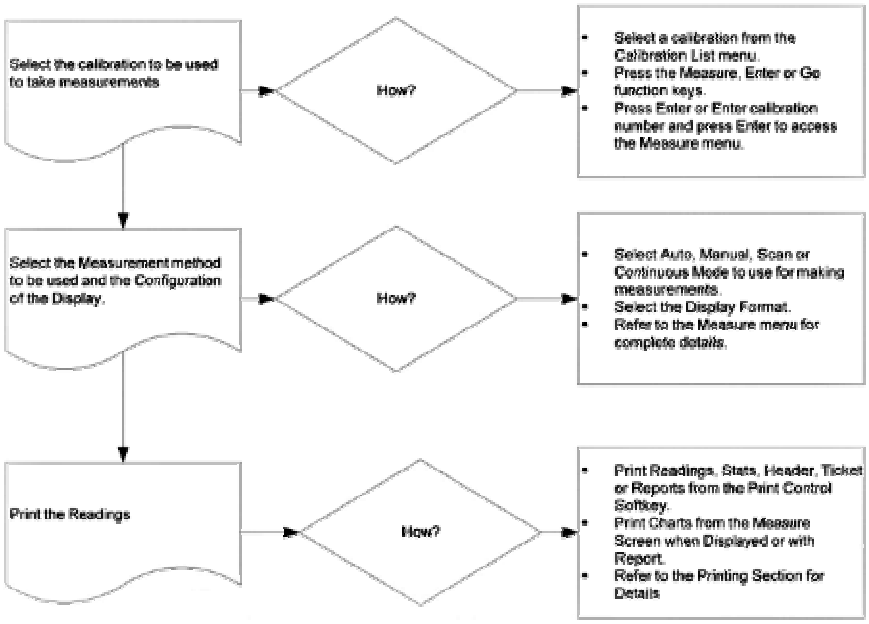
   h) Only the resultant average is available for use.

   i) Press the CLEAR key to delete the reading and remove it from memory, if desired.

9.2 Measurement Process

The flow chart diagram shown outlines the steps involved in making a measurement and performing printing functions.

How to Make and Print Measurements



9.3 Measurement Screens

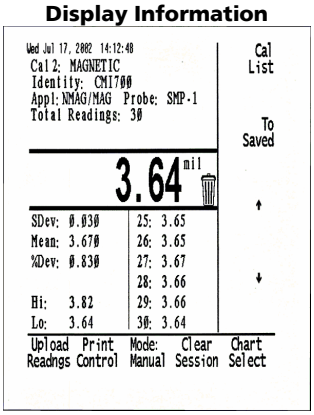
The Measure Screen is used to take measurements and view statistics. It is also used to print readings, stats, charts, ticket, header, or report. The format in which the Measure screen displays can be selected from three styles: Readings, Trend Chart or X Bar & R Chart. With each of these styles, either saved or session stats and readings are shown depending on whether the softkey toggle "To Saved" or "To Session" was pressed. The Measure screen shown is the default format. To access the Measure screen, select a Calibration from the Calibration List menu, and press the MEASURE, ENTER or GO function keys. Press ENTER to confirm or type a different calibration number and press ENTER. If the foot switch option is installed, it performs the same function in Measure mode as the GO key.

9.3.1 Measure Screen – Single Reading

The Measure Screens that show previous readings display information about the calibration being used, the last measurement taken, Icons, statistical calculations, and the six previous readings. A more detailed description is given below.

The functions of the softkeys displayed on the screen are described on the following page.

Display Information



CALIBRATION INFORMATION The following are displayed in sequence below the date.

1) The number and name of the calibration in use.
2) The identity specified in the calibration.
3) The application selected in the calibration.
4) The probe type.
5) Total readings. (Either the total taken in this session or the total saved with this calibration depending on whether saved or session readings are being shown.)

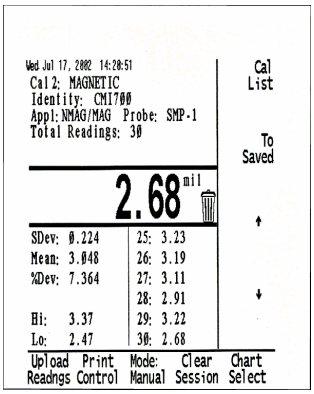
LAST READING The last reading taken, with the precision and the units specified in the calibration, is displayed in the center of the screen. If a reading is taken outside of the upper or lower limit, it will display in reverse video. (White numbers on a black background.)

ICONS PROBE - When in AUTO mode the probe icon is displayed. If the icon is shown above the horizontal surface, the instrument is ready to take a reading. If the icon is shown in contact with the surface, the probe must be lifted away from the sample being measured before another reading can be taken.
FOLDER - Displays after TO SAVED softkey is pressed. Indicates saved mode where all stats refer to saved readings.
OR
TRASH CAN - Icon shown above. Displays after TO SESSION softkey is pressed. Indicates session mode where all stats refer to readings taken since you last entered Measure Screen.

STATISTICAL CALCULATIONS The statistical calculations are made from session (TRASH CAN) or saved (FOLDER) readings depending on what mode the screen is in. SDev is the standard deviation; Mean is the average of the readings; %Dev is (SDev/Mean)*100; Hi and Lo displays the values of the highest and lowest reading taken; Range is the difference between the highest and lowest reading.

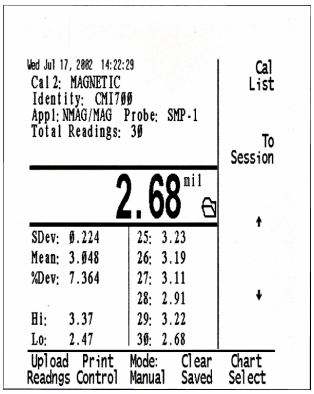
READINGS Displays the last reading taken, along with the five previous readings.

Session Readings Screen
Single Reading per Measurement Option Selected



KEY INPUT	RESULT
Upload Readings	Uploads readings to the serial port.
Print Control	Access the Print Control screen. Refer to Section 10.1 Print Control Screen for details.
Mode:	Selects the method used to make measurements. The Auto and Cont. modes may not be available, depending on the probes and applications selected in the Calibration. Scan mode is not available if multiple measurements per reading is enabled for the calibration. Auto - Measurements are automatically taken, displayed and stored in memory as soon as the probe is placed in contact with the sample. The last reading taken can be deleted and removed from memory by pressing the CLEAR function key. Manual - The GO key must be pressed before a measurement is taken, displayed and stored in memory. The last reading taken can be deleted and removed from memory by pressing the CLEAR function key. Cont. - Measurements are taken continuously and displayed. Press the GO key to store the last reading displayed in memory. A small number is displayed after "Cont.," indicating the time interval between measurements. Use the ± function key to scroll through the available time intervals of 1 through 6. Scan - Measurements are taken during the time period specified in Setup, while the probe is moved around an area on the sample. The average is displayed and saved in memory. The last reading can be deleted and removed from memory by pressing the CLEAR key.
Clear Session	Clears all session stats and readings.
Chart Select	Select one of the three formats for the measurement screen. Display the readings as shown above or display a Trend Chart, X BAR & R, or histogram charts as shown below. Press the softkey to scroll through the screen selections.
Arrow Keys	Used to scroll up or down through the readings that have been taken and display them.
Cal List	Returns to the Calibration List.
To Saved	Access the Saved Readings Screen described below.

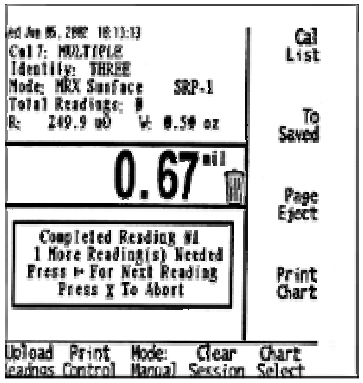
Saved Readings Screen
Single Reading per Measurement Option Selected



KEY INPUT	RESULT
Upload Readings	Uploads readings to the serial port.
Print Control	Access the Print Control screen. Refer to the Print Control Screen section for details.
Mode:	Selects the method used to make measurements. The Auto and Cont. modes may not be available, depending on the probes and applications selected in the Calibration. Scan mode is not available if multiple measurements per reading is enabled for the calibration. Auto - Measurements are automatically taken, displayed and stored in memory as soon as the probe is placed in contact with the sample. The last reading taken can be deleted and removed from memory by pressing the CLEAR function key. Manual - The GO key must be pressed before a measurement is taken, displayed and stored in memory. The last reading taken can be deleted and removed from memory by pressing the CLEAR function key. Cont. - Measurements are taken continuously and displayed. Press the GO key to store the last reading displayed in memory. A small number is displayed after "Cont.," indicating the time interval between measurements. Use the ± function key to scroll through the available time intervals of 1 through 6. Scan - Measurements are taken during the time period specified in Setup, while the probe is moved around an area on the sample. The average is displayed and saved in memory. The last reading can be deleted and removed from memory by pressing the CLEAR key.
Clear Saved	Clears all saved stats and readings.
Chart Select	Select one of the three formats for the measurement screen. Display the readings as shown above or display a Trend Chart or X Bar & R charts as shown below. Press the softkey to scroll through the screen selections.
Arrow Keys	Used to scroll up or down through the readings that have been taken and display them.
Cal List	Returns to the Calibration List.
To Session	Access the Session Readings Screen previously described.

9.3.2 Measure Screen – Multiple Readings

Multiple Readings per Measurement Option Selected



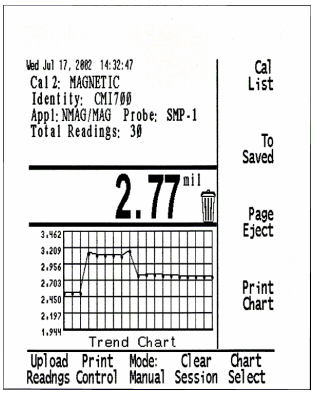
The screen shown above will appear when multiple Measurements Per Reading are selected for the calibration from the Change Calibration Screen #1. A maximum of 20 measurements per reading can be specified. All of the softkeys function as described in the single Readings Screen on the previous page. The only difference is in the Sequence of Operation described below. The Scan Mode is not available when multiple readings are enabled.

Sequence of Operation

- Select a Mode to be used for the measurement. Select from Auto, Manual, or Count modes.
- Place the probe in contact with the sample to be measured.
- In Auto mode, a reading will be taken as soon as the probe contacts the sample. In Manual or Cont modes, the reading will be taken when the GO function key is pressed. A beep will sound after the reading is taken.
- The screen display will change to read "Completed Reading #1" and will also display the number of readings remaining to be taken for the measurement.
- In Auto mode the probe must be lifted from the sample and then placed in contact with it again to take the next reading. In Manual or Count modes, the GO function key must be pressed to take the next reading.
- After the last reading has been taken the multiple reading pop-up screen will disappear, and the average of the readings taken will display on the screen.
- The measurement is now accepted and saved. Press the CANCEL function key to delete the measurement.
- Press the CANCEL function key at any time during the measurement sequence to abort the process, and discard the readings taken.

9.3.3 Measure Screen - Trend Chart Screen

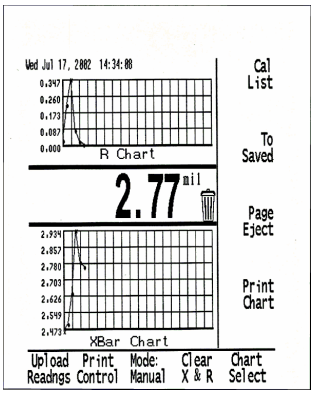
Measurements are made from the Trend Chart Screen in the same manner as from the Readings Screen. The trend chart is a graph of the value of the last 19 individual readings and replaces the sequential listing of measurements displayed in the Readings Screen. From the Readings Screen, access this screen by pressing the CHART SELECT softkey. If you exit the Measure menu from this screen, it will display when you re-enter the Measure menu. The softkey functions are the same as described in the Measure Screens showing previous readings except for the following additional softkeys.



KEY INPUT	RESULT
Print Chart	Press this softkey to print the chart as displayed on the screen.
Page Eject	Ejects page from printer.

9.3.4 Measure Screen - X Bar and R Chart Screen

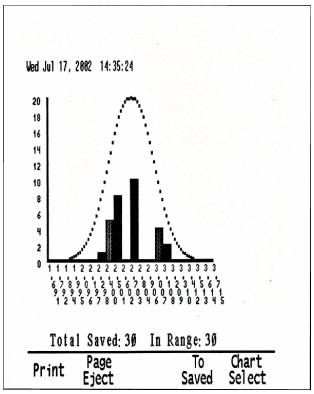
Measurements are made from the X Bar & R Screen in the same manner as the Readings Screen. The readings are displayed as X Bar and R Charts with the group size specified in the calibration used for the measurements. From the Trend Chart screen shown above, access this screen by pressing the CHART SELECT softkey. If you exit the Measure menu from this screen, it will display when you re-enter the Measure menu. The softkey functions are the same as described in the Readings screen except for the following additions.



KEY INPUT	RESULT
Print Chart	Press this softkey to print both charts as displayed on the screen.
Clear X & R	Clears the statistical data, from the X Bar and R charts. Clears either Session data or Saved data, dependent on the type of chart selected. The readings and the data for the Trend chart are not affected.
Page Eject	Ejects page from printer.

9.3.5 Histogram Chart Screen

Access this screen by pressing the CHART SELECT softkey from the Measure menu. Displays the histogram and CPK of the readings made with this calibration. The values for the readings are shown along the X (horizontal) axis and the number of readings are shown along the Y (vertical) axis. CPK is the capability index.



KEY INPUT	RESULT
Print	Press this softkey to print the histogram displayed on the screen. To retrieve the document from the printer, return to the Print Control screen and press the PAGE EJECT softkey.
Page Eject	Eject printer page.
To Session	Press to display Session Histogram. This softkey toggles between TO SESSION and TO SAVED.
Chart Select	Advances to Readings Screen.

10 Printing

Individual readings, statistical calculations, calibration list, calibration information, a Header, a Ticket, X-Bar & R charts, trend charts, or a histogram can be printed. When the printer type selected is "Plain 80 col.," none of the charts or histogram will print. Refer to the table below for specific print information.

When printing individual readings, the instrument will respond differently to the print commands depending on the type of printer selected. A dot matrix or DPU-411 type printer will print the reading taken, along with any header or ticket if they have been selected, and automatically eject the page. Inkjet type printers will print the reading taken and advance the page one line. Laser type printers internally store information until a whole page of data is accumulated before printing.

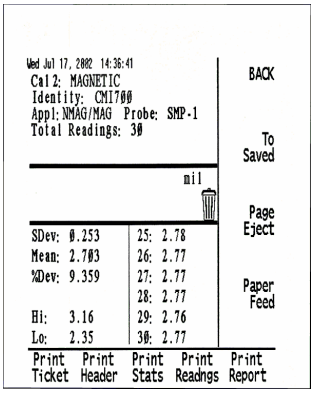
A page eject command is required, when using either laser or Inkjet printers, to immediately retrieve the document from the printer after a reading has been taken. It is best to use the PAGE EJECT softkey in the Print Control screen for this purpose. If a key from the printer's control panel is used, it may cause automatic page ejects to occur in the middle of future pages.

TO PRINT	ACTION REQUIRED
Individual Readings	Choose SETUP/PRINTER OPTIONS/PRINT READING IMMEDIATE OR DELAYED or the LONG versions of these.
Header or Ticket	Press the PRINT HEADER or the PRINT TICKET softkey from the Print Control screen or choose SETUP/PRINTER OPTIONS/MORE OPTIONS/PRINT TICKET or PRINT HEADER IF ASKED or ALWAYS.
Charts	Press the PRINT CHART softkey from the Readings screen. The type of chart displayed will print. For the histogram press PRINT when it is displayed.
Statistical Calculations	From the Print Control screen, press PRINT STATS softkey. This will print the number of total readings, mean, standard deviation, percent deviation, accuracy, CPK, and the High and Low readings and range for session or saved readings depending on which are displayed.
Groups of Readings	From the Print Control screen, press the PRINT READINGS softkey to print all of the readings taken at this measurement session or saved if saved readings are shown.
Calibration Information	From the Calibration List menu, press the VIEW softkey. Then press the PRINT CAL softkey to print the calibration parameters or the PRINT STATS softkey to print all of the readings that have been saved with the calibration.
Calibration List	From the Calibration List menu, press the PRINT LIST softkey.
Report	From the Print Control screen press Print Report. This will print everything checked in SETUP/PRINTER OPTIONS/MORE OPTIONS/REPORT FORMAT. This includes ticket, header, stats, readings and charts.

10.1 Print Control Screen

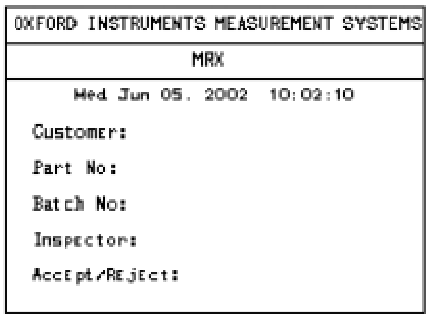
Access this screen by pressing the PRINT CONTROL softkey from the Measure menu. Use this menu to print a ticket, header, stats, readings, or report. For Inkjet or laser

printers, you can print a reading and immediately retrieve the document if you use the PAGE EJECT softkey after printing.



KEY INPUT	RESULT
Print Ticket	Prints a ticket on the page. See below for a sample ticket.
Print Header	Prints a header on the page. See below for a sample header.
Print Stats	Prints session or saved stats (whichever is currently displayed).
Print Readings	Prints session or saved readings (whichever is currently displayed).
Print Report	Prints everything checked in setup report format (SETUP/PRINTER OPTIONS/MORE OPTIONS/REPORT FORMAT)
Paper Feed	Issues a paper feed command to load a sheet of paper into the printer.
Page Eject	Ejects the sheet of paper in the printer, after printing has stopped.
To Session (To Saved)	When pressed, displays session (saved) readings.
Back	Returns to the previous menu.

10.2 Sample Ticket



10.3 Sample Header

```
Wed Jun 05, 2002  13:03:35
6: Surface (SRP)
MRX Surface

        *** Saved Stats ***
  Total Readings 22  Mean 0.664 mil
     SDev 0.031 mil  %Dev 4.653%
          Accuracy 0.013 mil
     High 0.71 mil  Low 0.62 mil
            Range 0.09 mil
```

11 Specifications

11.1 General Specifications

Memory	8000 bytes, non volatile
Accuracy	± 1%, ± -0.1 µm referred to reference standards.
Outputs	DB 25 female Parallel Printer Port and DB 9 male RSS232C Serial Port
Unit Conversions	Select from mils, µm, µin, mm, in or % as units for display.
Wieght	6 lbs. (2.79 Kg)
Dimensions	(W) 11.5 " (29.21 cm) (D) 10.5 " (26.67 cm) (H) 5.5 " (13.97 cm)
Display	Large LCD 480(W) x 320(H) pixels, backlit, wide angle view.
Statistics	Mean, high and low, standard deviation, % deviation and CPK.
Charts	Histogram, Trend, X Bar and R.

11.1.1 Eddy Current Mode

Application	Range	Standard Probes	Right Angle Probes
Non-Conductive on Conductive (Non-Magnetic)	0 – 40 mils 0 – 1000 µm	EP-3, ECP, ECP-M	REP_3, R-ECP
Zinc on Steel	0 – 1.5 mils 0 – 37.5 µm	EP-3, EP-4, EP-3M, EP-4M, ECP, ECP-M	REP-3, REP-3M, REP-4M, R-ECP
Cadmium on Steel	0 – 1.5 mils 0 – 37.5 µm	EP-3, EP-4, EP-3M, EP-4M, ECP, ECP-M	REP-3, REP-3M, REP-4M, R-ECP
Copper on Steel	0 – 1.5 mils 0 – 37.5 µm	EP-3, EP-4, EP-3M, EP-4M, ECP, ECP-M, EP-5	REP-3, REP-3M, REP-4M, R-ECP
Copper on Epoxy	0.7 – 5.0 mils 17.5 µ - 125 µm	EP-3, EP-4, EP-4M	REP-4M
Nickel on Steel (electroplated)	0 – 1.3 mils 0 – 32.5 µm	EP-4, EP-4M	REP-4
Nickel on Steel (electroplated)	1 – 3.0 mils 25 µm – 75 µm	EP-5	

11.1.2 Magnetic Mode

Application	Range	Standard Probes	Right Angle Probes

Non-Magnetic on Magnetic (Steel)	0 – 50 mils 0 – 1250 µm	SMP-1	RSMP-1

11.1.3 Nickel Mode

Application	Range	Standard Probes	Right Angle Probes
Electroplated Nickel on Non-Magnetic	0 – 5 mils 0 – 125 µm	NI-MS/TE, NIP	

11.2 MRX Module

11.2.1 TRP Micro Probe

Minimum hole diameter	0.010 in
Maximum hole diameter	0.040 in

11.2.2 TRP Standard Probe

Minimum hole diameter	0.020 in
Maximum hole diameter	Board thickness

11.3 BMX Module

11.3.1 PM-147 Isotope

Coating	Base	Range
Cadmium	Copper	0 – 250 µin, 0 – 6.25 µm
Cadmium	Steel	0 – 250 µin, 0 – 6.25 µm
Chrome	Aluminum	0 – 500 µin, 0 – 12.5 µm
Chrome	Copper	0 – 500 µin, 0 – 12.5 µm
Copper	Epoxy	0 – 230 µin, 0 – 5.75 µm
Copper	Aluminum	0 – 230 µin, 0 – 5.75 µm
Gold	Steel	0 – 80 µin, 0 – 2 µm
Gold	Silver	0 – 80 µin, 0 – 2 µm
Gold	Nickel	0 – 80 µin, 0 – 2 µm
Gold	Kovar	0 – 80 µin, 0 – 2 µm
Gold	Epoxy	0 – 80 µin, 0 – 2 µm
Gold	Aluminum	0 – 80 µin, 0 – 2 µm
Gold	Copper	0 – 80 µin, 0 – 2 µm
Nickel	Aluminum	0 – 230 µin, 0 – 5.75 µm
Rhodium	Gold	0 – 190 µi, 0 – 4.75 µm
Rhodium	Nickel	0 – 120 µin, 0 - 3 µm
Silver	Steel	0 – 250 µin, 0 – 6.25 µm
Silver	Aluminum	0 – 250 µin, 0 – 6.25 µm
Silver	Copper	0 – 250 µin, 0 – 6.25 µm
Silver	Gold	0 – 250 µin, 0 – 6.25 µm
Silver	Kovar	0 – 250 µin, 0 – 6.25 µm
Silver	Nickel	0 – 250 µin, 0 – 6.25 µm
Tin	Kovar	0 – 250 µin, 0 – 6.25 µm
Tin	Aluminum	0 – 250 µin, 0 – 6.25 µm
Tin	Copper	0 – 250 µin, 0 – 6.25 µm
Tin	Steel	0 – 250 µin, 0 – 6.25 µm
Tin Lead	Copper	0 – 140 µin, 0 – 3.5 µm

11.3.2 TL-204 Isotope

Coating	Base	Range
Cadmium	Steel	0 – 1500 µin, 0 – 37.5 µm
Cadmium	Copper	0 – 1500 µin, 0 – 37.5 µm

Chrome	Copper	0 – 2000 µin, 0 - 50 µm
Chrome	Aluminum	0 – 2000 µin, 0 - 50 µm
Copper	Epoxy	0 – 1000 µin, 0 - 25 µm
Copper	Aluminum	0 – 1000 µin, 0 - 25 µm
Gold	Copper	0 - 350 µin, 0 – 8.75 µm
Gold	Epoxy	0 - 350 µin, 0 – 8.75 µm
Gold	Kovar	0 - 350 µin, 0 – 8.75 µm
Gold	Nickel	0 - 350 µin, 0 – 8.75 µm
Gold	Silver	0 - 350 µin, 0 – 8.75 µm
Gold	Steel	0 - 350 µin, 0 – 8.75 µm
Gold	Aluminum	0 - 350 µin, 0 – 8.75 µm
Nickel	Aluminum	0 – 1000 µin, 0 - 25 µm
Platinum	Nickel	0 - 350 µin, 0 – 8.75 µm
Silver	Steel	0 – 750 µin, 0 – 18.75 µm
Silver	Nickel	0 – 750 µin, 0 – 18.75 µm
Silver	Kovar	0 – 750 µin, 0 – 18.75 µm
Silver	Copper	0 – 750 µin, 0 – 18.75 µm
Silver	Aluminum	0 – 750 µin, 0 – 18.75 µm
Tin	Copper	0 – 1500 µin, 0 – 37.5 µm
Tin	Steel	0 – 1500 µin, 0 – 37.5 µm
Tin	Kovar	0 – 1500 µin, 0 – 37.5 µm
Tin	Aluminum	0 – 1500 µin, 0 – 37.5 µm
Tin Lead	Copper	0 – 1000 µin, 0 – 37.5 µm

11.3.3 SR-90 Isotope

Coating	Base	Range
Copper	Aluminum	0 – 5000 µin, 0 - 125 µm
Copper	Epoxy	0 – 5000 µin, 0 - 125 µm
Gold	Copper	0 – 1200 µin, 0 - 30 µm
Gold	Kovar	0 – 1200 µin, 0 - 30 µm
Gold	Nickel	0 – 1200 µin, 0 - 30 µm
Gold	Steel	0 – 1200 µin, 0 - 30 µm
Silver	Copper	0 – 3500 µin, 0 –87.5 µm
Silver	Nickel	0 – 3500 µin, 0 –87.5 µm
Silver	Kovar	0 – 3500 µin, 0 –87.5 µm
Silver	Steel	0 – 3500 µin, 0 –87.5 µm
Tin	Steel	0 – 3500 µin, 0 –87.5 µm
Tin	Copper	0 – 3500 µin, 0 –87.5 µm
Tin Lead	Copper	0 – 4000 µin, 0 - 100 µm

12 Maintenance

The CMI 700 is a reliable laboratory quality, precision instrument capable of being operated in a shop environment. However, its successful continued operation is contingent upon performing minimal maintenance.

12.1 Cleaning

Maintenance of the CMI 700 is limited to the external cleaning of the individual components. The removal of dust or particles can be achieved with a soft brush, lint free cloth, or by blowing away, the foreign matter with low-pressure compressed air. To remove embedded or hardened dirt use a mild detergent solution diluted with water or a commercial cleaner recommended for plastics.

WARNING
WHEN CLEANING UNIT, DO NOT ALLOW ANY FOREIGN LIQUID TO SPILL INTO THE UNIT. BE PARTICULARLY CAREFUL AROUND THE BACK OF THE UNIT WHERE THE CONNECTORS ARE LOCATED.

12.2 Battery

An internal battery is used to maintain the readings stored in memory when the instrument is turned off or removed from its external power source. To determine whether a new battery is needed, make a few measurements with any calibration and leave the CMI 700 unplugged from its external power source for several minutes. Reconnect the unit to its external power source and turn on. If the readings have been retained for this period, the battery is good. If the readings were not retained, the battery requires replacement.

13 AG-1 Accessory Guide

The CMI AG-1 Accessory Guide is used in conjunction with Beta Backscatter Thickness Testers to position the GM-1 Tube Assembly accurately onto the sample or, when the guide is inverted, to place calibration standards and samples onto the GM-1 Tube Assembly (with its installed isotope and aperture) for calibration/recalibration or sample measurement. The accessory guide, when used with the proper adapter, can also be used to support the NIMS/TE probe to assure its accurate and perpendicular movement onto the sample.

13.1 Preparation for Use

13.1.1 General

After receipt of the AG-1 Accessory Guide, perform the following operations in preparation for its use in conjunction with the noted associated instruments:

1. If required, install the lamp housing into the rear of the guide and secure it to the guide with the thumbscrew. Then insert the lamp assembly connector into the appropriate socket at the rear of the BMX. With the instrument connected to a proper power source, refer to the lamp and cross hair adjustment procedure to maximize the lamp intensity and align the cross hairs centrally with the guide axis which is coincident with the installed probe or GM-1 Tube Assembly axis.

2. With the accessory guide in a normal orientation (resting on the neoprene contact pads), loosen the follower lock screw one or two full turns and then turn the positioning knob full clockwise.

13.1.2 GM-1 Tube Assembly

Slide the side plate dented access cover to the side. Insert the GM-1 Tube Assembly with the aperture facing down into the guide bore and position tube assembly so that its side mounting hole is aligned with the guide follower slot positioned under the access cover. Use the supplied special hex socket wrench and install the mounting screw through the follower slot and fully into the tube assembly mounting hole. It may be necessary to slightly readjust the tube assembly position in order to thread in the mounting screw. Turn the positioning knob counterclockwise and clockwise and check that the tube assembly moves down and up. Then close the access cover.

13.1.3 NIMS/TE Probe and Adapter

Slide the side plate dented access cover to the side. Insert prove adapter (setscrew facing up) into guide bore and position the adapter so that its side mounting hole is aligned with the guide follower slot positioned under the access cover. Use the supplied special hex socket wrench and install the mounting screw through the follower slot and fully into the adapter mounting hole. It may be necessary to slightly readjust the adapter position in order to thread in the mounting screw. Turn the positioning knob counterclockwise and clockwise and check that the probe adapter moves down and up. Then close the access cover. Insert the probe into the probe adapter and secure in the desired position with the adapter setscrew.

13.1.4 Electrical Connections

The only electrical connection required to place the accessory guide into operation is inserting the lamp assembly connector into the mating socket on the BMX.

13.1.5 Preliminary Check of Equipment

Before using the AG-1 Accessory Guide, the operator should make the following preliminary checks to determine that the guide is functioning properly:

1. Check that the lamp operates (maximizing lamp intensity is performed only upon replacement of a burned out lamp) to project the illuminated cross hairs onto the working surface and the cross hair intersection is coincident with the probe or GM-1 Tube Assembly axis. If necessary, refer to the applicable procedures outlined under ADJUSTMENTS.

2. With the follower lock screw loose, check that the probe or tube assembly moves up and down as the positioning knob is turned. With the positioning knob full counterclockwise, check that the follower lock screw can be tightened to prevent the probe or GM-1 Tube Assembly from moving.

13.2 Operation

Once the accessory guide is prepared for use, the lamp intensity and cross hairs aligned, and the lamp illuminated, it is only necessary to carefully place the accessory guide onto the sample. Align the cross hairs with that portion of the sample to be measured and proceed with the measurement. Small samples may be positioned within the guide bore under the cross hairs and the probe or GM-1 Tube Assembly lowered with the positioning knob to contact the sample.

IMPORTANT
IF THE FOLLOWER LOCK SCREW IS NOT SUFFICIENTLY LOOSE, THE GM-1 TUBE ASSEMBLY WILL NOT LOWER SUFFICIENTLY TO CONTACT THE SAMPLE RESULTING IN ERRONEOUS READINGS.

Use of the magnifier permits precision alignment of the cross hairs on the sample. Magnifier angle adjustment should be accomplished with the adjusting thumbwheel rather than with the magnifier lens. The accessory guide may also be used in an inverted position (resting on the four rubber feet) with the probe or GM-1 Tube Assembly locked in position (follower lock screw tightened). This position is recommended when calibrating a Beta Backscatter Thickness Tester. Calibration standards and samples may then be placed on the probe or tube assembly when calibrating/recalibrating or making measurements.

13.3 Adjustments

13.3.1 Maximizing Lamp Illumination

Each time the lamp is replaced, the lamp housing should be rotated within its retaining clamp to maximize the lamp illumination and cross hair projection onto the working surface. With a new lamp installed and the lamp housing secured at the rear of the guide, loosen the small screw in the retaining clamp and rotate the lamp housing to obtain maximum illumination on the working surface. Then tighten the retaining clamp screw.

13.3.2 Centering Crosshairs

Once the cross hair intersection is coincident with the probe or GM-1 Tube Assembly axis, it is seldom if ever necessary to repeat the adjustment procedure. If the adjustment procedure is necessary, proceed as follows:

1. Slide the side plate dented access cover to the side and remove the mounting screw used to secure the probe adapter or GM-1 Tube Assembly in the accessory guide bore; remove the probe adapter or tube assembly.

2. With the accessory guide in a normal orientation (resting on the neoprene contact pad) install the supplied cross hair alignment guide, with the small inscribed circle facing up, in the end of the guide bore contacting the work surface.

3. With the instrument connected to a proper power source and the lamp assembly connector inserted into the appropriate instrument socket providing power for the lamp, not the position of the projected cross hairs on the alignment guide inscribed circle. The cross hair intersection should be centered within the circle. If not, adjust for front-to-back misalignment by turning the associated adjusting screw with the supplied hex socket screwdriver. This adjusting screw is accessible from the front of the guide just below the light projection recess. To adjust for side-to-side misalignment, turn the associated adjusting screw with the same supplied hex socket screwdriver. This adjusting screw is accessible through the hole in the side plate after the positioning knob is in the full counterclockwise position. Be sure to insert the hex socket screwdriver straight into the hole and turn slightly, as required, to engage the adjusting screw socket.

4. After the adjustment is complete, remove the cross hair adjustment guide and reinstall the adapter and probe or the GM-1 Tube Assembly, as applicable, in accordance with the procedures outlined under PREPARATION FOR USE.

13.4 Preventative Maintenance

13.4.1 General

The Model AG-1 Accessory Guide is used in conjunction with coating measurement instruments that are capable of being operated in a laboratory or shop environment.

Successful continued operation of the accessory guide, as with the coating measurement instruments, is contingent upon performing the following minimal preventive maintenance procedure. Failure to perform these procedures can result in a reduction in the expected service life of the accessory guide or contamination of the samples.

Preventative maintenance of the accessory guide is limited to external cleaning. Clean the guide monthly or whenever the accumulation of dust and dirt is sufficient to be observed. The removal of dust and loose foreign particles can be accomplished by using a soft brush or lint-free cloth or by blowing away the foreign matter with low pressure compressed air. To remove imbedded or hardened dirt or other stubborn deposits, use a minimum of isopropyl (rubbing) alcohol on a stiff bristle brush and dry with a clean, lint-free cloth. Be certain to keep the neoprene contact pad and four rubber feet thoroughly clean to prevent possible contamination of the samples. Be particularly careful when cleaning around the side plate as well as the rear lamp housing not to allow the cleaning solution to get into the instrument. Clean the magnifier with lens tissue or a clean, dry, lint-free cloth.

CAUTION:
BETA PARTICLES ARE CONSTANTLY EMITTED THROUGH THE APERTURE. USE TWEEZERS OR OTHER TOOLS TO PLACE SMALL PARTS OVER THE MEASURING OPENING. DO NOT LOOK DIRECTLY INTO THE OPENING.

14 GM-1 and GM-2 Probes

14.1 Introduction

This section contains operating information for the GM-1 and GM-2 measurement probes. These devices are designed to be used for beta-backscatter coating thickness measurement in conjunction with an electronics unit which supplies the voltage to the Geiger tube and counts the pulses from it. These probes may be applied directly to the work to be measured or it may be used with various guides.

14.1.1 Precautions

1. The GM-1 and GM-2 probes contain radioactive material and are subject to various government regulations.

2. The Geiger tube and radioisotope source contained in the GM-1 and GM-2 probes are expensive components and should be handled carefully. Take care not to drop the probe or otherwise subject it to severe shock.

14.2 General Information

The GM-1 and GM-2 probes each consist of a cylindrical housing with a measuring opening (aperture) at one end and cable with a BNC connector at the other (see Figures 1 and 2). The cable supplies the operating voltage to the Geiger tube and conducts the signal back to the unit. The radioactive source is mounted behind the aperture, emitting beta particles through the opening. The sample being measured is laid across the opening and the particles are then backscattered from the sample, back through the aperture, and into the Geiger tube. The number of beta particles backscattered are counted by the Geiger tube.

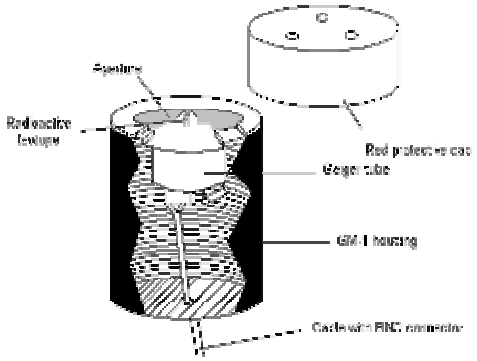


Figure 1: GM-1 Probe

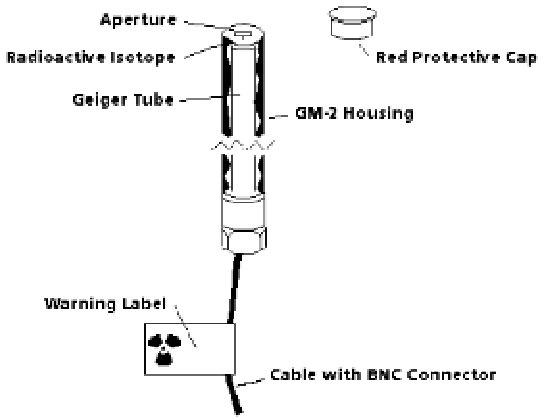


Figure 2: GM-2 Probe

14.3 Usage Information

The probe is used by keeping the measuring opening firmly against the work surface to be measured. This can be done by using the several probe guides available from Oxford Instruments Measurement Systems or by making a fixture of your own. The probe must be held completely steady on the work during the measuring time. The measuring opening serves to mask off the exact area to be measured.

14.4 Isotope Specifications

The GM-1and GM-2 probes are available in three strengths. The desired strength is determined by the thickness of the coating being measured.

Isotope	Symbol	Half-Life/*Working life (years)	Energy (MeV)
Promethium-147	PM-147	2.6	0.22
Thallium-204	TL-204	3.8	0.76
Strontium/Yttrium-90	SR-90	28.9/62.4 hr	0.54/2.27

*Working-life is defined as point in time when the energy emitted by the source will have degenerated to a point where measurement times will more than double in order to get a specific performance as defined by standard deviation. For example, to

the user, the measurement will require twice the time as compared to when first purchased due to a gradual loss in energy over time.

14.5 Storage

When not in use, the GM-1 and GM-2 probes must be stored in a secure place. The red protective cap should be placed on the probe to prevent the escape of beta particles.

14.6 Cleaning

Should your GM-1 and GM-2 require exterior cleaning, we suggest the use of a general detergent. Be sure not to saturate cloth to point that liquid runs along the barrel and into the aperture. Wipe dry after cleaning. Should debris get lodged into aperture, DO NOT attempt to clean. Return to Oxford Instruments Measurement Systems for service.

NOTE:
DUE TO NRC AND STATE REGULATIONS, THE APERTURE CAN ONLY BE CHANGED AT THE FACTORY BY A QUALIFIED TECHNICIAN.

14.7 Selection of Aperture Size

The ideal aperture choice is the one with the largest opening that will completely cover or be covered by the part being measured. If the opening is too large, beta particles will escape into the air instead of being backscattered into the Geiger tube. If the opening is too small, the counts being backscattered will be reduced, affecting the repeatability of the readings.

Because of the small effective area of the source, any opening over .062" can be considered "large" and larger openings will have little effect on the repeatability of the measurements.

Cylindrical Surfaces

* In order to permit the use of flat thickness standards even when the measurement surface is curved, it is necessary to use a slit-type opening of a width which makes the effect of curvature negligible. The part will rest slightly down into the slit, but if the slit is narrow enough, this will be insignificant.

* The length of the slit should be shorter than the length of the part being measured.

- As with flat parts, choose the largest possible opening that can be used on the parts being measured. If the opening is too small, the measurement area will be reduced, reducing the reproducibility of the readings.

The following chart shows the maximum aperture widths recommended for various cylindrical diameters.

Minimum cylinder diameter		Maximum aperture width	
Inches	**Mm**	**Inches**	**Mm**
.016	.41	.010	.25
.020	.51	.014	.36
.037	.94	.020	.51
.060	1.6	.025	.64
.120	3.0	.035	.89
.180	4.6	.045	1.1

14.8 Radioisotope Precautions and Regulations

The radioactive isotopes used in the GM-1 and GM-2 probes systems emit beta particles and proper precautions should be taken when handling these devices. All of the source elements are sealed sources of low activity and present a minimal health hazard.

The following precautions should be taken when handling the GM-1 and GM-2 probes.

* The GM-1 and GM-2 probes may only be disassembled by a qualified technician carrying a license to do so.

* The plastic cap must be kept on the probe when not in use to block the emission of radioactive output.

* Do not look directly into the opening.

* Avoid radioactive exposure by keeping hands (or any part of the body) away form the opening. Use tweezers to position small parts for measuring.

* Protect the probe from physical damage by keeping it in its box or in the probe guide at all times.

* Never poke anything through the measuring opening.

* When shipping probe back to the factory put the red protective cap on the probe.

14.8.1 Disposal of Radioactive Probes

NRC regulations require that the GM-1and GM-2 probes may not be discarded, transferred, or sold except by a licensed facility.

* A radioactive probe cannot be sold directly to another company. The probe must be returned to Oxford Instruments Measurement Systems so that a legal transfer can be made. It will then be sent to the new company.

* Radioactive material must be lawfully disposed. When the probe is no longer needed or used, return the probe to Oxford Instruments so that the disposal can be properly reported.

14.8.2 Labeling

The actual activity in the device is shown on the yellow and magenta label which is attached to the probe cable. This label must not be removed. When shipping any probe, the package need not be labeled on the outside if the probe is properly labeled on the inside.

14.8.3 Leak Testing

The United States Nuclear Regulatory Commission regulations require that the GM-1 and GM-2 probes be leak tested every six (6) months after being received. Testing for leakage of radioactive material is accomplished by sending the entire probe, with the red protective cap, with a purchase order to Oxford Instruments for servicing. CMI will perform the necessary leak tests and test the performance of the probe.

14.8.4 NRC Regulations

In summary, the regulations state:

* There is no specific license required by the user.

* The probe can be used under general license provision 31.5 and/or specific regulations in the agreement, if applicable.

* Within the required time period, Oxford Instruments will notify the US NRC and/or the appropriate state agency that a device containing a radioactive isotope has been shipped to that state.

* If you are in an agreement state, you are required to notify the state agency.

* Notify the regulatory agency of your state for any special registration that may be required.

14.8.5 Potential Radiation Exposure Levels

In addition to the low activity of the sources, most of the beta particles given off by the radioactive sources used in the GM-1 and GM-2 probes are of low enough energy that they will be stopped by clothing. The actual amount of beta radiation to which an operator may be exposed depends on many variables, including:

* The type of guide used

* The actual isotope being used

* The size of the aperture being used

* The length of time that the operator's hands are within the radiation emitted by an uncovered source (note that if the aperture is covered by a sample or standard, there is virtually zero radiation above the sample or standard).

* Assuming one worker measures 100 parts per day at a 10 second placement time per part, for 250 days per year, using tweezers to place and remove the part, we can estimate the following maximum dosage (to the hand).

* PM-147: 1,200 micro curie 2,044 mrem/yr (20.4 mSv/yr)

* TL-204: 75 micro curie 3,694 mrem/yr (36.9 mSv/yr)

* SR-90: 5 micro curie 4,025 mrem/yr (40.3 mSv/yr)

The maximum allowable dose to the hands according to 32 ILL. Adm. Code 330.280 (d) (1) (ii) (10 CFR 32.51) is 5000 mrem/yr (50mSv/yr) for generally licensed items.

14.8.6 Customer Service/Technical Support

In the event that you should experience problems with your GM-1 or GM-2, our System Support Group is prepared to assist you. Please call 847-439-4404 and ask for customer service. Be prepared with the following information:

* Model number

* Serial number

* Description of problem

Your call will be instantly recorded in an "Incident Report" data base. You will be directed by the customer service representative with clear directions as to how to proceed. Should your probe require service, a Return Authorization number will be assigned and you will be asked to ship the unit back to Oxford Instruments Measurement Systems. Please follow the instructions below for returning probes.

14.8.7 Shipping Instructions

When shipping probes back to the manufacturer, the following guidelines must be observed.

* The red cap must be placed on the end of the probe. If the red cap is not on the probe, it will automatically be replaced and you will be charged accordingly for a new cap.

* The yellow and magenta label must be attached to the probe cable.

* Place the probe in a sturdy cardboard box. Use cushioning material to minimize movement and any possible damage.

* Enclose a purchase order and packing slip describing the service to be done (i.e. leak testing, performance, disposal, etc.). These written instructions must include the name of the consignee, and the notice "This package conforms to the conditions and limitations specified in 49CFR173.422 for excepted radioactive material, instruments, and articles, UN2911."

* Indicate any adverse conditions to which the probe may have been subjected (i.e. dropping, lack of performance, disposal, etc.).

* No labeling of radioactive material is needed on the outside of the box as long as the yellow and magenta label is attached to the probe cable.

* Any common carrier, postal service, etc., may be used to transport the sealed box. The shipper is responsible for compliance to U.S. Department of Transportation, U.S. Nuclear Regulatory Commission, and other applicable regulations.

14.8.8 Further Information

If you have any further questions about safety, use of the GM-1 or GM-2 probe, or the regulations governing its use, please contact the Radiation Safety Officer or Assistant Radiation Officer of Oxford Instruments. We will be pleased to be of assistance.

Agreement States
These various state agencies should be contacted regarding regulations for the possession of radioactive material. These 27 states operate independently of the US NRC. If you reside in any other state, the NRC should refer you to the appropriate agency.

Alabama 334-206-5391
Office of Radiation Control
Department of Public Health
PO Box 303017
Montgomery, AL 36130-3017

Arizona 602-255-4845
Arizona Radiation Regulatory Agency
4814 South 40th Street
Phoenix, AZ 85040

Arkansas 501-661-2108
Division of Radiation Control
Arkansas Department of Health
5800 W. 10th St. Suite 100
Little Rock, AR 72204-1755

California 916-322-3482
Radiologic Health Branch
Department of Health Services
PO Box 942732
Sacramento, CA 94234-7320

Colorado 303-692-3030
Laboratory and Radiation Services Division
Department of Public Health and Environment
8100 Lowry Blvd.
Denver, CO 80230-6928

Florida 904-487-1004
Bureau of Radiation Control
Department of Health
4052 Bald Cypress Way, SE, Bin C21
Tallahassee, FL 32399-1741

Georgia 404-362-2675
Radioactive Materials Program
422 International Parkway, Suite 114

Illinois 217-785-9900
Division of Radioactive Materials
Department of Nuclear Safety

Atlanta, GA 30354

1035 Outer Park Drive
Springfield, IL 62704

Iowa 515-281-3478
Bureau of Radiological Health
Department of Public Health
Lucas State Office Building
Des Moines, IA 50319

Kansas 785-296-1561
Bureau of Air & Radiation
Department of Health & Environment
1000 SW Jackson, Suite 310
Topeka, KS 66612-1366

Kentucky 502-564-7818
Radiation Health & Toxic Agents Branch
Cabinet for Health Services
275 East Main Street
Frankfort, KY 40621-0001

Louisiana 225-765-0892
Office of Environmental Services
Department of Environmental Quality
7290 Bluebonnet Rd.
Baton Rouge, LA 70884-2135

Maine 207-287-5676
Division of Health Engineering
Radiation Control Program
10 State House Station
Augusta, ME 04333-0010

Maryland 410-631-3300
Radiologic Health Program
2500 Broening Hwy
Baltimore, MD 21224

Massachusetts 617-727-6214
Radiation Control Program
Department of Public Health
174 Portland St., 5th floor
Boston, MA 02114

Mississippi 601-987-6893
Division of Radiological Health
State Department of Health
PO Box 1700
Jackson, MS 39215-1700

Nebraska 402-471-8566
Health & Human Services System
Department of Regulation & Licensure
PO Box 95007
Lincoln, NE 68509-5007

Nevada 702-885-5394
Radiological Health
Department of Human Resources
1179 Fairview Dr. Suite 102
Carson City, NV 89701-5405

New Hampshire 603-271-4588
Radiological Health Bureau
6 Hazen Dr.
Concord, NH 03301-6527

New Mexico 505-984-0020
Radiation Protection Bureau
Environment Department
PO Box 26110
Santa Fe, NM 87502

New York 518-402-7590
Bureau of Envirnmental Radiation Protection
State Health Department
547 River St.
Albany, NY 12203

North Carolina 919-571-4141
Division of Radiation Protection
Department of Environment & Natural Resources
3825 Barrett Dr.
Raleigh, NC 27609-7221

North Dakota 701-224-2348
Division of Air Quality
State Department of Health
1200 Missouri Ave.

NRC - Federal 1-800-368-5642
www.nrc.gov

Bismarck, ND 58506-5520

Ohio 614-644-2727
Bureau of Radiation Protection
Department of Health
35 E. Chestnut St.
Columbus, OH 43266

Oklahoma 405-702-5155
Department of Environmental Quality
PO Box 1677
Oklahoma City, OK 73101-1677

Oregon 503-731-4014
Radiation Protection Services Section
800 NE Oregon St., Suite 260
Portland, OR 97232

Rhode Island 401-222-2438
Division of Occupational Health &
Radiation Control
Department of Health
3 Capitol Hill, Room 206
Providence, RI 02908-5097

South Carolina 803-545-4400
Bureau of Radiological Health
Department of Health & Environmental
Control
2600 Bull St.
Columbia, SC 29201

Tennessee 615-532-0360
Division of Radiological Health
3rd Floor, L&C Annex
401 Church Street
Nashville, TN 37243-1532

Texas 512-834-6679
Bureau of Radiation Control
Department of Health
1100 W. 49th Street
Austin, TX 78756-3189

Utah 801-536-4250
Division of Radiation Control
Department of Environmental Quality
168 North 1950 West
Salt Lake City, UT 84144-4850

Washington 206-753-3353
Division of Radiation Protection
Department of Health
PO Box 47827
Olympia, WA 98504-7827