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Patents Pending

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Operating Precautions

The MARS must be grounded. In the event of an electrical short circuit, grounding reduces the risk of electric shock by providing an escape wire for electric current. This instrument is equipped with a cord having a grounding wire with a grounding plug. The plug must be plugged into an outlet that is properly installed and grounded. Consult a qualified electrician or service technician if the grounding instructions are not completely understood or if doubt exists as to whether the instrument is properly grounded. If it is necessary to use an extension cord, use only a 3-wire extension cord that has a 3-blade grounding plug and a 3-slot receptacle that will accept the plug from the instrument. The marked rating of the extension cord must be equal to or greater than the electrical rating of the instrument.

The possibility of instrument-induced electromagnetic interference (EMI) is minimal if the instrument is operated as outlined in this manual. The instrument should not be placed close to any electrical device susceptible to EMI. It is suggested by the manufacturer that the user post a sign warning pacemaker wearers that a microwave device is in operation. If the instrument is suspected of inducing EMI, a microwave leakage measurement should be performed as outlined in this manual. Leakage measured above the legal limit of 5 mW/cm² should be reported to the CEM Service Department.

Cardiac pacemakers require magnets to control their operation during checkout. If the instrument is equipped with an optional magnetic sample stirrer which contains very high static magnetic fields, some danger exists if a pacemaker is positioned in close proximity of the instrument cavity (such as placing the head into the instrument cavity to perform a visual inspection). If the instrument is suspected of interfering with the operation of a pacemaker, the instrument should be turned off or the pacemaker wearer should move away from the instrument.

This instrument utilizes high voltages and microwave radiation. Instrument service and repair should be performed only by those trained in repair and maintenance of high voltage and microwave power systems.

Warnings, cautions and notes are included throughout this manual and should be read thoroughly and strictly follows.

WARNING: A warning is inserted for essential information used to emphasize dangerous or hazardous conditions to the operation, cleaning and maintenance of the instrument which may result in personal injury.

CAUTION: A caution is inserted for essential information used to emphasize procedures which, if not strictly followed, may result in damage or destruction to the instrument or improper instrument operation.

NOTE: A note is inserted for emphasis of procedures or conditions which may otherwise be misinterpreted or overlooked and to clarify possible confusing situations.

This instrument complies with United States Code of Federal Regulations 21CFR Part 1030.10 (C) for microwave leakage. A verification report is on file. This instrument complies with FCC Requirements in the United States Code of Federal Regulations (47CFR Part 18) - Industrial, Scientific and Medical (ISM) Equipment - emissions requirements. A verification report is on file.

The name "Teflon" is used throughout this manual. Teflon® is a registered trademark of the E.I. DuPont Company.

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Introduction

The Microwave Accelerated Reaction System, Model MARS®, is designed for laboratory use in digesting, dissolving, hydrolyzing, extracting or drying a wide range of materials. Its primary purpose is the rapid preparation of samples for analysis by atomic absorption (AA) and inductively coupled plasma (ICP) emission spectroscopy and gas or liquid chromatography.

The MARS consists of

- a microwave power system with operator selectable output of
- 0 - 1200 watts $\pm 15\%$, (1500 watts $\pm 15\%$ by IEC Method)
- a fluoropolymer-coated microwave cavity,
- a cavity exhaust fan and tubing to vent fumes,
- a digital computer programmable for 100 programs consisting of up to five stages each,
- an alternating or continuous mode turntable system,
- 3 door safety interlocks and an interlock monitoring system to prevent microwave emission when door is open.

The MARS uses microwave energy to heat samples. Compounds such as water and other polar liquids absorb microwave energy rapidly. A sample placed inside a microwave transparent vessel with a polar liquid or ionic solution (usually an acid) in the MARS is subjected to rapid heating and elevated pressures, causing the sample to digest or dissolve in a short time.

At full power, the MARS delivers approximately 1200 watts (1500 watts IEC) of microwave energy at a frequency of 2450 MHz. A microcomputer controls and monitors operations.

General Safety

Microwave sample preparation imposes a unique set of safety considerations beyond the basics of good laboratory practice. General guidelines for safe operation of laboratory microwave systems are presented below.

1. All vessel components must be dry and free of particulate matter. Drops of liquid or particles will absorb microwave energy, causing localized heating which may char and damage vessel components, leading to possible vessel failure.
2. Never heat liquids in a sealed vessel or container that is not equipped with a pressure relief device.
3. CEM does not recommend use of Parr Microwave Acid Digestion Bombs inside MARS systems. Such usage constitutes unreasonable operating conditions because Parr bombs cannot be connected to the pressure and temperature control mechanisms of the MARS and all software safeguards and safety relief devices are bypassed. CEM will not be responsible for damage to the MARS Microwave Digestion System or personal injuries resulting from use of Parr microwave acid digestion bombs.
4. Never attempt to digest samples larger than 0.5 grams if the organic content and composition of the sample is unknown.
5. Minimum volume for the MARS cavity is 10mL of acid or 50mL of water.
6. When working with an unknown sample, always perform a predigestion step in an unsealed, open vessel, allowing a minimum of 15 minutes time for the reaction of volatile or easily oxidized compounds to subside before sealing the vessel and microwave heating.
7. Microwave heating of alkaline or salt solutions in open or closed vessels will concentrate these solutions, causing precipitation of salts and formation of crystal deposits on vessel walls. These crystal deposits will absorb microwave energy, causing localized heating which may char and damage vessel components, leading to possible failure.
8. Never install a MARS inside a laboratory fume hood. Acid and chemical fumes may attack the electrical components, resulting in possible damage and malfunctioning of the cavity door safety interlocks. The proper method for installation of the system and connection to a laboratory fume hood are described in this manual.

Compounds Unsuitable for Closed Vessel Microwave Digestion

WARNING

Acid decomposition of certain chemical compounds or types of samples constitutes unreasonable, hazardous misuse of CEM microwave digestion systems. The classes of compounds listed below are unsuitable for closed vessel microwave digestion because they are highly reactive with oxidizing acids and/or may become nitrated and potentially explosive. Absence of a particular chemical compound from this list does not imply microwave acid decomposition of such a sample is safe under all conditions. CEM will not be responsible for damage to equipment and facilities or personal injuries resulting from microwave digestion of such compounds/samples.

- Explosives (TNT, Nitrocellulose, etc.)
- Propellants (Hydrazine, Ammonium Perchlorate, etc.)
- Pyrophoric chemicals
- Hypergolic mixtures (Nitric Acid and Phenol, Nitric Acid and Triethylamine, Nitric Acid and Acetone, etc.)
- Animal Fats (Esters of glycerol capable of nitration and the formation of nitroglycerin or other nitrated organic compounds)
- Aviation Fuels (JP-1, etc.)
- Acetylides
- Glycols (Ethylene Glycol, Propylene Glycol, etc.)
- Perchlorates (Ammonium, Potassium, etc.)
- Ethers (Cellosolve - Ethylene Glycol Phenyl ether, etc.)
- Lacquers
- Alkanes (Butane, Hexane, etc.)
- Ketones (Acetone, Methyl Ethyl Ketone, etc.) and alcohols (methanol, etc.)

Installation

The MARS instrument should be installed on a laboratory work bench with access to a fume hood or other means of fume disposal.

Tools Required

- Wrench
- Lab Coat
- Gloves
- Eye Protection

Installation Site

To install the MARS, choose a location that:

1. provides at least 8 in. (20 cm) space on each side and 6 in. (15 cm) space in the rear for proper ventilation.
2. is free from vibration of large equipment and/or walk-through traffic.
3. is away from the primary laboratory exits and walk-through traffic.
4. provides a temperature range of 41°F (5°C) to 104°F (40°C).
5. provides adequate bench space for sample handling and printer placement (if applicable).
6. permits the instrument to be connected to a dedicated, grounded outlet. The MARS instrument should be operated on a stabilized, constant voltage AC power supply, and the voltage must be within $\pm 10\%$ of the specified level. (See "Specifications," page 90.)

Note: Measure line voltage to ensure that it meets system specifications.

CAUTION

Line voltage fluctuations greater than 10% will affect instrument performance.

7. provides access to a fume hood or other means of fume disposal.

CAUTION

Never install an MARS system inside a laboratory fume hood. Acid and chemical fumes may attack electrical components, resulting in possible damage and malfunctioning of the cavity door safety interlocks.

Unpacking

1. Carefully open the shipping carton, using caution to avoid puncturing or tearing the foam packaging. Remove the foam and top cardboard packing material.

NOTE

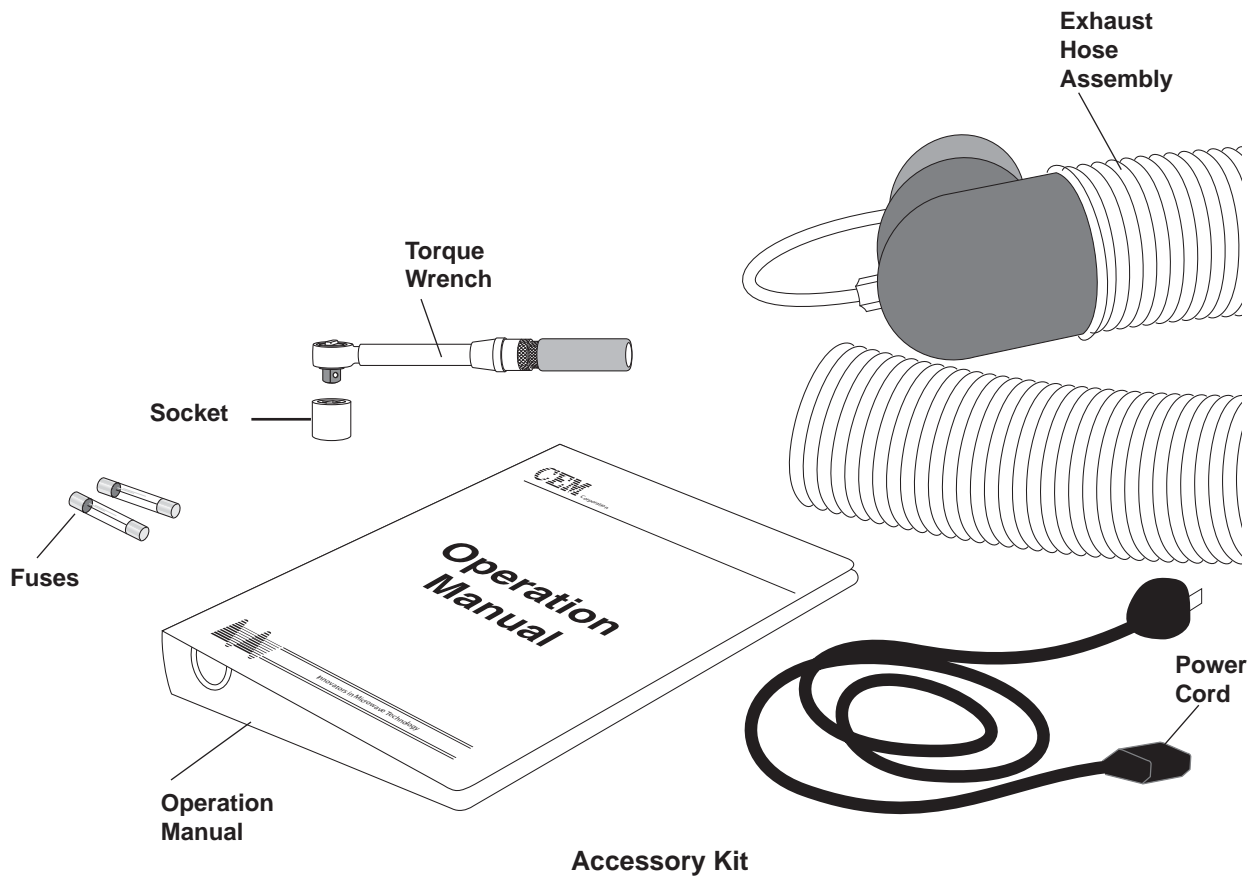
Retain all packing material for use if returning the instrument to the manufacturer for service.

2. With at least two people for lifting, locate the handles on each side of the lifting carton and lift the instrument from the shipping carton and place it on a laboratory bench. Carefully remove the lifting carton and plastic wrap from the instrument. Remove the instrument information sheet from the cavity of the instrument. Place this sheet into the Operation Manual for future reference.

Verify that all accessories listed below (illustrated in figure 1) have been included:

- Detachable Power Cord
- Exhaust Hose Assembly consisting of
 - 8' x 3" Hose
 - 3" Elbow
 - Hose Clamp
 - Drain Line Fitting
 - 5' Silicone Drain Tubing
 - 3 Plastic Pipe Plugs
- 15A Fuse (2)
- Operation Manual with Installation Check List

Optional items such as digestion vessels, turntable, or capping system may have been included in the shipment. Carefully check the packing list(s) and the contents of shipping cartons to verify that all items listed are included. Notify CEM Corporation or the local subsidiary or distributor of any discrepancies.



Inspection

1. Inspect the instrument for any cracks, dents, or warping.
2. Inspect the door for any damage and for proper alignment. When closed, the door should seat firmly against the front of the microwave cavity. The push button on the top of the instrument must release and engage the door latch mechanism.

WARNING

If damage is noted, do not attempt instrument operation.

If the instrument has been damaged in shipping, contact the freight carrier to report damage and to file a damage report. Contact the CEM Service Department or the local subsidiary or distributor to report damage and to request service information.

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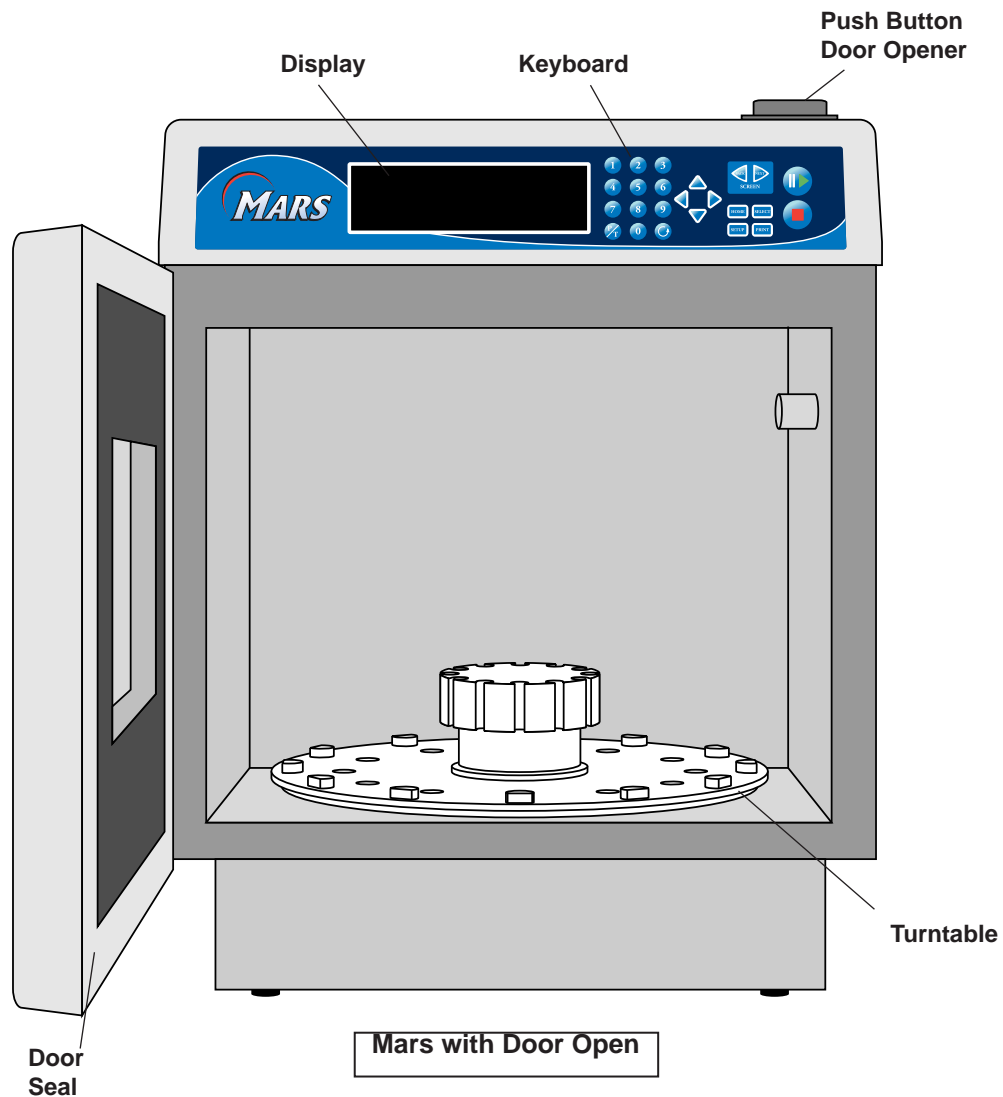
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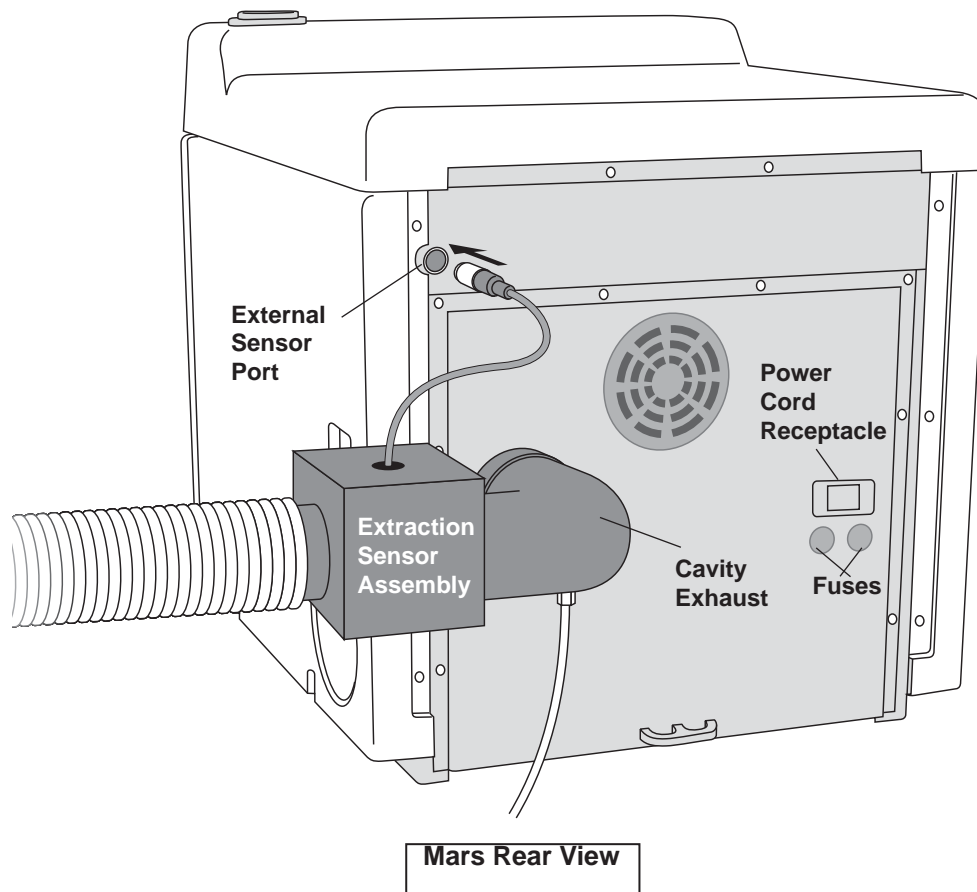
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Instrument Description

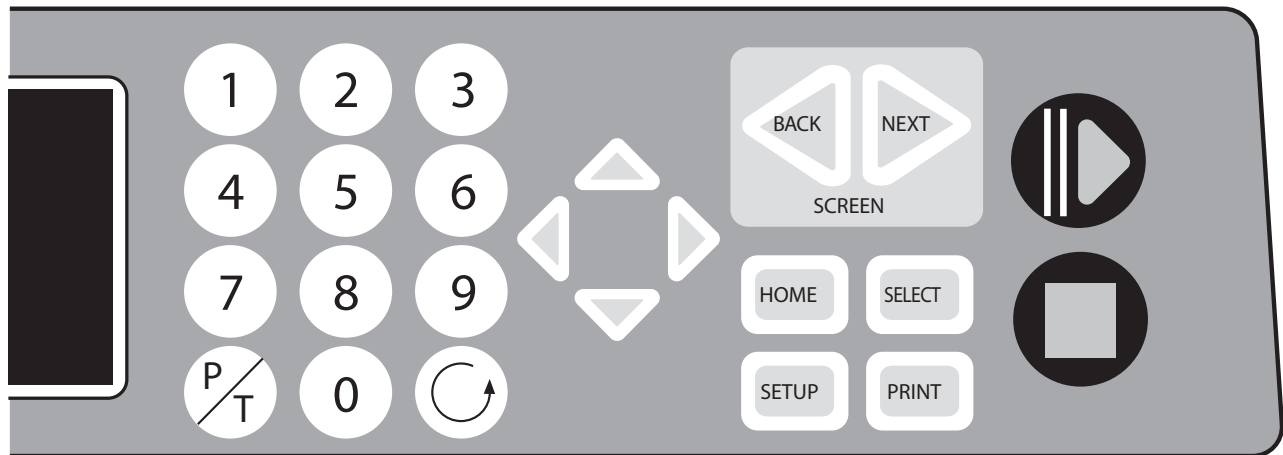
- **Display** - shows menus, method parameters and instrument status on an 8 line x 40 character vacuum fluorescent display.
- **Keyboard** - allows the operator to control operational parameters such as power, time, pressure, and method names.
- **Push Button Door Opener** - operates cavity door latch mechanism
- **Door Seal** - ensures tight fit between door and interior cavity of the MARS to prevent microwave leakage.
- **Turntable Drive Lug** - allows the turntable drive shaft to pass through the cavity floor and engage the turntable. (figure 9, page 49)
- **Printer and Computer Ports** - allow communication with external devices for display and printout of data. Refer to "System Setup." (figure 3, page 8)
- **TempGuard Guide Block** - locates the turntable for the opening of the TempGuard observation port.



- **Power Switch** - turns AC power on and off to the instrument
- **Cavity Exhaust Outlet** - exhausts fumes from the microwave cavity.
- **Cavity Exhaust Blower Motor** - directs air from the microwave cavity to the exhaust outlet.
- **Nameplate** - lists model, serial number, operating voltage, frequency, and current draw.
- **Magnetron Cooling Fan** - draws room air past the magnetron.
- **Power Cord** - conducts power from the AC outlet to the instrument. It is detachable.
- **Power Cord Receptacle** - receives the female end of the power cord.
- **Fuses** - prevent electrical power overload.
- **External Water Line** (Optional) - allows the user to monitor and control the pressure in a closed vessel during microwave heating.
- **Inlet/Outlet Ports** (Optional) - allow temperature and/or pressure monitoring and control lines to be introduced into the microwave cavity.
- **External Sensor Port** (Optional) - permits interface of optional instrument features
- **Extraction Sensor Assembly** (Optional) - permits interface of the extraction sensor assembly



- **Start/Pause** - begins the method currently displayed on the screen or pauses the operation during any stage of the method
- **Stop** - stops operation of method and returns to the main menu
- **Home** - returns to the main menu from any point in the software selections
- **Select** - enters selected parameter, method, etc. and in some instances advances to the next screen
- **Setup** - permits entering or editing of system parameters
- **Print** - permits printing of method data, system information, method program and/or setup parameters
- **Arrow Keys** - scroll through selections such as methods, vessels, etc.
- **Back** - returns to the previous screen during editing or creating a method or in setup menus
- **Next** - advances to the next screen during editing or creating a method or in setup menus
- **P/T** - toggles current pressure and temperature on instrument screen and displays a pressure, temperature versus time curve during a test
-  - rotates the turntable when the instrument door is open



Keyboard

Turntable Drive System

The MARS is furnished with an alternating and/or continuous turntable drive system. Rotational configuration is automatically selected by the vessel choice. During sample heating in alternating style, the turntable rotates 355°, then reverses direction to prevent pressure sensing or fiberoptic temperature sensors from becoming entangled and damaged. The turntable always operates when the microwave power is on. The turntable stops rotating when the microwave sample preparation cycle ends, when the “Stop” key is pressed, or when the instrument door is opened.

Exhaust

The MARS is equipped with an exhaust blower to remove corrosive or harmful fumes and flammable vapors from the cavity. The blower moves air at the rate of 3.6 m³/minute (125 ft³/minute).

Optional Inlet/Outlet Ports

Two Inlet/Outlet Ports, located on the right side of the instrument, permit access to the interior of the cavity for optional pressure and temperature control.

WARNING

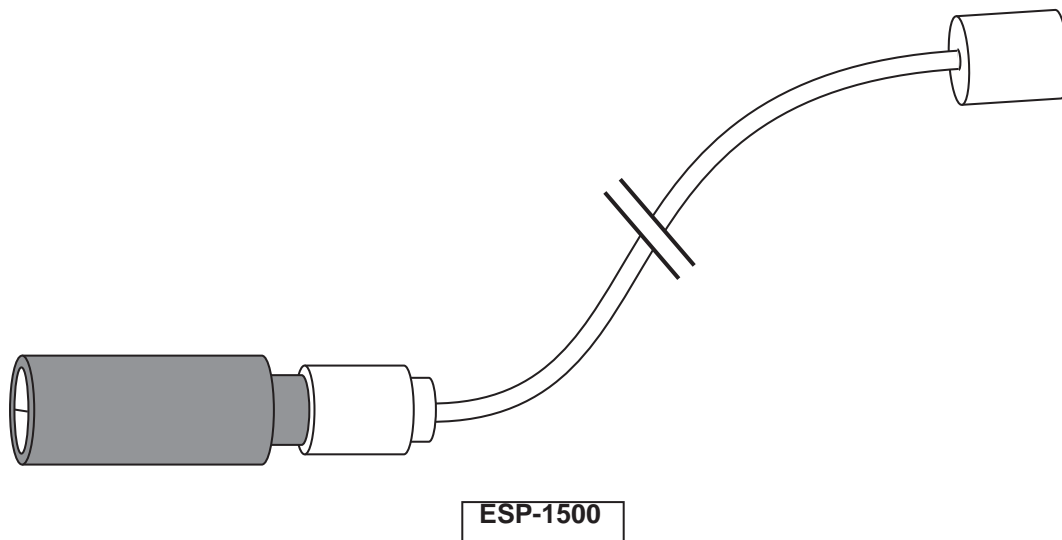
Never insert metallic objects such as wire into the inlet/outlet ports nor modify the ports. Serious microwave leakage and/or electrical shock may result. The inlet/outlet ports of the MARS are electrically grounded to the microwave cavity and are designed to prevent leakage of microwave energy.

Standard Pressure Control System

The standard pressure control system for the MARS is the ESP-1500 Plus (Electronic Sensor - Pressure) which monitors and controls pressure conditions inside sample vessels. The instrument is equipped with a quick-disconnect connection for the ESP.

The ESP-1500 Plus consists of two parts: 1) the control electronics and connector which are included in the instrument, and 2) the ESP sensor which is mounted to the reference vessel. The connector is located in the upper front right-hand corner of the cavity. The ESP sensor consists of a pressure sensing load-cell mechanism and a pressure line. During system operation, the sensor should be mounted securely to the cavity connector. The ESP is designed for use with the HP-500 Plus, XP-1500 and GreenChem Plus vessels.

During system operation, the ESP-1500 Plus measures pressure as forces inside the vessel are transmitted via the pressure line and press directly on the load cell. It sends a pressure signal from the load cell mechanism to the MARS electronic control which determines microwave energy delivery based on method heating requirements. Pressure is displayed graphically and digitally on the display screen.



Optional Pressure Control System

The MARS is also designed for use with an optional external water line control system to monitor and control pressure conditions inside sample vessels.

With this system, tubing is attached to a sample vessel and routed outside the microwave cavity through one of the inlet-outlet ports. This tube is connected to a panel-mounted fitting leading to the pressure control components located in the base of the MARS.

Pressure is sensed by a transducer and displayed on the screen.

Refer to the Options section of this manual for setup instructions for the external water line control system with applicable vessels.

CAUTION

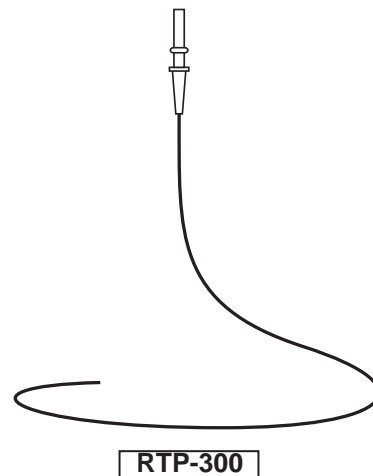
Never use more than one type of vessel simultaneously in a MARS System.

Standard Temperature Control System

The standard temperature control system for MARS is the RTP-300 Plus (Resonance Temperature Probe) which monitors and controls temperature conditions inside sample vessels.

A microwave transparent temperature probe is inserted into the thermowell of a sample vessel and connected to a snap-in port in the center of the roof of the instrument cavity. From there the signal extends to a special temperature control on the system controller board.

A feedback signal from the RTP-300 Plus probe to the magnetron of the system regulates microwave power output to maintain a selected temperature parameter.



CAUTION

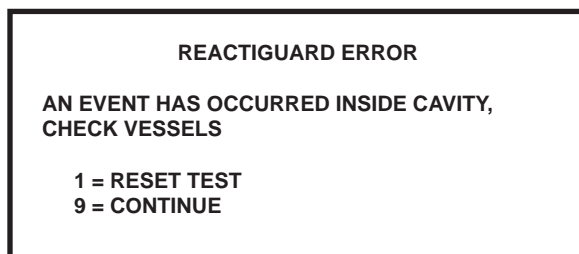
The RTP-300 Plus probe and the thermowell are both fragile. Exercise care when handling either of them.

Optional Temperature Control System

The MARS system is also designed for use with an optional infrared control system. This system is optional for use with certain vessel sets. With this system, two infrared temperature sensors are located below the cavity floor.

ReactiGuard Cavity Sensing System

The MARS is equipped with an audible sensing system to detect the occurrence of a vessel event inside the microwave cavity. When an event (such as the venting of a vessel relief device) is detected, an embedded software safeguard pauses the microwave heating program and displays the ReactiGuard Error message on the screen.



WARNING

Exercise extreme caution while attempting to identify the underlying cause(s) of a detected vessel event. Proper precautions must be taken to avoid contact with reagents or reagent vapors. Protective gear should be worn as outlined in the user's safety program for hazardous materials and the reagent manufacturer's material safety data sheet. Refer to these guidelines for proper handling and disposal of reagents.

Once the cause of the event has been determined, press either the "9" key to continue the method test or the "1" key to restart the method test.

The function of ReactiGuard is to protect against secondary instrument damage due to an undetected vessel event and continued heating of released liquids/vapors inside the cavity.

WARNING

ReactiGuard alerts the operator to the occurrence of an event with a vessel inside the cavity; therefore, CEM recommends that ReactiGuard be "on" at all times.

Normal operating status of the safeguard is enabled or "on." The ReactiGuard cavity sensing system may be inactivated, turned "off," if the user elects to disable this feature. Refer to "System Setup."

Optional TempGuard™ Sensor

The optional TempGuard™ sensor is a safety device for measurement of temperature inside each vessel in the system. An infrared lens and sensor are located in the front right corner of the cavity floor. As the vessels rotate over the sensor, the temperature of each vessel is measured.

If the temperature in any vessel surpasses the maximum allowable temperature programmed during instrument setup (150-310°C), TempGuard stops microwave production and displays an error message indicating the position of the vessel in which the temperature has exceeded the programmed limit.

WARNING

Because excessive temperature can damage vessel components, exercise extreme caution when removing a vessel which has exceeded TempGuard limits. Proper precautions must be taken to avoid contact with reagents or reagent vapors. Protective gear should be worn as outlined in the user's safety program for hazardous materials and the reagent manufacturer's material safety data sheet. Refer to these guidelines for proper handling and disposal of reagents.

Optional Sample Stirrer

The optional sample stirrer is a rotating magnetic field in the bottom of the instrument which works in conjunction with stirring bars placed in the vessel liners to ensure a homogeneous sample.

WARNING

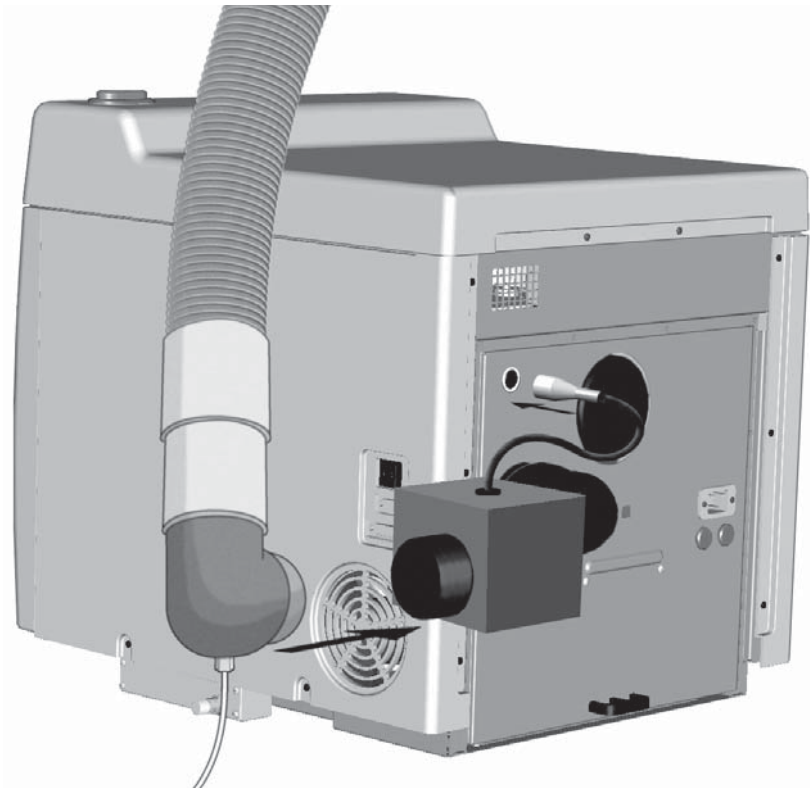
Because cardiac pacemakers require magnets to control operation during checkout, if the MARS instrument is equipped with an optional sample stirrer, some danger exists if a pacemaker is positioned in close proximity to the instrument cavity. If the instrument is suspected of interfering with the operation of a pacemaker, the instrument should be turned off or the pacemaker wearer should move away from the instrument.

1. Position the instrument on the selected work bench.
2. Install the exhaust hose on the instrument as follows:
 - a. The open end of the elbow attached to the exhaust tubing has three tapped holes, all plugged with plastic pipe plugs. Insert the cavity exhaust duct with any one of the three tapped holes. Remove the pipe plug from the hole which will point downward.
 - b. Install the drain fitting into the hole. After hand-tightening the fitting, use a wrench and tighten it an additional 1/4 turn. Check the inside of the elbow to ensure the end of the fitting does not protrude beyond the inner surface of the elbow. If necessary, loosen the fitting until the inside edge of the fitting is flush with the inside of the elbow.

CAUTION

If the fitting is not flush with the inside of the elbow, liquid will pool around the end of the fitting. Corrosion damage to the instrument may result.

- c. Insert the elbow (with hose and drain fitting attached and pointing downward) into the exhaust duct.
- d. If applicable, insert the elbow directly into the solvent sensor (figure 7).
- e. Attach the open end of the drain line to a suitable receptacle to collect condensate from the exhaust hose.



Exhaust Hose Installation

NOTE

CEM recommends that the exhaust hose be installed in a bypass type fume hood with a vertical sash.

3. Place the exhaust hose in the fume hood through the front sash or connect the hose to a duct on the side of the fume hood.

NOTE

The cavity exhaust system of the MARS has an airflow rate of 3.6 m³/minute (125 ft.³/minute).

CAUTION

The fume hood must have adequate inflow and ventilation capacity. A fume hood of inadequate ventilation capacity or undersized exhaust ducting will cause an accumulation of fumes and buildup of back pressure in the fume hood, ductwork and into the MARS system. This can result in premature failure of the exhaust blower.

Refer to Appendix C for a list of references for proper sizing and testing of laboratory fume hoods.

4. The MARS must be connected to a dedicated electrical outlet. Using a VOM (Volt/Ohm meter) verify the voltage of this dedicated electrical line. Based on the available voltage, position the voltage selection switch as follows:

| | | |
|---------------------|------------------|---------------------------|
| 208/230 Volt System | <219Volts - 280 | 219 Volts and above - 230 |
| 220/240 Volt System | <229 volts - 220 | 230 Volts and above - 240 |

5. Plug the power cord into the instrument and into the dedicated electrical outlet which meets system specifications. The MARS is compatible with IBM, Epson, Epson Color, Canon Color, and Citizen Color printers.

Printer Setup

1. Refer to the printer manual and connect the printer to the instrument with an appropriately configured cable.

Note: For instruments with pressure and/or temperature control, the printer cable will plug into the software module installed in the printer port.

2. Connect the printer to an AC power source.
3. Refer to “System Setup” for printer options.

CEM Methods

The CEM Directory in the MARS system contains US EPA methods, microwave power measurement tests and several methods which can be used as guidelines for the creation of new methods for similar sample types.

Note: Ensure that the vessel used is the vessel which is programmed into the method selected.

US EPA

US EPA methods include:

- SW-3015 Microwave Assisted Acid Digestion of Aqueous Samples
- SW-3051 Microwave Assisted Acid Digestion of Sludges, Soils and Sediments
- SW-3052 Microwave Assisted Acid Digestion of Siliceous and Organically Based Matrices
- NPDES Closed Vessel Microwave Digestion of Wastewater Samples for Metal Determination

Note: The above EPA methods are included for both the XP-1500 and HP-500 vessels

Power Measurement Methods

Microwave power measurement methods include:

- 300 Watts - Beaker
- 600 Watts - Beaker
- 1200 Watts - Beaker

Refer to pages 61 and 62 for procedures for performing power tests and calculating microwave power.

QC Methods

- QC ESP/RTP Ramp to Pressure
- QC RTP Ramp to Temperature

Sample Methods

- Waste Oil - XP-1500
- Tool Steel - HP-500
- Polyethylene - XP-1500
- Oyster Tissue - HP-500
- Rice - XP-1500
- Plant Tissue 1 - HP-500
- Plant Tissue 2 - HP-500
- Fertilizer - Xpress
- Styrene - Xpress

NOTE

Methods in the CEM Directory can be edited by the instrument operator; however, edited methods must be re-named. Renamed methods are automatically stored in the User Directory.

Instrument Do's and Don't's

This instrument utilizes high voltages and microwave radiation in its operation. Instrument service and repair should be undertaken only by technicians trained in repair and maintenance of high voltage and microwave power systems.

Do not attempt to digest samples larger than 0.5 grams if organic content and composition of sample are unknown. Unknown samples should be predigested for a minimum of 15 minutes in an unsealed vessel without any heating prior to attempting a closed vessel digestion.

Daily, remove the ESP cable connection from the bulkhead connection and thoroughly clean the connector with a paper towel or soft cloth. Wipe and clean both the inside and outside surfaces of the connector. If necessary, dampen the towel with isopropyl alcohol to assist in cleaning.

To avoid possible malfunction of the capacitor relays, do not turn the instrument off within 15 seconds after operation with microwave power. If the instrument is inadvertently turned off within 15 seconds after microwave power production, perform 300, 600 and 1200-watt power checks stored in the CEM Directory. If the power is not within specifications at any of the three wattages, refer to the service section of this manual for procedures for troubleshooting this problem.

Never install a MARS system inside a laboratory fume hood. Acid and chemical fumes may attack the electrical components, resulting in possible damage and malfunctioning of the cavity door safety interlocks.

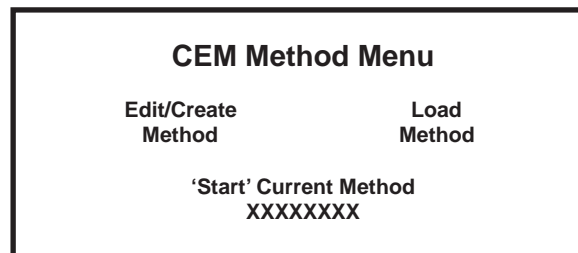
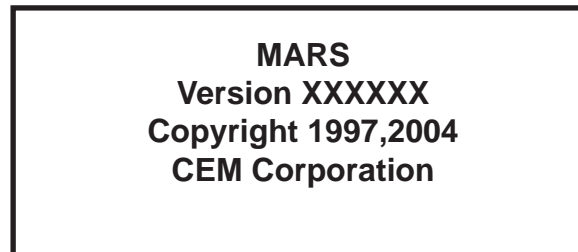
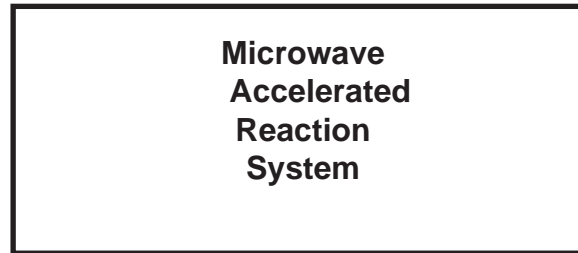
If the MARS is equipped with a sample stirrer, some danger exists if a pacemaker is positioned in close proximity to the instrument cavity.

If the MARS is equipped with Xpress dual IR sensors, each IR window or lens in the cavity floor should be cleaned weekly or after any spillage by wiping each lens with a damp soft cloth.

Instrument Setup

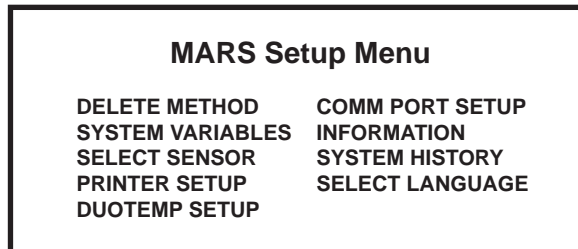
The Setup Menu permits instrument entry of system variables, printer and communication port setup; language selection; access of system information and history; method deletion; and pressure and temperature sensor calibration.

Position the power switch in the “on” position. The following screens will appear in succession, ending with the Method (Main) Menu.



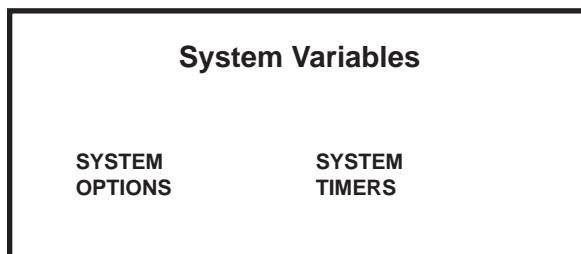
Setup Menu

1. From the Main Menu, press the SETUP key.

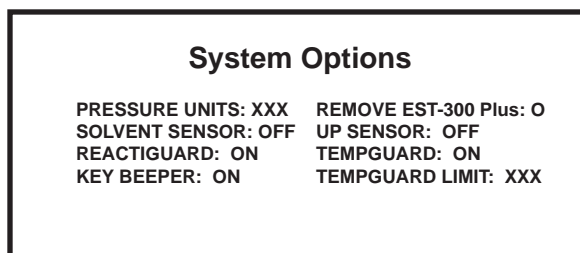


System Variables

- Using the arrow keys, highlight “System Variables.” Press the SELECT key.



- Using the arrow keys, highlight “System Variables.” Press the SELECT key.



Pressure Units

- Pressure units can be displayed in either psi, Bar or KPa. Using the arrow keys, highlight “Pressure Units.” Press the “SELECT” key to toggle and select the desired choice (psi, Bar, KPa).

Solvent Sensor

- Solvent Sensor should be turned “on” if using the solvent sensor option. Using the arrow keys, highlight Solvent Sensor. Press the “SELECT” key to toggle between “on” and “off.” The default setting on power-up for the solvent sensor is “Off.” Each time the instrument is turned off and back on, the solvent sensor is “Off.” The instrument software will not permit the Solvent Sensor and UP Sensor to be turned on simultaneously.

ReactiGuard

- ReactiGuard detects and alerts the user to an event in a vessel and can be turned on and off. Using the arrow keys, highlight “ReactiGuard.” Press the “SELECT” key to toggle between “on” and “off.”

WARNING

ReactiGuard alerts the operator to the occurrence of an event with a vessel; therefore, CEM recommends that ReactiGuard be “on” at all times.

WARNING

Use extreme caution while attempting to identify the underlying cause(s) of a detected vessel event. Proper precautions must be taken to avoid contact with reagents. Protective gear should be worn as outlined in the user’s safety program for hazardous materials and the reagent manufacturer’s material safety data sheet. Refer to these guidelines for proper handling of the reagent.

Key Beeper

- The key beeper is an audible “beep” after each key stroke and can be turned on and off. Using the arrow keys, highlight “Key Beeper.” Press the “SELECT” key to toggle between “on” and “off.”

EST-300

9. If this type sensor is installed, "Remove EST-300" is a screen to remind the user to remove the EST-300 temperature controller prior to removal of the control vessel from the instrument. It can be turned on and off. Using the arrow keys, highlight "Remove EST-300" Press the "SELECT" key to toggle between "on" and "off."

Universal Pressure Sensor

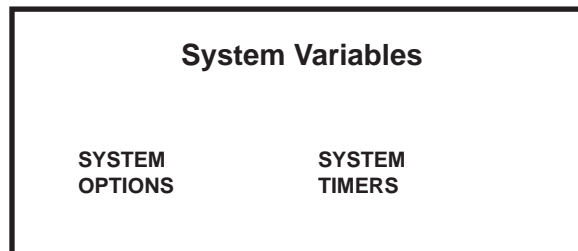
10. The universal pressure sensor is an optional gas sensor used to detect emission from the vessels. Based on the amount of emission detected, the sensor will turn the microwaves off for 15 seconds or 45 seconds or terminate the method. If the universal pressure sensor is installed, it can be turned on and off. The default setting for this sensor is "Off." To turn the sensor on, use the arrow keys to highlight the "UP Sensor." Press the "SELECT" key to toggle the sensor "On" and "Off." The instrument software will not permit the solvent sensor and the UP sensor to be turned on simultaneously.

TempGuard

12. TempGuard™ is an optional infrared sensor for measuring temperature in the vessels. It can be turned on and off. Using the arrow keys, highlight "TempGuard." Press the "SELECT" key to toggle between "on" and "off."

TempGuard Limit

13. TempGuard limit is user programmable from 150 - 310°C. If a vessel reading exceeds the TempGuard limit, the instrument automatically stops microwaves, and an error message appears on the screen. Using the arrow keys, highlight "TempGuard Limit." Use the numerical keys to enter the desired temperature limit.
14. Press the "BACK" key to return to the "System Variables" screen.



15. Using the arrow keys, highlight "System Timers." Press the SELECT key.

Cool Down Time

16. The post-run cool down time appears at the end of a digestion and counts down to permit sufficient cool down time prior to opening the instrument door and removing the vessels from the turntable. Post-run cool down time can be set from 0 - 999 minutes. Default cool down time is 5 minutes. Using the arrow keys, highlight "Cool Down Time." Use the numerical keys to enter the desired post-run cool down time.

WARNING

CEM recommends that a post-run cool down time be used for each digestion performed in the MARS instrument to prevent the possibility of operator burns or acid spills.

Screen Saver Time

17. The screen saver time is set to determine the length of time the instrument can be idle prior to the screen saver appearing on the screen. Screen saver time can be set from 0 - 999 minutes. Default screen saver time is 5 minutes. Using the arrow keys, highlight "Screen Saver Time." Use the numerical keys to enter the desired screen saver time.

CAUTION

To lengthen the lifetime of the display screen, CEM recommends that a screen saver time be used at all times.

18. Using the arrow keys, highlight "Set Clock." Press the SELECT key.

Set Clock

DATE: XX/XX/XX
TIME: (24 Hour Format): XX:XX
DATE FORMAT: XX/XX/XX

Set Clock

19. Using the arrow keys, highlight "Date Format." Press the "SELECT" key to toggle between DD/MM/YYYY (Day/Month/Year) and MM/DD/YYYY (Month/Day/Year). Using the arrow keys, highlight "Date." Use the numerical keys to enter the appropriate date.
20. Using the arrow keys, highlight "Time." Use the numerical keys to enter the appropriate time. The time should be entered on a 24-hour basis. For example, 1:00p.m. should be entered as 13:00.
21. Press the "NEXT" key to return to the "MARS Setup Menu" screen.

MARS Setup Menu

| | |
|------------------|-----------------|
| DELETE METHOD | COMM PORT SETUP |
| SYSTEM VARIABLES | INFORMATION |
| SELECT SENSOR | SYSTEM HISTORY |
| PRINTER SETUP | SELECT LANGUAGE |
| DUOTEMP SETUP | |

Select Sensor

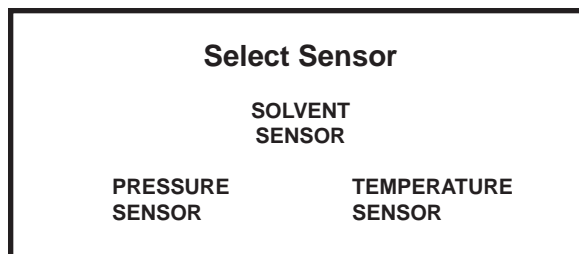
22. . Using the arrow keys, highlight "Select Sensor." Press the SELECT key.

Note: The solvent sensor is an option for the MARS instrument. Based on whether or not the optional solvent sensor is installed, one of the two following screens will appear.

Select Sensor

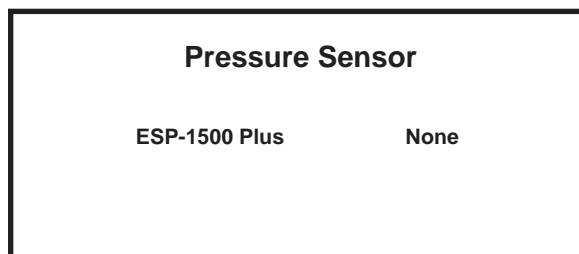
| | |
|--------------------|-----------------------|
| PRESSURE SENSOR | TEMPERATURE SENSOR |
|--------------------|-----------------------|

or

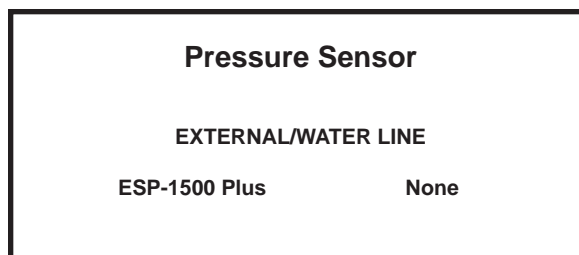


23. Refer to step 24 for setup procedures for pressure control. Refer to step 34 for setup procedures for temperature control. Refer to step 42 for setup procedures for the optional solvent sensor.

24. Using the arrow keys, highlight "Pressure Sensor." Press the SELECT key. Based on the type of pressure sensor(s) being used with the instrument, one of the two following screens will appear.



or



Note: The ESP-1500 Plus is the standard method of pressure control. The external water line is an optional method.

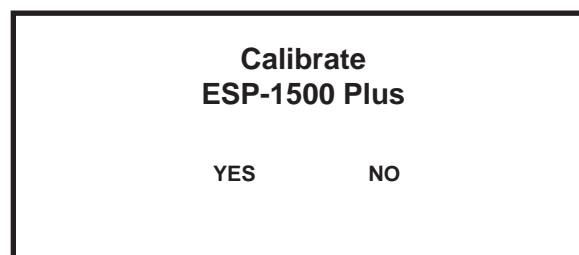
25. Using the arrow keys, highlight the appropriate pressure sensor to be used with the system.

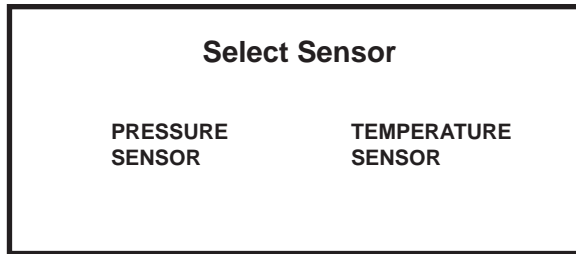
26. If no pressure control is to be used, highlight "None" and press the "BACK" key to return to the "Select Sensor" screen.

Note: If using the ESP-1500 Plus sensor, proceed with step 24. If using the external water line for pressure control, proceed to step 29.

Zero Pressure Sensor

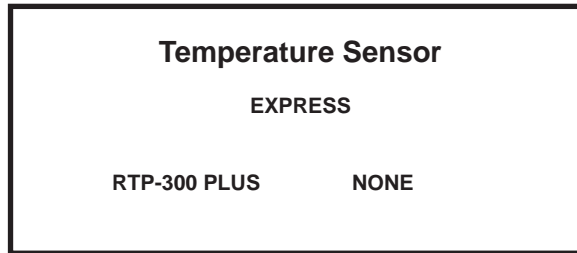
27. If the ESP-1500 Plus is selected, carefully connect the ESP-1500 Plus pressure controller to the connector port on the right side of the instrument cavity. Rotate the ESP-1500 Plus while gently pushing it into the connector port until it slips into the correct position. This rotation is to align the ESP-1500 Plus and the connector port. Once the connector is properly aligned, push the ESP-1500 Plus into the connector port until the polypropylene guard is fully seated against the connector port. Press the "SELECT" key to "zero" the pressure sensor. The following screen will be displayed.



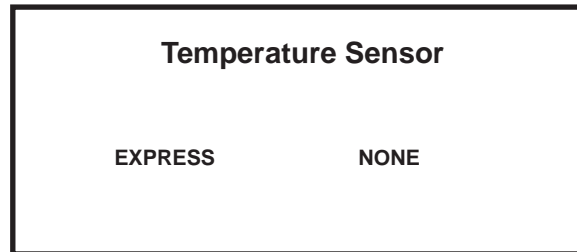


Temperature Sensor

34. Using the arrow keys, highlight "Temperature Sensor." Press the "SELECT" key.



or

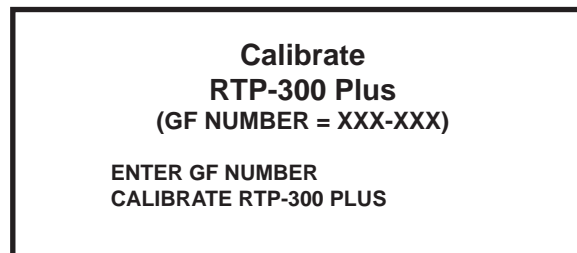


Note: The RTP-300 Plus is the standard method of temperature control.

35. Using the arrow keys, highlight the appropriate temperature sensor to be used with the system.

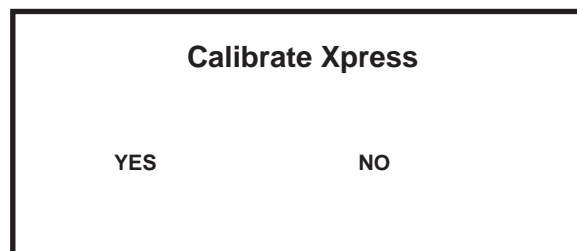
36. If no temperature control is to be used, highlight "None." Press the "SELECT" key to return to the "Select Sensor" screen.

37. If using the RTP-300 Plus temperature sensor, highlight "RTP-300 Plus." Press the "SELECT" key. The following screen will be displayed.



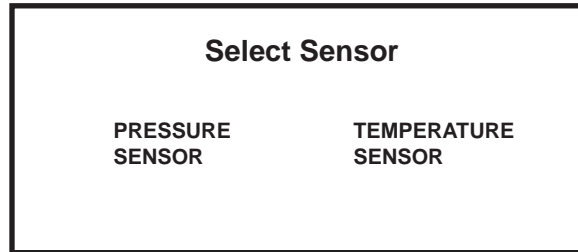
38. Press the "BACK" key two times to return to the "Select Sensor" screen

39. If using the Xpress temperature control, highlight "Xpress." Press the "SELECT" key. The following screen will be displayed.

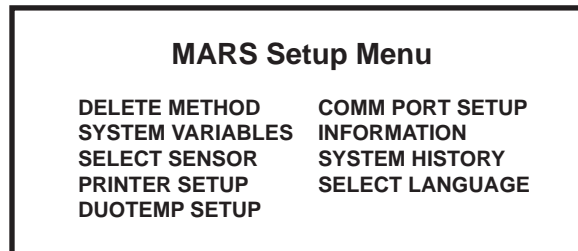


Note: The instrument defaults to “No” on the Calibrate Express screen.

40. Press the “SELECT” key to return to the “Select Sensor” screen.

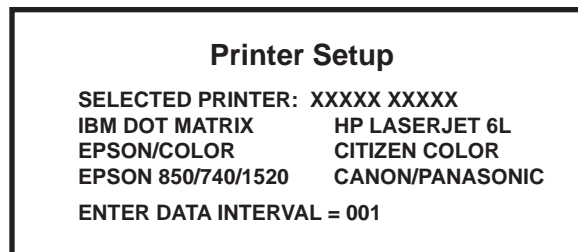


41. Press the “BACK” key to return to the “Setup Menu” screen



Printer Setup

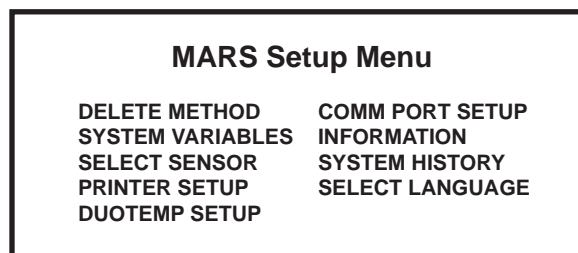
42. Using the arrow keys, highlight “Printer Setup.” Press the SELECT key.



43. Using the arrow keys, highlight the appropriate printer to be used with the instrument.

44. Press the “SELECT” key to highlight the data interval. Using the numerical keys, enter the number of seconds (1 - 999) selected to send data to the printer. The instrument default setting is 1 second.

45. Press the “NEXT” key to return to the “MARS Setup Menu” screen.

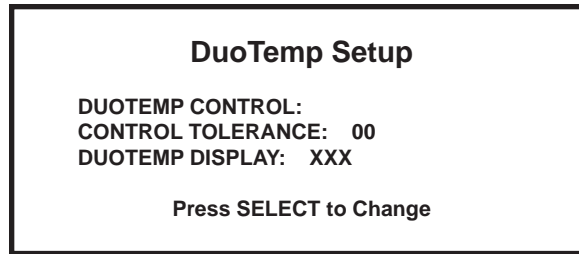


DuoTemp Setup

If the TempGuard infrared sensor option and the RTP-300 Plus fiber-optic temperature sensor are both installed, the Duo-Temp control may be used. DuoTemp automatically switches the control temperature for the method to the hottest vessel in the method batch.

An additional option permits the hottest vessel to be used at a defined temperature above the method control point in control tolerance.

46. Using the arrow keys, highlight “DuoTemp Setup.” Press the SELECT key.



47. Using the arrow keys, highlight “DuoTemp Control.” Press the SELECT key to toggle and select “On” or “Off.”

Note: When DuoTemp Control is turned off, temperature control reverts to the single reference vessel control.

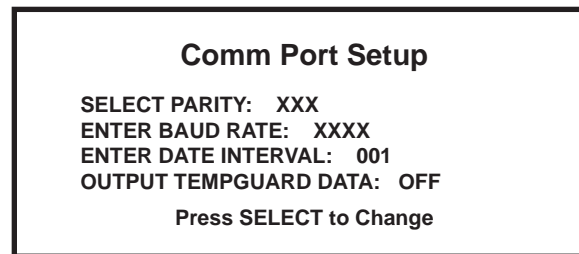
48. Using the arrow keys, highlight “Control Tolerance.” Use the numerical keys to enter a temperature difference below the hottest value permitted for the method setpoint.

49. Using the arrow keys, highlight “DuoTemp Display.” Press the SELECT key to toggle and select “On” or “Off.” When turned “on,” this feature displays the number of the current control vessel (the hottest vessel) in the bottom right hand corner of the screen during performance of a method.

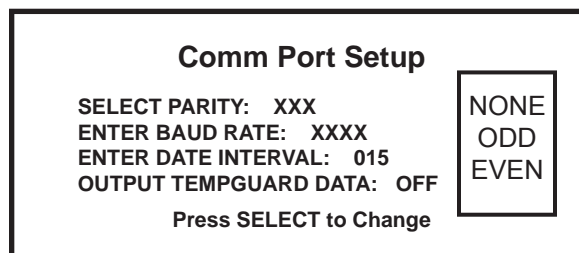
Note: DuoTemp does not affect the performance or function of the TempGuard feature. TempGuard is a separate safety limit and is activated in the “System Options” screen.

Communication Port Setup

50. Using the arrow keys, highlight “Comm Port Setup.” Press the SELECT key.

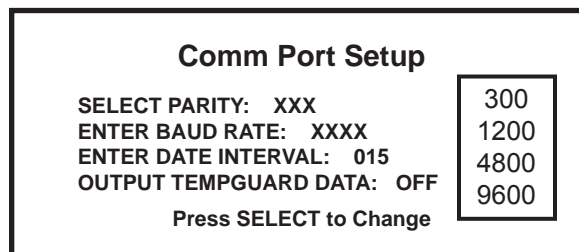


51. To set up the communication port parameters, use the arrow keys to highlight the parity. Press the “SELECT” key.



52. Using the arrow keys, highlight the desired parity. Press the “SELECT” key to return to the “Comm Port Setup” screen.

53. Use the arrow keys to highlight the baud rate. Press the “SELECT” key.



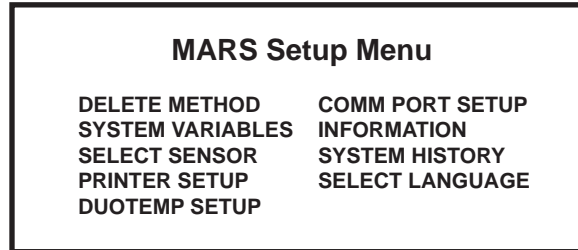
54. Using the arrow keys, highlight the desired baud rate. Press the “SELECT” key to return to the “Comm Port Setup”

54. Use the arrow keys to highlight the data interval. Using the numerical keys, enter the selected data interval rate (0-999 seconds). Default interval rate for sending data through the PC connector is 1 second

Note: To use “Output TempGuard Data” to view individual temperatures of vessels, a special software package is required. If TempGuard is activated, and the vessel selected is not Xpress, “Output TempGuard Data” should be turned on.

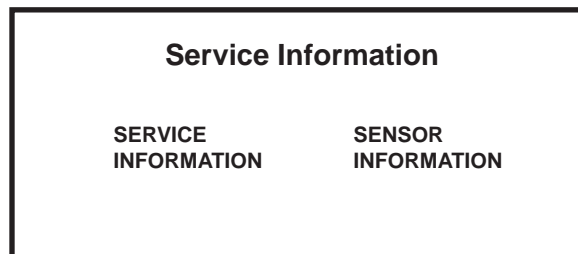
56. Using the arrow keys, highlight “Output TempGuard Data.” Press the “SELECT” key to toggle “on” or “off.”

57. Press the “NEXT” key to return to the “MARS Setup Menu” screen.



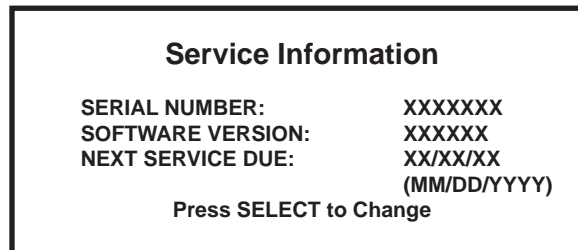
Information

58. Using the arrow keys, highlight “Information.” Press the SELECT key.



Service Information

59. Using the arrow keys, highlight “Service Information.” Press the SELECT key to view the “Service Information” screen.



Note: The information on the “Service Information” screen is for user information only and cannot be changed or reentered except immediately following an instrument cold start. If necessary due to an instrument cold start, use the keyboard and reenter the instrument serial number and next service due date.

60. Press the “BACK” key to return the “System Information” screen.

61. Using the arrow keys, highlight “Sensor Information.” Press the “SELECT” key to view the “Sensor Information” screen.

| Sensor Information | |
|---------------------|---------------|
| CURRENT PRESSURE | ON |
| CURRENT TEMPERATURE | ON |
| TEMPGUARD | NOT INSTALLED |
| REACTIGUARD | ON |

Note: The information on the “Sensor Information” screen is for user information only and cannot be changed.

62. Press the “NEXT” key to return to the “MARS Setup Menu” screen.

| MARS Setup Menu | |
|------------------|-----------------|
| DELETE METHOD | COMM PORT SETUP |
| SYSTEM VARIABLES | INFORMATION |
| SELECT SENSOR | SYSTEM HISTORY |
| PRINTER SETUP | SELECT LANGUAGE |
| DUOTEMP SETUP | |

System History

63. Using the arrow keys, highlight “System History.” Press the SELECT key.

| System History | |
|---------------------------|--------------|
| SYSTEM RUN TIME | 000000 HOURS |
| MAGNETRON RUN TIME | 000000 HOURS |
| LAST PRESSURE CALIBRATION | XX/XX/XXXX |
| LAST TEMP CALIBRATION | XX/XX/XXXX |
| TOTAL METHODS RUN | 0000000 |

Note: The information on the “System History” screen is for user information only and cannot be changed.

64. Press the NEXT key to return to the “Mars Setup Menu” screen.

| MARS Setup Menu | |
|------------------|-----------------|
| DELETE METHOD | COMM PORT SETUP |
| SYSTEM VARIABLES | INFORMATION |
| SELECT SENSOR | SYSTEM HISTORY |
| PRINTER SETUP | SELECT LANGUAGE |
| DUOTEMP SETUP | |

Language

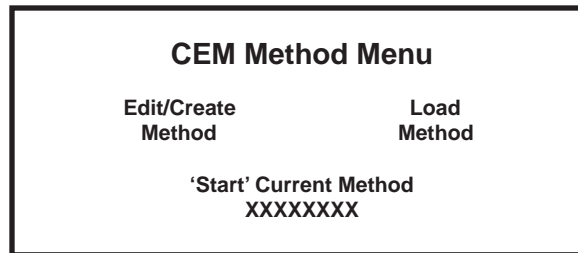
65. Using the arrow keys, highlight “Select Language.” Press the SELECT key.

| Select Language |
|-----------------|
| GERMAN |
| FRENCH |
| ITALIAN |
| SPANISH |
| ENGLISH |

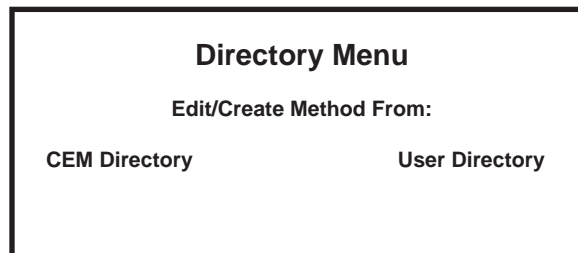
66. Use the arrow keys to highlight the desired language to be displayed on the instrument screens (German, French, Italian, Spanish or English). Press the SELECT key. Press the NEXT key to return to the “MARS Setup Menu” screen. Press the HOME key to return to the Main Menu.

Edit Method

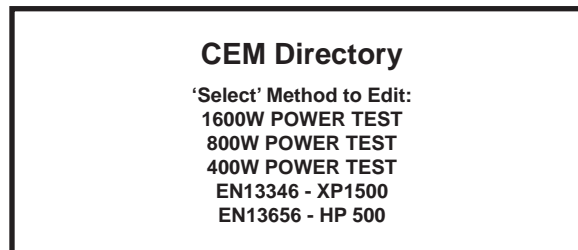
Methods in the CEM Directory or User Directory can be edited for specific samples. Edited versions of methods in the CEM directory must be renamed. The edited version will be saved in the User Directory. User methods cannot be saved in the CEM Directory. A maximum of 100 methods can be stored in the User Directory. Edited versions of methods in the User Directory should be renamed if the original method is still required; otherwise, the original method information will be lost.



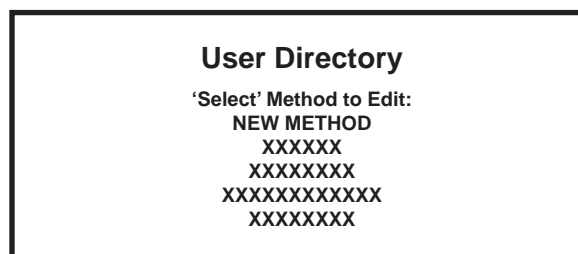
1. Using the arrow keys, highlight "Edit/Create Method." Press the SELECT key.



2. To edit a CEM method or user method, use the arrow keys to highlight the appropriate directory. Press the SELECT key.



or



CAUTION

To avoid losing all edited information, do not press the HOME key from any of the edit screen(s).

3. Using the arrow keys, highlight the CEM method to be edited.
4. To review the parameters of the method to be edited, press the "1" key. Based on the selected method, a screen such as the one below will be displayed.

| User Directory | | | | | | | |
|----------------|-------|------|-------|------|-----|------|-------|
| STAGE | POWER | RAMP | PSI | ° C | S | HOLD | |
| | MAX | % | | | | | |
| 1 | 000W | 000 | 00:00 | 0000 | 200 | X | 00:00 |
| 2 | 000W | 000 | 00:00 | 0000 | 200 | X | 00:00 |
| 3 | 000w | 000 | 00:00 | 0000 | 200 | X | 00:00 |
| 4 | 000W | 000 | 00:00 | 0000 | 200 | X | 00:00 |
| 5 | 000w | 000 | 00:00 | 0000 | 200 | X | 00:00 |

5. Press the BACK key to return to the selected directory screen.

6. Press the SELECT key to edit the selected method.

Vessel Selection

| Select Vessel Type | | |
|--------------------|--------------|-----------|
| HP-500 | OMNI/XP-1500 | ACV/QDV |
| UDV/HDV | HTV | PFA |
| BEAKER | SRV | QXP |
| Xpress | ACV/LEV | CleanChem |
| GreenChem | | |

Note: If the instrument is equipped with The Xpress optional IR control only, the above screen will not appear.

Control Selection

7. Using the arrow keys, highlight the type vessel to be used for the method. Press the “SELECT” key.

| Select Control Type |
|---------------------|
| STANDARD CONTROL |
| RAMP TO TEMPERATURE |
| RAMP TO PRESSURE |
| POWER/TIME CONTROL |
| MICROVAP |

Method Parameters

8. Using the arrow keys, highlight the type control to be used for the method. Press the “SELECT” key.

Note: If “SRV” is selected in step 7 as the vessel to be utilized, only “Standard Control” or “Power/Time Control” can be highlighted and selected in step 8. SRV should not be selected if using HP or XP vessels with AV covers. In this case, select the appropriate vessel type.

Note: The “Enter Method Parameters” screen will differ based on the selected control type, the number of stages and use of the optional stirrer (S).

Note: If MicroVap is selected as the control mechanism, the PSI column will be replaced by a programmable temperature delta. Refer to the MicroVap Instructions for additional information.

Note: If “Xpress” is selected in step 7 as the vessel to be utilized, the pressure column will be eliminated.

Note: The “Enter Method Parameters” screen will differ based on the selected control type, the number of stages and use of the optional stirrer (S).

| ENTER METHOD PARAMETERS | | | | | | |
|-------------------------|-------|------|-------|------|-----|---------|
| STAGE | POWER | TIME | PSI | ° C | S | HOLD |
| | MAX | % | | | | |
| X | XXXW | XXX | XX:XX | XXXX | XXX | X XX:XX |

Standard Control with Optional Stirrer

| ENTER METHOD PARAMETERS | | | | | | |
|-------------------------|-------|------|-------|------|-----|---------|
| STAGE | POWER | RAMP | PSI | ° C | S | HOLD |
| | MAX | % | | | | |
| 1 | XXXXW | XXX | XX:XX | XXXX | XXX | X XX:XX |
| 2 | XXXXW | XXX | XX:XX | XXXX | XXX | X XX:XX |

Press Select to Change

Ramp to Temperature without Optional Stirrer

| ENTER METHOD PARAMETERS | | | | | | |
|-------------------------|-------|------|-------|------|-----|---------|
| STAGE | POWER | RAMP | PSI | ° C | S | HOLD |
| | MAX | % | | | | |
| 1 | XXXXW | XXX | XX:XX | XXXX | XXX | X XX:XX |
| 2 | XXXXW | XXX | XX:XX | XXXX | XXX | X XX:XX |
| 3 | XXXXw | XXX | XX:XX | XXXX | XXX | X XX:XX |
| 4 | XXXXW | XXX | XX:XX | XXXX | XXX | X XX:XX |

Press Select to Change

Ramp to Pressure with Optional Stirrer

| ENTER METHOD PARAMETERS | | | | | | |
|-------------------------|-------|------|-------|--|---|-------|
| STAGE | POWER | Time | | | | |
| S | MAX | % | HOLD | | | |
| X | XXXXW | XXX | XX:XX | | X | XX:XX |

Power/Time Control with Optional Stirrer

9. To change the wattage, use the arrow keys to highlight the wattage to be edited. Press the “SELECT” key. The following screen will appear for choosing the desired wattage.

Note: General guidelines for 100% power are as follows:

- 1 - 2 Vessels 300 watts
- 3 - 5 Vessels 600 watts
- 6 or more Vessels 1200 watts

| STAGE | POWER | S | HOLD |
|-------|-------|---|-------|
| 1 | 400W | X | XX:XX |
| 2 | 800W | X | XX:XX |
| | 1600W | | |

Press Select to Change

10. Using the arrow keys, highlight the desired wattage. Press the SELECT key to select the wattage and to return to the “Enter Method Parameters” screen.

| ENTER METHOD PARAMETERS | | | | | | |
|-------------------------|-------|------|-------|------|-----|---------|
| STAGE | POWER | RAMP | PSI | ° C | S | HOLD |
| | MAX | % | | | | |
| 1 | XXXXW | XXX | XX:XX | XXXX | XXX | X XX:XX |
| 2 | XXXXW | XXX | XX:XX | XXXX | XXX | X XX:XX |

Press Select to Change

11. Use the arrow keys to highlight the next parameter to be edited. Use the numerical keys to enter % power, ramp time, PSI, temperature and/or hold time.

Note: Based on the vessel type chosen for the method, the instrument will not accept pressures or temperatures higher than the maximum allowable parameters for the selected vessel. If a parameter higher than the maximum for the vessel is entered, a “beep” will sound, and the entered parameter will not be stored. If no control is selected, the instrument will not accept pressures and temperatures. The following table indicates the maximum pressure and temperature for each vessel which can be utilized in the MARS instrument.

| Vessel Type | Max. Pressure (psi) | Max Temperature (°C) |
|-------------|---------------------|----------------------|
| HP-500 | 350 | 210 |
| XP-1500 | 800 | 240 |
| | 600 | 260 |
| | 100 | 300 |
| ACV/QDV | <200 | 200 |
| UDV/HDV | 600 | 200 |
| PFA | 120 | 200 |
| Beaker | -- | 300 |
| HTV | -- | 115 |
| AutoVent | -- | -- |
| QXP | 600 | 300 |
| GreenChem | 200 | 200 |
| Xpress | -- | 260 |

12. If using the optional stirrer, use the arrow keys to highlight the stirrer speed. Press the SELECT key. The following screen will appear for choosing the desired stirrer speed.

| STAGE | POWER | RAMP | PSI | ° C | S | HOLD |
|-------|-------|------|-------|------|-----|---------|
| 1 | XXXXW | XXX | XX:XX | XXXX | XXX | X XX:XX |
| 2 | XXXXW | XXX | XX:XX | XXXX | XXX | X XX:XX |

STIRRER SPEED

0 = OFF
1 = LOW
2 = MEDIUM
3 = HIGH

Press Select to Choose

Note: For viscous and/or reactive samples, either low or medium stirrer speed should be selected. For samples with a viscosity similar to water, medium or high speed should be used. For inorganic samples, high speed should be used.

13. Using the arrow keys, highlight the desired stirrer speed. Press the “SELECT” key to select the stirrer speed and to return to the “Enter Method Parameters” screen.

| ENTER METHOD PARAMETERS | | | | | | |
|-------------------------|-------|------|-------|------|-----|---------|
| STAGE | POWER | RAMP | PSI | ° C | S | HOLD |
| | MAX | % | | | | |
| 1 | XXXXW | XXX | XX:XX | XXXX | XXX | X XX:XX |
| 2 | XXXXW | XXX | XX:XX | XXXX | XXX | X XX:XX |
| 3 | XXXXw | XXX | XX:XX | XXXX | XXX | X XX:XX |
| 4 | XXXXW | XXX | XX:XX | XXXX | XXX | X XX:XX |

Press Select to Change

CAUTION

If parameters and/or method information of a user method are edited and a new name is not entered, the new parameters will be saved under the original name.

Note: If a new name was not selected for an edited CEM Method or if a name is selected which already exists in the User Directory, one of the two following screens will appear.

Rename Method
CHANGES HAVE BEEN MADE TO A
CEM METHOD
PRESS SELECT TO EDIT METHOD NAME
PRESS HOME TO IGNORE CHANGES

or

Rename Method
A METHOD WITH THIS NAME
ALREADY EXISTS
PRESS SELECT TO EDIT METHOD NAME
PRESS HOME TO IGNORE CHANGES

23. Press the SELECT key. The “Method Name” screen will appear. Follow the necessary procedures outlined in steps 16 through 22 to complete the editing process.

Create Method

New methods can be created in the User Directory only. A maximum of 100 methods can be stored in the User Directory.

CEM Method Menu

| | |
|-----------------------|----------------|
| Edit/Create Method | Load Method |
|-----------------------|----------------|

'Start' Current Method
XXXXXXXX

1. Using the arrow keys, highlight "Edit/Create Method." Press the SELECT key.

Directory Menu

Edit/Create Method From:

| | |
|---------------|----------------|
| CEM Directory | User Directory |
|---------------|----------------|

2. Use the arrow keys to highlight "User Directory." Press the SELECT key.

User Directory

NEW METHOD
XXXXXX
XXXXXXXX
XXXXXXXXXXXXXX
XXXXXXXXXX
XXXXXXXXXX

3. Use the arrow keys to highlight "New Method." Press the SELECT key.

Vessel Selection

Select Vessel Type

| | | |
|-----------|--------------|-----------|
| HP-500 | OMNI/XP-1500 | ACV/QDV |
| UDV/HDV | HTV | PFA |
| BEAKER | SRV | QXP |
| Xpress | ACV/LEV | CleanChem |
| GreenChem | | |

Note: If the instrument is equipped with The Xpress optional IR control only, the above screen will not appear.

4. Using the arrow keys, highlight the type vessel to be used for the method. Press the "SELECT" key.

Note: If "SRV" is selected in step 4 as the vessel to be utilized, only "Standard Control" or "Power/Time Control" can be highlighted and selected in step 6.

Sample Selection

Sample Type

ORGANIC
INORGANIC
WATER

Note: If “Xpress” is the selected vessel, a sample type must be selected. If “Xpress” is not selected, the above screen will not appear.

5. Using the arrow keys, highlight the sample type to be used for the method. Press the “SELECT” key.

Control Selection

| | |
|---|--|
| Select Control Type | |
| STANDARD CONTROL RAMP TO TEMPERATURE RAMP TO PRESSURE POWER/TIME CONTROL MICROVAP | |

Note: If the MARS is equipped with RTP-300 Plus or Xpress temperature control, CEM recommends the use of “Ramp to Temperature” control type.

6. Using the arrow keys, highlight the type control to be used for the method. Press the “SELECT” key. Based on the type control selected, one of the following screens will appear.

Method Parameters

| | | | | | | | |
|-------------------------|-------|-----|-------|------|-----|---|-------|
| ENTER METHOD PARAMETERS | | | | | | | |
| STAGE | POWER | | TIME | PSI | °C | S | HOLD |
| | MAX | % | | | | | |
| X | 400W | 000 | 00:00 | 0000 | 000 | 0 | 00:00 |
| Press Select to Change | | | | | | | |

Standard Control with Optional Stirrer

| | | | | | | | |
|-------------------------|-------|-----|-------|------|-----|---------|-------|
| ENTER METHOD PARAMETERS | | | | | | | |
| STAGE | POWER | | RAMP | PSI | °C | | HOLD |
| | MAX | % | | | | CONTROL | |
| 1 | 400W | 000 | 00:00 | 0000 | 000 | | 00:00 |
| Press Select to Change | | | | | | | |

Ramp to Temperature without Optional Stirrer

| | | | | | | | |
|-------------------------|-------|-----|-------|------|-----|---|-------|
| ENTER METHOD PARAMETERS | | | | | | | |
| STAGE | POWER | | RAMP | PSI | °C | S | HOLD |
| | MAX | % | | | | | |
| 1 | 400W | 000 | 00:00 | 0000 | 000 | 0 | 00:00 |
| Press Select to Change | | | | | | | |

Ramp to Pressure with Optional Stirrer

| | | | | | |
|-------------------------|-------|-----|-------|--|---|
| ENTER METHOD PARAMETERS | | | | | |
| STAGE | POWER | | TIME | | S |
| | MAX | % | | | |
| X | 400W | 000 | 00:00 | | 0 |
| Press Select to Change | | | | | |

Power/Time Control with Optional Stirrer

| ENTER METHOD PARAMETERS | | | | | | | |
|-------------------------|-------|------|-------|------|---------|------|-------|
| STAGE | POWER | RAMP | DELTA | ° C | S | HOLD | |
| | MAX | % | | | CONTROL | | |
| 1 | 400W | 000 | 00:00 | 0000 | 000 | 0 | 00:00 |

Press Select to Change

Microvap

7. Use the arrowkeys to highlight the wattage. Press the SELECT key. The following screen will appear for selecting the desired wattage.

| STAGE | POWER | S | HOLD |
|-------|-------|---|-------|
| 1 | 400W | X | XX:XX |
| 2 | 800W | X | XX:XX |
| | 1600W | X | XX:XX |

Press Select to Change

8. Using the arrow keys, highlight the desired wattage. Press the SELECT key to select the wattage and to return to the “Enter Method Parameters” screen.

Note: General guidelines for 100% power are as follows:

| | |
|-------------------|------------|
| 1 - 2 Vessels | 400 watts |
| 3 - 5 Vessels | 800 watts |
| 6 or more Vessels | 1600 watts |

| ENTER METHOD PARAMETERS | | | | | | | |
|-------------------------|-------|------|-------|------|---------|------|-------|
| STAGE | POWER | RAMP | PSI | ° C | S | HOLD | |
| | MAX | % | | | CONTROL | | |
| 1 | 400W | 000 | 00:00 | 0000 | 000 | 0 | 00:00 |

Press Select to Change

9. Use the arrow keys to highlight the next parameter. Use the numerical keys to enter % power, ramp time, PSI, temperature and/or hold time.

Note: Based on the vessel type chosen for the method, the instrument will not accept pressures or temperatures higher than the maximum allowable parameters for the selected vessel. If a parameter higher than the maximum for the vessel is entered, a “beep” will sound, and the entered parameter will not be stored. If no control is selected, the instrument will not accept pressures and temperatures. The following table indicates the maximum pressure and temperature for each vessel which can be utilized in the MARS instrument.

15. Press the "NEXT" key.

Method Information

Method Information

SAMPLE DESCRIPTION:
REAGENTS:
NUMBER OF VESSELS: 0 0
AV. SAMPLE WT.: 0.00 GM
AV. SAMPLE VOL.: 000mL

Press Select to Change

16. Using the arrow keys, highlight the first field of method information for which data is to be entered.

17. If "Sample Information" or "Reagents" is highlighted in step 15, press the "SELECT" key. The applicable screen will appear.

SAMPLE DESCRIPTION:

0 1 2 3 4 5 6 7 8 9 A B C D E F G H I J
K L M N O P Q R S T U V W X Y Z Á Â Ã Ä
Å Ç È É Ê Ë Ì Í Î Ï Ò Ó Ô Õ Ö Ù Ú Û Ü .

SPACE DELETE

or

REAGENTS:

0 1 2 3 4 5 6 7 8 9 A B C D E F G H I J
K L M N O P Q R S T U V W X Y Z Á Â Ã Ä
Å Ç È É Ê Ë Ì Í Î Ï Ò Ó Ô Õ Ö Ù Ú Û Ü .

SPACE DELETE

18. Using the arrow keys, highlight the first letter or number of the information to be entered. Press the "SELECT" key. Continue selecting the letters/numbers and pressing the "SELECT" key for each letter/number (24 maximum) until the desired information is displayed on the screen. If additional information is required, use the arrow keys to highlight the desired field of information for which data is to be entered and continue with step 18. If information is not desired in the other fields, press the "NEXT" key to return to the Main Menu.

19. If "Number of Samples," "Average Sample Weight" or "Average Sample Volume" is selected in step 15, use the numerical keys to enter the desired information. Use the arrow keys to highlight additional fields of information which are to be entered. When all information is entered, press the "NEXT" key to return to the Main Menu.

Note: If a name is entered which already exists in the User Directory, the instrument will not permit the user to save the method. The following screen will appear.

Rename Method

A METHOD WITH THIS NAME
ALREADY EXISTS

PRESS SELECT TO EDIT METHOD NAME

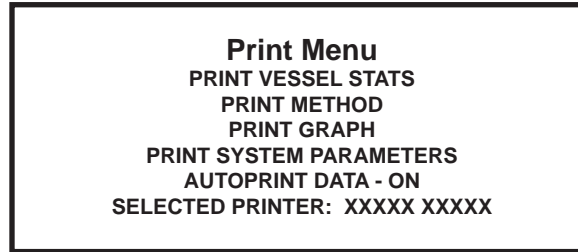
PRESS HOME TO IGNORE CHANGES

20. Press the "SELECT" key. The "Method Name" screen will appear. Follow the necessary procedures outlined in steps 13 through 18 to complete the process of creating a method.

21. To print a copy of the method as created, press the "PRINT" key.

Print

22. To print a copy of the method as created, press the "Print" key.



23. Using the arrow keys, highlight "Print Method." Press the SELECT key. Press the HOME key to return to the Main Menu.

Load Method

A method can be loaded from either the CEM Directory or the User Directory.

CEM Method Menu

| | |
|-----------------------|----------------|
| Edit/Create Method | Load Method |
|-----------------------|----------------|

'Start' Current Method
XXXXXXXX

- To load a method, use the arrow keys to highlight "Load Method." Press the SELECT key.

Note: If the method is to be performed is showing on the screen as the current method, press the START key.

Directory Menu

Edit/Create Method From:

| | |
|---------------|----------------|
| CEM Directory | User Directory |
|---------------|----------------|

- Use the arrow keys to highlight either "CEM Directory" or "User Directory." Press the SELECT key.

CEM Menu

'Select' Method to Edit:
XXXXXXXXXX
XXXXXXXXXX
XXXXXXXXXX
XXXXXXXXXX
XXXXXXXXXX

or

User mENU

'Select' Method to Edit:
NEW METHOD
XXXXXX
XXXXXXXXXX
XXXXXX XXXXXX
XXXXXXXXXX

- Use the arrow keys to highlight the method to be performed. Press the SELECT key to return to the Main Menu. The loaded method will appear on the Main Menu as the "current method."
- To review the parameters of the current method displayed on the screen, press the "1" key. Based on the selected method, a screen such as the one below will be displayed on the screen.

ENTER METHOD PARAMETERS

| STAGE | POWER MAX | RAMP % | PSI CONTROL | ° C | S | HOLD |
|-------|--------------|-----------|----------------|------|-----|---------|
| 1 | 000W | 000 | 00:00 | 0000 | 200 | X 00:00 |
| 2 | 000W | 000 | 00:00 | 0000 | 200 | X 00:00 |
| 3 | 000W | 000 | 00:00 | 0000 | 200 | X 00:00 |
| 4 | 000W | 000 | 00:00 | 0000 | 200 | X 00:00 |

Press Select to Change

Perform Method

WARNING

CEM recommends that a post-run cool down time be used for each digestion performed in the MARS instrument to prevent the possibility of operator burns or acid spills.

CAUTION

To lengthen the lifetime of the display screen, CEM recommends that a screen saver time be used at all times.

WARNING

Proper precautions must be taken to avoid contact with reagents or reagent vapors. Protective gear should be worn as outlined in the user's safety program for hazardous materials and the reagent manufacturer's material safety data sheet. Refer to these guidelines for proper handling and disposal of the reagent.

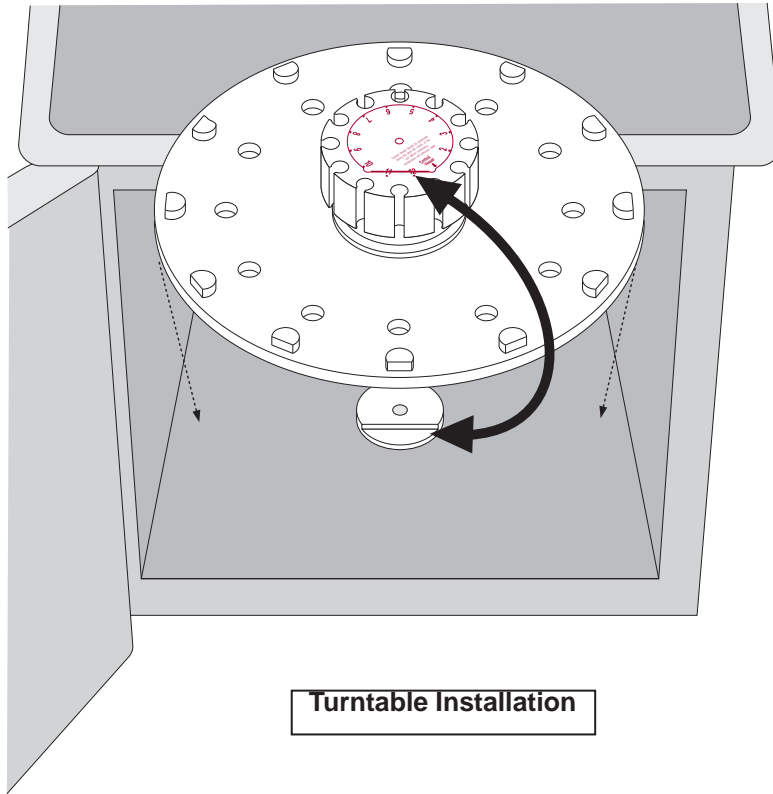
WARNING

ReactiGuard alerts the operator to the occurrence of an event with a vessel; therefore, CEM recommends that ReactiGuard be "on" at all times.

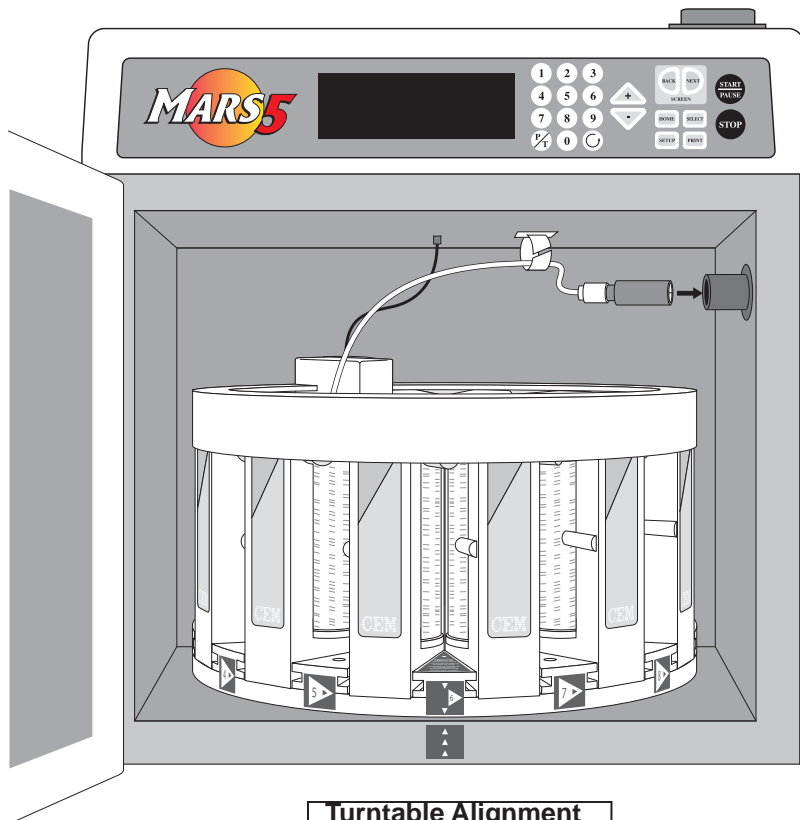
WARNING

Use extreme caution while attempting to identify the underlying cause(s) of a detected vessel event. Always wear protective gear such as gloves, a lab coat, eye protection, etc.

1. Prepare the vessels selected for the digestion in accordance with procedures outlined in the Vessel Manual. Note: Minimum volume for the MARS cavity is 10mL of acid or 50mL of water.
2. Install the turntable into the instrument, ensuring that the flat edge on the bottom of the turntable corresponds with the flat edge of the turntable lug (figure 9, page 45). Note: If using Plus vessels, the vessels can be installed into the turntable prior to turntable installation into the
3. instrument cavity.
4. If using temperature and/or pressure control, ensure that the appropriate sensors are installed in the control vessel.
5. Install the vessels in the turntable. Place the ESP into the center of the turntable with the pressure line attached to the control vessel. Press the turntable key to rotate the turntable for ease of vessel installation. The control vessel should be installed last in the control vessel position. If all positions of the turntable are not utilized, arrange the vessels symmetrically.
6. Place the vessel retaining ring on the vessels with the notch of the retaining ring resting on the control vessel.



Turntable Installation



Turntable Alignment

6. If the instrument is equipped with the Xpress control option only, simply place the turntable on the drive lug.
7. Align the ESP with the connector port. Rotate the ESP-1500 Plus while gently pushing it into the connector port until it slips into the correct position. This rotation is to align the ESP-1500 Plus and the connector port. Once the connector is properly aligned, push the ESP-1500 Plus into the connector port until the polypropylene guard is fully seated against the connector port.

CAUTION

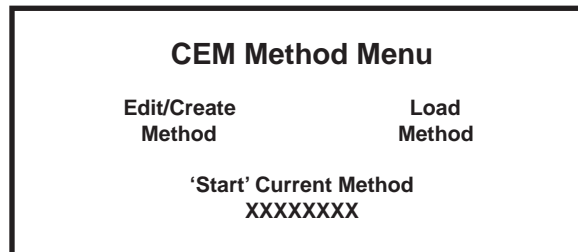
During installation of the ESP-1500 Plus, use caution to prevent loosening the pressure line nut which can cause leakage, leading to corrosion of the connections on the sensor and bulkhead fitting.

CAUTION

Ensure that the pressure line of the ESP-1500 Plus does not become entangled in the RTP-300 Plus temperature controller.

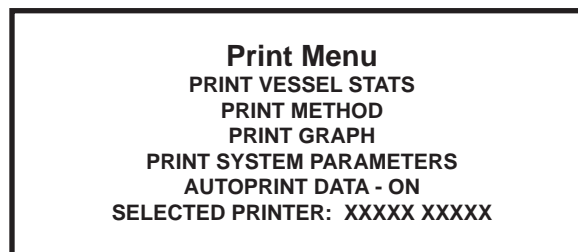
Note: If using the optional external water line pressure controller, contact CEM for instructions for proper installation instructions.

8. Without crossing over the pressure tubing, snap the RTP-300 Plus into the connector located in the center of the roof of the cavity.
9. Position the pressure tubing in the guide ring mounted on the roof of the cavity.



Note: Ensure that the method to be performed is shown as the “current method” on the Main Menu. If necessary, refer to “Load Method” in this manual to load the applicable method.

10. If data is to be printed during performance of the method, press the “PRINT” key to ensure that “Autoprint Data” is on.



11. If necessary, use the arrow keys to highlight “Autoprint Data.” The “SELECT” key toggles the function on and off. Press the “HOME” key to return to the main menu.
12. Press the “START” key.
13. If using the ESP-1500 Plus, and it is reading in excess of 50 psi, the following warning screen will appear.

WARNING

**CANNOT ZERO ESP-1500 Plus
RUN ABORTED**

1 = RESET TEST
2 = ZERO AND CONTINUE
9 = BYPASS ESP-P1500 Plus ZERO

14. Press “1” to reset the method, 2 to force the instrument to zero the ESP-1500 Plus and continue the method, or “9” to bypass the reading and continue with the method.


15. During the method, screens displayed will differ based on the selected type of control as outlined below.


Note: A moving wave on the screen will indicate that microwaves are being generated. A flat line will indicate that no microwaves are present.

WARNING


Because cardiac pacemakers require magnets to control operation during checkout, if the MARS is equipped with a sample stirrer, some danger exists if a pacemaker is positioned in close proximity to the instrument cavity. If the instrument is suspected of interfering with the operation of a pacemaker, the instrument should be turned off or the pacemaker wearer should move away from the instrument.


Standard

| | | | |
|---|---|---------|------|
| STAGE X OF X | METHOD: XXXXXXXX | XX% | XXXW |
| |  | | |
| CURRENT | XX:XX | XXX PSI | XXX° |
| PROGRAM | XX:XX | XXX PSI | XXX° |
| STATUS: HEATING SAMPLE TO XXX PSI, XXX° | | | * |

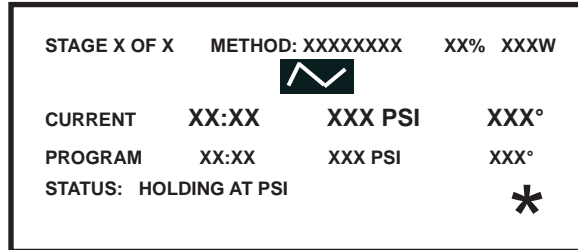
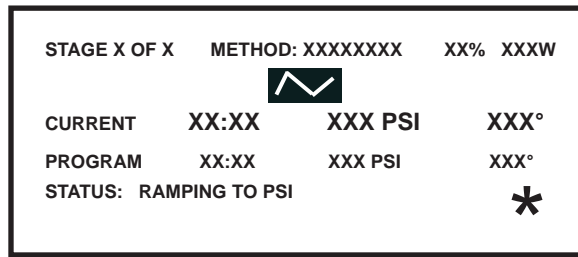
| | | | |
|--------------------------------------|---|---------|------|
| STAGE X OF X | METHOD: XXXXXXXX | XX% | XXXW |
| |  | | |
| CURRENT | XX:XX | XXX PSI | XXX° |
| PROGRAM | XX:XX | XXX PSI | XXX° |
| STATUS: CONTROLLING AT XXX PSI, XXX° | | | * |

Ramp to Temperature

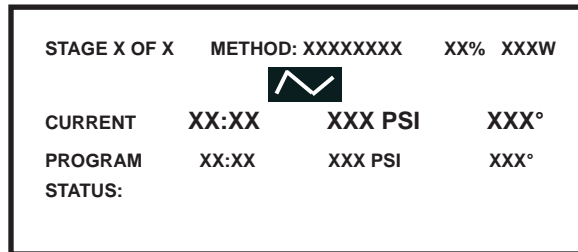
| | | | |
|-------------------------|---|---------|------|
| STAGE X OF X | METHOD: XXXXXXXX | XX% | XXXW |
| |  | | |
| CURRENT | XX:XX | XXX PSI | XXX° |
| PROGRAM | XX:XX | XXX PSI | XXX° |
| STATUS: RAMPING TO XXX° | | | * |

| | | | |
|-------------------------|---|---------|------|
| STAGE X OF X | METHOD: XXXXXXXX | XX% | XXXW |
| |  | | |
| CURRENT | XX:XX | XXX PSI | XXX° |
| PROGRAM | XX:XX | XXX PSI | XXX° |
| STATUS: HOLDING AT XXX° | | | * |

Ramp to Pressure

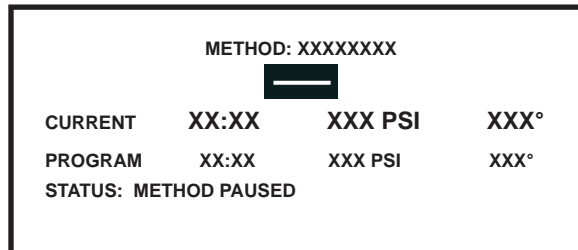


Power/Time



Pause

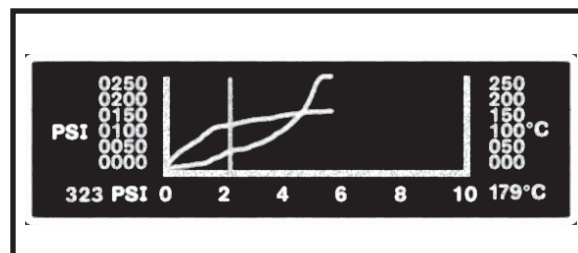
16. If the “PAUSE” key is pressed during performance of a method, the following screen will be displayed.



Note: The flat line indicates that no microwaves are being generated.

17. If the “P/T” key is pressed during performance of a method (for any control type), a graph of the current status of the method will be displayed on the screen.

Graph



Door Open Message

18. If the instrument door is opened during performance of a method, the following screen will be displayed.

```

METHOD: XXXXXXXX
  ───
CURRENT  XX:XX   XXX PSI   XXX°
PROGRAM  XX:XX   XXX PSI   XXX°
STATUS: METHOD PAUSED

```

Note: The flat line indicates that no microwaves are being generated.

Power Adjustment

19. If the instrument adjusts the circuitry to accomplish a new power setting, the following screen will be displayed.

```

METHOD: XXXXXXXX
  ───
CURRENT  XX:XX   XXX PSI   XXX°
PROGRAM  XX:XX   XXX PSI   XXX°
STATUS: ADJUSTING POWER

```

20. If the temperature or pressure in the control vessel exceeds the maximum parameter for the vessel type, the method will be aborted, and the instrument will proceed to post-run “cool down” operation.

```

METHOD: XXXXXXXX
ABORTED DUE TO HIGH PRESSURE/TEMPERATURE

  XX:XX  XXX PSI  XXX°
  COOL DOWN
  PRESS ANY KEY

```

Note: The selected post-run cool down time and the current pressure and temperature will be displayed. The instrument will count down the cool down time. At the end of the cool down time, four audible beeps will sound.

```

TEMPGUARD TEMPERATURE ERROR

VESSEL XX EXCEEDS
MAXIMUM ALLOWABLE TEMPERATURE

TEST ABORTED

PRESS ANY KEY TO CONTINUE

```

If TempGuard™ (optional) detects a vessel temperature which exceeds the maximum temperature for the vessel type, the TempGuard™ temperature error appears, indicating the vessel number in which the temperature is excessive. The method is aborted, and the instrument will proceed to post-run “cool down” operation. Remove the vessels from the instrument and find the problem with the vessel.

21. When the method is complete or if the “STOP” key is pressed, the instrument will proceed to post-run “cool down” operation if it is turned on in the system Setup procedure.

WARNING

CEM recommends that a post-run cool down time be used for each digestion performed in the MARS instrument to prevent the possibility of operator burns or acid spills.

**METHOD: XXXXXXXX
COMPLETE
XX:XX XXX PSI XXX°
COOL DOWN
PRESS ANY KEY**

Note: The selected post-run cool down time and the current pressure and temperature will be displayed. Once the pressure drops below 50 psi, the screen will read "<50 psi" rather than an actual pressure reading. The instrument will count down the cool down time. At the end of the cool down time, four audible beeps will sound.

Note: The selected post-run cool down time and the current pressure and temperature will be displayed. Once the pressure drops below 50 psi, the screen will read "<50 psi" rather than an actual pressure reading. The instrument will count down the cool down time. At the end of the cool down time, four audible beeps will sound.

Note: With Xpress vessels and control, temperature data cease to be updated at the end of the cool down time because the turntable rotation will cease.

If the post-run cool down time is turned off in the system Setup procedure, once the method is complete or if the "STOP" key is pressed, press the "P/T" key to display the current pressure and/or temperature in the control vessel to assist in determining when the vessels can be safely removed from the instrument cavity.

Refer to instructions for specific type of vessels to determine proper procedures for removing vessels from instrument and turntable.

Pressure/Temperature Display

**PRESSURE: XXX PSI
TEMPERATURE: XXX °C
RTP-300 Plus ESP-1500 Plus (XXX-XXXX)**

Note: If using the Xpress, EST-300 Plus and/or the ESP-1500 Plus sensors, the applicable sensor(s) will be identified on the above screen.

If using the EST-300 and the "Remove EST-300" function is turned on in the System Setup procedure, the following screen will flash at the end of the post-run cool down time to remind the operator to remove the EST-300 from the snap-in ceiling connector prior to removal of the control vessel from the instrument cavity.

**REMOVE EST-300 Plus
BEFORE REMOVING
CONTROL VESSEL**

CAUTION

When removing the EST-300 from the bulkhead fitting, pull the EST-300 straight down. Excessive lateral pressure can damage and/or break the bulkhead fitting or the fiberoptic probe.

Print

25. To print either vessel temperature statistics (X-press option only), a graph of the last test, the results of the last 6 tests performed or a copy of the selected method, press the "PRINT" key.

Print Menu
 PRINT VESSEL STATS
 PRINT METHOD
 PRINT GRAPH
 PRINT SYSTEM PARAMETERS
 AUTOPRINT DATA - ON
 SELECTED PRINTER: XXXXX XXXXX

26. Using the arrow keys, highlight the desired print function. Press the “SELECT” key.

Note: “Print Vessel Stats” is a check of Xpress vessels to determine which vessels achieved the setpoint temperature.

If “Print Vessel Stats” is selected, the printer will print a list of the 40 Xpress vessels, indicating if the vessel reached the set temperature (1 = “yes,” 0 = “no”). For vessels which did not acheive the set tempeature, the actual temperature reached is printed as shown below.

| | | |
|--|---|-----|
| Vessel Statistics: Reached Temp. 0 = no, 1 = yes | | |
| Vessel 1: | 1 | |
| Vessel 2: | 1 | |
| Vessel 3: | 1 | |
| Vessel 4: | 1 | |
| Vessel 5: | 0 | 194 |
| Vessel 6: | 1 | |
| Vessel 7: | 1 | |
| Vessel 8: | 0 | 195 |

If “Print Graph” is selected, the following screen will appear.

Print Graph Menu

1. XXXXXXXX XX/XX/XXXX
2. XXXXXXXX XX/XX/XXXX
3. XXXXX XXXXX XX/XX/XXXX
4. XXXXXX XX/XX/XXXX
5. XXXXX XXXXXXXX XX/XX/XXXX

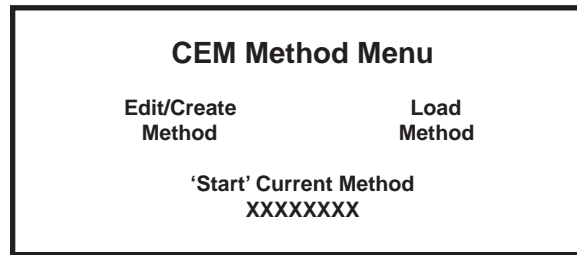
27. Using the arrow keys, highlight the appropriate method to graph. Press the “SELECT” key. The graph will be printed and the following screen will be displayed.

Graphing Data

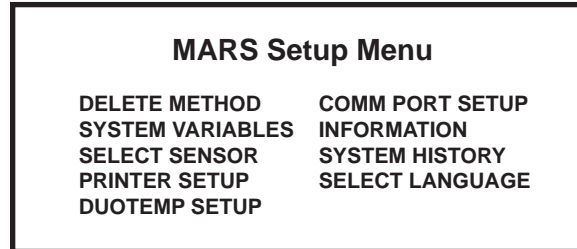
METHOD NAME: XXXXXXXX
 DATA COLLECTED: XX/XX/XXXX

28. Press the “BACK” key to return to the Print Menu or press the “HOME” key to return to the main menu.

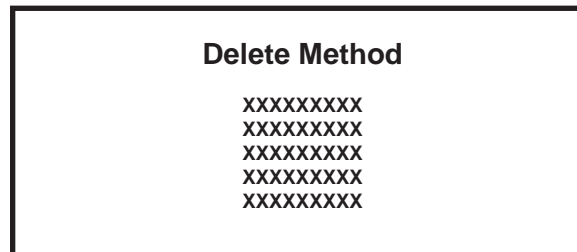
Delete Method



1. From the Main Menu, press the SETUP key.

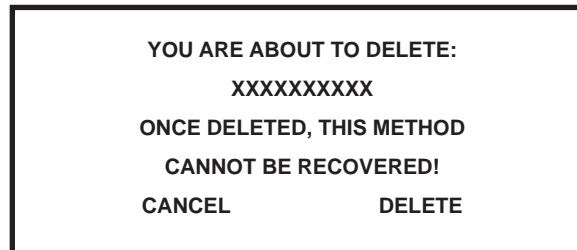


2. Using the arrow keys, highlight "Delete Method." Press the "SELECT" key.



3. Using the arrow keys, highlight the method to be deleted from the user menu. Press the "SELECT" key.

Note: Methods stored in the CEM Directory cannot be deleted.



Note: If the decision is made to not delete the method, use the arrow keys to highlight "Cancel." Press the "SELECT" key to cancel the method deletion.

4. Using the arrow keys, highlight "Delete" to delete the selected method. Press the "SELECT" key.

Maintenance, Troubleshooting and Service

This section covers routine maintenance, troubleshooting and minor parts replacement. For service and repair, contact the CEM Service Department or local CEM subsidiary or distributor. A routine preventive maintenance program is recommended to ensure optimum performance of the MARS.

WARNING

This instrument utilizes high voltages and microwave radiation. Instrument service and repair should be performed only by technicians trained in repair and maintenance of high voltage and microwave power systems.

WARNING

Proper precautions must be taken to avoid contact with reagents or reagent vapors. Protective gear should be worn as outlined in the user's safety program for hazardous materials and the reagent manufacturer's material safety data sheet. Refer to these guidelines for proper handling and disposal of reagents.

Routine Maintenance and Cleaning

After Each Sample Test - When using Omni Vessels, MARS Xpress Vessels or open-vessel technology, wipe the entire cavity with warm water applied with a soft cloth. If necessary, use a mild cleanser, but rinse thoroughly to avoid leaving any residue or reagents

Daily - Remove the ESP Plus cable connection from the connector port and thoroughly clean the connector with a paper towel or soft cloth. Thoroughly wipe and clean both the inside and outside surfaces of the connector. If necessary, dampen the towel with isopropyl alcohol to assist in cleaning.

Daily - Remove the ESP Plus cable connection from the connector port and thoroughly clean the connector with a paper towel or soft cloth. Thoroughly wipe and clean both the inside and outside surfaces of the connector. If necessary, dampen the towel with isopropyl alcohol to assist in cleaning.

Weekly - Clean and dry Omni, MARS Xpress and open vessels.

Weekly - When using vessel types other than Omni, MARS Xpress, or open vessels, wipe the cavity with warm water applied with a soft cloth. If necessary, use a mild cleanser, but rinse thoroughly to avoid leaving any residue on the cavity. Do not use abrasive cleansers because they may scratch the fluoropolymer cavity coating, degrading its ability to resist corrosive vapors. Rinse and thoroughly dry all cleaned areas.

Weekly - Clean the exhaust outlet by removing the exhaust hose and wiping the space inside the exhaust outlet with a paper towel or disposable cloth. To clean the exhaust hose, disconnect it from the blower exhaust duct, flush it with water and allow it to dry before reconnecting it to the blower duct.

WARNING

Acid tends to condense and collect inside the blower duct and can cause severe skin burns. Wear rubber gloves when cleaning the cavity exhaust outlet and/or hose.

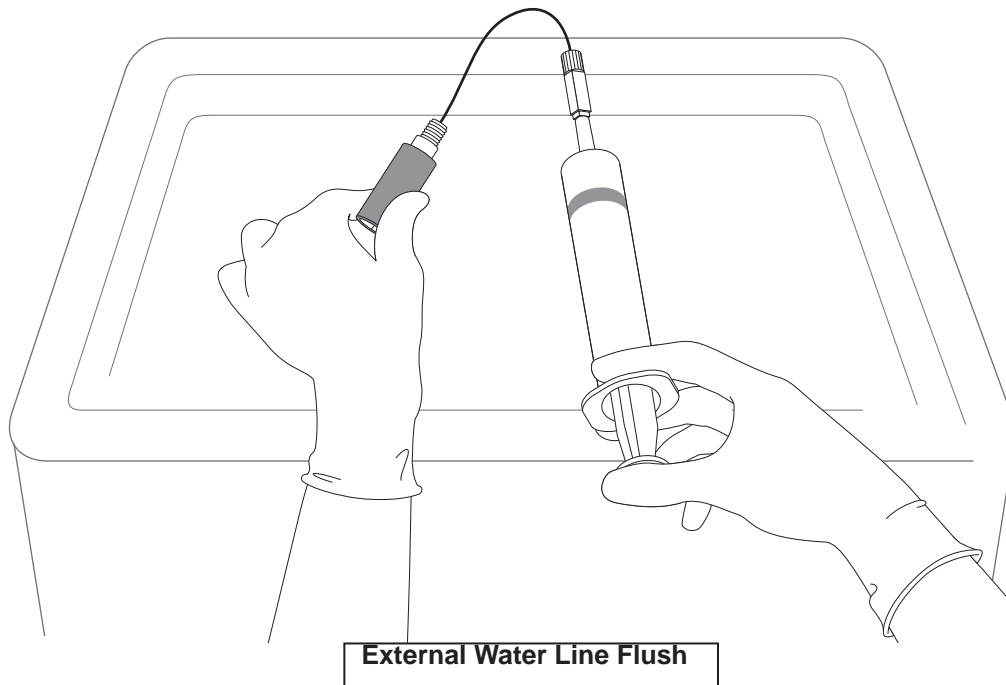
Weekly - Examine the door, cavity edge and door interlocks to verify that they are clean and, if applicable, working properly. Ensure there has been no loosening of or damage to the door hinges or latch. Ensure that the door closes securely.

Microwave leakage measurement - Refer to the instructions in this manual.

Microwave power measurement - Refer to the instructions in this manual.

Cleaning of ESP-1500 Plus

1. Prepare a 60cc syringe fitted with a 7" length of 0.060" diameter Teflon tubing.
2. Remove the pressure line from the ESP-1500 Plus.
3. Fill the syringe with 20mL of deionized water. Insert the tubing attached to the syringe into the ESP-1500 Plus until it touches the bottom of the pressure fitting.
4. Ensuring that the ESP-1500 Plus is placed so that any excess water will be safely contained, flush the ESP-1500 Plus with the entire 20mL of deionized water.
5. Remove the tubing and syringe from the ESP-1500 Plus. Fill the syringe with air.
6. Reinsert the tubing into the ESP-1500 Plus. Using the syringe, push the air into the ESP to help remove the excess water.



External Water Line Flush

The external water line pressure control system should be flushed at the end of each shift or workday to prevent corrosion.

1. Disconnect the pressure line from the control vessel. Place an empty beaker in the instrument cavity or on the turntable. Place the disconnected end of the pressure line in the beaker.
2. If applicable, remove the syringe from its packing. Remove and discard the plastic tip attached to the syringe.
3. Fill the syringe with distilled or deionized water.
4. Attach the syringe to the open end of the external flush fitting.
5. Push the plunger on the syringe to force all the water from the syringe into the pressure system. The water will drain from the pressure tubing into the beaker. Discard the water in accordance with applicable safety procedures.
6. The syringe may be left attached to the flush fitting.

Microwave Leakage Measurement

The door and cavity are very durable and are designed for reliable operation under severe laboratory conditions. External radiation checks are performed on the MARS at several points in the manufacturing process, ensuring that leakage from the finished instrument is only a fraction of that allowed by U.S. law (5 mW/cm²).

The door of the MARS is equipped with a safety interlock system which stops the generation of microwave energy when the door is opened or ajar. If the interlock system fails, a monitoring mechanism will blow the fuse(s) through which power is supplied to the magnetron, rendering the microwave power system inoperable.

To verify that door seals and interlocks are working properly, the MARS should be tested periodically for microwave leakage. Use the following procedure to measure microwave leakage:

1. Create a method using a beaker as the selected vessel, 1200 watts, 100% power, 2 minutes ramp time, 0 pressure, 240°C temperature, stirrer off, and 0 hold time.
2. Place a beaker containing 100mL of water in a vessel position of the turntable.
3. Load the created method and press “Start” to begin the method.
4. Use a suitable RF field strength meter (microwave detector) such as the Holaday Model HI-1500 (available from CEM Corporation, P/N 300500). Slowly move the RF probe around the door perimeter and around the fan grills to check for microwave leakage.

NOTE

CEM does not recommend use of meters available in electronics stores because they are prone to give erroneous readings and lack the necessary sensitivity to properly test an instrument for microwave leakage.

The U.S. Government defines excessive microwave leakage as 5 mW/cm². If the instrument shows excessive microwave leakage, do not attempt further operation. Contact the CEM Corporation Service Department or the local CEM subsidiary or distributor for further instructions.

Microwave Power Measurement

Use the following procedure to determine actual power output at 300, 600 and 1200 watts.

1. Install the turntable in the microwave cavity.
2. With the main menu displayed, highlight “Load Method.” Press the “SELECT” key. The “Directory Menu” screen will appear.
3. Use the arrow keys to highlight “CEM Directory.” Press the “SELECT” key. The “CEM Menu” screen will appear.
4. Use the arrow keys to highlight “400W Power Test.” Press the “SELECT” key to return to the main menu.
5. Place 1000 mL of ambient temperature (18-22 °C) deionized water in a 1000 mL Teflon® or polypropylene beaker.
6. Using a thermometer with 0.1 °C gradations, measure and record the initial water temperature, T_i . Ensure that the thermometer is immersed to its indicated immersion line prior to reading the temperature.
7. Remove the thermometer from the beaker. Carefully place the beaker in vessel #1 position on turntable. Gently close the door to avoid spilling any of the water.

NOTE

MARS Express instruments require the use of the CEM turntable adapter (134717) or removal of the sleeves from the turntable in order to place the beaker in the proper position for power measurement.

8. Press “Start.”

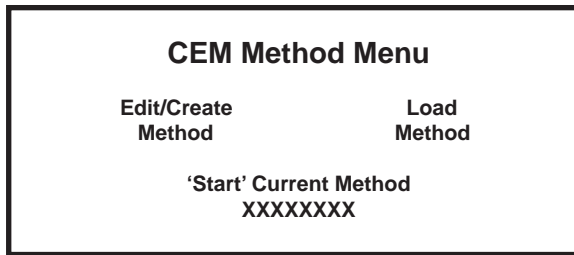
9. At the end of the programmed time (2 minute), remove the beaker from the microwave cavity. Stir the water thoroughly for 30 seconds, then measure and record the peak temperature reading. This is the final temperature, Tf.

The microwave power output is calculated as follows:

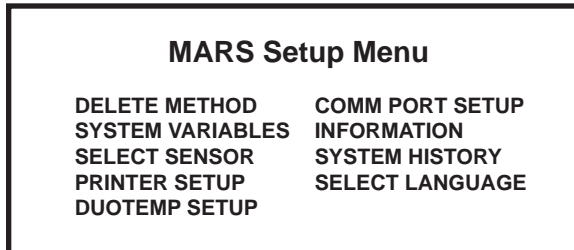
$$\text{Power in Watts} = 47 (T_f - T_i)$$

10. If the measured power is below 340W, repeat the microwave power measurement. If the power remains less than 340W, the instrument is not producing adequate microwave power at the 400W selection
11. Repeat steps 2 through 9 for the 800W and 1600W power tests.
12. If the measured power is below 680W for the 800W power test, repeat the power measurement. If the power remains less than 680W, the instrument is not producing adequate microwave power at the 800W selection.
13. If the measured power is below 1360W for the 1600W power test, repeat the power measurement. If the power remains less than 1360W, the instrument is not producing adequate microwave power at the 1600W selection.
14. If the instrument is not producing sufficient wattage, refer to the Troubleshooting Guide in this manual
15. Note: In order to perform an IEC power test, specialized equipment is required. CEM Corporation has provided this power test as a means of comparison between MARS instruments. The above power test incorporates a factor to convert the results of this test into an IEC wattage. Actual IEC power tests using specialized equipment are performed at CEM Corporation headquarters.

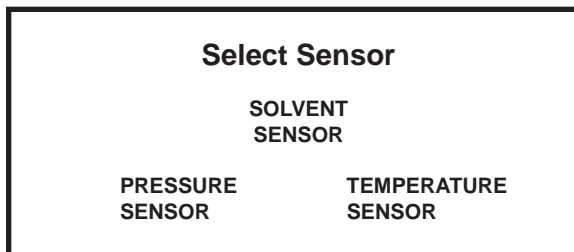
Pressure Calibration - ESP-1500 Plus



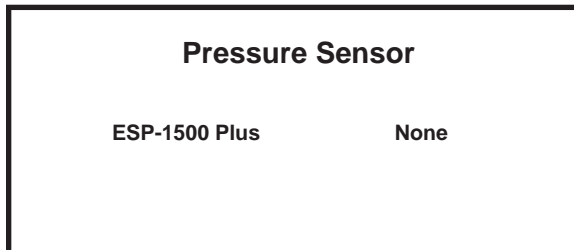
1. Press the SETUP key



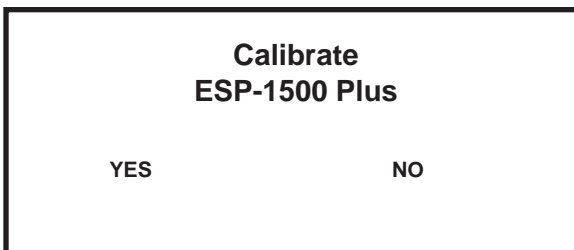
2. Using the arrow keys, highlight "Select Sensor." Press the SELECT key.



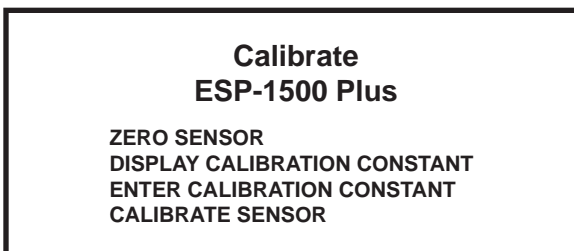
3. Using the arrow keys, highlight "Pressure Sensor." Press the SELECT key.



4. Using the arrow keys, highlight "ESP-1500 Plus." Press the SELECT key.



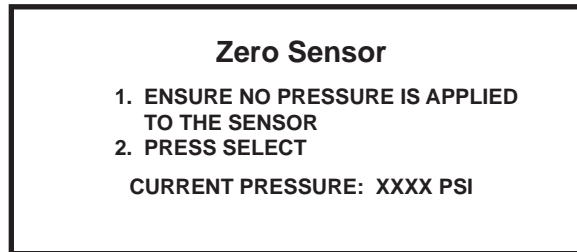
5. Using the arrow keys, highlight "Yes." Press the SELECT key. The following screen will be displayed.



6. Using the arrow keys, highlight the appropriate calibration function, and press the SELECT key.

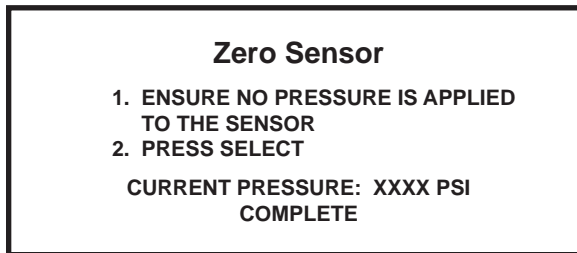
Zero Sensor

Note: To zero the sensor, continue with step 7. To display the calibration constant, proceed to step 9. To enter the calibration constant, proceed to step 10. To calibrate the ESP-1500 Plus, proceed to step 13.



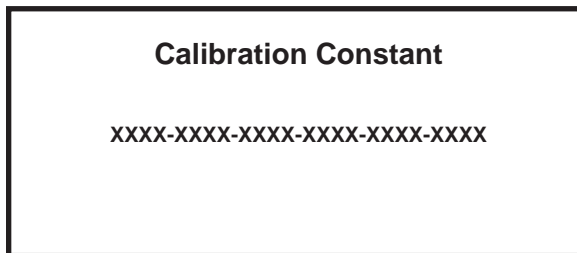
Note: “Zero Sensor” guarantees reset of the sensor to “0” for the ESP-1500 Plus.

7. Ensure that no pressure is applied to the sensor. Press the SELECT key. The following screen will be displayed, indicating that the procedure is complete.



8. Press the BACK key to return to the “Pressure Calibration” screen or the HOME key to return to the Main Menu.

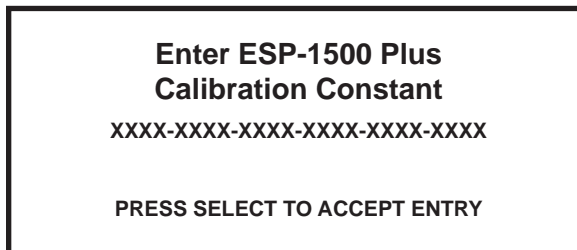
Display Calibration Constant



9. Record the calibration constant for future reference and/or entry if calibration of the ESP-1500 Plus is lost or distorted.

Enter Calibration Constant

10. Press the BACK key to return to the “Pressure Calibration” screen or the HOME key to return to the Main Menu.



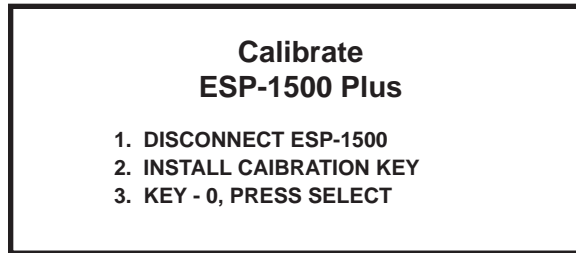
11. Use the numerical keys to enter the previous calibration constant for the ESP-1500 Plus.
12. Press the BACK key to return to the “Pressure Calibration” screen or the HOME key to return to the Main Menu.

Calibration

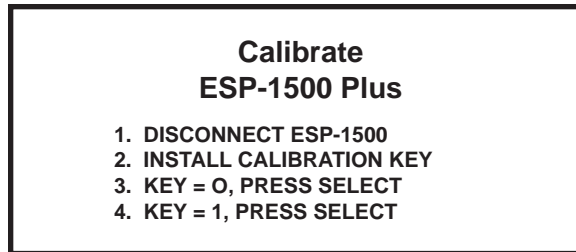
NOTE

The instrument door should remain open during pressure calibration. If the instrument door is closed and opened during calibration, the pressure/temperature screen will appear and all calibration information entered will be eliminated.

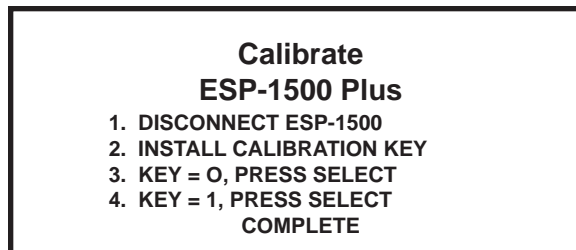
13. A CEM ESP/EST calibration device (p/n 565350) is required to calibrate the circuitry of the ESP-1500 Plus. Disconnect the sensor from the pressure/temperature connector in the right front side of the instrument cavity. Install the calibration device in the connector, ensuring that the calibration device locks into position. Set the calibration device on "0." Close the instrument door.



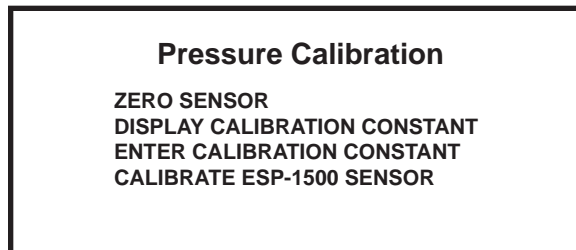
14. Wait approximately 3 seconds. Press the SELECT key.



15. Set the calibration device on "1." Wait approximately 3 seconds. Press the SELECT key.

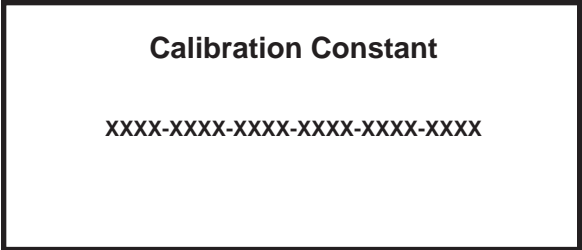


16. Press the BACK key to return to the "Pressure Calibration" screen.



17. Remove the calibration device from the connector.

18. Use the arrow keys to highlight "Display Calibration Constant." Press the SELECT key.



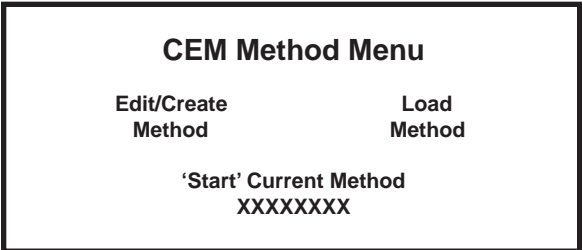
- 19. Record the new calibration constant for future reference or entry.
- 20. Press the “HOME” key to return to the main menu.

Verification of ESP-1500 Plus Pressure/Temperature Measurements

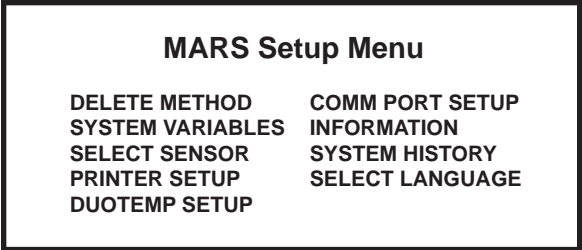
- 21. To verify proper operation of the ESP-1500 Plus pressure control system, perform the
- 22. procedures outlined below:
- 23. Refer to the applicable vessel (XP-1500 or HP-500) instructions in the Options section of this manual, and assemble and install a control vessel containing 50mL of distilled water.
- 24. Install the ESP-1500 Plus connector into the connector in the front right side of the cavity.
- 25. Access the CEM Directory, load the method “QC ESP/RTP,” and perform the method.

The final pressure stages of 200 psi should be reached with measured temperatures at 200°C ± 10°C.

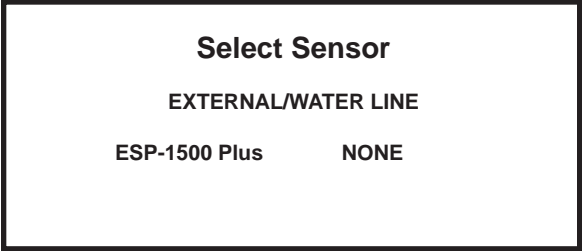
Pressure Calibration - External Water Line



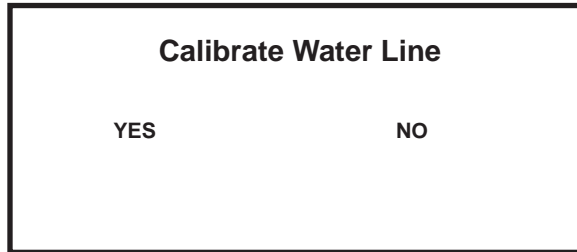
- 1. Press the SETUP key



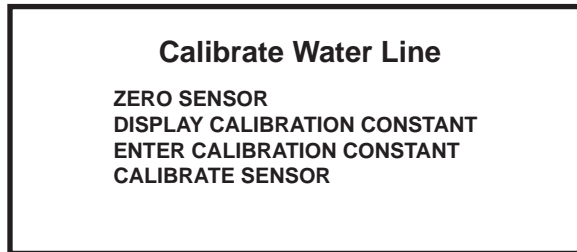
- 2. Using the arrow keys, highlight “Select Sensor.” Press the SELECT key.



- 3. Using the arrow keys, highlight “External/Water Line.” Press the SELECT key.



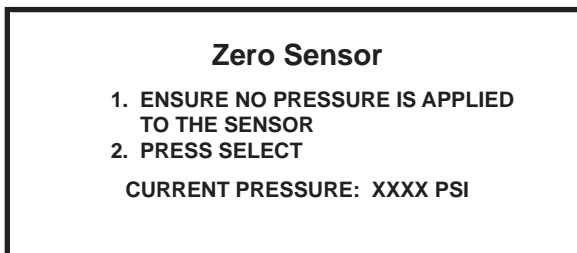
5. Using the arrow keys, highlight “Yes.” Press the SELECT key. The following screen will be displayed.



6. Using the arrow keys, highlight the appropriate calibration function, and press the SELECT key.

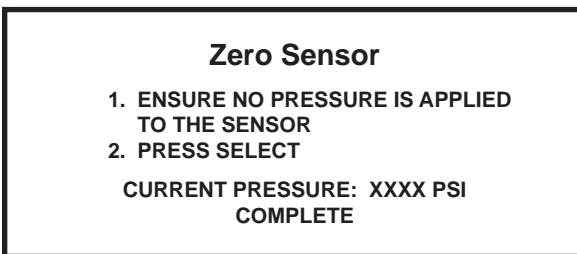
Zero Sensor

Note: To zero the sensor, continue with step 7. To display the calibration constant, proceed to step 9. To enter the calibration constant, proceed to step 10.



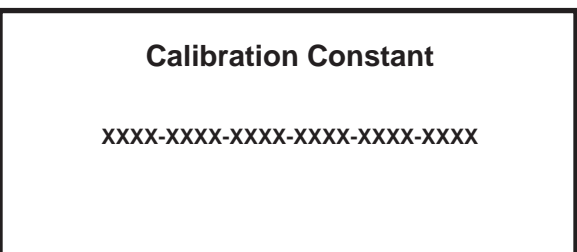
Note: “Zero Sensor” guarantees reset of the sensor to “0” for the ESP-1500 Plus or the external water line.

7. Ensure that no pressure is applied to the sensor. Press the SELECT key. The following screen will be displayed, indicating that the procedure is complete.



8. Press the BACK key to return to the “Pressure Calibration” screen or the HOME key to return to the Main Menu.

Display Calibration Constant



9. Record the calibration constant for future reference and/or entry if calibration of the external water line is lost or distorted.

Enter Calibration Constant

10. Press the BACK key to return to the “Pressure Calibration” screen or the HOME key to return to the Main Menu.

**Enter External Water Line
Calibration Constant**

XXXX-XXXX-XXXX-XXXX-XXXX-XXXX

11. Use the numerical keys to enter the previous calibration constant for the external water line.

12. Press the BACK key to return to the “Pressure Calibration” screen or the HOME key to return to the Main Menu.

Temperature Calibration - RTP-300 Plus

CEM Method Menu

| | |
|-----------------------|----------------|
| Edit/Create Method | Load Method |
|-----------------------|----------------|

‘Start’ Current Method
XXXXXXXX

1. Press the SETUP key

MARS Setup Menu

| | |
|------------------|-----------------|
| DELETE METHOD | COMM PORT SETUP |
| SYSTEM VARIABLES | INFORMATION |
| SELECT SENSOR | SYSTEM HISTORY |
| PRINTER SETUP | SELECT LANGUAGE |
| DUOTEMP SETUP | |

2. Using the arrow keys, highlight “Select Sensor.” Press the SELECT key.

Select Sensor

TEMPGUARD
SENSOR

| | |
|--------------------|-----------------------|
| PRESSURE SENSOR | TEMPERATURE SENSOR |
|--------------------|-----------------------|

3. Using the arrow keys, highlight “Temperature Sensor.” Press the SELECT key.

Temperature Sensor

RTP-300 Plus

| | |
|---------------|------|
| ESP-1500 Plus | None |
|---------------|------|

4. Using the arrow keys, highlight “RTP-300 Plus.” Press the SELECT key.

**Calibrate
RTP-300 Plus**
(GF NUMBER = XXX-XXXX)

ENTER GF NUMBER
CALIBRATE RTP-300 PLUS

5. Using the arrow keys, highlight “Enter GF Number.” Press the SELECT key.

**RTP-300 Plus
Enter GF Number**
XXX-XXXX

PRESS SELECT TO ACCEPT ENTRY.

6. Use the numerical keys to enter the GF Number printed on the RTP-300 Plus probe. Press the “SELECT” key to return to the calibration screen.

CAUTION

The GF Number printed on the RTP-300 Plus probe must be entered for each probe prior to use in order to accurately measure temperature.

**Calibrate
RTP-300 Plus**
(GF NUMBER = XXX-XXXX)

ENTER GF NUMBER
CALIBRATE RTP-300 PLUS

7. Use the arrow keys, highlight “Calibrate RTP-300 Plus.” Press the SELECT key.

**Calibrate
RTP-300 Plus**

1. PLACE PROBE IN STABLE BATH.
2. ENTER BATH TEMPERATURE XXX C
3. PRESS SELECT
CURRENT TEMPERATURE: XXX C

8. Insert the RTP-300 Plus into the connector in the center of the instrument cavity.
9. Place the RTP-300 Plus in a beaker of water. Using the numeric keyboard, enter the temperature of the water as indicated on the thermometer.
10. Press the “SELECT” key. The “current temperature” on the screen should read the same as the temperature entered in step 7.
11. If necessary, repeat steps 7 and 8 to verify proper calibration of the RTP-300 Plus.

Verification of RTP-300 Plus Temperature Measurements

To verify proper operation of the RTP-300 Plus temperature control system, perform the procedures outlined below:

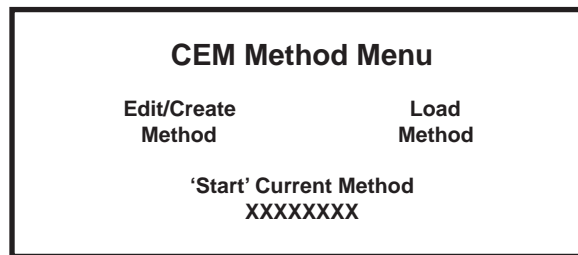
1. Refer to the applicable vessel (XP-1500 or HP-500 Plus) instructions in the Options section of this manual, and assemble and install a control vessel containing 50mL of distilled water.
2. Install the RTP-300 Plus connector on the temperature connector in the center of the roof of the instrument cavity.
3. Access the CEM Directory, load the method "QC ESP/RTP," and perform the method.

The final pressure stages of 200 psi should be reached with measured temperatures at $200^{\circ}\text{C} \pm 10^{\circ}\text{C}$.

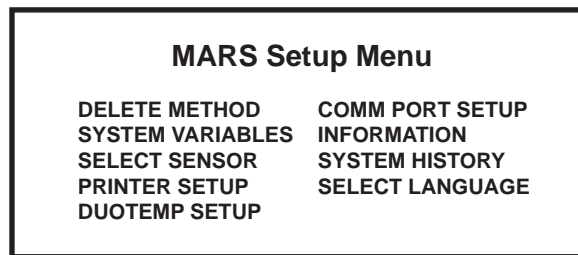
Temperature Calibration - IR Sensor(s)

Note: The Intelli-temp Calibrator Kit (907330 - 120V or 907430 - 240V) which includes the calibrator and adaptor is required to perform an IR calibration on the instrument.

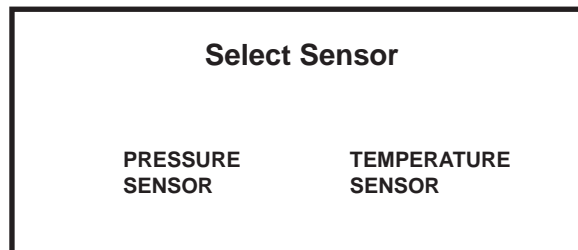
1. The instrument must be plugged into the electrical outlet and turned on.
2. Remove the plastic shield from the floor of the instrument.
3. Plug the Intelli-Temp calibrator into an electrical outlet close enough to the instrument for it to be placed on the instrument floor. Permit the calibrator to warm until the "Ready" light is illuminated.



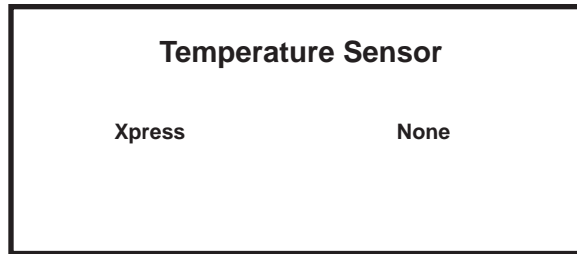
4. Press the SETUP key



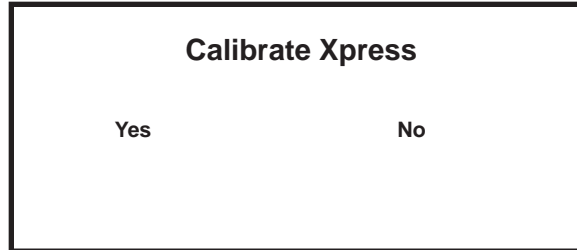
5. Using the arrow keys, highlight "Select Sensor." Press the SELECT key.



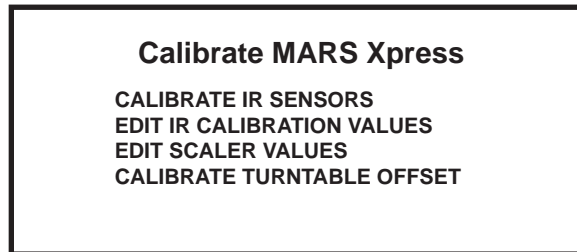
6. Using the arrow keys, highlight "Temperature Sensor." Press the SELECT key.



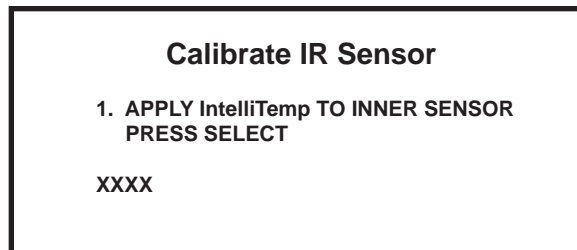
7. Using the arrow keys, highlight “Xpress.” Press the SELECT key. The following screen will be displayed.



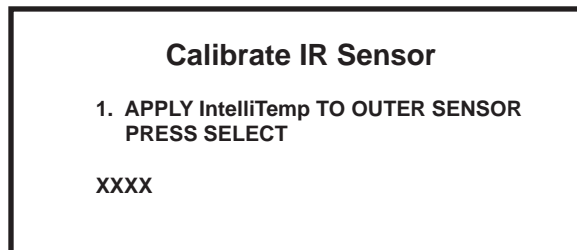
8. Using the arrow keys, highlight “Yes.” Press the SELECT key. The following screen will be displayed.



9. Using the arrow keys, highlight “Calibrate IR Sensors.” Press the SELECT key.



10. Ensure that the “Ready” light on the Intelli-Temp calibrator is illuminated. Place the calibrator adaptor over the inner IR sensor (sensor nearest the turntable drive lug) with the smaller opening of the adaptor directly over the sensor. Place the Intelli-Temp calibrator over the adaptor (calibrator positioned upside down with the opening mating with the opening of the adaptor). Wait for a stable reading. Press the “SELECT” key. The following screen will appear.



11. Place the calibrator adaptor over the outer IR sensor with the smaller opening of the adaptor directly over the sensor. Place the Intelli-Temp calibrator over the adaptor (calibrator positioned upside down with the opening mating with the opening of the adaptor). Wait for a stable reading. Press the “SELECT” key.

12. The instrument automatically returns to the Main Menu.

Verification of IR Sensor(s) Temperature Calibration

To verify proper calibration of the Xpress IR sensors, perform the procedures outlined below:

Note: The Intelli-temp Calibrator Kit (907330 - 120V or 907430 - 240V) which includes the calibrator and adaptor is required to verify IR calibration.

1. The instrument must be plugged into the electrical outlet and turned on.
2. Remove the plastic shield from the floor of the instrument.
3. Plug the Intelli-Temp calibrator into an electrical outlet close enough to the instrument for it to be placed on the instrument floor. Permit the calibrator to warm until the "Ready" light is illuminated.

| | |
|------------------------------------|----------------|
| CEM Method Menu | |
| Edit/Create Method | Load Method |
| 'Start' Current Method XXXXXXXX | |

4. Press the SETUP key

| | |
|------------------------|-----------------|
| MARS Setup Menu | |
| DELETE METHOD | COMM PORT SETUP |
| SYSTEM VARIABLES | INFORMATION |
| SELECT SENSOR | SYSTEM HISTORY |
| PRINTER SETUP | SELECT LANGUAGE |
| DUOTEMP SETUP | |

5. Using the arrow keys, highlight "Select Sensor." Press the SELECT key.

| | |
|----------------------|-----------------------|
| Select Sensor | |
| PRESSURE SENSOR | TEMPERATURE SENSOR |

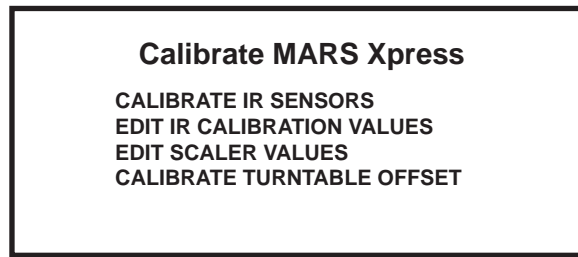
6. Using the arrow keys, highlight "Temperature Sensor." Press the SELECT key.

| | |
|---------------------------|------|
| Temperature Sensor | |
| Xpress | None |

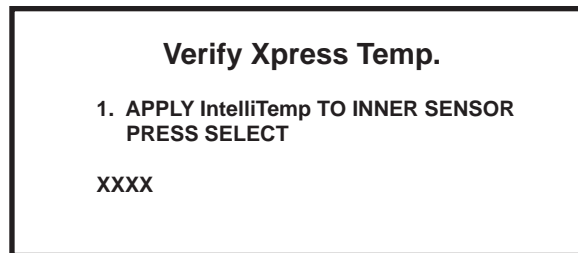
7. Using the arrow keys, highlight "Xpress." Press the SELECT key. The following screen will be displayed.

| | |
|-------------------------|----|
| Calibrate Xpress | |
| Yes | No |

8. Using the arrow keys, highlight “Yes.” Press the SELECT key. The following screen will be displayed.



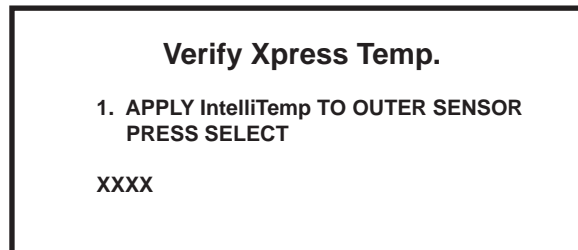
9. Using the arrow keys, highlight “Calibrate IR Sensors.” Press the NEXT key. The following screen will be displayed.
Note: Do Not press SELECT. Pressing SELECT will enter the calibration screen.



10. Ensure that the “Ready” light on the Intelli-Temp calibrator is illuminated. Place the calibrator adaptor over the inner IR sensor (sensor nearest the turntable drive lug) with the smaller opening of the adaptor directly over the sensor. Place the Intelli-Temp calibrator over the adaptor (calibrator positioned upside down with the opening mating with the opening of the adaptor). The calibration value on the screen should read 130 °C ±2 °C.

11. If the calibration value does not read 130 C ± 2 °C, the inner IR sensor should be recalibrated.

12. Press the “SELECT” key. The following screen will be displayed.

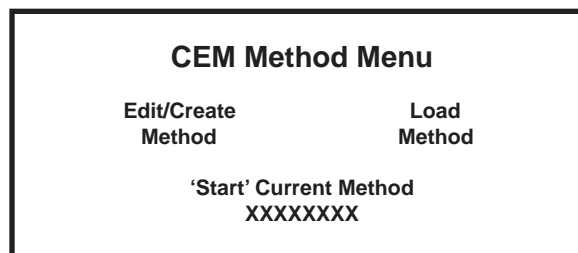


13. Place the calibrator adaptor over the outer IR sensor with the smaller opening of the adaptor directly over the sensor. Place the Intelli-Temp calibrator over the adaptor (calibrator positioned upside down with the opening mating with the opening of the adaptor). The calibration value on the screen should read 130 °C ±2 °C.

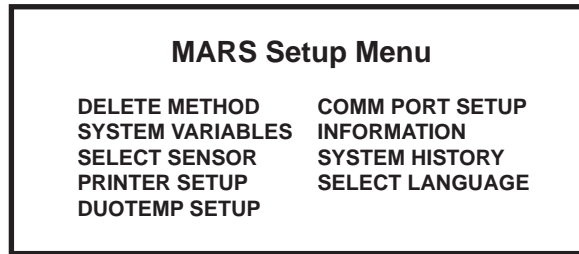
14. If the calibration value does not read 130 C ± 2 °C, the outer IR sensor should be recalibrated.

Enter Previous IR Sensor Calibration Values

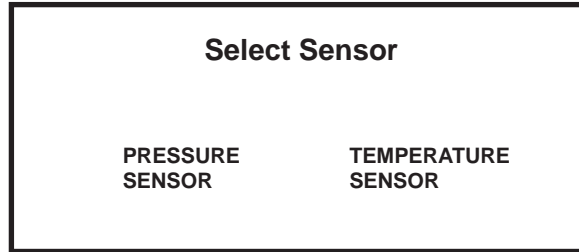
To enter previous IR calibration values, follow the procedures outlined below.



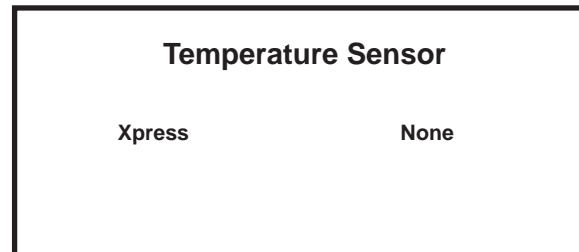
1. Press the SETUP key



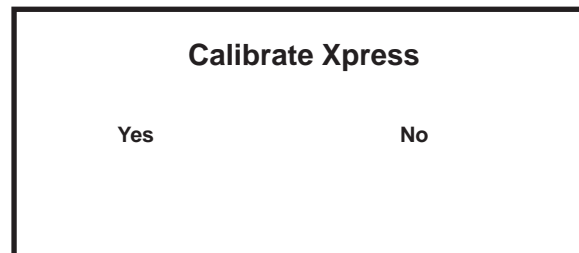
2. Using the arrow keys, highlight "Select Sensor." Press the SELECT key.



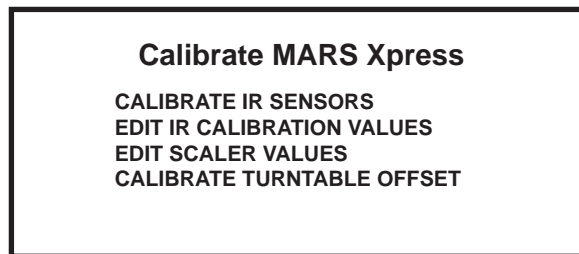
3. Using the arrow keys, highlight "Temperature Sensor." Press the SELECT key.



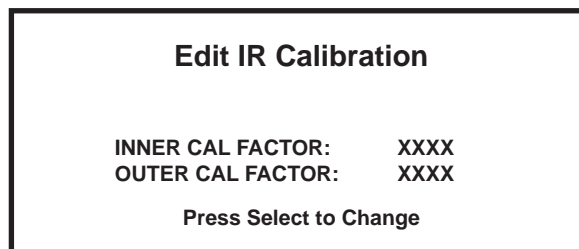
4. Using the arrow keys, highlight "Xpress." Press the SELECT key. The following screen will be displayed.



5. Using the arrow keys, highlight "Yes." Press the SELECT key. The following screen will be displayed.



6. Using the arrow keys, highlight "Edit IR Calibration Values." Press the SELECT key. The following screen will be displayed.

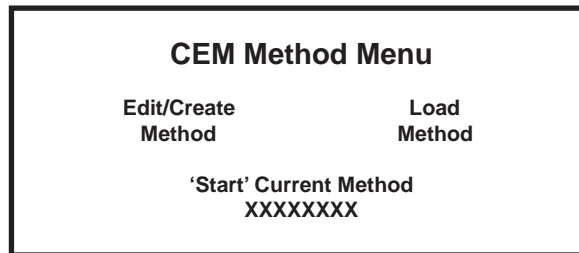


7. Using the arrow keys, highlight the inner calibration factor value. Using the numeric keypad, enter the previous calibration value. Press the SELECT key to accept the new value.

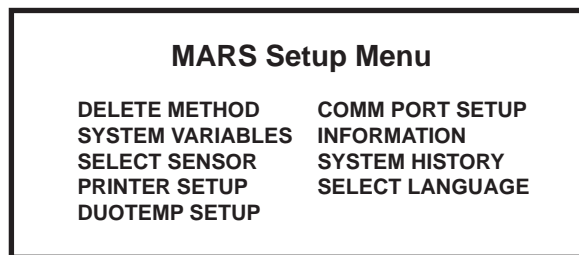
8. Using the arrow keys, highlight the outer calibration factor value. Using the numeric keypad, enter the previous calibration value. Press the "SELECT" key to accept the new value.
9. Press the "HOME" key.

Edit Scaler Values

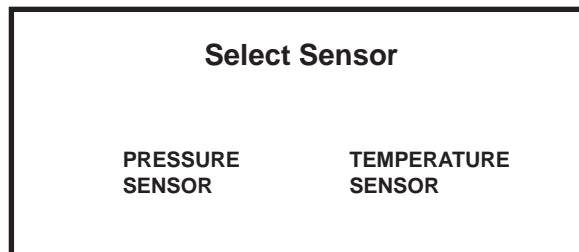
Note: Factory scaler values should not be edited without specific instructions from CEM personnel.



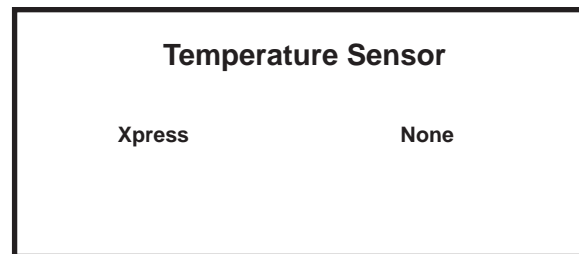
1. Press the SETUP key



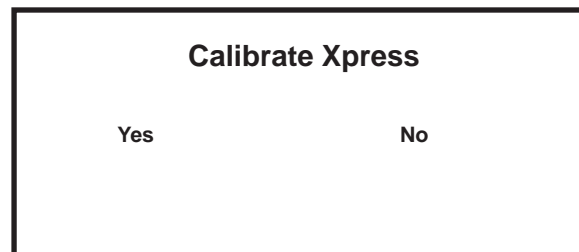
2. Using the arrow keys, highlight "Select Sensor." Press the SELECT key.



3. Using the arrow keys, highlight "Temperature Sensor." Press the SELECT key.



4. Using the arrow keys, highlight "Xpress." Press the SELECT key. The following screen will be displayed.



5. Using the arrow keys, highlight "Yes." Press the SELECT key. The following screen will be displayed.

Calibrate MARS Xpress

CALIBRATE IR SENSORS
 EDIT IR CALIBRATION VALUES
 EDIT SCALER VALUES
 CALIBRATE TURNTABLE OFFSET

6. Using the arrow keys, highlight “Edit Scaler Values.” Press the SELECT key. The following screen will be displayed.

Edit IR Values

Organic Inner Scaler: XXX CI: XXX
 Organic Outer Scaler: XXX CU: XXX
 Inorganic Inner Scaler: XXX
 Inorganic Outer Scaler: XXX
 Press Select to Change

CAUTION
 Scaler Values should not be edited without specific instructions from CEM personnel.

Turntable Offset Calibration

CEM Method Menu

Edit/Create Load
 Method Method

‘Start’ Current Method
 XXXXXXXX

1. Press the SETUP key

MARS Setup Menu

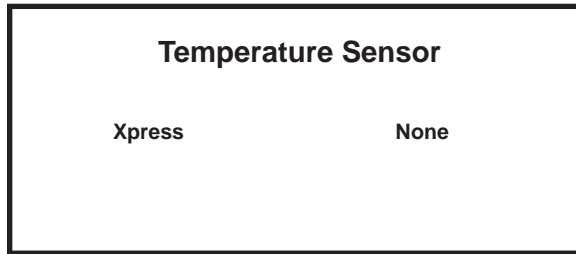
DELETE METHOD COMM PORT SETUP
 SYSTEM VARIABLES INFORMATION
 SELECT SENSOR SYSTEM HISTORY
 PRINTER SETUP SELECT LANGUAGE
 DUOTEMP SETUP

2. Using the arrow keys, highlight “Select Sensor.” Press the SELECT key.

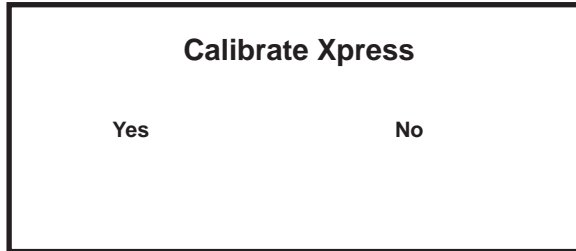
Select Sensor

PRESSURE TEMPERATURE
 SENSOR SENSOR

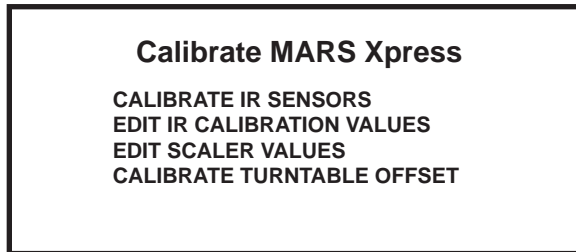
3. Using the arrow keys, highlight “Temperature Sensor.” Press the SELECT key.



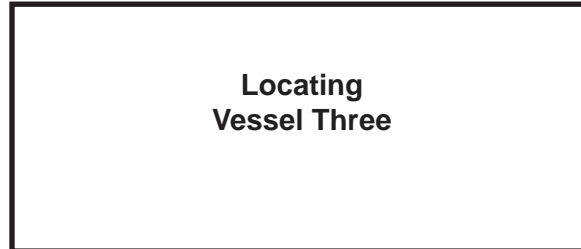
4. Using the arrow keys, highlight "Xpress." Press the SELECT key. The following screen will be displayed.



5. Using the arrow keys, highlight "Yes." Press the SELECT key. The following screen will be displayed.



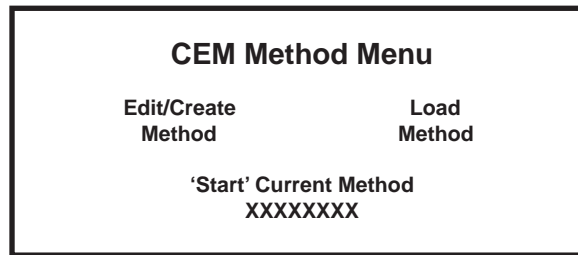
6. Using the arrow keys, highlight "Calibrate Turntable Offset." Press the SELECT key. The following screen will be displayed.



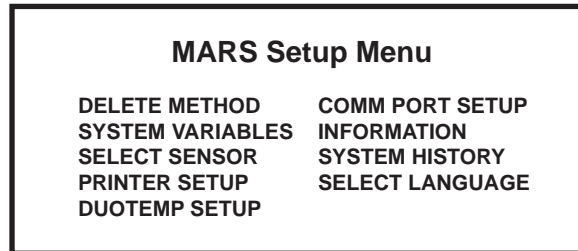
CAUTION

Do not edit the turntable offset value without specific instructions from CEM Service personnel.

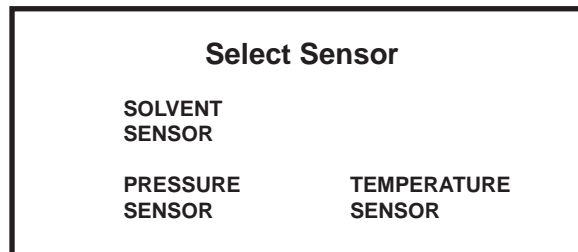
Solvent Sensor Calibration



1. Press the SETUP key



2. Using the arrow keys, highlight "Select Sensor." Press the SELECT key.



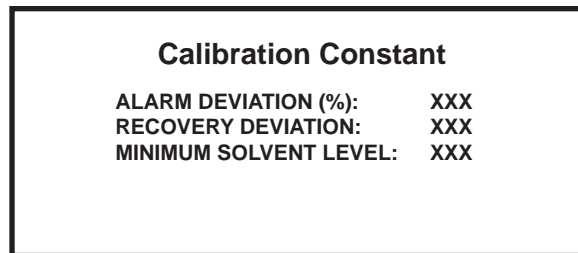
3. Using the arrow keys, highlight "Solvent Sensor." Press the SELECT key.



4. Using the arrow keys, highlight the appropriate calibration function. Press the SELECT key.

Note: To display the calibration constants, proceed to step 5. To calibrate the solvent sensor, proceed to step 7.

Display Calibration Constant



5. Record the calibration constants for future reference and entry if calibration of the solvent sensor is lost or distorted.
6. Press the "HOME" key to return to the main menu or the "BACK" key to return to the "Calibrate Solvent Sensor" screen for additional calibration procedures.

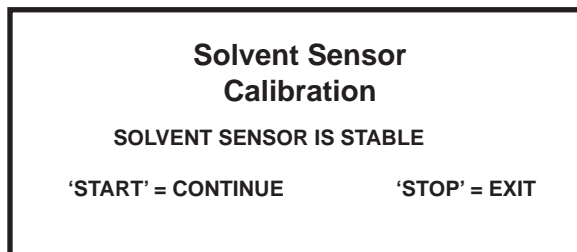
Sensor Calibration

7. The instrument performs a 90-second sensor stability test to determine if the sensor remains within its boundaries. If the solvent sensor is not stable, the following screen will appear.

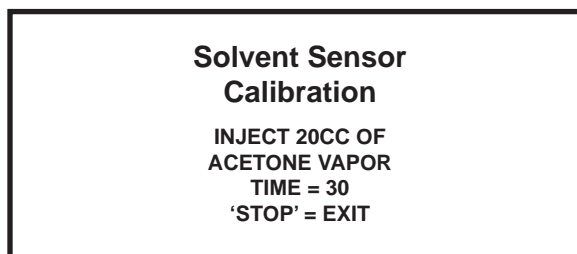


Note: If necessary, the stability test will be repeated up to five (5) times to verify stability. If, after performing stability tests and making adjustments, the sensor remains unstable, a solvent detection error message will appear.

8. At the end of the stability test(s), the following screen will appear.

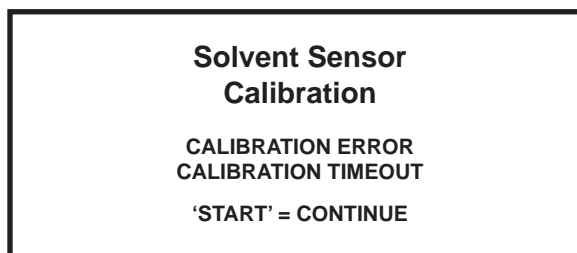


9. Press the START key.

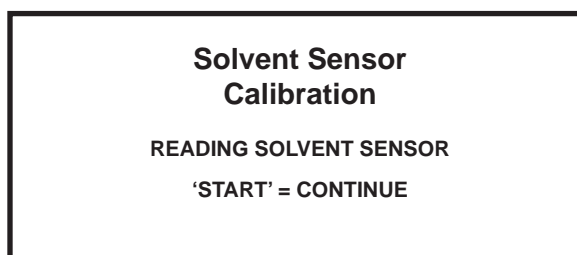


10. During the 30-second countdown time, use a syringe and inject 20cc of acetone vapor into the perforation located underneath the left side of the instrument (facing front of instrument). The perforation is approximately 4" from the front of the cavity.

Note: If the acetone vapors are not injected prior to the end of the 30-second time period, the following screen will appear.



11. Once the acetone vapors are injected into the instrument cavity, the following screen will appear.



Note: As the sensor determines the amount of acetone vapor (solvent) in the cavity, if it detects too much acetone vapor or if the sensor is faulty, the following two (2) screens may appear.

**Solvent Sensor
Calibration**
SENSOR OUT OF RANGE
ALLOW SENSOR TO STABILIZE
AND RECALIBRATE
'START' = CONTINUE

**Solvent Sensor
Calibration**
ALLOW SENSOR TO STABILIZE
FOR VERIFICATION TEST
'START' = CONTINUE

12. After the sensor determines the amount of acetone vapor in the cavity and stabilizes, the following screen will appear.

**Solvent Sensor
Calibration**
INJECT 20 CC OF
ACETONE VAPOR
TIME = 30
'STOP' = EXIT

13. Repeat steps 10 and 11.

14. If the calibration is acceptable, the following screen will appear.

Note: Unacceptable calibration is caused by a $\pm 1-3\%$ difference in the two acetone vapor injections.

**Solvent Sensor
Calibration**
CALIBRATION COMPLETE
'START' = CONTINUE

15. If the calibration is not acceptable, the following screen will appear.

**Solvent Sensor
Calibration**
VERIFICATION FAILURE
ALARM POINT NOT VALID
'START' = CONTINUE

16. If the calibration is not acceptable, repeat the previous calibration procedures.

Troubleshooting Chart

| Condition | Possible Cause |
|--|---|
| Instrument Inoperative | Instrument not plugged into electrical outlet Power switch not in "on" position Blown fuse Loose connection to power switch Faulty power switch Faulty DC power supply |
| No Microwave Power | Instrument door ajar Incorrect percentage of power selected Interlock(s) not properly adjusted or faulty Faulty controller board Faulty thermal switch Faulty high voltage component |
| Low Microwave Power | Low line voltage Incorrect wattage parameter Incorrect voltage switch setting Incorrect percentage of power selected Faulty high voltage relay(s) Faulty high voltage component |
| Fuse Blows When Door is Opened | Interlock(s) not properly adjusted Faulty interlock(s) |
| Fuse Blows Repeatedly During Operation | Low line voltage Faulty high voltage component Faulty DC power supply Faulty controller board Faulty continuous power supply |
| Inoperative Turntable | Loose or broken turntable belt Faulty turntable motor Faulty controller board |
| Turntable Not Alternating | Loose or faulty turntable belt Faulty turntable sensor Faulty turntable motor Faulty controller board |
| No Display | Loose or broken wiring connections Loose or faulty interface cable Faulty display Faulty controller board |
| Inoperative Keyboard | Loose or faulty interface cable Faulty keyboard Faulty controller board |
| Inoperative Vessel Stirring Motor | Loose or broken stirring motor belt Faulty Stirring Motor |
| Erratic Pressure* (ESP-1500 Plus) | Incorrect A/D setting Leakage from vessel Loose vent fitting Loose bulkhead connector Improper grounding connection Faulty ESP-1500 Plus Faulty controller board |

Troubleshooting Chart (Continued)

| Condition | Possible Cause |
|--|--|
| Erratic Pressure (External Water Line) | Leakage from vessel Loose vent fitting Loose connection on pressure relief valve Faulty pressure relief valve Loose connection on 2-way valve Faulty 2-way valve Faulty pressure transducer electrical connector Faulty pressure transducer |
| Erratic Temperature (RTP-300 Plus) | Broken thermowell Faulty RTP-300 Plus Faulty controller board |
| Microwave Leakage | Improperly adjusted instrument door Damaged instrument door |
| Inoperative Cavity Light | Faulty light bulb Loose connection(s) Faulty connection(s) Faulty controller board |
| Tangled Pressure Sensing Line | Control vessel not positioned properly in turntable Turntable not alternating |
| Vapors in Laboratory | Loose drain valve Leakage from vessel Ruptured membrane Vent hose to fume hood not installed Faulty blower assembly |
| No Rise in Pressure in Control Vessel | Leakage at vent fitting Rupture membrane not installed Thermowell loose in vessel ESP-1500 Plus unattached or faulty Sample does not absorb microwave energy Liquid does not generate pressure upon heating Vessels improperly torqued |
| No Rise in Temperature in Control Vessel | Sample not microwave absorbing Temperature probe inserted incorrectly Temperature probe connected incorrectly |
| Ruptured Optional Vessel Membrane | Excessive amount of reactive organic sample Leakage from control vessel resulting in abnormal pressure buildup in other vessels Closed microwave transparent valve |
| Venting Relief Valve | Excessive amount of reactive organic compounds Closed microwave transparent valve Two-way valve in incorrect position |
| Loose Pressure Sensing Tube in Control Vessel | Tubing not fully inserted and sealed into mating fitting with ferrule nut Closed microwave transparent valve |

Error Messages

The following error messages may appear during system operation due to operator error, improper system operation or component failure.

TURNTABLE FAILURE
THE TURNTABLE MOTOR/SENSOR ASSEMBLY
IS NOT FUNCTIONING PROPERLY.

1 = RETEST TURNTABLE
2 = ALLOW SOFTWARE OVERRIDE OF SENSOR

The turntable failure error message indicates that the turntable has not properly initialized upon turning the system on. Press the "1" key to retest the turntable. If the turntable error is still present, press the "9" key to permit the instrument software to override the turntable sensor. Contact the CEM Service Department or local subsidiary or distributor.

THERMAL OVERLOAD ERROR
THE MICROWAVE POWER CIRCUIT
IS NOT FUNCTIONING, CHECK FANS

TEST ABORTED
PRESS ANY KEY TO CONTINUE

The thermal overload error indicates that a door interlock switch is improperly adjusted or that the magnetron or isolator cooling fan is not operating properly. The current method is aborted. Verify proper operation of the door interlocks and fans. Press any key on the keyboard to continue system operation.

PRESSURE/TEMPERATURE DROP ERROR
PRESSURE OR TEMPERATURE
HAS DROPPED TOO RAPIDLY

1 = RETEST TURNTABLE
2 = ALLOW SOFTWARE OVERRIDE OF SENSOR

The pressure/temperature drop error indicates that the pressure or temperature has dropped 20% or more during a 5 second period. The instrument will not begin monitoring until the pressure/temperature rises above 75 psi or 75 degrees. The drop in pressure/temperature could be caused by leakage from the control vessel, an improper or loose connection, or a faulty pressure or temperature sensor. The operator must decide whether or not to continue the method. To continue the method, press the "9" key to return to the method, followed by the "START" key. To discontinue the method and reset the instrument, press the "1" key to return to the main menu, followed by the "START" key to restart the method.

REACTIGUARD ERROR
AN EVENT HAS OCCURRED INSIDE CAVITY,
CHECK VESSELS

1 = RESET TEST
9 = CONTINUE

The ReactiGuard error message indicates that some type of event has occurred with a vessel such as a ruptured membrane disk, an exploded vessel, or a relatively loud noise inside or near the instrument cavity. The operator must decide whether or not to continue the method. To continue the method, press the "9" key to return to the method, followed by the "START" key. To discontinue the method and reset the instrument, press the "1" key to return to the main menu, followed by the "START" key to restart the method.

LINE VOLTAGE ERROR
INCORRECT LINE VOLTAGE. CANNOT OPERATE
INSTRUMENT AT SPECIFIED POWER LEVEL
CHECK WATTAGE SELECTION
TEST ABORTED
PRESS ANY KEY TO CONTINUE

The line voltage error message indicates that the AC voltage supplied to the instrument has dropped below or risen above the operating specifications of 90V - 130V (110V instruments) or 195V - 265V (230V instruments). The method in progress is aborted. Press any key on the keyboard to return to the main menu.

CAUTION

Line voltage should be corrected prior to attempting instrument operation.

PRINTER ERROR
AN ERROR OCCURRED WHILE PRINTING
CHECK PRINTER
PRINT ABORTED
PRESS ANY KEY TO CONTINUE

The printer error indicates that the printer is out of paper or that it failed to communicate with the instrument within a specified amount of time. The print command is aborted. Press any key on the keyboard to continue system operation. Verify that the printer has paper. Refer to the printer handbook for troubleshooting procedures. Once the problem is corrected, press the "PRINT" key to continue printing the desired data.

TEMPGUARD FAILURE
THE TEMPGUARD IS NOT
FUNCTIONING PROPERLY
CONTACT CEM SERVICE
1 = RESET TEST
9 = BYPASS TEMPGUARD

If the TempGuard™ (optional) does not detect any change in temperature in the vessels after a specified period of time, the TempGuard failure error appears. Lift the turntable and clean the face of the sensor. Press the "1" key to continue the method. If the error is detected a second time, the operator has a choice of bypassing the sensor and continuing system operation by pressing the "9" key or discontinuing use of the instrument until the sensor is replaced. Contact the CEM Service Department or the local subsidiary or distributor.

CAUTION

The TempGuard™ is an optional safety device to prevent overheating of vessels. If the sensor is bypassed, a risk of damage to the vessel(s) and/or instrument is possible due to overheating.

TEMPGUARD TEMPERATURE ALARM
VESSEL XX EXCEEDS
MAXIMUM ALLOWABLE TEMPERATURE
TEST ABORTED
PRESS ANY KEY TO CONTINUE

If the TempGuard™ (optional) detects a vessel temperature which exceeds the maximum temperature for the vessel type, the TempGuard temperature alarm screen appears, indicating the vessel number in which the temperature is excessive. The method is aborted. Remove the vessels from the instrument. Find the problem with the vessel. Press any key on the keyboard to return to the main menu.

CAUTION

The TempGuard™ is an optional safety device to prevent overheating of vessels. If the sensor is bypassed, a risk of damage to the vessel(s) and/or instrument is possible due to overheating.

RTP-300 Plus ERROR COMMUNICATIONS FAILURE

1 = RESET THERMO-OPTIC SYSTEM
9 = SELECT ALTERNATE TEMPERATURE SENSOR

The RTP-300 Plus error message indicates a problem with the Thermo-Guard temperature sensor. The error can be one of the following:

- Communications Timeout Failure - sensor fails to complete communication of data
- RTP-300 Plus Probe Failure - probe is broken or defective
- Temperature Outside Lookup Table - sensor is out of calibration
- RTP-300 Plus A/D Failure - faulty module
- RTP-300 Plus System Failure - faulty module
- RTP-300 Plus LED Failure - faulty sensor
- Communications Failure - communication failure between MARS and sensor
- Command Failure - invalid command sent to sensor
- Invalid Header - sensor is transmitting incorrect data due to noise, etc.
- Decay Time Is Marginal - faulty sensor
- LED Current Is High or Erratic - malfunctioning sensor

Press the “1” key to attempt to reset the RTP-300 Plus sensor. Press the “9” key to select no temperature control.

WARNING

COLD START EXECUTED

This warning indicates that an instrument cold start is in progress and will possibly eliminate all saved data such as calibration information and methods from the computer. The instrument will cold start upon installation of a new E-PROM for software upgrades or installation of a new CPU board.

TURNTABLE FAILURE
THE TURNTABLE HAS FAILED
REMOVE TURNTABLE THEN TURN
UNIT OFF TO RECOVER
(CODE 07)

The Turntable Failure message indicates that the turntable has rotated too far. The failure is identified by a code 07. To recover from the failure, turn the instrument off, then back on. If the turntable continues to indicate the failure, contact the CEM Service Department or nearest subsidiary or distributor for any turntable failure and identify the applicable code number.

WARNING
A/D INTERRUPT NOT RESPONDING
TURN UNIT OFF TO RESET

This warning indicates that the instrument will not properly monitor temperature or pressure. Turn the instrument off, then back on. If this warning is not cleared, contact the CEM Service Department or the nearest CEM subsidiary or distributor.

WARNING
CANNOT ZERO ESP-1500 Plus
RUN ABORTED
1 . RESET TEST
2 . ZERO AND CONTINUE
9 . BYPASS ESP-1500 Plus ZERO

The warning indicates that the pressure reading is above 50 psi upon attempt to zero the ESP-1500 Plus. Press the "1" key to return to the main menu and the "START" key to restart the method. Press the "2" key to continue the method even though the known pressure is not correct. Press the "9" key to bypass the ESP-1500 Plus sensor and continue the method.

CALIBRATION ERROR
ESP-1500 Plus IS NOT CALIBRATED
PRESS ANY KEY

The ESP-1500 Plus calibration error message indicates that the ESP-1500 Plus sensor is out of calibration, that the constant has been entered incorrectly, or that the ESP-1500 Plus is faulty. Press any key to return to the main menu.

CALIBRATION ERROR
WATER LINE IS NOT CALIBRATED
PRESS ANY KEY

The external water line calibration error message indicates that the water line is out of calibration, that the constant has been entered incorrectly, or that the water line is faulty. Press any key to return to the main menu.

METHOD ERROR
TEMPERATURE DEVICE IS NOT ENABLED
FOR TEMPERATURE CONTROL
RUN ABORTED
PRESS ANY KEY

This method error message indicates that method parameters indicate temperature control, but no temperature sensor is selected. The current method is aborted. Press any key to return to the main menu.

METHOD ERROR
PRESSURE DEVICE IS NOT ENABLED
FOR PRESSURE CONTROL
RUN ABORTED
PRESS ANY KEY

This method error message indicates that method parameters indicate pressure control, but no pressure sensor is selected. The current method is aborted. Press any key to return to the main menu.

PREVENTIVE MAINTENANCE FOR THIS SYSTEM
SHOULD BE SCHEDULED. CONTACT CEM CORP.
OR YOUR LOCAL DISTRIBUTOR.
PRESS ANY KEY

This message advises the user that the instrument should have preventive maintenance performed by a CEM Certified Service Technician to prevent future downtime.

SERVICE DATE IS NOT SET
PRESS ANY KEY

This message appears after an instrument cold start which erases service information.

COMMUNICATIONS FAILURE BETWEEN
TURNTABLE BOARD AND MAIN CPU
PRESS ANY KEY

This error message indicates that there is no communication between the controller board and the turntable board. The current method is aborted. Press any key to return to the main menu. Contact the CEM Service Department or the nearest CEM subsidiary or distributor.

Temperature Selection Error
Cannot Select Fiberoptic device
while Xpress vessel selected
PRESS ANY KEY

This error message indicates an incorrect vessel selection. Xpress vessels cannot be utilized with the fiberoptic temperature sensor. The current method is aborted. Press any key to return to the main menu. Access the Setup menu and ensure that the proper vessel is selected for use with the temperature sensor, or if using Xpress vessels, ensure that the temperature sensor is not selected.

**Pressure Device Error
Pressure Device Detected
while Xpress vessel selected**

Remove Pressure Device

PRESS ANY KEY

This error message indicates an incorrect vessel selection. Xpress vessels cannot be utilized with a pressure sensor. The current method is aborted. Press any key to return to the main menu. Access the Setup menu and ensure that the proper vessel is selected for use with the pressure sensor, or if using Xpress vessels, ensure that the pressure sensor is not selected.

Repair and Service

WARNING

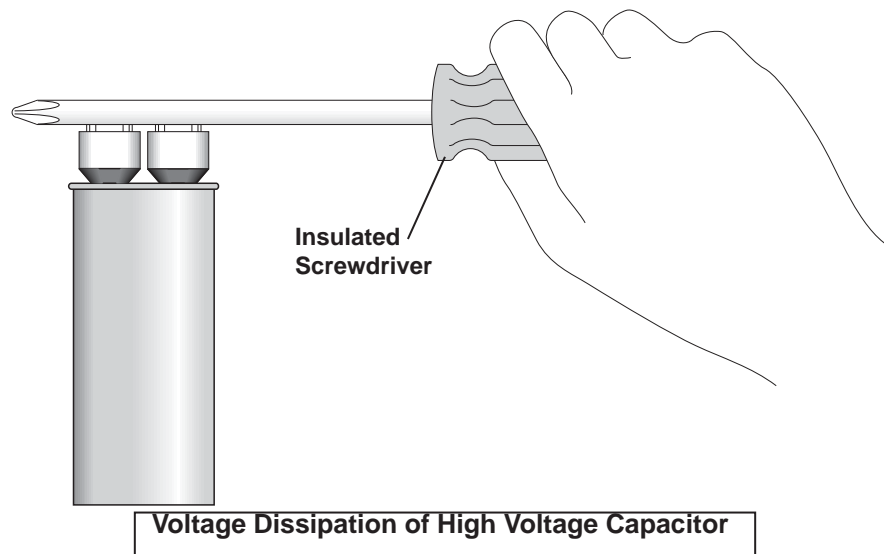
This instrument utilizes high voltages and microwave radiation in its operation. Instrument service and repair should be undertaken only by technicians trained in repair and maintenance of high voltage and microwave power systems.

The MARS is constructed in modular form to facilitate troubleshooting and repair. It is recommended that troubleshooting and repair by the user be limited to identifying and replacing parts such as printed circuit boards, fans, lamps, or motors.

WARNING

Disconnect the instrument from the AC power source prior to performing any service procedure.

Prior to any troubleshooting or service procedures in the high voltage section or area, bridge the contacts of the high voltage capacitor using the metal shaft of a well insulated screwdriver to discharge the residual voltage in the capacitor. This will prevent exposure to high voltage discharge during troubleshooting or service.



Before replacing the high voltage plate assembly after any service procedure involving the microwave generating components, visually check the magnetron, transformers, triac, and high voltage capacitor to ensure that the electrical connections are secure.

Any service to or inspection of the MARS which requires

- removal of the high voltage plate assembly or
- replacement of components in the
 - door,
 - interlock mechanism,
 - microwave generation system, or
 - microwave transmission system

should be followed by a microwave leakage measurement to verify that leakage is less than 5 mW/cm².

Ordering Information

For assistance and pricing of replacement parts and microwave sample preparation accessories, contact:

CEM Corporation
Service Department
P.O. Box 200
3100 Smith Farm Road
Matthews, NC 28106-0200 USA
800.726.5551 (phone within USA)
01.704.821.7015 (phone outside of USA)
Fax: 704.821.4369
service@cemhelp.com (email)
www.cemservice.us (Web Site)

United Kingdom Subsidiary
CEM Microwave Technology Ltd.
2 Middle Slade
Buckingham Industrial Park
Buckingham MK18 1WA
United Kingdom
44.1.280.822873 (phone)
44.1.280.822342 (fax)

German Subsidiary
CEM GmbH
Carl-Friedrich-Gauss-Strasse 9
47475 Kamp-Lintfort
Germany
49.2842.96440 (phone)
49.2842.964411 (fax)

Italian Subsidiary
CEM S.r.l.
Via Dell' Artigianato, 6/8
Italy
39.1693.55780 (phone)
39.35.891661 (fax)

French Subsidiary
CEM μ Wave S.A.S.
Immeuble Ariane
Domaine Technologique de Saclay
4, Rue Rene' Razel
91892 Arsay France
33.1693.55780 (phone)
33.1601.96491 (fax)
Fax: (39) 35-891661

Japanese Subsidiary
CEM Japan K.K.
5-8-8 Shinjuku, Shinjuku-Ku
Tokyo 160-0022
Japan
03.5368.2507 (phone)
03.5368.2508 (fax)

Specifications

Electrical Requirements

208/230 VAC (200-253 VAC), 60 Hz, 15A @ 230 VAC
220/240 VAC (202-250 VAC), 50 Hz, 15A @ 240 VAC
Detachable Power Cord, I.E.C. and U.L. approved

Safety Features

Variance in line voltage can affect microwave power output. Three independent door safety interlocks, including an interlock monitoring system, plus two independent thermal switches are used in each instrument to prevent instrument operation and microwave emissions in case of improper door closure or misalignment. The instrument is equipped with a turntable interlock system which causes the turntable to rotate when microwave power is on. The instrument complies with HHS standards under 21 CFR, Part 1030.10, Subparts (C)(1), (C)(2), and (C)(3). ReactiGuard™ continuous cavity monitoring system disables magnetron if cavity disturbances occur.

Magnetron Frequency

2455 MHz

Power Output

400 watts ±15%, 800 watts ±15% or 1600 watts ±15%
1500 watts IEC Method)

Magnetron Protection

Solid State Isolator (U.S. Patent 4,835,354) to protect magnetron from reflected energy, ensuring constant power output.

Microwave Cavity

Heavy-duty, multi-layer fluoropolymer coating

Inlet/Outlet Ports

(2) 0.3125 in. I.D. Ports for 0.250 in. (6mm) tubing

Dimensions

(Overall) 25" x 20" x 23" (D x W x H)

Weight

120 lbs. (with vessels 146 lbs.)

Printer Port

25-Pin, Epson and IBM Compatible

Computer Compatibility

80C188 on-board computer controls all system functions.

System can perform all functions with or without connection to an external PC. RS 232, 9-Pin, IBM PC compatible BITS System (Built-In Test System) Checks/monitors line voltage, magnetron life, turntable operation, temperature control, status/operation, exhaust system, halogen lamp life, door safety interlocks.

Internal Diagnostic Software

ESP-1500 Plus Pressure Control System

Inboard pressure control system to monitor and control equilibrium/reaction pressure. Pressure is sensed 200 times per minute. Internal pressure control system able to monitor up to 1500 psi

RTP-300 Plus Temperature Control System Turntable Design

Temperature device for in-situ measurement inside sealed sample vessels. Temperature range 0 - 330°C.

PerfectCircle™ provides absolute radial symmetry. Turntable rotates 355° and reverses 8.5 times per minute to ensure even vessel heating or rotates continuously depending upon vessel selection.

Sensors

All sensors including pressure and temperature sensing devices located within the microwave cavity are microwavetransparent or shielded to ensure accurate readings and to eliminate arcing (ignition) hazards.

Service Accessibility

One panel access to system main circuitry for convenient service and upgrading capability.

Patents

CEM Microwave Systems and vessel designs may be covered by any one of the following U.S. patents: 04835354, 04080168, 05369034, 04672996, RE034373, 05230865, 04877624, 04672996, 05206479, 05427741. Other patents pending

Emission and Safety Approvals

U.S. and Canada

Complies with FCC part 18 (47 CFR part 18 Industrial, Scientific, and Medical Equipment)

U.S.: ETL* approved to UL Standard 61010A-1 (laboratory Equipment)

Canada: ETL** approved to standard CAN/CSA C22.2 No. 1010.1 (Laboratory Equipment)

European Community

Conforms to EC norm EN61326-1 EMC requirements for electrical equipment for measurement, control and laboratory use

Conforms to EC norm EN61010-1 (Safety requirements for electrical equipment for measurement, control and laboratory use - Part 1)

*ETL and UL are equivalent nationally recognized testing laboratories

**ETL is an approved testing laboratory by the standards council of Canada



78355
Conforms to UL Std. 3101



Certified to
CAN/CSA C22.2 No. 1010.1



Warranty

What Is Covered:

CEM Corporation warrants that the instrument will be free of any defect in parts or workmanship and will, at its option, replace or repair any defective part (excluding consumables) or instrument.

For How Long:

This warranty remains in effect for 365 days from date of delivery to the original purchaser.

What Is Not Covered:

This warranty does not cover parts or workmanship which have been damaged due to:

- Neglect, abuse or misuse,
- Damage caused by or to test samples,
- Damage incurred during instrument relocation,
- Damage caused by or to any attached equipment,
- Use of incorrect line voltages or fuses,
- Fire, flood, "acts of God" or other contingencies beyond the control of CEM Corporation,
- Improper or unauthorized repair, or
- Any other damage caused by purchaser or its agents.

Responsibilities of Purchaser:

To ensure warranty coverage, purchaser must:

- Use the instrument according to directions,
- Connect the instrument properly to a power supply of proper voltage,
- Replace blown fuses,
- Replace consumables and
- Clean the instrument as required.

How to Get Service:

Purchaser should contact the Service Department of CEM Corporation or his distributor for return authorization and for proper crating and shipping instructions to return instrument, freight prepaid, for service. On-site repairs by an authorized service technician are available through the CEM Service Department. Travel costs will be charged to the purchaser for on-site repairs.

Within the U.S.

CEM Corporation
3100 Smith Farm Rd.
Matthews, NC 28106-0200
(800) 726-5551
Fax: (704) 821-7894
E-mail: service@cemhelp.com

Outside the U.S.

CEM Corporation
3100 Smith Farm Rd.
Matthews, NC 28106-0200
(704) 821-7015
Fax: (704) 821-7894

Warranty Disclaimer:

CEM Corporation hereby excludes and disclaims any warranty of merchantability or fitness for any particular purpose. No warranty, express or implied, extends beyond the face hereof. CEM Corporation shall not be liable for loss of use of instrument or other incidental or consequential costs, expenses or damages incurred by the purchaser or any other user.

Purchaser's Rights Under State Law:

This warranty gives the purchaser specific legal rights, and the purchaser may also have other rights which vary from state to state.

Customer Support Service Contacts

For customer support in the areas of service, applications or sales, call the following toll-free numbers.

- Applications Assistance (800) 726-3331
- Service Assistance (800) 726-5551
- Sales Assistance (800) 726-3331

Appendix A

The following is an example of power and time calculation for instruments for methods without temperature or pressure feedback control.



Soil (EPA 3051) 7 Vessels

Microwave Sample Preparation
File Name: 3051-7.pgm

Note Rev. Date: 5/98
Category: Environmental

Sample Type: Soil
Application Type: Acid Digestion
Vessel Type: AutoVent 500
Number of Vessels: 7
Reagents: Nitric Acid (70%)

Sample Volume: 0.5 gram

| Acid Type | Volume |
|-----------|--------|
| Nitric | 10 mL |

Tighten vessel frame screw to 1/2 turn past finger tight.

Heating Program: Standard Control
Maximum Power Level: 1200W

| Stage | Wattage | Time (min.) |
|-------|---------|-------------|
| (1) | 600 W* | 5:30 |
| (2) | 350 W* | 4:30 |

*To determine the percentage of 1200W power level required to produce 600W, use the following formula:

$$\% \text{ Power} = \frac{600\text{W}}{\text{Measured power @ 100\%}} \times 100$$

OR:

To approximate the percentage of power required to produce 600W, use the following formula:

$$\% \text{ Power} = \frac{600\text{W}}{1200\text{W}} \times 100$$

NOTE A: This procedure is a reference point for sample digestion using the CEM Microwave Sample Preparation System and may need to be modified or changed to obtain the required results on your sample.

NOTE B: To avoid the potential for chemical burns, manual venting of CEM closed vessels should be performed only when wearing hand, eye and body protection and only when the vessel contents are at or below room temperature.

Appendix B

Conversion Tables

Volume Equivalents

| meter ³ | foot ³ | gallon | Liter | quart | inch ³ | cc |
|---------------------------|--------------------------|--------------------------|----------------------|---------------------------|-------------------|--------------------------|
| 1 | 35.31 | 264.2 | 1000 | 1056.8 | 61023 | 1 X 10 ⁶ |
| 28.317 x 10 ⁻³ | 1 | 7.4822 | 28.317 | 29.92 | 1728 | 28.317 x 10 ³ |
| 3.785 x 10 ⁻³ | 0.1337 | 1 | 3.785 | 4 | 231 | 3785 |
| 1 x 10 ⁻³ | 0.03531 | 0.2642 | 1 | 1.057 | 61.023 | 1000 |
| 9.463 x 10 ⁻³ | 0.03342 | 0.25 | 0.9463 | 1 | 57.75 | 946.25 |
| 1.638 x 10 ⁻⁵ | 5.787 x 10 ⁻⁴ | 43.29 x 10 ⁻⁴ | 0.01639 | 0.01732 | 1 | 16.387 |
| 1 x 10 ⁻⁶ | 35.31 x 10 ⁻⁶ | 2.642 x 10 ⁻⁴ | 1 x 10 ⁻³ | 10.568 x 10 ⁻⁴ | 0.06102 | 1 |

Pressure Equivalents

| Pa | MPa | atm | bar | kg/km ² | psi | inches Hg | microns Hg |
|-------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|------------------------|-------------------------|
| 1 | 1x10 ⁻⁶ | 9.8692x10 ⁻⁶ | 1x10 ⁻⁵ | 1.0197x10 ⁻⁵ | 1.4504x10 ⁻⁴ | 2.953x10 ⁻⁴ | 7.50059 |
| 1x10 ⁶ | 1 | 9.8692 | 10 | 10.1971 | 145.04 | 295.30 | 7.5006x10 ⁶ |
| 101325 | 0.101325 | 1 | 1.01325 | 1.0332 | 14.696 | 29.921 | 760x10 ³ |
| 100000 | 0.1 | 0.98692 | 1 | 1.01971 | 14.504 | 29.53 | 750.059x10 ³ |
| 98066.5 | 0.098067 | 0.96784 | 0.98067 | 1 | 14.223 | 28.959 | 735.56x10 ³ |
| 6894.757 | 6.8948x10 ⁻³ | 0.06805 | 0.06895 | 0.07031 | 1 | 2.036 | 51.715x10 ³ |
| 3386.389 | 3.3864x10 ⁻³ | 0.03342 | 0.03386 | 0.03453 | 0.49116 | 1 | 2.54x10 ⁴ |
| 0.133322 | 1.3332x10 ⁻⁷ | 1.3158x10 ⁻⁶ | 1.3332x10 ⁻⁶ | 1.3595x10 ⁻⁶ | 19.337x10 ⁻⁶ | 39.37x10 ⁻⁶ | 1 |

Temperature Equivalents

$$^{\circ}\text{C} = \frac{^{\circ}\text{F} - 32^{\circ}}{1.8}$$

$$^{\circ}\text{F} = 1.8 (^{\circ}\text{C}) + 32^{\circ}$$

$$^{\circ}\text{K} = ^{\circ}\text{C} + 273.15^{\circ}$$

Composition of Concentrated Reagent Grade Acids

| Chemical | Approx. Formula Weight of Reagent | Strength of Concd. Reagent | Assay Limits (% w/w) | Molarity of Concd. Reagent | Milliliters of Concd. Reagent Necessary to Prepare 1 Liter of 1 Molar Soln. | Normality of Concd. Reagent | Milliliters of Concd. Reagent Necessary to Prepare 1 Liter of 1 Normal Soln. |
|---|-----------------------------------|----------------------------|----------------------|----------------------------|---|-----------------------------|--|
| Acetic Acid, Glacial (CH ₃ COOH) | 60.053 | 99.8 | 99.7-99.9 | 17.4 | 57.5 | 17.4 | 57.5 |
| Hydrochloric Acid (HCl) | 36.461 | 37.2 | 36.5-38.0 | 12.1 | 82.5 | 12.1 | 82.5 |
| Hydrofluoric Acid (HF) | 20.006 | 49.0 | 48.0-51.0 | 28.9 | 34.5 | 28.9 | 34.5 |
| Nitric Acid (HNO ₃) | 63.013 | 70.4 | 69.0-71.0 | 15.9 | 63.0 | 15.9 | 63.0 |
| Phosphoric Acid (H ₃ PO ₄) | 97.995 | 85.5 | 85.0-87.0 | 14.8 | 67.5 | 44.4 | 22.5 |
| Sulfuric Acid (H ₂ SO ₄) | 98.079 | 96.0 | 95.0-98.0 | 18.0 | 55.5 | 36.0 | 28.0 |

Weight Conversion Table for Acids

| | | |
|----------------------|-------------------|-----------------------|
| Acetic Acid, Glacial | 500 ml = 1.16 lb. | 2.5 liters = 5.8 lb. |
| Hydrochloric Acid | 500 ml = 1.32 lb. | 2.5 liters = 6.6 lb. |
| Hydrofluoric Acid | 500 ml = 1.25 lb. | 4 liters = 10 lb. |
| Nitric Acid | 500 ml = 1.56 lb. | 2.5 liters = 7.8 lb. |
| Phosphoric Acid | 500 ml = 1.88 lb. | 2.5 liters = 9.4 lb. |
| Sulfuric Acid | 500 ml = 2.02 lb. | 2.5 liters = 10.1 lb. |

Fractional Units of Measure Conversion Data

| Prefix | Factor | Fraction | |
|--------|---------------------|-----------------------------|----------------------------|
| centi | 10 ⁻² = | 1/100 | part per hundred |
| milli | 10 ⁻³ = | 1/1,000 | part per thousand |
| micro | 10 ⁻⁶ = | 1/1,000,000 | part per million (ppm) |
| nano | 10 ⁻⁹ = | 1/1,000,000,000 | part per billion (ppb) |
| pico | 10 ⁻¹² = | 1/1,000,000,000,000 | part per trillion (ppt) |
| femto | 10 ⁻¹⁵ = | 1/1,000,000,000,000,000 | part per quadrillion (ppq) |
| atto | 10 ⁻¹⁸ = | 1/1,000,000,000,000,000,000 | part per quintillion |

| Percent | Parts/Million | Parts/Billion | Parts/Trillion |
|------------|---------------|---------------|----------------|
| .001% = | 10 ppm | | |
| .0001% = | 1 ppm = | 1000 ppb = | 1,000,000 ppt |
| .00001% = | .1 ppm = | 100 ppb = | 100,000 ppt |
| .000001% = | .01 ppm = | 10 ppb = | 10,000 ppt |
| | .001 ppm = | 1 ppb = | 1,000 ppt |
| | .0001 ppm = | .1 ppb = | 1,000 ppt |
| | | .01 ppb = | 100 ppt |
| | | .001 ppb = | 1 ppt |

Particle Size Conversion Table

| Sieve "Mesh" | Sieve Opening | | Sieve "Mesh" | Sieve Opening | | Sieve "Mesh" | Sieve Opening | | Sieve "Mesh" | Sieve Opening | |
|-----------------|---------------|-------------|-----------------|---------------|-------------|-----------------|---------------|-------------|-----------------|---------------|-------------|
| | Inches | Millimeters | | Inches | Millimeters | | Inches | Millimeters | | Inches | Millimeters |
| 1 | 1.00 | 25.4 | 3-1/2 | 0.223 | 5.66 | 20 | 0.0331 | 0.841 | 120 | 0.0049 | 0.125 |
| 7/8 | 0.875 | 22.6 | 4 | 0.187 | 4.76 | 25 | 0.0278 | 0.707 | 140 | 0.0041 | 0.105 |
| 3/4 | 0.750 | 19.0 | 5 | 0.157 | 4.00 | 30 | 0.0234 | 0.595 | 170 | 0.0035 | 0.088 |
| 5/8 | 0.625 | 16.0 | 6 | 0.132 | 3.36 | 35 | 0.0197 | 0.500 | 200 | 0.0029 | 0.074 |
| .530 | 0.530 | 13.5 | 7 | 0.111 | 2.83 | 40 | 0.0165 | 0.420 | 230 | 0.0025 | 0.063 |
| 1/2 | 0.500 | 12.7 | 8 | 0.0937 | 2.38 | 45 | 0.0139 | 0.354 | 270 | 0.0021 | 0.053 |
| 7/16 | 0.438 | 11.2 | 10 | 0.0787 | 2.00 | 50 | 0.0117 | 0.297 | 325 | 0.0017 | 0.044 |
| 3/8 | 0.375 | 9.51 | 12 | 0.0661 | 1.68 | 60 | 0.0098 | 0.250 | 400 | 0.0015 | 0.037 |
| 5/16 | 0.312 | 8.00 | 14 | 0.0555 | 1.41 | 70 | 0.0083 | 0.210 | | | |
| .265 | 0.265 | 6.73 | 16 | 0.0469 | 1.19 | 80 | 0.0070 | 0.177 | | | |
| 1/4 | 0.250 | 6.35 | 18 | 0.0394 | 1.00 | 100 | 0.0059 | 0.149 | | | |

Note: To convert millimeters to microns, move decimal point three places to the right. Example: 0.125 millimeters converts to 125 microns.

Appendix C

Chemical Elements and Symbols

| Element | Symbol | Element | Symbol |
|-------------|--------|--------------|--------|
| Actinium | Ac | Mercury | Hg |
| Aluminum | Al | Molybdenum | Mo |
| Americium | Am | Neodymium | Nd |
| Antimony | Sb | Neon | Ne |
| Argon | Ar | Neptunium | Np |
| Arsenic | As | Nickel | Ni |
| Astatine | At | Niobium | Nb |
| Barium | Ba | Nitrogen | N |
| Berkelium | Bk | Nobelium | No |
| Beryllium | Be | Osmium | Os |
| Bismuth | Bi | Oxygen | O |
| Boron | B | Palladium | Pd |
| Bromine | Br | Phosphorus | P |
| Cadmium | Cd | Platinum | Pt |
| Calcium | Ca | Plutonium | Pu |
| Californium | Cf | Polonium | Po |
| Carbon | C | Potassium | K |
| Cerium | Ce | Praseodymium | Pr |
| Cesium | Cs | Promethium | Pm |
| Chlorine | Cl | Protactinium | Pa |
| Chromium | Cr | Radium | Ra |
| Cobalt | Co | Radon | Rn |
| Copper | Cu | Rhenium | Re |
| Curium | Cm | Rhodium | Rh |
| Dysprosium | Dy | Rubidium | Rb |
| Einsteinium | Es | Ruthenium | Ru |
| Erbium | Er | Samarium | Sm |
| Europium | Eu | Scandium | Sc |
| Fermium | Fm | Selenium | Se |
| Fluorine | F | Silicon | Si |
| Francium | Fr | Silver | Ag |
| Gadolinium | Gd | Sodium | Na |
| Gallium | Ga | Strontium | Sr |
| Germanium | Ge | Sulfur | S |
| Gold | Au | Tantalum | Ta |
| Hafnium | Hf | Technetium | Tc |
| Helium | He | Tellurium | Te |
| Holmium | Ho | Terbium | Tb |
| Hydrogen | H | Thallium | Tl |
| Indium | In | Thorium | Th |
| Iodine | I | Thulium | Tm |
| Iridium | Ir | Tin | Sn |
| Iron | Fe | Titanium | Ti |
| Krypton | Kr | Tungsten | W |
| Lanthanum | La | Uranium | U |
| Lawrencium | Lr | Vanadium | V |
| Lead | Pb | Xenon | Xe |
| Lithium | Li | Ytterbium | Yb |
| Lutetium | Lu | Yttrium | Y |
| Magnesium | Mg | Zinc | Zn |
| Manganese | Mn | Zirconium | Zr |
| Mendelevium | Md | | |

Appendix D

Guidelines for Laboratory Fume Hoods

The following references, codes and standards provide guidelines for proper sizing and performance testing of laboratory fume hoods.

1. **Laboratory Fume Hood Specifications and Performance Testing Requirements**, Environmental Medical Service, Massachusetts Institute of Technology, Cambridge, MA, 1991.
2. **Method of Testing Performance of Laboratory Fume Hoods**, ASHRAE Standard 110-1985 RA.
3. Chamberlin, R., and Leahy, J., **Laboratory Fume Hood Standards**, EPA Report 68-01-4661, 1978.
4. Chamberlin, R., and Leahy, J., **Development of Quantitative Containment Performance Tests for Laboratory Fume Hoods**, EPA Contract No. 68-01-6197, June, 1982.
5. British Standards Institution, **Draft Standard for Safety Requirements for Fume Cupboards, Performance Testing, Recommendation on Installation and Use**, BSI Document 79/52625 DC, London, United Kingdom, August, 1979.
6. Fuller, F. H., and Etchells, A. W., **The Rating of Laboratory Hood Performance**, ASHRAE Journal, 49-53, October, 1979.
7. Ivany, R., First, M. W., and DiBerardinis, L. J., **A New Method for Quantitative, In-Use Testing of Laboratory Fume Hoods**, American Industrial Hygiene J. 50(5), 275-280, 1989.
8. Scientific Apparatus Makers Association, Standard for Laboratory Fume Hoods, **Laboratory Equipment II**, Washington, DC, 1975.
9. Schuyler, G., and Waechter, W., **Performance of Fume Hoods in Simulated Laboratory Conditions**, Report No. 487-1605 by Rowan, William, Davies and Irwin, Inc., (under contract to Health and Welfare Department, Canada), 1987.