Hardware Reference Manual

7400 Series

VSM System

The 7400 Series includes:

Model 7404 VSM System with 4-inch Electromagnet

Model 7407 VSM System with 7-inch Electromagnet

Model 7410 VSM System with 10-inch Electromagnet

Lake Shore Cryotronics, Inc.
575 McCorkle Blvd.
Westerville, Ohio 43082-8888 USA

E-Mail Addresses:
sales@lakeshore.com
service@lakeshore.com

Visit Our Website:
www.lakeshore.com

Fax: (614) 891-1392
Telephone: (614) 891-2243

Rev. 2.5 P/N 119-625 **29 September 2014**

LIMITED WARRANTY STATEMENT

WARRANTY PERIOD: THREE (3) YEARS

1. Lake Shore warrants that products manufactured by Lake Shore (the "Product") will be free from defects in materials and workmanship for three years from the date of Purchaser's physical receipt of the Product (the "Warranty Period"). If Lake Shore receives notice of any such defects during the Warranty Period and the defective Product is shipped freight prepaid back to Lake Shore, Lake Shore will, at its option, either repair or replace the Product (if it is so defective) without charge for parts, service labor or associated customary return shipping cost to the Purchaser. Replacement for the Product may be by either new or equivalent in performance to new. Replacement or repaired parts, or a replaced Product, will be warranted for only the unexpired portion of the original warranty or 90 days (whichever is greater)..

2. Lake Shore warrants the Product only if the Product has been sold by an authorized Lake Shore employee, sales representative, dealer or an authorized Lake Shore original equipment manufacturer (OEM).

3. The Product may contain remanufactured parts equivalent to new in performance or may have been subject to incidental use when it is originally sold to the Purchaser.

4. The Warranty Period begins on the date of Purchaser's physical receipt of the Product or later on the date of operational training and verification (OT&V) of the Product if the service is performed by Lake Shore, provided that if the Purchaser schedules or delays the Lake Shore OT&V for more than 30 days after delivery then the Warranty Period begins on the 31st day after Purchaser's physical receipt of the Product.

5.This limited warranty does not apply to defects in the Product resulting from (a) improper or inadequate installation (unless OT&V services are performed by Lake Shore), maintenance, repair or calibration, (b) fuses, software, power surges, lightning and non-rechargeable batteries, (c) software, interfacing, parts or other supplies not furnished by Lake Shore, (d) unauthorized modification or misuse, (e) operation outside of the published specifications, (f) improper site preparation or site maintenance (g) natural disasters such as flood, fire, wind, or earthquake, or (h) damage during shipment other than original shipment to you if shipped through a Lake Shore carrier.

6.This limited warranty does not cover: (a) regularly scheduled or ordinary and expected recalibrations of the Product; (b) accessories to the Product (such as probe tips and cables, holders, wire, grease, varnish, feed throughs, etc.); (c) consumables used in conjunction with the Product (such as probe tips and cables, probe holders, sample tails, rods and holders, ceramic putty for mounting samples, Hall sample cards, Hall sample enclosures, etc.); or, (d) non-Lake Shore branded Products that are integrated with the Product.

7. To the extent allowed by applicable law,, this limited warranty is the only warranty applicable to the Product and replaces all other warranties or conditions, express or implied, including, but not limited to, the implied warranties or conditions of merchantability and fitness for a particular purpose. Specifically, except as provided herein,

Lake Shore undertakes no responsibility that the products will be fit for any particular purpose for which you may be buying the Products. Any implied warranty is limited in duration to the warranty period. No oral or written information, or advice given by the Company, its Agents or Employees, shall create a warranty or in any way increase the scope of this limited warranty. Some countries, states or provinces do not allow limitations on an implied warranty, so the above limitation or exclusion might not apply to you. This warranty gives you specific legal rights and you might also have other rights that vary from country to country, state to state or province to province.

8.Further, with regard to the United Nations Convention for International Sale of Goods (CISC,) if CISG is found to apply in relation to this agreement, which is specifically disclaimed by Lake Shore, then this limited warranty excludes warranties that: (a) the Product is fit for the purpose for which goods of the same description would ordinarily be used, (b) the Product is fit for any particular purpose expressly or impliedly made known to Lake Shore at the time of the conclusion of the contract, (c) the Product is contained or packaged in a manner usual for such goods or in a manner adequate to preserve and protect such goods where it is shipped by someone other than a carrier hired by Lake Shore.

9. Lake Shore disclaims any warranties of technological value or of non-infringement with respect to the Product and Lake Shore shall have no duty to defend, indemnify, or hold harmless you from and against any or all damages or costs incurred by you arising from the infringement of patents or trademarks or violation or copyrights by the Product.

10. THIS WARRANTY IS NOT TRANSFERRABLE. This warranty is not transferrable.

11. Except to the extent prohibited by applicable law, neither Lake Shore nor any of its subsidiaries, affiliates or suppliers will be held liable for direct, special, incidental, consequential or other damages (including lost profit, lost data, or downtime costs) arising out of the use, inability to use or result of use of the product, whether based in warranty, contract, tort or other legal theory, regardless whether or not Lake Shore has been advised of the possibility of such damages. Purchaser's use of the Product is entirely at Purchaser's risk. Some countries, states and provinces do not allow the exclusion of liability for incidental or consequential damages, so the above limitation may not apply to you.

12. This limited warranty gives you specific legal rights, and you may also have other rights that vary within or between jurisdictions where the product is purchased and/or used. Some jurisdictions do not allow limitation in certain warranties, and so the above limitations or exclusions of some warranties stated above may not apply to you.

13. Except to the extent allowed by applicable law, the terms of this limited warranty statement do not exclude, restrict or modify the mandatory statutory rights applicable to the sale of the product to you.

CERTIFICATION

Lake Shore certifies that this product has been inspected and tested in accordance with its published specifications and that this product met its published specifications at the time of shipment. The accuracy and calibration of this product at the time of shipment are traceable to the United States National Institute of Standards and Technology (NIST); formerly known as the National Bureau of Standards (NBS).

FCC NOTICE

This equipment generates, uses, and can radiate radio-frequency energy and, if not installed and used in accordance with this manual, may cause interference to radio communications. As temporarily permitted by regulation, operation of this equipment in a residential area is likely to cause interference, in which case the user at his own facility will be required to take whatever measures that may be required to correct the interference.

SOFTWARE LIMITATIONS

Lake Shore has worked to ensure that the 7400 Series VSM Software is as free of errors as possible, and that the results you obtain from the system are accurate and reliable. However, understand that with any computer software the possibility of software errors exists.

In any important research, as when using any laboratory equipment, results should be carefully examined and rechecked before final conclusions are drawn. Neither Lake Shore nor anyone else involved in the creation or production of this software can pay for loss of time, inconvenience, loss of use of the product, or property damage caused by this product or its failure to work, or any other incidental or consequential damages. Use of our product implies that you understand the Lake Shore license agreement and statement of limited warranty.

SOFTWARE LICENSE AGREEMENT

This software is protected by United States copyright law and international treaty provisions. Lake Shore provides this software package and grants you (the user of the software) a non-exclusive and non-transferable right to use this software. Unless as provided in this Agreement, any attempt to sublicense, lease, rent, assign, or transfer this license or this software is void. To maintain software warranty, the source code must not be modified. Any changes made to the VSM Software source code is at the user's risk. Lake Shore will assume no responsibility for damage or errors incurred as result of any changes made to the source code.

Under the terms of this agreement you may use the VSM Software on any one computer. A single archival copy is permitted for the sole purpose of protecting the software from loss. Any unauthorized duplication or use of the VSM Software in whole or in part, in print, or in any other storage and retrieval system is forbidden.

TRADEMARK ACKNOWLEDGMENT

Many manufacturers and sellers claim designations used to distinguish their products as trademarks. Where those designations appear in this manual and Lake Shore was aware of a trademark claim, they appear with initial capital letters and the ™ or ® symbol.

CalCurve™, Cernox™, Duo-Twist™, Quad-Lead™, Quad-Twist™, Rox™, and SoftCal™ are trademarks of Lake Shore Cryotronics, Inc.

Duco® Cement is a trademark of Devcon Consumer Products

IDEAS® is a trademark of Unisys Corporation and is licensed for use with Lake Shore software drivers.

MS-DOS® & Windows® are trademarks of Microsoft Corp.

NI-488.2™ is a trademark of National Instruments

OmniPlex™ is a trademark of APD Cryogenics, Inc.

PC, XT, AT, and PS-2 are trademarks of IBM

Scotch® is a trademark of 3M

Shockwatch® is a trademark of Media Recovery, Inc.

Swagelok® is a trademark of Swagelok Company

Tackiwax® is a trademark of CSC Scientific Co., Inc.

Teflon® is a trademark of DuPont De Nemours

CE

Declaration of Conformity

We, **Lake Shore Cryotronics, Inc.**
575 McCorkle Blvd.
Westerville, OH 43082-8888 USA

hereby declare that the equipment specified conforms to the following Directives and Standards:

Application of Council directives: **73/23/EEC**
89/336/EEC

Standard to which Conformity is declared:................ **EN61010-1:2001**
Overvoltage II
Pollution Degree 2

EN61326 A2:2001
Class A
Annex B

Model Numbers:... **7404, 7407, 7410**

Ed Maloof 3/1/04

Ed Maloof
Printed Name

Vice President of Engineering
Position

Electromagnetic Compatibility (EMC) for the 7400 Series VSM System

Electromagnetic Compatibility (EMC) of electronic equipment is a growing concern worldwide. Emissions of and immunity to electromagnetic interference is now part of the design and manufacture of most electronics. To qualify for the CE Mark, the 7400 Series VSM System meets or exceeds the requirements of the European EMC Directive 89/336/EEC as a **CLASS A** product. A Class A product is allowed to radiate more RF than a Class B product and must include the following warning:

WARNING: This is a Class A product. In a domestic environment, this product may cause radio interference in which case the user may be required to take adequate measures.

The instrument was tested under normal operating conditions with sensor and interface cables attached. If the installation and operating instructions in the Hardware Reference Manual and corresponding Software Help Files are followed, there should be no degradation in EMC performance.

This instrument is not intended for use in close proximity to RF Transmitters such as two-way radios and cell phones. Exposure to RF interference greater than that found in a typical laboratory environment may disturb the sensitive measurement circuitry of the instrument.

Pay special attention to instrument cabling. Improperly installed cabling may defeat even the best EMC protection. For the best performance from any precision instrument, follow the grounding and shielding instructions in the Hardware Reference Manual and corresponding Software Help Files. In addition, the installer of the 7400 Series VSM System should consider the following:

- Shield measurement and computer interface cables.
- Leave no unused or unterminated cables attached to the instrument.
- Make cable runs as short and direct as possible. Higher radiated emissions is possible with long cables.
- Do not tightly bundle cables that carry different types of signals.

TABLE OF CONTENTS

Chapter/Paragraph	*Title*	*Page*
1	**PRE-INSTALLATION**	**1-1**
1.0	GENERAL	1-1
1.1	SITE PLANNING	1-1
1.2	SYSTEM POWER AND GROUND REQUIREMENTS	1-4
1.3	ENVIRONMENTAL REQUIREMENTS	1-4
1.4	INSPECTING AND UNPACKING	1-5
1.5	SITE PREPARATION	1-6
1.5.1	Power Supply Site Preparation	1-6
1.5.2	Electromagnet Site Preparation	1-7
1.6	RETURN AND SHIPPING PROCEDURE	1-7
1.6.1	Additional Magnet Shipping Instructions	1-7
1.7	SAFETY	1-7
1.7.1	Handling Liquid Helium and Liquid Nitrogen	1-8
1.7.2	Recommended First Aid for LHe or LN_2 Exposure	1-9
1.7.3	Electrostatic Discharge	1-9
1.7.3.1	Identification of Electrostatic Discharge Sensitive Components	1-9
1.7.3.2	Handling Electrostatic Discharge Sensitive Components	1-9
1.7.4	Instrument Safety	1-10
1.7.5	Safety Symbols	1-10
2	**INSTALLATION OVERVIEW**	**2-1**
2.0	GENERAL	2-1
2.1	VIBRATION DAMPING FRAME FEET AND MAGNET PAD PLACEMENT	2-1
2.2	MAGNET, FRAME, AND VSM DRIVE LEVELING	2-2
2.3	PLUMBING THE COOLING WATER	2-2
2.3.1	Electromagnet Cooling Water	2-2
2.3.2	Flow Switch	2-4
2.3.3	Power Supply Cooling Water	2-6
2.3.4	Avoiding Cooling Water Condensation	2-8
2.4	HOOKING UP CABLES	2-9
2.4.1	Instrument Console/Computer	2-9
2.4.1.1	Model 736 VSM Controller Connections	2-9
2.4.1.2	Model 142 Amplifier Connections	2-11
2.4.1.3	Computer Connections	2-12
2.4.2	Magnet/VSM Drive	2-13
2.4.2.1	4-inch Electromagnet Connections	2-13
2.4.2.2	7-inch Electromagnet Connections	2-14
2.4.2.3	10-inch Electromagnet Connections	2-15
2.4.2.4	VSM Drive Connections	2-16
2.4.3	Standard X-Axis Coil Wiring	2-17
2.4.4	Gaussmeter Probe Holder Installation	2-18
2.4.4.1	Gaussmeter Probe Orientation	2-19
2.4.4.2	Changing Probes	2-19
2.4.4.3	Probe Handling	2-19
2.4.4.4	Probe Operation	2-19
2.4.4.5	Probe Accuracy Considerations	2-20
2.4.5	Power Supply	2-21
2.4.5.1	Model 643 Magnet Power Supply Wiring	2-21
2.4.5.2	Model 648 Magnet Power Supply Wiring	2-22

TABLE OF CONTENTS (Continued)

Chapter/Paragraph *Title* *Page*

2.5 CHANGING THE MAGNET GAP 2-23
2.6 SAMPLE HOLDERS 2-24
2.6.1 Bulk Sample Holder 2-24
2.6.2 Liquid Sample Holder 2-24
2.6.3 Thin-Film Sample Holders 2-25
2.7 SAMPLE TAILS....2-26
2.7.1 Sample Tail Key 2-26
2.8 MOUNTING A SAMPLE TAIL....2-26
2.9 SAMPLE SADDLING 2-28

3 OPTIONS....3-1
3.0 GENERAL 3-1
3.1 LOW TEMPERATURE CRYOSTAT OPTION (74018)....3-1
3.1.1 Unpacking and Setup 3-3
3.1.2 Equipment Needed For Cryostat Installation....3-3
3.1.3 Preparation for Cool Down 3-3
3.1.4 Installation....3-4
3.1.5 Cool Down 3-15
3.1.6 Cryostat Temperature Control Domains....3-15
3.1.7 Operation 3-16
3.1.8 Shut Down 3-17
3.1.9 Operational Techniques 3-17
3.2 ROTATION OPTION (74030) 3-19
3.3 VECTOR OPTION (74031/32)....3-21
3.3.1 Installation....3-21
3.3.2 Calibration....3-21
3.3.3 Maintenance 3-22
3.4 HIGH TEMPERATURE OVEN OPTION (74034) 3-24
3.4.1 Oven Specifications....3-24
3.4.2 Oven Requirements....3-26
3.4.3 Installation....3-27
3.4.4 Operation Overview....3-39
3.4.5 Vacuum Pump Inlet Filter 3-39
3.4.6 Sample Holder Cleaning....3-40
3.4.7 Storage 3-40
3.4.8 Heater Temperature vs. Sample Zone Temperature 3-40
3.4.9 Curie Temperature Measurements....3-41

APPENDIX A – GLOSSARY OF TERMINOLOGY A-1

APPENDIX B – REFERENCE INFORMATION.... B-1

APPENDIX C – LAKE SHORE MODEL 340 TEMPERATURE CONTROLLER C-1

CHAPTER 1

PRE-INSTALLATION

1.0 GENERAL

This chapter provides pre-installation information for the 7400 Series VSM System. Unless a model number is specified, the information in this chapter is considered to be "generic" to all systems.

1.1 SITE PLANNING

The customer is responsible for site planning. Research the physical location, environment, power, ventilation, safety, and local building, electrical, and safety codes *before* system installation. See Figures 1-1 thru 1-3 for physical dimensions of suggested site layouts. Other configurations are possible, with the primary constraint being cable length and the need to maintain a 1 meter (3 foot) minimum distance between the console and the magnet. After initial screening, evaluate sites according to location, space, power, and structural integrity. The following are generic site preparation instructions. Due to the customized nature of VSM installations, the instructions sent directly to the customer prior the installation take precedence.

1. **Location**: Convenient for equipment and supply delivery, and handy to related work areas for efficient operation. Especially important is sufficient access for a lift to move and place an electromagnet. Place the magnet in an area free from major vibration from motors, pumps, forklifts, etc.; it may interfere with VSM System Operation. Place the magnet as far away as possible from equipment containing large AC magnetic fields, including the magnet power supply; they can induce signals large enough to overload the magnetometer input amplifiers.

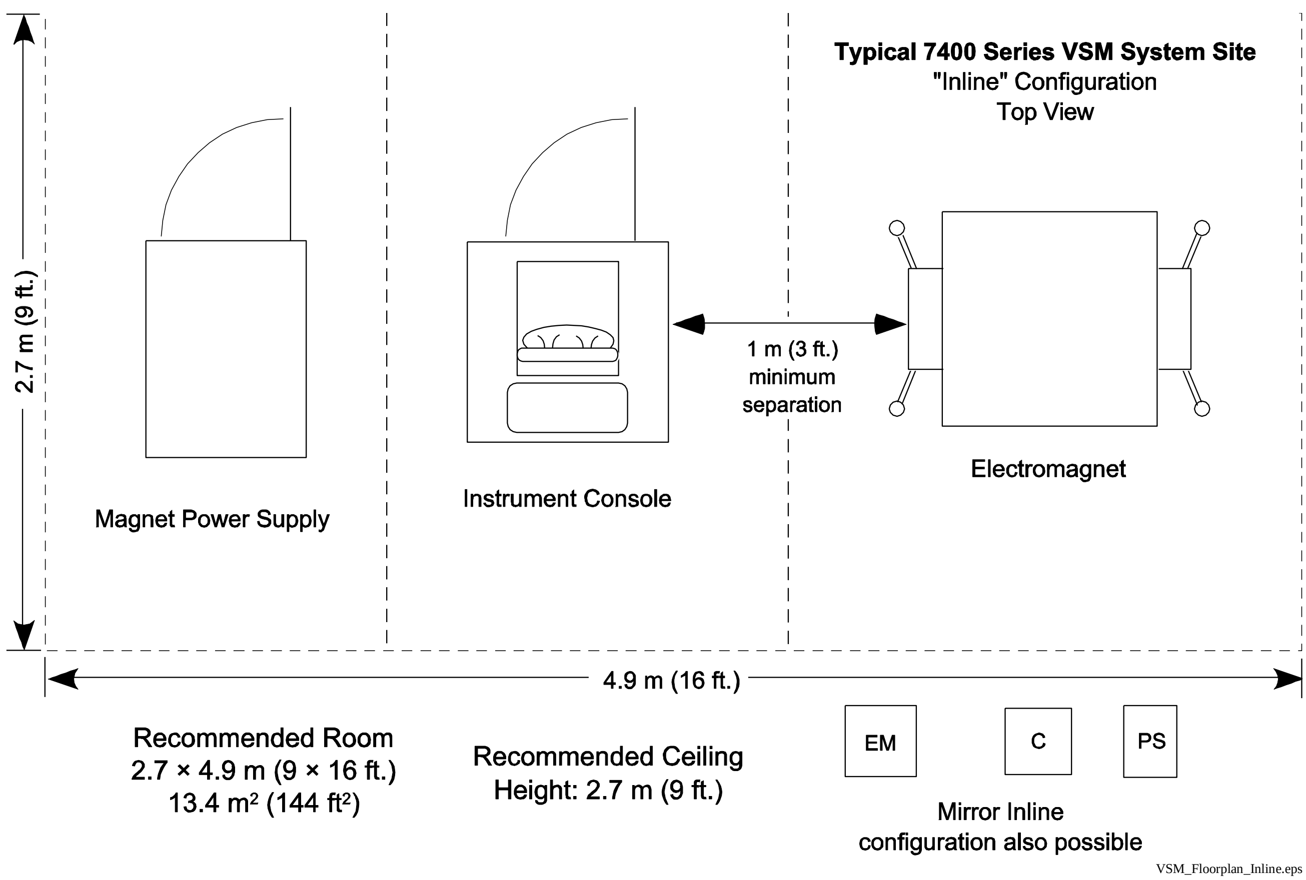


Figure 1-1. Typical 7400 Series VSM System Floor Plan – Inline

Site Planning (Continued)

2. **Space**: Adequate for system installation, operation, potential expansion, service, and storage of supplies. Space and layout requirements depend on the system selected. A minimum ceiling height of 2.7 meters (9 feet) is recommended.
3. **Power**: Adequate for system requirements, potential expansion, and wiring for maximum efficiency and economy of operation. Refer to Paragraph 1.5.
4. **Structural Integrity**: Level floor strong enough to support anticipated loads and free from extraneous vibrations or magnetic fields. Heavy concrete ground floors usually prove best, not only because they have the required strength, but such a floor also transmits minimal building vibration to the magnetometer. Vibrations transmitted to consoles may degrade system performance. In general, a ground floor is preferred over a higher floor. Also, there should be no equipment placed next to the VSM system that would emit or be susceptible to high levels of magnetic interference (distribution boxes, vibration equipment, x-ray machines, etc.). You must also consider the need for proper lifting equipment to move the magnet to the final location.
5. **Cooling Water Requirement**: Both the electromagnet and power supply require access to cooling water. Refer to Table 1-2 for electromagnet and Table 1-3 for power supply cooling requirements.

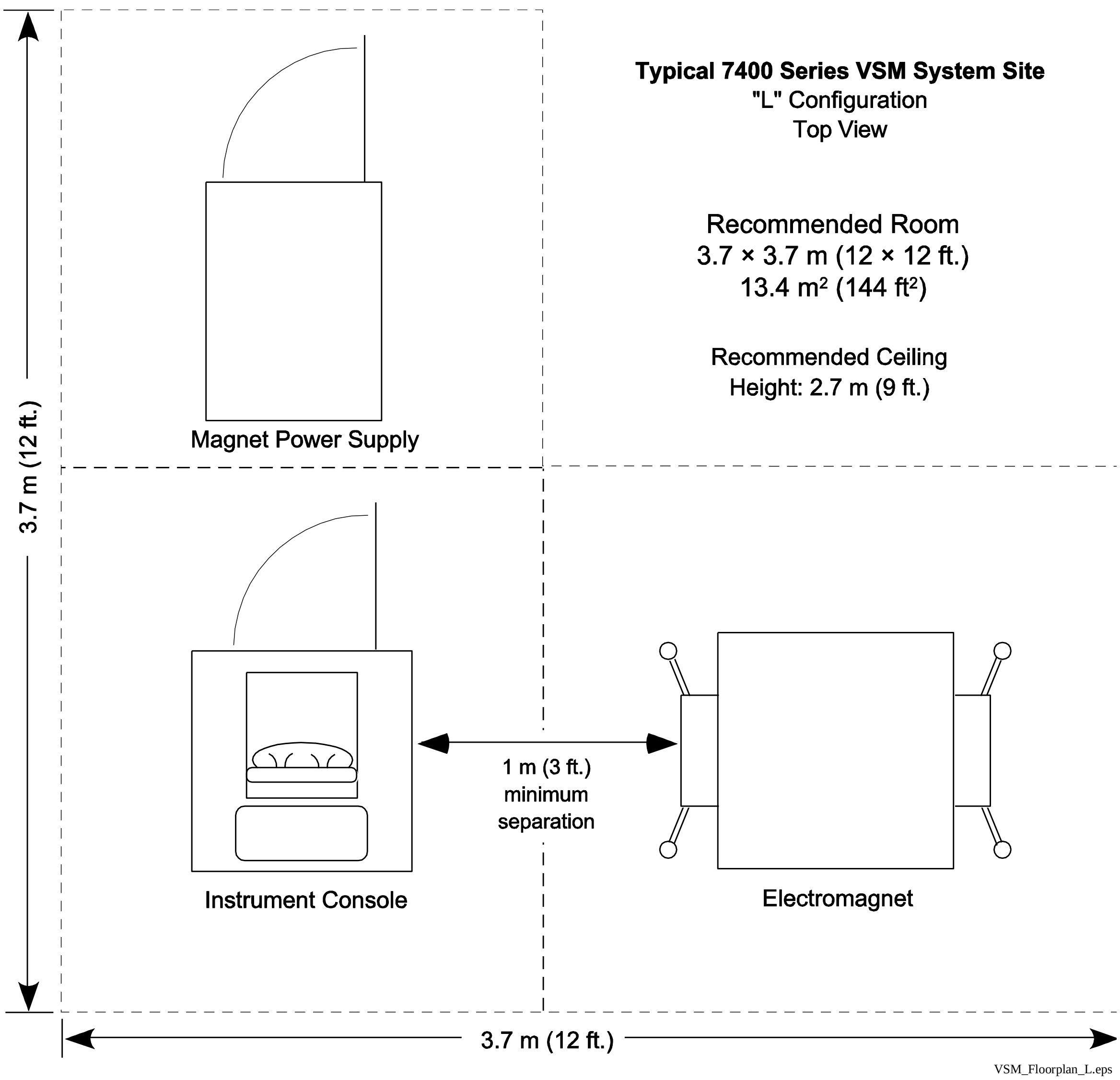


Figure 1-2. Typical 7400 Series VSM System Floor Plan – "L"

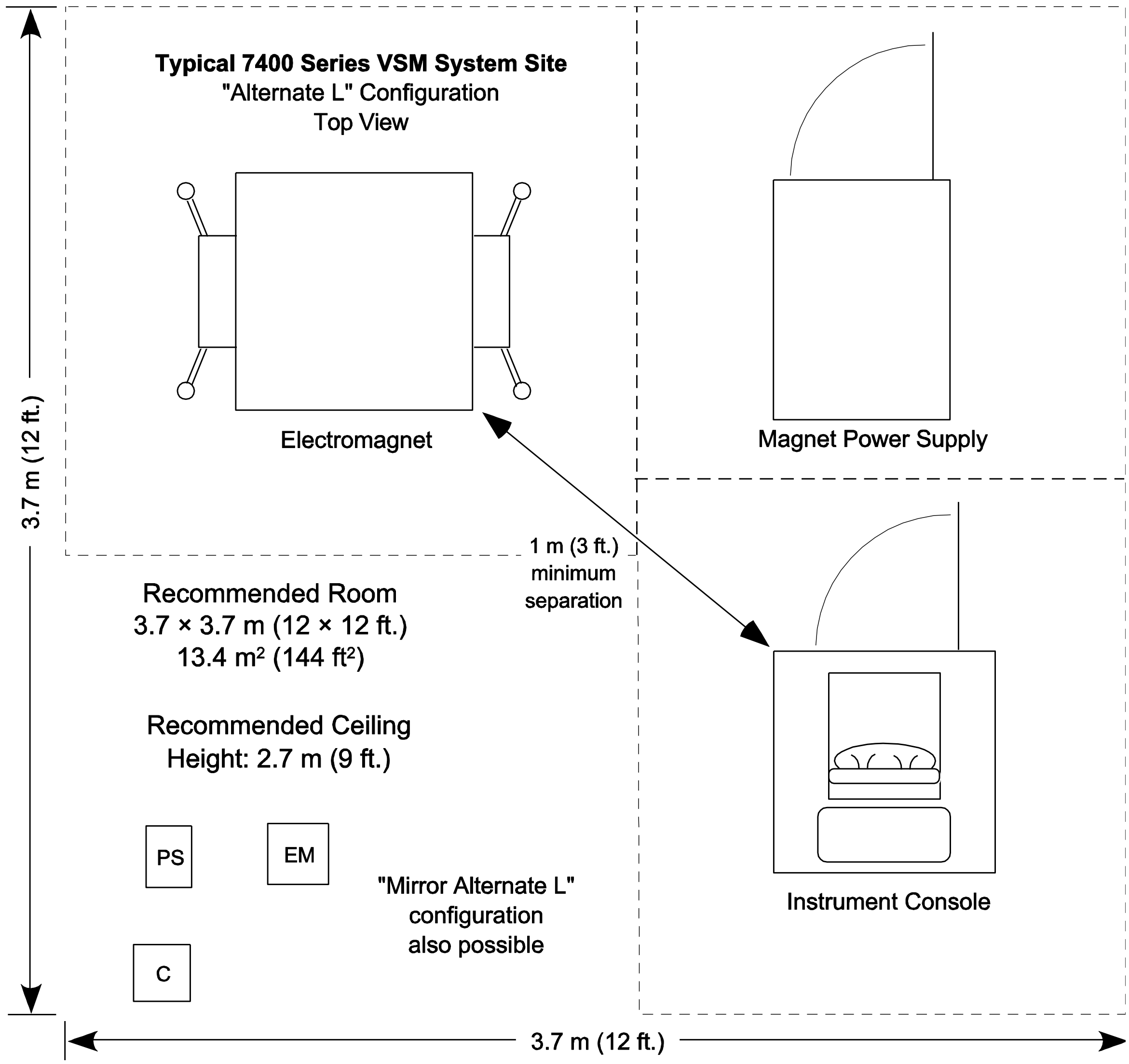


Figure 1-3. Typical 7400 Series VSM System Floor Plan – Alternate "L"

1.2 SYSTEM POWER AND GROUND REQUIREMENTS

The AC power source for the 7400 Series VSM System must be frequency and voltage regulated and isolated from sources that may generate Electromagnetic Interference (EMI). Ground Fault Interrupter (GFI) and Transient Surge Protection circuitry at the AC source are also strongly recommended. In areas where AC voltage is variable, consider a constant voltage transformer. If power outages are a problem, consider an Uninterruptible Power Supply (UPS).

The Model 736 VSM Controller, computer, flat-panel monitor, and any other optional instrumentation draws power from an outlet strip that is internal to the VSM console. The VSM console and InkJet printer each require a grounded single-phase electrical outlet. Do not use two-wire (without ground) AC power. Power requirements are defined in Table 1-3. Check with a electrician to ensure you conform to local electrical codes.

CAUTION: Do not attempt to apply electrical power to the system until all instruments have been checked for proper input power settings and fuse/circuit breaker ratings.

The factory presets the 7400 Series electrical component power requirements for proper operation upon receipt. Verify input power settings for each instrument are correct for the power source voltage before applying power to the main input power cable.

Ground instrument panels and cabinets. The safety ground provides a true ground path for electrical circuitry and, in the event of internal electrical faults such as shorts, carries the entire fault current to ground to protect users from electrical shock. The Power Strip in the Instrument Console has a three-conductor power input connector which grounds equipment in the Instrument Console when plugged into a 3-wire receptacle.

When the earth ground connection is likely impaired, render the VSM System inoperative and secure it against any unintended operation until qualified service personnel verifies its safety. The connection is likely impaired if:

1. Shows visible damage.
2. Fails to perform the intended measurement.
3. Has been subjected to prolonged storage under unfavorable conditions.
4. Has been subjected to severe transport stresses.

Electromagnetic interference (EMI) is both a natural and man-made phenomena which may degrade electronic system performance. Natural EMI includes thunderstorms, solar disturbances, cosmic rays, etc. Man-made EMI includes fixed and mobile transmitters, high voltage power lines, power tools, fluorescent lights, and other equipment containing motors, heaters, etc. Protect the AC source from EMI. Consider transient surge protectors for lightning protection.

1.3 ENVIRONMENTAL REQUIREMENTS

To meet and maintain specifications, operate the system at an ambient temperature range of 18 – 28 °C (64 – 82 °F). Operate it within the range of 15 – 35 °C (59 – 95 °F) with less accuracy. The system is intended for laboratory use. Although no specific humidity or altitude specifications exist, relative humidity of 20% to 80% (no condensation) and altitudes from sea level to 2.4 km (8,000 feet) are generally acceptable.

Adequately ventilate the work area to prevent build-up of potentially life-threatening concentrations of nitrogen gas (refer to Paragraph 1.7). Oxygen content monitor/alarms should be installed near the work site to warn against low oxygen levels if liquid cryogens are used. The air-conditioning system should filter dust and other particulates to reasonable levels. Consult an air-conditioning expert about special filtering if salt air, corrosive gases, conductive powder or other air pollutants exist.

1.4 INSPECTING AND UNPACKING

Set pallets on level surface. Inspect shipping containers for external damage. Make all claims for damage (apparent or concealed) or partial loss of shipment in writing to Lake Shore within 5 days from receipt of goods. If damage or loss is apparent, notify shipping agent immediately.

Shockwatch® indicators are included to aid in judging the condition of received goods (see Figure 1-4). Please accept shipment even if Shockwatch® is red. Note it on the bill of lading and inspect for damage immediately.

Shockwatch.bmp

Figure 1-4. Shockwatch Indicator

Cut off strapping, lift off lid, and locate the packing list included with the system. Use it to check receipt of all components, cables, accessories, and manuals as the system is unpacked. Inspect for damage. Inventory all components supplied before discarding any shipping materials. **Be sure to fill out and send instrument warranty cards.**

Remove the box from the top of the Instrument Console. Use four people to lift the Instrument Console from the pallet. Do not lift the console at the top: always lift from the bottom. Note how the console was supported on the pallet for future reference. Foam blocks between the instruments support their weight during shipment; remove them, or simply leave them in place. To transport the unit, first insert the foam blocks.

If there is instrument freight damage, file claims promptly with the carrier and insurance company, and advise Lake Shore of such filings. Advise Lake Shore immediately of missing parts. Lake Shore cannot be responsible for any missing parts unless notified within 60 days of shipment. The standard Lake Shore Warranty appears on the A Page (immediately behind the title page) of this manual.

1.5 SITE PREPARATION

The site must be prepared before your new 7400 Series VSM System arrives. The instructions in this section are generic to all VSM installations. The VSM console and electromagnet with mounting structure should be uncrated and inspected for damage upon arrival. Do not unpack the head drive (smaller wood crate 22 x 19 x 19 inches) since it is very sensitive and can be damaged if mishandled. The head drive is shipped inside another bigger wood crate. It is ok to open the bigger crate but leave the head crate unopened and do not place it upside down. The customer should examine the enclosed copy of the packing list in order to check the order for completeness. In addition, before the scheduled installation date, the VSM console and electromagnet with mounting structure should be removed from their shipping pallets and moved into the designated installation area. Any special equipment and personnel required to move the VSM system should be available, if necessary, at the time of installation. Refer to Table 1-1.

Table 1-1. Typical Shipping Weights and Dimensions

	Model 7404	Model 7407	Model 7410
Instrument Console, VSM Head, Computer, and Printer	392 kg (900 pounds) / 122 × 84 × 165 cm (48 × 33 × 65 in.) Power Supply placed inside console	318 kg (700 pounds) / 122 × 84 × 165 cm (48 × 33 × 65 in.)	
Power Supply		281 kg (620 pounds) 91.4 cm x 116.8 mm x 121.9 mm (36 in x 46 in x 48 in)	
Electromagnet with Base	325 kg (715 pounds) 107 × 94 × 135 cm (43 × 37 × 53 in.)	680 kg (1500 pounds) 81 × 117 × 119 cm (32 × 46 × 47 in.)	1800 kg (3970 pounds) 92 × 104 × 122 cm (36 × 41 × 48 in.)
Magnet Platform	N/A		91 kg (200 pounds) 92 × 92 × 61 cm (36 × 36 × 24 in.)

1.5.1 Power Supply Site Preparation

The Electromagnet Power Supply (EMPS) requires one water supply line and one return line for cooling. The water connections are standard ½-inch hose barb fittings. The Power Supply requires a continuous water flow with a temperature between +15 °C and +25 °C (**non-condensing**) and a local thermometer and flowmeter to measure these parameters. **Too cold a water supply can cause condensation and severe damage to the power supply.** The power supply requires a **separate dedicated 3-phase** electrical supply line with safety ground (3 phase plus 1 safety ground wires). The neutral is not needed (delta configuration). The current draw for the Power Supply and configuration for the input voltage is presented in the Table 1-2.

Table 1-2. Power Supply Cooling Water and Electrical Supply

	Model 7404 / Model 643 Magnet Power Supply	Model 7407 and 7410 / Model 648 Magnet Power Supply
Cooling Water	6 liters per minute (1.5 gpm)	7.6 liters per minute (2 gpm)
Supply (your unit will be configured per settings determined at time of order) †	3-phase with ground (4-wire). Voltages: 208V, 13A per phase or 400V, 6.5A per phase.	3-phase with ground (4-wire). Voltages: 208V, 23A per phase or 400V, 12 A per phase.

* If the cooling water is too cold, it can cause condensation and severe damage to the power supply. The water temperature must be above dew point.

† The customer is responsible for the power cabling between the facility power and the electrical connectors on the back of the power supply.

! The Model 643 Power Supply can create high in-rush currents (about 10 times higher than the nominal current) and requires a thermal circuit breaker that will support the initial surge. Our experience is that magnetic based breakers will routinely turn off the entire circuit and should not be used.

1.5.2 Electromagnet Site Preparation

The electromagnet requires one water supply line and one return line for cooling. The water connections are standard ¾-inch garden hose fittings, one female and one male. The electromagnet requires a continuous water flow with a temperature between +15 °C and +25 °C (**non-condensing**) and a local thermometer and flowmeter to measure these parameters. The electromagnet is equipped with a flow switch that will inhibit the output of the power supply if the water flow falls below flow requirements specification or if the coils' temperature rises above 60 °C. For 7404 and 7407 the vibration isolation should be placed under the electromagnet's base. Refer to Table 1-3.

Table 1-3. Electromagnet Cooling Water Requirements

	Model 7404	Model 7407	Model 7410
Cooling Water	8 liters per minute (2 gallon per minute)	12 liters per minute (3 gallons per minute)	16 liters per minute (4 gallons per minute)

* Electromagnet is equipped with a flow switch that inhibits the power supply output if the water flow falls below this specification.

1.6 RETURN AND SHIPPING PROCEDURE

If any part of the system appears to be damaged or operate incorrectly, contact Lake Shore or a factory representative for a Returned Goods Authorization (RGA) Number. Returns may not be accepted without an RGA number. Attach a tag with the following information when returning:

1. RGA Number.
2. Model and Serial Number.
3. User's Name, Company, Address, Phone Number, and Fax Number.
4. Malfunction Symptoms.

CAUTION: If returning a power supply or electromagnet, any water left in the cooling lines may freeze during shipping and cause irreversible damage.

Pack the equipment in the original shipping crate (if possible). Fasten it upright to a pallet large enough and rated to handle the weight. Use compressed air to force water out of the cooling lines.

Affix shipping labels, **FRAGILE** warnings, **UPRIGHT** labels, and weight of the shipment on the outside of the crate. Also write the RGA number on the outside of the shipping crate and on packing slip. Use a shipping company that can handle the weight.

1.6.1 Additional Magnet Shipping Instructions

CAUTION: The magnet coils freely rest on the poles. To prevent damage, fix coils in place during shipment.

Wedge padded wood blocks or high density foam between the coils to hold them against the magnet frame. Protect the magnet by wrapping in heavy paper or plastic. Seal with plastic tape. Make a wood box large enough to cover the whole magnet without touching it and fasten it to the pallet.

1.7 SAFETY

Train personnel in proper emergency measures such as electrical power shut off, fire department notification, fire extinguishing, and personnel and records evacuation. Here is a list of suggested personnel safety considerations:

- Ground Fault Interrupter (GFI) AC circuits.
- Cryogenic Safety Gloves, Apron, Goggles/Faceshield, and Apparel.
- Fire Extinguisher.
- Oxygen Concentration Monitor/Alarm.
- Magnetic Field Warning Signs.
- Fireproof Safe for Data, Original Software and Documentation Storage.
- Emergency Lighting.

Safety (Continued)

Locate in the immediate vicinity fire extinguisher(s) that extinguish all three classes of fires: A, B, and C. Class A is ordinary combustibles like wood, paper, rubber, many plastics, and other common materials that burn easily. Class B is flammable liquids like gasoline, oil, and grease. Class C is energized electrical equipment including wiring fuse boxes, circuit breakers, machinery, and appliances. Do not use chemical extinguishers even though they are less expensive and cover all classes of fires. They may damage electronic equipment. Use a Carbon Dioxide or Halon fire extinguisher.

During the planning stage, consult local experts, building authorities, and insurance underwriters on locating and installing sprinkler heads, fire and smoke sensing devices, and other fire extinguishing equipment.

Locate an oxygen concentration monitor and alarm in the system work area near the system. Locate another in the Dewar storage area. LHe and LN_2 can rapidly replace the breathing atmosphere in an enclosed area with no warning. Oxygen concentration monitor and alarms are the best way to reduce this potential hazard.

An electromagnet can generate large magnetic fields. Post signs at each entrance to the work area that state: “Warning: High Field Magnets – Fringe fields may be hazardous to pacemakers and other medical devices. Keep magnetic materials clear of area.” Paint a yellow magnetic field warning line on the floor 1 meter (3 feet) from the sides of the electromagnets.

Locate a fireproof safe at or near the work site for temporary storage of data and copies of original system software and documentation. Store duplicate copies of vital data well away from the system area, also in a fireproof storage vault or safe.

Even where not required by code, install some type of automatic, battery-operated emergency lighting in case of power failure or fire.

1.7.1 Handling Liquid Helium and Liquid Nitrogen

Helium and Nitrogen are colorless, odorless, and tasteless gases. When properly cooled, the gases liquefy. Liquid helium (LHe) and liquid nitrogen (LN_2) may be used in conjunction with the 7400 Series. Although not explosive, there are certain safety considerations in the handling of LHe and LN_2.

Operate all cryogenic containers (Dewars) in accordance with manufacturer instructions. Safety instructions are normally posted on the side of each Dewar. Keep cryogenic Dewars in a well-ventilated place, protected from the weather, and away from heat sources.

Transfer LHe and LN_2 and operate storage Dewar controls in accordance with manufacturer/supplier instructions. During transfer, follow all safety precautions written on the storage Dewar and recommended by the manufacturer.

WARNING: Liquid helium and liquid nitrogen are potential asphyxiants and can cause rapid suffocation without warning. Store and use liquid helium and liquid nitrogen in an adequately ventilated area. DO NOT vent the container in confined spaces. DO NOT enter confined spaces where gas may be present unless area is well-ventilated. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

WARNING: Liquid helium and liquid nitrogen can cause severe frostbite to exposed body parts. DO NOT touch frosted pipes or valves. For frostbite, consult a physician immediately. If a physician is unavailable, warm the affected parts with water that is near body temperature.

WARNING: When using compressed argon gas, nitrogen gas or helium gas, follow Compress Gas Association (CGA) best practices, applicable Safety Data Sheet (SDS) and applicable local safety requirement.

Two essential safety aspects of handling LHe are adequate ventilation and eye and skin protection. Although helium and nitrogen gases are non-toxic, they are dangerous because they replace air in a normal breathing atmosphere. Liquid helium is an even greater threat because a small amount of liquid evaporates to create a large amount of gas. Store and operate cryogenic Dewars in open, well-ventilated areas.

When transferring LHe and LN_2, protect eyes and skin from accidental contact with liquid or the cold gas issuing from it. Protect eyes with full face shield or chemical splash goggles; safety glasses (even with side shields) are inadequate. Always wear special cryogenic gloves (Tempshield Cryo-Gloves® or equivalent) when handling anything that is, or may have been, in contact with the liquid or cold gas, or with cold pipes or equipment. Wear long sleeve shirts and cuffless trousers long enough to prevent liquid from entering shoes.

1.7.2 Recommended First Aid for LHe or LN2 Exposure

Post an appropriate Material Safety Data Sheet (MSDS) obtained from the manufacturer/distributor at every site that stores and uses LHe and LN_2. The MSDS specifies symptoms of overexposure and first aid.

If a person exhibits symptoms of asphyxia such as headache, drowsiness, dizziness, excitation, excessive salivation, vomiting, or unconsciousness, remove to fresh air. If breathing is difficult, give oxygen. If breathing stops, give artificial respiration. Call a physician immediately.

If exposure to cryogenic liquids or cold gases occurs, restore tissue to normal body temperature of 37 °C (98.6°F) by bathing it in warm water not exceeding 40 °C (105 °F). DO NOT rub the frozen part, either before or after rewarming. Protect the injured tissue from further damage and infection and call a physician immediately. Flush exposed eyes thoroughly with warm water for at least 15 minutes. In case of massive exposure, remove clothing while showering with warm water. The patient should not drink alcohol or smoke. Keep warm and rest. Call a physician immediately.

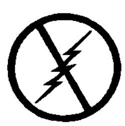
1.7.3 Electrostatic Discharge

Electrostatic Discharge (ESD) may damage electronic parts, assemblies, and equipment. ESD is a transfer of electrostatic charge between bodies at different electrostatic potentials caused by direct contact or induced by an electrostatic field. The low-energy source that most commonly destroys Electrostatic Discharge Sensitive (ESDS) devices is the human body, which generates and retains static electricity. Simply walking across a carpet in low humidity may generate up to 35,000 volts of static electricity.

Current technology trends toward greater complexity, increased packaging density, and thinner dielectrics between active elements, which results in electronic devices with even more ESD sensitivity. Some electronic parts are more ESDS than others. ESD levels of only a few hundred volts may damage electronic components such as semiconductors, thick and thin film resistors, and piezoelectric crystals during testing, handling, repair, or assembly. Discharge voltages below 4000 volts cannot be seen, felt, or heard.

1.7.3.1 Identification of Electrostatic Discharge Sensitive Components

Below are various industry symbols used to label components as ESDS:

1.7.3.2 Handling Electrostatic Discharge Sensitive Components

Observe all precautions necessary to prevent damage to ESDS components before attempting installation. Bring the device and everything that contacts it to ground potential by providing a conductive surface and discharge paths. As a minimum, observe these precautions:

1. De-energize or disconnect all power and signal sources and loads used with unit.
2. Place unit on a grounded conductive work surface.
3. Ground technician through a conductive wrist strap (or other device) using 1 MΩ series resistor to protect operator.
4. Ground any tools, such as soldering equipment that will contact unit. Contact with operator's hands provides a sufficient ground for tools that are otherwise electrically isolated.
5. Place ESDS devices and assemblies removed from a unit on a conductive work surface or in a conductive container. An operator inserting or removing a device or assembly from a container must maintain contact with a conductive portion of the container. Use only plastic bags approved for storage of ESD material.
6. Do not handle ESDS devices unnecessarily or remove from the packages until actually used or tested.

1.7.4 Instrument Safety

Observe the following general safety precautions during all phases of instrument operation, service, and repair. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended instrument use. Lake Shore assumes no liability for Customer failure to comply with these requirements.

Lake Shore instrumentation protects the operator and surrounding area from electric shock or burn, mechanical hazards, excessive temperature, and spread of fire from the instrument. Environmental conditions outside of the conditions detailed in Paragraph 1.3 may pose a hazard to the operator and surrounding area. In addition, power supply voltage fluctuations must not exceed ±10% of the nominal voltage.

Ground Instruments

To minimize shock hazard, connect instrument chassis and cabinet to an electrical ground. Most Lake Shore instruments come with a three-conductor AC power cable. Plug the power cable into an approved 3-contact electrical outlet or use a three-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The instruments should share an earth ground with the 3-phase safety ground. The power jack and mating plug of the power cable meet Underwriters Laboratories (UL) and International Electrotechnical Commission (IEC) safety standards.

Do Not Operate In an Explosive Atmosphere

Do not operate instruments in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

Prevent Cooling Water Condensation

Do not operate the power supply when cooling water temperature is at or lower than the dew point for local atmospheric conditions. Condensation on cooling water lines inside the power supply can cause severe damage. Refer to Paragraph 2.3.4 for additional details.

Only Connect One Measurement Option at a Time

To prevent incorrect measurements and possible damage to the options, only one measurement option should be connected to the cables from the instrument console. Always remove all the cables from one option before connecting cables to another option.

Keep Away From Live Circuits

Operating personnel must not remove instrument covers. Refer component replacement and internal adjustments to qualified maintenance personnel. Do not replace components with power cable connected. To avoid injuries, always disconnect power and discharge circuits before touching them.

Do Not Substitute Parts or Modify Instrument

Do not install substitute parts or perform any unauthorized modification to instruments. Return the instruments to an authorized Lake Shore representative for service and repair to ensure that safety features are maintained.

Cleaning

Do not submerge any instruments. Clean only exterior surfaces with a damp non-abrasive cloth and mild detergent.

1.7.5 Safety Symbols

- Direct current (power line).
- Alternating current (power line).
- Alternating or direct current (power line).
- 3~ Three-phase alternating current (power line).
- Earth (ground) terminal.
- Protective conductor terminal.
- Frame or chassis terminal.
- On (supply).
- Off (supply).
- Equipment protected throughout by double insulation or reinforced insulation (equivalent to Class II of IEC 536 - see Annex H).
- Caution: High voltages; danger of electric shock. Background color: Yellow; Symbol and outline: Black.
- Caution or Warning - See instrument documentation. Background color: Yellow; Symbol and outline: Black.
- Fuse.

CHAPTER 2

INSTALLATION OVERVIEW

2.0 GENERAL

The 7400 Series VSM System was electrically and mechanically inspected and operationally tested prior to shipment. It should be free from mechanical damage and in perfect working order upon receipt. Unless a specific model number is specified, the information in this chapter is considered to be "generic" to all systems.

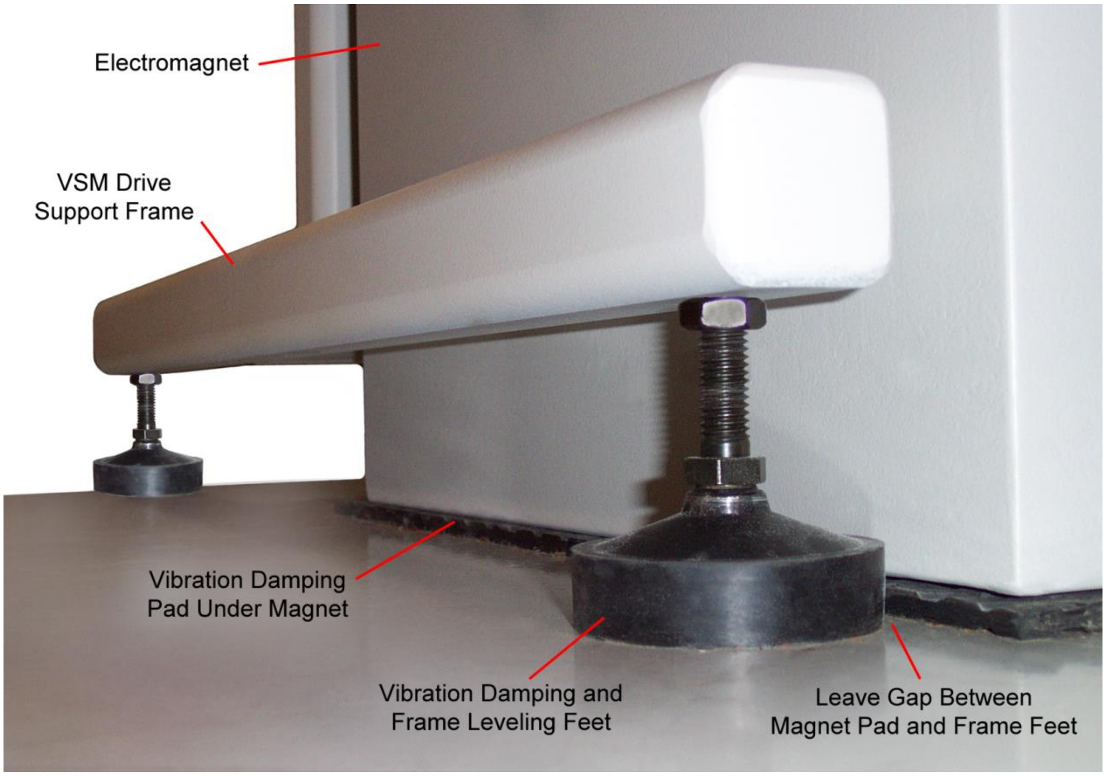
2.1 VIBRATION DAMPING FRAME FEET AND MAGNET PAD PLACEMENT

The Model 7404 rings are taped to a bag on the magnet frame. Be sure to remove them and place them in a safe place as you unpack your system. The Model 7407 black vibration pad is packaged in the electromagnet crate.

Once the VSM System site is selected, the magnet must be installed with the appropriate vibration isolation.

- **4-inch magnet**: The 4 vibration isolation rings should be placed under the electromagnet’s base, close to the 4 mounting holes,
- **7-inch magnet**: The vibration damping pad should be placed under the electromagnet’s base, in a centered position.
- **10-inch magnet**: no additional vibration damping is required.

Next, position the VSM Drive support frame around the electromagnet. Be sure to leave an even physical gap between the electromagnet and frame feet. Also be sure that no parts of the electromagnet and support frame physically touch. See Figure 2-1.



Frame_Feet.bmp

Figure 2-1. Placement of Vibration Damping Leveling Feet and Floor Pad

2.2 MAGNET, FRAME, AND VSM DRIVE LEVELING

The magnet, frame, and VSM Drive need to be level for best performance. One can use a standard torpedo level to make sure all components are aligned properly. For leveling the system, the following conventions are used to reference directions in this document:

X Direction = from left to right when facing the system.

Y Direction = from front to back when facing the system.

Magnet: Place a level across the pole pieces of the magnet to reference alignment in the X direction. The Y direction is not important. Shim with metal discs or plates to align. Place any shims on the top side of the vibration pad.

Frame: The alignment of the frame depends on the weight set upon it, so check the frame only when the drive is mounted and positioned in the measurement location. Place a level across the top plate of the frame. Position the level in the X and Y directions to determine how much adjustment it requires. Loosen nuts and rotate feet to raise or lower the vibration damping feet. Be sure to tighten nuts after the frame is leveled. See Figure 2-1.

NOTE: Do not let the frame touch the magnet. Do not let the vibration pad under the magnet touch the frame leveling feet.

VSM Drive: If the frame is level, the drive should not require any adjustment. Use the lid of the drive box to determine the alignment of the VSM drive. Use washers under the mounts to adjust the level.

2.3 PLUMBING THE COOLING WATER

Provided proper flow and temperature are maintained, standard municipal water systems are generally suitable to cool the magnet and power supply. Do not use distilled water. Use a water filter, flow meter, and pressure gauges to monitor coolant water flow.

The customers must provide components to mate with the possible connections. If garden hose fittings are not convenient, the Customer may remove them and make alternative connections.

2.3.1 Electromagnet Cooling Water

Inlet and outlet cooling lines must be hooked up to the rear of the electromagnet. The electromagnet should get dedicated cooling lines, i.e., not in series with the power supply cooling water. The water connections for the 4- and 7-inch electromagnets are standard ¾-inch garden hose fittings; one female and one male, and are shown in Figures 2-2 and 2-3, respectively.

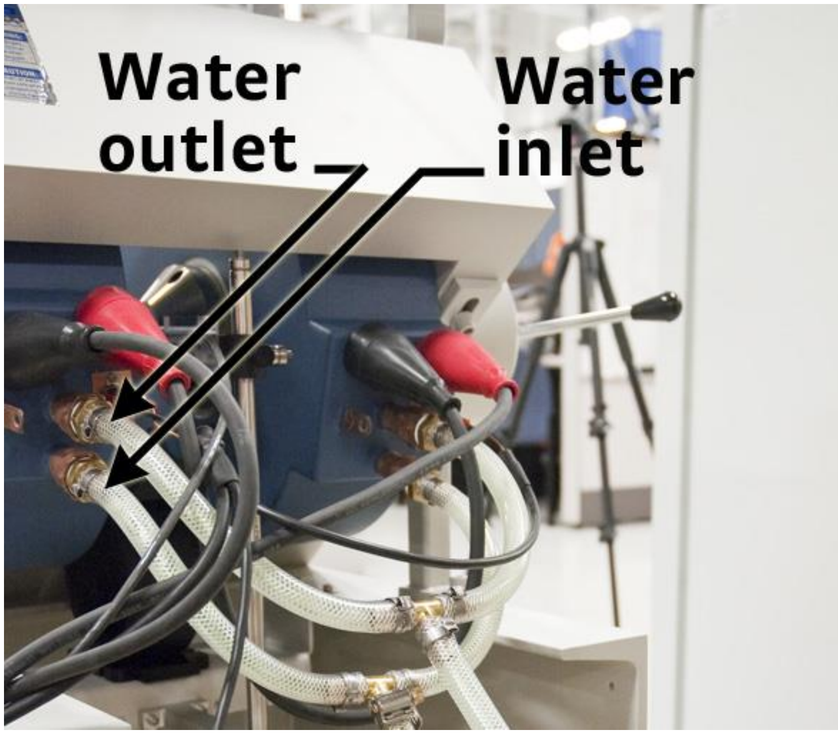


Figure 2-2. Cooling Water for 4-inch Magnet

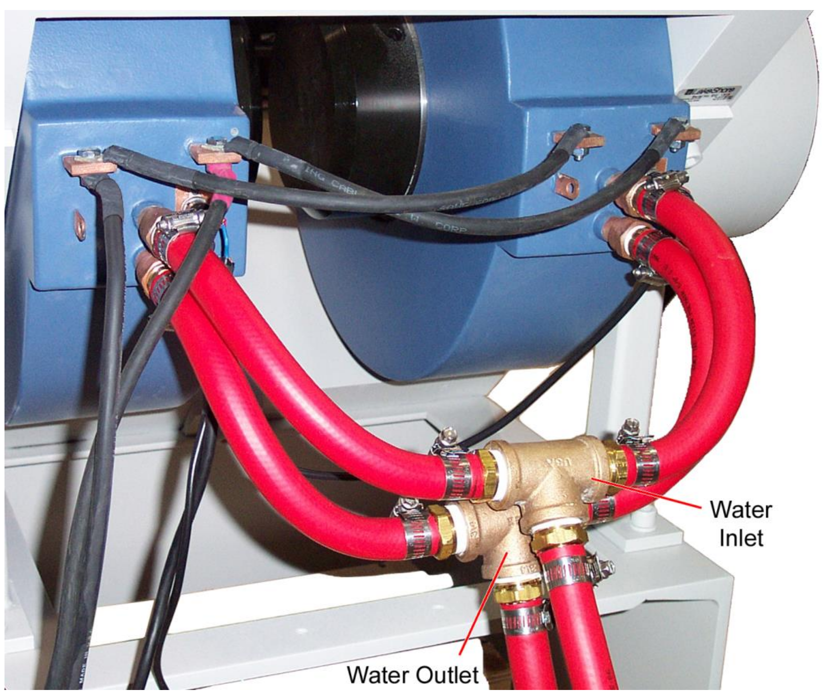


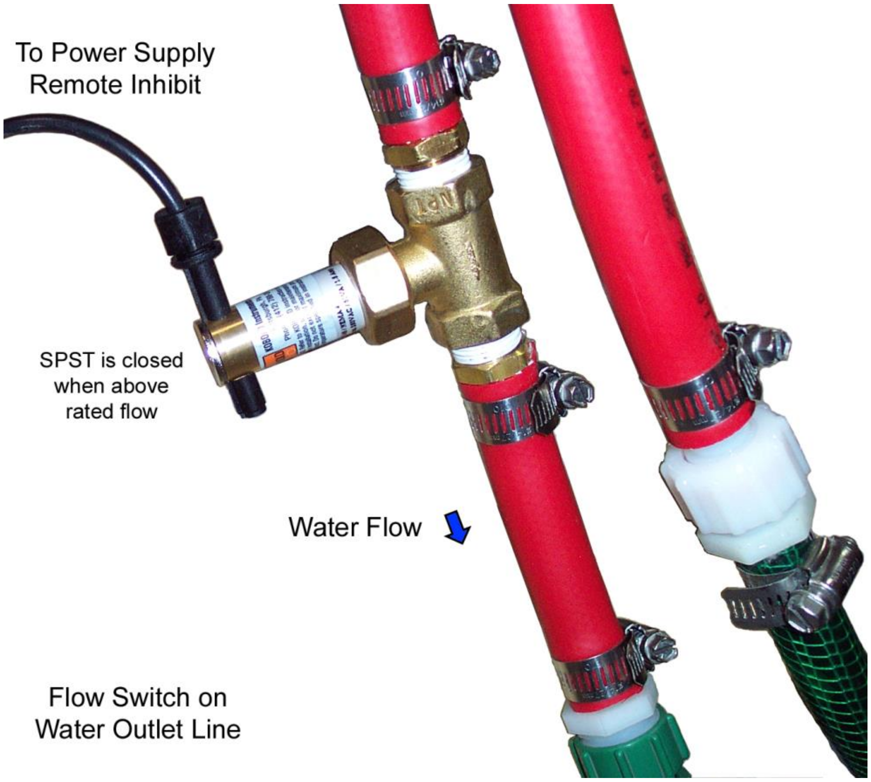
Figure 2-3. Cooling Water for 7-inch Magnet

2.3.2 Flow Switch

A flow switch is included on the cooling water outlet of the electromagnet. In the event of insufficient water flow, the switch will open forcing the power supply output to zero, and a Magnet Flow Switch Fault will appear on your computer screen. Each magnet uses a different type of switch, which are rated for the minimum water flow in liters (gallons) per minute. The 4-inch magnet is rated for 8 lpm (2 gpm), the 7-inch for 12 lpm (3 gpm), and the 10-inch for 16 lpm (4 gpm).

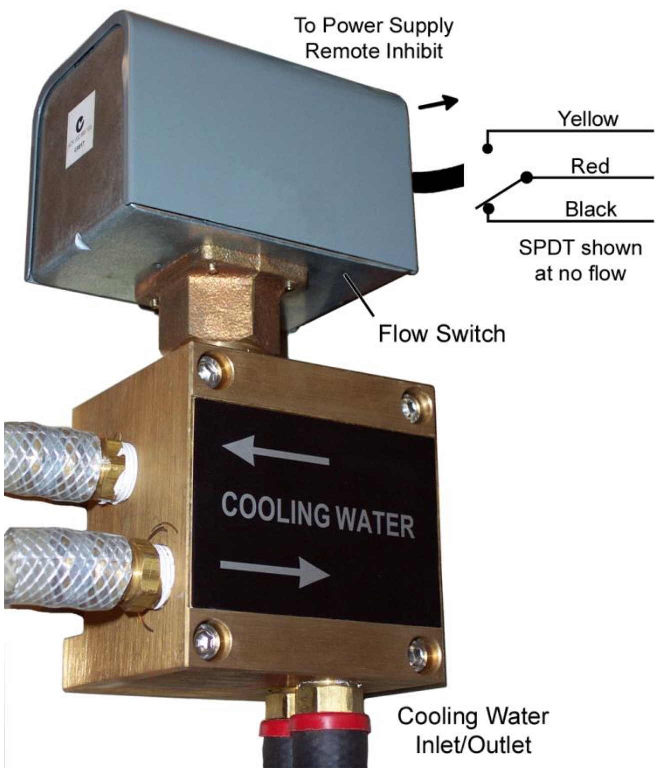
For proper operation, keep the flow switch out of the field generated by the electromagnet. In general, connecting the switch at the end of a foot-long hose is sufficient to avoid any interference. During normal operation, cooling water must be flowing through the magnet before the power supply can be turned on.

NOTE: Fault indication due to flow is instantaneous (no delay). May want to use a water line unaffected by pressure variations (toilets, etc.)



Flow_Switch_7.bmp

Figure 2-5. Flow Switch for 4-inch and 7-inch Magnet (7-inch shown)



Flow_Switch_10.bmp

Figure 2-6. Flow Switch for 10-inch Magnet

2.3.3 Power Supply Cooling Water

Supply and return water supply lines are required to cool the magnet power supply. The water connections for the magnet power supply use standard ½-inch hose barb fittings. Hose and clamps shown are not provided.

CAUTION: Too cold a supply can cause condensation and severe damage to the power supply. Refer to Paragraph 2.3.4 for further details.

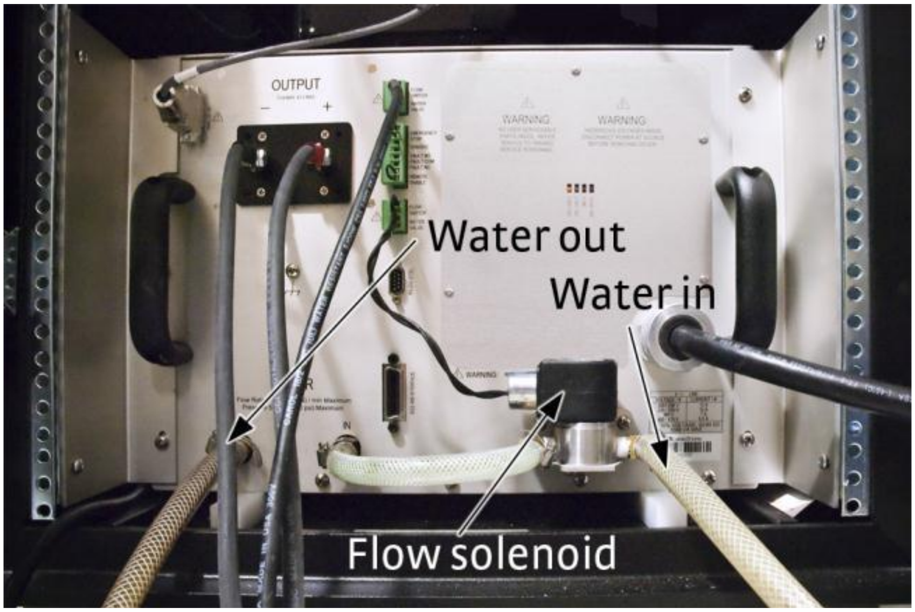


Figure 2-7 Typical water connections on the Model 643 power supply

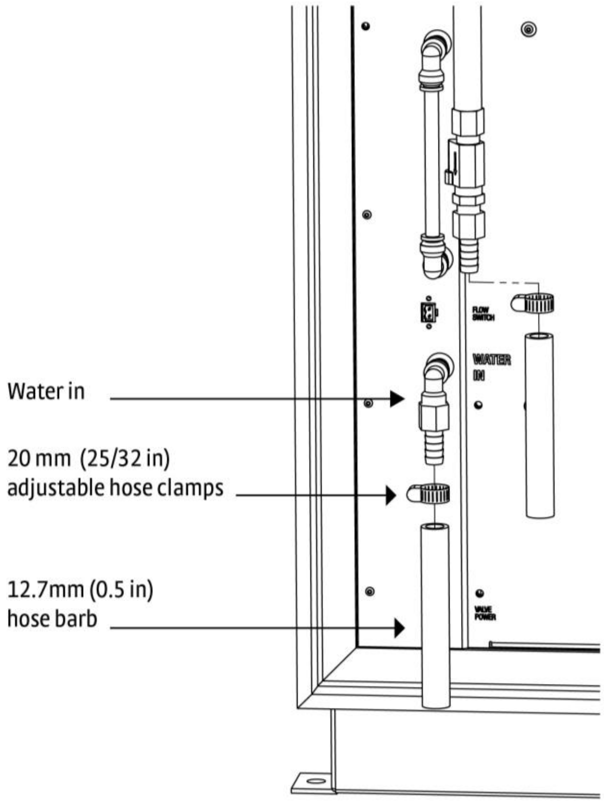


Figure 2-8. Typical water connections on the Model 648 power supply

* Hoses and clamps shown are not provided.

2.3.4 Avoiding Cooling Water Condensation

If the temperature of the cooling water is too cool relative to the air temperature and humidity, condensation can occur. Condensation inside the power supply can cause severe damage. To avoid condensation, the power supply operator must remain cognizant of the ambient air temperature, cooling water temperature, and the relative humidity. Lake Shore defines the limits of these conditions as follows: ambient temperature = 18 – 28 °C (64 – 82 °F), cooling water temperature = 15 – 25 °C (59 – 77 °F), and humidity = 20 – 80% (non-condensing). Knowing the actual state of these conditions, the operator can calculate the dew point, or temperature at which condensation will occur. Tables 2-1 and 2-2 are included to aid in dew point calculation.

NOTE: Newer power supplies are equipped with a moisture sensor. This sensor will trigger an External Fault that will inhibit the output of the power supply. This fault can also be triggered by the absence of cooling water flow.

Table 2-1. Dew Point Calculation Table (In Degrees Celsius)

	% Relative Humidity																		
°C	*100*	*95*	*90*	*85*	*80*	*75*	*70*	*65*	*60*	*55*	*50*	*45*	*40*	*35*	*30*	*25*	*20*	*15*	*10*
32	32	31	31	29	28	27	26	24	23	22	20	18	17	15	12	9	6	2	0
29	29	28	27	27	26	24	23	22	21	19	18	16	14	12	10	7	3	0	–
27	27	26	25	24	23	22	21	19	18	17	15	13	12	10	7	4	2	0	–
24	24	23	22	21	20	19	18	17	16	14	13	11	9	7	5	2	0	–	–
21	21	20	19	18	17	16	15	14	13	12	10	8	7	4	3	0	–	–	–
18	18	17	17	16	15	14	13	12	10	9	7	6	4	2	0	–	–	–	–
16	16	14	14	13	12	11	10	9	7	6	5	3	2	0	–	–	–	–	–

Table 2-2. Dew Point Calculation Table (In Degrees Fahrenheit)

	% Relative Humidity																		
°F	*100*	*95*	*90*	*85*	*80*	*75*	*70*	*65*	*60*	*55*	*50*	*45*	*40*	*35*	*30*	*25*	*20*	*15*	*10*
90	90	88	87	85	83	81	79	76	74	71	68	65	52	59	54	49	43	36	32
85	85	83	81	80	78	76	74	72	69	67	64	61	58	54	50	45	38	32	–
80	80	78	77	75	73	71	69	67	65	62	59	56	53	50	45	40	35	32	–
75	75	73	72	70	68	66	64	62	60	58	55	52	49	45	41	36	32	–	–
70	70	68	67	65	63	61	59	57	55	53	50	47	44	40	37	32	–	–	–
65	65	63	62	60	59	57	55	53	50	48	45	42	40	36	32	–	–	–	–
60	60	58	57	55	53	52	50	48	45	43	41	38	35	32	–	–	–	–	–

Example: Determine the actual air temperature and relative humidity. Find the closest air temperature in the left-hand column and the closest relative humidity across the top. If the air temperature is 24 °C (75 °F) and the relative humidity is 35%, the intersection of the two shows a dew point of 7 °C (45 °F). Therefore, for the given conditions, the cooling water must remain above 7 °C (45 °F) to prevent condensation.

2.4 HOOKING UP CABLES

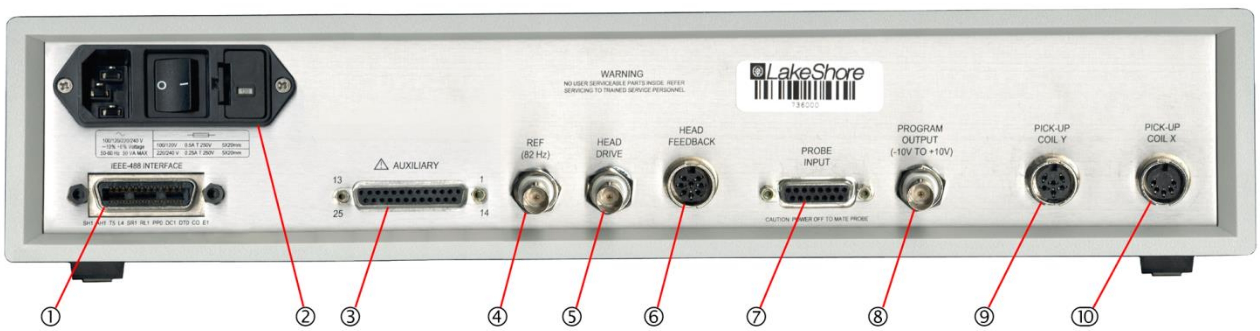
There are three major parts to the 7400 Series VSM System: Instrument Console/Computer, Magnet/VSM Drive, and Magnet Power Supply.

2.4.1 Instrument Console/Computer

The Instrument Console contains the Model 736 VSM Controller and Model 142 Amplifier. A power distribution strip is included inside the cabinet. The computer and monitor reside on top of the console.

2.4.1.1 Model 736 VSM Controller Connections

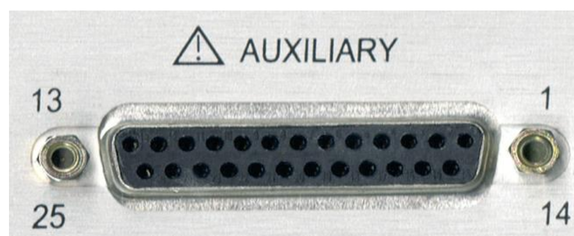
Rear panel connections for the Model 736 VSM Controller are shown in Figure 2-9. The Model 736 weighs 5.2 kilograms (11.4 pounds).



736_Back.bmp

Figure 2-9. Model 736 VSM Controller Rear Panel

1. **IEEE-488 INTERFACE:** The IEEE-488 Connector provides computer interface with the Model 736. A list of IEEE-488 commands that the Model 736 understands is provided in the Software Help Files.
2. **Line Input Assembly:** Power is provided to the Model 736 through the line input assembly.
3. **AUXILARY:** The DB-25 Auxiliary connector contains the following input/output options: two relays, four digital (TTL) inputs, EMU X and Y monitor voltages, and digital and analog supply voltages. There is an input for an external head drive on/off signal. If any of the power supply lines are accidentally shorted to ground, the line fuse may blow, but no internal circuitry should be damaged. Not used in this application.



Pin	Description	Pin	Description
1	EMU X (±2.5 VDC)	14	EMU Ground
2	EMU Y (±2.5 VDC)	15	EMU Ground
3	Gaussmeter Monitor Out (±2.5 VDC)	16	Analog GND
4	+15 Volt Analog	17	Auxiliary EMU X Input
5	–15 Volt Analog	18	Auxiliary EMU Y Input
6	Head On/Off	19	Digital GND
7	Digital Input 4 (TTL)	20	Digital GND
8	Digital Input 3 (TTL)	21	Digital GND
9	Digital Input/Output 2 (TTL)	22	+5 Volts Digital
10	Digital Input/Output 1 (TTL)	23	Relay 1 NC – 30 VDC, 3A
11	Relay 1 NC – 30 VDC, 3A	24	Relay 1 Common
12	Relay 1 Common	25	Relay 1 NO – 30 VDC, 3A
13	Relay 1 NO – 30 VDC, 3A	-	-

Model 736 VSM Controller (Continued)

4. **REF (82 Hz):** This BNC provides an external reference that is exactly equal to the reference used at the phase sensitive detector of the EMU signal. The output (on the center pin) is a 0 to 5 volt square wave (TTL) that is in phase with the EMU signal. The outer shell is ground. Not used in this application.

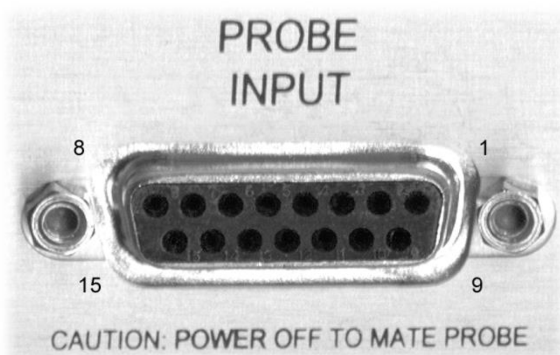
5. **HEAD DRIVE:** The output (on the center pin) from this BNC consists of a digitally generated 82 Hertz sine wave that connects to **Input 1** on the Model 142 Amplifier rear panel, which in turn creates the head vibration needed to perform a measurement. The outer shell is ground. The cable connects to the **DRIVE** connector on the rear of the VSM Drive.

6. **HEAD FEEDBACK:** This 8-pin DIN connector provides the input for the head drive feedback signal. This signal is used to keep the amplitude of the head drive constant. The head drive feedback signal is generated by an eddy current sensor located in the drive head that is powered by the –24 volt supply. The cable connects to the **FEEDBACK** connector on the rear of the VSM Drive.

Pin	Description	Pin	Description
1	Head Feedback	5	Shield
2	Ground	6	Ground
3	+15 Volts	7	–24 Volts
4	–15 Volts	8	No Connection

7. **PROBE INPUT:** The Model 736 incorporates a built-in gaussmeter. The DA-15 Probe Input connector accepts the same probes used with the Lake Shore Model 450 Gaussmeter.

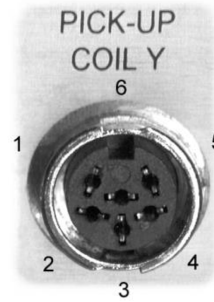
CAUTION: The Model 736 VSM Controller must be powered off before attempting to remove or attach the probe. The probe memory may be erased if connected with power on. Software operation requires the probe be connected.



Pin	Description	Pin	Description
1	Input+	9	INPUT–
2	No Connection	10	No Connection
3	No Connection	11	GND 1
4	ITEMP+ (Not read by 736)	12	Vcc
5	ITEMP– (Not read by 736)	13	A/D CLK
6	No Connection	14	EE-DATA
7	No Connection	15	Ic–
8	Ic+	—	—

8. **PROGRAM OUTPUT (–10V TO +10V):** The output (on the center pin) from this BNC consists of a ±10 VDC output used to control an external magnet power supply. The outer shell is ground. This output can be used in an open- or closed-loop configuration. In closed-loop mode, an internal digital PI control loop will control the output based on the field reading and the desired field setting.

Model 736 VSM Controller (Continued)



9. PICK-UP COIL Y: This 6-pin DIN connector provides input to the Model 736 from the signal generated by the optional Y-Coil. This signal is only used when the Vector Option is installed.

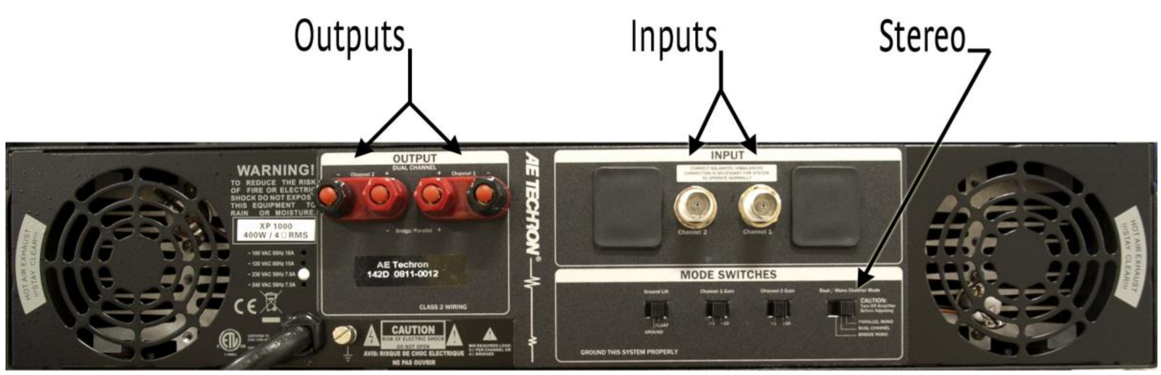
Pin	Description	Pin	Description
1	Ground	4	EMU-
2	EMU+	5	No Connection
3	Shield	6	No Connection

10. PICK-UP COIL X: This 5-pin DIN connector provides input to the Model 736 from the signal generated by the X-Coil.

Pin	Description	Pin	Description
1	Ground	4	EMU-
2	EMU+	5	No Connection
3	Shield	—	—

2.4.1.2 Model 142 Connections

The rear panel connections of the Model 142 Amplifier are defined as follows. See Figure 2-10.



Amplifier_Rear.bmp

Figure 2-10. Model 142 Amplifier Rear Panel

1. **Stereo:** Sets the amplifier into Stereo mode. Even though only one channel is actually being used in this application, leave the amplifier set to Stereo Mode.

2. **Input 1:** The BNC cable from Input 1 connects to the **Head Drive** BNC connector on the Model 736 rear panel.

3. **OUTPUTS CH-1:** A dual banana plug connects to the Channel 1 output. The side of the plug with the extended "tab" is the negative side, which goes to the black connector. This cable terminates at the 8-pin MIL-C **Drive/Feedback** connector on the rear of the VSM Drive. Channel 2 (CH-2) is not used. The CH LEVEL knobs on the front panel are disabled at the factory.

2.4.1.3 Computer Connections

The computer connections are defined as follows. See Figure 2-11. The monitor (not shown) also requires input and power connections.

CAUTION: Do not install any third-party software on this computer. Installing other software may cause conflicts with the operation of the 7400 Series VSM System and can have unintended consequences. Lake Shore assumes no responsibility for damage to the system as the result of unauthorized software installation.

NOTE: Because of the volatility of the computer market, the computer shown here is a typical representative. Your actual computer may vary in form, but the functions will remain.

NOTE: The password for the Windows Administrator logon is "LakeShore".

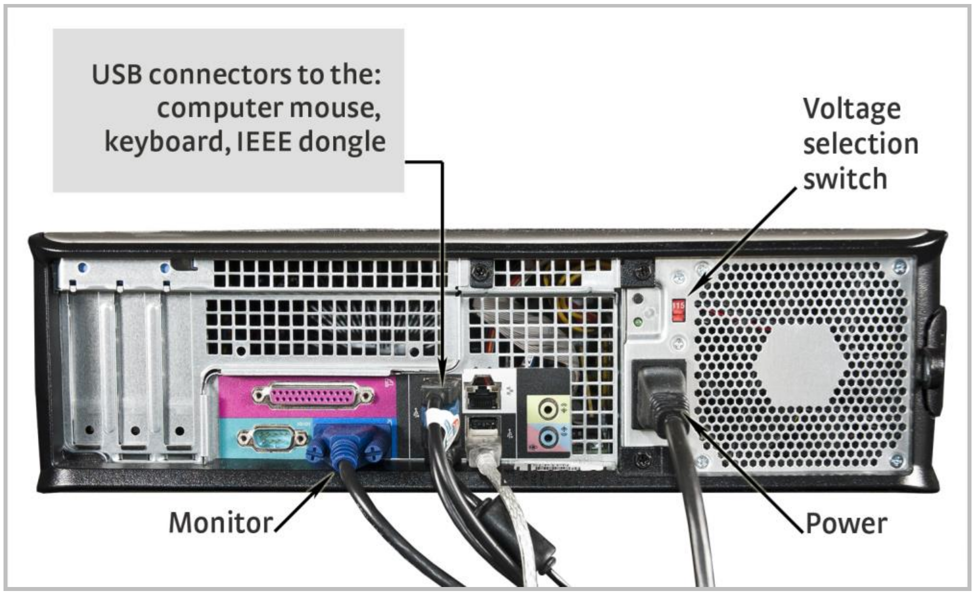


Figure 2-11. Computer Rear Panel

Mouse: This USB connector goes to the computer mouse.

Keyboard: This USB connector goes to the computer keyboard.

Monitor: This connector goes to the computer monitor.

Power: This power cord runs inside the Instrument Console and plugs into the Distribution Strip.

(Also run the monitor power connector to this same Distribution Strip.)

Voltage Selection Switch: If your computer includes this switch, make sure it matches your local power requirements.

NOTE: While Ethernet is provided with the computer, Lake Shore assumes no responsibility for making the computer communicate with your network.

IEEE-488 Interface: One of the computer's rear USB ports connects to the external IEEE-488 interface's USB connector. The external IEEE-488 interface also connects to the Model 736's IEEE-488 connector. The interface provides the communications link between the computer and many of the instruments in the console. If any other optional instruments besides the Model 736 are added, they can be "daisy-chained" to the interface with additional IEEE-488 cables

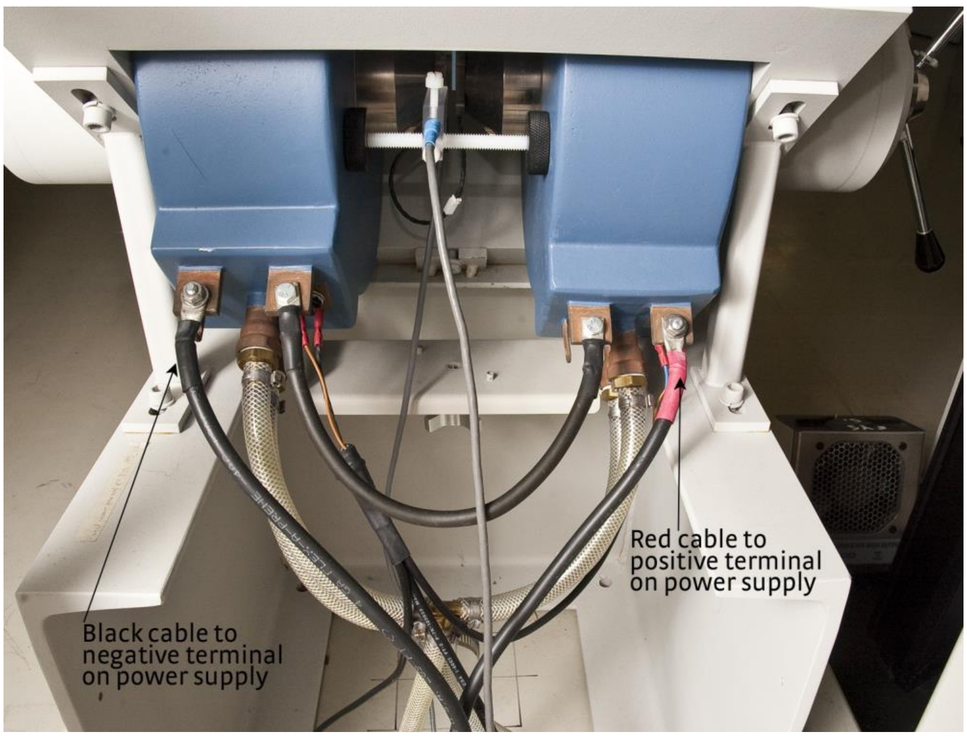
2.4.2 Magnet/VSM Drive

This section details electrical connections from the electromagnet and VSM Drive. Magnets are wired to match the output of the power supply. In general, the VSM magnet is wired to a nominal resistance of 0.5 ohm. However, the magnets and power supplies physically look different. The water connections should already be made (Paragraph 2.3).

2.4.2.1 4-Inch Electromagnet Connections

4-inch magnet wiring connections are shown in Figure 2-12.

1. The 4-inch magnet coils are wired in series. When viewing the magnet from the rear:
    a. The red (+) cable from the power supply is attached on the right terminal of the right coil.
    b. The black (–) cable from the power supply is attached on the left terminal on the left coil.
    c. The jumper cable connects to the remaining, inner terminals.
2. The red (+) cable from the magnet runs to the (+) connection on the power supply. The black (–) cable from the magnet runs to the (–) connection on the power supply.



4in_Wiring.bmp

Figure 2-12. Typical 4-inch Magnet Wiring Connections

2.4.2.2 7-Inch Electromagnet Connections

7-inch magnet wiring connections are shown in Figure 2-13.

1. The 7-inch magnet coils are wired in parallel. When viewing the magnet from the rear:
    a. The red (+) cable from the power supply is attached to the right terminal of the left coil.
    b. The black (–) cable from the power supply is attached to the left terminal on the left coil.
    c. One jumper cable connects to the left terminals of both coils (as shown), and the second jumper cable connects to the right terminals of both coils.
2. The red (+) cable from the magnet runs to the (+) connection on the power supply. The black (–) cable from the magnet runs to the (–) connection on the power supply.
3. The water flow switch (shown in Figure 2-5), is wired in series with the two thermal over-temperature switches; one on each coil. See Figure 2-14 for a typical wiring. The cable from the water flow switch and over-temperature switches runs to the power supply interlock connection.

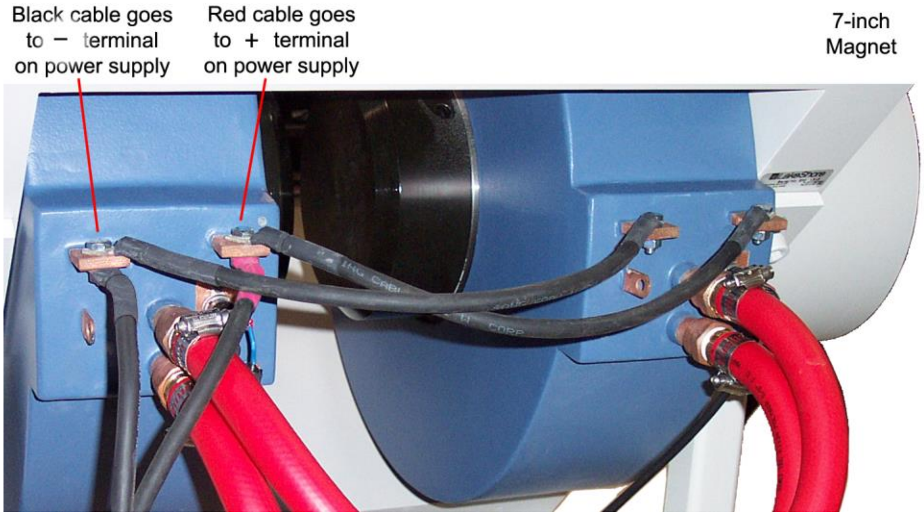
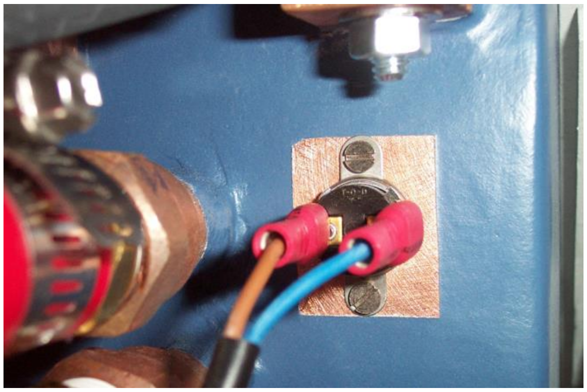


Figure 2-13. Typical 7-inch Magnet Wiring Connections (shown with safety cover removed for clarification)



7in_T_Switch.bmp

Figure 2-14. Typical 7-inch Magnet Thermal Switch Connections

2.4.2.3 10-Inch Electromagnet Connections

10-inch magnet wiring connections are shown in Figure 2-15.

1. The 10-inch magnet coils are wired in series. When viewing the magnet from the rear:
   a. The red (+) cable from the power supply is attached on the left terminal of the left coil.
   b. The black (–) cable from the power supply is attached on the right terminal on the right coil.
   c. The jumper cable connects to the remaining, inner terminals.
2. The red (+) cable from the magnet runs to the (+) connection on the power supply. The black (–) cable from the magnet runs to the (–) connection on the power supply.
3. The water flow interlock switch and thermal over-temperature switches are pre-wired to the terminal block. The cable from the power supply interlock connection runs to Pins 1 and 4 on the terminal block.

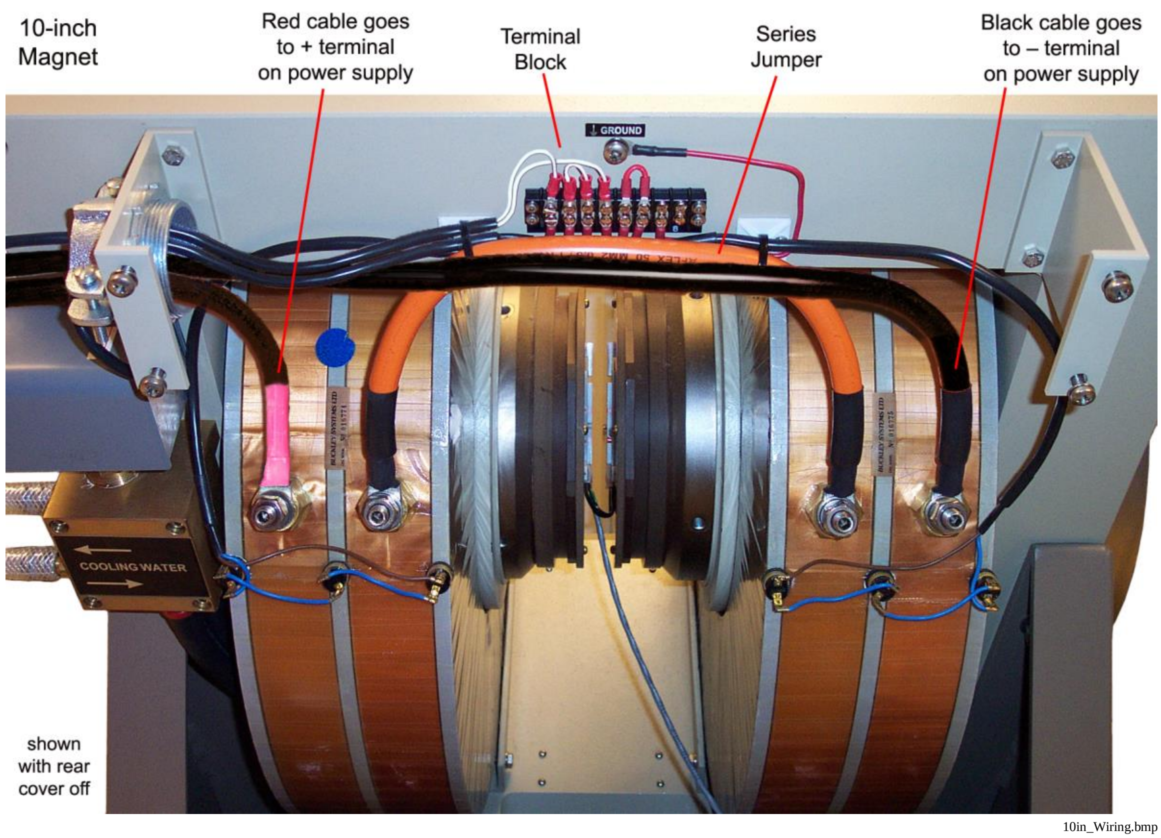


Figure 2-15. Typical 10-inch Magnet Wiring Connections (Rear Cover Removed)

2.4.2.4 VSM Drive Connections

The standard VSM drive has only two connections: drive/feedback and a D-type connector for the auto-rotation option. See Figure 2-16.

1. The drive/feedback uses an 8-pin MIL-C connector. The drive end of the drive/feedback connector is connected to the dual banana **OUTPUT CH-1** connector on the rear of the Model 142 Amplifier. The feedback end of the drive/feedback connector is connected to the head feedback 8-pin DIN connector on the rear of the Model 736 VSM Controller.

3. If the Auto-Rotation option is installed, a 9-pin D-type cable is added. It connects to the motor controller mounted in the VSM instrument console.

Figure 2-16. Typical VSM Drive Connections

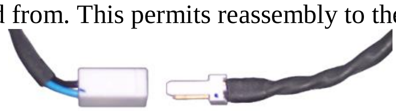
2.4.3 Standard X-Axis Coil Wiring

Coils are available in 1- inch (mini) and 2-inch (large) varieties. When coils are specified as part of the original order, the coils are permanently mounted to the pole face. The connecting cable between the coils is normally left in place during shipping. The cable running from the coil assembly is attached to the **PICKUP COIL X** connector on the Model 736 VSM Controller.

A typical Model 740 EMSC mini coil pre-mounted on a 4-inch magnet is shown in Figure 2-17. A typical Model 740 ESC large coil pre-mounted on a 7-inch magnet is shown in Figure 2-18. The coil mount on the 10-inch magnet will look similar to this. Finally, a typical coil wiring diagram is shown in Figure 2-19.

CAUTION: If the pole caps are ever removed, be sure to first disconnect the cable (shown below) running between the coils and mark the location of the pole caps with respect to the pole they were removed from. This permits reassembly to the same location.

Model 740 EMSC mini coil cable connector



Model ESC large coil cable connector

NOTE: If you have the optional Vector Coils installed, the Y-axis cable is attached to the PICKUP COIL Y connector on the Model 736 VSM Controller.

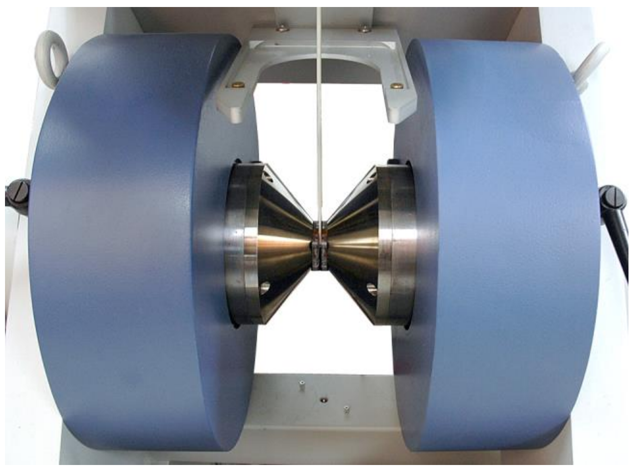


Figure 2-17. Typical Model 740 EMSC mini coils with EM7-2P pole caps on a Model EM7-HV magnet

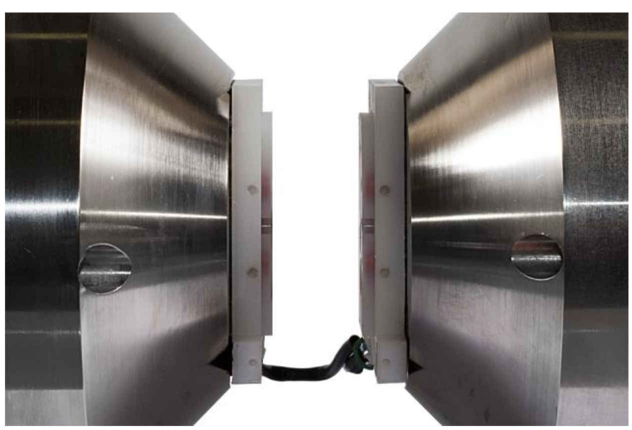


Figure 2-18. Typical Model 740 ESC large coils with EM7-4P pole caps on the Model EM7-HV magnet

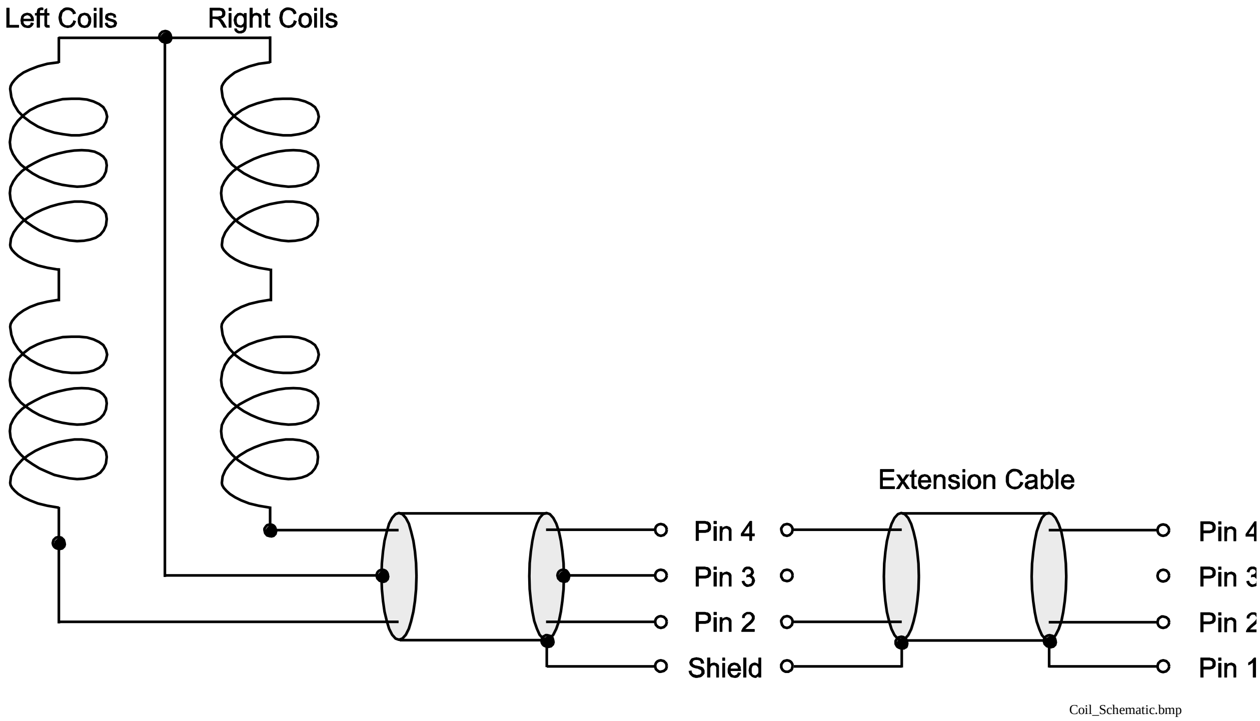


Figure 2-19. Typical Coil Wiring Diagram

2.4.4 Gaussmeter Probe Holder Installation

Mount the gaussmeter probe near the sample between the magnet pole pieces. Mount the flat side of the probe parallel with the pole faces and secure it.

1. To install Gaussmeter probe holder, turn the 2 knurled end pieces to tighten against the coils. See Figure 2-20.
2. Tighten the front screw to lock the mounting block against the threaded rod. Do not over tighten.

CAUTION: Exercise care when handling the gaussmeter probe; its tip is very fragile. Stressing the gaussmeter probe tip may alter its calibration. Any excess force can easily break the sensor. Broken sensors are irreparable.

3. Carefully place the gaussmeter probe into the holder. Turn top screw to hold it in position. Always secure gaussmeter probe by the body; securing the tip can cause irreparable damage.

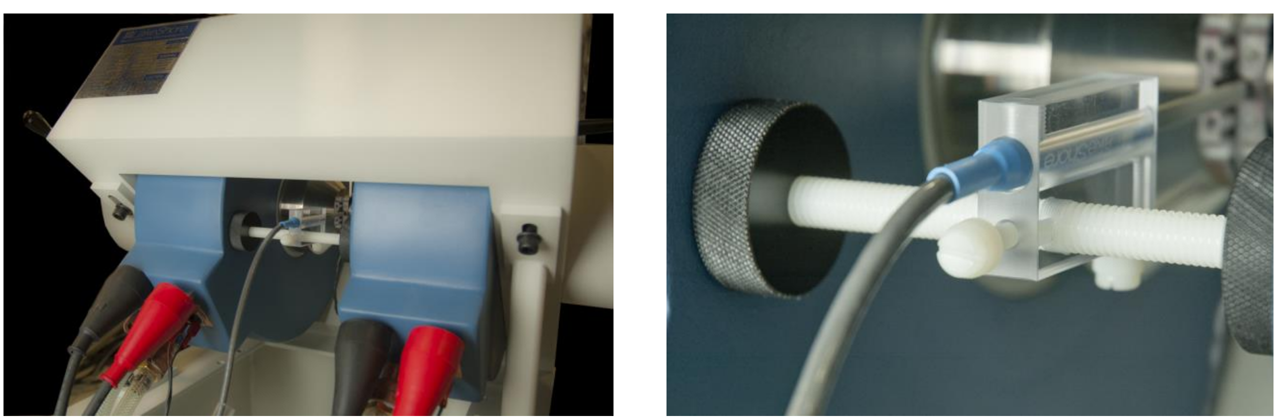


Figure 2-20. Gaussmeter Probe Holder Installation

2.4.4.1 Gaussmeter Probe Orientation

The orientation of the gaussmeter probe is critical to field control. If you are unsure of correct orientation, use the following procedure.

1. With the magnet power supply OFF and local regulation set to zero, place the gaussmeter probe in the electromagnet noting the orientation of the Lake Shore Snowflake symbol.
2. Turn the power supply ON in INTERNAL PROGRAMMING mode. Manually set a positive current of a few amps corresponding to approximately 500 Oe.
3. Read the gaussmeter display in the VSM software to ensure the field reading is positive. If the field reading is negative, reverse the orientation of the probe.
4. When done, reduce current to zero and turn OFF power supply.

2.4.4.2 Changing Probes

An Electrically Erasable Programmable Read Only Memory (EEPROM) is included in each probe. The EEPROM stores specific information that the gaussmeter built into the Model 736 VSM Controller requires for operation. The information includes serial number, probe sensitivity, and field compensation data.

CAUTION: The probe must be connected to the rear of the Model 736 before applying power. Probe memory may be erased if connected with power on.

When the instrument is powered up, the probe memory is downloaded to the Model 736. This is how the built-in gaussmeter knows which ranges are available and which error correction to apply. To change probes, first turn power off, remove the existing probe, and then plug in the new probe. When power is restored, the characteristics of the new probe are downloaded to memory. Normal operation may continue after the new probe offset is nulled using the Zero Probe operation. If the instrument is powered up with no probe attached, the VSM software will report an error message.

2.4.4.3 Probe Handling

Although every attempt has been made to make the probes as sturdy as possible, the probes are still fragile. This is especially true for the exposed sensor tip of some transverse probes. Care should be taken during measurements that no pressure is placed on the tip of the probe. The probe should only be held in place by securing at the handle. The probe stem should never have force applied. Any strain on the sensor may alter the probe calibration, and excessive force may destroy the Hall generator.

CAUTION: Care must be exercised when handling the probe. The tip of the probe is very fragile. Stressing the Hall sensor can alter its calibration. Any excess force can easily break the sensor. Broken sensors are not repairable.

When the probe is not in use, the protective tubes provided should be placed over the probe handle and stem in order to protect the tip. When not in use, the probe should be stored separately in some type of rigid container. The cardboard and foam container that Lake Shore probes are shipped in may be retained for probe storage.

2.4.4.4 Probe Operation

In the DC mode of operation, the orientation of the probe affects the polarity reading. On a transverse probe, the Lake Shore name printed on the handle indicates the side for positive (+) flux entry. On an axial probe, positive (+) flux entry is always from the front of the probe. See Figure 2-21.

NOTE: For best results, the instrument and probe should warm up for at least 5 minutes before zeroing the probe, and at least 30 minutes for rated accuracy. The probe and the zero gauss chamber should be at the same temperature.

If the exact direction of the magnetic field is unknown, the proper magnitude is determined by turning on **Max Hold** and slowly adjusting the probe. As the probe turns and the measured field rises and falls, its maximum value is held on the display. Make note of the probe orientation at the maximum reading to identify the field orientation.

2.4.4.5 Probe Accuracy Considerations

NOTE: Probe readings are dependent upon the angle of the sensor in relation to the magnetic field. The farther from 90° the angle between the probe and the field, the greater the percentage of error. For example, a 5° deviation causes a 0.4% error, a 10° deviation causes a 1.5% error, etc.

NOTE: For best results, the instrument and probe should warm up for at least 5 minutes before zeroing the probe, and at least 30 minutes for rated accuracy. The probe and the zero gauss chamber should be at the same temperature.

The user must consider all the possible contributors to the accuracy of the reading. Both the probe and instrument have accuracy specifications that may impact the actual reading. The probe should be zeroed before making critical measurements. The zero probe function is used to null (cancel) out the zero offset of the probe or small magnetic fields. It is normally used in conjunction with the zero gauss chamber, but may also be used with an open probe (registering the local earth magnetic field).

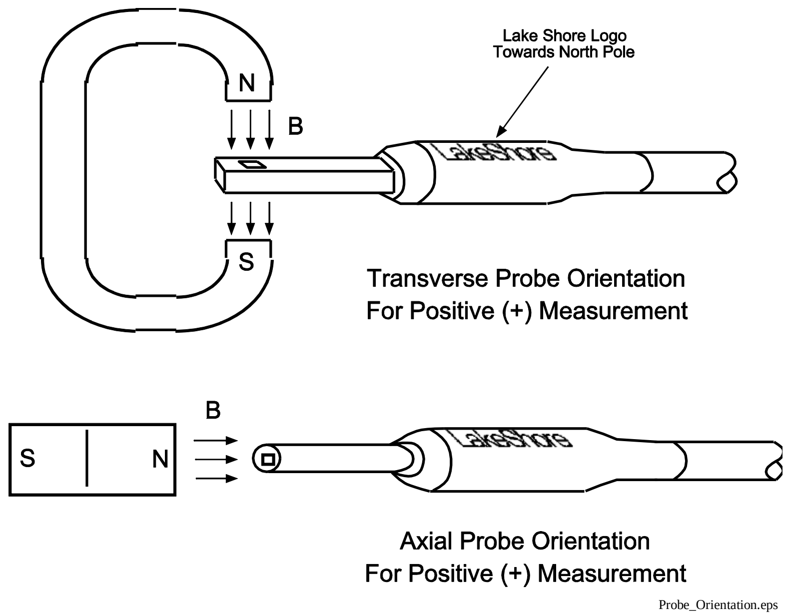


Figure 2-21. Probe Orientation for Positive Measurement

NOTE: The Model 736 VSM Controller does not read the temperature compensation table stored in the gaussmeter probe.

Probe readings are dependent on the angle of the sensor (Hall sensor) in relation to the magnetic field. Maximum output occurs when the flux vector is perpendicular to the plane of the sensor. This is the condition that exists during factory calibration. The greater the deviation from orthogonality (from right angles in either of three axes), the larger the error of the reading. For example, a 5° variance on any one axis causes a 0.4% error, a 10° misalignment induces a 1.5% error, etc. See Figure 2-22.

Tolerance of instrument, probe, and magnet must be considered for making critical measurements. The accuracy of the Model 736 reading is better than ±0.20% of reading and ±0.05% of range. Absolute accuracy readings for the Model 736 and gaussmeter probe is a difficult specification to give, because all the variables of the measurement are difficult to reproduce. For example, a 1° error in alignment to the magnetic field causes a 0.015% reading error. Finally, the best probes have an accuracy of ±0.15%. This implies that the absolute accuracy measurement of a magnetic field is not going to reliably be better than ±0.15% under the best of circumstances, and more likely to be 0.20% to 0.25%.

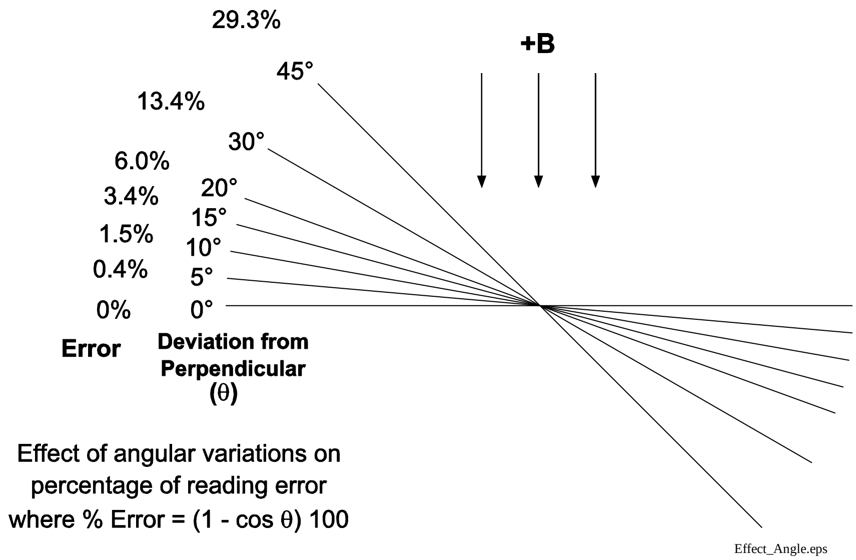


Figure 2-22. Effect of Angle on Measurements

2.4.5 Power Supply

Although three different models of power supply are used, they have similar wiring connections. Per the site preparation instructions (paragraph 1.5), the Customer is responsible for providing the hookup from the electrical box at back of the power supply to the electrical service.

2.4.5.1 Model 643 Magnet Power Supply Wiring

Model 643 wiring is shown in Figure 2-23.

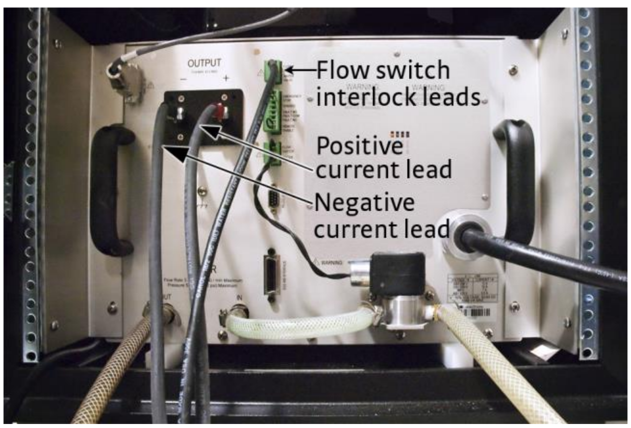


Figure 2-23. Magnet Power Supply Rear Panel Connections

Analog I/O connector Connects to the **Program Output** BNC on the rear panel of the Model 736 VSM Controller.

NOTE: The positive and negative leads must be wired properly to maintain the correct polarity.

Power Supply Output – Positive (+): The wire marked in red goes to the positive terminal of the electromagnet.
Power Supply Output – Common (–): The wire marked in black goes to the negative terminal of the electromagnet.
Magnet flow switch: This is the power supply inhibit connector. It is connected to a single water flow and two thermal cutoff switches in series, any of which can inhibit the output of the power supply.

2.4.5.2 Model 648 Magnet Power Supply Wiring

Model 648 wiring is shown in Figure 2-24 and Figure 2-25.

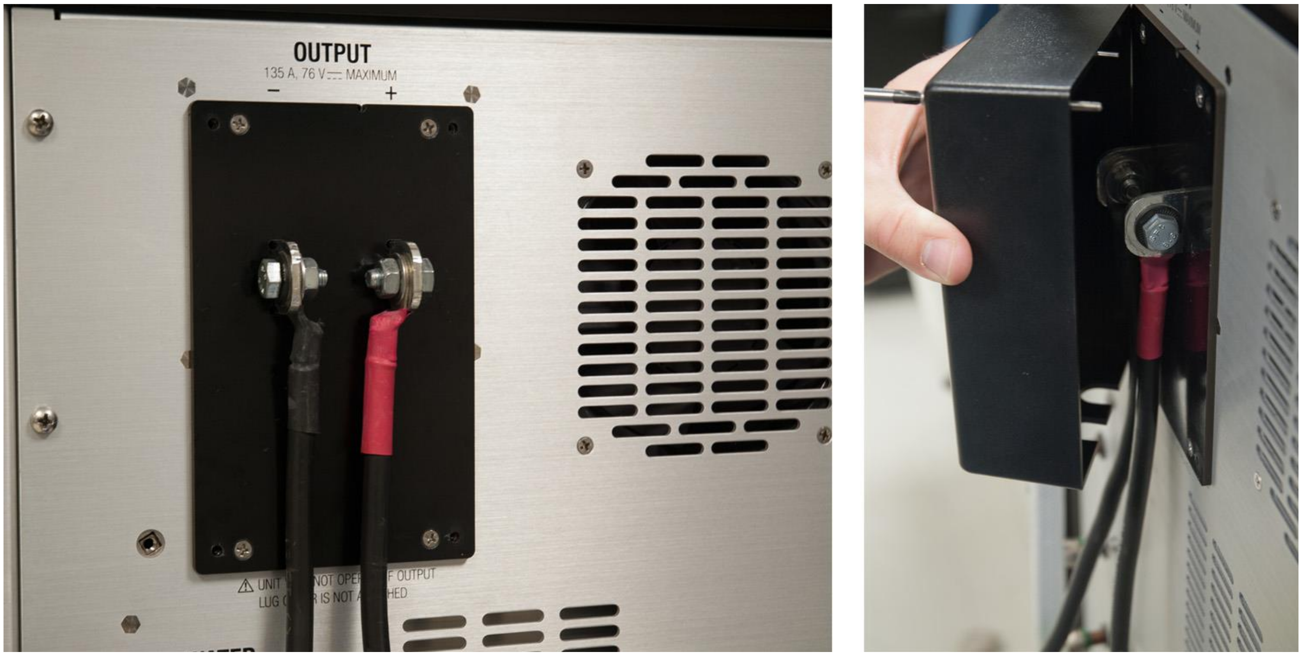


Figure 2-24. Model 648 Output Connections

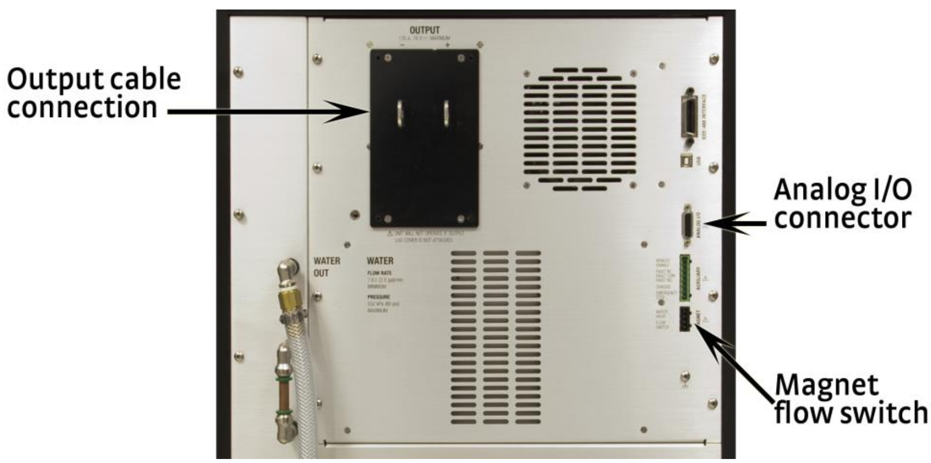


Figure 2-25. Model 648 Rear Panel Connections

Analog I/O connector Connects to the **Program Output** BNC on the rear panel of the Model 736 VSM Controller.

NOTE: The positive and negative leads must be wired properly to maintain the correct polarity.

Power Supply Output – Positive (+): The wire marked in red goes to the positive terminal of the electromagnet.

Power Supply Output – Common (–): The wire marked in black goes to the negative terminal of the electromagnet.

Magnet flow switch: This is the power supply inhibit connector. It is connected to a single water flow and two thermal cutoff switches in series, any of which can inhibit the output of the power supply.

2.5 CHANGING THE MAGNET GAP

While changing the magnet gap is an easy procedure, there are a sufficient number of cautions that must be observed to warrant a separate section. The controls shown in Figure 2-26 are typical for all magnets.

CAUTION: Before changing the magnet gap, remove the Gaussmeter probe from the holder, then remove the holder. This will prevent damage to the probe from falling if widening the gap, or crushing the probe/holder if narrowing the gap.

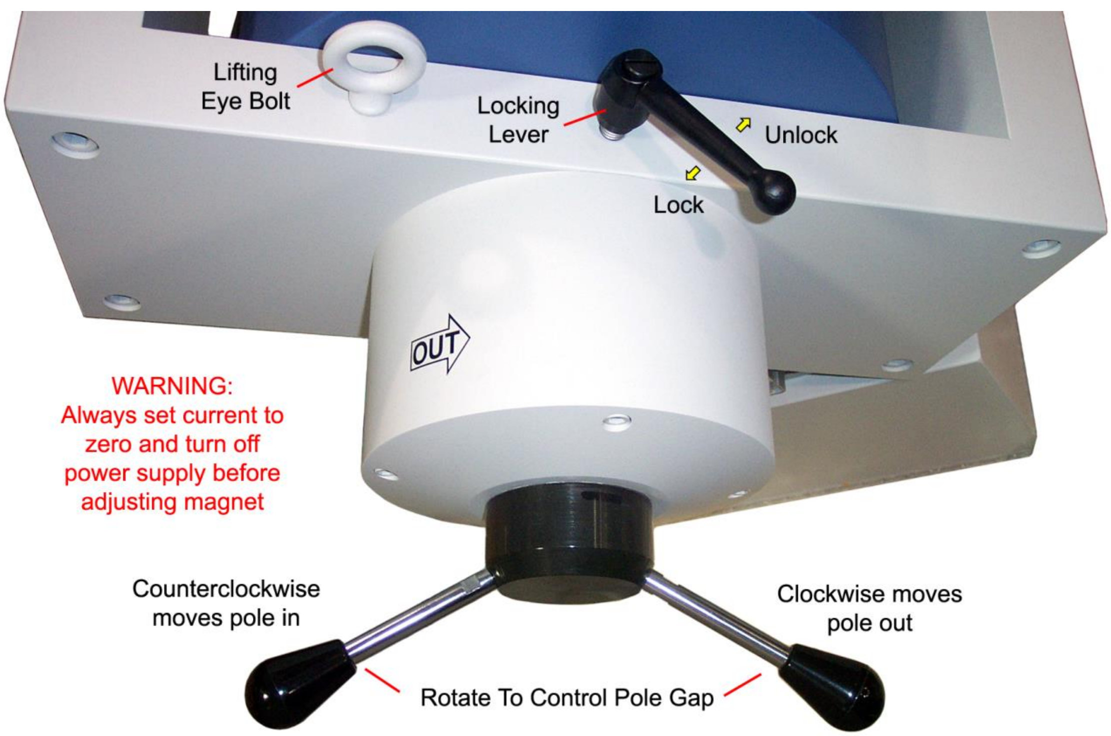
1. Remove the Gaussmeter probe. Place the probe in a safe place where it will not be stressed or crushed. Remove the probe holder.

WARNING: Always set the current to zero and turn off the power supply before attempting to adjust the magnet gap.

2. After setting current to zero and turning off the power supply, use the locking levers to unlock the poles. (Note that the locking levers for the 4-inch magnet include both left- and right-handed threads, and therefore will operate oppositely to lock and unlock the poles.)

CAUTION: If moving the poles closer together, care must be used to ensure the pickup coils and gaussmeter probe are not damaged (crushed). Sufficient clearance must be left for the sample tail and cup. If moving the poles further apart, care must be used to ensure the coil connecting cable is not stressed or broken.

3. Rotate the handles clockwise to move the poles out, or counterclockwise to move the poles in.
4. Move the locking levers to the locked position.
5. Install the probe holder, install the Gaussmeter probe, and then position the probe in the magnet gap.
6. Turn on the power supply and run the magnet through one complete loop (maximum positive and negative fields). This will "set" the poles into a stable position.
7. Use the nickel standard to run a moment gain calibration.



Magnet_Gap.bmp

Figure 2-26. Setting the Magnet Gap

2.6 SAMPLE HOLDERS

The sample holders used with the VSM are made of Kel-F[1]. Kel-F, or PolyChloroTriFluoroEthylene, is a fluorocarbon-based polymer and is commonly abbreviated PCTFE. PCTFE offers the unique combination of physical and mechanical properties, nonflammability, chemical resistance, near zero moisture absorption, and excellent electrical properties. These characteristics cannot be found in any other thermoplastic fluoropolymer with a useful temperature range of –240 to +204 °C (–400 to +400 °F). Specifications: AMS 3650, MIL-P-46036, ASTM-D-1430-95 Type 1 Grade 3; FDA Regulation 21 CFR 177.1380.

All sample holders are cleaned to remove any contaminants that may affect the background signal. Contaminants are dissolved by first using an ultrasonic etching in a detergent, then an ultrasonic etching in an acid solution, then followed by a rinse prior to final packaging. Three types of sample holders are provided: Bulk, Liquid, and Thin-Film.

2.6.1 Bulk Sample Holder

The bulk sample holder comes in two parts: top and bottom. The top contains a threaded portion that attaches to the sample rod, and another threaded portion that goes inside the sample cup. See Figure 2-27.

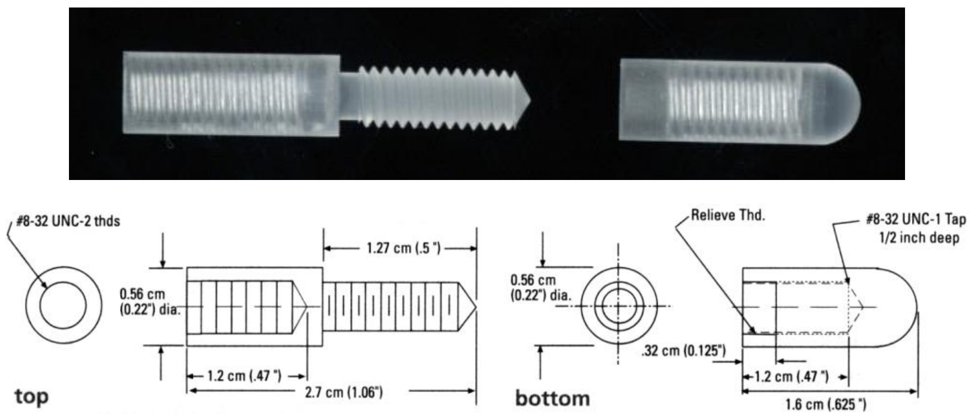


Figure 2-27. Model 730931 Bulk Sample Holder (P/N 651-450)

2.6.2 Liquid Sample Holder

The liquid sample holder comes in two parts: top and bottom. The top contains a threaded portion that attaches to the sample rod, and another threaded portion that goes inside the sample cup. See Figure 2-28.

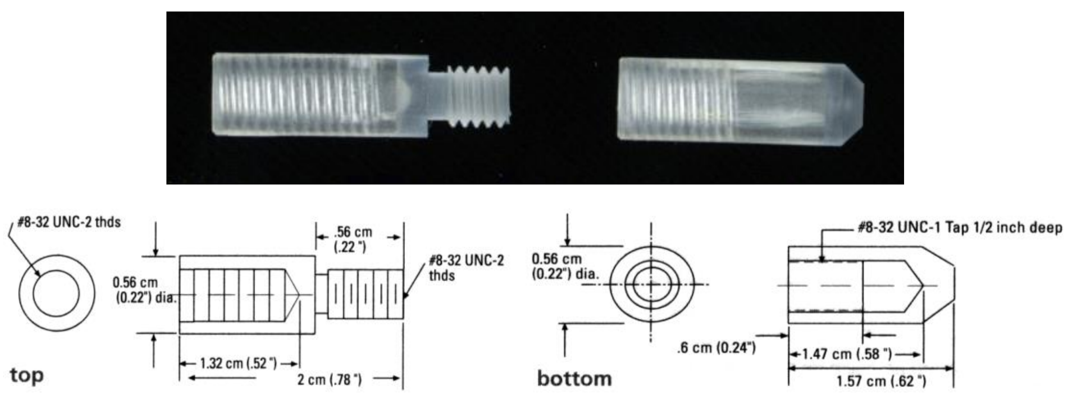


Figure 2-28. Model 730935 Liquid Sample Holder (P/N 651-454)

[1] The Kel-F® brand is a registered trademark of 3M, but they discontinued production in 1995. The only remaining brand, Neoflon®, is made by Daikin Industries of Japan.

2.6.3 Thin-Film Sample Holders

The thin-film sample holders come in a single part. The top has a threaded portion that attaches to the sample rod, while the bottom contains a flat area suitable for mounting a thin-film sample. Two sample holder types are provided: See Figure 2-29 for the Model 730933 for side-mounting samples (for mounting samples perpendicular to the field) and Figure 2-30 for the Model 730934 for bottom-mounting samples (for mounting samples parallel to the field).

Suggested adhesives to mount sample films to the holders include:

1. Tackiwax® by CSC Scientific Co., Inc.
2. Beeswax.
3. Duco® Cement by Devcon Consumer Products.
4. Double-coated Scotch® tape by 3M.

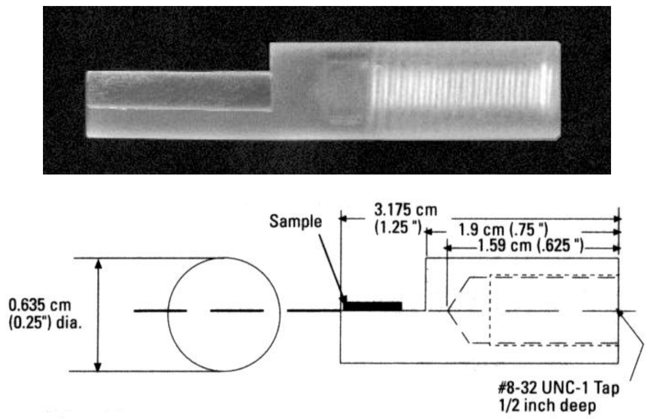


Figure 2-29. Model 730933 Side-Mounted Thin-Film Sample Holder (P/N 651-452)

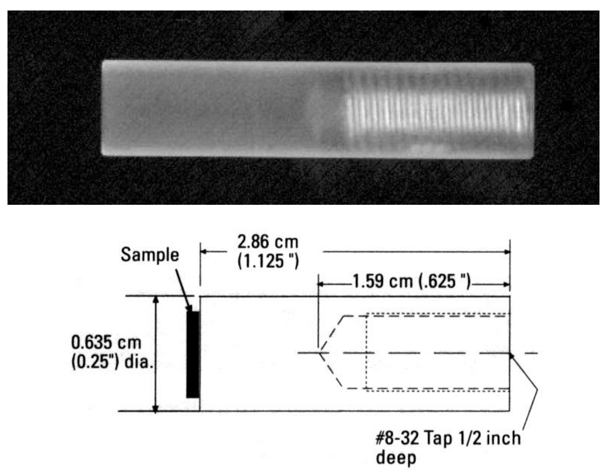


Figure 2-30. Model 730934 Bottom-Mounted Thin-Film Sample Holder (P/N 651-453)

2.7 SAMPLE TAILS

The 7400 Series VSM System uses three different Sample Tails: one Standard and two Small Gap. The standard tail consists of a fiberglass rod with a threaded Kel-F® adapter on the end to accept a sample holder (see Figure 2-31). The small gap tails consists of a continuous fiberglass rod which permits minimum gap experiments with thin-film samples. The bottom-mount sample tail is shown in Figure 2-32 and the side mount in Figure 2-33.

To minimize contaminants, Lake Shore suggests wearing surgical-style gloves when handling the sample tail and holders. If the sample tail should become contaminated, it can be cleaned using de-ionized water or rubbing alcohol.

NOTE: Custom sample tails are available by special order. Contact Lake Shore for details.

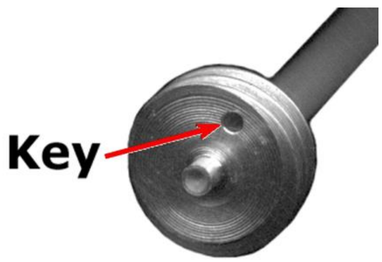
Figure 2-31. Standard Sample Tail Assembly (P/N 651-913)

Figure 2-32. Small-Gap Bottom-Mount Sample Tail Assembly (P/N 651-914)

Figure 2-33. Small-Gap Side-Mount Sample Tail Assembly (P/N 651-915)

2.7.1 Sample Tail Key

At the top of the sample tail is the threaded portion that mates to the speaker drive at the bottom of the VSM control head. When attaching the sample tail to the drive, first align the hole (or key) in the threaded portion with the post on the drive, then finger-tighten the knurled connection. Thumb and index finger tightening is sufficient. Do not use any tools to tighten this connection.



2.8 MOUNTING A SAMPLE TAIL

CAUTION: Do not use excessive force when tightening threaded parts. Thumb and index finger force alone is sufficient. Kel-F is a soft material and the threads can easily be stripped.

CAUTION: Keep the tail perpendicular when attaching to the drive. Excess torque on the tail will damage the tail and alignment of the drive.

1. Insert the sample into the sample holder assembly. Thread the sample holder assembly into the bottom of the sample tail. Finger tighten.

NOTE: This procedure assumes the head has been moved forward and there are no obstructions to the sample tail when the head is slid back into position. If proper care is taken to avoid applying undue stress or torque on the sample tail, subsequent samples can be loaded without moving the control head.

2. To attach the sample tail to the VSM drive, lift up the captive knurled coupling nut, move the sample tail up so the key in the threaded cap mates with the guide pin, then finger tighten the captive knurled coupling nut to the threaded cap. See Figure 2-34.
3. As you slide the head back into measurement position, watch the sample holder and tail as they approach the pickup coils. Ensure that nothing catches or applies pressure to the sample holder or tail.
4. Observe the vertical position of a point on the sample holder about ¼ inch from its lower end relative to the windings of the pickup coils; this point should be centered vertically with respect to them. If it is not, adjust the position of the sample by manipulating the Z-axis control shown in Figure 2-35.
5. Position the sample at the geometric center of the pickup coils by performing the saddling procedure (refer to Paragraph 2.9).

CAUTION: To prevent bending the sample tail, whenever possible, remove the tail before changing the sample holder or sample.

Figure 2-34. Attaching the Sample Tail

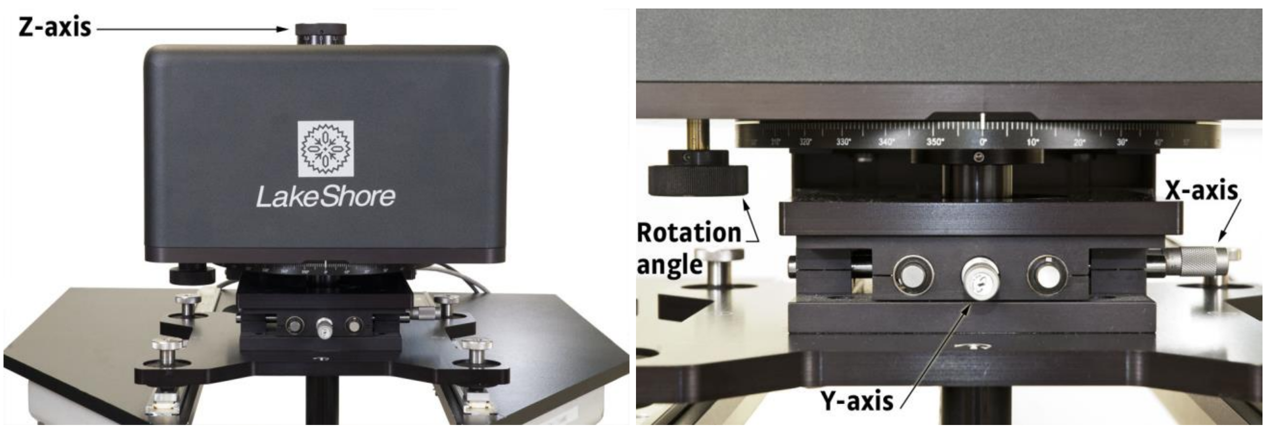


Figure 2-35. Aligning the Sample

2.9 SAMPLE SADDLING

The sample should be positioned at the geometric center of the pickup coils, a procedure known as "saddling." On a standard electromagnet system, the saddle point is found by finding the local extrema of the moment signal in the X, Y, and Z directions. Generally, the X (left to right) position should be a local minimum in the moment signal (or its absolute value, to be precise). The Y (front to back) position is a local maximum, and the Z (up and down) position can be either a maximum or a shallow minimum between two maxima, depending on the separation between the coils. For very weak samples, it is a good idea to saddle using a strong sample (such as a saturated nickel standard), with the same geometry as the weak sample, attached in the same manner as the weak sample to be tested.

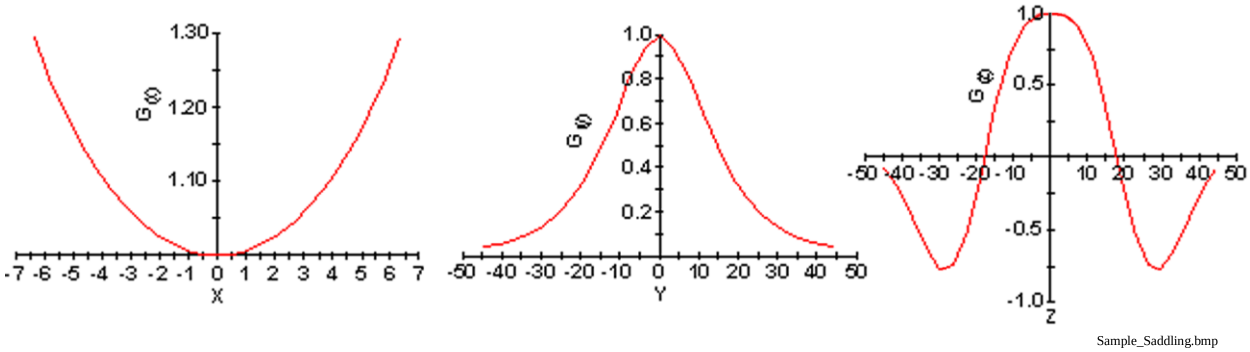


Figure 2-36. X-, Y-, and Z-Axis Saddling

The Z-axis in Figure 2-36 shows a single peak. However, depending on the coil set and magnet gap, a double peak can also be seen on the Z axis. If your system displays a double peak, then Z-axis saddling is to the minimum point between the two peaks as shown in Figure 2-37.

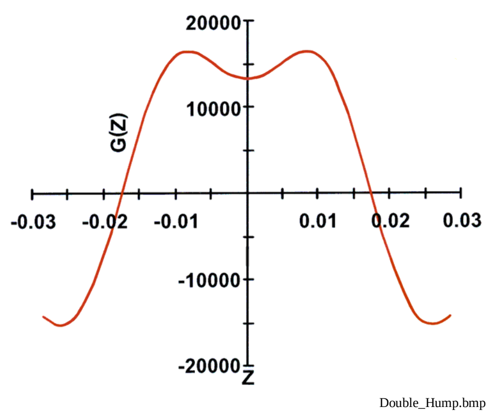


Figure 2-37. Double Peak Z-Axis Saddling

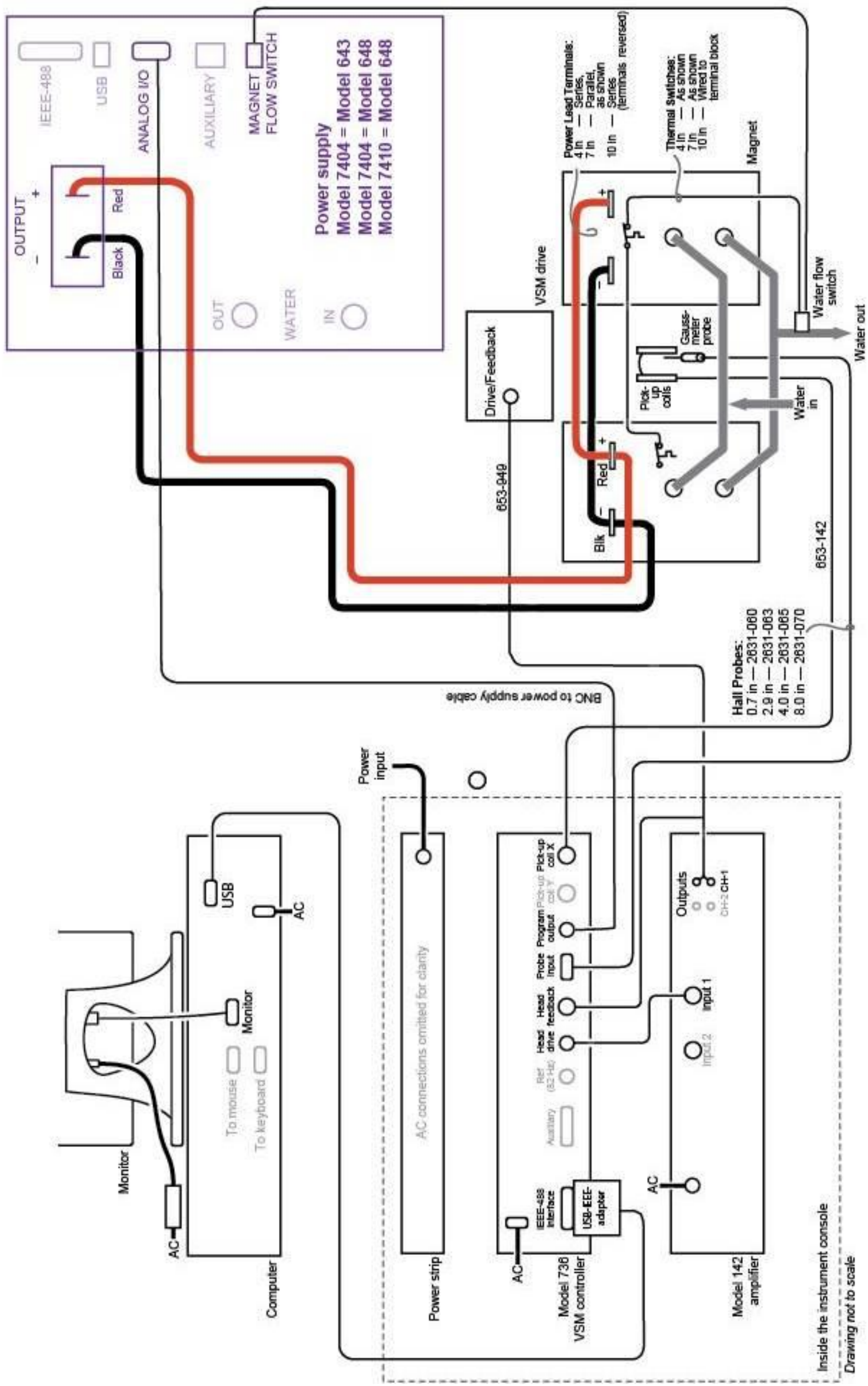


Figure 2-38. Typical 7400 Series VSM System Wiring

CHAPTER 3

OPTIONS

3.0 GENERAL

This chapter provides information on the 7400 Series VSM System Options. Unless otherwise specified, the information in this chapter is considered to be "generic" to all systems.

CAUTION: To prevent incorrect measurements and possible damage to the options, only one measurement option should be connected to the cables from the instrument console. Always remove the cables from one option before connecting cables to another option.

3.1 LOW TEMPERATURE CRYOSTAT OPTION (74018)

This continuous flow cryostat combines a detachable flexible transfer line with a cryostat to provide quick refrigeration from below 4.2 K to 450 K. Liquid helium is continuously transferred through a vacuum jacketed, superinsulated flexible transfer line to a vaporizer/heat exchanger at the bottom of the sample chamber. The liquid is then vaporized and heated to some specified temperature. The gas travels upwards along the sample space to cool the sample and intercept the heat loads coming down the tube. A needle valve located at the bottom of the leg (which goes inside a storage Dewar), controls the cryogen flow to the sample mount.

NOTE: This description uses liquid helium for operation. Operation with nitrogen is very similar. Except the lowest temperature the cryostat can achieve is 77.6 K.

Temperatures above the cryogen boiling point (4.2 K) are obtained by controlling the amount of the helium delivered to the vaporizer sending an appropriate current through a heater at the vaporizer. This heater, as well as any control thermometer supplied, will be wired to an electrical feedthrough at the top of the cryostat vacuum jacket. See Figure 3-1 for typical cryostat details, Figure 3-2 for typical transfer line details, and Figure 3-3 for a typical VSM System wiring diagram that includes the cryostat.

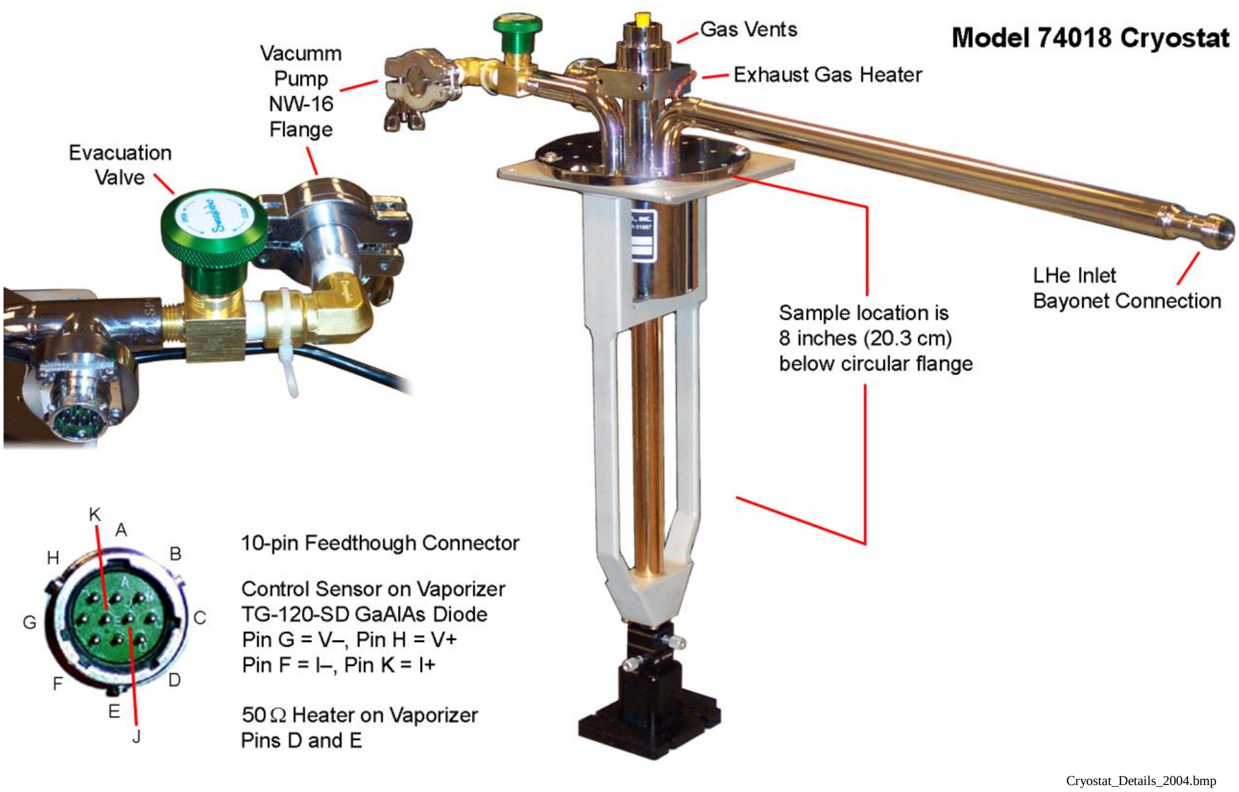


Figure 3-1. Typical Model 74018 Cryostat Details

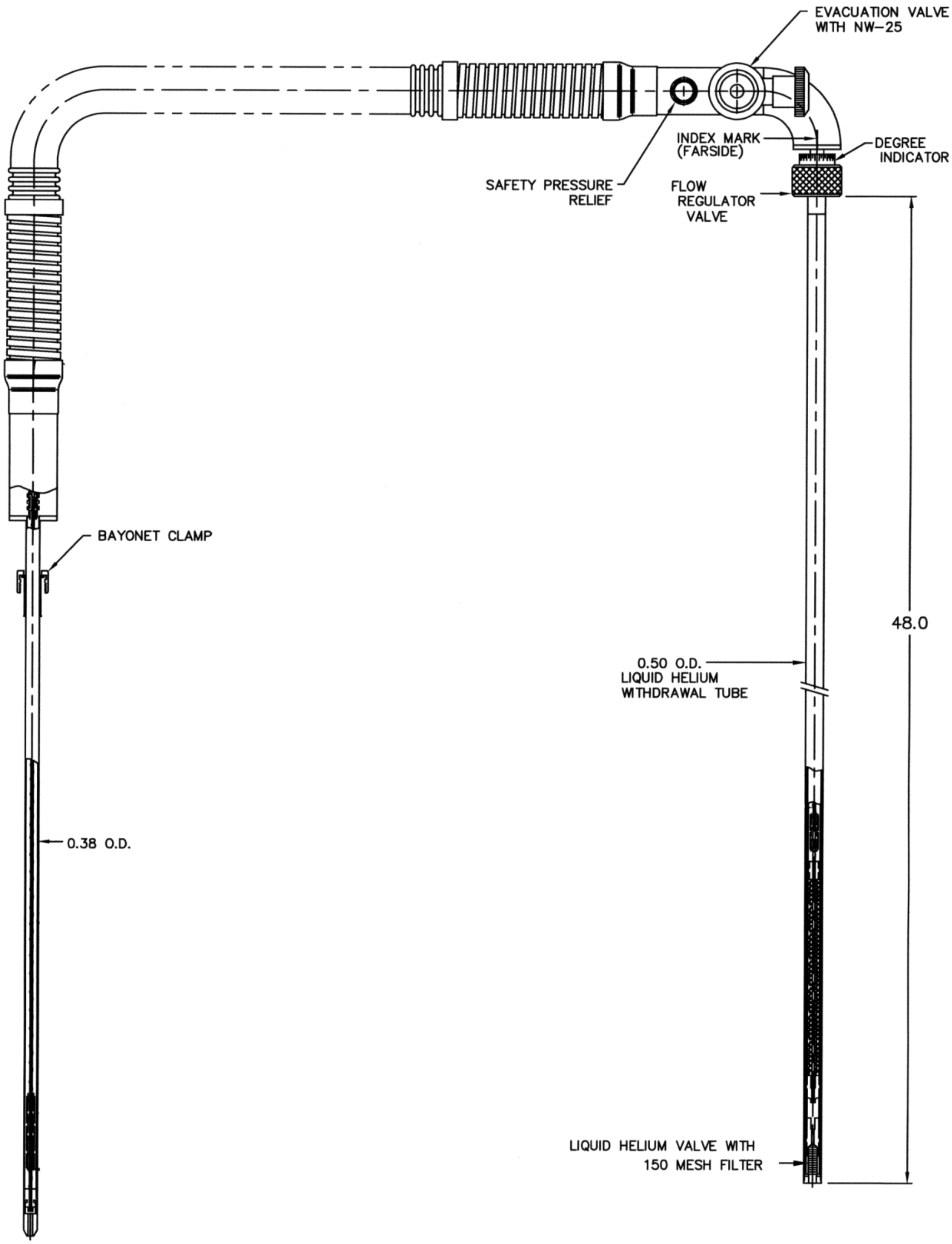


Figure 3-2. Typical Transfer Line Details

3.1.1 Unpacking and Setup

After removal of the protective padding and shipping supports, the cryostat can be visually inspected for any damage incurred during shipment. Before removing the cryostat from the shipping crate, it is advisable to have prepared a stand to support it. A square plate mounted on the top of the vacuum jacket was provided to be supported by a laboratory stand and clamps assembly for storage when the cryostat is not being used with the VSM system. The proper face of the shipping crate should be removed first to expose the padded cryostat. After removal of the protective padding and shipping supports, the cryostat can be visually inspected for any damage incurred during shipment. Please report any visible damage to the crate or cryostat to your shipping/receiving department, and to us as soon as it is noticed.

3.1.2 Equipment Needed for Cryostat Installation

1. A mechanical vacuum pump and foreline trap with pressure capability below 5×10^{-3} Torr and pumping speed of at least 30 liters per minute.
2. A Pirani or thermocouple vacuum gauge capable of measuring pressures from 1 – 500 or 1000 microns (10^{-3} – 1 Torr).
3. A gas cylinder and regulator capable of delivering clean, dry, helium gas at controlled low pressure. Gauges should be capable of measuring delivery pressures of 10 – 25 centimeters of mercury above atmospheric pressure (2 – 5 psi).
4. A liquid helium storage vessel. The transfer line furnished with the cryostat is well suited for 25 liter storage vessels, and readily adaptable to other capacity storage vessels. Cryogenic fluid suppliers often furnish these storage vessels on a rental basis.

   WARNING: Nitrogen gas and Helium gas are potential asphyxiants and can cause rapid suffocation without warning. Use them only in an adequately ventilated area. DO NOT vent or use them in confined spaces. Follow Compress Gas Association (CGA) best practices, applicable Safety Data Sheet (SDS) and applicable local safety requirement.

5. A Lake Shore Model 336 Temperature Controller with optional thermocouple input card to perform the cryostat temperature control function.
   Note: A Lake Shore Model 340 Temperature Controller may also be used with the 7400 Series VSM System. If you use the Model 340, please see Appendix C.
6. Miscellaneous vacuum hose, rubber stoppers, and hose for helium gas.

3.1.3 Preparation for Cool Down

The Model 74018 cryostat is shipped with the transfer line vacuum space and the cryostat vacuum space evacuated. This is a result of the final testing at the factory, and it helps ensure clean vacuum spaces. As a precaution against deterioration of the vacuum, which arises sometimes during transit or a prolonged storage period, the vacuum space of the cryostat should be re-evacuated prior to use and continuously pumped when operated above 300 K. Pump the vacuum space at least 30 minutes before introducing liquid into the cryostat. Refer to Figure 3-1 for the location of the evacuation (bellow sealed) valves. The vacuum space of the transfer line should be re-evacuated every 12 months or when the outer surface felt cold during operation. This is best done with a good pumping station (e.g., a cold trapped rotary/diffusion pumping station) capable of bringing the ultimate pressure down to approximately 10^{-5} Torr. After evacuation, all valves should be firmly closed, but care should be exercised to avoid damaging the seat with too much pressure.

The vacuum jackets are usually protected against cold leaks with a pressure relief valve, which will vent any pressure that exceeds 2 to 4 psig. The transfer line pressure relief is located opposite the evacuation valve, while the cryostat vacuum shroud pressure relief is located on top of the cryostat vacuum jacket.

When evacuation of either vacuum space is initiated, always be sure that the pressure on the pump side of the evacuation valve is lower than the pressure in that vacuum space. This is done to avoid drawing oil vapor from the pump into the vacuum space. Thus, one should not pump any vacuum space while the system is cold, since the liquid helium could cryopump to a lower pressure than the pumping station in use.

The rigid leg of the transfer line has a built-in activated charcoal getter to help maintain excellent vacuum when this leg is inserted in the cryogen storage Dewar. Thus, it is preferable to maintain this space under vacuum at all times and never allow helium gas or moist air inside this space. In the event moisture or helium does accidentally enter the space, a pumping station should be attached to the space for several days in order to bring the pressure down to an acceptable level.

This cryostat can be operated with either liquid nitrogen or liquid helium. The storage Dewar should have a top center ½-inch diameter liquid withdraw port for the transfer line. The ceiling of the room must be higher than the length of the transfer line inlet tube which is about 60 inches plus the height of the storage Dewar. The helium storage Dewar also should have a 4 psig relief valve installed in the liquid space for pressure regulation during the operation. The nitrogen Dewar should have 10 psig valve instead.

3.1.4 Installation

This section details the process of installation of a VSM Model 74018 Cryostat Option. It is separated into sections for convenience. Depending on the operation you wish to perform, different sections of the installation are to be performed.

A ***Initial Installation on an Existing Room Temperature VSM***

If the Cryostat is being installed on an existing, room-temperature only VSM, all the sections below must be completed. This includes the attachment of the option mount to the base VSM and alignment of the cryostat Assembly to this Mount in addition to the steps required for day-to-day cryostat operations. These steps are noted under Column A, in the following table.

B ***Initial Installation on an Existing Variable Temperature VSM***

If the Cryostat Option is being installed for the first time on a VSM where another temperature option has already been installed, the option mount hardware has already been attached to the VSM and, therefore, Section 4, 'Mounting Option Hardware Attachment' is not required. In this case, follow the instructions under Column B, in the following table.

C ***Everyday Use on an Existing Variable Temperature VSM***

For simple, day-to-day use of the cryostat, Sections 4, 'Mounting Option Hardware Attachment' and 6, 'Cryostat Assembly to Option Mount Alignment' are not required. Here, only the instructions under Column C, in the following table, needs be followed.

		Initial Installation on an Existing Room Temperature VSM	*Initial Installation on an Existing Variable Temperature VSM*	*Everyday use on an Existing Variable Temperature VSM*
Section	Title	**A**	**B**	**C**
1	Prepare VSM Head Drive	YES	YES	YES
2	Set EM gap	YES	YES	YES
3	Saddle and Calibrate at Room Temperature	YES	YES	YES
4	Mounting Option Hardware attachment	YES	–	–
5	Install Cryostat and Tail	YES	YES	YES
6	Cryostat Assembly to Option Mount Alignment	YES	YES	–
7	Make Connections (see Figure 3-3)	YES	YES	YES
8	Apply Vacuum	YES	YES	YES
9	Verify Noise-Free System	YES	YES	YES
10	Install Sample	YES	YES	YES

Complete Model 74018 Installation Instructions:

WARNING: Always set the current to zero and turn off the power supply before attempting to adjust the magnet gap.

1. Prepare VSM Head Drive.
   a. With VSM in operating position, verify VSM Head is level.
   b. Turn off the VSM Drive from the VSM main software screen.
   c. Remove sample tails and holders attached to the VSM Drive.
   d. Verify the stops in the VSM Head Drive's sliding track are set such that the VSM Head Drive can be moved back and clear the cryostat sample opening.
   e. Verify the rear stops are not be set too far rearward – The VSM Head Drive should not hit any part of the frame (check clearance of VSM Head Drive's protruding center tube).
   f. Slide VSM Head Drive rearward.

WARNING: Never slide the head drive back with a sample tail installed in the head. Damage can occur to both the sample tail and the head if forced.

2. Set EM gap.
   a. The magnet gap should be set to 51 mm (2 inches) for the 730ESC large gap pick-up coils and set to 38 mm (1.5 inches) for 740EMSC small gap pick-up coils.
   b. If the gap has been changed since the last cryostat use, the pole caps may have to be moved such that the cryostat is centered.
      i. Remove Hall probe from center of electromagnet air gap.
      ii. Disconnect small jumper cable between the coils at the connector.
      iii. Move Right pole inward until it aligns with the vertical centerline of the magnet.
         1. Use the pole adjusters to move the right pole cap furthest inwards until it stops. One may need to move the left one out to allow the right cap to fully thread to a stop. This is done on the 7404 and 7407 only.
         2. A plumb line can be used to establish this centerline for the 7410.
      iv. Move Right pole outward the number of turns specified on the electromagnet pole adjuster turn chart. (Use the pole adjuster spokes to count turns.)
      v. Repeat step ii with the Left pole. It is not necessary to move the right pole out to give the left pole space to thread in fully.
      vi. Move Left pole outward the number of turns specified on the electromagnet pole adjuster turn chart.
      vii. Moving Left and Right poles the identical number of turns, adjust electromagnet until desired airgap is obtained.
      viii. Reconnect jumper cable between the coils.

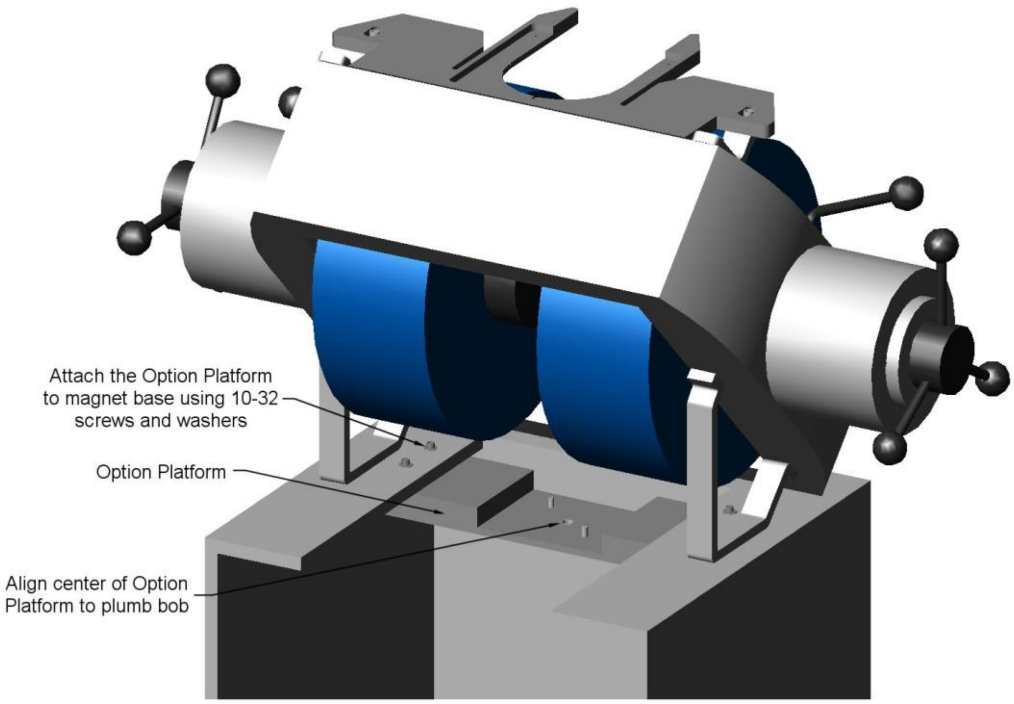
   Electromagnet Pole Adjuster Turn Chart

Coils	7404	7407	7410
730ESC	15-1/2 turns	13-1/2 turns	8-1/3 turns
740EMSC	11-1/2 turns	10-1/2 turns	6-1/3 turns

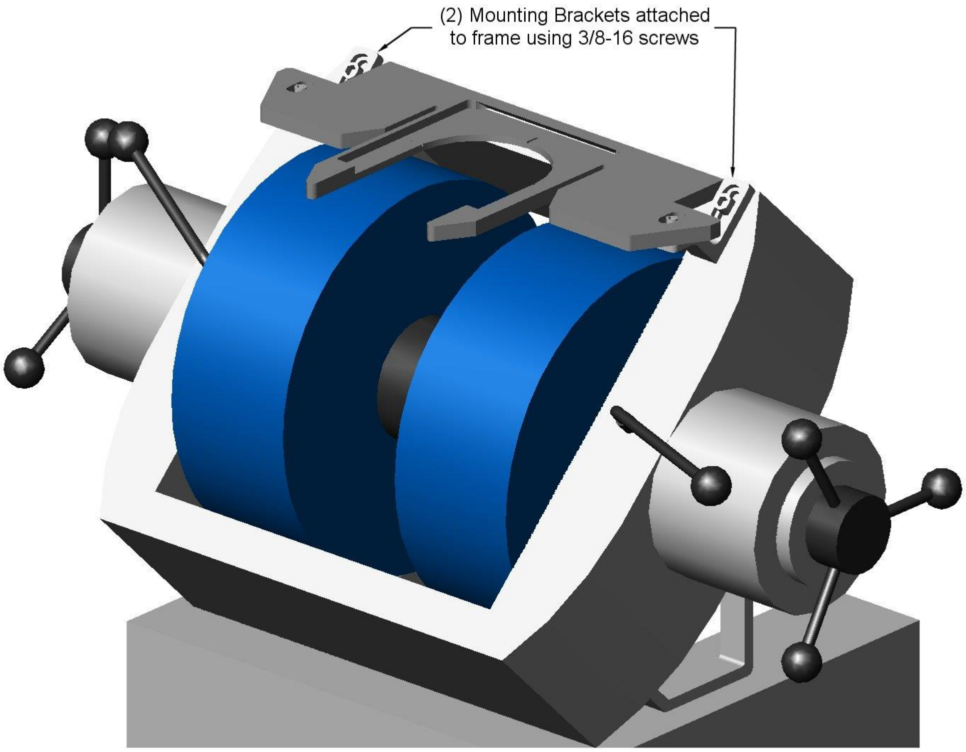
   c. Adjust the location of the hall probe such that it cannot be damaged during cryostat installation.
      i. A slot is provided in the coil sets to accept the Hall Probe from behind.
      ii. Verify Probe Polarity when replacing.
3. Saddle and Calibrate at Room Temperature.
   a. Turn on the power supply.
   b. Cycle the power supply through one complete loop (maximum positive and negative fields).
   c. Cryostat option remains removed.
   d. Install the Quartz sample tail with Kel-F holder and Nickel sample.
   e. Saddle Nickel. (This saddling step will put the sample tail in the correct position with respect to the VSM sensing coils and no position adjustment should be done to the head or the magnet poles after saddling.)
   f. Perform moment gain calibration with nickel standard.
   g. Remove the sample tail

NOTE: Skip Section 4 when following methods **B** or **C**

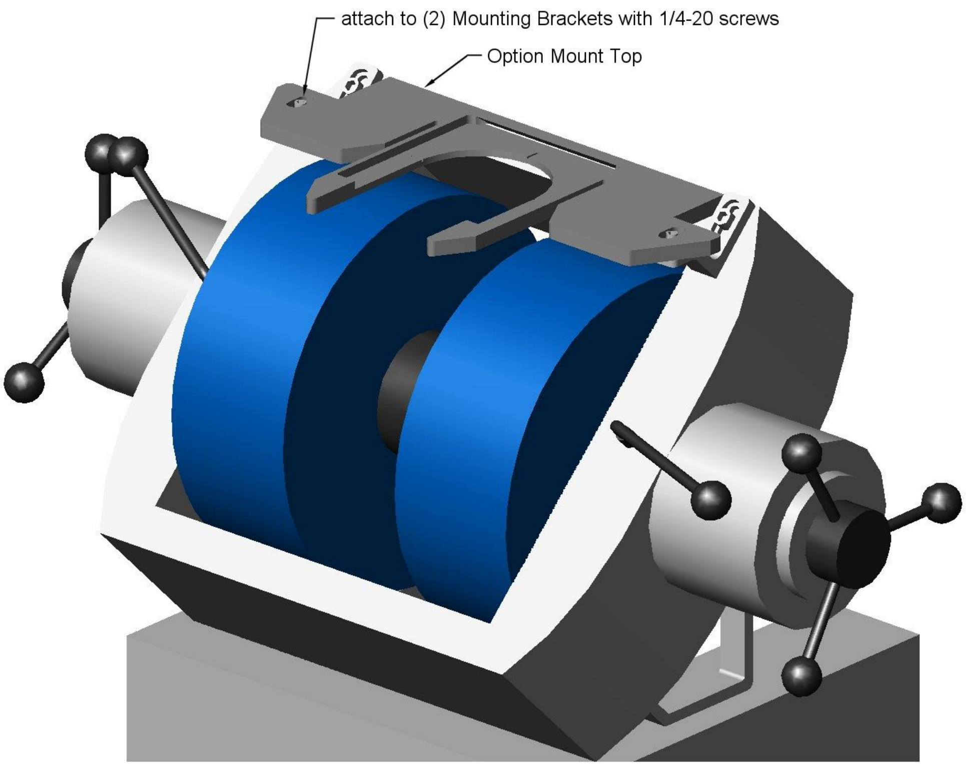
4. Mounting Option Hardware attachment
   a. 7404 Option Mounting (Use section 4a if system is 4 inch electromagnet). Attach following hardware and align, but do not tighten screws fully.
      i. Attach the Option Platform to the base of the magnet using 10-32 screws and washers.
         1. Remove sample tail and attach supplied plumb bob to VSM Head.
         2. Using end of plumb bob as a reference for centerline, attach Option Platform to electromagnet base.
            a. Start by using tapped holes that are offset from the center of the plate to mount the platform furthest forward.
            b. Align the plate using the oversized holes and switch to other tapped holes if necessary.
         3. Remove plumb bob.



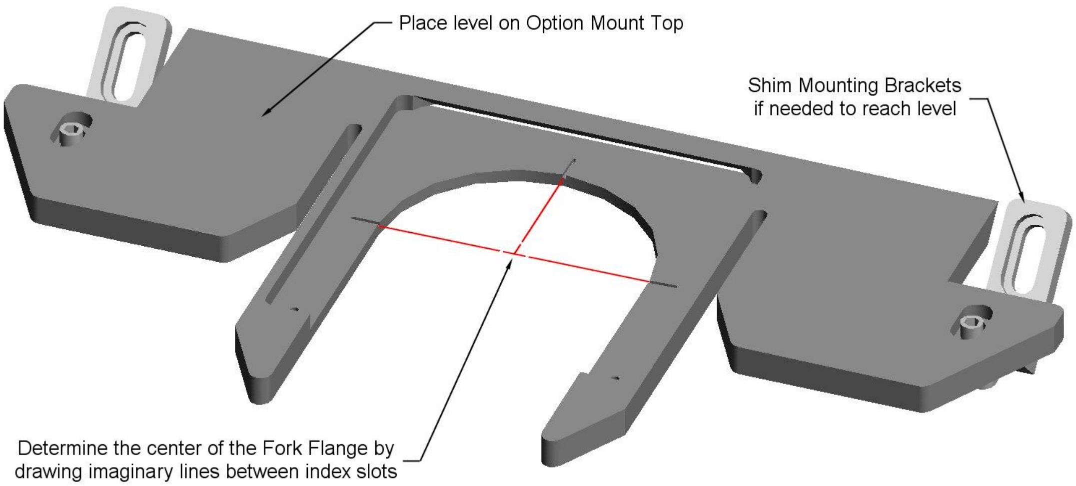
ii. Attach the two Mounting Brackets to the frame of the electromagnet using 3/8-16 screws.



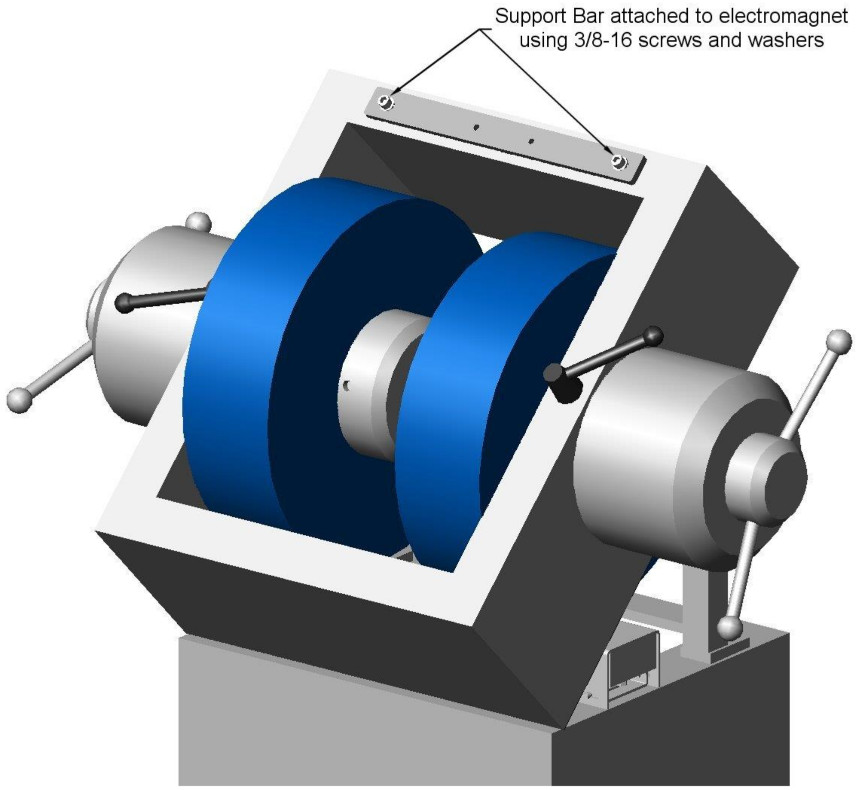
iii. Attach Option Mount Top to the mounting brackets using 1/4-20 socket head cap screws.



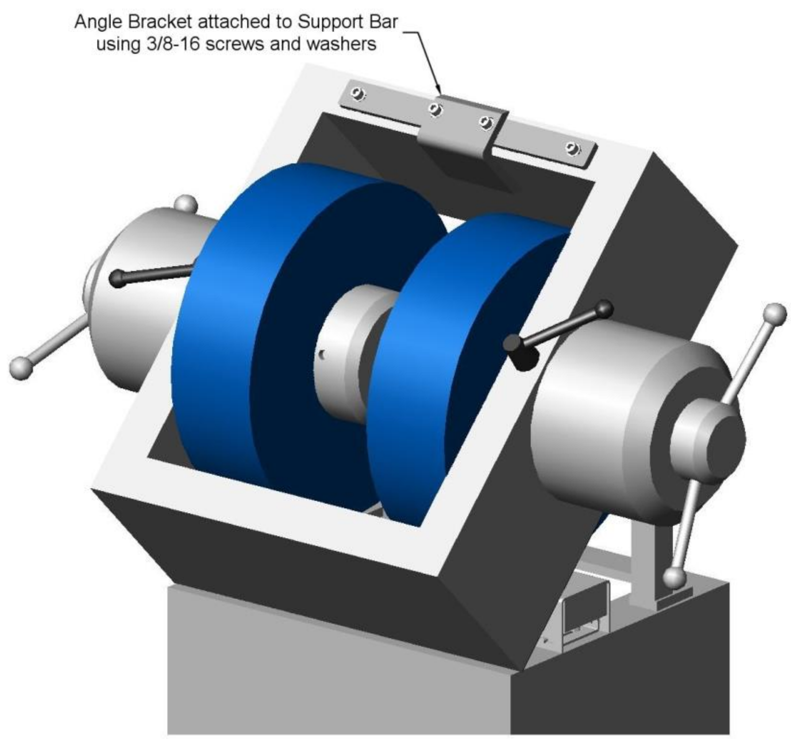
1. Option Mount Top must be leveled and aligned in XY.
   a. Place level on Option Mount Top and shim Mounting Brackets if needed to reach level.
   b. There is a recessed area on the Fork Flange where the exchange plate mounts. The distance from the recessed area to the flat surface on Option Mount Platform/Bottom Mount is 17 and 1/8 inches. Adjust Mounting Brackets as needed using the slots.
   c. Align Option Mount Top to correct Y position using slots.
      i. Attach plumb bob to VSM Head.
      ii. Use a scale to determine the center of the Fork Flange. Adjust Option Mount Top so centerline is inline with the sample tail centerline.



b. 7407 Option Mounting (Use section 4b if system is 7 inch electromagnet). Attach following hardware and align, but do not tighten screws fully.
   i. Attach the Support Bar to the top of the electromagnet using socket head cap screws and washers.

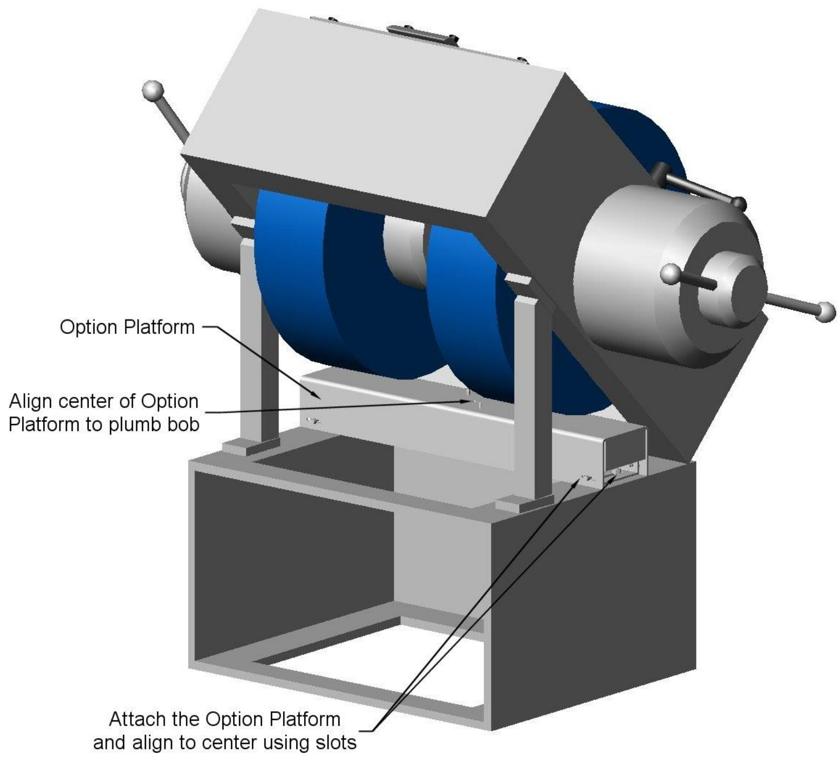


ii. Attach the Angle Bracket to the Support Bar using socket head cap screws and washers.

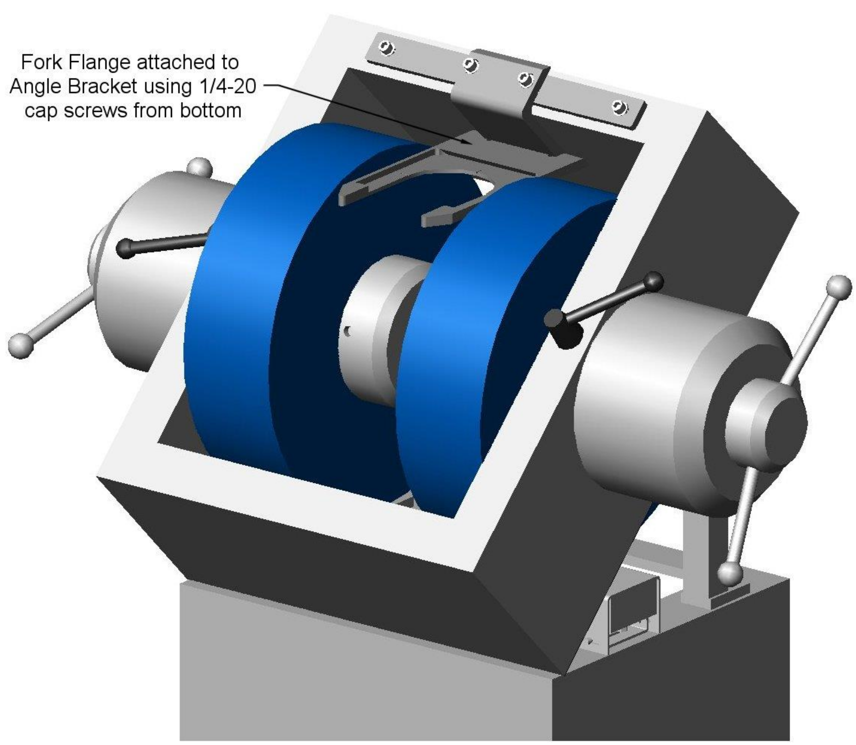


iii. Attach the Option Platform to the magnet base.

1. Remove sample tail and attach supplied plumb bob to VSM Head.
2. Using end of plumb bob as a reference for centerline, attach Option Platform to electromagnet base using 1/4-20 screws, washers, and nuts.
3. Remove plumb bob.



iv. Attach the Fork Flange to the Angle Bracket using 1/4-20 screws.



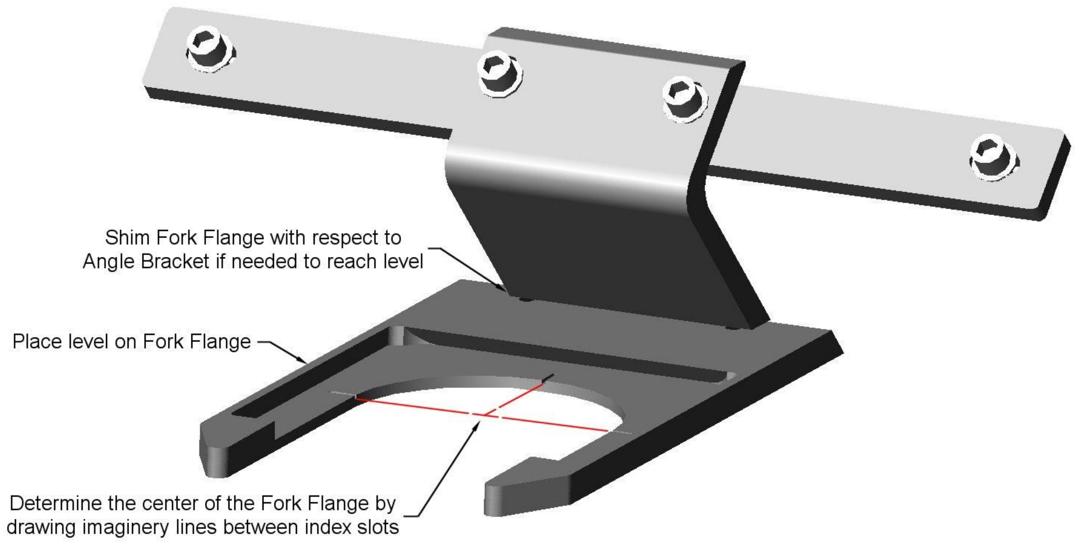
1. Fork Flange must be leveled and aligned in XY.
   a. There is a recessed area on the Fork Flange where the exchange plate mounts. The distance from the recessed area to the flat surface on Option Mount Platform/Bottom Mount is 17 and 1/8 inches. Adjust Angle Bracket as needed using the slots.

b. Place level on Fork Flange and use available adjustment slots to level Fork Flange in the XY plane

c. Align Fork Flange to correct X and Y positions.

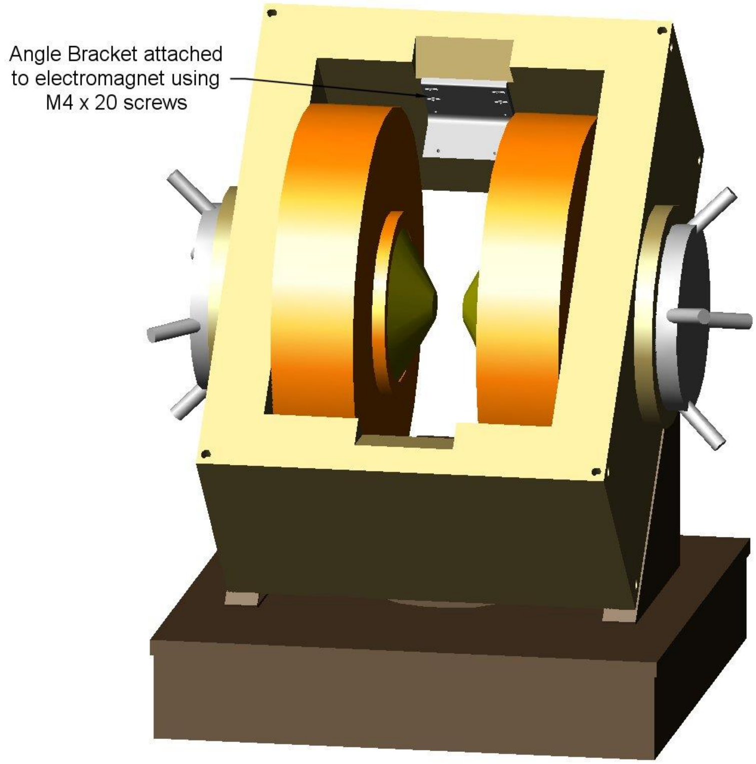
   i. Attach a sample tail to VSM Head.

   ii. Use a scale to determine the center of the Fork Flange. Adjust Support Bar and Angle Bracket so Fork Flange centerline is common with the sample tail centerline.

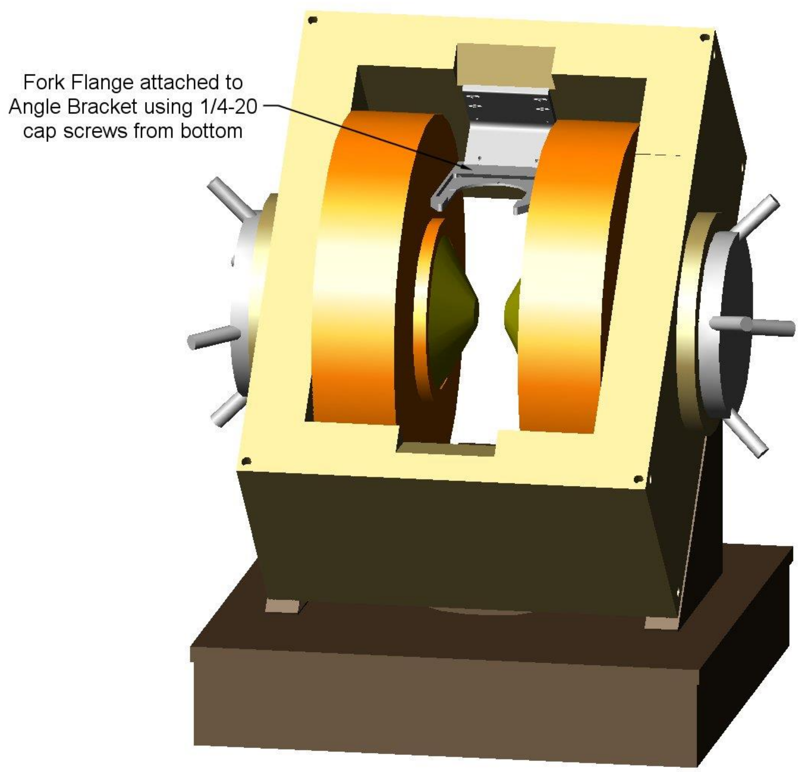


c. 7410 Option Mounting (Use section 4c if system is 10 inch electromagnet). Attach following hardware and align, but do not tighten screws fully.

   i. Attach the Angle Bracket to the top of the electromagnet using M4X20 screws and washers.



ii. Attach the Fork Flange to the Angle Bracket using 1/4-20 screws.

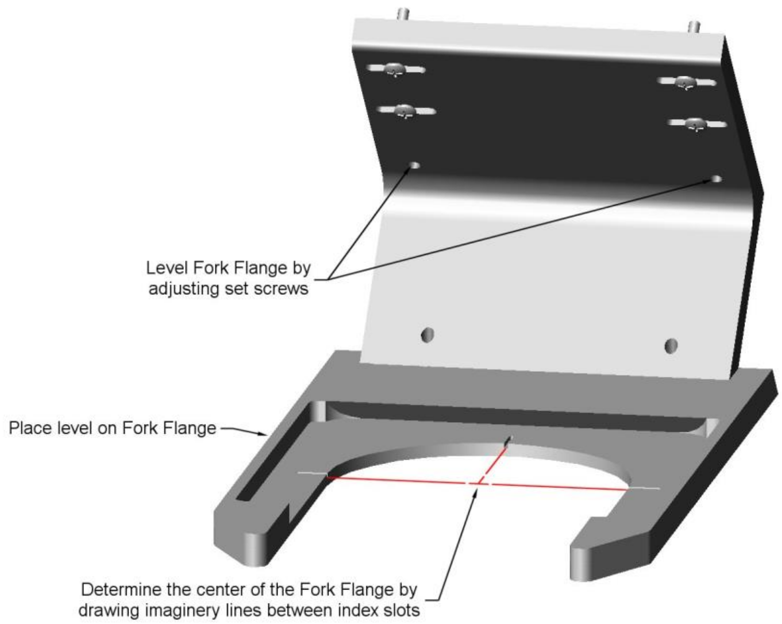


1. Fork Flange must be leveled and aligned in XY.
   a. Place level on Fork Flange and use available adjustment set screws to level Fork Flange in the XY plane

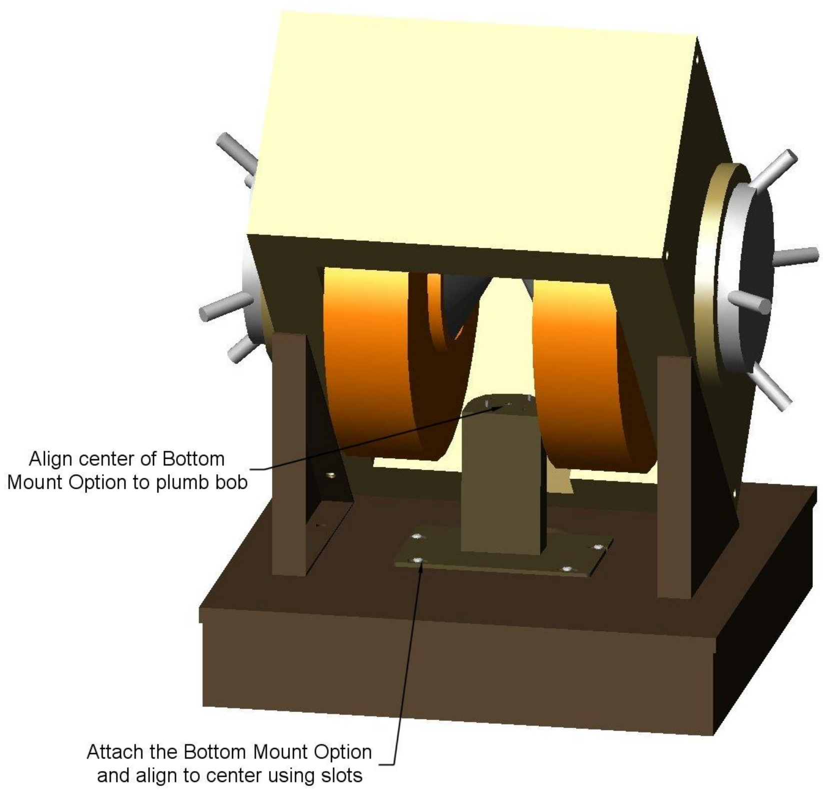
b. Align Fork Flange to correct X and Y positions.

i. Attach plumb bob to VSM Head.

ii. Use a scale to determine the center of the Fork Flange. Adjust Angle Bracket so Fork Flange centerline is inline with the sample tail centerline.

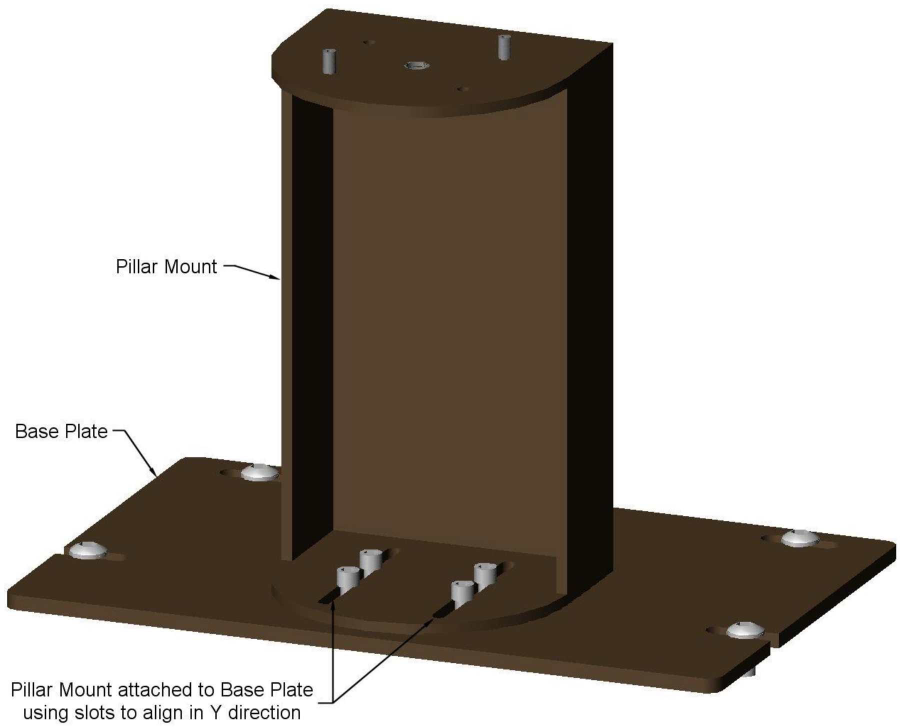


iii. Attach the Bottom Mount Option to the magnet base.



1. Remove sample tail and attach supplied plumb bob to VSM Head.

2. There is a recessed area on the Fork Flange where the exchange plate mounts. The distance from the recessed area to the flat surface on Option Mount Platform/Bottom Mount is 17 and 1/8 inches. Add washers between Base Plat and Pillar Mount as needed to reach this distance.
3. Using end of plumb bob as a reference for centerline, attach Bottom Mount Option to electromagnet base.
   a. Attach Base Plate to Magnet using slots to align in the X direction.
   b. Attach Pillar Mount to Base Plate using slots to align in Y direction.



4. Remove plumb bob.

d. Tighten Mounting Hardware.

5. Install Cryostat and Tail
   a. Mount cryostat Assembly
      i. Place the cryostat Assembly onto the Top Mounting.
      ii. The angled edge of the Option Exchange Plate should face rearward and interface with the rear of Top Mounting.
      iii. Check to ensure Mounting Plate is centered on Bottom Mount and clears raised Location Guide Pins.
      iv. Tighten large Captive Clamping Knob to secure bottom of Cryostat Option to Option Mount.
      v. Attach two brass knurled thumbscrews to secure Option Exchange Plate to Top Mounting.
   b. Place a sample tail into the cryostat opening
      i. Move the head rearward to clear cryostat opening.
      ii. Place sample tail in cryostat.
      iii. Move the head forward into operating position.
      iv. With one hand, raise sample tail slightly to meet VSM Head.
      v. Attach sample tail to VSM Head Drive being careful to ensure no stress is put on the sample tail.

NOTE: Skip Section 6 when following method **C**

6. Cryostat Assembly to Option Mount Alignment
   a. Visually note the difference between sample tail centerline and center of the cryostat's sample space opening. The goal is to have an even space around the tail such that it will not touch the cryostat's opening.
   b. Loosen screws attaching cryostat circular flange to Option Exchange Plate.
   c. Move Cryostat Option to align the top of the sample tail with respect to the opening of the sample space.
   d. Tighten screws attaching cryostat circular flange to Option square flange.
   e. Turn the head on.
   f. Use the X-Y stage in the base of the option to tilt the option to minimize rubbing.
      i. Start by adjusting the XY stage such that the cryostat is centered in the magnet gap.
      ii. When adjusted correctly, the tail in the cryostat will make very little noise.
      iii. Rotate and check for noise, adjusting lower XY stage as needed.

Once the option is set in this manner, the option can be removed and replaced by loosening the hand knob at the bottom and removing the two thumbscrews on the top. It is not necessary to make position adjustments when installing the unit in the future. The following electrical and vacuum connections are required for operation.

7. Make Connections (see Figure 3-3)
   a. Controller
      i. Connect the BNC Analog Out 2 to Input 2 of the Model 142 Amplifier.
      ii. Connect the cryostat Temperature Sensor and Heater Cable to the rear panel of a Model 336 Temperature Controller.
         1. Connect the cable's 10 pin circular connector to the mating receptacle on the 74018 cryostat.
         2. Route the cable to the instrument console.
         3. Connect Input A and the Heater Output banana connector. Input B is not used.
   b. Pump
      i. Connect a roughing pump to the pump-out port of the cryostat vacuum jacket.
         1. Attach a good mechanical pump to the cryostat vacuum pumpout flange.
         2. Use the tubing provided by the system or good rubber vacuum hose.
         3. Drop hose loosely to the ground to damp out the vibration if possible.
         4. A thermocouple-type or Pirani vacuum gauge may be attached between the vacuum hose and the pump to monitor the pressure in the vacuum space.
      ii. An oil trap must be mounted between the pump and the cryostat to prevent pump oil from reaching the heater element (required to maintain cryostat warranty).
      iii. Turn on roughing pump and open evacuation valve to start evacuating the cryostat vacuum jacket.
8. Apply Vacuum
   a. Pump on the vacuum annulus to a pressure < 2.7 Pa (20 milliTorr).
   b. Leave the pump running through the operation.
   c. Close the evacuation valve to isolate the pump from the cryostat vacuum jacket before cooling down.
9. Verify Noise-Free System
   a. See document #073-03-00, 'VSM Low Temperature Cryostat QC' for relevant QC procedures. This can also be found in section 5.3 of the 7400 VSM Installation Reference Binder.
   b. Verify calibration.
   c. Check noise at 0 degrees operating angle. Check noise during sample tail rotation.
10. Install Sample
    a. Move the VSM Drive backward to clear the cryostat opening.

b. Place the sample tail into the cryostat.

c. Move the VSM Drive forward to its normal operating position at the stop.

d. Attach sample tail.

3.1.5 Cool Down

1. Close the needle valve at the bottom of the SuperTran (storage Dewar) leg, by turning the knurled knob flow valve regulator (right handed screw as observed from below the knob).
2. Open the transfer line needle valve one to two full turns. Insert the inlet rigid leg (0.5" O.D.) into a storage Dewar very slowly, while allowing the cryogen vapor to vent out of the Dewar and flush air out of the transfer line and the cryostat. The slow insertion avoids violent boil off and cooling off the transfer line and cryostat too quickly After the leg bottoms out, close the vents and leave the 4 psig relieve valve in the volume to regulate the pressure for deliver the liquid to the cryostat. Now lift up the leg about 1 cm from the bottom to avoid any frozen debris at the bottom. (In rare cases, you may have to use a pressurized helium gas bottle to pressurize the Dewar, if the pressure will not build up for operation. See next step.)
3. Using pressurized helium gas, pressurize the storage container to about 3 psig. A pressurization manifold with a (0–5 psig) pressure gauge may have been provided for the Dewar. Some storage Dewars may have an equivalent arrangement for this purpose. Please note that it is easier (and less wasteful) to increase the pressure in the storage Dewar than to decrease it.
4. When one can feel the helium exit the transfer line, insert the “male” bayonet of the transfer line into the cryostat section and (hand) tighten the 0-ring compression sealing knurled nut (on the cryostat side). Next tighten the second knurled nut (on the transfer line side) to ensure a good mechanical joint. After cooldown, this second nut should be re-tightened to make up for differential contraction in the bayonet.
5. Start VSM software and open up the temperature display window. Ramp the set point to 20 K (For nitrogen operation, ramp to set point 100 K.)
6. Monitor the temperature sensor continuously. In 5-10 minutes, the inner line and cryostat will start to cool down (slowly at first, then very rapidly) and the temperature reading will start to drop. Close the valve to about ¼ to ¾ turn open (this setting varies from unit to unit) or previous operating setting. Adjust the valve again such that it takes about 19% current on heater range Medium to control the system at 20 K (For nitrogen operation adjust flow for 25% current on heater range High to control the system at 100 K.)
7. Check that the pressure inside the storage Dewar is at the proper operation pressure, and maintain this pressure throughout this procedure.
8. Wait for at least 30 minutes for the system to reach thermal equilibrium. Make valve adjustment as needed to maintain the correct heater output.

3.1.6 Cryostat Temperature Control Domains

Cryostat temperature domain settings for the Model 336 Temperature Controller for helium are detailed in Table 3-1 and for nitrogen in Table 3-2.
Note: The values in this table are set by the software, and therefore, are for informational purposes only.

Table 3-1. Cryostat Temperature Domains for Helium

Zone	*Begin/End T (K)*	*P*	*I*	*Power Range*	*Ramp Rate (K/min)*	*Settle Band/Time*
1	4 – 10	70	100	Medium	2	0.5 / 5
2	10 – 25	20	70	Medium	2	0.5 / 5
3	25 – 75	20	40	High	5	0.5 / 5
4	75 – 90	30	20	High	10	0.5 / 5
5	90 – 135	40	10	High	15	0.5 / 5
6	135 – 175	40	10	High	15	1 / 5
7	175 – 250	30	10	High	20	1 / 5
8	250 – 350	25	10	High	20	1 / 5
9	350 – 450	15	20	High	20	2 / 10

Table 3-2. Cryostat Temperature Domains for Nitrogen

Zone	*Begin/End T (K)*	*P*	*I*	*Power Range*	*Ramp Rate (K/min)*	*Settle Band/Time*
1	75 – 90	20	30	High	10	0.5 / 5
2	90 – 135	20	20	High	10	0.5 / 5
3	135 – 175	20	20	High	10	1 / 5
4	175 – 250	20	15	High	15	1 / 5
5	250 – 350	20	15	High	20	1 / 5
6	350 – 450	20	10	High	20	2 / 10

The helium curve is in location 23 and the nitrogen curve is in location 24. The proper domains will be set when the VSM software starts.

NOTE: If this option was ordered with the VSM system, sensor curves 23 and 24 were loaded into the temperature controller at the factory for reading and controlling the sample temperature. If you requested this option after the VSM system was delivered, you will need to install the appropriate sensor curves to curve locations 23 and 24 on the temperature controller. The curve can be found on the sensor CD included with the option. Use the Curve Handler software on your desktop or provided with the sensor CD or VSM software CD to download the curves to locations 23 and 24.

3.1.7 Operation

It is important to ensure that helium is definitely flowing through the vaporizer prior to passing any current through this heater. If no flow exists, vaporizer temperature can increase very rapidly causing heater burnout or damage to the joints.

CAUTION: This cryostat must **not** operate above the rated temperature of 450 K and with a temperature controller other than the one delivered with the system.

1. Adjustments in the cryogen flow can be made at any time either to increase the cooling power (just above the cryogen boiling point), or to reduce the cryogen consumption at higher temperatures. For best operation, however, the user should follow the setting giving specifically for the unit. In either case, the sample mount temperature should never exceed 450 K. The vacuum space must be pumped continuously when operating the cryostat above room temperature.
2. To operate between 20 K and 450 K, no additional valve adjustment will be needed. Temperature experiments may be started once the temperature is stabilized.
3. To operate below 20 K, one needs to stabilize the system to about 20 K before cooling further to the lowest required operating temperature. The experiment should always be started at the lowest required temperature point.

Basic Flow Valve Adjustments for Helium Operation

Range	*Adjust Temp. Point*	*Heater Power / Range*	*Suggested Wait Time*
20 – 450 K	20 K	19% / Medium	30 minutes
8 – <20 K	8 K	19% / Medium	30 minutes
5.5 – <8 K	5.5 K	17% / Medium	15 minutes
<5.5	Each Point	0	–

Basic Flow Valve Adjustment for Nitrogen Operation

Range	*Adjust Temp. Point*	*Heater Power / Range*	*Suggested Wait Time*
77 K, 85 – 450 K	100 K	25% / High	30 Minutes

4. In order to change samples, it is only necessary to disconnect the sample holder/tail from the VSM drive, slide the drive backward and lift out the sample holder slowly. To prevent condensation on the tail/sample, it is advisable to ramp the temperature to 300 K before removing the tail. During this operation, the helium vapor flow in the sample tube should be maintained, in order to preclude the admission of any air to the sample zone. It is important to make sure no moisture is present on the sample tail/holder before insert it back into the cryostat.

3.1.8 Shut Down

Upon the completion of the experiment, the needle valve at the bottom of the transfer line leg should be closed. This prevents any cryogen from reaching the sample mount and allows any cryogen remaining in the inner line or sample tube to vent safely outside the cryostat via top sample tube, while stopping any air or moisture from entering. Disconnect the transfer line from the cryostat. The storage Dewar should then be de-pressurized, and the SuperTran leg removed in order to reduce the heat input into the liquid inside the Dewar.

3.1.9 Operational Techniques

In order to maintain the high performance of this cryostat, it is recommended that the following suggestions and precautions be followed:

1. Always maintain the utmost cleanliness inside the vacuum shroud. Any elastomer seals should be very lightly coated with a high vacuum grease, and evacuation of this space is best done using a diffusion pumping station.
2. It is preferable to maintain a vacuum in the flexible line vacuum space and cryostat vacuum space at all times. Evacuate the cryostat prior to each use. Evacuation should be done while the inner space is at room temperature. The transfer line will need to be evacuated periodically with a turbomolecular pumping station. This should be done while the inner line is at room temperature. Helium gas and moist air should never be allowed inside these spaces.
3. During the initial cool down with helium, one may have the cryostat settling at a temperature between 15 -20 K with no heater output for 30 minutes before following the Flow adjustment heater table for the valve settings.
4. For operating close to 4.2K, adjust the valve to deliver just enough liquid to hold the temperature. Too much liquid will frost up the sample opening.
5. Make sure the transfer line is at room temperate and dry before inserting into cryogen.
6. Do not heat the vaporizer or sample mount to a temperature above 450 K.
7. Do not bend the flexible transfer line to a radius of less than 12 inches (30 cm).
8. Do not over tighten the needle (flow control) valve at the bottom of the transfer leg.
9. Do not operate the cryostat with other temperature controller or manual power supply.
10. It is preferable to have an anti-oscillation device on your helium storage Dewar, and keep the end of the transfer leg about one centimeter above the bottom of the storage Dewar.
11. Use a 4 psig relief valve on the helium Dewar for maintain the Dewar working pressure. Use a 10 psig relief valve for nitrogen Dewar.
12. To remove a blockage developed in the cryostat, one must warm up the cryostat by ramp the temperature to 300 K. Remove the transfer line according to the procedure in Shut Down section. Wait the line to warm to room temperature, then install the line into the cryostat. Flush the system with helium gas for 5 minute by connecting a 1 to 2 psig helium gas line at inlet of the transfer line.

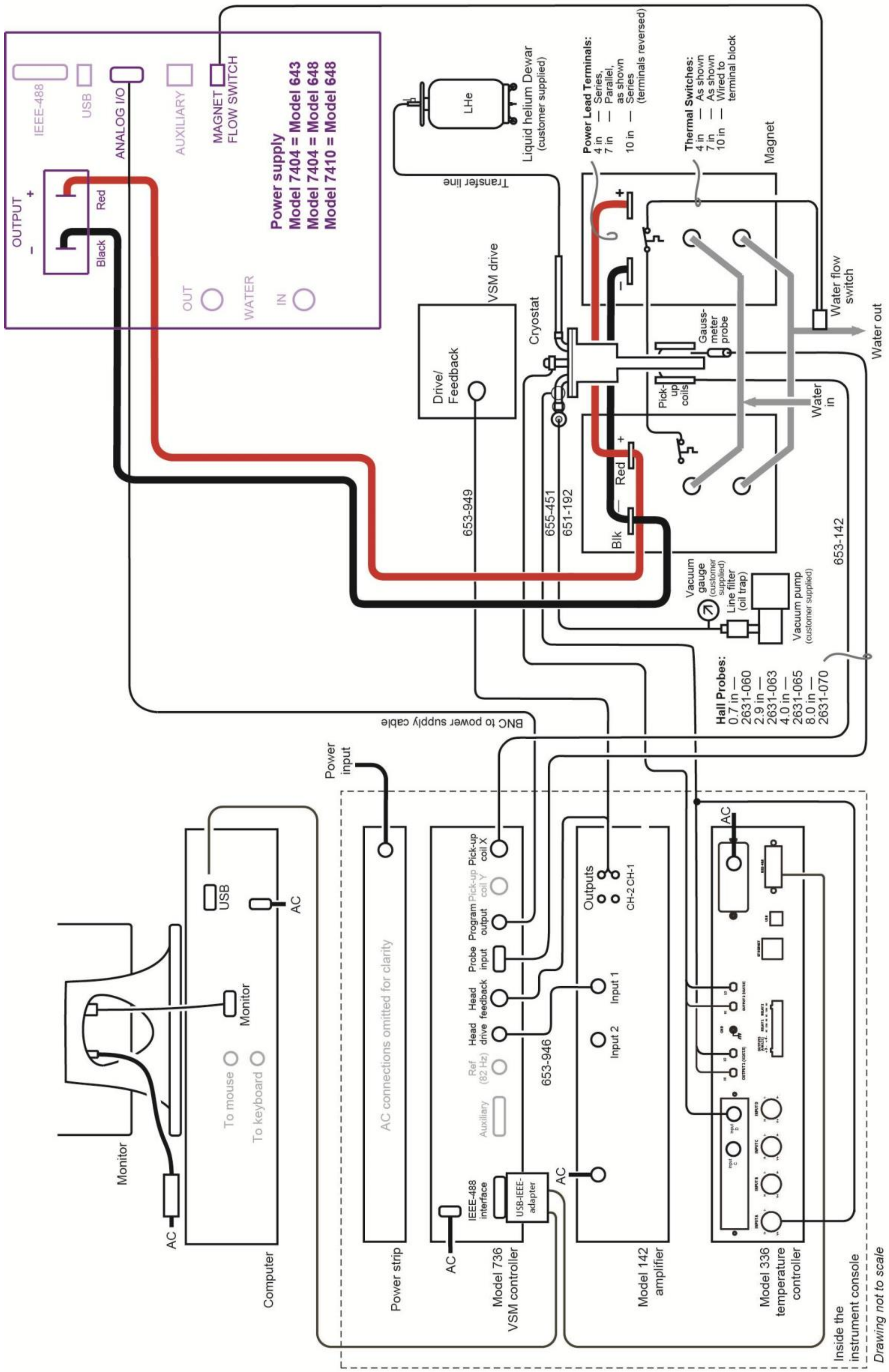


Figure 3-3. Typical 7400 Series VSM System with Optional 74018 Wiring

3.2 ROTATION OPTION (74033)

The Model 74030 Rotation Option allows the user to automatically vary the sample orientation relative to the direction of applied magnetic field. A stepping motor on the VSM drive head controls the motion. See Figure 3-4. Two limit switches determine HOME and END positions of rotation. All stepping motor controller communication is through the RS-232 serial interface to the PC. Rotation option cabling is detailed in Figure 3-6.

CAUTION: Do not rotate the sample with the manual knob when the VSM software is running. This will cause the software to loose its angle position information.

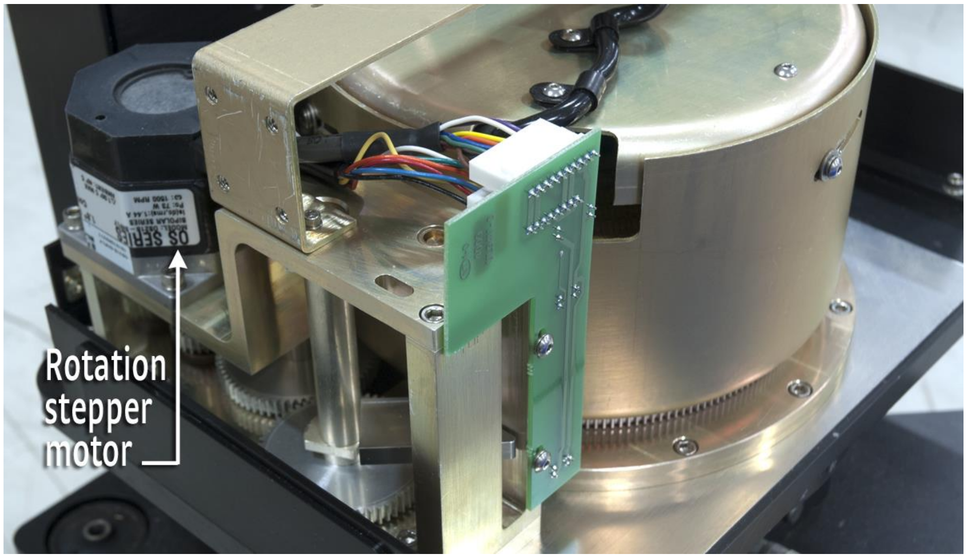


Figure 3-4. Auto-rotation option inside VSM drive

The angle of rotation is within a single plane defined by the direction of applied magnetic field, called the x-axis, and perpendicular to the direction of vibration, called the z-axis. See Figure 3-5.

- All parameters are measured as a function of rotation angle.
- Rotation is programmable to a resolution of <1° for rotating the sample from 0° to 720°.

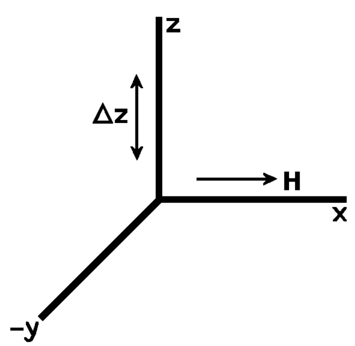


Figure 3-5. VSM Reference Frame

Periodically calibrate the rotation option to ensure an accurate degree/steps constant. Install the Nickel sample prior to calibration. To initiate calibration, select **Rotation** under the **Calibration** menu.

To set an angle for a field or temperature sweep, use the **Static Control** menu under the **Magnetometer Operations** menu.

To perform a magnetization versus angle experiment at a fixed field and temperature, use the **Angle** menu under the **Define Experiment** menu to setup the data points.

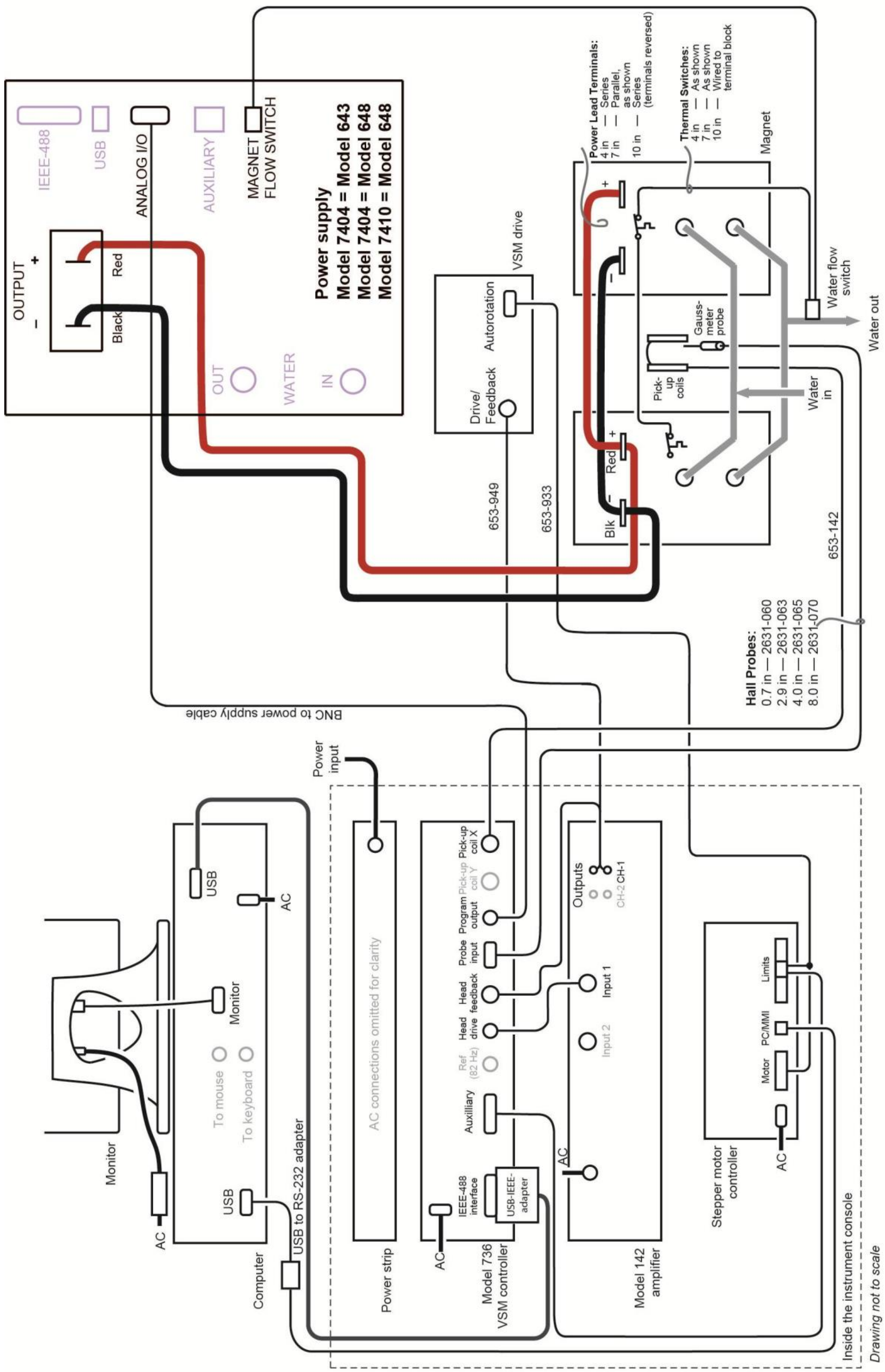
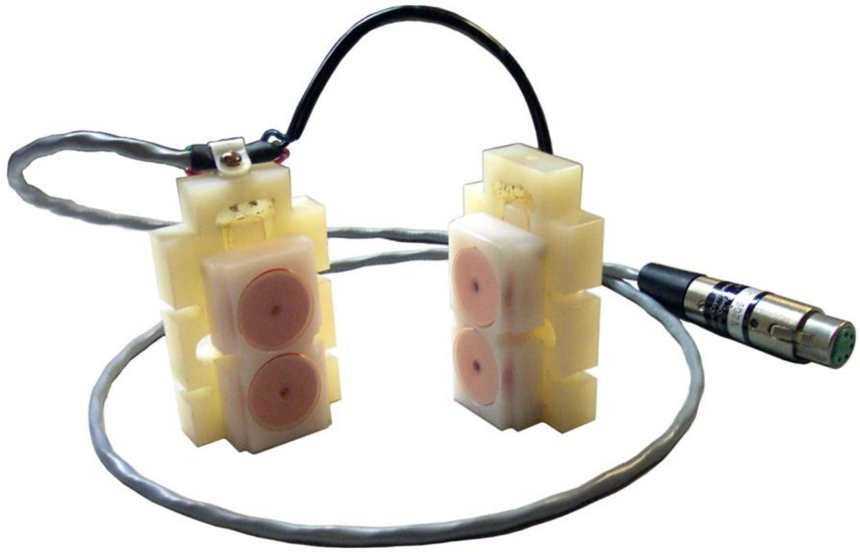


Figure 3-6. Typical 7400 Series VSM System with Optional 74033 Rotation Wiring

3.3 VECTOR OPTION (74031 AND 74032)

In reference to the Vector Option pick-up coil set, the x-axis measures the magnetic moment parallel to the applied magnet field and the y-axis measures the magnetic moment perpendicular to the applied magnet field. The Model 736 VSM Controller can obtain both x- and y-axis magnetic moment measurements simultaneously. Two different sizes of Vector coils are offered: 74031 with 1-inch coils and 74032 with 2-inch coils. See Figure 3-7.



Vector_Coils.bmp

Figure 3-7. Typical Vector Coils

3.3.1 Installation

WARNING: Always set the current to zero and turn off the power supply before attempting to adjust the magnet gap.

First, refer to Paragraph 2.5 for the procedure to change the magnet gap. Since the x-axis coils are normally affixed to the pole caps, use the vector coils as a template to set the gap so that the y-axis coils can be attached to the x-axis coils. See Figure 3-8). Carefully tighten the screws holding the x-axis and y-axis coils together. Place the gaussmeter probe mounting bracket onto the coil set and place the gaussmeter probe in to the indexed stop. Tighten the front right gaussmeter probe mounting bracket screws. To adjust gaussmeter probe orientation, refer to Paragraph 2.4.4. Route the cable to the instrument console and plug the connector to the rear panel of the Model 736 VSM Controller in the connector labeled PICKUP COIL Y. See Figure 3-9.

3.3.2 Calibration

Y-axis coils calibration uses X-axis coils calibration as a reference. Calibrate Y-axis coils with a permanent magnet at an applied field of zero gauss. First, measure the magnetic moment of a permanent magnet with the X-axis coils. Rotate the permanent magnet 90° to produce a positive moment in the Y-axis coils (see Figure 3-5). Adjust the Y-axis coil moment reading to equal the X-axis coil moment reading.

NOTE: The magnetization axis of the permanent magnet rotates –90° according to the rotation index on the VSM drive head. Proper calibration requires the sample saddled after rotation. For the Y-axis coils, the minimum and maximum emu outputs required to saddle the sample interchange. The X-direction saddle is now a maximum emu output and the Y-direction saddle is a minimum emu output.

After obtaining the new saddle point, allow the software to measure the Y-axis emu value and determine a calibration constant. This calibration constant is stored until a new calibration is performed.

3.3.3 Maintenance

When handling the vector coil set, take care not to break any wires. The pick-up coil wires are encased within the coil form, but damage may occur if the unit is dropped or exposed to moisture or large electrical currents. When separating the y-axis coils from the x-axis coils take care not to strain any of the cables or their pin connectors. In addition, when adjusting the coil set, do *not* disassemble the coil protection mount.

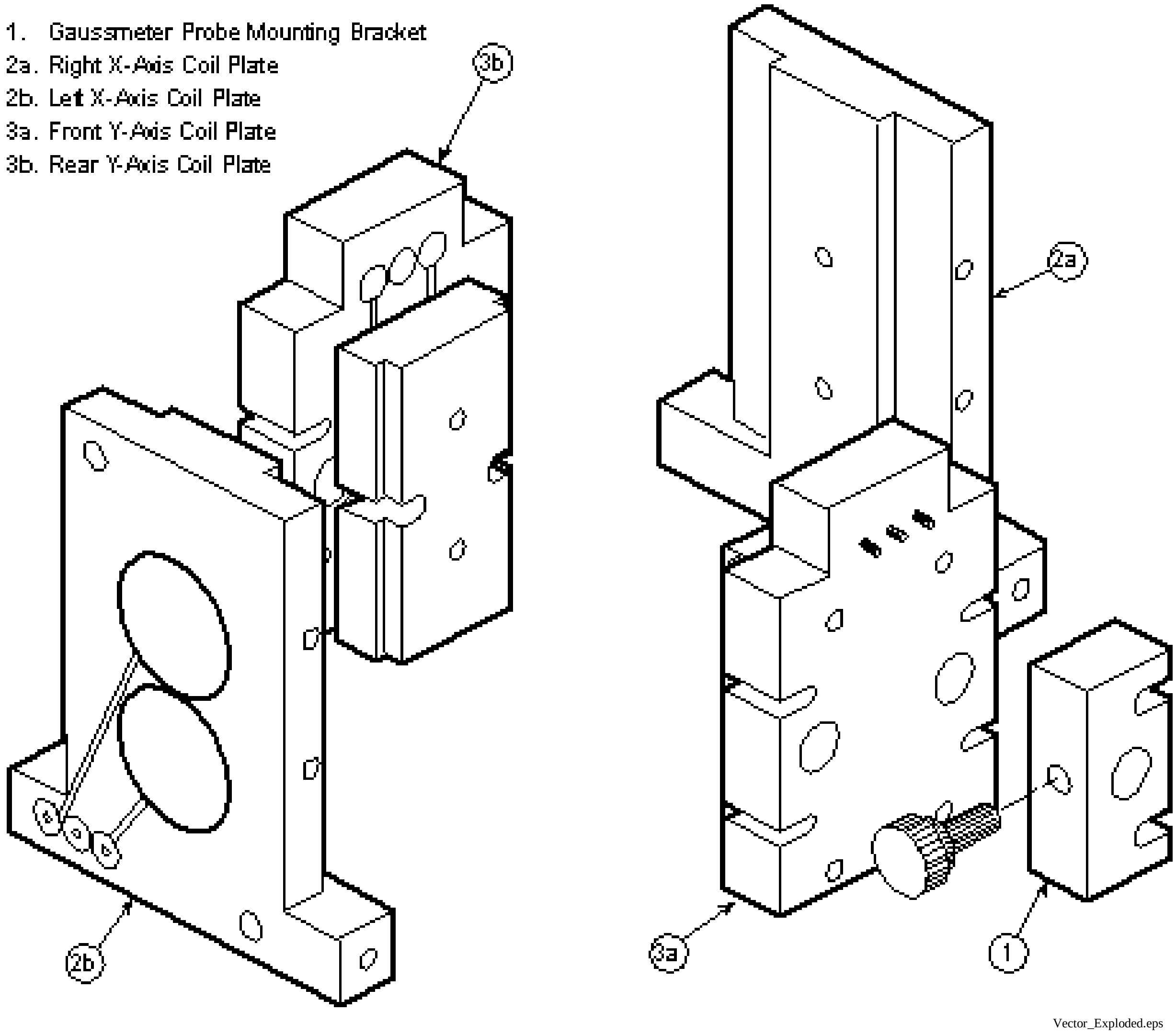


Figure 3-8. Typical Vector Coil Exploded View

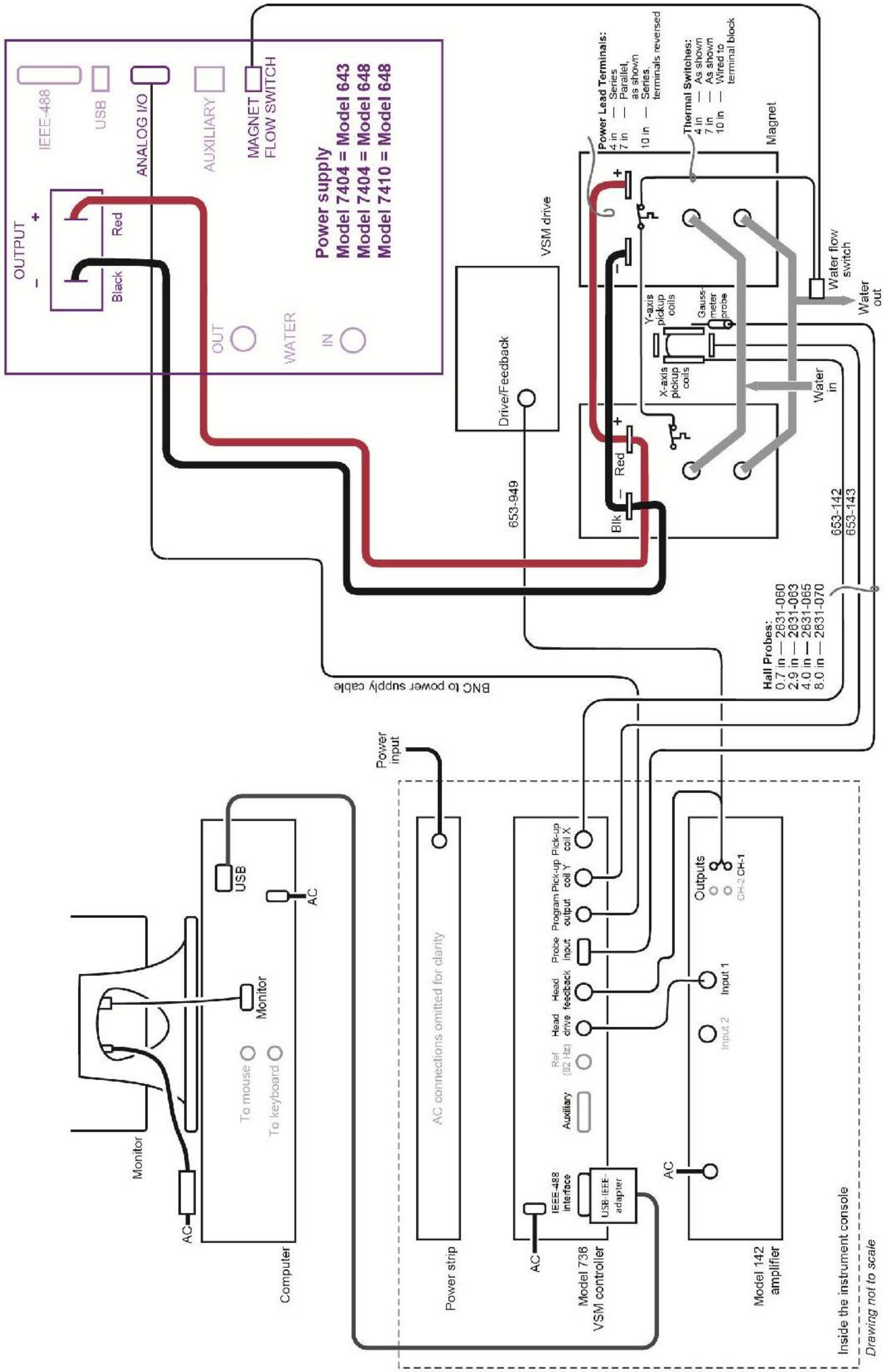


Figure 3-9. Typical 7400 Series VSM System with Optional 74031 or 74032 Vector Wiring

3.4 HIGH TEMPERATURE OVEN OPTION (74034)

The Model 74034 Oven Assembly allows the 7400 Series VSM System to investigate magnetic properties of materials at high temperatures. See Figure 3-10 for a typical oven assembly.

The oven option is made of non-magnetic materials, consisting of an electrically-heated outer tube assembly with efficient vacuum and reflective thermal insulation. The sample-zone temperature range extends to 1000 °C (1832 °F) and requires only 61 watts to maintain this temperature. Even at the highest operating temperature, outer case temperature is normally under 200 °C (392 °F) at the hottest spot. During operation above room temperature, a mechanical vacuum pump capable of maintaining inlet pressures down to <50 micron must be connected to the oven vacuum port and operated continually. (A pump rated at < 5 micron total blank off pressure will be a good choice.) The standard sample tail consists of a quartz rod attached to a boron-nitride sample cup.

To reduce the atmospheric oxygen in the sample space, a fill port is provided for flushing the opening of the sample space with inert gas. (Lake Shore recommends supply 80 cc/min. of Argon gas at 5 – 10 psi.) A chromel-alumel thermocouple facilitates temperature measurement and control.

The 74034 Oven is perfect for measuring Curie temperatures of materials up to 1000 °C (1832 °F). The inherent sensitivity of the 7400 Series VSM System determines Curie temperature at relatively low field intensities. The steeper change in magnetic moment significantly increases accuracy.

WARNING: Nitrogen gas is potential asphyxiant and can cause rapid suffocation without warning. Use them only in an adequately ventilated area. DO NOT vent or use them in confined spaces. Follow Compress Gas Association (CGA) best practices, applicable Safety Data Sheet (SDS) and applicable local safety requirement.

3.4.1 Oven Specifications

FUNCTION: Extends 7400 Series VSM System temperature range. Obtains controlled sample-zone temperatures to 1000 °C (1832 °F).

INSTALLATION: No system modifications are necessary. Refer to Paragraph 3.4.2 for details.

HEATER: Integral 20 Ω (±20%) heater coil.

POWER REQUIREMENTS: 0 – 2.0 A (maximum) of well-filtered DC. Sustained maximum rated temperature with nominal 61 watts. Never exceed 80 watts maximum power.

TEMPERATURE MEASUREMENT AND CONTROL: Lake Shore Model 336 Temperature Controller with Model 3060 Thermocouple input card for measuring and control oven operation.

SAMPLE ENVIRONMENT: Evacuate the sample zone or fill it with gas appropriate to the experiment.

HEATING RATE: Maximum heating rate of at least 80 °C (176 °F) per minute at maximum input power of 80 watts. Figure 3-11 shows a typical heating/cooling cycle at 25 °C (77 °F) ambient and <50 μ vacuum. The sample space heats to 1000 °C (1832 °F) in about 15 minutes.

COOLING RATE: With vacuum of <50 microns, the cooling time constant is nominally 1000 seconds. *Maintain vacuum while cooling*. The vacuum port of the oven may be opened to the atmosphere when temperature drops below 200 °C (392 °F). It cools in about 3 hours.

SAMPLE ZONE DIMENSIONS: Inside diameter = 9/32 inch; Outside diameter = 3/4 inch (at signal coils).

VACUUM CONNECTION: KF-16 flange at oven vacuum port. Attach flex line from oven to filter and vacuum pump in that order.

HEATER/THERMOCOUPLE CONNECTOR: Hermetically sealed 4-pin electrical receptacle. Matching plug with cable furnished with unit.

SAMPLE TAIL: Sample tail attaches to 7400 VSM Drive by threaded fitting. Standard sample tail consists of fused quartz rod with high-purity boron-nitride sample holder.

ADDITIONAL EQUIPMENT NEEDED:

1. Mechanical pump capable of a blanked-off total pressure of <5 microns.
2. Pressurized Argon gas with pressure regulator capable of maintaining 5 – 10 psi while deliver 100 cc/min.

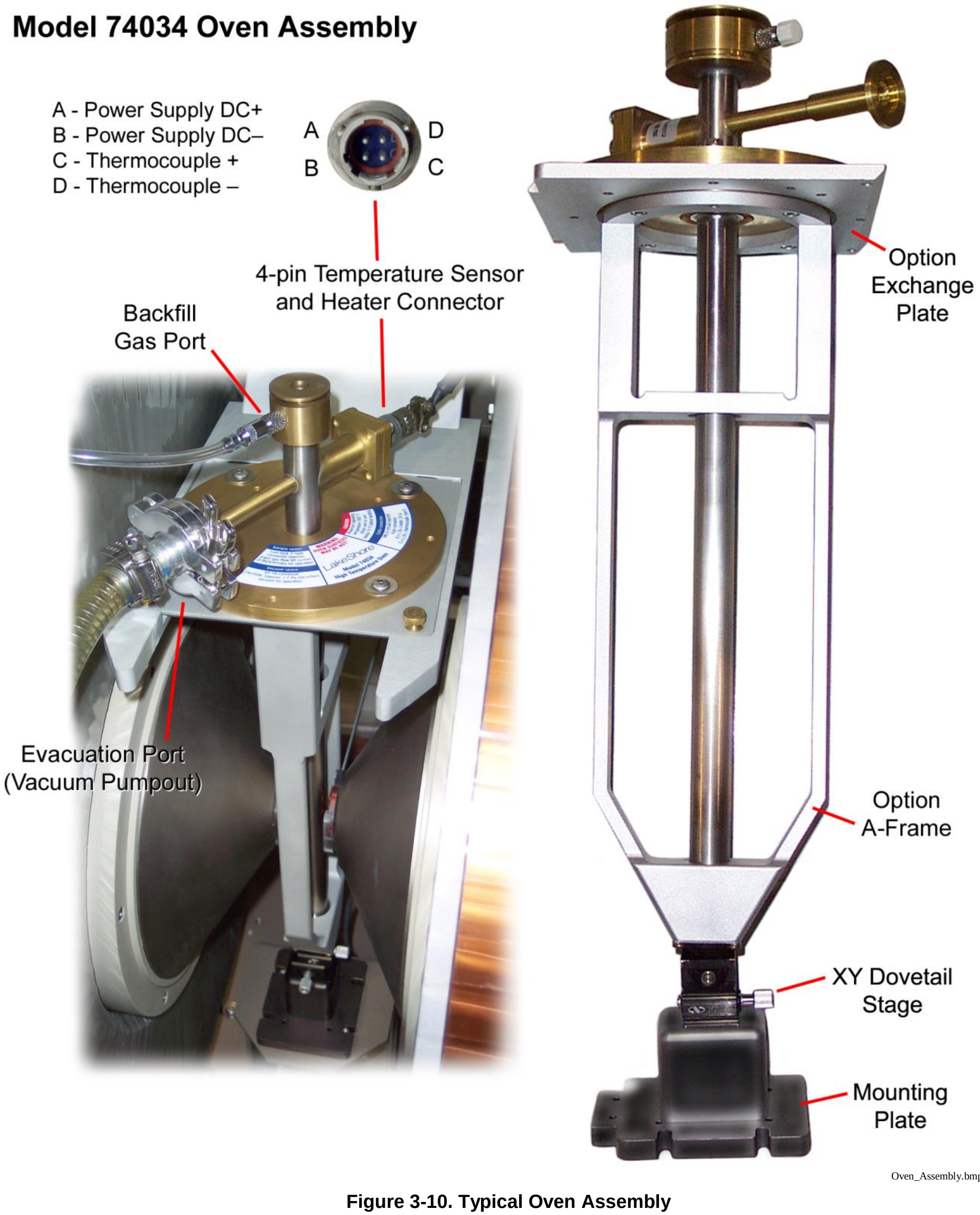


Figure 3-10. Typical Oven Assembly

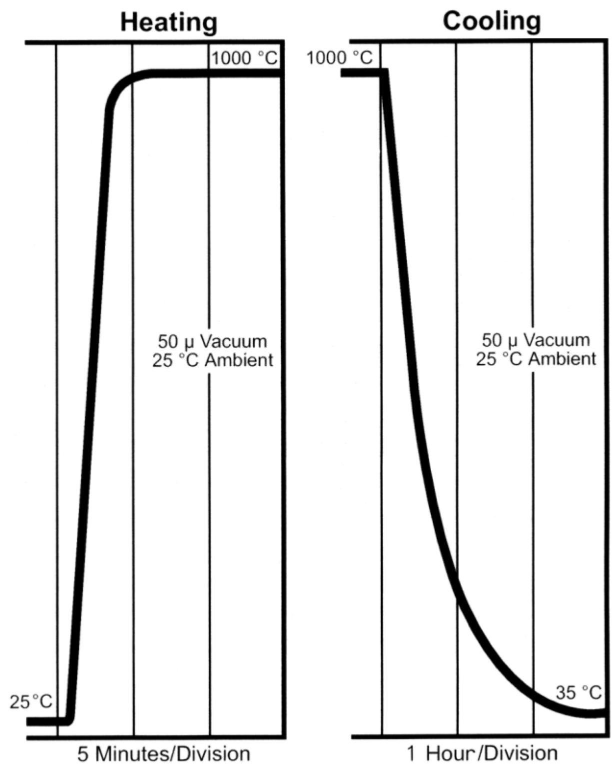


Figure 3-11. Heating and Cooling Curves

3.4.2 Oven Requirements

The following equipment should be present to before attempting Installation of a Model 74034 oven:

- 651-034 .... Oven Option Mechanical Assembly.
- 336 .... Model 336 Temperature controller installed in VSM electrical console.
- 3060 .... Model 3060 TC card installed in Model 336, above.
- 653-216 .... 4-pin accessory cable.
- 651-190 .... Oven Gas Handling Kit with flow meter.
- 651-192 .... Vacuum Handling Kit, includes anti-backstreaming oil filter for pump (above) and KF-16 Vacuum hose.
- Customer Provided........ Mechanical pump capable of a blanked-off total pressure of <0.7 Pa (5 milliTorr) vacuum.
- Customer Provided........ Pressurized Argon gas with pressure regulator capable of maintaining 34.5 kPa (5 psi) to 69 kPa (10 psi) while deliver 100 cc /min (0.0035 cfm).

3.4.3 Installation

This section details the process of installation of a VSM Model 74034 Oven Option. It is separated into sections for convenience. Depending on the operation you wish to perform, different sections of the installation are to be performed.

A ***Initial Installation on an Existing Room Temperature VSM***

If the Oven is being installed on an existing, room-temperature only VSM, all the sections below must be completed. This includes the attachment of the option mount to the base VSM and alignment of the Oven Assembly to this Mount in addition to the steps required for day-to-day Oven operations. These steps are noted under Column A, in the following table.

B ***Initial Installation on an Existing Variable Temperature VSM***

If the Oven Option is being installed for the first time on a VSM where another temperature option has already been installed, the option mount hardware has already been attached to the VSM and, therefore, Section 4, 'Mounting Option Hardware Attachment' is not required. In this case, follow the instructions under Column B, in the following table.

C ***Everyday use on an Existing Variable Temperature VSM***

For simple, day-to-day use of the oven, Sections 4, 'Mounting Option Hardware Attachment' and 6, 'Oven Assembly to Option Mount Alignment' are not required. Here, only the instructions under Column C, in the following table, needs be followed.

		Initial Installation on an Existing Room Temperature VSM	Initial Installation on an Existing Variable Temperature VSM	Everyday use on an Existing Variable Temperature VSM
Section	Title	**A**	**B**	**C**
1	Prepare VSM Head Drive	YES	YES	YES
2	Set EM gap	YES	YES	YES
3	Saddle and Calibrate at Room Temperature	YES	YES	YES
4	Mounting Option Hardware attachment	YES	–	–
5	Install Oven and Tail	YES	YES	YES
6	Oven Assembly to Option Mount Alignment	YES	YES	–
7	Make Connections (see Figure 3-16)	YES	YES	YES
8	Apply Vacuum	YES	YES	YES
9	Verify Noise-Free System	YES	YES	YES
10	Install Sample	YES	YES	YES

Complete Model 74034 Installation Instructions:

WARNING: Always set the current to zero and turn off the power supply before attempting to adjust the magnet gap.

1. Prepare VSM Head Drive.
   a. With VSM in operating position, verify VSM Head is level.
   b. Turn off the VSM Drive from the VSM main software screen.
   c. Remove sample tails and holders attached to the VSM Drive.
   d. Verify the stops in the VSM Head Drive's sliding track are set such that the VSM Head Drive can be moved back and clear the oven sample opening.
   e. Verify the rear stops are not be set too far rearward – The VSM Head Drive should not hit any part of the frame (check clearance of VSM Head Drive's protruding center tube).
   f. Slide VSM Head Drive rearward.

WARNING: Never slide the head drive back with a sample tail installed in the head. Damage can occur to both the sample tail and the head if forced.

2. Set EM gap.
   d. The magnet gap should be set to 51 mm (2 inches) for the 730ESC large gap pick-up coils and set to 38 mm (1.5 inches) for 740EMSC small gap pick-up coils.
   e. If the gap has been changed since the last oven use, the pole caps may have to be moved such that the oven is centered.
      i. Remove Hall probe from center of electromagnet air gap.
      ii. Disconnect small jumper cable between the coils at the connector.
      iii. Move Right pole inward until it aligns with the vertical centerline of the magnet.
         1. Use the pole adjusters to move the right pole cap furthest inwards until it stops. One may need to move the left one out to allow the right cap to fully thread to a stop. This is done on the 7404 and 7404 only.
         2. A plumb line can be used to establish this centerline for the 7410.
      iv. Move Right pole outward the number of turns specified on the electromagnet pole adjuster turn chart. (Use the pole adjuster spokes to count turns.)
      v. Repeat step ii with the Left pole. It is not necessary to move the right pole out to give the left pole space to thread in fully.
      vi. Move Left pole outward the number of turns specified on the electromagnet pole adjuster turn chart.
      vii. Moving Left and Right poles the identical number of turns, adjust electromagnet until desired airgap is obtained.
      viii. Reconnect jumper cable between the coils.

Electromagnet Pole Adjuster Turn Chart

Coils	7404	7407	7410
730ESC	15-1/2 turns	13-1/2 turns	8-1/3 turns
740EMSC	11-1/2 turns	10-1/2 turns	6-1/3 turns

   f. Adjust the location of the hall probe such that it cannot be damaged during oven installation.
      i. A slot is provided in the coil sets to accept the Hall Probe from behind.
      ii. Verify Probe Polarity when replacing.
3. Saddle and Calibrate at Room Temperature.
   a. Turn on the power supply.
   b. Cycle the power supply through one complete loop (maximum positive and negative fields).
   c. Oven option remains removed.
   d. Install the Quartz sample tail with Kel-F holder and Nickel sample.
   e. Saddle Nickel. (This saddling step will put the sample tail in the correct position with respect to the VSM sensing coils and no position adjustment should be done to the head or the magnet poles after saddling.)
   f. Perform moment gain calibration with nickel standard).
   g. Remove the sample tail

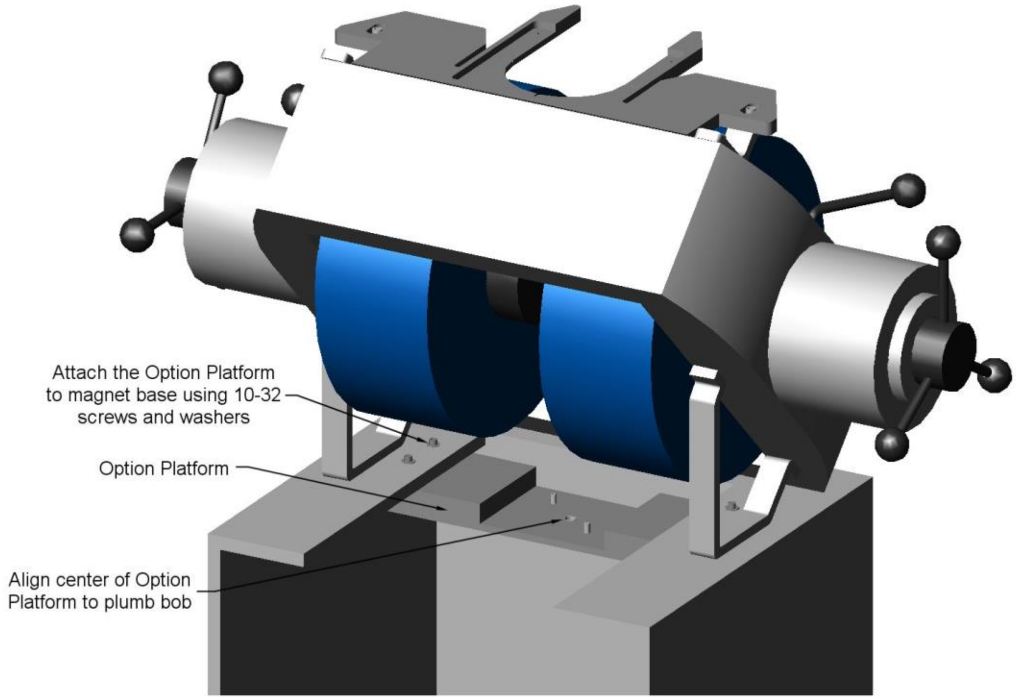
NOTE: Skip Section 4 when following methods **B** or **C**

4. Mounting Option Hardware attachment
   a. 7404 Option Mounting (Use section 4a if system is 4 inch electromagnet). Attach following hardware and align, but do not tighten screws fully.
      i. Attach the Option Platform to the base of the magnet using 10-32 screws and washers.
         1. Remove sample tail and attach supplied plumb bob to VSM Head.
         2. Using end of plumb bob as a reference for centerline, attach Option Platform to electromagnet base.

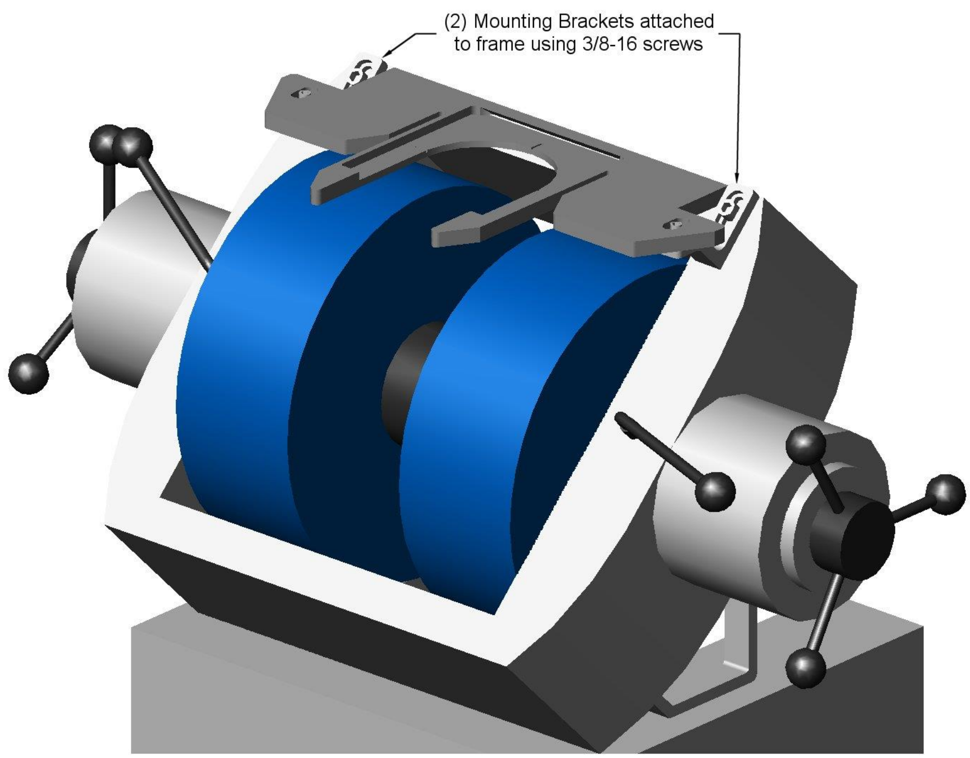
a. Start by using tapped holes that are offset from the center of the plate to mount the platform furthest forward.

b. Align the plate using the oversized holes and switch to other tapped holes if necessary.

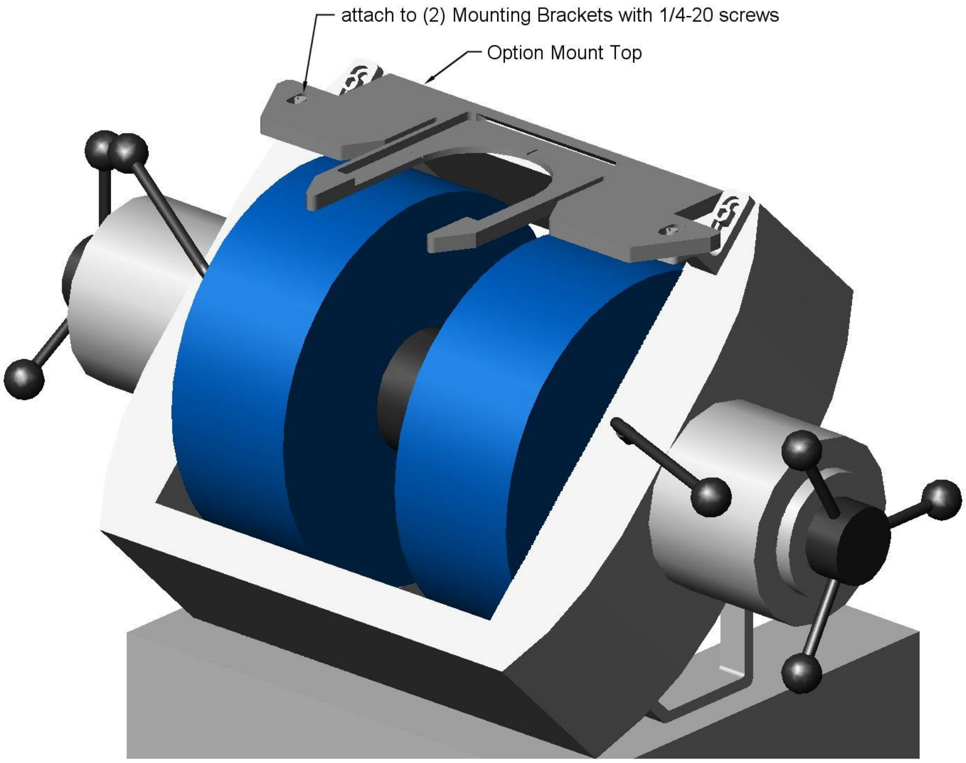
3. Remove plumb bob.



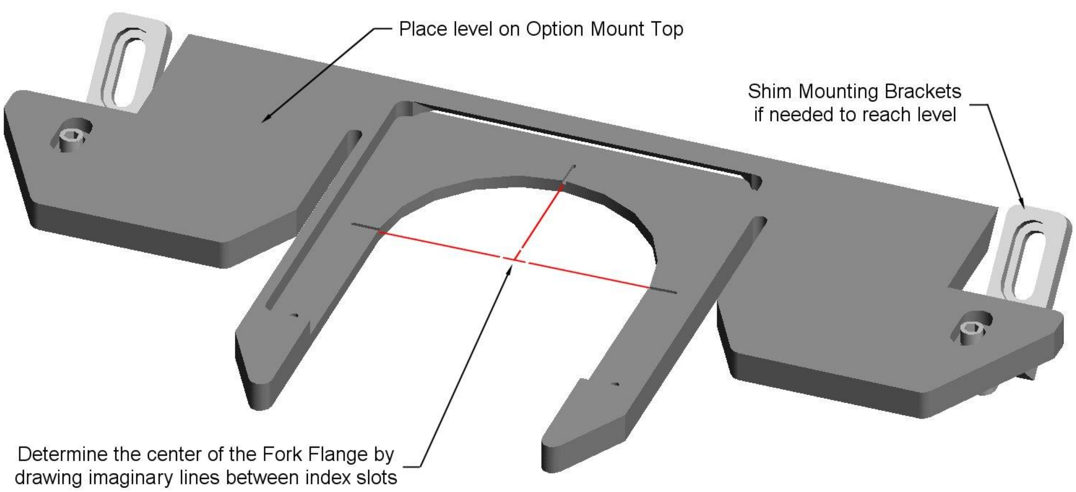
ii. Attach the two Mounting Brackets to the frame of the electromagnet using 3/8-16 screws.



iii. Attach Option Mount Top to the mounting brackets using 1/4-20 socket head cap screws.

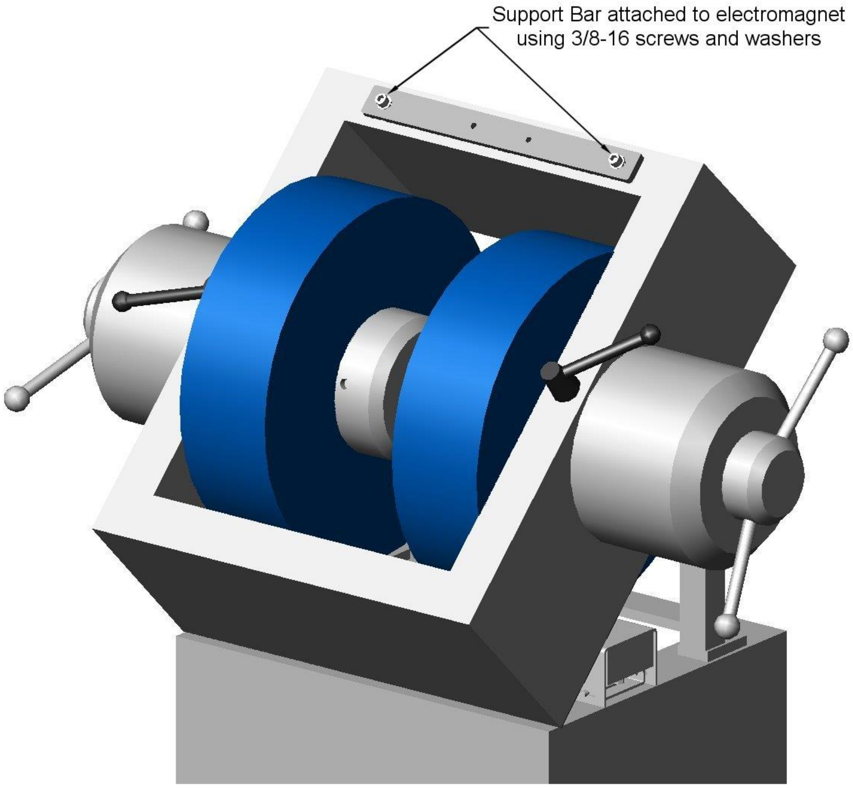


1. Option Mount Top must be leveled and aligned in XY.
    a. Place level on Option Mount Top and shim Mounting Brackets if needed to reach level.
    b. There is a recessed area on the Fork Flange where the exchange plate mounts. The distance from the recessed area to the flat surface on Option Mount Platform/Bottom Mount is 17 and 1/8 inches. Adjust Mounting Brackets as needed using the slots.
    c. Align Option Mount Top to correct Y position using slots.
        i. Attach plumb bob to VSM Head.
        ii. Use a scale to determine the center of the Fork Flange. Adjust Option Mount Top so centerline is inline with the sample tail centerline.

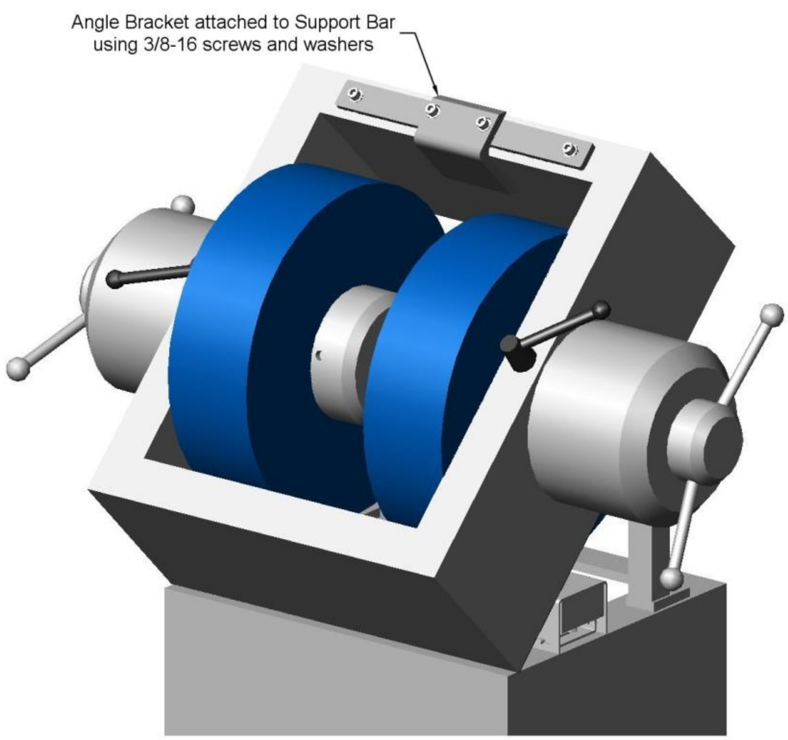


b. 7407 Option Mounting (Use section 4b if system is 7 inch electromagnet). Attach following hardware and align, but do not tighten screws fully.

i. Attach the Support Bar to the top of the electromagnet using socket head cap screws and washers.

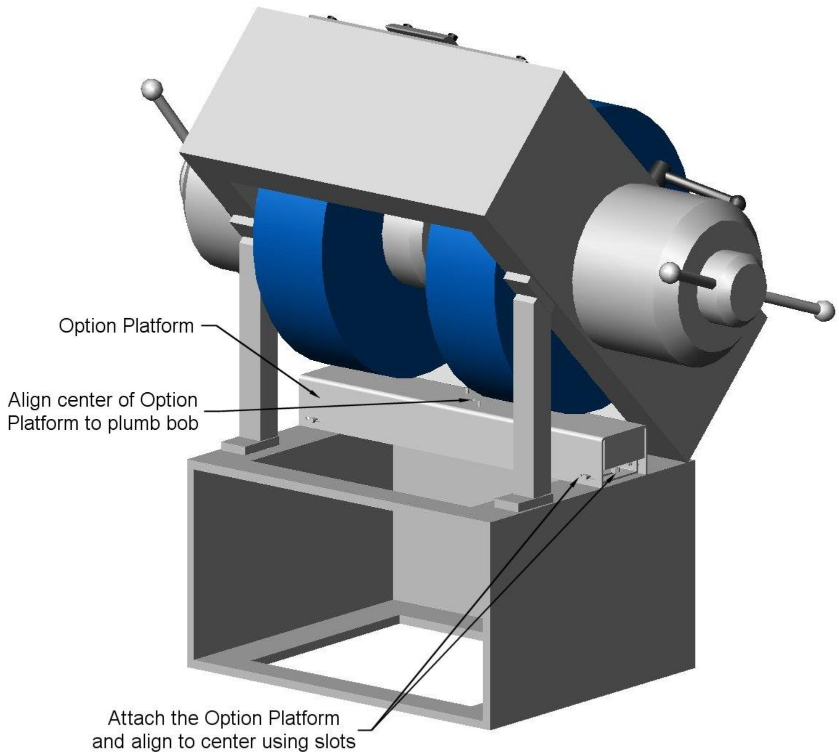


ii. Attach the Angle Bracket to the Support Bar using socket head cap screws and washers.

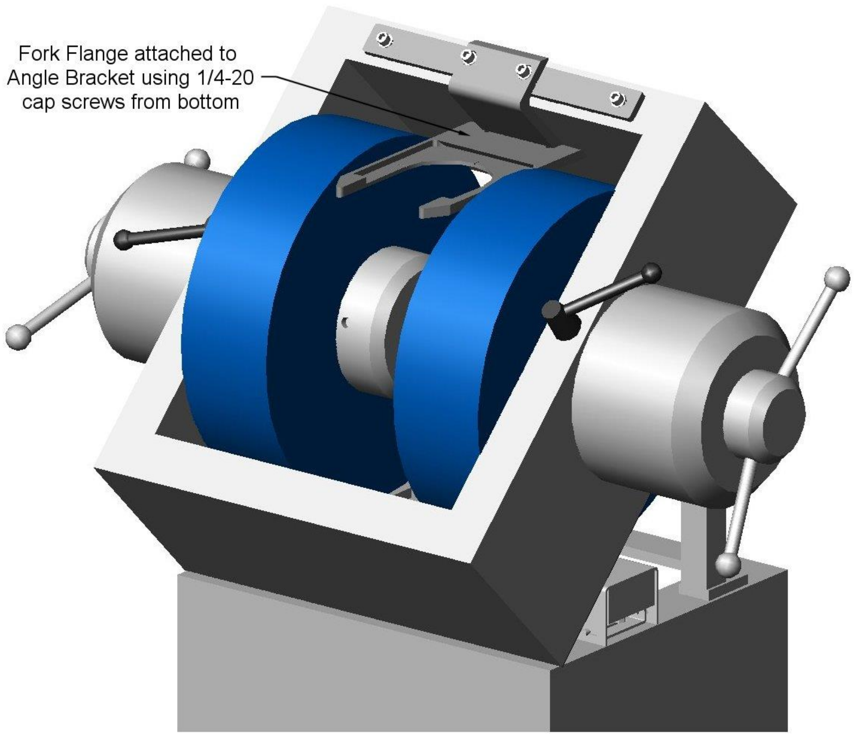


iii. Attach the Option Platform to the magnet base.

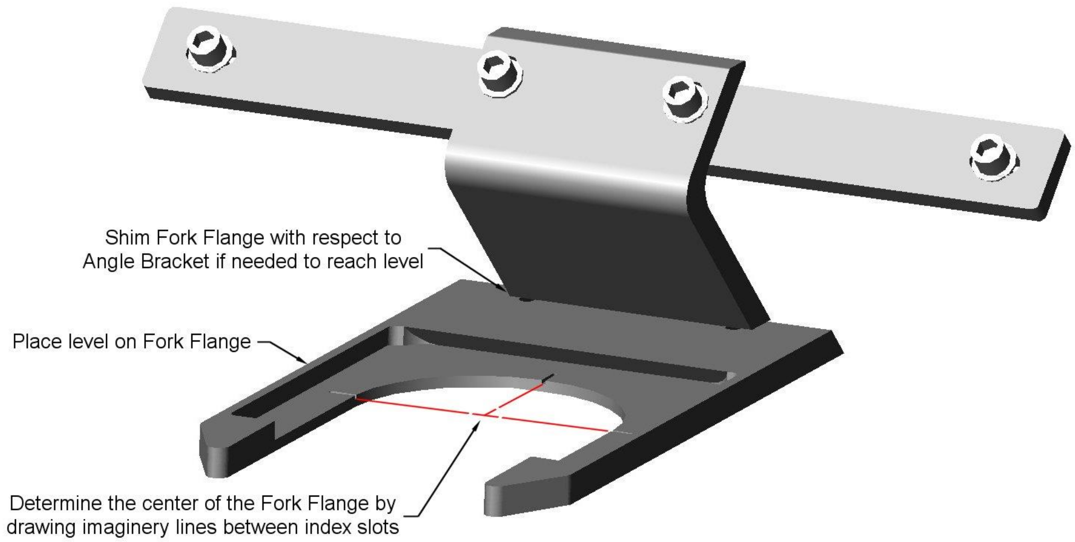
1. Remove sample tail and attach supplied plumb bob to VSM Head.
2. Using end of plumb bob as a reference for centerline, attach Option Platform to electromagnet base using 1/4-20 screws, washers, and nuts.
3. Remove plumb bob.



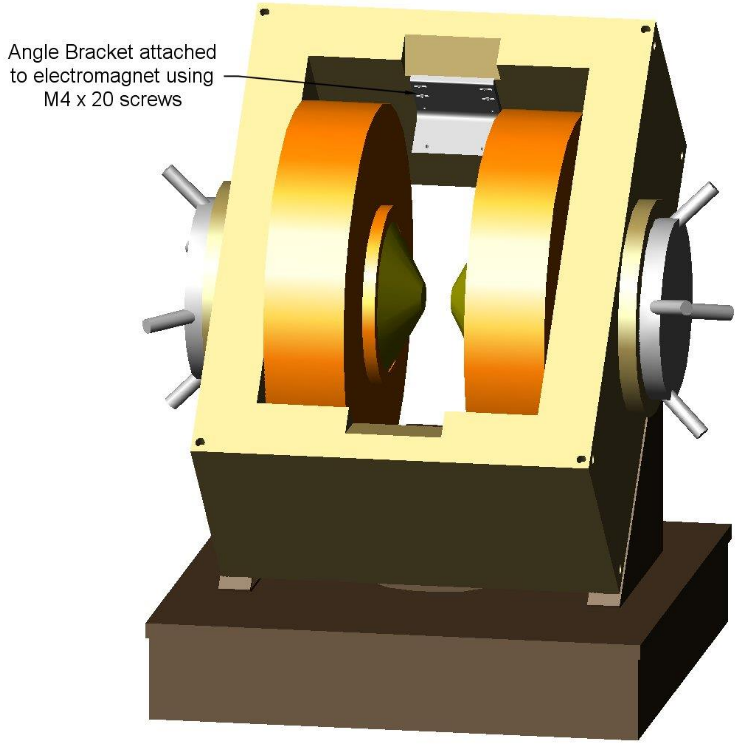
iv. Attach the Fork Flange to the Angle Bracket using 1/4-20 screws.



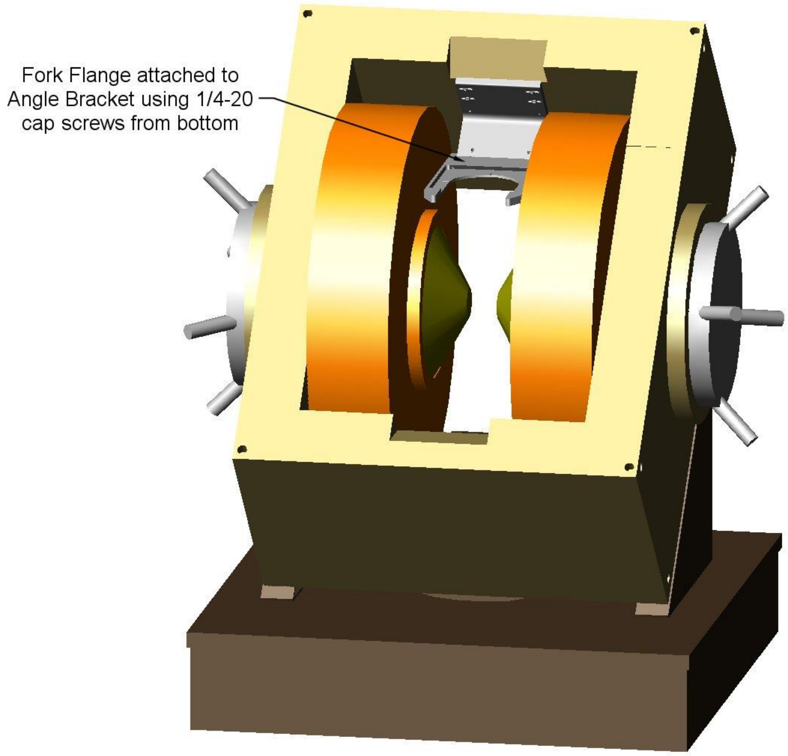
1. Fork Flange must be leveled and aligned in XY.
    a. There is a recessed area on the Fork Flange where the exchange plate mounts. The distance from the recessed area to the flat surface on Option Mount Platform/Bottom Mount is 17 and 1/8 inches. Adjust Angle Bracket as needed using the slots.
    b. Place level on Fork Flange and use available adjustment slots to level Fork Flange in the XY plane
    c. Align Fork Flange to correct X and Y positions.
        i. Attach a sample tail to VSM Head.
        ii. Use a scale to determine the center of the Fork Flange. Adjust Support Bar and Angle Bracket so Fork Flange centerline is common with the sample tail centerline.



c. 7410 Option Mounting (Use section 4c if system is 10 inch electromagnet). Attach following hardware and align, but do not tighten screws fully.
    i. Attach the Angle Bracket to the top of the electromagnet using M4X20 screws and washers.



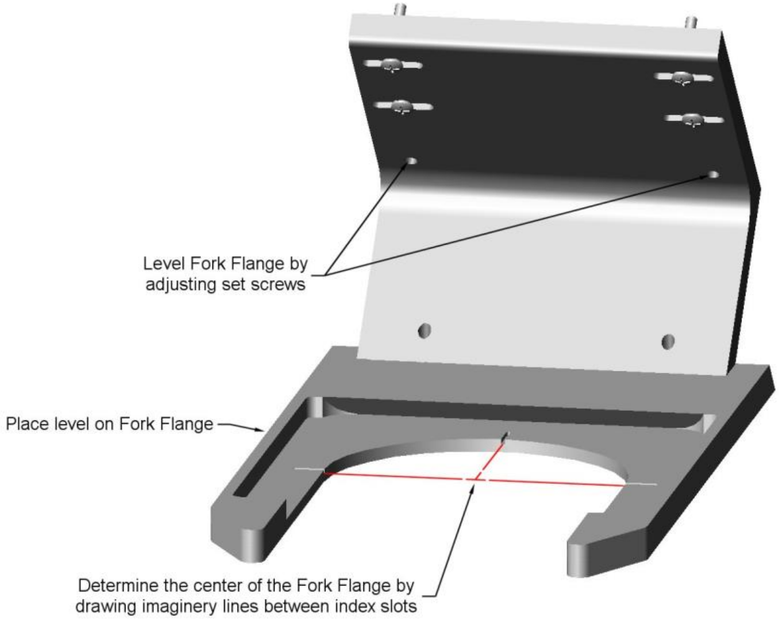
ii. Attach the Fork Flange to the Angle Bracket using 1/4-20 screws.



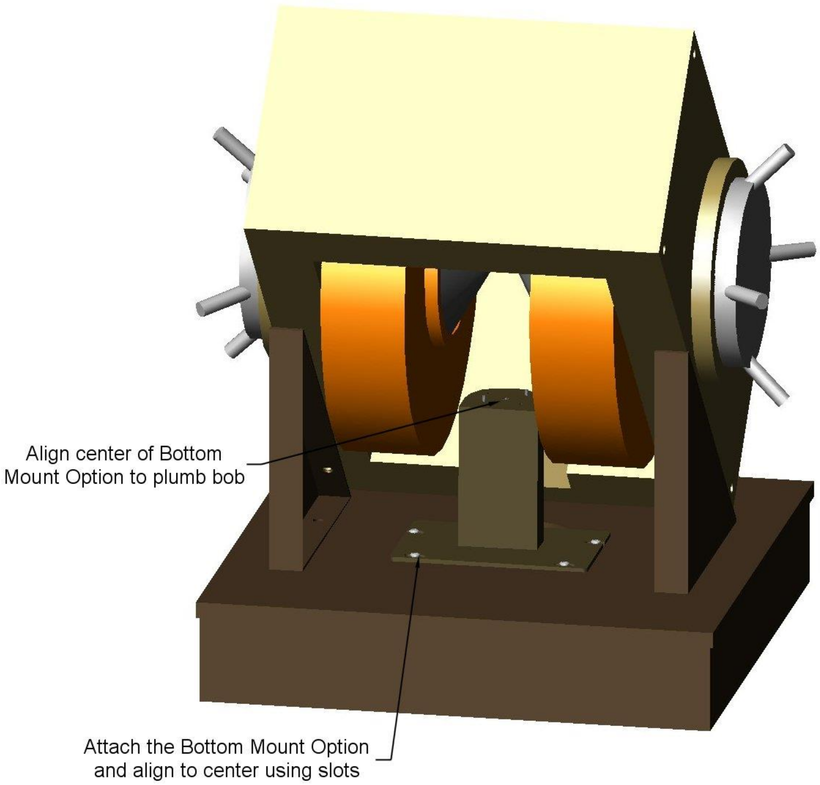
1. Fork Flange must be leveled and aligned in XY.
    a. Place level on Fork Flange and use available adjustment set screws to level Fork Flange in the XY plane
    b. Align Fork Flange to correct X and Y positions.

i. Attach plumb bob to VSM Head.

ii. Use a scale to determine the center of the Fork Flange. Adjust Angle Bracket so Fork Flange centerline is inline with the sample tail centerline.

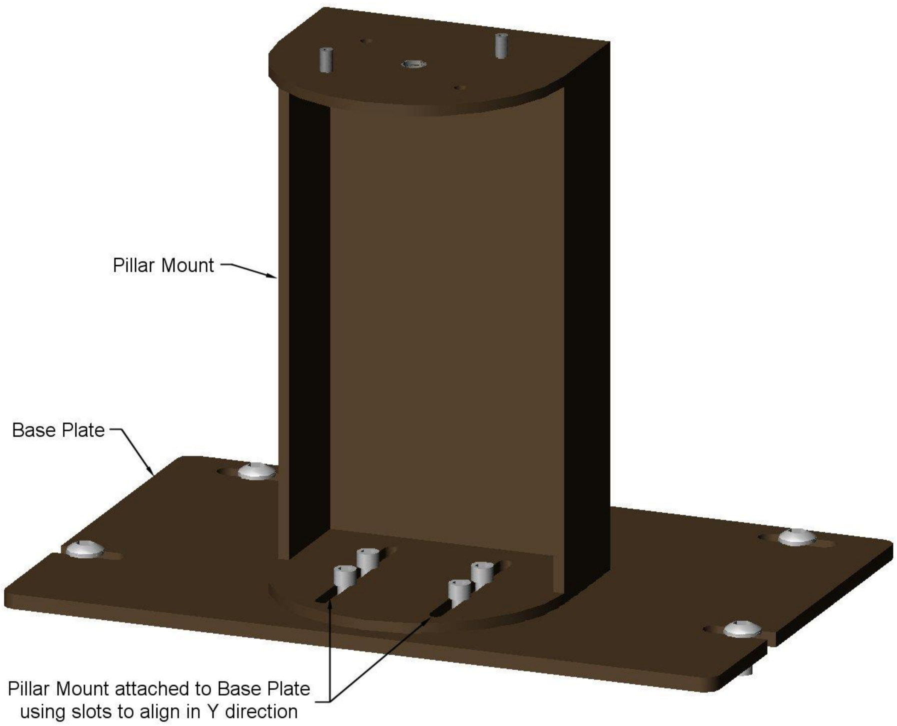


iii. Attach the Bottom Mount Option to the magnet base.



1. Remove sample tail and attach supplied plumb bob to VSM Head.
2. There is a recessed area on the Fork Flange where the exchange plate mounts. The distance from the recessed area to the flat surface on Option Mount Platform/Bottom Mount is 17 and 1/8 inches. Add washers between Base Plat and Pillar Mount as needed to reach this distance.

3. Using end of plumb bob as a reference for centerline, attach Bottom Mount Option to electromagnet base.
    a. Attach Base Plate to Magnet using slots to align in the X direction.
    b. Attach Pillar Mount to Base Plate using slots to align in Y direction.



4. Remove plumb bob.

d. Tighten Mounting Hardware.

5. Install Oven and Tail
    a. Mount Oven Assembly
        i. Place the Oven Assembly onto the Top Mounting.
        ii. The angled edge of the Option Exchange Plate should face rearward and interface with the rear of Top Mounting.
        iii. Check to ensure Mounting Plate is centered on Bottom Mount and clears raised Location Guide Pins.
        iv. Tighten large Captive Clamping Knob to secure bottom of Oven option to Option Mount.
        v. Attach two brass knurled thumbscrews to secure Option Exchange Plate to Fork Flange.
    b. Place a sample tail into the oven opening
        i. Move the head rearward to clear Oven opening.
        ii. Place sample tail in oven.
        iii. Move the head forward into operating position.
        iv. With one hand, raise sample tail slightly to meet VSM Head.
        v. Attach sample tail to VSM Head Drive being careful to ensure no stress is put on the sample tail as the sample tail is made of quartz and is breakable.

NOTE: Skip Section 6 when following method **C**

6. Oven Assembly to Option Mount Alignment

a. Visually note the difference between sample tail centerline and center of the Oven's sample space opening. The goal is to have an even space around the tail such that it will not touch the oven's opening.

b. Loosen screws attaching Oven circular flange to Option Exchange Plate.

c. Move Oven option to align the top of the sample tail with respect to the opening of the sample space.

d. Tighten screws attaching Oven circular flange to Option square flange.

e. Turn the head on.

f. Use the X-Y stage in the base of the option to tilt the option to minimize rubbing.

   i. Start by adjusting the XY stage such that the oven is centered in the magnet gap.

   ii. When adjusted correctly, the tail in the oven will make very little noise.

   iii. Rotate and check for noise, adjusting lower XY stage as needed. Use the software, set to the lowest range that will not overload (lowest or second lowest range), then while watching the RMS reading, adjust the XY stage until the reading is approximately 5 μemu.

Once the option is set in this manner, the option can be removed and replaced by loosening the hand knob at the bottom and removing the two thumbscrews on the top. It is not necessary to make position adjustments when installing the unit in the future.

The following electrical and vacuum connections are required for operation.

7. Make Connections (see Figure 3-16)

   a. Controller

      i. The Lake Shore Model 336 temperature controller must have a 3060 thermocouple card installed.

      ii. Connect the oven Temperature Sensor and Heater Cable to the rear panel of a Model 336 Temperature Controller

         1. Connect the cable's 4 pin circular connector to the mating receptacle on the 74034 oven.

         2. Route the cable to the instrument console.

         3. Connect the Type K thermocouple (chromel and alumel) to the C input of the 336.

            a. Yellow lead (Chromel) is positive.

            b. Red lead (alumel) is negative.

         4. The ± banana plug goes to the heater output of the 336.

         5. Ground cable by inserting single banana ground lead to banana jack on 336 marked 'Ground'.

   b. Pump

      i. Connect a roughing pump to the pump-out port of the oven body.

         1. Attach a good mechanical pump to the oven vacuum pumpout flange.

         2. Use the tubing provided by the system or good rubber vacuum hose.

         3. Drop hose loosely to the ground to damp out the vibration if possible.

         4. A thermocouple-type or Pirani vacuum gauge may be attached between the vacuum hose and the pump to monitor the pressure in the vacuum space.

      ii. An oil trap must be mounted between the pump and the oven to prevent pump oil from reaching the heater element (required to maintain oven warranty).

      iii. Turn on the roughing pump to start evacuating the vacuum jacket of the oven.

   c. Argon. It is important to keep the argon gas flowing through the entire experiment to keep the air out of the oven sample space.

      i. Connect 34.5 kPa (5 psi) to 69 kPa (10 psi) Argon gas supply line to the flowmeter mounted on the VSM support frame.

      ii. To eliminate air quickly from the sample space, insert a long needle connected to Argon gas line into the over sample space. Flush the space for 30 seconds before connecting the line to the opening of the oven. This only needs to be done once at setup.

iii. Maintain 60 to 100 cc/min flow at the opening of the oven while it is heated to keep most of the air get into the oven sample space.

iv. Raise temperature to 200 °C for 1 hour to remove gas molecules attached to the sample space wall.

8. Apply Vacuum
   a. Pump on the vacuum annulus to a pressure <6.7 Pa (50 milliTorr).
   b. Maintain this vacuum during heating and measurement periods.
   c. Although vacuum must be maintained during cool down, pressure may allow to rise moderately, up to 67 Pa (500 milliTorr), to achieve a more rapid cool down.
9. Verify Noise-Free System
   a. Refer to document 072-03-00 – VSM High Temperature Oven QC, for relevant QC procedures. This can also be found in Section 5.3 of the 7400 VSM Installation Reference Binder.
   b. Verify calibration.
   c. Check noise at 0 degrees operating angle. Check noise during sample tail rotation. Use the momentmeter on the VSM Controller front panel to verify the RMS noise at any angle (0°, 90°, 180°, 270°, and 360°) has <5 µemu of noise.
10. Install Sample
   a. Move the VSM Drive backward to clear the oven opening.
   b. Place the sample tail into the oven.
   c. Move the VSM Drive forward to its normal operating position at the stop.
   d. Attach sample tail.

CAUTION: Boron-nitride elements are fragile. Exercise extreme caution during assembly, insertion, and removal. Boron nitride was chosen for these parts because of its resistance to high temperature, its chemical inertness, and its relatively non-magnetic nature. Although other materials may be used, appropriate care must be exercised in their selection.

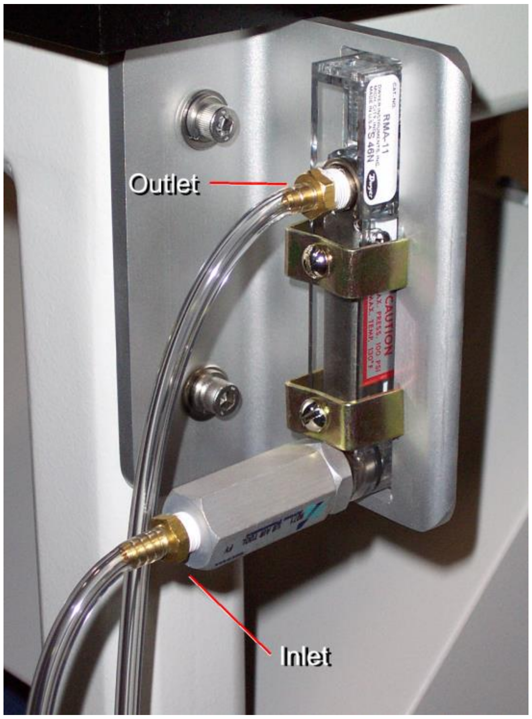


Figure 3-12. Typical Flow Meter Assembly

3.4.4 Operation Overview

High temperature oven operation is straightforward. A special high temperature sample tail replaces the standard sample tail. After establishing the required vacuum, begin operation at elevated temperatures. There is no need to cool the oven to change the sample. The temperature of the outer tube of the oven around the sample space can reach 150 °C (302 °F) during operation. Do not touch the body of the oven or let the oven body touch the coils.

Never try to achieve temperatures higher than 1000 °C (1832 °F). Higher temperatures may severely shorten the life of the oven. Always maintain vacuum with temperatures above 200 °C (392 °F). While operating, maintain a pressure of not over 50 microns. Pressure may rise to 500 microns—but no higher, during cool down. DO NOT open annulus to the atmosphere at temperatures above 200 °C (392 °F). Exceeding these limits damages the oven.

The oven vacuum space must be continuously pumped with a pump capable of 50 microns (or better) vacuum. A two-stage vacuum pump with a 1 cfm (28 lpm) pumping speed and ultimate vacuum of 2×10^3 Torr is a good choice. A vacuum pump inlet filter (Paragraph 3.4.5) should be used if an oil-seal pump is used. Failure to use a filter may allow vacuum pump oil to reach the heater, and severely reduce its life.

NOTE: If this option was ordered with the VSM system, sensor 27 was loaded into the temperature controller at the factory for reading and controlling the sample temperature. If you requested this option after the VSM system was delivered, you will need to install the appropriate sensor curve to curve location 27 on the temperature controller. The curve can be found on the sensor CD included with the option. Use the Curve Handler software on your desktop or provided with the sensor CD or VSM software CD to download the curves to locations 27.

Refer to Table 3-3 for Model 336 Temperature Controller domain settings. The heater resistance of the oven is 20 ohms. Verify or set the following parameters for the Model 336 Temperature Controller:

Input Setup
Input: C
Room Comp: ON
Room Cal.: (leave blank)
Curve: 27, Type K
Range: ±50 mV

Control Setup
Loop 1
Enable: On
Power Up: ON
Setpt. Units: Temp C
Htr Ω: 20
Ctrol. Mode: Manual PID
Filter: OFF
Control Limits Temp: 1274 K
Max. Current: 2 A

Display Format (typical)
Displ: Temp C
Control Loops: Loop 1
Large Output: OFF
Heat Display: Current

NOTE: The display format may have to be customized depending upon what options or additional features are purchased with a VSM system

Table 3-3. Model 336 Oven Domains

Zone	*Begin/End Temp. (°C)*	*P*	*I*	*Power Range*	*Ramp Rate (°C/min.)*	*Time (min.) / ΔT*
1	25 – 120	50	1	Medium	2	5 / 0.5
2	120 – 250	20	2	High	3	5 / 0.5
3	250 – 500	20	3	High	3	5 / 0.5
4	500 – 1000	20	4	High	5	5 / 0.5
5	1000 – 0	10	10	off	25	0

3.4.5 Vacuum Pump Inlet Filter

The Vacuum Pump Inlet Filter housing is constructed of low-vacuum aluminum or steel housings for non-hazardous/ non-corrosive applications. The Grade 102 filter cartridges prevent oil backstreaming from the pump to the evacuated chamber, while at the same time protect the pump from damage by submicron particles at relatively low concentration. Under normal operating conditions, the filter should be replaced after 12 months of service.

Features

- Protect vacuum pumps from damage by solids and liquids
- Prevent loss of valuable or hazardous materials
- Prevent oil back-streaming

Specifications

- Maximum Vacuum Rating: 10^{-6} Torr at 38 °C (100 °F)
- NW25 Adapter Fittings

3.4.6 Sample Holder Cleaning

CAUTION: Gloves must be worn to prevent sample holder contamination.

To ensure measurement accuracy, keep sample-holder parts free of contamination. High temperatures produced by the oven tend to compound contamination. Fortunately, boron-nitride is a relatively inert material. Use a strong cleaning solution without fear of damage to sample holder parts. In most instances, a solution of 50% concentrated hydrochloric acid and 50% concentrated nitric acid suffices. See Figure 3-13.

Boron_Tip.bmp

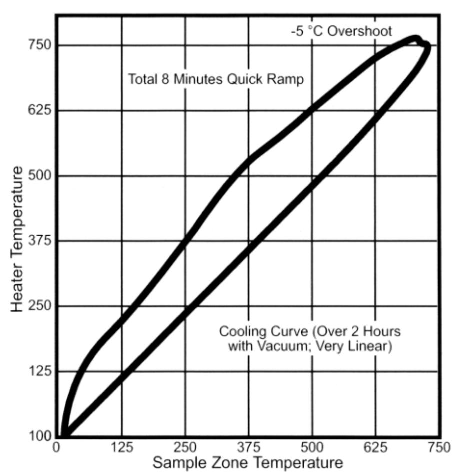
Figure 3-13. Boron-Nitride Sample Holder (P/N 652-197 & -198)

3.4.7 Storage

Store the oven in any position. Stopper the vacuum tubulation to minimize moisture absorption by the ceramic heater insulation which causes outgassing on subsequent heating.

3.4.8 Heater Temperature vs. Sample Zone Temperature

It is important to distinguish between heater temperature and sample zone temperature. The supplied internal thermocouple monitors the heater temperature. Changes in sample zone temperature always lag changes in heater temperature. This may be important in some experiments. Figure 3-14 shows a plot of sample zone temperature versus heater temperature for an instrumented oven with a thermocouple installed inside the sample holder. The measurements were made while rapidly sweeping the temperature from 30 °C (86 °F) to 750 °C (1382 °F) in about 8 minutes. Temperature differences between the heater and the sample zone as large as 150 °C (302 °F) occurred. Smaller temperature differences occur with a slower sweep. To ensure good results, sweep the temperature slowly.



Sample_Zone.bmp

Figure 3-14. Sample Zone Temperature versus Heater Temperature

3.4.9 Curie Temperature Measurements

Temperature sweep rates also influence Curie temperature measurements. Temperature that increases too rapidly may yield invalid results. Figure 3-15A shows results of a half-hour EMU versus Temperature measurement of a Nickel sample. Note how the rapid temperature sweep causes the curve to flatten and drop almost vertically starting at about 400 °C (752 °F). This is not a valid measurement. Figure 3-15B shows much better results by repeating the same measurement with a 2-hour temperature sweep. To ensure good results, sweep the temperature slowly.

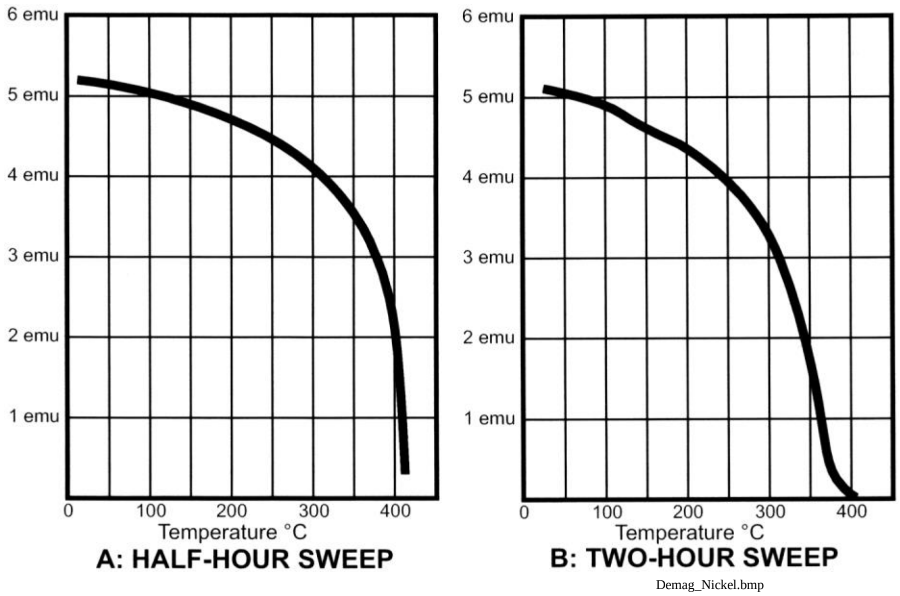


Figure 3-15. Demagnetization of Nickel as a Function of Temperature at Two Temperature Sweep Speeds

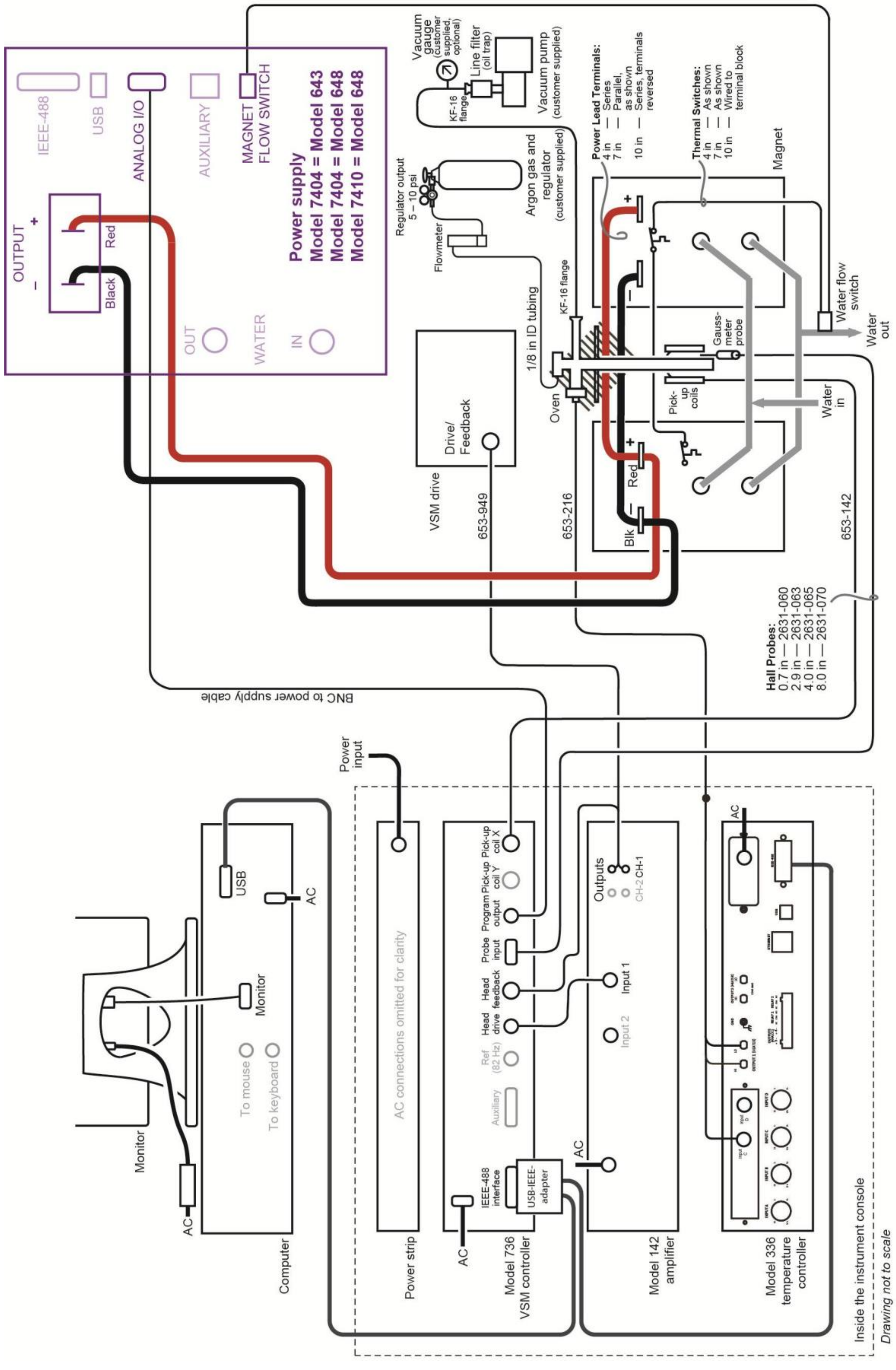


Figure 3-16. Typical 7400 Series VSM System with Optional 74034 Oven Wiring

APPENDIX A

GLOSSARY OF TERMINOLOGY

accuracy. The degree of correctness with which a measured value agrees with the true value.[2]

electronic accuracy. The accuracy of an instrument independent of the sensor.

sensor accuracy. The accuracy of a temperature sensor and its associated calibration or its ability to match a standard curve.

actuator arm. Pivot arm with coil assembly on one end and read/write heads on the other end.

algorithm. A set of well-defined rules for the solution of a problem in a finite number of steps.[1]

American Standard Code for Information Exchange (ASCII). A standard code used in data transmission, in which 128 numerals, letters, symbols, and special control codes are represented by a 7-bit binary number as follows:

Bits b7 b6 b5 →					0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
b4	b3	b2	b1	Row \ Col.	0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	DLE	SP	0	'	P	@	p
0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	$	4	D	T	d	t
0	1	0	1	5	ENG	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	’	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF	SS	*	:	J	Z	j	z
1	0	1	1	11	VT	ESC	+	;	K	[	k	(
1	1	0	0	12	FF	FS	,	<	L	~	l	¯
1	1	0	1	13	CR	GS	—	=	M	]	m	)
1	1	1	0	14	SO	RS	.	>	N	^	n	|
1	1	1	1	15	SI	US	/	?	O	_	o	DEL

American Wire Gage (AWG). Wiring sizes are defined as diameters in inches and millimeters as follows:

AWG	Dia. In.	Dia. mm	AWG	Dia. In.	Dia. mm	AWG	Dia. In.	Dia. mm	AWG	Dia. In.	Dia. mm
1	0.2893	7.348	11	0.0907	2.304	21	0.0285	0.7230	31	0.0089	0.2268
2	0.2576	6.544	12	0.0808	2.053	22	0.0253	0.6438	32	0.0080	0.2019
3	0.2294	5.827	13	0.0720	1.829	23	0.0226	0.5733	33	0.00708	0.178
4	0.2043	5.189	14	0.0641	1.628	24	0.0207	0.5106	34	0.00630	0.152
5	0.1819	4.621	15	0.0571	1.450	25	0.0179	0.4547	35	0.00561	0.138
6	0.1620	4.115	16	0.0508	1.291	26	0.0159	0.4049	36	0.00500	0.127
7	0.1443	3.665	17	0.0453	1.150	27	0.0142	0.3606	37	0.00445	0.1131
8	0.1285	3.264	18	0.0403	1.024	28	0.0126	0.3211	38	0.00397	0.1007
9	0.1144	2.906	19	0.0359	0.9116	29	0.0113	0.2859	39	0.00353	0.08969
10	0.1019	2.588	20	0.0338	0.8118	30	0.0100	0.2546	40	0.00314	0.07987

ampere. The constant current that, if maintained in two straight parallel conductors of infinite length, of negligible circular cross section, and placed one meter apart in a vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per meter of length.[2] This is one of the base units of the SI.

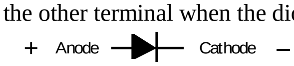
ampere-turn. A MKS unit of magnetomotive force equal to the magnetomotive force around a path linking one turn of a conducting loop carrying a current of one ampere; or 1.26 gilberts.

ampere/meter (A/m). The SI unit for magnetic field strength (H). 1 ampere/meter = $4\pi/1000$ oersted ≈ 0.01257 oersted.

analog data. Data represented in a continuous form, as contrasted with digital data having discrete values.[1]

analog output. A voltage output from an instrument that is proportional to its input. From an instrument such as a digital voltmeter, the output voltage is generated by a digital-to-analog converter with a discrete number of voltage levels.

anode. The terminal that is positive with respect to the other terminal when the diode is biased in the forward direction.[2]



area. A measure of the size of a two-dimensional surface, or of a region on such a surface.[1]

area·turns. A coil parameter produced by the multiplication of the area and number of turns of a magnet. Gives an indication of the sensitivity of a coil.

B. Symbol for magnetic flux density. *See* Magnetic Flux Density.

baud. A unit of signaling speed equal to the number of discrete conditions or signal events per second, or the reciprocal of the time of the shortest signal element in a character.[2]

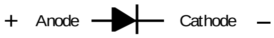
bipolar magnet. A permanent magnet that has been magnetized in two different field directions, with one side being designated north and the other south.

bit. A contraction of the term “binary digit”; a unit of information represented by either a zero or a one.[2]

CalCurve™ Service. The service of storing a mathematical representation of a calibration curve on an EEEPROM or installed in a Lake Shore instrument. Previously called Precision Option.

calibration. To determine, by measurement or comparison with a standard, the correct (accurate) value of each scale reading on a meter or other device, or the correct value for each setting of a control knob.[1]

cathode. The terminal from which forward current flows to the external circuit.[2]



Celsius (°C) Scale. A temperature scale that registers the freezing point of water as 0 °C and the boiling point as 100 °C under normal atmospheric pressure. Celsius degrees are purely derived units, calculated from the Kelvin Thermodynamic Scale. Formerly known as “centigrade.” *See* Temperature for conversions.

cgs system of units. A system in which the basic units are the centimeter, gram, and second.[2]

coercive force (coercive field). The magnetic field strength (H) required to reduce the magnetic induction (B) in a magnetic material to zero.

coercivity. generally used to designate the magnetic field strength (H) required to reduce the magnetic induction (B) in a magnetic material to zero from saturation. The coercivity would be the upper limit to the coercive force.

compliance voltage. *See* current source.

Curie temperature (Tc). Temperature at which a magnetized sample is completely demagnetized due to thermal agitation. Named for Pierre Curie (1859 – 1906), a French chemist.

current source. A type of power supply that supplies a constant current through a variable load resistance by automatically varying its compliance voltage. A single specification given as “compliance voltage” means the output current is within specification when the compliance voltage is between zero and the specified voltage.

demagnetization. when a sample is exposed to an applied field (H_a), poles are induced on the surface of the sample. Some of the returned flux from these poles is inside of the sample. This returned flux tends to decrease the net magnetic field strength internal to the sample yielding a true internal field (H_{int}) given by: $H_{int} = H_a – DM$,where M is the volume magnetization and D is the demagnetization factor. D is dependent on the sample geometry and orientation with respect to the field.

deviation. The difference between the actual value of a controlled variable and the desired value corresponding to the setpoint.[1]

differential permeability. The slope of a B versus H curve: $\mu_d = dB/dH$.

differential susceptibility. The slope of a M versus H curve: $\chi_d = dM/dH$.

digital controller. A feedback control system where the feedback device (sensor) and control actuator (heater) are joined by a digital processor. In Lake Shore controllers the heater output is maintained as a variable DC current source.

digital data. Pertaining to data in the form of digits or interval quantities. Contrast with analog data.[2]

dimensionless sensitivity. Sensitivity of a physical quantity to a stimulus, expressed in dimensionless terms. The dimensionless temperature sensitivity of a resistance temperature sensor is expressed as $S_d = (T/R)(dR/dT)$ which is also equal to the slope of R versus T on a log-log plot, that is $S_d = d \ln R / d \ln T$. Note that absolute temperature (in Kelvin) must be used in these expressions.

drift, instrument. An undesired but relatively slow change in output over a period of time, with a fixed reference input. *Note:* Drift is usually expressed in percent of the maximum rated value of the variable being measured.[2]

electromagnet. A device in which a magnetic field is generated as the result of electrical current passing through a helical conducting coil. It can be configured as an iron-free solenoid in which the field is produced along the axis of the coil, or an iron-cored structure in which the field is produced in an air gap between pole faces. The coil can be water cooled copper or aluminum, or superconductive.

electron. An elementary particle containing the smallest negative electric charge. *Note:* The mass of the electron is approximately equal to 1/1837 of the mass of the hydrogen atom.[2]

electrostatic discharge (ESD). A transfer of electrostatic charge between bodies at different electrostatic potentials caused by direct contact or induced by an electrostatic field.

error. Any discrepancy between a computed, observed, or measured quantity and the true, specified, or theoretically correct value or condition.[2]

extrema. Mathematical term that defines the two extremes of a measurement: maxima and minima. Extrema can be either be relative or absolute, where relative is in relation to other nearby (local) maxima and minima and absolute represents the overall maxima and minima for the entire measurement.

Fahrenheit (°F) Scale. A temperature scale that registers the freezing point of water as 32 °F and the boiling point as 212 °F under normal atmospheric pressure. *See* Temperature for conversions.

flux (ϕ). The electric or magnetic lines of force in a region.[1]

flux density (B). Any vector field whose flux is a significant physical quantity; examples are magnetic flux density, electric displacement, and gravitational field.[1]

gamma. A cgs unit of low-level flux density, where 100,000 gamma equals one oersted, or 1 gamma equals 10^{-5} oersted.

gauss (G). The cgs unit for magnetic flux density (B). 1 gauss = 10^{-4} tesla = 1 Mx/cm^2 = $line/cm^2$. Named for Karl Fredrich Gauss (1777 – 1855) a German mathematician, astronomer, and physicist.

gaussian system (units). A system in which centimeter-gram-second units are used for electric and magnetic qualities.

general purpose interface bus (GPIB). Another term for the IEEE-488 bus.

gilbert (Gb). A cgs electromagnetic unit of the magnetomotive force required to produce one maxwell of magnetic flux in a magnetic circuit of unit reluctance. One gilbert is equal to $10/4\pi$ ampere-turn. Named for William Gilbert (1540 – 1603), an English physicist; hypothesized that the earth is a magnet.

gilbert per centimeter. Practical cgs unit of magnet intensity. Gilberts per cm are the same as oersteds.

Greek alphabet. The Greek alphabet is defined as follows:

Alpha	α	Α	Iota	ι	Ι	Rho	ρ	Ρ
Beta	β	Β	Kappa	κ	Κ	Sigma	σ	Σ
Gamma	γ	Γ	Lambda	λ	Λ	Tau	τ	Τ
Delta	δ	Δ	Mu	μ	Μ	Upsilon	υ	Υ
Epsilon	ε	Ε	Nu	ν	Ν	Phi	φ	Φ
Zeta	ζ	Ζ	Xi	ξ	Ξ	Chi	χ	Χ
Eta	η	Η	Omicron	ο	Ο	Psi	ψ	Ψ
Theta	θ	Θ	Pi	π	Π	Omega	ω	Ω

ground. A conducting connection, whether intentional or accidental, by which an electric circuit or equipment is connected to the earth, or to some conducting body of large extent that serves in place of the earth. *Note:* It is used for establishing and maintaining the potential of the earth (or of the conducting body) or approximately that potential, on conductors connected to it, and for conducting ground current to and from the earth (or of the conducting body).[2]

H. Symbol for magnetic field strength. *See* Magnetic Field Strength.

Hall effect. The generation of an electric potential perpendicular to both an electric current flowing along a thin conducting material and an external magnetic field applied at right angles to the current. Named for Edwin H. Hall (1855 – 1938), American physicist.

Hall mobility. The quantity μH in the relation $\mu H = R\sigma$, where R = Hall coefficient and σ = conductivity.[2]

hazard communication standard (HCS). The OSHA standard cited in 29 CFR 1910.1200 requiring communication of risks from hazardous substances to workers in regulated facilities.

Helmholtz coils. A pair of flat, circular coils having equal numbers of turns and equal diameters, arranged with a common axis, and connected in series; used to obtain a magnetic field more nearly uniform than that of a single coil.[1]

hertz (Hz). A unit of frequency equal to one cycle per second.

hole. A mobile vacancy in the electronic valence structure of a semiconductor that acts like a positive electron charge with a positive mass.[2]

hysteresis. The dependence of the state of a system on its previous history, generally in the form of a lagging of a physical effect behind its cause.[1] Also *see* magnetic hysteresis.

IEEE. Institute of Electrical and Electronics Engineers.

IEEE-488. An instrumentation bus with hardware and programming standards designed to simplify instrument interfacing. The addressable, parallel bus specification is defined by the IEEE.

initial permeability. The permeability determined at H = 0 and B = 0.

initial susceptibility. The susceptibility determined at H = 0 and M = 0.

integrator. A circuit or network whose output waveform is the time integral of its input waveform.[1]

international system of units (SI). A universal coherent system of units in which the following seven units are considered basic: meter, kilogram, second, ampere, kelvin, mole, and candela. The International System of Units, or Système International d'Unités (SI), was promulgated in 1960 by the Eleventh General Conference on Weights and Measures. For definition, spelling, and protocols, *see* Reference 3 for a short, convenient guide.

interpolation table. A table listing the output and sensitivity of a sensor at regular or defined points which may be different from the points at which calibration data was taken.

intrinsic coercivity. The magnetic field strength (H) required to reduce the magnetization (M) or intrinsic induction in a magnetic material to zero.

intrinsic induction. The contribution of the magnetic material (B_i) to the total magnetic induction (B).

$B_i = B - \mu_o H$ (SI) $B_i = B - H$ (cgs)

isolated (neutral system). A system that has no intentional connection to ground except through indicating, measuring, or protective devices of very-high impedance.[2]

Kelvin (K). The unit of temperature on the Kelvin Scale. It is one of the base units of SI. The word "degree" and its symbol (°) are omitted from this unit. *See* Temperature Scale for conversions.

Kelvin Scale. The Kelvin Thermodynamic Temperature Scale is the basis for all international scales, including the ITS-90. It is fixed at two points: the absolute zero of temperature (0 K), and the triple point of water (273.16 K), the equilibrium temperature that pure water reaches in the presence of ice and its own vapor.

line regulation. The maximum steady-state amount that the output voltage or current will change as the result of a specified change in input line voltage (usually for a step change between 105 – 125 or 210 – 250 volts, unless otherwise specified).

line of flux. An imaginary line in a magnetic field of force whose tangent at any point gives the direction of the field at that point; the lines are spaced so that the number through a unit area perpendicular to the field represents the intensity of the field. Also know as a Maxwell in the cgs system of units.

line voltage. The RMS voltage of the primary power source to an instrument.

load regulation. A steady-state decrease of the value of the specified variable resulting from a specified increase in load, generally from no-load to full-load unless otherwise specified.

M. Symbol for magnetization. *See* magnetization.

magnetic air gap. The air space, or non-magnetic portion, of a magnetic circuit.

magnetic field strength (H). The magnetizing force generated by currents and magnetic poles. For most applications, the magnetic field strength can be thought of as the applied field generated, for example, by a superconducting magnet. The magnetic field strength is not a property of materials. Measure in SI units of A/m or cgs units of oersted.

magnetic flux density (B). Also referred to as magnetic induction. This is the net magnetic response of a medium to an applied field, H. The relationship is given by the following equation: $B = \mu_o (H + M)$ for SI, and $B = H + 4\pi M$ for cgs, where H = magnetic field strength, M = magnetization, and μ_o = permeability of free space = $4\pi \times 10^{-7}$ H/m.

magnetic hysteresis. The property of a magnetic material where the magnetic induction (B) for a given magnetic field strength (H) depends upon the past history of the samples magnetization.

magnetic induction (B). *See* magnetic flux density.

magnetic moment (m). This is the fundamental magnetic property measured with dc magnetic measurements systems such as a vibrating sample magnetometer, extraction magnetometer, SQUID magnetometer, etc. The exact technical definition relates to the torque exerted on a magnetized sample when placed in a magnetic field. Note that the moment is a total attribute of a sample and alone does not necessarily supply sufficient information in understanding material properties. A small highly magnetic sample can have exactly the same moment as a larger weakly magnetic sample (*see* Magnetization). Measured in SI units as $A \cdot m^2$ and in cgs units as emu. 1 emu = 10^{-3} $A \cdot m^2$.

magnetic scalar potential. The work which must be done against a magnetic field to bring a magnetic pole of unit strength from a reference point (usually at infinity) to the point in question. Also know as magnetic potential.[1]

magnetic units. Units used in measuring magnetic quantities. Includes ampere-turn, gauss, gilbert, line of force, maxwell, oersted, and unit magnetic pole.

magnetization (M). This is a material specific property defined as the magnetic moment (m) per unit volume (V). M = m/V. Measured in SI units as A/m and in cgs units as emu/cm^3. 1 emu/cm^3 = 10^3 A/m. Since the mass of a sample is generally much easier to determine than the volume, magnetization is often alternately expressed as a mass magnetization defined as the moment per unit mass.

magnetostatic. Pertaining to magnetic properties that do not depend upon the motion of magnetic fields.[1]

material safety data sheet (MSDS). OSHA Form 20 contains descriptive information on hazardous chemicals under the OSHA Hazard Communication Standard (HCS). These data sheets also provide precautionary information on the safe handling of the gas as well as emergency and first aid procedures.

Maxwell (Mx). A cgs electromagnetic unit of magnetic flux, equal to the magnetic flux which produces an electromotive force of 1 abvolt in a circuit of one turn link the flux, as the flux is reduced to zero in 1 second at a uniform rate.[1]

neutral zone. The area of transition located between areas of a permanent magnet which have been magnetized in opposite directions.

MKSA System of Units. A system in which the basic units are the meter, kilogram, and second, and the ampere is a derived unit defined by assigning the magnitude $4\pi \times 10^{-7}$ to the rationalized magnetic constant (sometimes called the permeability of space).

NBS. National Bureau of Standards. Now referred to as NIST.

National Institute of Standards and Technology (NIST). Government agency located in Gaithersburg, Maryland and Boulder, Colorado, that defines measurement standards in the United States. *See* Standards Laboratories for an international listing.

negative temperature coefficient (NTC). Refers to the sign of the temperature sensitivity. For example, the resistance of a NTC sensor decreases with increasing temperature.

noise (electrical). Unwanted electrical signals that produce undesirable effects in circuits of control systems in which they occur.[2]

normalized sensitivity. For resistors, signal sensitivity (dR/dT) is geometry dependent; i.e., dR/dT scales directly with R; consequently, very often this sensitivity is normalized by dividing by the measured resistance to give a sensitivity, s_T, in percent change per kelvin. $s_T = (100/R)\,(dR/dT)$ %K, where T is the temperature in kelvin and R is the resistance in ohms.

oersted (Oe). The cgs unit for the magnetic field strength (H). 1 oersted = 10¾π ampere/meter ≈ 79.58 ampere/meter.

ohm (Ω). The SI unit of resistance (and of impedance). The ohm is the resistance of a conductor such that a constant current of one ampere in it produces a voltage of one volt between its ends.[2]

pascal (Pa). The SI unit of pressure equal to 1 N/m^2. Equal to 1.45×10^{-4} psi, 1.0197×10^{-5} kg$_f$/cm^2, 7.5×10^{-3} torr, 4.191×10^{-3} inches of water, or 1×10^{-5} bar.

permeability. Material parameter which is the ratio of the magnetic induction (B) to the magnetic field strength (H): $\mu = B/H$. Also *see* Initial Permeability and Differential Permeability.

platinum (Pt). A common temperature sensing material fabricated from pure platinum to make the Lake Shore PT family of resistance temperature sensor elements.

polynomial fit. A mathematical equation used to fit calibration data. Polynomials are constructed of finite sums of terms of the form $a_i x_i$, where a_i is the i^{th} fit coefficient and x_i is some function of the dependent variable.

positive temperature coefficient (PTC). Refers to the sign of the temperature sensitivity. For example, the resistance of a PTC sensor increases with increasing temperature.

pounds per square inch (psi). A unit of pressure. 1 psi = 6.89473 kPa. Variations include psi absolute (psia) measured relative to vacuum (zero pressure) where one atmosphere pressure equals 14.696 psia and psi gauge (psig) where gauge measured relative to atmospheric or some other reference pressure.

ppm. Parts per million, e.g., 4×10^{-6} is four parts per million.

precision. Careful measurement under controlled conditions which can be repeated with similar results. *See* repeatability. Also means that small differences can be detected and measured with confidence. *See* resolution.

prefixes. SI prefixes used throughout this manual are as follows:

Factor	Prefix	Symbol	Factor	Prefix	Symbol
10^{24}	yotta	Y	10^{-1}	deci	d
10^{21}	zetta	Z	10^{-2}	centi	c
10^{18}	exa	E	10^{-3}	milli	m
10^{15}	peta	P	10^{-6}	micro	µ
10^{12}	tera	T	10^{-9}	nano	n
10^{9}	giga	G	10^{-12}	pico	p
10^{6}	mega	M	10^{-15}	femto	f
10^{3}	kilo	k	10^{-18}	atto	a
10^{2}	hecto	h	10^{-21}	zepto	z
10^{1}	deka	da	10^{-24}	yocto	y

probe. A long, thin body containing a sensing element which can be inserted into a system in order to make measurements. Typically, the measurement is localized to the region near the tip of the probe.

remanence. The remaining magnetic induction in a magnetic material when the material is first saturated and then the applied field is reduced to zero. The remanence would be the upper limit to values for the remanent induction. Note that no strict convention exists for the use of remanent induction and remanence and in some contexts the two terms may be used interchangeably.

remanent induction. The remaining magnetic induction in a magnetic material after an applied field is reduced to zero. Also *see* remanence.

repeatability. The closeness of agreement among repeated measurements of the same variable under the same conditions.[2]

resistance temperature detector (RTD). Resistive sensors whose electrical resistance is a known function of the temperature, made of, e.g., carbon-glass, germanium, platinum, or rhodium-iron.

resolution. The degree to which nearly equal values of a quantity can be discriminated.[2]

display resolution. The resolution of the physical display of an instrument. This is not always the same as the measurement resolution of the instrument. Decimal display resolution specified as "n digits" has 10^n possible display values. A resolution of n and one-half digits has 2×10^n possible values.

measurement resolution. The ability of an instrument to resolve a measured quantity. For digital instrumentation this is often defined by the analog-to-digital converter being used. A n-bit converter can resolve one part in 2^n. The smallest signal change that can be measured is the full scale input divided by 2^n for any given range. Resolution should not be confused with accuracy.

root mean square (RMS). The square root of the time average of the square of a quantity; for a periodic quantity the average is taken over one complete cycle. Also known as effective value.[1]

scalar. A quantity which has magnitude only and no direction, in contrast to a vector.[1]

semiconducting material. A conducting medium in which the conduction is by electrons, and holes, and whose temperature coefficient of resistivity is negative over some temperature range below the melting point.[2]

semiconductor. An electronic conductor, with resistivity in the range between metals and insulators, in which the electric charge carrier concentration increases with increasing temperature over some temperature range. Note: Certain semiconductors possess two types of carriers, namely, negative electrons and positive holes.[2]

sensitivity. The ratio of the response or change induced in the output to a stimulus or change in the input. Temperature sensitivity of a resistance temperature detector is expressed as S = dR/dT.

setpoint. The value selected to be maintained by an automatic controller.[1]

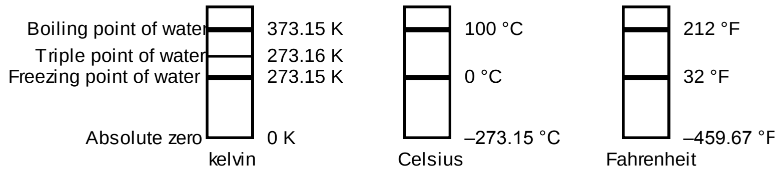
SI. Système International d'Unités. *See* International System of Units.

stability. The ability of an instrument or sensor to maintain a constant output given a constant input.

susceptance. In electrical terms, susceptance is defined as the reciprocal of reactance and the imaginary part of the complex representation of admittance: [suscept(ibility) + (conduct)ance].

susceptibility (χ). Parameter giving an indication of the response of a material to an applied magnetic field. The susceptibility is the ratio of the magnetization (M) to the applied field (H). χ = M/H. In both SI units and cgs units the volume susceptibility is a dimensionless parameter. Multiply the cgs susceptibility by 4π to yield the SI susceptibility. *See* also Initial Susceptibility and Differential Susceptibility. As in the case of magnetization, the susceptibility is often seen expressed as a mass susceptibility or a molar susceptibility depending upon how M is expressed.

temperature scales. *See* Kelvin Scale, Celsius Scale, and ITS-90. Proper metric usage requires that only kelvin and degrees Celsius be used. However, since degrees Fahrenheit is in such common use, all three scales are delineated as follows:



To convert kelvin to Celsius, subtract 273.15.
To convert Celsius to Fahrenheit: multiply °C by 1.8 then add 32, or: °F = (1.8 × °C) + 32.
To convert Fahrenheit to Celsius: subtract 32 from °F then divide by 1.8, or: °C = (°F – 32)/1.8.

temperature coefficient, measurement. The measurement accuracy of an instrument is affected by changes in ambient temperature. The error is specified as an amount of change (usually in percent) for every one degree change in ambient temperature.

tesla (T). The SI unit for magnetic flux density (B). 1 tesla = 10^4 gauss

thermal emf. An electromotive force arising from a difference in temperature at two points along a circuit, as in the Seebeck effect.[1]

tolerance. The range between allowable maximum and minimum values.

torque. For a single force, the cross product of a vector from some reference point to the point of application of the force with the force itself. Also known as moment of force and rotation moment.[1]

torque constant (K_t). The ratio of the torque delivered by a motor to the current supplied to it. K_t = N·m/A.

turns (N). One complete loop of wire.

Underwriters Laboratories (UL). An independent laboratory that establishes standards for commercial and industrial products.

unit magnetic pole. A pole with a strength such that when placed 1 cm away from a like pole, the force between the two is 1 dyne.

vector. A quantity that has both magnitude and direction, and whose components transform from one coordinate system to another in the same manner as the components of a displacement. Also known as a polar vector.[1]

volt (V). The difference of electric potential between two points of a conductor carrying a constant current of one ampere, when the power dissipated between these points is equal to one watt.[2]

volt-ampere (VA). The SI unit of apparent power. The volt-ampere is the apparent power at the points of entry of a single-phase, two-wire system when the product of the RMS value in amperes of the current by the RMS value in volts of the voltage is equal to one.[2]

watt (W). The SI unit of power. The watt is the power required to do work at the rate of 1 joule per second.[2]

weber (Wb). The unit of magnetic flux in the mks system, equal to the magnetic flux which, linking a circuit of one turn, produces in it an electromotive force of 1 volt as it is reduced to zero at a uniform rate in 1 second.[1]

References:

1 Sybil P. Parker, Editor. *Dictionary of Scientific and Technical Terms: Fifth Edition*. New York: McGraw Hill, 1994 (IBSN 0-07-113584-7)

2 Christopher J. Booth, Editor. *The New IEEE Standard Dictionary of Electrical and Electronic Terms: IEEE Std 100-1992, Fifth Edition.* New York: Institute of Electrical and Electronics Engineers, 1993 (IBSN 1-55937-240-0). Definitions printed with permission of the IEEE.

3 Nelson, Robert A. *Guide For Metric Practice,* Page BG7 – 8, Physics Today, Eleventh Annual Buyer's Guide, August 1994 (ISSN 0031-9228 coden PHTOAD)

APPENDIX B

REFERENCE INFORMATION

Table B-1. Conversion from CGS to SI Units

Quantity	Symbol	Gaussian & CGS emu[a]	Conversion Factor, C[b]	SI & Rationalized mks[c]
Magnetic flux density, Magnetic induction	B	gauss (G)[d]	10^{-4}	tesla (T), Wb/m^2
Magnetic Flux	ϕ	maxwell (Mx), G·cm^2	10^{-8}	weber (Wb), volt second (V·s)
Magnetic potential difference, magnetomotive force	U, F	gilbert (Gb)	$10/4\pi$	ampere (A)
Magnetic field strength, magnetizing force	H	oersted (Oe),[e] Gb/cm	$10^3/4\pi$	A/m[f]
(Volume) magnetization[g]	M	emu/cm^3[h]	10^3	A/m
(Volume) magnetization	4πM	G	$10^3/4\pi$	A/m
Magnetic polarization, intensity of magnetization	J, I	emu/cm^3	$4\pi \times 10^{-4}$	T, Wb/m^2[i]
(Mass) magnetization	σ, M	emu/g	1 $4\pi \times 10^{-7}$	A·m^2/kg Wb·m/kg
Magnetic moment	m	emu, erg/G	10^{-3}	A·m^2, joule per tesla (J/T)
Magnetic dipole moment	j	emu, erg/G	$4\pi \times 10^{-10}$	Wb·m[i]
(Volume) susceptibility	χ, κ	dimensionless emu/cm^3	— $(4\pi)^2 \times 10^{-7}$	Henry per meter (H/m), Wb/(A·m)
(Mass) susceptibility	χ_ρ, κ_ρ	cm^3/g, emu/g	$4\pi \times 10^{-3}$ $(4\pi)2 \times 10^{-10}$	m^3/kg H·m^2/kg
(Molar) susceptibility	χ_{mol}, κ_{mol}	cm^3/mol, emu/mol	$4\pi \times 10^{-6}$ $(4\pi)^2 \times 10^{-13}$	m^3/mol H·m^2/mol
Permeability	μ	dimensionless	$4\pi \times 10^{-7}$	H/m, Wb/(A·m)
Relative permeability[j]	μ_r	not defined	—	dimensionless
(Volume) energy density, energy product[k]	W	erg/cm^3	10^{-1}	J/m^3
Demagnetization factor	D, N	dimensionless	$1/4\pi$	dimensionless

NOTES:

a. Gaussian units and cgs emu are the same for magnetic properties. The defining relation is $B = H + 4\pi M$.

b. Multiply a number in Gaussian units by C to convert it to SI (e.g. $1\ G \times 10^{-4} T/G = 10^{-4} T$).

c. SI (Système International d'Unités) has been adopted by the National Bureau of Standards. Where two conversion factors are given, the upper one is recognized under, or consistent with, SI and is based on the definition $B = \mu_0(H + M)$, where to $\mu_0 = 4\pi \times 10^{-7}$H/m. The lower one is not recognized under SI and is based on the definition $B = \mu_0 H + J$, where the symbol I is often used in place of J.

d. 1 gauss = 10^5 gamma (γ).

e. Both oersted and gauss are expressed as cm$^{-1/2}$ g$^{1/2}$·s^{-1} in terms of base units.

f. A/m was often expressed as "ampere-turn per meter" when used for magnetic field strength.

g. Magnetic moment per unit volume.

h. The designation "emu" is not a unit.

i. Recognized under SI, even though based on the definition $B = \mu_0 H + J$. See footnote c.

j. $\mu_r = \mu/\mu_0 = 1 + \chi$, all in SI. μ_r is equal to Gaussian μ.

k. B H and μ_0M H have SI units J/m^3, M H and B H/4π have Gaussian units erg/cm^3.

R.B. Goldfarb and F.R. Fickett, U.S. Department of Commerce, National Bureau of Standards, Bolder, Colorado 80303, March 1985, NBS Special Publication 696. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Table B-2. Recommended SI Values for Physical Constants

Quantity	Symbol	Value (SI units)
Permeability of Vacuum	μ_0	$4\pi \times 10^{-7}$ H m^{-1}
Speed of Light in Vacuum	c	2.9979×10^{8} m s^{-1}
Permitivity of Vacuum	$\varepsilon_0 = (\mu_0 c^2)^{-1}$	8.8542×10^{-12} F m^{-1}
Fine Structure Constant, µ0ce2/2h	α α^{-1}	0.0073 137.0360
Elementary Charge	e	1.6022×10^{-19} C
Plank's Constant	h h = h/2π	6.6262×10^{-34} J Hz^{-1} 1.0546×10^{-34} J s
Avogadro's Constant	N_A	6.0220×10^{23} mol^{-1}
Atomic Mass Unit	1 u = 10^{-3} kg mol^{-1}/N_A	1.6605×10^{-27} kg
Electron Rest Mass	m_e	0.9109×10^{-30} kg 5.4858×10^{-4} u
Proton Rest Mass	m_p	1.6726×10^{-27} kg 1.0073 u
Neutron Rest Mass	m_n	1.6749×10^{-27} kg 1.0087 u
Magnetic Flux Quantum	ϕ = h/2e h/e	2.0679×10^{-15} Wb 4.1357×10^{-15} J Hz^{-1} C^{-1}
Josephson Frequency-Voltage Ratio	2e/h	483.5939 THz V^{-1}
Quantum of Circulation	$h/2m_e$ h/m_e	3.6369×10^{-4} J Hz^{-1} kg^{-1} 7.2739×10^{-4} J Hz^{-1} C^{-1}
Rydberg Constant	R_∞	1.0974×10^{7} m^{-1}
Proton Moment in Nuclear Magnetons	μ_p/μ_N	2.7928
Bohr Magneton	$\mu_B = eh/2m_e$	9.2741×10^{-24} J T^{-1}
Proton Gyromagnetic Ratio	γ_p	2.6752×10^{8} s^{-1} T^{-1}
Diamagnetic Shielding Factor, Spherical H_2O Sample	$1 + \sigma(H_2O)$	1.0000
Molar Mass Constant	R	8.3144 J mol^{-1} K^{-1}
Molar Volume, Ideal Gas (T_0 = 273.15K, p_0 = 1 atm)	$V_m = RT_0/p_0$	0,0224 m^3 mol^{-1}
Boltzman Constant	$k = R/N_A$	1.3807×10^{-23} J K^{-1}
Stefan-Boltzman Constant	$\sigma = (\pi^2/60)\, k^4/h^3\, c^2$	5.6703×10^{-8} W m^{-2} K^{-4}
First Radiation Constant	$c_1 = 2\pi hc^2$	3.7418×10^{-16} W m^{-2}
Second Radiation Constant	$c_2 = hc/k$	0.0144 mK
Gravitation Constant	G	6.6720×10^{-11} N m^2 kg^{-2}

Data (abbreviated to 4 decimal places) from CODATA Bulletin No. 11, ICSU CODATA Central Office, 19 Westendstrasse, 6 Frankfurt/Main, Germany. Copies of this bulletin are available from this office.

APPENDIX C

LAKE SHORE MODEL 340 TEMPERATURE CONTROLLER

A Lake Shore Model 340 Temperature Controller may also be used with the 7400 Series VSM System. If you use the Model 340, the following specifications differ from the 336, and apply to you.

3.1 LOW TEMPERATURE CRYOSTAT OPTION (74018)

3.1.2 Equipment Needed for Cryostat Installation

Note: A Lake Shore Model 340 Temperature Controller may also be used.

3.1.4 Installation

A Lake Shore Model 340 Temperature Controller may also be used. Connect the cryostat Temperature Sensor and Heater Cable to the rear panel of a Model 340 Temperature Controller.
Note: The connections in Figure 3-3 are similar with the Model 340.

3.1.6 Cryostat Temperature Control Domains

Cryostat temperature domain settings for the Model 340 Temperature Controller for helium and nitrogen are detailed below.

Cryostat Temperature Domains for Helium

Zone	*Begin/End T (K)*	*P*	*I*	*Power Range*	*Ramp Rate (K/min)*	*Settle Band/Time*
1	4 – 10	70	100	4	2	0.5 / 5
2	10 – 25	20	70	4	2	0.5 / 5
3	25 – 75	20	40	5	5	0.5 / 5
4	75 – 90	30	20	5	10	0.5 / 5
5	90 – 135	40	10	5	15	0.5 / 5
6	135 – 175	40	10	5	15	1 / 5
7	175 – 250	30	10	5	20	1 / 5
8	250 – 350	25	10	5	20	1 / 5
9	350 – 450	15	20	5	20	2 / 10

Table 3-2. Cryostat Temperature Domains for Nitrogen

Zone	*Begin/End T (K)*	*P*	*I*	*Power Range*	*Ramp Rate (K/min)*	*Settle Band/Time*
1	75 – 90	20	30	5	10	0.5 / 5
2	90 – 135	20	20	5	10	0.5 / 5
3	135 – 175	20	20	5	10	1 / 5
4	175 – 250	20	15	5	15	1 / 5
5	250 – 350	20	15	5	20	1 / 5
6	350 – 450	20	10	5	20	2 / 10

3.4 HIGH TEMPERATURE OVEN OPTION (74034)

3.4.1 Oven Specifications

TEMPERATURE MEASUREMENT AND CONTROL: Lake Shore Model 340 Temperature Controller with Model 3464 Thermocouple input card for measuring and control oven operation.

3.4.2 Oven Requirements

The following equipment should be present to before attempting Installation of a Model 74034 oven:

- 340 .... Model 340 Temperature controller installed in VSM electrical console.
- 3464 .... Model 3464 TC card installed in Model 340, above.

3.4.3 Installation

7. Make Connections

   Note: The connections in Figure 3-16 will differ with the Model 340.

   a. Controller

      i. The Lake Shore Model 340 temperature controller must have a 3464 thermocouple card installed.

      ii. Connect the oven Temperature Sensor and Heater Cable to the rear panel of a Model 340 Temperature Controller

         1. Connect the cable's 4 pin circular connector to the mating receptacle on the 74034 oven.
         2. Route the cable to the instrument console.
         3. Connect the Type K thermocouple (chromel and alumel) to the C input of the 340.
            a. Yellow lead (Chromel) is positive.
            b. Red lead (alumel) is negative.
         4. The ± banana plug goes to the heater output of the 340.
         5. Ground cable by inserting single banana ground lead to banana jack on 340 marked 'Ground'.

3.4.4 Operation Overview

Refer to Table 3-3 for Model 340 Temperature Controller domain settings. The heater resistance of the oven is 20 ohms.
Verify or set the following parameters for the Model 340 Temperature Controller:

Table 3-3. Model 340 Oven Domains

Zone	*Begin/End Temp. (°C)*	*P*	*I*	*Power Range*	*Ramp Rate (°C/min.)*	*Time (min.) / ΔT*
1	25 – 120	50	1	4	2	5 / 0.5
2	120 – 250	20	2	5	3	5 / 0.5
3	250 – 500	20	3	5	3	5 / 0.5
4	500 – 1000	20	4	5	5	5 / 0.5
5	1000 – 0	10	10	off	25	0