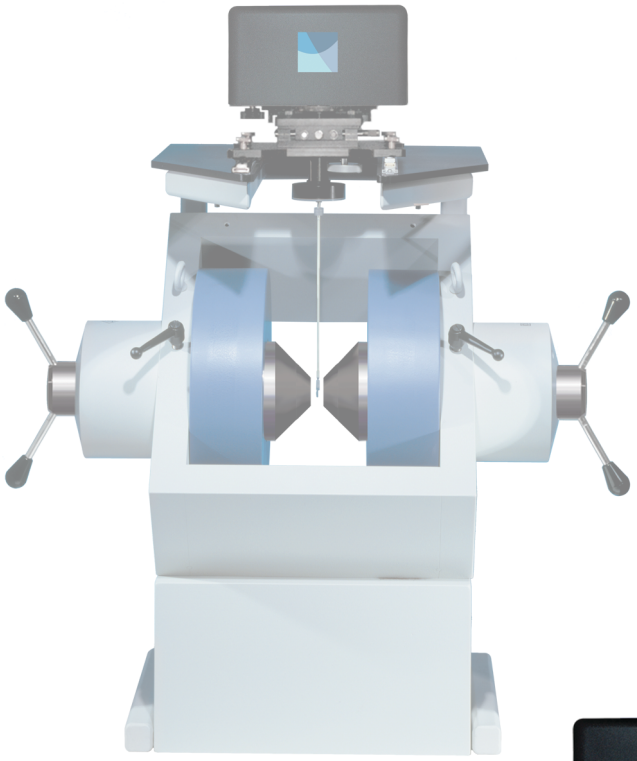
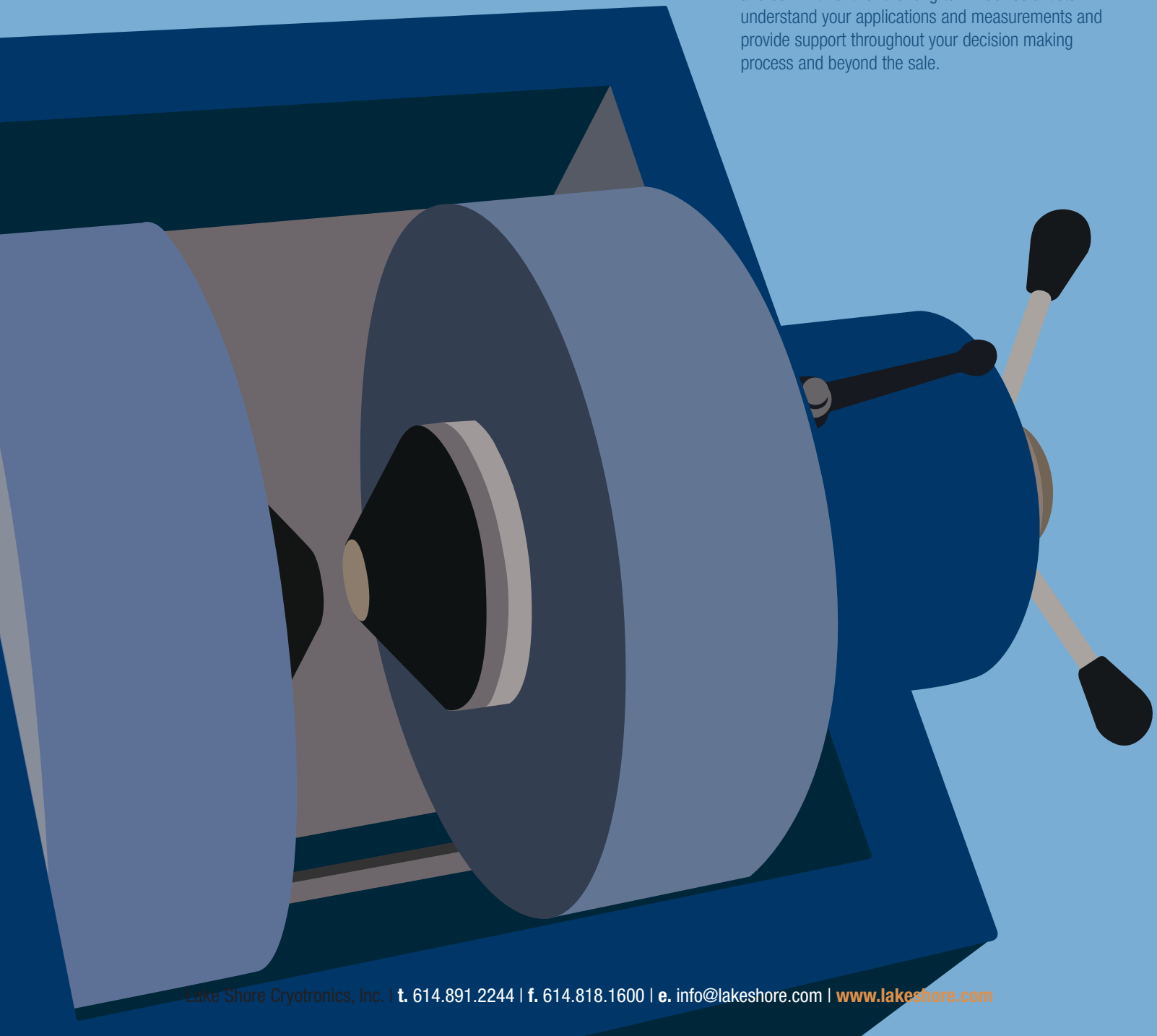


7400-S Series
Vibrating Sample Magnetometers

Lake Shore
CRYOTRONICS

3-year warranty and technical support

Lake Shore products are supported by a 3-year standard warranty, our confirmation of quality and commitment for the long term. Our scientists understand your applications and measurements and provide support throughout your decision making process and beyond the sale.



7400-S Series Vibrating Sample Magnetometers

Contents

Easy sample exchange — the sliding head mechanism allows easy sample exchange and positioning, ensuring reproducibility of measured results

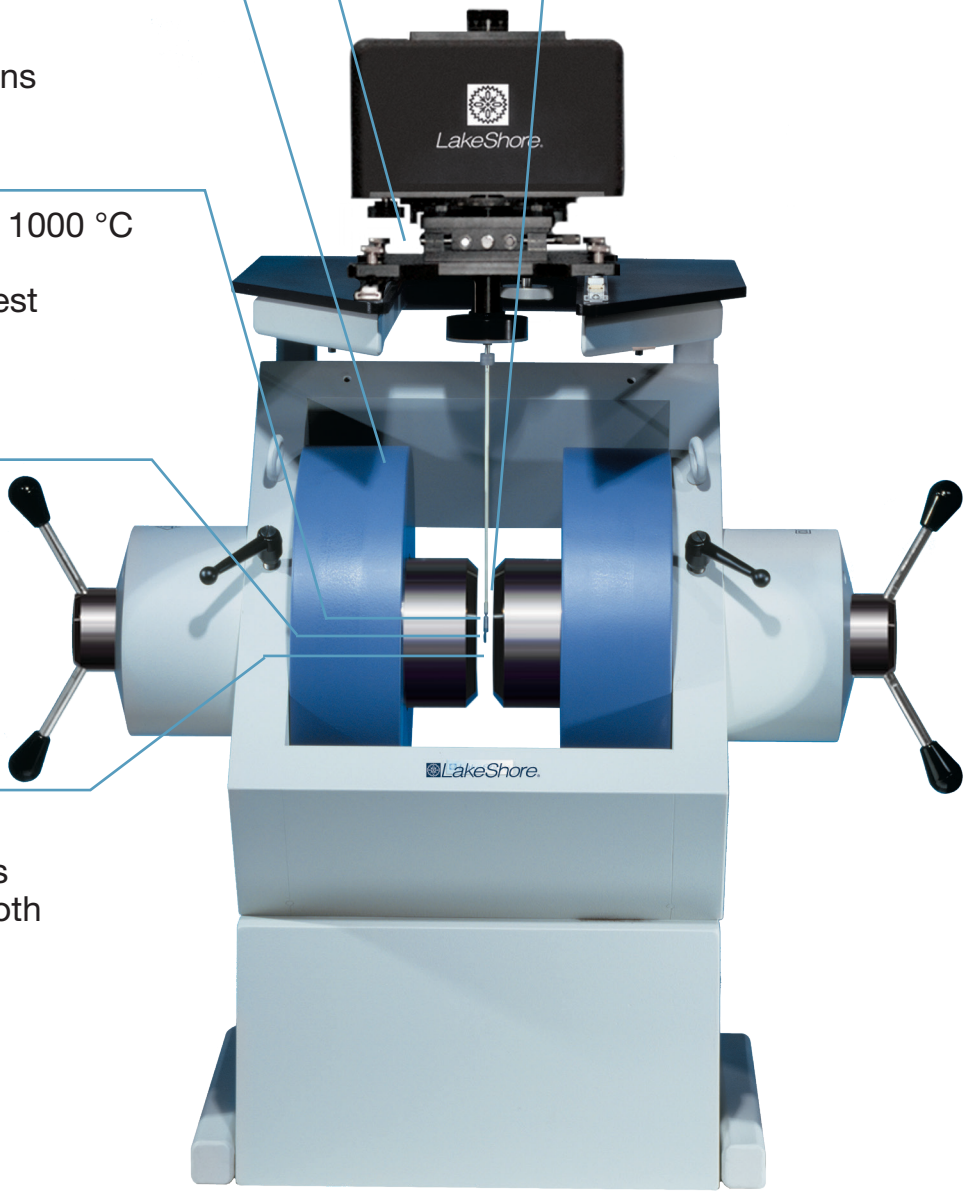
Multiple magnet configurations — 100 mm, 175 mm, and 250 mm (4 in, 7 in, and 10 in) variable-gap electromagnet-based configurations provide fields to 3.42 T

Variable temperature — measure samples from -269 °C to 1000 °C (4.2 K to 1273 K) with our variable temperature options — the broadest temperature range of any electromagnet-based VSM

Anisotropy measurements — vector coil and autorotation options enable investigations of magnetically anisotropic materials, including derived torque curves

Magnetoresistance probe — perform fast and accurate magnetoresistance measurements with this option as a function of both magnetic field and temperature

Sample holders — accommodate thin film, bulk, liquid, and powder samples



Integrated software — set up and execute measurement routines and experiments quickly and easily from the Windows® menu-driven interface

Detailed post processing — background corrections, automatic offset removal, derivative curves, parameter extraction, and more

Ergonomic workstation — in addition to housing all of the integrated electronics, the workstation acts as a convenient tabletop and has a drawer to store sample holders and samples

Control electronics — sensitive electromagnet-based VSM, featuring a noise floor as low as 60 nemu and moment stability of 0.05% per day

Sensitive, low noise floor electromagnet-based VSM system for the broadest measurement range

Materials

Magnetic thin films, multilayers, and heterostructures
- Particulate
- Continuous
- Magneto-optical
- Magnetic MEMS
- Magnetoresistors (MR)
  - Tunneling-MR (TMR)
  - Giant-MR (GMR)
  - Colossal-MR (CMR)

Nanomagnetic materials
Diluted magnetic semiconductors (DMS)
Paramagnets
Diamagnets
Superconductors
Spin glasses
Molecular magnetic materials
Nanocrystalline magnetic alloys
- Amorphous magnets
- Melt spun ribbons

Rare-earth permanent magnets
Ferrites
- Hard
- Semi-hard

Ferrofluids
Biological and biomedical
- Stents
- MRI contrast agents
- Nanoscale and microscale particles

Magnetic powders and inks

Direct and derived measurements as a function of field, temperature, and time

Field-dependent measurements
- Major and minor hysteresis loops
- Saturation magnetization (M_{SAT})
- Remanent magnetization (M_{REM})
- Remanent induction
- B_R
- Coercivity (H_C)
- Intrinsic coercivity (H_{Ci})
- Slope at H_C (S*)
- dM/dH derivative curves
- Differential susceptibility at H_C
- Switching field distribution (SFD)
- Flatness
- Squareness ratio (SQR)
- Initial magnetization curve
- 2^{nd} quadrant demagnetization curves
- Maximum energy
- Product (BH_{MAX})
- DC demagnetization (DCD) remanence
- Isothermal (IRM) remanence
- Permeability curves
- Pinned and free layer parameters
- Exchange field
- Magnetic anisotropy and rotational hysteresis
- Vector (anisotropy) measurements (m_x and m_y)

Torque curves: $\tau = \mu_0 \mathbf{M} \times \mathbf{H} = -\mu_0 M_y H_x \hat{k}$
Temperature dependent measurements M(T)
- Curie point
- Blocking temperature
- Superconducting transitions and more

Time dependent measurements M(t)
- Magnetic relaxation
- Magnetic viscosity

First order reversal curves (FORCs)

Ideal for the most demanding magnet characterization applications

What our customers are saying...

We use a Lake Shore VSM to characterize the temperature dependence of the properties of soft magnetic amorphous and nanocrystalline alloys. Current fields of study range from the interaction of superparamagnetic nanoparticles embedded in a matrix to the magnetocaloric effect in amorphous alloys. The high resolution of the system has eliminated our dependence on external SQUID equipment for measurements up to moderate magnetic fields.

Dr. Victorino Franco,
Dpto. Física de la Materia Condensada, Sevilla University, Spain

The Lake Shore VSM purchasing experience was the best ever compared to the other pieces of metallurgical test equipment I have acquired. Lake Shore excelled in technical and sales assistance. I was invited out for training and to witness the QC testing of the equipment before it was shipped, and this was a great help to me. Once I received the equipment, Lake Shore was quick to send someone out for the installation and training. It has always been easy for me to get in touch with the technical representative whenever I had a question.

I have not had a single problem with the power supply, electromagnet, computer, and software. The software and control program seems very logical and is easy to interact with.

I have no regrets about my purchase and am very pleased with the support provided by Lake Shore during the purchasing period and thereafter. They get my highest recommendation.

Jon Stinson,
Boston Scientific Scimed

Magnequench is a premier magnetic material producer that offers products with very tight magnetic property tolerances (some as tight as ±0.6%). In order to meet these high quality standards, we use seven Lake Shore VSMs throughout our production processes as well as at our Technical (R&D) center.

Magnequench production VSMs are run continuously (24 hours a day, 7 days a week), and Lake Shore VSMs have proven themselves to be very reliable based on this very demanding environment. Magnequench will most certainly look to Lake Shore when purchasing future VSM systems based on current Lake Shore VSM performance, as well as the wonderful customer support that Lake Shore provides.

Don Kirk Senior Project Engineer,
Magnequench International Inc.

Our research focuses on the development of novel EM materials and spintronic devices, which relies heavily on the characterization of magnetic properties of various types of nanostructured materials. The Lake Shore VSM is a workhorse with high sensitivity and rapid measurements that meet our demanding needs. The Lake Shore staff has been extremely helpful in supporting the instrument. What service — I truly appreciate their support of education and research.

Dr. John Q. Xiao Professor in Physics,

University of Delaware, Newark

The sensitivity of the Lake Shore VSM is as good as specified. We were able to measure ultrathin Co films of 4 Å with the area of ~10 mm^2. We had two publications of Co/Pt multilayers in Physical Review B in the past two years. This instrument facilitates collaborations with my colleagues. I'm particularly satisfied with the low temperature capability. We can measure magnetization down to 8 K with high sensitivity. It replaces our need for SQUID magnetometer for many of our projects.

Dr. Fengyuan Yang,

The Ohio State University

Use us as a resource!

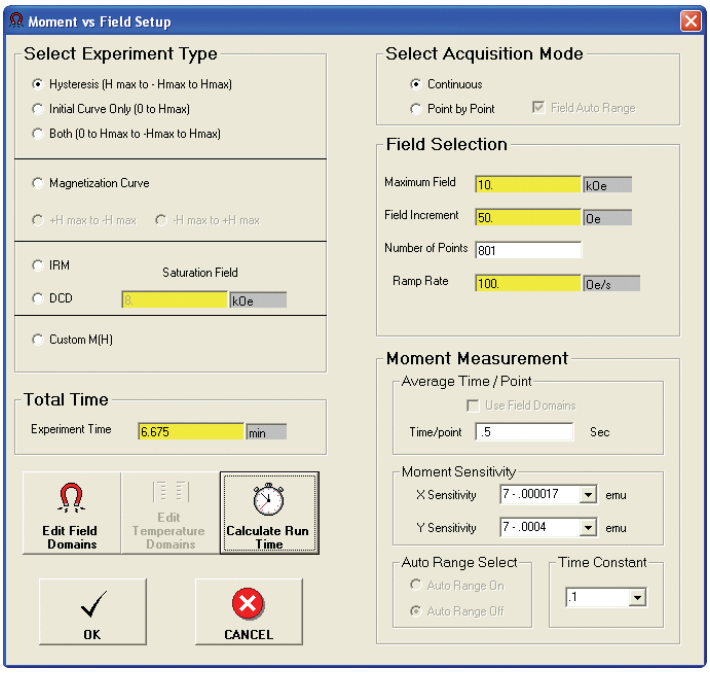
Our experts can advise you on the optimal system for your applications. To demonstrate the performance of our VSM and to ensure the proper configuration is selected, we can measure one of your actual samples at no charge to you. Get us involved early and benefit from our many years of experience.

System Application Software

The fully integrated IDEAS VSM software uses an intuitive Windows® interface for system operation, data acquisition, and analysis. Select a default experiment profile or customize your own profile to run a virtually unlimited number of experiments.

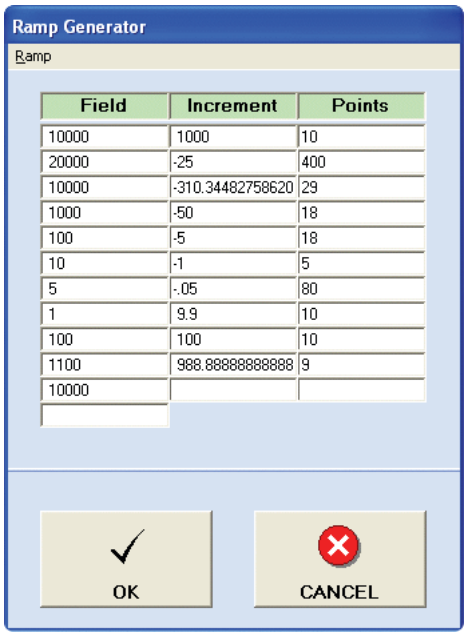
Set up and execute measurement routines and experiments quickly and easily. All system parameters and functions are controlled for unattended operation and any number of parameters can be automatically extracted from hysteresis loop data. Real-time field-dependent response tracks field changes for accurate curve shape definitions and parameter extraction.

Substrate corrections and backgrounds can be easily subtracted from measurement data. Calculate and display derivative curves, automatically remove offsets, and determine measurement results. Display real-time feedback of processed data in both tabular and graphical form in CGS or SI units.



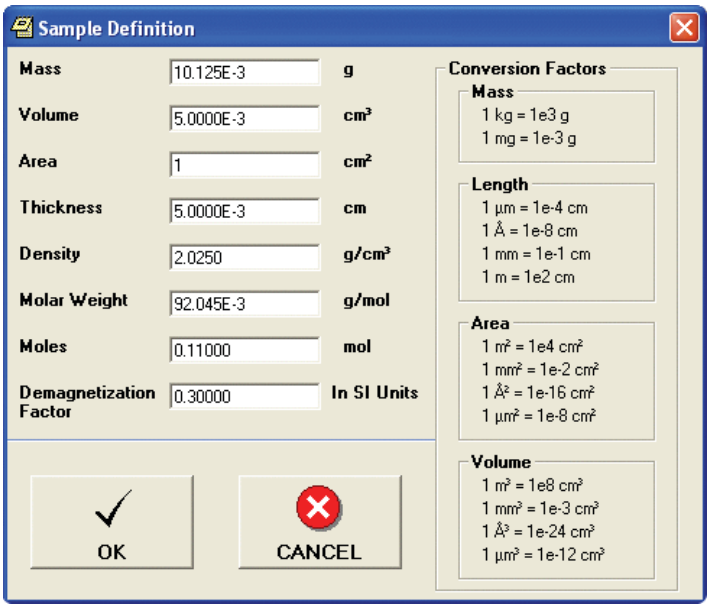
Moment vs. Field Setup

Set up a field experiment in either continuous or point-by-point mode.



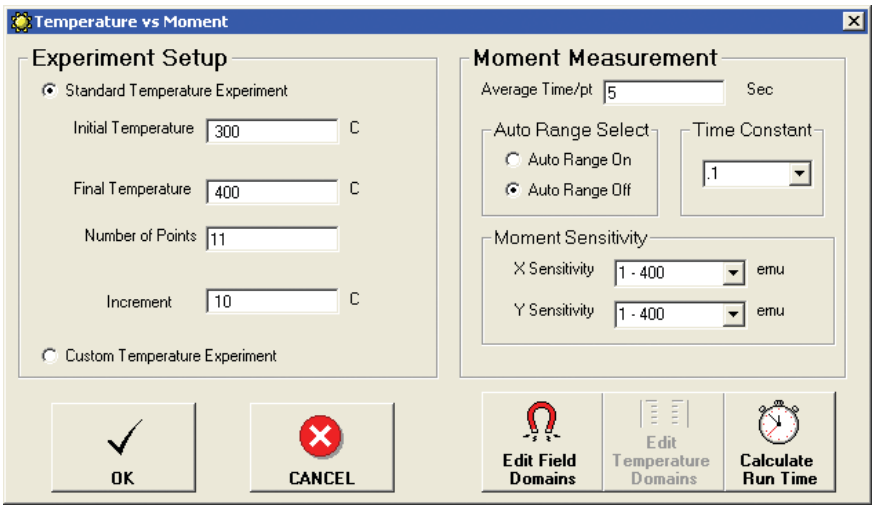
Ramp Generator

Generate a ramp profile based on field, temperature, or angle setup that is optimized to your material and application



Define Sample Parameters

Define sample parameters before or after recording data.



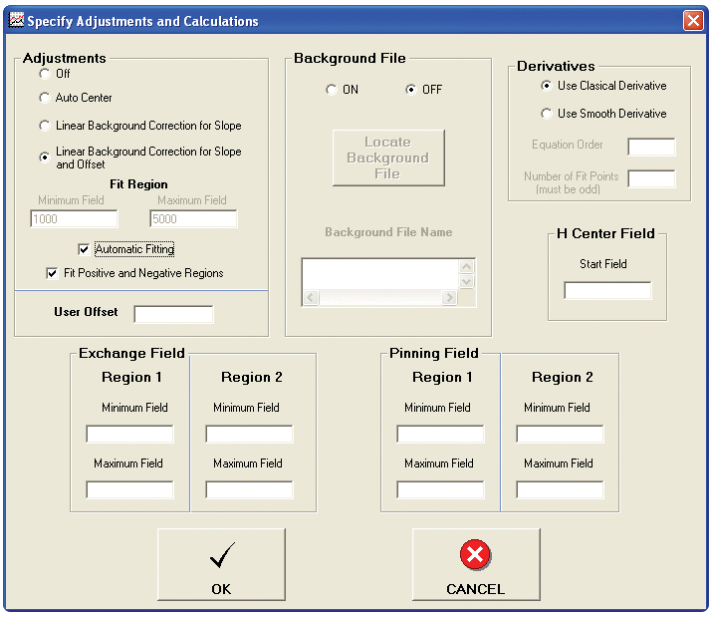
Temperature vs. Moment

Set up temperature-dependent measurement parameters.

Application notes

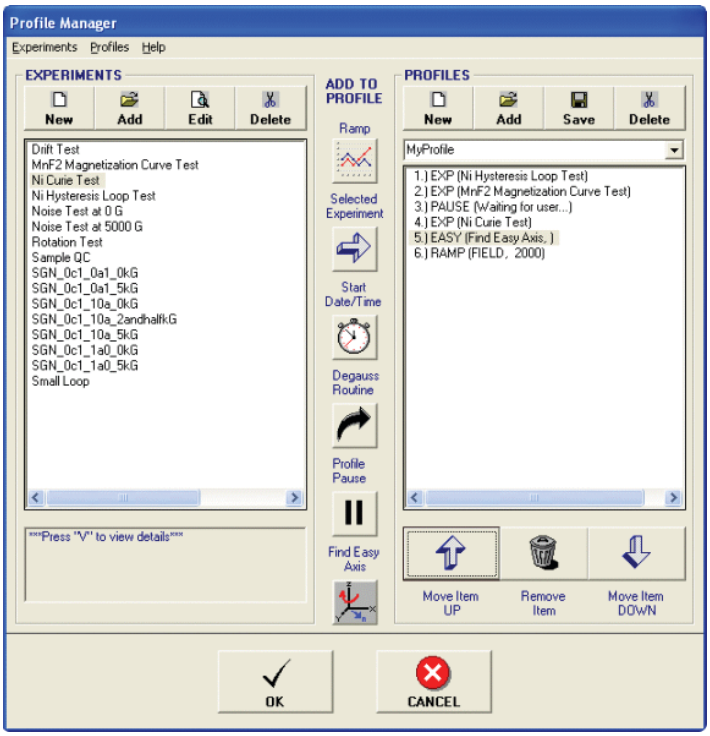
Download free from www.lakeshore.com or request at 614-891-2244. Full listing on page 22.

Put our IDEAS™ application software in control



Specify Adjustments and Calculations

Correct for offsets, sample holder or substrate contributions, and linear background slopes. Calculate derivative curves and determine exchange and pinning fields.

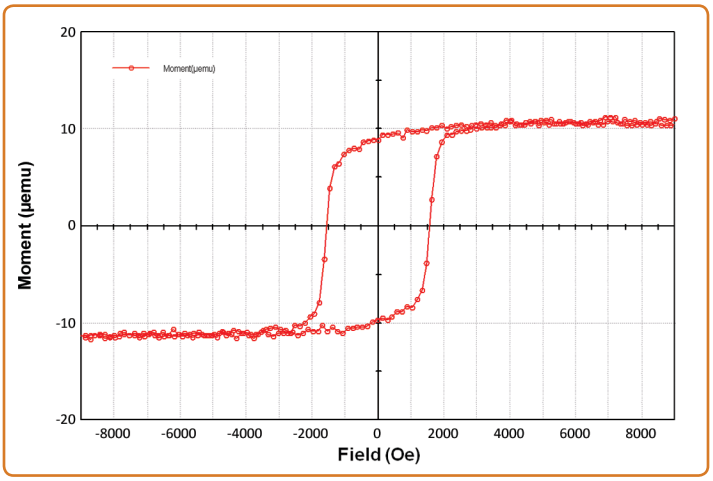


Profile Manager

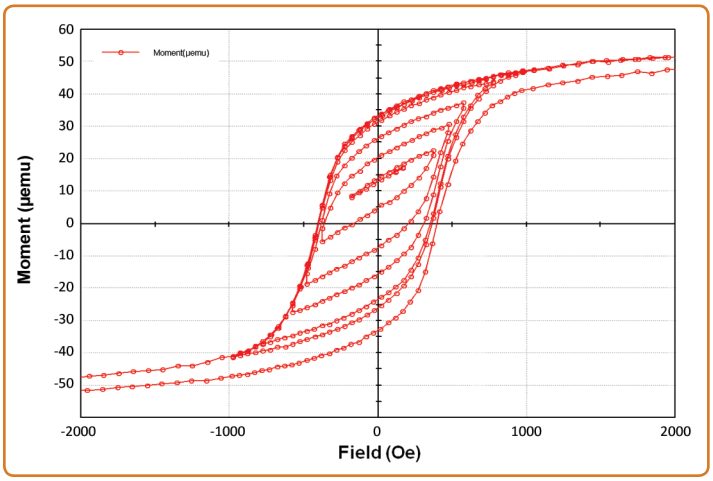
Define, save, and edit individual experiments as well as versatile profiles. Profiles allow you to automate sequences of multiple experiments along with other parameters, such as start date and time, and field and temperature ramps.

Measurements

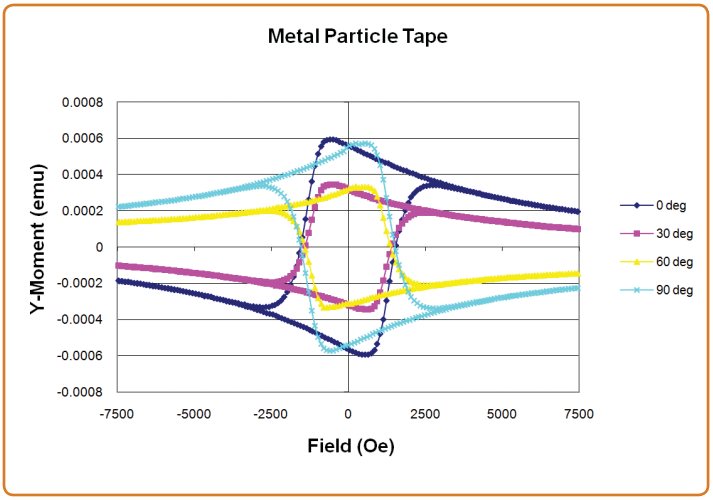
11 µemu CoPt hard disk film



Magnetic tape — minor loop results



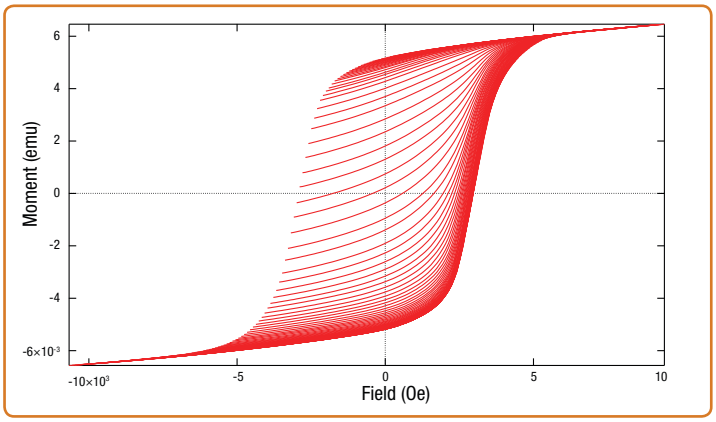
Vector results



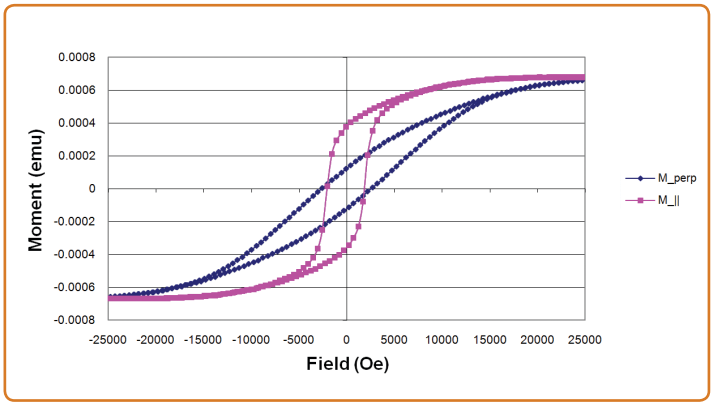
graph represents multiple data sets overlaid

Take even the most complex measurements with ease

FORCs for a ferrite sample

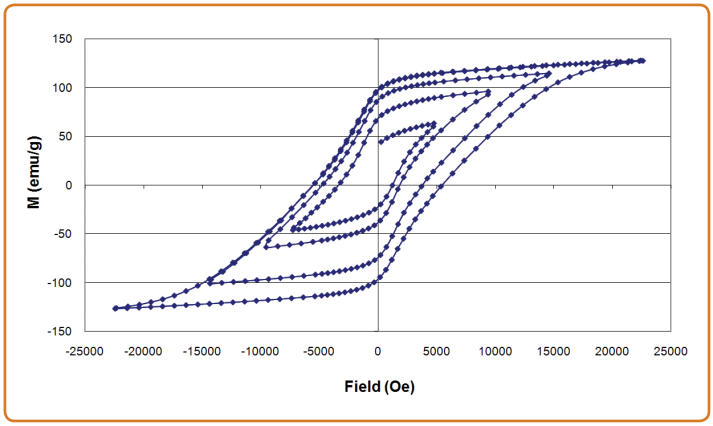


CoPt thin film — M(H) for H parallel and perpendicular to film plane

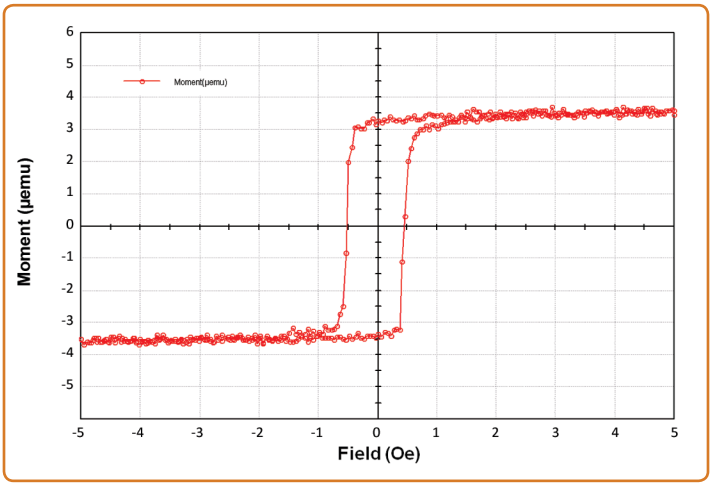


graph represents multiple data sets overlaid

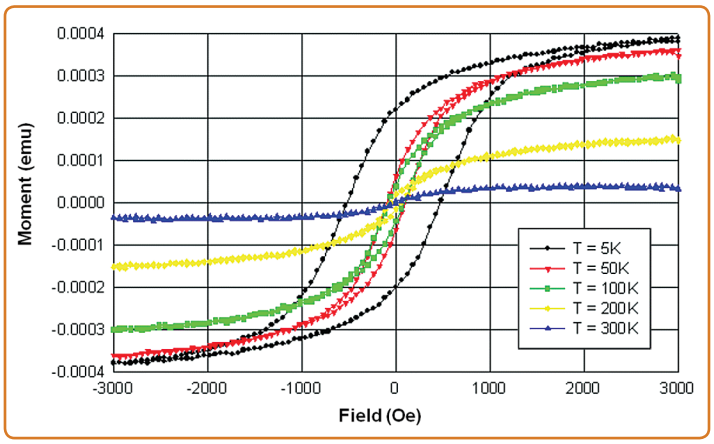
NdFeB — initial magnetization, minor and major loops



NiFe thin film (3 nm) — 3.5 nAm² (3.5 µemu) and 4 A/m (0.05 Oe) steps

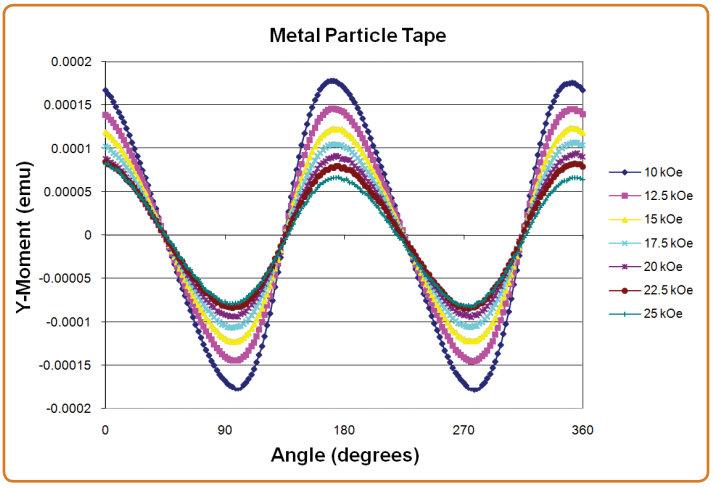


CMR film — low temperature results



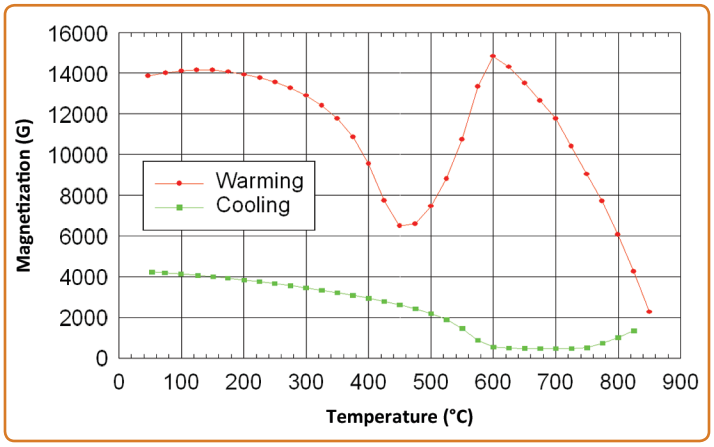
graph represents multiple data sets overlaid

m_y vs. H_x vs. θ



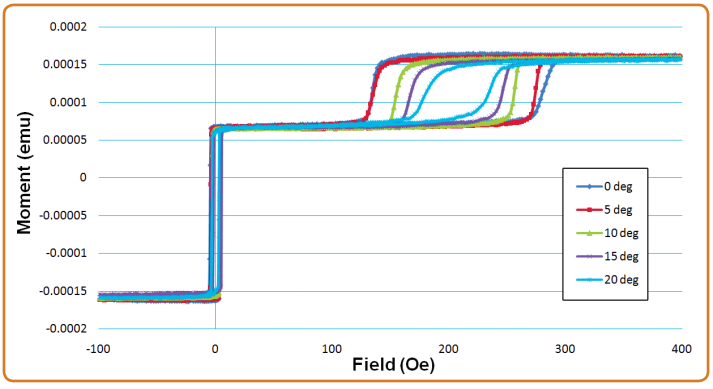
graph represents multiple data sets overlaid

M(T) on warming and cooling for a nanocrystalline melt-spun ribbon ($NdFeB_X$)



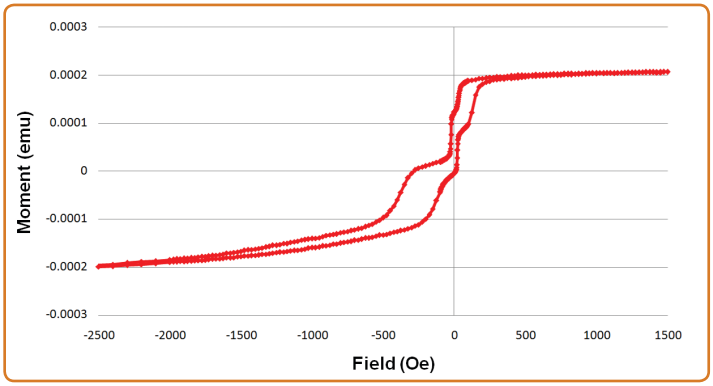
graph represents multiple data sets overlaid

Magnetic tunnel junction with Al_2O_3 barrier*



graph represents multiple data sets overlaid

Magnetic tunnel junction with MgO barrier*

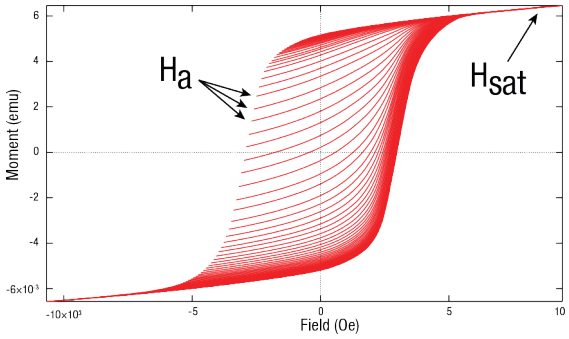


**Thanks to Professor Dr. John Q. Xiao's group at the University of Delaware, Newark for providing the samples for these measurements*

FORC Utility Software

First order reversal curve (FORC) measurements provide unprecedented insight into the magnetic properties of materials, information that is not possible to obtain from a hysteresis loop alone. FORC curves help in identifying the distribution of switching and interaction fields, and in distinguishing between multiple phases in composite or hybrid materials containing more than one phase.

A FORC is measured by saturating a sample in a field H_{sat}, decreasing the field to a reversal field H_a, then sweeping the field back to H_{sat} in a series of regular field steps H_b. This process is repeated for many values of H_a, yielding a series of FORCs. The measured magnetization at each step as a function of H_a and H_b gives $M(H_a, H_b)$, which is then plotted as a function of H_a and H_b in field space.



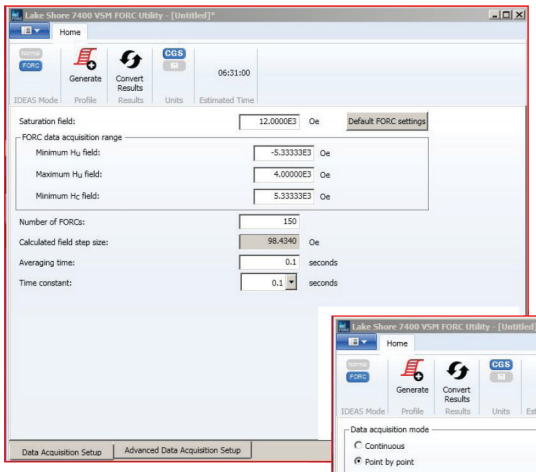
A FORC measurement

Lake Shore provides a downloadable FORC Data Acquisition Utility that provides a convenient way for users of Model 7400* and 7400-S VSMs to setup and run FORC measurements. Resulting data sets can be imported into popular FORC analysis software packages like FORCinel and VARIFORC.

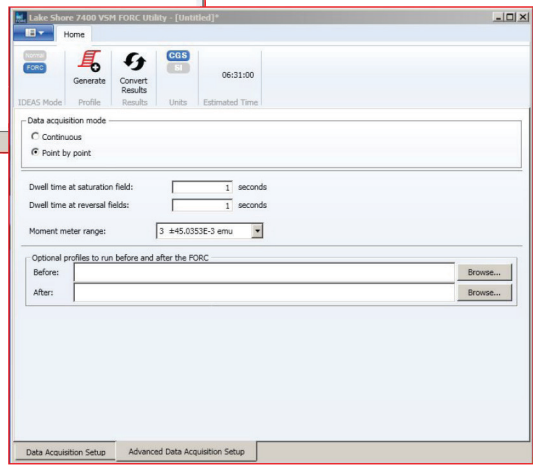
**A VSM controller firmware update is required for 7400 series systems*

The FORC utility enables the user to:

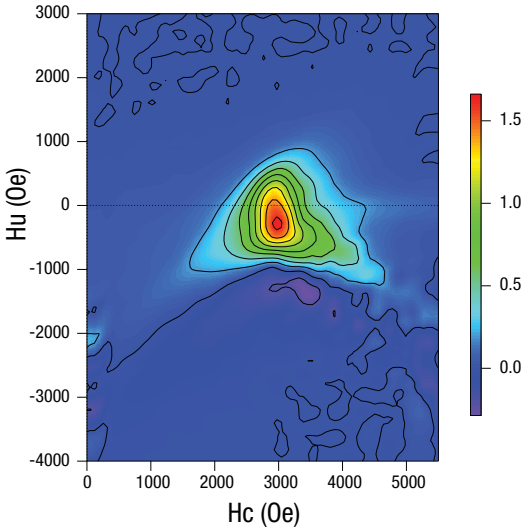
- Configure the 7400 series IDEAS software for FORC measurements
- Specify FORC parameters, or load them from a file
- Generate the necessary files to execute the FORC measurement



FORC Utility setup screens



The user then runs the measurement using the IDEAS software, after which the utility converts the results into a file that can be imported into FORCinel and other similar analysis packages.



FORC Analysis
R.J. Harrison, J.M. Feinberg, FORCinel: An improved algorithm for calculating first-order reversal curve distributions using locally weighted regression smoothing, Geochemistry, Geophysics, Geosystems. 9 11 (2008). FORCinel may be downloaded from: https://wserv4.esc.cam.ac.uk/nanopaleomag/?page_id=31

Software like FORCinel is used to view the FORC curves shown in the first diagram, and to derive FORC distribution diagrams such as the one shown above. The FORC distribution $\rho(H_a, H_b)$ is the mixed second derivative, i.e., $\rho(H_a, H_b) = -\partial^2 M(H_a, H_b)/\partial H_a \partial H_b$. Analysis packages will output graphical 2D or 3D FORC diagrams, contour plots of $\rho(H_a, H_b)$ with the axis rotated by changing coordinates from (H_a, H_b) to $H_c = (H_b - H_a)/2$ and $H_u = (H_b + H_a)/2$. These diagrams represent the distributions of interaction fields (H_u) and of switching fields (H_c).

For more information on the application of FORC measurements, see the library of application notes and papers at www.lakeshore.com.

Magnetocaloric Effect (MCE) Analysis Software

User-friendly software that enables Lake Shore VSM users to easily:

- Characterize first and second order phase transition materials
- Import Lake Shore IDEAS VSM data relating to isothermal magnetization curves M(H) and isofield magnetization curves M(T)
- Generate graphs showing the quality of data and the reliability of intermediate interpolation steps
- Calculate magnetic entropy change (peak values, full width at half maximum)
- Calculate refrigerant capacity, choosing from three widely accepted definitions

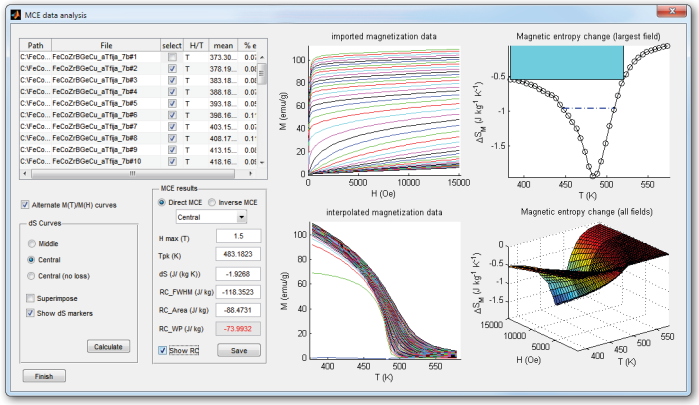
Offered in a free beta trial version, this software package allows Lake Shore 7300/7400/7400-S Series VSM users to more easily analyze candidate materials for magnetocaloric effect (MCE) behavior by calculating the magnetic entropy change and refrigerant capacity of the materials.

MCE software application note

Data files created by the Lake Shore IDEAS VSM software can be seamlessly imported into the MCE analysis software for experimental interpretation of magnetization curves. These include isothermal curves M(H), including magnetizing (0 to H_{max}), demagnetizing curves, or hysteresis loops, as well as isofield curves M(T), including increasing temperature (T_{min} to T_{max}), decreasing temperature (T_{max} to T_{min}), loops (T_{min}-T_{max}-T_{min} or T_{max}-T_{min}-T_{max}), or both as either point-by-point measurements or continuous temperature ramping in background.

The software features a user-friendly graphic interface that automatically populates tables with imported magnetization curve data and plots them as graphs displayed in a data analysis window. It then calculates relevant magnetocaloric parameters extracted from the magnetization curves as a function of the maximum applied field. Once calculations are made by the software, the program generates ASCII files that you can then use with your preferred graphics software to create plots for publication.

For more information about the software, its value in magnetocaloric research, and background on the parameters associated with characterizing the magnetocaloric response of a material, please download the “Determining Magnetic Entropy Change from Magnetic Measurements” application note from www.lakeshore.com.



This software is a beta trial version. It is designed to operate with the Lake Shore IDEAS VSM v3.6 or newer software output data files. Lake Shore VSM owners receiving this software acknowledge that they are receiving it without warranty and their only expectation of support will be what Lake Shore Cryotronics can reasonably provide during normal business hours (9 a.m. to 5 p.m. EDT).

Questions about software usage can be directed to Dr. Cosmin Radu, Lake Shore Applications Scientist, at cosmin.radu@lakeshore.com, or by e-mailing sales@lakeshore.com.

Developer/author

Lake Shore Cryotronics extends a special thank you to Dr. Victorino Franco for his work in developing this software package. We also greatly appreciate his ongoing collaboration with Lake Shore as we continue to optimize our VSM systems for emerging material characterization applications.

Victorino Franco obtained his PhD in Physics from Sevilla University (Spain) in 1999, where he is now a Professor at the Condensed Matter Physics Department.

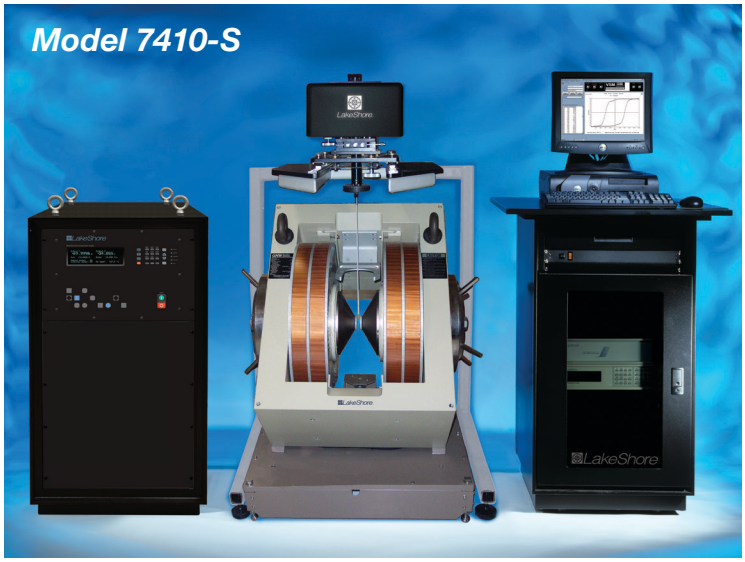
His research interest is focused on magnetic materials for energy applications, including soft magnetic materials and magnetocaloric materials. He has published more than 130 articles in peer reviewed journals, has been visiting professor at numerous universities and research labs in Europe, Asia and America and has been recipient of the Young Scientist Awards from the Spanish Royal Physical Society (in 2000) and from the Royal Order of Chivalry and Royal Academy of Sciences of Sevilla (in 2005).

Victorino is the Past Chair of the Magnetic Materials Committee of the Minerals Metals and Materials Society (TMS), the Conference Coordinator of the Spain Section of IEEE, and the Secretary and Treasurer of the Spain Chapter of IEEE Magnetic Society. He is also Editor of the journal Metallurgical and Materials Transactions E: Materials for Energy Systems.

For more about Victorino Franco, his latest research, and his published work, visit his research page at http://personal.us.es/vfranco/.


Model 7404-S


Model 7407-S
LakeShore


Model 7410-S
LakeShore

7400-S Series VSM Specifications

	7404-S	7407-S	7410-S
Magnet pole cap face diameter	50 mm (2.0 in)	50 mm (2.0 in)	50 mm (2.0 in)
APPLIED FIELD STRENGTH (±1%)			
Room temperature			
3.5 mm (0.14 in) sample access	2.63 T	3.05 T	3.42 T
10 mm (0.4 in) sample access	2.27 T	2.72 T	3.16 T
16 mm (0.64 in) sample access	1.94 T	2.46 T	2.92 T
With oven or cryostat option 6.4 mm (0.25 in) sample access	1.49 T	2.12 T	2.59 T
With single-stage variable temperature option 6.4 mm (0.25 in) sample access	1.75 T	2.28 T	2.76 T
MOMENT MEASUREMENT			
Noise floor (emu RMS)			
Room temperature			
0.1 TC; 0.1 s/pt (no averaging)	450 nemu		
0.1 TC; 1 s/pt	175 nemu		
0.1 TC; 10 s/pt	60 nemu		
With oven or cryostat option, 0.1 TC, 10 s/pt	2.5 µemu		
With single stage variable temperature option 0.1 TC, 10 s/pt	1.25 µemu		
With vector option 0.1 TC, 10 s/pt	5 µemu		
Dynamic range	1×10^{-7} to 10^{3} emu		
Time constants (TC)	0.1, 0.3, 1.0, 3.0, or 10.0 s		
Moment stability[1]	Less than 0.05% RMS of full scale/day at constant field, constant temperature, and highest range after a 5 h warm-up period		
Reproducibility	Better than ±0.5%, or ±0.1% of full scale, fixed rotation angle and range, with sample replacement		
Moment accuracy	Better than 1% of reading ±0.2% of full scale with a geometrically identical test sample and calibrant		
Sample mass	0 to 10 g (higher mass can be accommodated with decreased performance)		
FIELD MEASUREMENT			
Field accuracy	1% of reading or ±0.05% of full scale		
Field resolution			
2800 kA/m (35 kOe)	8 A/m (0.1 Oe)		
280 kA/m (3.5 kOe)	0.8 A/m (0.01 Oe)		
28 kA/m (350 Oe)	0.08 A/m (0.001 Oe)		
Closed loop field control stability	<0.05% RMS of full scale/h		
MANUAL ROTATION			
Setting resolution	<1°		
Setting reproducibility	<1°		
Rotation range	0 to 730°		
CERTIFICATIONS			
CE	yes		
Application of Council directives	2006/95/EC LVD 2004/108/EC EMC		
Standard to which conformity is declared	EN-61010-1:2010 - Overvoltage II, Pollution Degree 2 - LVD EN 61326-1:2013 - Class A, Annex B - EMC		
UTILITIES			
Total system cooling water power dissipation (50 or 60 Hz) — contact Lake Shore for the most current selection of available recirculating chillers	4.25 kW	13.4 kW	13.4 kW

[1] Tested with an AlNiCo sample in a 1 in sensing coil gap after system warm-up period with the sample vibrating at field. The AlNiCo samples' moment must be >50% of full scale moment range.

Please note: chiller power specifications listed are for 100% duty cycle. Many common magnet testing applications such as hysteresis loops will not require as much cooling power. Please consult Lake Shore for chiller recommendations for your specific applications.

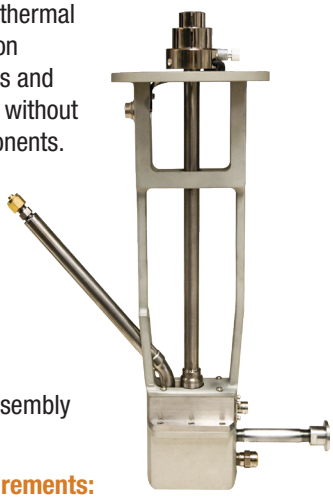
7400-S Series VSM Equipment

	7404-S	7407-S	7410-S
VSM head drive	Model 74014		
VSM frame	1		
Control electronics	Model 736-S		
Linear amplifier	Model 142		
Bipolar magnet power supply	Model 643	Model 648	
Mode	DC current source		
Maximum output	±35 V/±70 A (2450 W)	±75 V/±135 A (9.1 kW nominal)	
AC line input	204/8 VAC ±10%, 13 A/phase; 220/230 VAC ±10%, 12 A/phase; 380 VAC ±10%, 7 A/phase; 400/415 VAC ±10%, 6.5 A/phase at 50/60 Hz	200 VAC ±10%, 41 A/phase; 208 VAC ±10%, 40 A/phase; 220 VAC ±10%, 38 A/phase; 230 VAC ±10%, 37 A/phase; 380 VAC ±10%, 23 A/phase; 400 VAC ±10%, 21 A/phase; 415 VAC ±10%, 21 A/phase	
Cooling water requirements	Tap water or closed cooling system (optional chiller available) +15 °C to +30 °C	Tap water or closed cooling system (optional chiller available) +15 °C to +30 °C	
Flow rate	5.7 L (1.5 gal)/min minimum	7.6 L (2.0 gal)/min minimum	
Pressure drop	10 kPa (1.5 psi) at 5.7 L (1.5 gal)/min minimum for power supply only	159 kPa (23 psi) at 7.6 L (2.0 gal)/min minimum for power supply and mandatory flow switch	
Electromagnet	Model EM4-HVA	Model EM7-HV	Model EM10-HV
Pole diameter	100 mm (4 in)	180 mm (7 in)	250 mm (10 in)
Pole cap face diameter	50 mm (2 in)	50 mm (2 in)	50 mm (2 in)
Field homogeneity	±0.1% over 1 cm^3 (0.4 in^3)	±0.1% over centered 5 cm (2 in) diameter circle	±0.1% over centered 5 cm (2 in) diameter circle
Cooling water requirements	Tap water or closed cooling system (optional chiller available)	Tap water or closed cooling system (optional chiller available)	Tap water or closed cooling system (optional chiller available)
Inlet temperature	15 – 25 °C (59 – 77 °F)	15 – 32 °C (59 – 89 °F)	15 – 25 °C (59 – 77 °F)
Flow rate	7.6 L (2 gal)/min	11.4 L (3 gal)/min	15 L (4 gal)/min
Pressure drop	200 kPa (30 psi)	220 kPa (32 psi)	200 kPa (30 psi)
Hall probe	High sensitivity; 102 mm (4 in) aluminum stem		High sensitivity; 203 mm (8 in) aluminum stem
Pick-up coils	741SC and 741LC		
Instrument console	483 mm (19 in) rack		
Computer with IDEAS™ software	Model 740906		

Expand your capabilities with options

74035 single-stage variable temperature option

The single stage variable temperature assembly allows you to take measurements from 100 K to 950 K using LN_2, nitrogen, and argon gas. A single point measurement can be taken at 78 K. Only one hardware device is required to go from high to low temperatures, eliminating the need to remove or resaddle your sample. This ensures accurate measurements throughout the full scale temperature range. Rapid cool down from 950 K to room temperature and from room temperature to 100 K provides efficiency and high throughput. Like our full suite of variable temperature options, the single stage variable temperature assembly is mechanically isolated from the magnetometer head and sample, minimizing noise floor. Designed to deliver superior thermal performance, the unit's vacuum insulation prevents freeze over at low temperatures and can operate safely at high temperatures without the risk of damaging neighboring components.



Included with the 74035:

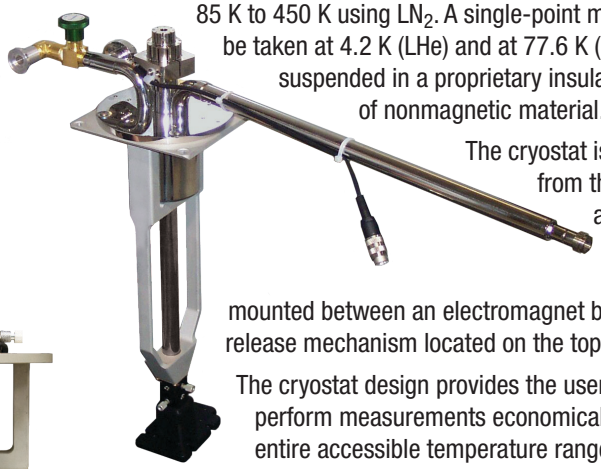
1. Single-stage variable temperature insert with mount
2. 25 liter LN_2 Dewar with condenser stand
3. Gas handling box
4. LN_2 transfer line with condenser assembly
5. Instrument cables

Supplemental 74035 equipment requirements:

1. Lake Shore 741-VTA variable temperature option kit
2. Sample rods and holders; recommended:
   a. With 7404-S and 7407-S: 740928 sample tail and holder kit
   b. With 7410-S: 740941 sample tail and holder kit
3. Argon gas cylinder with 344 kPa (50 psi) gas regulator and 3 mm hose barb (can also be a ¼ NPT female fitting)
4. Nitrogen gas cylinder with a 344 kPa (50 psi) gas regulator and 3 mm hose barb (can also be a ¼ NPT female fitting)
5. LN_2 source to fill the provided Dewar
6. Clean compressed air (276 kPa [40 psi])
7. Mechanical vacuum pump (E2M or equivalent) kit providing sample space blank off pressure of <0.67 Pa (5×10^{-3} Torr) for routine operation
8. Turbomolecular vacuum pump (Lake Shore TPS-FRG or equivalent) kit for cryogen transfer line maintenance — can also be used in place of the E2M rotary vacuum pump
9. A Pirani or thermocouple vacuum gauge capable of measuring pressures from 0.1 to 100 Pa (10^{-3} to 1 Torr)

74018 variable temperature cryostat

This VSM cryostat is designed for rapid sample cooling with either LHe or LN_2 as well as easy sample insertion and interchange. It allows you to take measurements from 5.5 K to 450 K using LHe and from 85 K to 450 K using LN_2. A single-point measurement can be taken at 4.2 K (LHe) and at 77.6 K (LN_2). The sample is suspended in a proprietary insulated tube constructed of nonmagnetic material.



The cryostat is mechanically isolated from the magnetometer head and sample, greatly reducing the system noise floor. It is mounted between an electromagnet base plate and a quick release mechanism located on the top of the electromagnet.

The cryostat design provides the user the capability to perform measurements economically over nearly the entire accessible temperature range with a single cryostat. The transfer line is included with the cryostat.

Included with the 74018:

1. Combination LHe/LN_2 cryostat with mount
2. LHe/LN_2 transfer line
3. Cryogen transfer kit
4. Instrument cables and related accessories
5. Sample rods and holders
   a. With 7404-S and 7407-S: 740929 sample tail and holder kit
   b. With 7410-S: 740943 sample tail and holder kit

Supplemental 74018 equipment requirements:

1. Lake Shore 741-VTA temperature option kit
2. A mechanical vacuum pump (Lake Shore E2M or similar) capable of achieving a pressure below 0.67 Pa (5×10^{-3} Torr) and a speed of 1 m^3/h, along with a KF-16 flange pump inlet
3. Access to turbomolecular vacuum pump (Lake Shore TPS-FRG or similar) capable of doing better than 1.33×10^{-3} Pa (10^{-6} Torr) for annual evacuation of transfer line vacuum space
4. LHe or LN_2 storage Dewar (Lake Shore 1220-50 or similar) with top withdraw fitting to accept the 12.7 mm (0.5 in) diameter transfer line — the transfer line furnished with the Model 74018 cryostat is particularly well adapted for use with 25 to 60 L storage vessels, and can be readily adapted to other capacity storage vessels (in most cases, a LHe Dewar will be provided by your local liquid gas distributor when LHe is delivered)
5. Gas cylinder with 1 to 5 psi pressure regulator to deliver clean, dry helium or nitrogen gas (depending on liquid cryogen)

Configure your system —

74034 high temperature oven

The high temperature oven assembly enables the 7400 or 7400-S Series VSM system to be used to investigate the magnetic properties of materials at high temperature. This option consists of an electrically heated outer tube assembly with efficient thermal insulation to permit sample-zone temperature from 100 °C to 1000 °C (373 K to 1273 K). Temperatures from 30 °C to 1000 °C (303 K to 1273 K) are also possible, however, below 100 °C (373 K) measurement time increases.

The inner sample zone chamber is lined with a special heat-resistant and intrinsically non-magnetic material. A sample holder is provided which consists of a quartz tube sample rod attached to a boron-nitride sample cup. The oven secures to a special isolation mount support structure, the only special consideration being that the air gap between the coils must accommodate the 19 mm (0.75 in) outside diameter of the oven. A mechanical vacuum pump capable of maintaining inlet pressures down to 0.67 Pa (5×10^{-3} Torr) must be supplied by the user.

This option features efficient thermal insulation, consisting of an evacuation outer chamber with multiple reflective heat shields. Sample zone temperatures as high as 1000 °C are attained with a power consumption of approximately 70 W. Two results of the low power consumption are minimal magnetic interference and increased temperature uniformity in the sample zone. The oven is particularly well suited to measuring Curie temperatures of ferromagnetic or ferrimagnetic materials at temperatures up to 1000 °C. The sensitivity of the VSM permits Curie temperature determinations at relatively low field intensities, allowing more inherently accurate determinations.

At room temperature and above, measurements may be performed on samples contained in an argon atmosphere to protect the sample from oxidation.

Included with the 74034:

1. Oven assembly with mount
2. Gas handling box
3. Nickel Curie sample cylinder
4. Instrument cables and related accessories
5. Sample rods and holders
   a. With 7404-S and 7407-S: 740928 sample tail and holder kit
   b. With 7410-S: 740941 sample tail and holder kit

Supplemental 74034 equipment requirements:

1. Lake Shore 741-VTA temperature option kit
2. A mechanical vacuum pump (Lake Shore E2M or similar) capable of achieving a blanked-off pressure below 0.67 Pa (5×10^{-3} Torr) and a pumping speed of 1 m^3/h, along with a KF-16 flange pump inlet
3. Argon gas cylinder with 5 to 10 psi regulator and 3 mm (1/8 in) hose barb

741-VTA temperature option kit

The autotuning cryogenic temperature controller is used to measure and control our full suite of variable temperature options. The 741-VTA includes a Lake Shore temperature controller, thermocouple

input card (when purchased for use with the high temperature oven or single stage variable temperature assembly), vacuum handling kit, mounting hardware (included with the 74035 SSVT option), flanges, hoses, connectors, and accessories. Note: only one 741-VTA is required for all variable temperature options.

exactly the way you need it

74046 magnetoresistance (MR) probe

The MR probe option performs fast and accurate measurements of MR, GMR spin-valve, CMR and other magnetoresistive materials as a function of both in-plane magnetic field and temperature. This measurement option includes data acquisition, control, and analysis software to automatically extract pertinent parameters for the device under test. These include free and pinned layer parameters of both simple and synthetic spin-valve sensors.

The MR probe features four in-line pins for solder-less connection to the sample and is interchangeable with the VSM sample rod for compatibility with variable temperature and autorotation options. The temperature range of use extends from 20 K to 450 K when used with the 74018 LHe/LN_2 cryostat, 325 K to 673 K with the 74034 oven, and 100 K to 673 K with the 74035 single-stage variable temperature assembly. Angular dependent MR measurements are possible when used in combination with the 74033 autorotation option. Contact pins maintain their position on the sample while the entire assembly rotates with respect to the magnetic field.

The fully automated MR software is an intuitive yet powerful user interface providing automatic control of all experimental parameters for unattended operation. Experiment recipes can be saved, retrieved, and edited, and measurement data can be displayed and exported in graphical or tabular format. Multiple step profiles can also be defined to allow for flexibility in the preparation steps and for developing annealing step process methodologies.

The MR probe option is composed of several user-replaceable parts, including contact pins, ceramic pin guides, a ceramic sample holder, a contact pressure spring, and a printed circuit board, providing the convenience of in-field maintenance.

Included with the 74046:

1. MR hardware insert
2. Lake Shore Model 776 matrix switch
3. Model 2400 Keithley sourcemeter
4. 4-wire I-V cable and MR adapter box
5. MR spare kit (2 PCBs, 1 contact pressure spring, 8 points, 1 pin guide, 1 lower holder — user-replaceable)

74033 autorotation

The rotation option allows you to automatically vary the sample orientation relative to the direction of the applied magnetic field. The angle of rotation is within a single plane defined by the direction of applied magnetic field, referred to as the x-axis. Angular variation is about the z-axis. Rotation is programmable to a resolution of <1° for rotating the sample from -10 to 730° and all parameters are measured as a function of rotation angle.

74032XY vector coils

The vector option extends the VSM measurement capabilities to facilitate investigations of anisotropic magnetic materials, allowing you to determine their vector magnetization components and susceptibility tensor. When used in combination with the 74033 autorotation option, the vector coils provide information that is essentially identical to that provided by a dedicated torque magnetometer. The 74032XY 2-inch vector coils are compatible with all variable temperature options.

E2M 2-stage rotary vacuum pump

Capable of achieving a pressure below 0.67 Pa (5×10^{-3} Torr) at 1 m^3/h, the 2-stage rotary vacuum pump is used for evacuating both the oven and cryostat vacuum spaces of our variable temperature options. This, or a similar vacuum pump, is required for daily operation of variable temperature options.

TPS-FRG turbomolecular vacuum pump station

Used to annually evacuate the cryogen transfer line of the optional cryostat and single stage variable temperature assembly (transfer line and kit are included with these options), the TPS-FRG provides vacuum to 1.33×10^{-3} Pa (10^{-6} Torr). In addition to annual cryogen transfer line maintenance, the turbomolecular vacuum pump can also be used in place of the E2M rotary vacuum pump for evacuating the cryostat vacuum space.

Recirculating chillers

Lake Shore offers NesLab® recirculating chillers in order to provide a complete laboratory solution. The NesLab chillers feature a CFC-free refrigeration system.

The refrigeration system uses a hermetically sealed compressor and hot gas bypass system of temperature control. This system eliminates on/off cycling and premature wear of the compressor. Strong pumps provide continuous flow even through cooling lines with small IDs.

7400-S Series VSM Option Specifications

Unless noted, options are compatible with both the 7400-S Series and the previous 7400 Series VSMs.

Model 74018 variable temperature cryostat		
With LHe	Temp range	4.2 K (base), 5.5 K to 450 K (control)
	Temp stability	±0.1 K
With LN_2	Temp range	77.6 K (base), 85 K to 450 K (control)
	Temp stability	±0.2 K
Temperature resolution		0.001 K
Cool-down time		5 min (15 min initial cool-down)
Nominal ramp rate		Continuous flow
LHe liquid usage		<1 L/h when operating >7 K
LN_2 liquid usage		<1 L/h when operating >85 K
Insulation		Vacuum
Sample zone dimensions	Bore size	7.1 mm (0.28 in)
	Outside diameter	22.4 mm (0.88 in)

Model 74033 autorotation		
Full range of rotation		-10 to 730°
Setting resolution		<1°
Setting repeat-ability		<1°

Model 74034 high temperature oven		
Temp range		303 K to 1,273 K
Temp stability		±0.1 K
Temp resolution		0.001 K
Maximum ramp rate		80 K/min at maximum heating rate of 80 W
Insulation		Vacuum plus multiple reflective shields
Sample zone dimensions	Bore size	7.1 mm (0.28 in)
	Outside diameter	19 mm (0.75 in)

Model 74035 single stage variable temperature option		
Temperature range		78 K (base), 100 K to 950 K (control)
Temperature stability		0.1 K RMS when operated with argon (high temperature) and 0.9 K RMS when operated with nitrogen (low temperature)
Temperature resolution		0.001 K
Gasses		LN_2 and nitrogen gas for T<350 K; argon for T>350 K
Cool-down time		15 min from room temp to 100 K, 40 min from 1,000 K to room temp
Nominal ramp rate (in the domain)		5 K/min
Hold time		Continuous flow
LN_2 usage		<0.75 L/h >100 K to 350 K
Nitrogen gas usage		3.2 L/min 100 K to 350 K
Argon gas usage		3.6 L/min
Insulation		Vacuum
Sample zone dimensions	Bore size	7.1 mm (0.28 in)
	Outside diameter	17.8 mm (0.7 in)

Model 74046 magnetoresistance (MR) probe	
Number of probes	4
Probe pin to pin spacing	0.9 mm
Total 4-pin spacing	2.7 mm
Nominal sample size	4.5 mm × 4.5 mm cross-section, maximum height 3 mm
Temperature range	20 K to 673 K
Current ranges	6 ranges; 1 µA to 100 mA
Resistance ranges	9 ranges: 0.2 Ω, 2 Ω, 20 Ω, 200 Ω, 2 kΩ, 20 kΩ, 200 kΩ, 2 MΩ, up to 10 MΩ
Probe tip compliance voltage	0 V to 5 V, measurement; 0 V to 100 V, contact formation

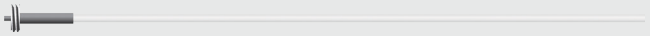
	7404-S or 7404	7407-S or 7407	7410-S or 7410
Model 74032XY standard vector coils[2]			
Pole caps	100 mm (4 in)	100 mm (4 in)	100 mm (4 in)
Air gap	50.8 mm (2 in)	50.8 mm (2 in)	50.8 mm (2 in)
Maximum applied field	7.7 kOe (0.77 T)	12.5 kOe (1.25 T)	20 kOe (2.0 T)
RMS noise (Y coils)	5 µemu	5 µemu	5 µemu
Sample access	25 mm (1 in)		
Torque density minimum (at maximum applied field)	38 × 10^{-3} dyn·cm	62 × 10^{-3} dyn·cm	60 × 10^{-3} dyn·cm

[2] Requires large diameter pole caps; sold separately for 7400 Series systems

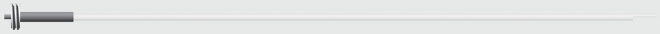
Integrated Sample Tail/Holders

For Model 7404-S/7404/7407-S/7407

740930 Quartz, thin film bottom



740931 Quartz, thin film side

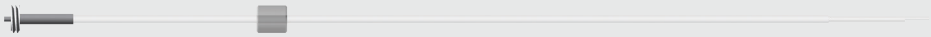


740933 Fiberglass, 3.5 mm air gap, thin film side

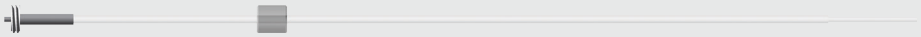
740934 Fiberglass, 3.5 mm air gap, thin film bottom

For Model 7410-S/7410

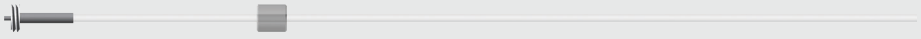
740937 Quartz, 3.5 mm air gap, thin film side



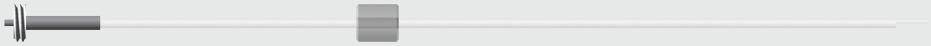
740938 Quartz, 3.5 mm air gap, thin film bottom



740944 Quartz, thin film bottom



740945 Quartz, thin film side

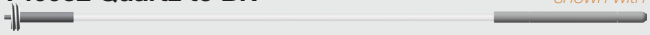


Sample Tails

For Model 7404-S/7404/7407-S/7407

740932 Quartz to BN

shown with the 730937 Disposable BN cup



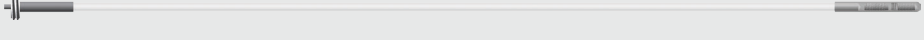
740935 Fiberglass

shown with the 730931 Kel-F bulk/powder upper and bottom cup

For Model 7410-S/7410

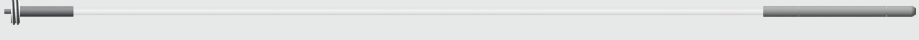
740939 Quartz to Kel-F®

shown with the 730931 Kel-F bulk/powder upper and bottom cup

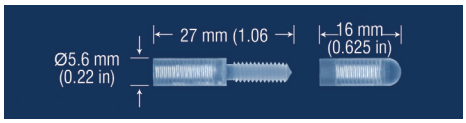


740942 Quartz to BN

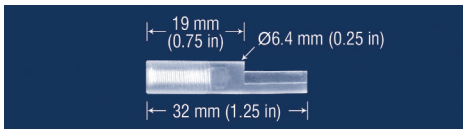
shown with the 730937 Disposable BN cup



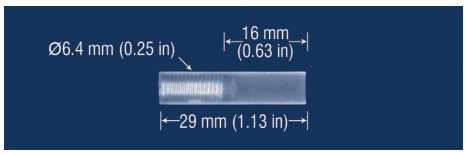
730931 Kel-F bulk/powder upper/bottom cup



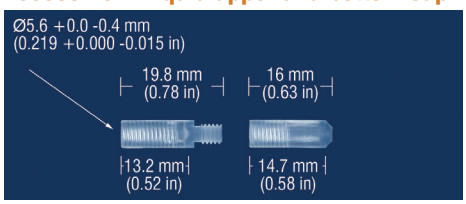
730933 Kel-F thin film side



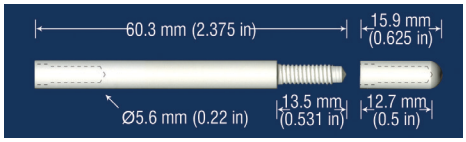
730934 Kel-F thin film bottom



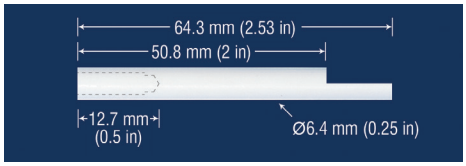
730935 Kel-F liquid upper and bottom cup



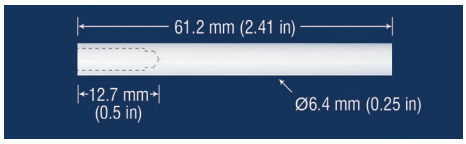
730937 Disposable BN cup



730938 BN thin film side



730939 BN thin film bottom



Recommended temperature usage

	Room temp	Model 74034 oven	Model 74018 cryostat	Model 74035 variable tempature
Quartz	✔	✔	✔	✔
Fiberglass	✔			
Kel-F®	✔		✔	✔ at RT and below
Boron nitride		✔		✔ above RT

Shipping Dimensions and Weight (w × d × h)

	Model 7404-S	Model 7407-S	Model 7410-S
Instrument console, electronics, head, and computer	122 cm × 84 cm × 165 cm (48 in × 33 in × 65 in) 392 kg (864 lb)	122 cm × 84 cm × 165 cm (48 in × 33 in × 65 in) 318 kg (700 lb)	122 cm × 84 cm × 165 cm (48 in × 33 in × 65 in) 318 kg (700 lb)
Electromagnet	109 cm × 94 cm × 135 cm (43 in × 37 in × 53 in) 471 kg (1038 lb)	122 cm × 97 cm × 128 cm (48 in × 38 in × 50 in) 860 kg (1896 lb)	107 cm × 107 cm × 114 cm (42 in × 42 in × 45 in) 1647 kg (3630 lb)
Electromagnet base	(magnet, base, and frame together)	(magnet, base, and frame together)	112 cm × 112 cm × 41 cm (44 in × 44 in × 16 in) 165 kg (363 lb)
Frame			122 cm × 109 cm × 147 cm (48 in × 43 in × 58 in) 341 kg (750 lb)
Power supply	(Included in instrument console)	109 cm × 79 cm × 117 cm (43 in × 31 in × 46 in) 331 kg (730 lb)	109 cm × 79 cm × 117 cm (43 in × 31 in × 46 in) 420 kg (926 lb)

Installation Dimensions and Weight (w × d × h)

	Model 7404-S	Model 7407-S	Model 7410-S
Instrument console, electronics, head, and computer	79 cm × 77 cm × 160 cm (31 in × 30 in × 63 in) 131 kg (289 lb)	79 cm × 77 cm × 160 cm (31 in × 30 in × 63 in) 57 kg (126 lb)	79 cm × 77 cm × 160 cm (31 in × 30 in × 63 in) 57 kg (126 lb)
Electromagnet, electromagnet base, and frame	84 cm × 82 cm × 140 cm (33 in × 32 in × 55 in) 307 kg (677 lb)	120 cm × 82 cm × 140 cm (47 in × 32 in × 55 in) 739 kg (1629 lb)	120 cm × 82 cm × 140 cm (47 in × 32 in × 55 in) 1392 kg (4259 lb)
Power supply	(Included in instrument console)	61 cm × 92 cm × 137 cm (24 in × 36 in × 54 in) 250 kg (551 lb)	61 cm × 92 cm × 137 cm (24 in × 36 in × 54 in) 273 kg (602 lb)

Application Notes

- Determination of the Magnetic Entropy Change from Magnetic Measurements
- First-Order-Reversal-Curve Analysis of Nanoscale Magnetic Materials
- Rock Magnetism and FORC Measurements
- FORC Measurements of Magnetic Materials
- Magnetic In-line Metrology for GMR Spin-Valve Sensors
- Finite Sample Size Effects on the Calibration of Vibrating Sample Magnetometers
- Low Moment Measurements with a Vibrating Sample Magnetometer
- Magnetic Anisotropy: Measurements with a Vector Vibrating Sample Magnetometer
- Measurements with a VSM—Permanent Magnet Materials
- The Performance of the Model 7400 VSM: Sensitivity
- Magnetic Media Measurements with a VSM

Visit www.lakeshore.com for the most up-to-date information

Site Requirements

A system-specific site prep checklist will be provided

Power

Instrumentation, computer, and optional vacuum pump require two standard single-phase electrical outlets (20 A maximum). Magnet power supply and optional recirculation chiller require 3-phase electrical outlets (21 A maximum).

Water

Electromagnet requires one supply and one return line for cooling with up to 15 L/min and 30 to 50 psi. Magnet power supply requires a minimum of 7.6 L/min with a maximum pressure of 80 psi and +15 °C to +30 °C water temperature.

Floor

The floor must support the weight of the magnet, supply, and the equipment used to move them into place. The weight of the console is negligible in comparison. 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.

The system also requires minimum spacing between each of the above three pieces and 0.75 m for access to the rear of the equipment. (See Installation Dimensions and Weight table).

Environment

The VSM requires a temperature-controlled environment that is relatively free of airborne dust and debris. 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.)

Ordering Information

7400-S Series Systems

7404-S	High sensitivity VSM with 4 in electromagnet, 643 magnet power supply
7407-S	High sensitivity VSM with 7 in electromagnet, 648 magnet power supply
7410-S	High sensitivity VSM with 10 in electromagnet, 648 magnet power supply
VSM-TRAINING	2 days on-site VSM operational training/verification— price includes travel time and expenses; *1 additional operational training/verification day required for each and every temperature option
VSM-TRAINING-1	Additional VSM operational training/verification days

Options

Unless noted, options are compatible with both the 7400-S Series and the previous 7400 Series VSMs.

74018	Cryostat, variable temperature LN_2 and LHe
74032XY	Vector option, X and Y coil set for 2 in gap
74033	Autorotation option for Model 736/736-S controller (not field upgradable — VSM head must be returned to Lake Shore) **NOTE:** for head design with serial number sequence 1740HREVXXXX
74034	Oven, high temperature
74035	Single stage variable temperature
74046	Magnetoresistance probe — can be used with high and low temperature options (740-VTA not included)
741-VTA	Variable temperature option kit
741SC	Small gap pick-up coils for 7400-S Series (not compatible with 7400 Series; one included with each 7400-S)
741LC	Large gap pick-up coils for 7400-S Series (not compatible with 7400 Series; one included with each 7400-S)

7400 Series Options/Accessories

74032XY	Vector option, X and Y coil set for 2 in gap (requires large diameter pole caps; sold separately for 7400 Series systems)
730ESC	2 in pick-up coils for 7400 Series (not compatible with 7400-S Series)
740EMSC	1 in thin pick-up coils for 7400 Series (not compatible with 7400-S Series)
MMT-6J04-VG-06	4 in Hall probe for EM4, EM7 with 1 and 2 in coils (for 736 controller); replaces 735952 and 735954
MMT-6J08-VG-06	8 in Hall probe for EM10 (for 736 controller); replaces 735958

Additional Accessories

TPS-FRG-100/120V	Compact turbo pumping system; includes V-81 turbo pump (NW 40) with oil free dry scroll backing pump, FRG-700 full range gauge, controller, and interface cable to USB port; includes Agilent 24 month warranty NOTE: requires SYS-TP-KIT
TPS-FRG-220/240V-CE	Compact turbo pumping system; includes V-81 turbo pump (NW 40) with oil free dry scroll backing pump, FRG-700 full range gauge, controller, and interface cable to USB port; includes Agilent 24 month warranty NOTE: requires SYS-TP-KIT
SYS-TP-KIT	Includes all components necessary to connect NW 40 turbo pumping system to the vacuum port of any Lake Shore system (except probe stations)
E2M-110/120V	Two-stage rotary vacuum pump with mist filter; 110 to 120 VAC NOTE: requires SYS-RP-KIT
E2M-220/240V	Two-stage rotary vacuum pump with mist filter; 220 to 240 VAC NOTE: requires SYS-RP-KIT
SYS-RP-KIT	Includes all components necessary to connect E2M rotary pump to the vacuum port of any Lake Shore system (except probe stations)
1220-50	50 L LN_2 Dewar with ½ in top withdraw port and 10 psi pressure relief valve

7400 Series Upgrades

Consult Lake Shore for information on upgrading your VSM system to the latest 7400-S series

Sample Accessories

Unless noted, accessories are compatible with both the 7400-S Series and the previous 7400 Series VSMs.

7404-S/7404 and 7407-S/7407 only

740927	Sample tail kit, fiberglass to Kel-F®, RT, includes 1 each of 740933/4/5 and 730935, and 3 each of 730931/3/4
740928	Sample tail kit, quartz to BN, RT and oven, includes 1 each of 740930/1/2 and 730937
740929	Sample tail kit, fiberglass to Kel-F® and quartz, RT and cryogenic, includes 1 each of 740930/1
740930	One piece quartz sample tail/holder, RT and oven, thin film bottom
740931	One piece quartz sample tail/holder, RT and oven, thin film side
740932	Sample tail only, quartz to BN, oven, used with 730937/8/9 sample holder
740933	3.5 mm air gap, 1-piece fiberglass sample tail/holder, thin film side
740934	3.5 mm air gap, 1-piece fiberglass sample tail/holder, thin film bottom
740935	Sample tail only, fiberglass, used with 730931/3/4/5 sample holder
HMMT-6J04-VR-06	Replacement 4 in Hall probe (7400-S only)

7410-S/7410 only

740939	Sample tail only, quartz to Kel-F®, RT, used with 730931/3/4 sample holder
740940	Sample tail kit, quartz to Kel-F®, RT, includes 1 each of 740937/8/9 and 730935, and 3 each of 730931/3/4
740941	Sample tail kit, quartz tail to BN cup, oven, includes 1 each of 740942 and 730937
740942	Sample tail only, quartz to BN, oven, used with 730937 sample holder
740943	Sample tail kit, fiberglass to Kel-F® and quartz, RT and cryogenic, includes 1 each of 740944/5
740944	1-piece quartz sample tail/holder, RT and oven, thin film bottom
740945	1-piece quartz sample tail/holder, RT and oven, thin film side
740937	3.5 mm air gap, 1-piece quartz sample tail/holder, thin film side
740938	3.5 mm air gap, 1-piece quartz sample tail/holder, thin film bottom
HMMT-6J08-VR-06	Replacement 8 in Hall probe (7400-S only)

7404-S/7404, 7407-S/7407, and 7410-S/7410

730931	Sample holder cup, upper and bottom portion, Kel-F®
730933	Sample holder, thin film side, Kel-F®
730934	Sample holder, thin film bottom, Kel-F®
730935	Sample holder, liquid, upper and bottom portion, Kel-F®
730937	Sample holder, disposable, oven, BN
730938	Sample holder, thin film side, oven, BN
730939	Sample holder, thin film bottom, oven, BN
730904	Ceramic putty for oven sample mount
730907	Test sample sphere, NIST-traceable
730908	Test sample, 99% pure nickel sphere
730909	Test sample, 99% pure nickel 1 mm sphere

Go to www.lakeshore.com for the current list of available recirculating chillers

Lake Shore 7400-S Series
Vibrating Sample Magnetometers and Accessories

7404-S VSM

7407-S VSM

7410-S VSM

Sample Rods and Tails

Options and Accessories

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