

## **Model 7304**

# **Vibrating Sample Magnetometer**

### **Introduction**

Lake Shore's Vibrating Sample Magnetometers perform magnetic measurements for materials research and development, quality control, and production testing.

The Model 7304 is capable of characterizing a variety of particulate and continuous magnetic media materials including; audio, video, and digital data tapes, flexible media, magneto-optical materials, sputtered and plated thin film materials including multilayer GMR, CMR, exchange-bias and spin valve materials. In addition to standard major and minor hysteresis loop measurements, the Lake Shore Model 7304 also measures remanence curves, and facilitates investigation of anisotropic materials with a vector option.

Permanent magnet materials including rare-earth magnets (NdFeB, SmCo, etc.), polymer-bonded magnets, electrical steels, iron oxides (ferrites), etc. are also readily characterized in the Model 7304. In addition to full loop properties, 2<sup>nd</sup> quadrant characteristics may be measured, energy products determined. Curie point determinations with an optional furnace are also possible.

The Model 7304 is also ideally suited for basic and applied research of magnetically hard and soft materials. Magnetic measurements over a broad range of magnetic fields and temperatures employing optional cryostats and a furnace are possible. Thin films, single crystals, bulk solids, powders, and liquids are all readily accommodated. Materials that may be characterized include; multilayer films, high and low temperature superconductors, molecular magnets, rare-earth and transition metal materials, spin-glasses, amorphous magnets, and more.



*\*(Picture may contain optional equipment and is subject to change)*

## Measurements

The following parameters are either directly measured or derived through the VSM software:

- Hysteresis Loops
  - Saturation magnetization (MSAT)
  - Retentivity or remanent magnetization (MREM)
  - Coercivity ( $H_C$ )
  - Slope at  $H_C$ , value of  $dM/dH$  or differential susceptibility at  $H_C$
  - $S^*$
  - Switching field distribution (SFD)
  - Flatness
  - Squareness ratio (SQR)
  - Hysteresis loss,  $W_S$
  - Others
- Minor hysteresis loops
- Initial magnetization curve
- DC remanence
- AC remanence
- Vector measurements ( $m_x$ ,  $m_y$ )
- Magnetization data as a function of time
- Magnetization data as a function of temperature (4.2 K to 1273 K with optional cryostat and/or oven) for transition temperature and Curie point determinations

## Materials

All types of magnetic materials:

- Diamagnetic, Paramagnetic, Ferromagnetic, Ferrimagnetic, Antiferromagnetic materials and Anisotropic materials
- High and low temperature superconducting materials (with optional cryostat)
- Particulate and continuous magnetic recording materials and GMR, CMR, exchange biased and spin-valve materials
- Magnetic-optical materials
- Rare earth and transition metal materials, amorphous alloys, metallized glassy materials, high-permeability alloys, multilayer intermetallic compounds, metallo-proteins, and all forms of ferrites
- Permanent magnet materials, ferrofluids, steels, inks, toner powders
- Bulk materials, powders, thin films, single crystals, and liquid materials are readily accommodated.

## Features

- Computer-automated data collection system providing up to 14.5 kG field strength while only occupying 8 square feet of floor space
- Measurement of moments as small as  $5 \times 10^{-6}$  emu in magnetic fields ranging from -14.5 to +14.5 kG
- Adjustable magnet air gap permits adjusting magnet/coils to suit sample and field strength requirements
- Bipolar power supply provides smooth continuous transition through zero field
- Fast data acquisition- average sample run (hysteresis loop) over full field range typically requires only minutes
- Windows™ NT/2000 menu driven color graphic software for system operation, data acquisition, and analysis. System software includes operation and control of the magnet power supply, VSM control unit, and gaussmeter. Real-time feedback of processed magnetic moment measurement data can be displayed in either graphical or tabular format.

- Water cooled magnet coils provide excellent field stability ( $\pm 0.05\%$  of full scale per day at constant field and temperature) when high power is required to achieve the maximum field capability.
- Vector option for automated measurement of  $m_x(\theta)$ ,  $m_y(\theta)$ , (see VSM options for specifications)
- Liquid helium or nitrogen cryostats for operation down to 4.2 K or 77 K (see individual option for specifications). Closed cycle refrigerator (CCR) option also available for cryogen-less operation to 15 K.
- Optional furnace insert for operation up to 1000 °C (1273 K) (see individual option for specifications)

## System Specifications

### General

#### Magnetic Moment

<b>Dynamic range</b>	$5 \times 10^{-6}$ emu to $10^3$ emu
<b>Noise</b>	$5 \times 10^{-6}$ emu at 0.9" gap; $50 \times 10^{-6}$ emu at 1.6" gap
<b>Time constants</b>	0.1 second, 0.3 second, 1.0 second, 3.0 seconds, or 10.0 seconds
<b>Output stability</b>	Better than $\pm 0.05\%$ of full scale per day for fixed coil geometry at constant field and temperature
<b>Absolute accuracy</b>	Better than 2% of reading $\pm 0.2\%$ of full scale
<b>Reproducibility</b>	Better than $\pm 1\%$ , or $\pm 0.15\%$ of full scale, whichever is greater
<b>Gaussmeter ranges</b>	300 G, 3 kG, 30 kG, 300 kG
<b>Field dynamic range</b>	0.05 Gauss to 300 kG
<b>Field noise in gauss</b>	0.05 G for high stability probe HST (High Stability Probe)
<b>Field accuracy in gauss</b>	1% of reading or $\pm 0.05\%$ of full scale
<b>Field stability in gauss</b>	$\pm 0.05\%$ of full scale
<b>Maximum field strength</b>	$\pm 14.5$ kG (standard configuration with air gap of 2.3 cm (0.9") 10 kG @ 1.6" gap
<b>Shipping weight</b>	Three (3) crates totaling 352 kg (775 lbs)

*\*Allow 216 cm (85") ceiling clearance from the center of the magnet for removing sample rod assembly.*

## Equipment

### Lake Shore Model 7304 consisting of:

Model 735 VSM Electronics  
 Model 730EMSC mini pick-up coils  
 VSM head assembly and mounting structure

#### Model 450 Gaussmeter

<b>Resolution</b>	$\pm 1$ part out of 300,000
<b>Ranges</b>	Seven ranges from 300.000 mG to 300.000 kG full scale ranges
<b>Precision</b>	Up to 0.0007% of full scale for 300 G and above ranges

Hall probe HST  $\pm 300$  kG

### Electromagnet Model EM4-HV (Variable Gap)

<b>Pole diameter</b>	10.2 cm (4")
<b>Pole face diameter</b>	5.1 cm (2")
<b>Cooling water requirements</b>	Tap water or closed cooling system (opt. chiller available)
<b>Flow rate</b>	1 gallon per minute (4 liters/minute)

### Model 662 Bipolar Power Supply

<b>Maximum output</b>	$\pm 35$ volts/ $\pm 70$ amps (2.4 kW)
<b>AC line input</b>	208/220/380/400 VAC, 50-60 Hz
<b>Cooling water requirements</b>	Tap water or closed cooling system (opt. chiller available)
<b>Flow rate</b>	1.7 gallons per minute (6 liters/minute) $+11$ °C to $+25$ °C

## Instrumentation console, magnet/VSM stand and mounting structure

### Sample holders (3 of each holder supplied)

<b>Powder</b>	3 mm (0.13") diameter x 6.35 mm (0.25") long
<b>Thin-film bottom</b>	6.35 mm (0.25") diameter
<b>Thin-film side</b>	6.35 mm (0.25") long x 12.7 mm (0.5") wide
<b>Liquid (holder purchased separately)</b>	3 mm (0.13") diameter x 6.35 mm (0.25") long; nominal volume 100 $\mu$ l

### Computer

$\geq$ 2.6 GHz Intel processor,  $\geq$ 40 GB hard drive,  $\geq$ 256 MB of RAM, 32 MB USB Memory Stick, CD-ROM, LCD monitor, Windows™ NT/2000, and National Instruments GPIB / IEEE-488 interface.

### IDEAS™ VSM Software

Windows™ NT/2000 menu driven, enhanced color-graphic software for system operation, data acquisition and analysis. System software includes operation and control of the magnet power supply, VSM control unit, and 450 gaussmeter. Real-time feedback of processed magnetic moment measurement data can be displayed in either graphical or tabular format. Standard measurements such as hysteresis loops, moment/time and moment/temperature are built into the control software.

### Printer

HP InkJet printer

## Options

### Available Options and Accessories

Cryostats (helium, helium/nitrogen, and nitrogen), Closed cycle refrigerator, High Temperature Oven, Vector Option, Helmholtz coils, Chillers

### System Specifications with Options Installed

#### Y Vector Option

Model Number	Model 73031
VSM operating air gap	2.5 cm (1")
Maximum field strength	14 kG
Sample access (w/coil installed)	0.7 cm (0.3")
Noise sensitivity	10 $\mu$ emu

#### Oven, Cryostats

VSM operating air gap	4.12 cm (1.6")
Maximum field strength	9 kG
Sample access	0.64 cm (0.25")
Noise sensitivity	100 $\mu$ emu

#### Closed Cycle Refrigerator- Requires an H magnet

VSM operating air gap	4.12 cm (1.6")
Maximum field strength	9 kG
Sample access	0.64 cm (0.25")
Noise sensitivity	$5 \times 10^{-4}$ emu