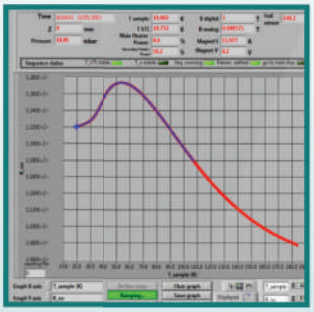
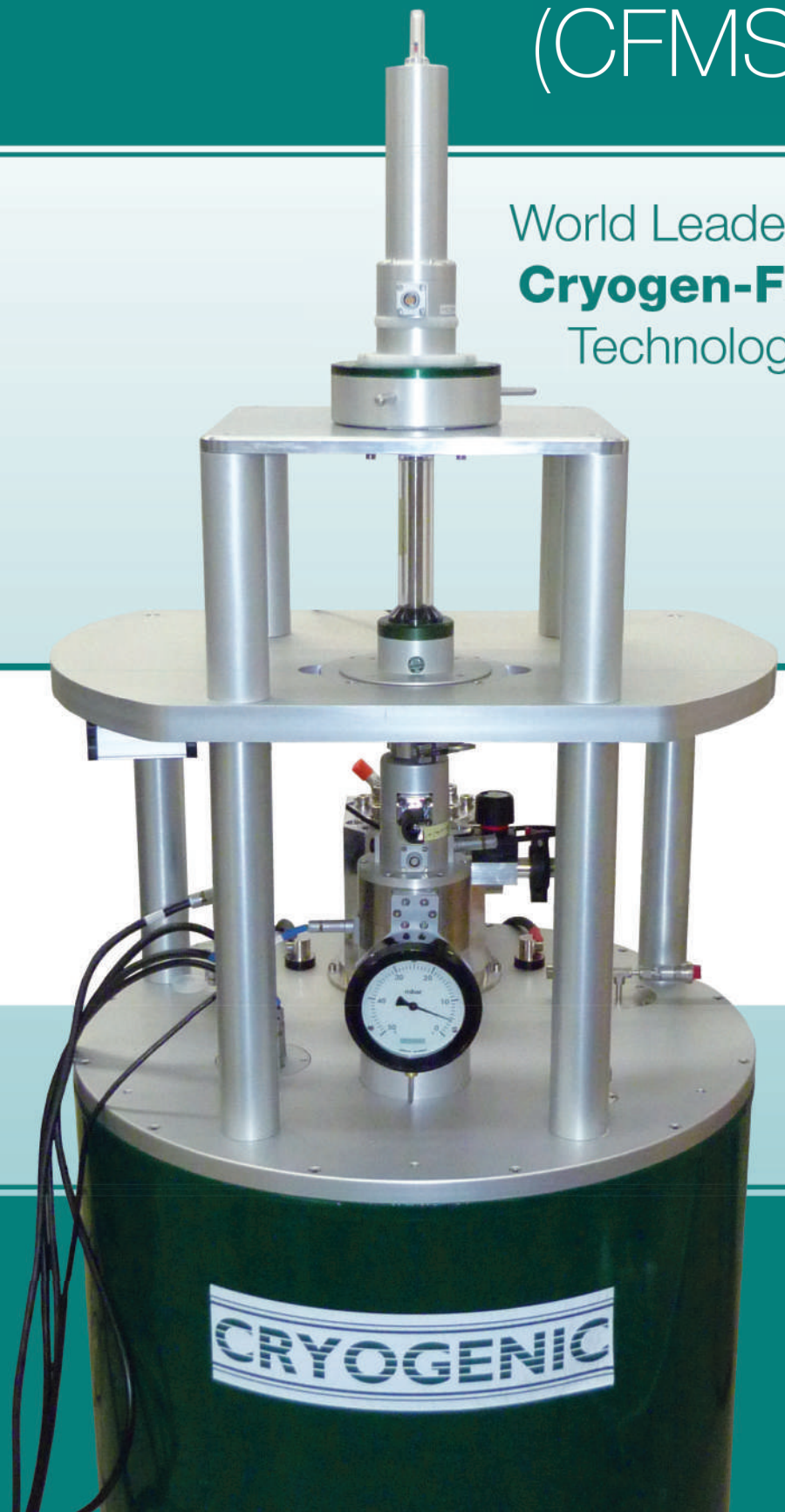
CRYOGENIC

www.cryogenic.co.uk

Cryogen-Free Measurement System (CFMS)

World Leaders in **Cryogen-Free** Technology

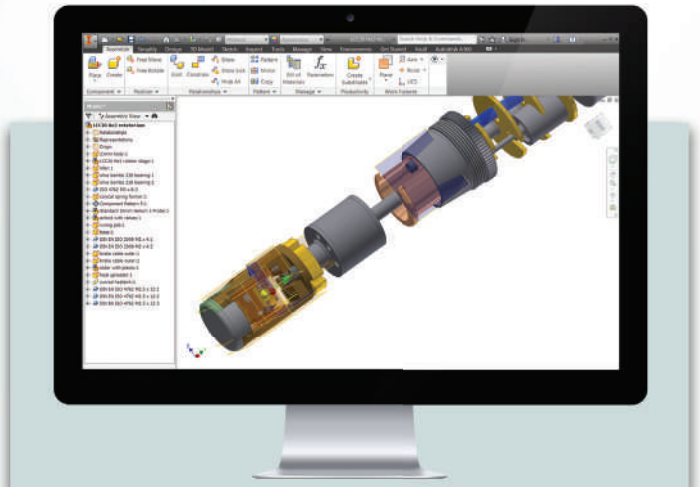




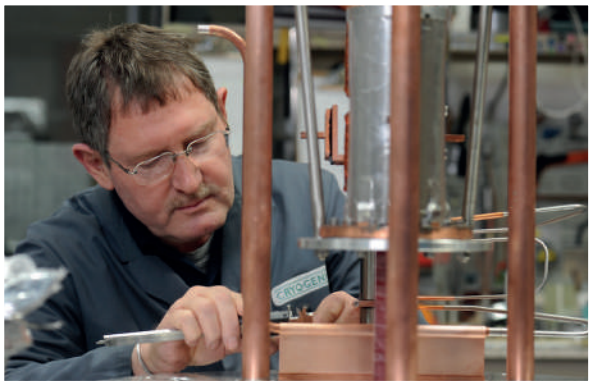
Cryogen-Free System Platforms

Cryogenic Ltd is the leading supplier of superconducting magnets and low temperature measurement systems which operate without liquid helium.

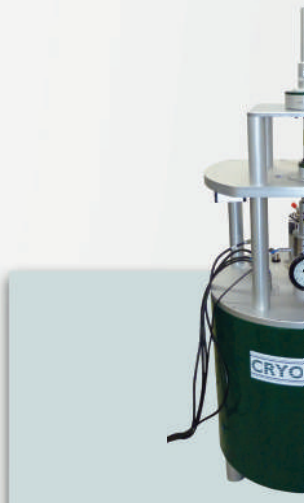
We continually invest in our products, processes and accompanying technologies in order to maintain our success as the market leader in the use of cryogen-free systems for research in Physics, Chemistry and Medicine in the international market place.



Design



Build



Complete

Our corporate objective is to continue this development organically in the market place. The use of low-temperature technology is growing because of the new areas of science now accessible through the use of Cryogen-Free technology to reach temperatures a few degrees above zero, which liberates modern researchers in diverse disciplines from the difficulties of using and reliably obtaining liquid cryogens.

Our business growth is founded upon successful project completion and customer referrals.

We understand the importance of supporting our customers. As a supplement to field-service and direct access to our engineers, we are able to provide this support over the internet, carrying out diagnostics on system operation as well as giving software upgrades and operational advice. We also have service and customer support staff based in London and overseas who carry out routine service as well as supporting in-field systems.

Aftercare

Results

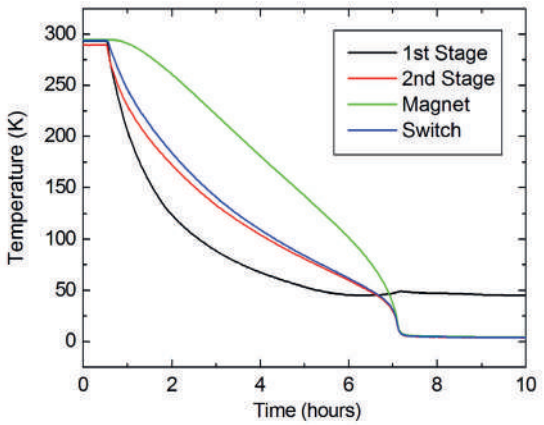
System

Magnetic Field up to 18 T

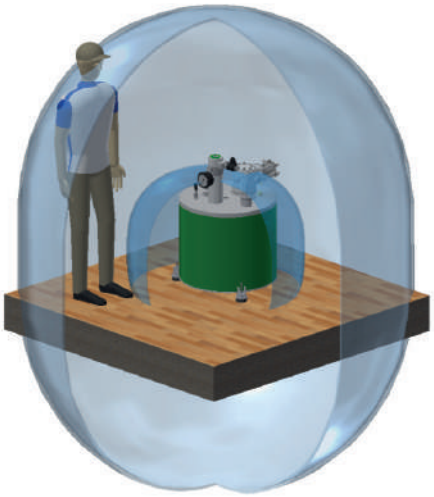
The Cryogen-Free Measurement System (CFMS) from Cryogenic Ltd is a modular research system designed to enable the user to perform a wide range of material characterisation experiments in variable field and variable temperature environments.

The base system of every CFMS is made up of a Cryogen-Free Superconducting magnet with an Integrated Variable Temperature Insert (VTI). An automatic needle valve is available for ease of system control. Complementing this is a range of specifically designed measurement modules with associated electronics for magnetic, electrical, thermal property and ultra-low temperature measurements.

Magnet configurations up to ±18 Tesla are available with a standard temperature range of 1.6 K – 400 K. Active shielding is available for magnets 9 T and higher. A window can be added to the base of the system to allow sample illumination.



Cooldown of 5 T mini cryogen-free measurement system



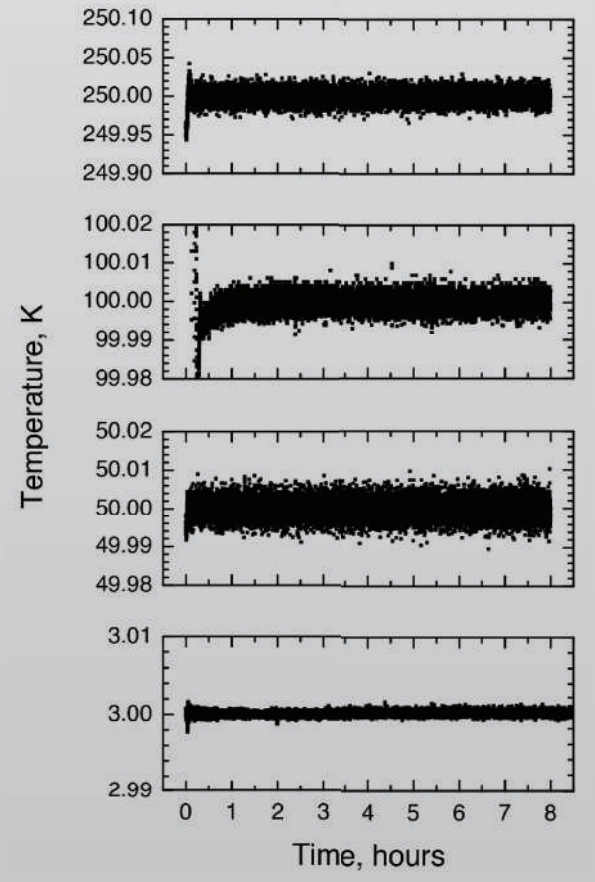
5 G line for shielded and unshielded 9 T magnet

Software

A Cryogenic LabVIEW software suite is supplied as standard to control all aspects of the system operation and measurement protocols, and provides the user with a capability to develop their own plug-in modules for customised experiments. The software allows the user to select the type of measurement to be made, to create, store and retrieve measurement sequences and to customise the range of variables measured at each point in a sequence.

Temperature Stability

The sample temperature stability was recorded at several representative temperatures. At each temperature, data were recorded continuously for 8 hours. The standard deviation of the measured temperature from the setpoint is shown in the table.



Temperature, K	Standard deviation, mK
3	0.3
50	2.4
100	2.0
250	8.0

Electronics

Cryogenic Ltd supplies its systems with a wide range of brand name electronics such as Keithley voltage and current source, Zurich Instruments Lock-in Amplifiers and LakeShore temperature controllers.

20 bit Superconducting Magnet Power Supply:

The Cryogenic SMS series intelligent magnet power supplies have been developed over many years to meet the needs of magnet operators. The power supplies are designed and made in house to suit varying system specifications. High resolution 20 bit power supplies are provided as standard which offer a stability of 3 – 5 ppm/K. Cryogenic's LabVIEW based software allows automated control of the power supply. Our standard range of power supplies are suitable for most laboratory systems. For special applications such as fast ramp magnets we can provide high voltage high power units to meet more exacting requirements.

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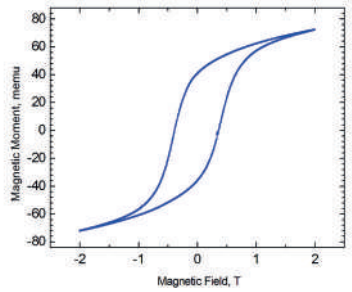
Magnetic Measurements

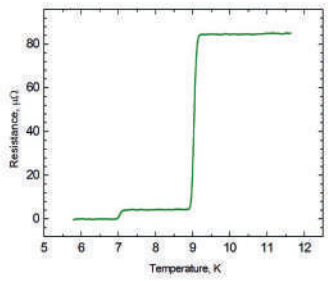
Magnetic moment vs Field, at 1.6 K



The magnetic properties measurement module comprises a Vibrating Sample Magnetometer (VSM) for measurements of DC magnetic moment, and a Susceptometer for measurements of AC magnetic susceptibility. A heated sample platform compatible with both measurements is available.

Electrical Measurements

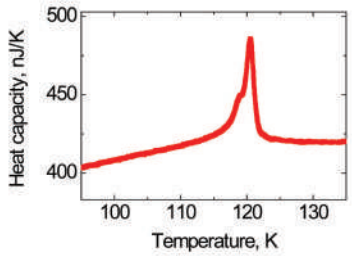
Resistance vs Temperature, in zero applied field



The electrical properties measurement module provides a range of techniques using DC or AC current or voltage sources, and a selection of sample mounts with a different number of contacts, suitable for different sample geometries. The temperature range available with this module can be extended up to 700 K using the heated sample probe, or down to 300 mK using the ^{3}He insert. Rotating sample platforms are available.

Thermal Measurements

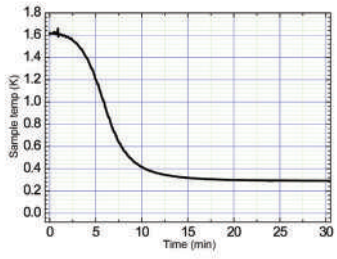
Heat capacity vs Temperature in zero applied field



Cryogenic offers sensitive probes for measurements of heat capacity, and a Thermal Transport probe for combined measurement of thermal conductivity, thermal EMF (or Seebeck coefficient) and electrical resistance. The software can then calculate the thermoelectric figure of merit. These measurements require thermal and electrical contacts at opposite sides of the sample and the probe is adaptable to different geometries.

Ultra-Low Temperature

Cool down of a sample from 1.6 K (VTI base temperature) to a ^{3}He pot base temperature of less than 300 mK



For users who need ultra-low temperatures and a high magnetic field, Cryogenic Ltd manufacture specialised ^{3}He Refrigerators and Dilution Refrigerators designed for operation inside the cryogen-free measurement system sample space. Both refrigerators are fully compatible with all AC and DC electrical property measurement options.

Vibrating Sample Magnetometer (VSM)

The Cryogenic VSM is designed to measure DC magnetic moment. In order to generate a signal proportional to the magnetic moment, the sample is set to vibrate in a constant (or slowly varying) applied field. The signal is detected by a pair of pick-up coils. The coils sense the variation of magnetic flux due to the sample movement. The pick-up coils are located inside the Variable Temperature Insert (VTI) within the bore of the superconducting magnet. The signal is detected by a lock-in amplifier.

Typical Measurements

- Magnetic hysteresis loops
- Temperature dependencies

Typical Samples

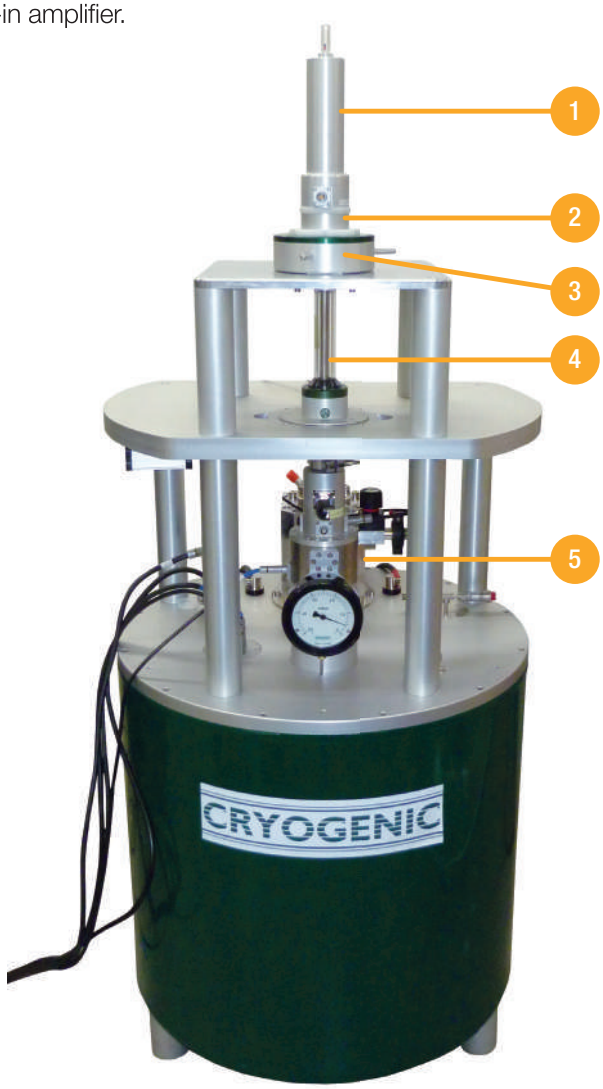
- Bulk samples
- Thin films
- Powders
- Liquids

Performance

VSM frequency	20 Hz typical
VSM amplitude	2 mm
Measurement Range	10^{-6} to 100 emu
Sample size	<6 mm typically
RMS Sensitivity	$<2 \times 10^{-6}$ emu/√Hz
Relative RMS noise	$<(2 \times 10^{-6}$ emu + 5×10^{-7} emu/T)/√Hz

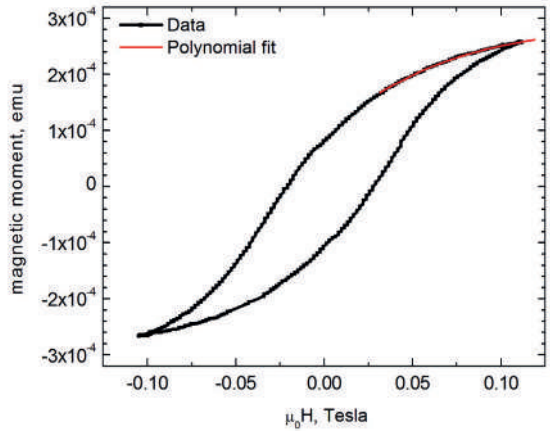
Key Features

- Magnet able to operate in swept or persistent mode
- Automated gas handling system and calibration procedure
- Auto sample position optimisation routine
- Pick-up coils located close to the samples for highest sensitivity
- Vibrator fitted with moving coil motion detector for amplitude control
- Rigid and thermally stable carbon fibre sample rod
- Combined VSM and AC susceptibility module
- Active vibration damping of the drive motor
- Easy to use and accurate manual positioning

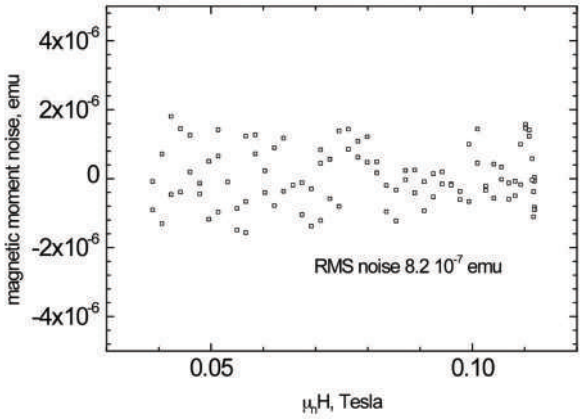


Key

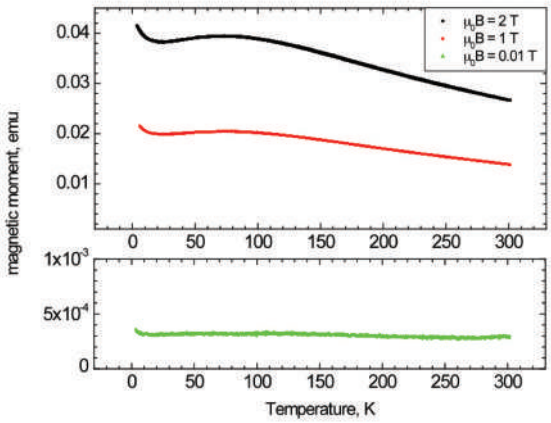
1. VSM Vibrator
2. Vibration Damping Unit
3. Manual Positioning System
4. Perspex Airlock
5. Pulse Tube Coldhead



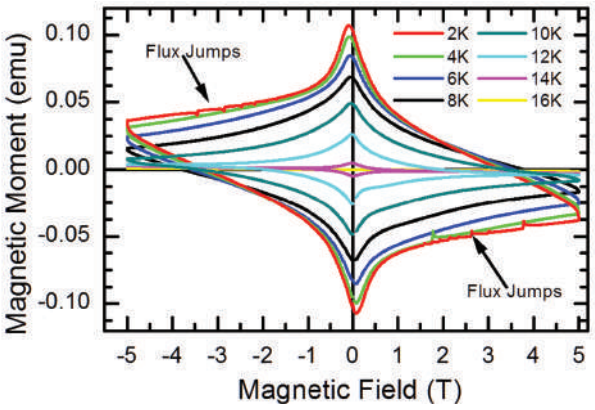
Magnetisation loop of a weakly magnetic sample of a diluted solution of magnetite nanoparticles.



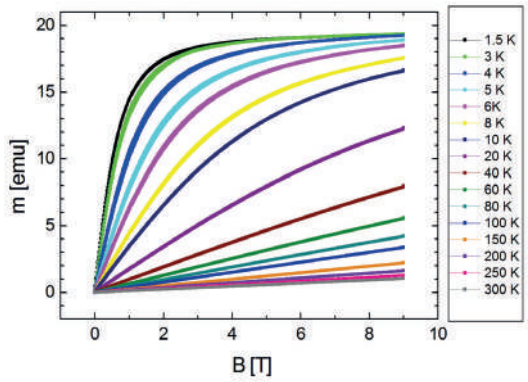
Result of subtracting the polynomial curve from the data of the dilute magnetic nanoparticles shown to the left demonstrating the sensitivity of the measurement.



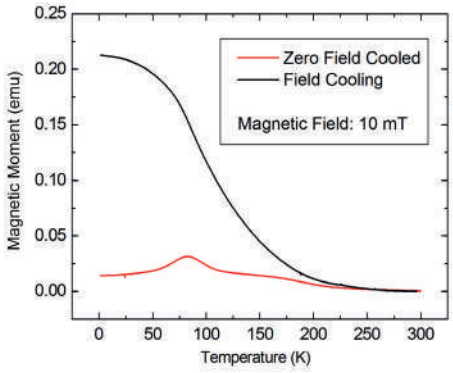
Magnetic Moment of palladium as a function of temperature.



Magnetic moment of a short sample Nb_3Sn conductor as a function of magnetic field, at different temperatures. Flux jumps occur at 2 K, but not at higher temperatures.



Magnetic moment of the paramagnetic material $Gd_2(SO_4).8H_2O$ as a function of field at different temperatures.



Magnetic moment of a spin glass measured during heating of the sample in a 10 mT field, after cooling in field and without field.

Heated VSM Probes

Two heated VSM probes are offered to allow measurement of the DC magnetic moment at temperatures of up to either 700 K or 1000 K. Both of these probes feature a specially designed sample mount to ensure excellent temperature control. The 700 K probe works with a standard set of pickup coils, making it compatible with VSM and AC Susceptibility. The 1000 K probe comes with a specially designed set of pick-up coils to withstand the elevated temperatures. These probes are ideally suited for studying the Curie temperature of various materials.

Key Features

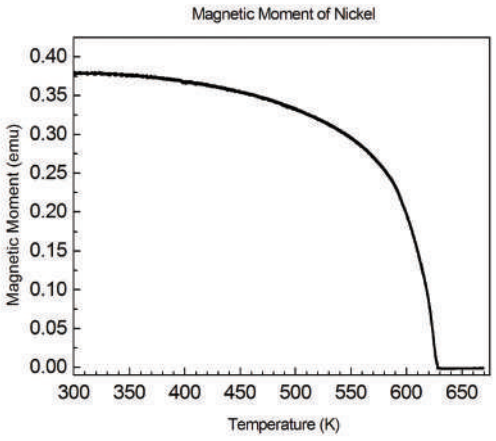
- Sample in vacuum
- Sample mounts for parallel or perpendicular alignment to B
- Miniature, non-magnetic wire-wound heater at the end of the vibrating rod
- Non-magnetic Pt thermometer
- Temperature range options:
  - 200 K to 700 K
  - 200 K to 1000 K
- 5mm x 5mm typical sample size

Typical Samples

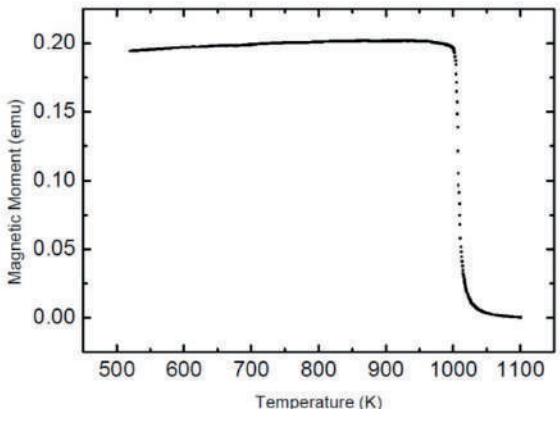
- Bulk samples
- Thin films
- Powders
- Liquids

1000 K VSM

700 K VSM



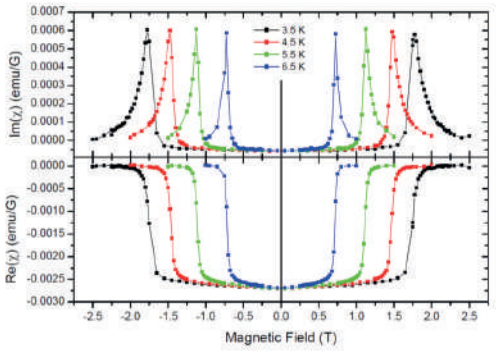
Magnetic moment as a function of temperature for a standard nickel sample measured up to 700 K.



Magnetic moment as a function of temperature of iron sample measured up to 1000 K.

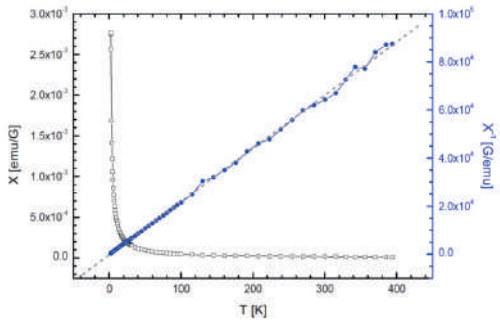
AC Magnetic Susceptibility

AC susceptibility is measured from the response of a sample to oscillating magnetic field. In simple materials and at low frequencies, the sample's magnetic moment follows the field synchronously, the measured AC signal has the same phase as the oscillating field and the susceptibility measures the derivative of the magnetic moment, dm/dH. In more complex situations where magnetodynamics is involved, there is a phase lag between the susceptibility signal and the field, so that the result can be presented as real (in-phase) and imaginary (out-of-phase) parts of the susceptibility. The method is particularly useful for studying magnetodynamics and phase transitions.



Temperature range

Low temperature superconducting alloy measured using AC susceptibility with automatic background subtraction. The real and imaginary parts of the signal are measured simultaneously. The superconducting transition can be seen as a step in the real part and a sharp peak in the imaginary part of the signal.



Gadolinium sulphate ACS over temperature

AC susceptibility of $Gd_2(SO_4)_3.8H_2O$ with sample extraction from the coils set and compensation of background signal.

Typical Measurements

- Magnetic phase transitions
- Magnetic characterisation
- Superconducting phase transition
- Spin-glasses

Typical Samples

- Bulk samples
- Thin films
- Powders
- Liquids

Performance

Frequency range	1 Hz to 20 kHz
AC field amplitude	≤5 mT @ 10 Hz
Sample size	Typically <6 mm
Phase setting accuracy	0.1° (Real and Imaginary Parts)
Sensitivity	10^{-7} emu/Gauss

Key Features

- Parasitic signals eliminated by moving sample between pick-up coil centres
- Auto sample position optimisation routine
- Wide frequency range with high sensitivity
- Possibility to interchange between VSM and AC magnetic susceptibility measurement techniques without removing the sample

Resistivity and Hall Effect (DC & AC)

The Electrical Transport module provides a capability to perform DC resistance measurements and Hall voltage measurements in samples with resistance in the range from 100 nΩ to 1 GΩ. Cryogenic offers a selection of sample platforms with different numbers of sample connections and suitable for different sample sizes. Probe wiring options include twisted pairs, miniature coaxial cables (for high-frequency measurements) or triaxial lines (for very low current measurements).

We offer a module to conduct AC resistance measurements. The option includes a special sample probe with micro-coaxial cable wiring, Keithley AC/DC current source and Zurich Instruments Lock-in amplifier.

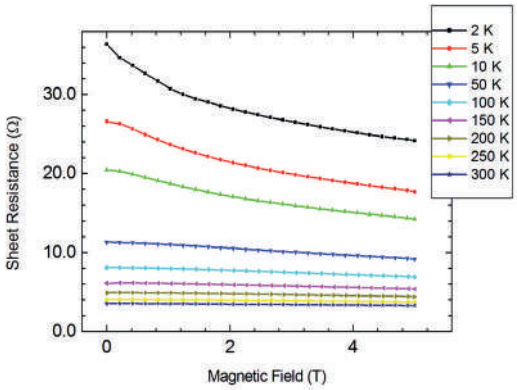
Typical DC Measurements

- Resistance & magnetoresistance
- Current-Voltage (I-V) characteristics
- Critical current
- Hall Effect

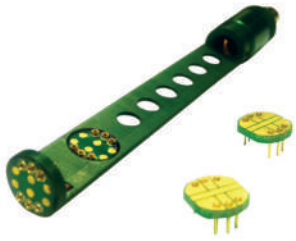
Typical AC Measurements

- Real and imaginary parts of impedance Z
- Varying temperature: Z(T)
- Varying magnetic field: Z(H)
- Varying source current: Z(I) (I-V characteristic)
- Hall voltage (4-terminal configuration)

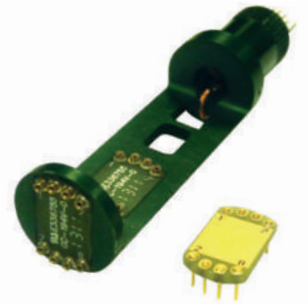
Performance	
Noise base	1nV / √Hz
Voltage range	DC: 10 nV to 100 V / AC: 10 nV to 1 V
Current range	DC: 1 nA to 1 A / AC: 1 pA to 100 mA
AC frequency range	1 mHz to 100 kHz
Phase-setting accuracy	0.10 (real & imaginary parts)
Measurement accuracy	0.1% across range: 1Ω to 1MΩ
Sensitivity	±10 nΩ RMS (typical)
Multiple sample mounts	Fixed (1, 2 or 5 sample options)



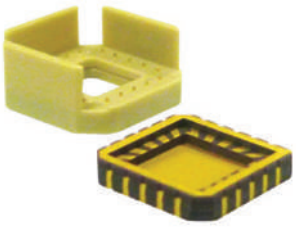
Sheet resistance as a function of magnetic field, measured using the van der Pauw method.



6 pin sample chip and probe end



8 pin sample chip and probe end



20 pin sample chip Multi sample probe and probe end

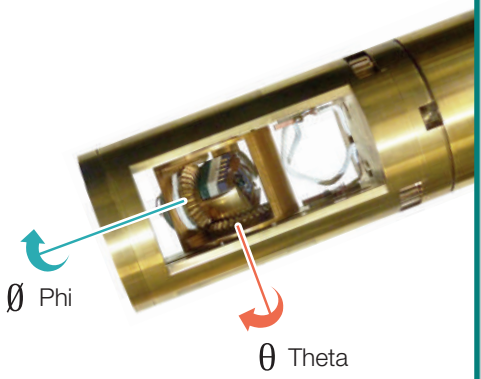
Multi sample probe

Single and Double Axis Rotators

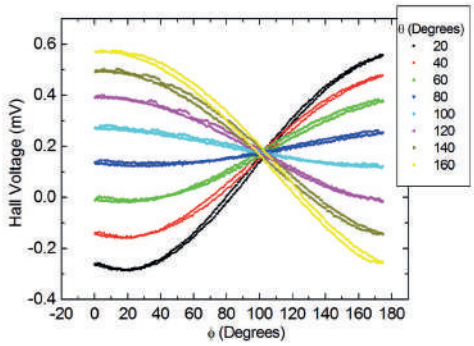
Cryogenic Ltd introduces its range of single or double axis rotators.

Each insert allows the measurement of the electrical properties of materials at different angles to the magnetic field without the need for remounting. A range of sample mounts are available to suit different sample sizes.

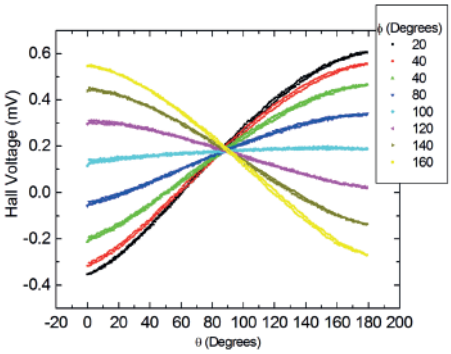
All inserts are designed to fit into a cryogen-free measurement system with a 30 mm bore.



Hall Voltage Measured using a Two Axis Rotator: Phi Sweeps

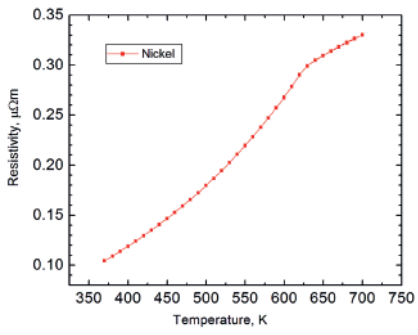


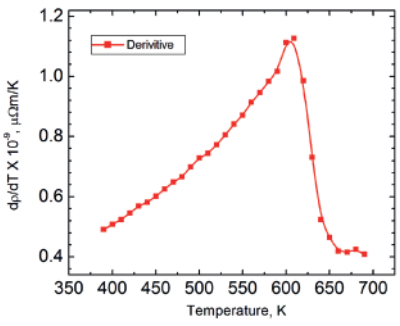
Hall Voltage Measured using a Two Axis Rotator: Theta Sweeps



Heated Resistivity Probe

- Temperature range from 200 K – 700 K
- Sample space is a 10 mm × 10 mm square, suitable for thin films, sheets or wires
- Configurable in a μΩ to MΩ range
- Fits all Cryogenic measurement systems
- Allows 2-point, 4-point, Hall and van der Pauw measurements to be made
- Comes with all necessary electronics and control software





The Curie point of nickel is known to be 632 K. A lower scattering rate is observed in the fully magnetised state, as each scattering event must be accompanied by a spin flip. Therefore a shoulder in the resistance data is observed at the Curie point, which is clearly resolved at the correct temperature using this insert.

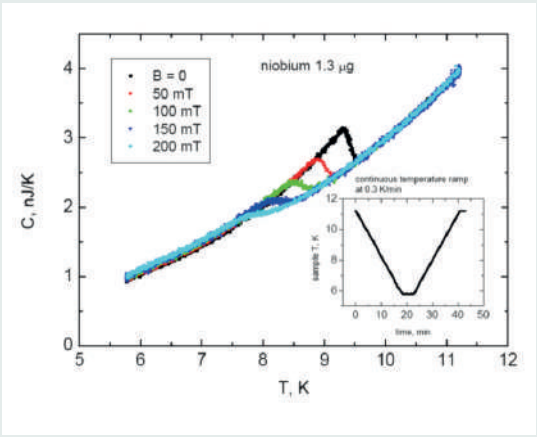
Heat Capacity: AC Calorimeter

The Cryogenic Limited miniature AC calorimeter is designed to measure the heat capacity of samples weighing as little as one microgram. The AC technique offers unsurpassed sensitivity combined with simplicity of operation.

The sample is mounted on to the calorimeter membrane using thermally conductive vacuum grease and placed in a closed cell with low-pressure exchange gas. The sample mount is then plugged into the standard probe as shown below. The probe is inserted into the VTI through an airlock.

Performance

Sensor patterned on Si_3N_4 Membrane	
Sample mass	1 µg to 200 µg
Temperature range	3 K to 300 K
Temperature Modulation	
Frequency	0.1 to 100 Hz typical
Amplitude	0.01 to 0.1 K
Sensitivity	1 nJ/K at 10 K
Typical sample size	0.1 mm x 0.1 mm x 0.1 mm



Heat capacity of niobium measured as a function of temperature at different fields using the AC method. The excellent accuracy of this method allows the superconducting transition to be resolved in great detail.

Key Features

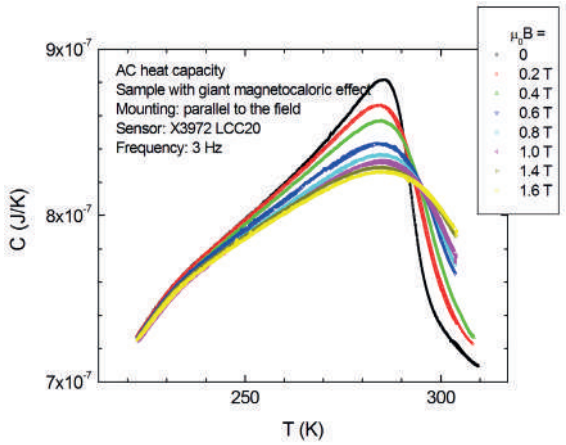
Low amplitude of temperature oscillations:
Ideally suited to investigations of narrow phase transitions.

Fast measurement:
Allowing heat capacity to be recorded as a function of continuously varying external parameters (temperature or field), through a phase transition.

High sensitivity:
The calorimeter is manufactured using silicon nitride membrane technology.

Robustness and durability:
Single sensor can be used for many sample replacements.

Sample size:
Under ideal conditions the lateral sample size matches the size of the miniature heater patterned on the membrane.

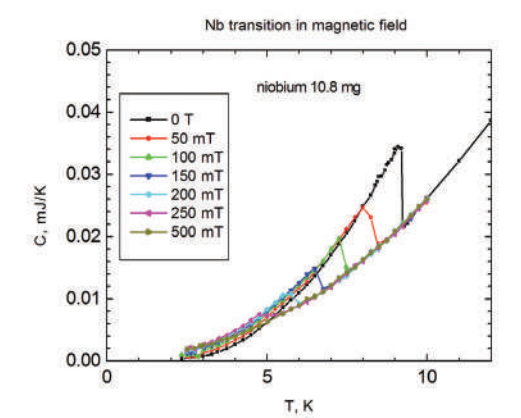


Gd measured as a function of temperatures at different magnetic fields. The peak in the heat capacity corresponds to the Curie temperature of Gd. The large magnetocaloric effect means that Gd can be used for magnetic cooling.

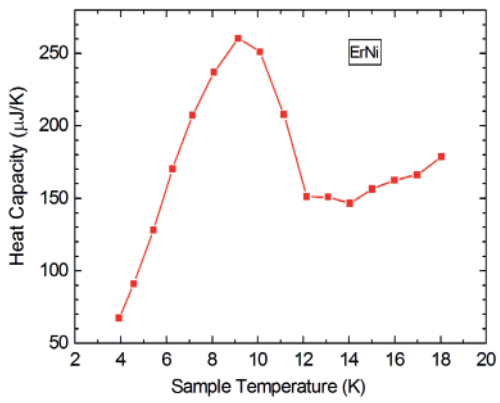
Heat Capacity: Relaxation Method

The relaxation method is an alternative, and complementary, way of measuring heat capacity. It is intrinsically slower, but can be used to study larger samples. The measurement is performed using our top-loading vacuum probe. Samples are mounted in a light-weight aluminium container.

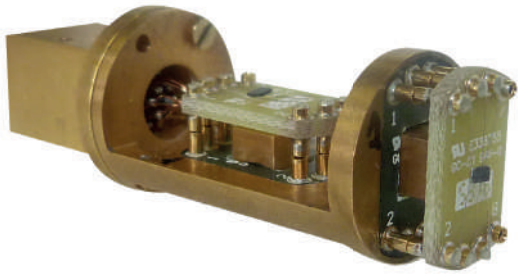
Design of the sample platform is adjusted to the expected range of heat capacity, so the method can be used for samples of various sizes by simply replacing the platform.



Heat capacity of niobium measured as a function of temperature at different fields using the relaxation method. The superconducting transition can clearly be seen. The large heat capacity measured for this sample allows very accurate measurement of the heat capacity.



Plot of the heat capacity of ErNi as a function of temperature measured using the relaxation method. The maximum in the heat capacity at close to 10 K corresponds to the Curie temperature of the material. This phase transition makes ErNi a good material for the regenerator in Gifford-McMahon cryocoolers.



Performance

Sample mass	1 mg to 200 mg
Larger sample size	typically 1 mm³
Sensitivity	1% of full signal
Temperature range	3 K to 300 K

Key Features

Ease of sample change:

Probe loading via airlock means that samples can be changed without heating the VTI

High accuracy:

Larger sample size compared to AC calorimetry allows more precise measurement of absolute value of heat capacity

High Vacuum sample chamber:

Sample vacuum is maintained by a turbo pump. This ensures that the heat budget into the sample is carefully measured

Multiple sample loading as standard:

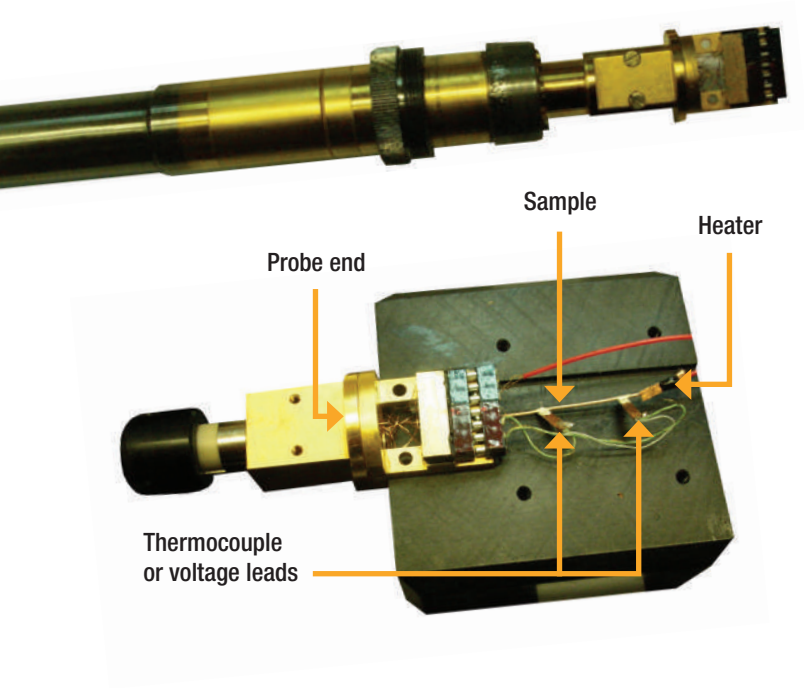
Two samples may be loaded at once to allow quicker sample turn-around

Thermal Transport

The thermal transport measurement option is used to measure thermal conductivity, thermal EMF (Seebeck effect) and resistivity simultaneously in a single experimental setup to determine the thermoelectric figure of merit.

The sample platform is mounted inside a cone-sealed inner vacuum chamber (IVC) at the end of a special measurement probe. Wires entering the IVC are carefully thermally grounded so that the operation of the probe at low temperatures is not compromised. To measure the thermal conductivity and thermal EMF, four-point geometry is employed to eliminate sample boundary effects.

Thermal conductivity and thermal EMF are usually measured simultaneously in a single experiment, using the scanning unit provided with the system. The electrical resistance can be measured during the same experimental run, i.e. without the need to remove the sample from the probe.



Typical Measurements

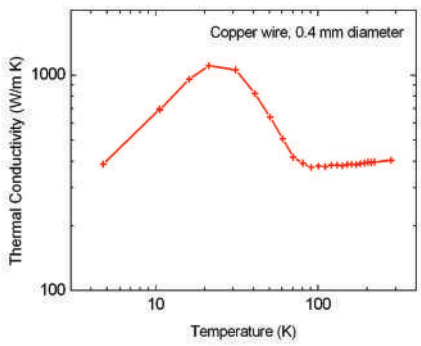
- Thermal Conductivity
- Seebeck Coefficient
- Resistivity

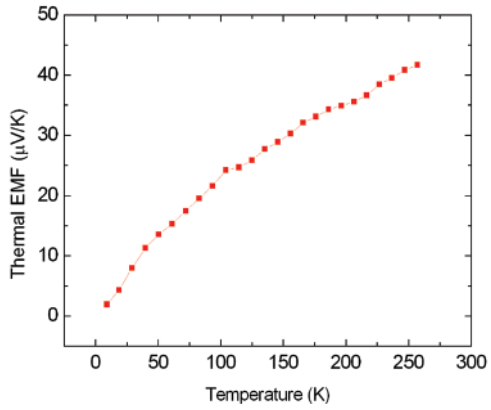
Performance

Temperature range	2 K to 350 K
Typical sample size	1 mm x 1 mm x 10 mm
Range of thermal conductance 300 K	1 µW/K to 1 W/K
Range of thermal conductance 10 K	0.1 µW/K 10 mW/K
Range of thermal EMF measurement	1 µV/K to 1 V/K
Absolute accuracy	Better than 5%

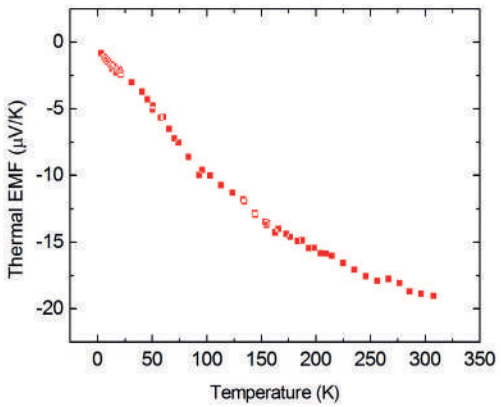
Thermal Conductivity of Copper

For pure metals the thermal conductivity is dominated by free electron contributions. At very low temperatures the thermal conductivity rises linearly with temperature due to the increasing number of free electrons. As the temperature is increased further the thermal conductivity falls due to increased scattering from phonons. As a result a maximum is developed near to 20 K. The height and position of this maximum is determined primarily by the density of impurities, which are the dominant source of scattering at low temperatures.





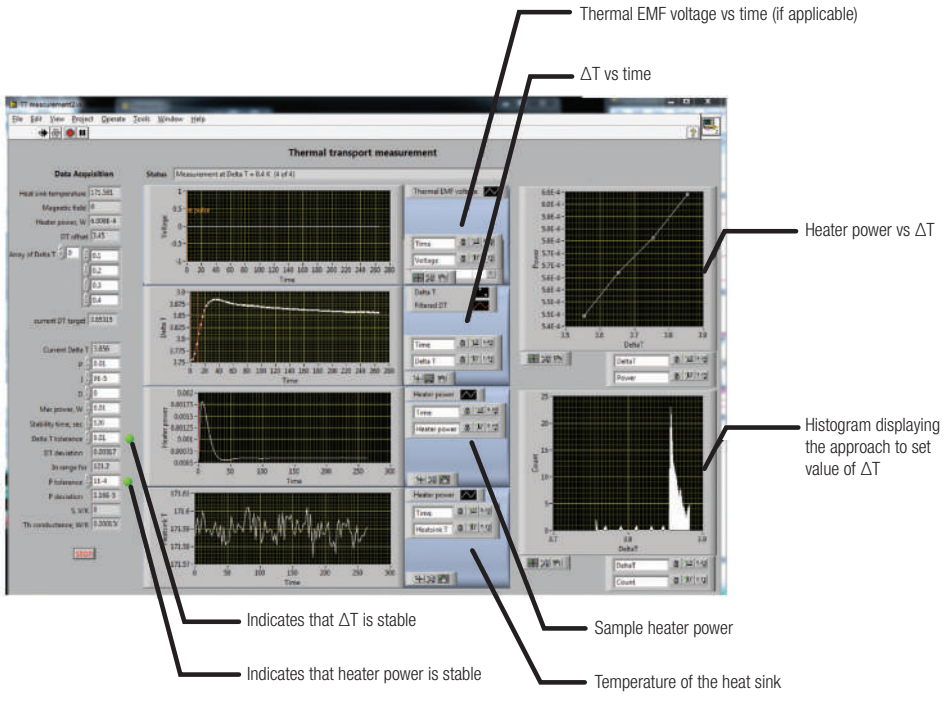
Thermal EMF of a copel (copper-nickel alloy) sample



Thermal EMF of nickel thin film

The thermal EMF is measured simultaneously with the thermal conductivity. From these measurements and the resistivity measurements the software automatically calculates the thermoelectric figure of merit.

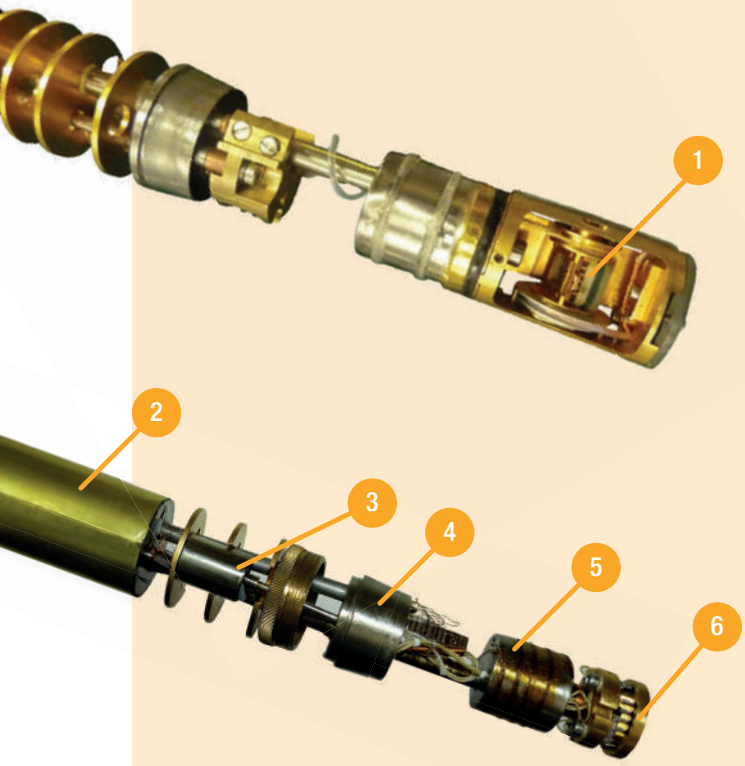
The best results in terms of the measurement accuracy and speed are obtained using a differential method. The system is set to generate a predefined temperature difference ΔT across the sample, and measures the required heat power P. The process is repeated for several values of ΔT and the thermal conductivity is calculated from the slope of P vs ΔT. The measurement procedure is fully automated. The appearance of the software procedure is shown in the figure.



^{3}He Refrigerator With 300 mK Base Temperature

Using only the cooling power of the VTI and two internal temperature-controlled sorption pumps, the sample platform of the Helium-3 Insert can be maintained at any temperature from 300 mK to above 300 K. The insert fits inside the CFMS variable temperature space and has a working volume of liquid ^{3}He of approximately 1.5 cc. The standard insert features a gold-plated copper sample mounting surface, with a central tapped hole for mounting of sample sockets. An adaptor is provided to allow the use of standard resistivity sample mounts.

Parasitic ^{3}He Probe Ends



Key

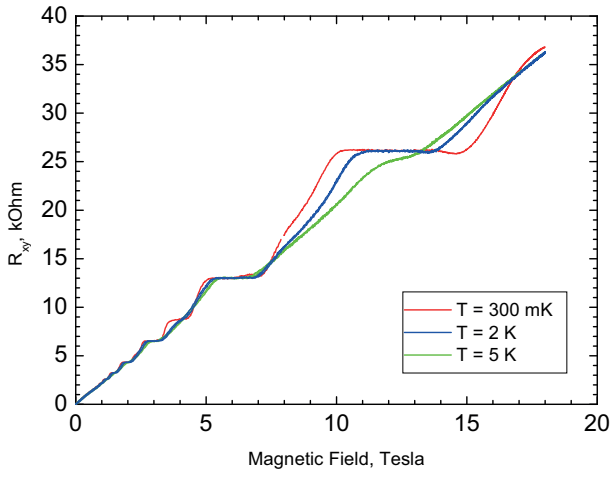
1. Rotating Sample Stage with 20-pin LCC socket
2. Main Sorption pump
3. Exchange Gas Sorption pump
4. Stainless Steel Conical Seal
5. ^{3}He Pot
6. Standard Sample Stage with 6-Pin Plug-in

Performance

- » Better than 300 mK base temperature
- » Sample in vacuum
- » Top-loads directly into the VTI
- » ^{3}He condensation stage cooled by VTI
- » Typically 24 hours hold time

Key Features

- » ^{3}He is permanently sealed within the insert, this prevents accidental gas loss
- » Sample space: 16 mm diameter, 15 mm length
- » No mechanical pumps required for probe operation
- » A range of sample platforms with different contact configurations available
- » Optional rotation stage
- » Fully compatible with DC and AC resistivity options

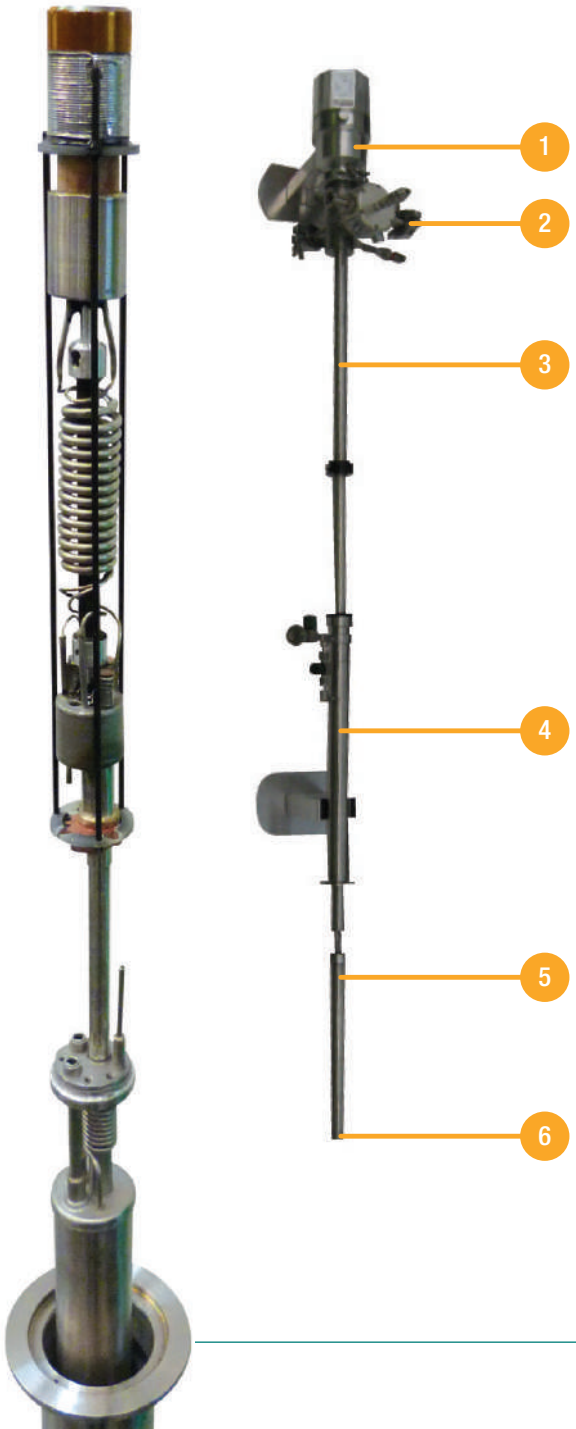


Hall resistance measurement of an GaAs-AlGaAs quantum well. Individual Landau levels are clearly resolved when the measurement is carried out at 300 mK.

Dilution Refrigerator With Base Temperature 50 mK

The Cryogenic Dilution Refrigerator is designed to work within the variable temperature insert. The cooling power of the VTI is used for initial mixture condensation and for continuous circulation mode. The sample platform of the Dilution Refrigerator can be cooled to temperatures below 50 mK in a magnetic field of up to 18 T. The base temperature under constant magnetic field rises only a few mK in comparison with the zero field condition.

The insert features an ultra-low temperature sample socket which is easily accessible through the bottom of the cone seal for sample exchange.



Performance

- » Base temperature <50 mK
- » Cool down from room temperature to 50 mK within 8 hours

Key Features

- » Sample space 12 mm in diameter
- » Simple access to sample space through conical seal
- » Standard six-pin sample plug-in mounting
- » Three twisted pairs for sample connections fitted as standard
- » Compatible with our standard 30 mm VTI
- » Calibrated resistance sensor fitted to mixing chamber
- » Additional calibrated thermometers for different temperature stages
- » Integrated high vacuum cryopump controllable with a heater
- » Software for operation/data logging with LakeShore 372 resistance bridge
- » Automated gas handling system
- » Fully compatible with DC and AC resistivity options

Key

1. TurboMolecular Pump for ^{3}He Circulation
2. Probe Instrumentation Connectors
3. Still Pumping Line
4. Airlock
5. Indium Seal
6. Inner Vacuum Can (IVC)

System Specifications

Cryogen Free Integrated Variable Temperature Insert

Sample space	30 mm	
Temperature range (with continuous gas flow in VTI)	1.6 K to 400 K	
With optional inserts (not available for all measurements):	Up to 1000 K with heated sample platform. Down to 0.3 K with Helium-3 insert.	
Temperature control: (with LakeShore series unit)	5 mK @ 10 K 10 mK @100 K 50 mK @ 300 K	
Typical sample cooldown time to 1.6 K	60 minutes	
Temperature stabilisation time for a typical 10 K temperature step	Accuracy: ± 1 K ± 0.1 K ± 0.01 K	Set time: 1 minute 10 minutes 15 minutes

Mini CFMS

Maximum magnetic field	3 – 7 Tesla
Central field homogeneity for VSM	0.1% over 1cm x Ø 1cm cylinder at field centre
Persistent mode decay rate	10 ppm/hr
Cooldown time	< 12 hours
System continuous operation	30,000 hours

Standard CFMS

Maximum magnetic field	9 – 18 Tesla
Central field homogeneity for VSM	0.1% over 3 cm x Ø 1 cm cylinder at field centre
Persistent mode decay rate	30 ppm/hr
Cooldown time	24 – 48 hours
System continuous operation	30,000 hours

AC Susceptibility

Maximum AC field	20 G at 100 Hz
Sensitivity at 1 kHz	10^{-7} emu at 4 K
Useful range of frequency	1 Hz to 20 KHz
Maximum sample size	<6 mm diameter

700 K Resistivity

Temperature range	200 K – 700 K
Standard sample size	10 mm × 10 mm square

Vibrating Sample Magnetometer

Vibration amplitude	Typically 2 mm
Vibration frequency	Typically 20 Hz
Maximum sample space	<6 mm
Optimum sample size	2 mm sphere
Noise base (10 sec averaging)	1 x 10^{-6} emu RMS
Dynamic range (standard)	10^{8}
Accuracy and reproducibility	0.5 % with 2 mm sphere
RMS noise level	2 x 10^{-6} emu/√Hz + B x 5 x 10^{-7} emu / T /√Hz

700 K VSM and ACS

Standard temperature range	200 K – 700 K
Sample size	5 mm x 5 mm x 5 mm

1000 K VSM

Standard temperature range	200 K – 1000 K
Sample size	5 mm x 5 mm x 5 mm

Resistivity and Hall Effect

Maximum sample size	5 mm x 10 mm
Supply current range	1 nA to 1 A
Resistance measurement range (DC)	100 nΩ to 1 GΩ
Voltage sensitivity	10 nV to 100 V
Accuracy of resistance measurement	< 0.1% 1-10^{6} ohm

Thermal Transport

Temperature range	2 – 350 K
Range of thermal conductance measurement	1 µW/K – 1W/K at 300 K 0.1 µW/K – 10 mW/K at 10 K
Absolute accuracy	Better than 5%
Range of thermal EMF measurement	1 µV/K to 1 V/K
Absolute accuracy	Better than 5%
Typical sample size	1 mm x 1 mm x 10 mm

Heat Capacity: AC Calorimeter

Typical sample mass	1 µg to 200 µg
Temperature range	3 K to 300 K
Frequency	0.1 to 100 Hz typical
Amplitude	0.01 to 0.1 K
Sensitivity	1 nJ/K at 10 K
Typical sample size	0.1 mm x 0.1 mm x 0.1 mm

Heat Capacity: Relaxation Method

Sample mass	1 mg to 200 mg
Larger sample size	typically 1 mm^3
Sensitivity	1% of full signal
Temperature range	3 K to 300 K

Ultra-Low Field

Supply current range	± 300 mA
Range	20 – 30 mT
Accuracy	10^{-4}
Step size	1 µT

Dilution Refrigerator

Base temperature	<50 mK
Cooldown time from room temperature to 50 mK	300 K – 50 mK in less than 8 hours
Sample space	12 mm diameter Compatible with standard 6 pin resistivity plug-ins

^{3}He Insert: Standard and Rotating

Base temperature	<300 mK
Working temperature range	<300 mK – 325 K
Outer diameter	28 mm (to suit 30 mm VTI)
^{3}He capacity	Total ^{3}He gas volume 1.5 STP litres. Working volume in normal use approx 1.0 STP litres.
Initial cooldown time	2 hours from room temperature sample change to ^{3}He condensation temperature under standard cryogen-free VTI operating conditions
Recondensation time	25 minutes to condense 90% of ^{3}He charge and cool pot to below 2 K
Performance	24 hours at 285 mK with zero load. 12 hours at 340 mK with 25 µW load. 2 hours at 550 mK with 185 µW load.

“Cryogenic Ltd was very responsive to our demands, and we are very pleased with the final product. The magnet has been a great success for us, and we are very happy with its operation. The first scientific results published using this equipment appeared in Nature Physics in 2012 (J. Chang et al., Nature Physics 8, 871 (2012)).”

Dr. Elizabeth Blackburn
Lecturer in Condensed Matter Physics
University of Birmingham

Customer Support

The Cryogenic Customer Support team is committed to quickly and effectively addressing and resolving questions regarding your system. Customer Support staff are available Monday through to Friday from 9:00 AM to 6:00 PM to answer calls and respond to your emails. Cryogenic Ltd uses skills-based routing to ensure that specialized technical engineers are available to address your question. Free Technical support service is also available by e-mail to respond to your concerns and provide support needed for successful running of your system.

Please contact our customer service team if you have any concerns using sales@cryogenic.co.uk or complete the customer service form on our website at www.cryogenic.co.uk.

Pre-Sales Technical Support

For customers with special requirements our team of experienced physicists and engineers can design and build complex and very sophisticated Cryogenic magnet systems.

Our experienced sales team and technical design staff are always happy to discuss customer requirements in this specialised technology based on our more than 30 years in-depth experience.

After Sales Support

Cryogenic has a philosophy to ensure that the systems delivered are installed and used correctly in order to safeguard the customer's investment. Cryogenic's dedicated installation team, based in key locations around the world and at our Head Quarters in the UK, are hugely experienced and boasts detailed knowledge of the complete running of the system.

We have a service team in many international regions, including China, India, Japan, USA and Germany.

Once installed, the user is trained on how to operate the equipment and, of equal importance, how to carry out basic maintenance, thereby reducing service call-outs and prolonging the life of the equipment. Cryogenic has a dedicated training team which takes on these tasks and has vast experience suitable training methods, staff issues and potential pitfalls.

Remote Assistance

All critical parts of our systems are fitted with diagnostic sensors, and the diagnostic information is automatically logged in the background as the system operates. If a customer has difficulties running the system, or has questions about particular measurements or experiments, our engineers can use remote connection to the system computer in order to perform a comprehensive check of the system's performance, and to provide advice and assistance.

Software Upgrades

We continually work on improving the functionality of the system control software. If you wish to check for updates, please contact the software team for support and assistance.

Cryogenic World Wide Network

For locations of our global agents, please visit - www.cryogenic.co.uk/contacts/worldwide-agents-and-partners

Service and Maintenance

To give confidence to our valued customers and a peace of mind, Cryogenic Ltd offers a number of service and maintenance contracts, up to a 10 year period.

The contracts can be tailored according to customer requirements, which can include;

Telephone Support

- Customer support team available on call 5 days a week.
- Any technical requests for support will be provided by a suitable technical engineer

Preventative Maintenance Visits

- Regular site visits by a field service engineer to extend equipment life. Equipment is checked, cleaned and configured to ensure that it continues to perform to the highest possible standards.

Emergency Call-Outs

- Our engineers are located internationally to respond quickly within the response time set.
- Our Field Service Engineers arrive with sufficient tools and spares and endeavour to complete any work in a single visit.

Workshop Repairs

- Any products that cannot be repaired on site are returned to Cryogenic Ltd headquarters for review or return to manufacturers as required.
- The product is given priority status, repaired and re-installed as soon as possible.
- We aim to ensure minimum downtime to the system.

Replacement And Spare Parts

- If your system requires any spares or replacement parts, these are included in the contract.
- Consumables are excluded.

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