

Product Brochure

Pulsed Field Magnetometer (PFM) 8th generation – PFM08

The PFM08 range of magnet characterisation magnetometer can accurately measure the magnetic hysteresis loop and extract key values for all high-grade magnetic materials such as NdFeB, SmCo and coated magnets. With a maximum field of 10.5T (8356 kA/m / 105 kOe) even the most coercive materials and highest grades of NdFeB or SmCo can be measured, while traditional permeameters cannot measure these high coercivity materials due to pole piece saturation limitations. The 8th generation of PFMs from Hirst uniquely feature the eddy current correction (patented F-2F algorithm), Self-Demagnetisation Field (SDF) correction function (to allow accurate measurement of a wide range of samples from cylinders, cuboids and arbitrary sample shapes), and Hirst proprietary Self De-magnetisation Field Function SDFF™ (patented) which accurately generates an open to closed circuit mapping (O2C™). The first generation of Hirst industrial PFM was launched in 1998 and the company won an Institute of Physics business award for the SDFF™ technology in 2020. HirstLab v2.0 software and Hirst proprietary SDFF™ technology has been implemented in collaboration with the National Institute of Metrology (NIM), Beijing, as part of a contract for the first 8th generation PFM placed by NIM.



PFM08-10 AT

PFM08-10 HT

PFM08-40 HT / MT

PFM08-70 HT

Key benefits

- All high-grade permanent magnets can be fully characterised such as NdFeB (inc AH), SmCo and coated magnets
- Full 4 quadrant measurement of magnetic hysteresis loop, full BH curves
- Can test samples that are magnetised or unmagnetised
- The PFM contains an integral capacitive discharge magnetiser (and demagnetiser) producing a field of over 10T meaning the highest grades of permanent magnetic material can be tested (which is not possible on traditional permeameters)
- User friendly HirstLab v2.0 software for fast precise measurements
- HirstLab v2.0 software automatically extracts critical parameters: Remanence: B_r , Coercivity: H_{cj} , H_{cB} , Maximum energy product: BH_{Max} , Saturation values: H_{sat} , J_{sat} , Squareness Coefficients: H_k , H_k/H_{cj} , S_a , and more are all automatically extracted from every measurement and displayed separately alongside JH and BH loops.
- Unique Self Demagnetisation Field Function SDFF™ in HirstLab v2.0 which accurately generates an open-to-closed circuit mapping (O2C™) for the magnet sample giving accurate closed loop magnet parameters. Generation 8 PFMs give permeameter-like measurements for the highest grades of magnets
- Range of sample sizes: 1x1x1mm to 70mm as standard and larger sample sizes on request.
- Sample shapes: cylinder, cuboid, and arbitrary shapes with built in Self-Demagnetisation Field (SDF) shape correction function.
- Precision sample temperature measurement with integral high precision temperature control:
 - Temperature measurements from -5°C to +5°C of room ambient (23 °C) for AT models on standard samples
 - Up to +230°C on some HT models
 - Down to -40°C for the PFM08-40 MT
- Temperature control precision near ambient of $\pm 0.2^\circ\text{C}$
- Repeatability better than $\pm 0.2\%$ at ambient temperature for H_{cj} and B_r on standard samples
- Meets IEC (International Electrotechnical Commission) TR-62331 specifications for permanent magnets which is a non-destructive testing method.

Applications

- Designed for characterisation of hard magnetic materials in both production control and research applications. for all permanent magnet materials (Ferrite, NdFeB, SmCo, AlNiCo) including high grade NdFeB coated samples
- Thin sample mode for accurate measurement of 8mmx1 and 10mmx1 and thicker slices for GBD testing on 08-10 and 8-40. The small sample size of 1x1x1mm supports measurements of grain boundary diffusion (GBD) samples and the large sample PFMs support quality control applications in EV manufacture with samples sizes up to 70mm.
- The ambient temperature (AT) versions of the PFM are ideal for production testing and quality control.
- Some high temperature versions support measurement up to 230°C for development and quality control.
- Low temperature versions support measurements down to -40°C for materials research.

Hirst Pulsed-Field Magnetometry systems

Designed for industrial use, the PFM offers fast, accurate, full hysteresis loop measurements of all industrial magnets, with unparalleled speed and repeatability. Capable of non-destructive testing and characterisation of industrial permanent magnet materials in a rapid, non-contact, open circuit process. The process needs no pre-magnetisation of magnets (unlike permeameters) and can deliver a magnetised or demagnetised magnet at the end of the cycle.



Above: PFM08-10 AT sample holder stick, A PFM08-10 AT in operation. Samples stick storage on the side of the PFM08-10 and sample temperature measurement displays.



Above: PFM08-40 HT in operation showing the semi-automated sample loading mechanism.

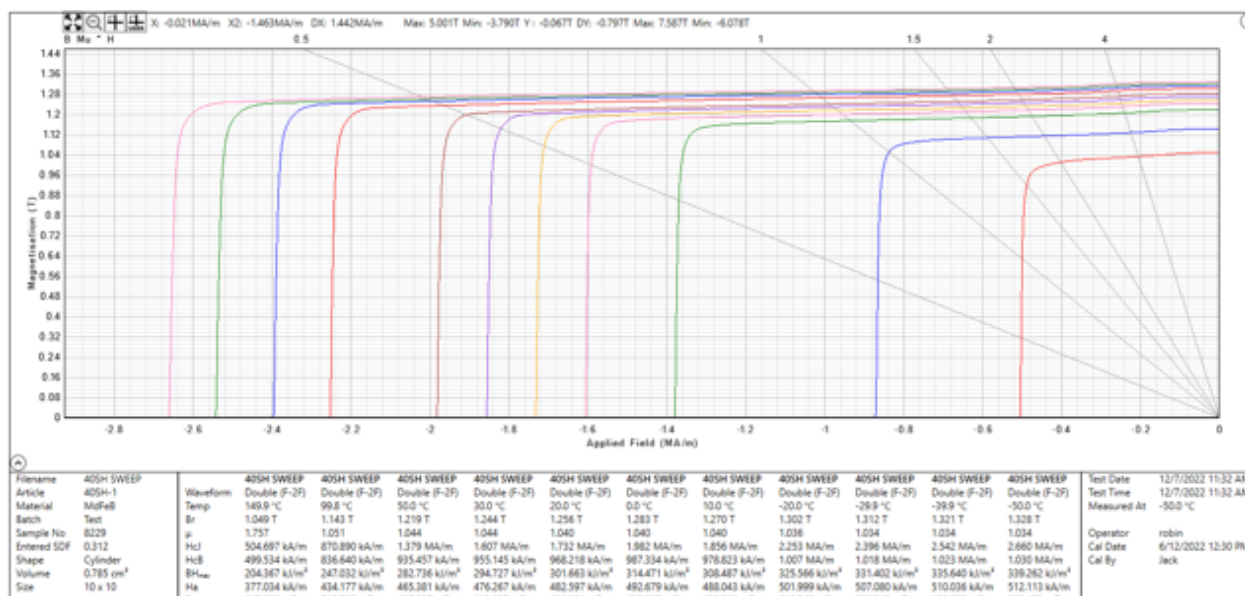
The generation 8 PFMs can measure manually loaded virgin or pre-magnetised permanent magnets and measure their full 4 quadrant hysteresis loop in a fraction of the time taken by any other technique. The system offers repeatability of measurements at speeds that are simply unattainable with other methods of measurement.

Operation

The measurement process involves generating large pulsed magnetic fields. These pulsed magnetic fields drive the magnet around its major hysteresis loop. Suitably placed pickup coils detect the applied field and the magnets response to the applied field. J and H signals are fed to the PC where they are processed to form JH and BH loops representing the characteristics of the material.

Temperature control and monitoring

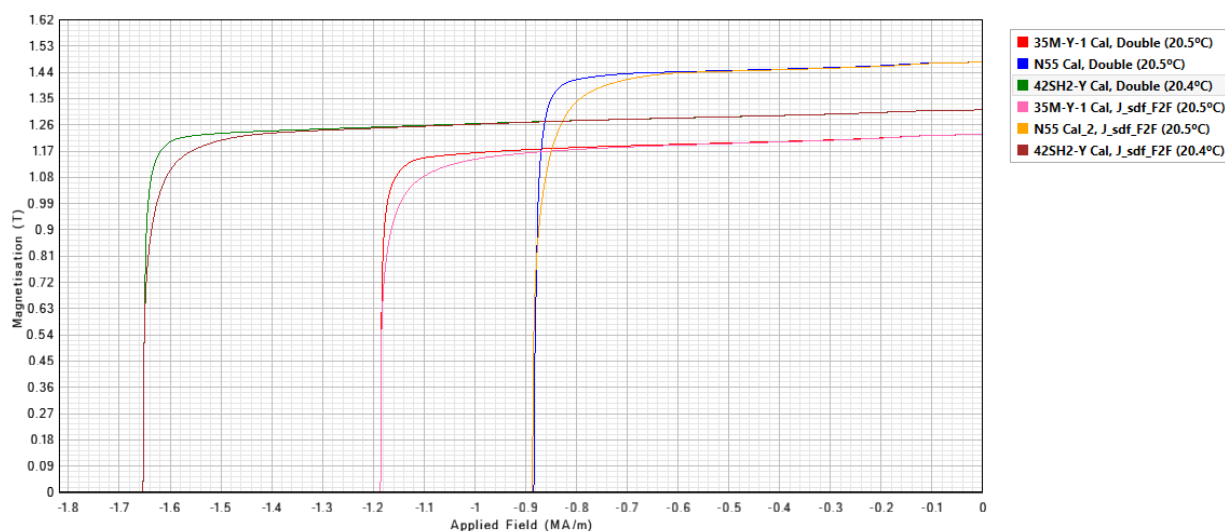
The system has been specifically designed to operate at high temperatures to provide measurements up to 230°C for certain HT models.



The above graphs show the 2nd quadrant demagnetisation curves from measurements of the same magnet at various temperatures, from +150°C (230°C is the maximum for certain HT models) down to -40°C, produced on the PFM08-40 MT.

Easy to use software

All Hirst PFM systems are supplied with comprehensive software, HirstLab v2.0. The HirstLab software combines all of Hirst's expertise and PFM technology into a single, easy-to-use package. The software manages the operation of the machine and maintains a database with the history of all measurements. A flexible plotting tool provides multiple views of the measured data.



The above figure shows SDF corrected demagnetisation curves plotted alongside the SDF™ permeameter equivalent curve. It is straight forward to select many other views of the data as required.

All the PFM's functions are accessible through the user interface including the extensive data processing and storage features. The software follows similar design to many other applications that run on Microsoft Windows™ creating a familiar environment and reducing the time to learn the software.

HirstLab v2.0 can produce a detailed report describing the characteristics of the measured sample or a summary report from a set of measurements.

Measurement database for 100% traceability

A measurement database stores every measurement made on the system ensuring 100% traceability and making it impossible to lose a measurement. A more traditional system of entering filenames is also available but it is not a requirement to use it. Especially useful for industrial quality assurance (QA) and similar applications. The database can be stored on a central server so that multiple PFM machines can be monitored from a central location. The database supports filtering through a range of parameters such as operator name, sample data etc, which allows easy recollection of any previous data.

Along with a measurement database HirstLab v2.0 also provides a sample database. Details of sample properties, dimensions, and required measurement parameters can be stored. When a measurement of that sample is taken the measurement settings are automatically set-up based on the parameters stored in the sample database. The sample details are also used in the processing of data to produce JH and BH loops that are calibrated to unit volume.

Article Name	Material	Description	Shape	Dim A	Dim B	Dim C	Volume
44H-1	NdFeB		Cylinder	10	10	0	0.785398
45M-1	NdFeB		Cylinder	10	10	0	0.785398
45SH	NdFeB	45SH Hirst Standard	Cylinder	10	10	0	0.7853
45SH2-Y-1	NdFeB	NIM 2020 standard	Cylinder	1.0047	1.0035	0	7.946
46H-1	NdFeB	NIM Standard	Cylinder	9.902	10.021	0	0.772
48H-1	NdFeB		Cylinder	10	10	0	0.785398
48H#5	NdFeB	Hirst standard #5	Cylinder	10	10.02	0	0.78542
48M-1	NdFeB		Cylinder	10	10	0	0.785398
48SH-1	NdFeB	NIM Standard	Cylinder	10	10	0	0.785398
50M-Y-1	NdFeB		Cylinder	10	10	0	0.785398
52H-1	NdFeB		Cylinder	10	10	0	0.785398
52M-1	NdFeB		Cylinder	10	10	0	0.785398
AM-1	NdFeB		Cylinder	10	10	0	0.784
AM-2	NdFeB		Cylinder	10	10	0	0.785398
BE108	N42	Bunting coated cylinder	Cylinder	4.9	14.98	0	0.863593
BE113	N42	Bunting coated cylinder	Cylinder	4.98	24.98	0	2.440642
BE114	N42	Bunting coated cylinder	Cylinder	4.95	29.95	0	3.487295
BE336	N42	Bunting coated cylinder	Cylinder	4.96	20.07	0	1.569156
BE641	N42	Bunting coated cylinder	Cylinder	4.99	4.94	0	0.095641
BE645	N42	Bunting coated cylinder	Cylinder	4.92	9.94	0	0.381792

Automatically extracts critical measurement parameters

Remanence: B_r , Coercivity: H_{cj} , H_{cb} , Maximum energy product: BH_{max} , Saturation values: H_{sat} , J_{sat} , Squareness Coefficients: H_k , H_k/H_{cj} , S_a , and more are all automatically extracted from every measurement and displayed separately alongside JH and BH loops.

Data export facilities

Comprehensive data export facilities allow data to be easily migrated to other software applications. Exporting to .csv, .JSON, and .nc and more formats is supported.

Full graphical display

The software can simultaneously display multiple loops in either one or multiple windows for easy comparisons. A comparison function is available for the demagnetisation quadrant to highlight any differences between measurements. Data is also available as a hard copy via a printer and can be displayed with a choice of S.I. and/or c.g.s. Units and a fully customisable report format.

Range overview

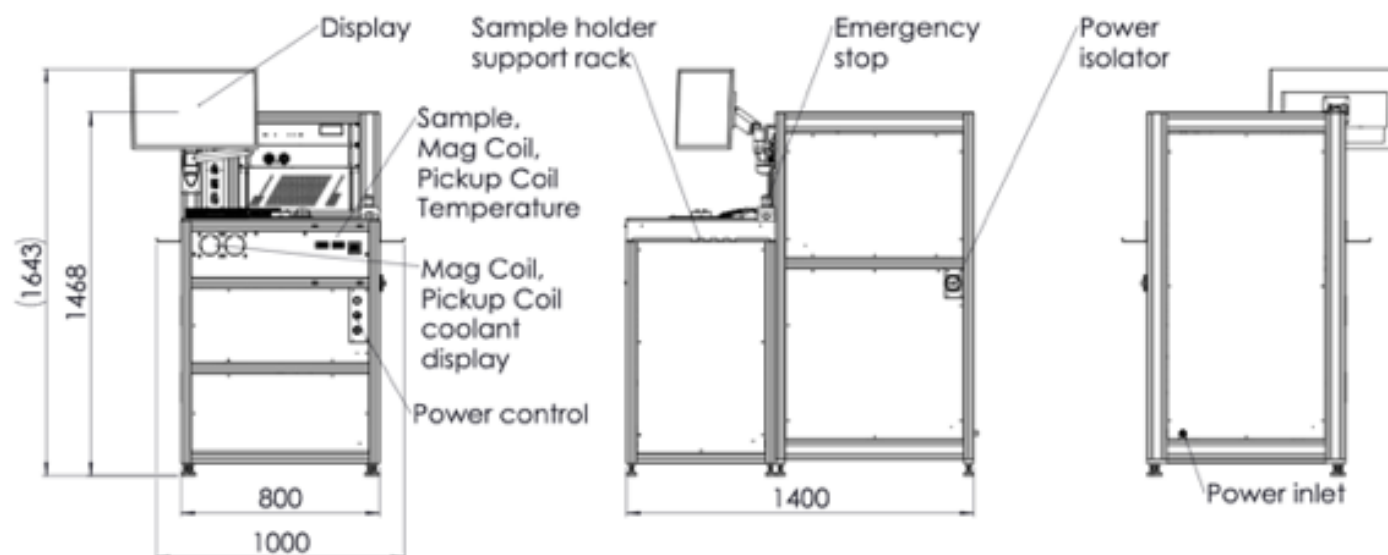
Product Number	Sample size	Sample Management	Typical Application
PFM08-10 AT +20 MH	5-10mm diagonal, 1-20mm height	Manual	Magnet supply chain with thin sample mode for GBD with optional small sample kit samples down to 1x1x1mm (ambient testing)
PFM08-10 HT +20+200 MH	5-10mm diagonal, 1-20mm height	Manual	Magnet supply chain with thin sample mode for GBD with optional small sample kit samples down to 1x1x1mm (ambient testing) and optional 220DegC stick for thin and larger samples
PFM08-40 HT+20+220 AH	5-40mm diagonal, 1-30mm height	Automatic	Modular PFM for use in magnet supply chain with thin sample mode for GBD with optional small sample kit for samples down to 1x1x1mm - also ideal for magnet user quality control
PFM08-40 MT -40+220 AH	5-40mm diagonal, 1-30mm height	Automatic	National labs and materials research and thin sample for GBD with small sample set options for 1x1x1mm
PFM08-70 HT +20 +230AH	5-70mm diagonal, 5-20mm height	Automatic	Magnet supply chain and magnet user quality control

Technical data

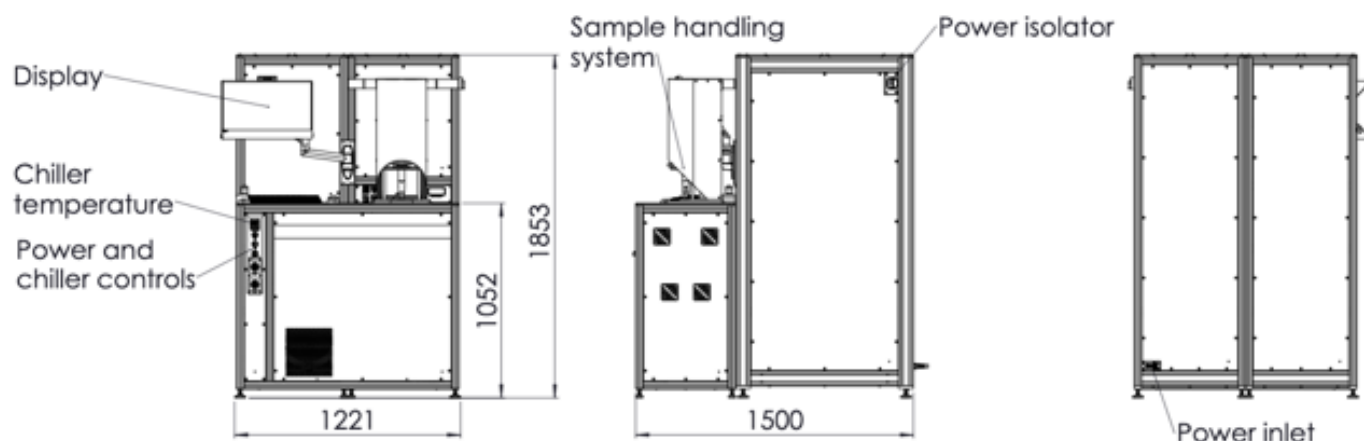
Magnetisation pulse	Full period sine wave
Magnetiser Energy, Voltage and Peak field	PFM08-10: 9kJ, 3000V, 10T peak (7958kA/m / 100k Oe) PFM08-40 and 08-70: 45kJ, 3000V, 10.5T peak (8356 kA/m / 105k Oe)
Eddy current removal	Compensation for linear and non-linear rate dependant effects via Hirst proprietary F-2F algorithm
Field correction	Built in Self-Demagnetisation Field (SDF) shape correction function
Permeameter equivalent curve	Hirst proprietary Self De-magnetisation Field Function SDF TM which accurately generates an open to closed circuit mapping (O2C TM) for the magnet sample giving accurate closed loop magnet parameters
Standard Sample sizes	PFM08-10 test area 5-20mm diagonal, 1-20mm height (optional small sample kit down to 1x1x1mm) PFM08-40 test area 5-40mm diagonal, 1-30mm height (optional small sample kit down to 1x1x1mm) PFM08-70 test area 5-70mm diagonal, 5-20mm height (upper sample volume limit of 12,000mm ³)
Sample shapes	Cylinder, cuboid, any prism with flat top and bottom surfaces. Small sample and arbitrary shapes can also be measured with sample support shoes to ensure good thermal contact for sample temperature accuracy. Thin sample mode on 08-10 and 08-40 for testing thin slices (GBD)
Sample temperature stabilisation*	PFM08-10 AT: $\pm 0.5^{\circ}\text{C}$ (sample at ambient) PFM08-10 HT : $\pm 0.2^{\circ}\text{C}$ (sample at ambient) PFM08-40 HT / MT and PFM08-70 HT: $\pm 0.2^{\circ}\text{C}$ (sample at ambient)
Repeatability*	B_r and H_{cj} $\pm 0.2\%$ for 08-10 (ambient measurement, standard samples) B_r and H_{cj} $\pm 0.2\%$ for 08-40 (ambient measurement, standard samples) B_r and H_{cj} $\pm 0.2\%$ for 08-70 (ambient measurement, standard samples)
Display and controls	Windows 11 computer, Intel i5 processor, 1TB storage, intuitive software with simple test initiation controls and full database system, 24" HD colour monitor, wireless keyboard and mouse (supplied)
Colours and materials	Steel and Aluminium case
Dimensions / Weight	PFM08-10: 1643mm x 1000mm x 1468mm / 700kg PFM08-40: 1863mm x 1221mm x 1500mm / 1100kg PFM08-70: 1863mm x 1221mm x 1500mm / 1100kg
Connectivity	100 Mbps ethernet via RJ45, WIFI and USB

Machine Operating Temperature Range	+18 °C to +23 °C
Power Supply	PFM08-10: Single Phase 220/240VAC 50-60Hz 32A or 110VAC option Max 3m cable length PFM08-40 & PFM08-70: Single Phase 220/240VAC 50-60Hz 32A or 110VAC option Max 3m cable length (and an additional single phase 220/240VAC 50-60Hz 16A or 110VAC option for external chiller power connection is required)

*For specific sample performance data, see detailed specification document.



PFM08-10 AT and HT (above)



PFM08-40 HT/ MT and PFM08-70 HT (above)

Warranty and Calibration

Supplied calibrated with 1 year warranty. A calibration is required every year to maintain the highest levels of performance – Hirst has a dedicated team of installation and service engineers, available to travel worldwide to install and support equipment, service contracts are available. Contact your local distributor for details.

Accessories

Basic reference magnet sample packs:-

- **RM-AT** - Ambient N40H, N42SH samples with NIM certification
- **RM-HT** - contains RM-AT samples plus 100°C and 150 °C samples with NIM certification
- **RM-HT+** - contains RM-HT samples plus 180 °C sample with NIM certification



Hirst Magnetic Instruments has been active in providing solutions for 60 years in magnetics and magnetic measurement. Hirst manufactures precision hand-held gaussmeters, fluxmeters, demagnetisers, bench top & workstation industrial magnetisers, industrial production-line magnetisers, pulsed field magnetometers (PFMs) for characterising magnetic materials.

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