

MTM Seminar

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Outline



- 1. Introduction**
- 2. Measuring Range & Precision**
- 3. Split-Coil Permeameter**
- 4. Coercimeter(s)**
- 5. Foerster Probes**
- 6. Austenitic steel permeability measuring system at 4.2 K**
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Introduction

Magnetic & austenitic steel measurements for the purpose of quality control (QA) have been extensively used at CERN since the early days of the organization.

Over the years, a number of measuring systems have been built in-house or acquired.

These measurements have been done essentially for the class of materials known as soft magnetic materials, with a coercivity (H_c) ranging from 0 to few hundreds of A/m, and relative permeability (μ_r) from 1 to 100.000.

LHC Measurements (production phase)

About 20 000 measurements at Cockerill for the LHC steel
(1997 – 2006)

54 measuring session at CERN for the Austenitic steel
(2002 – 2005) 300 samples measured

Catalogue of Systems



Magnetic Steel

Permeameter Split-Coil (1 system at CERN + 1 installed at Oxybel)
Permeameter for measurements at cold. Installed in Bld 230

Coercimeter for thin sheets (Labeled LEP)
Coercimeter LHC

Both are installed in Bld 927

Austenitic Steel

Foerster probe 1.068.
Foerster probe 1.069.

These are two industrial instruments used to measure permeability up to $\mu_r=2$

Permeability measuring system at 4.2K for austenitic steel installed on Bld 230.

Measurements precision



Coercimeters	1% - 3%
Permeameter	
- permeability	1% - 2%
- coercivity	2%
Foerster probe	5%
Austenitic Steel at 4.2 K	
	3% - 10%

The Foerster probe is an industrial instrument which is calibrated against national standard.

The other systems are in house CERN fabrication.

All measurements can be done in few minutes (1 to 15) except for permeability measurements of austenitic steel at 4.2K which requires a couple of days.

Split-Coil Permeameter



Determination of the magnetic properties of low carbon steel in all common quality grades and of other soft magnetic materials. The sample is exposed to a defined magnetic field within a measuring coil.

Maximum current: ± 40 A.

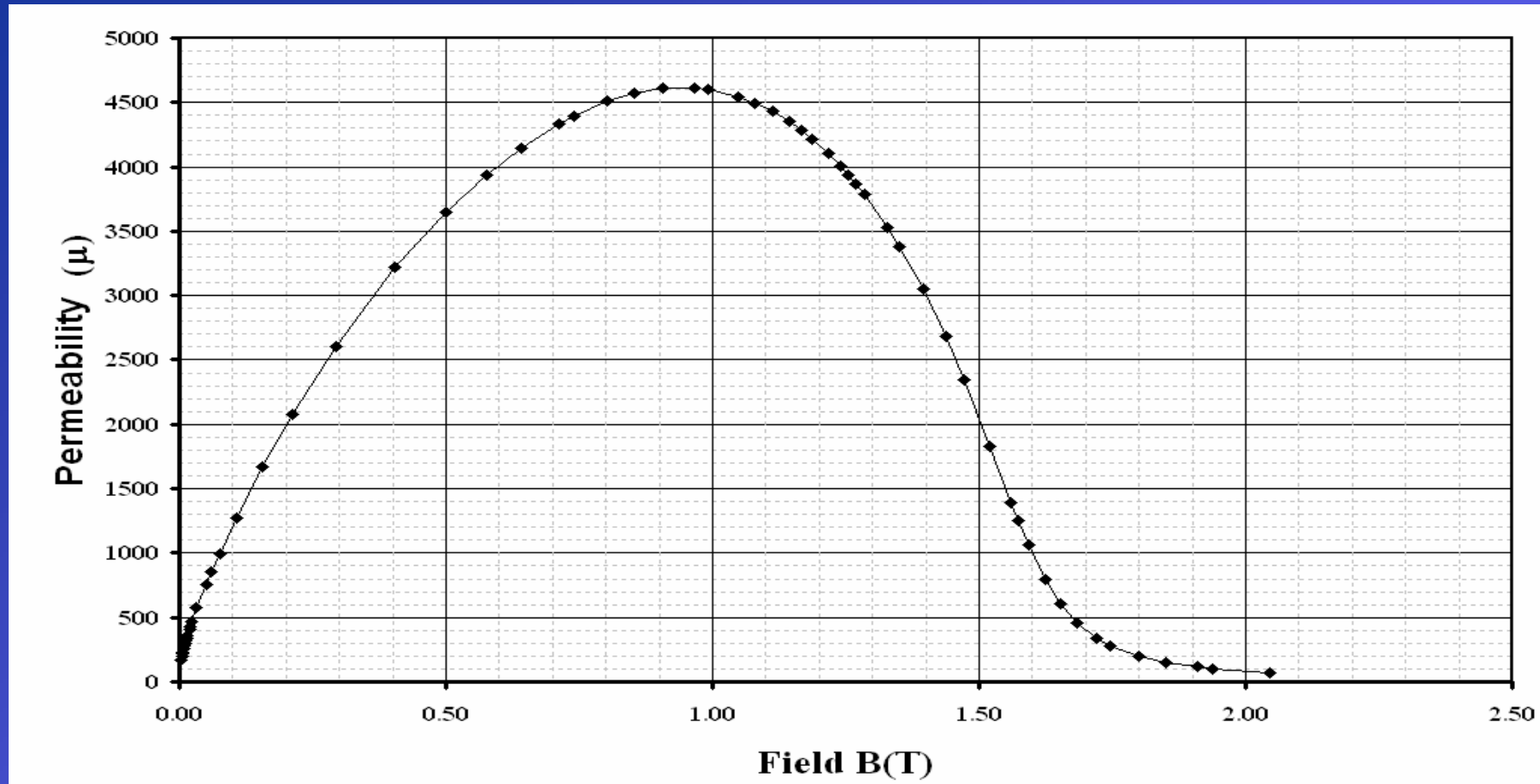
Maximum voltage: ± 15 V.

Excitation field up to 24 000 A/m

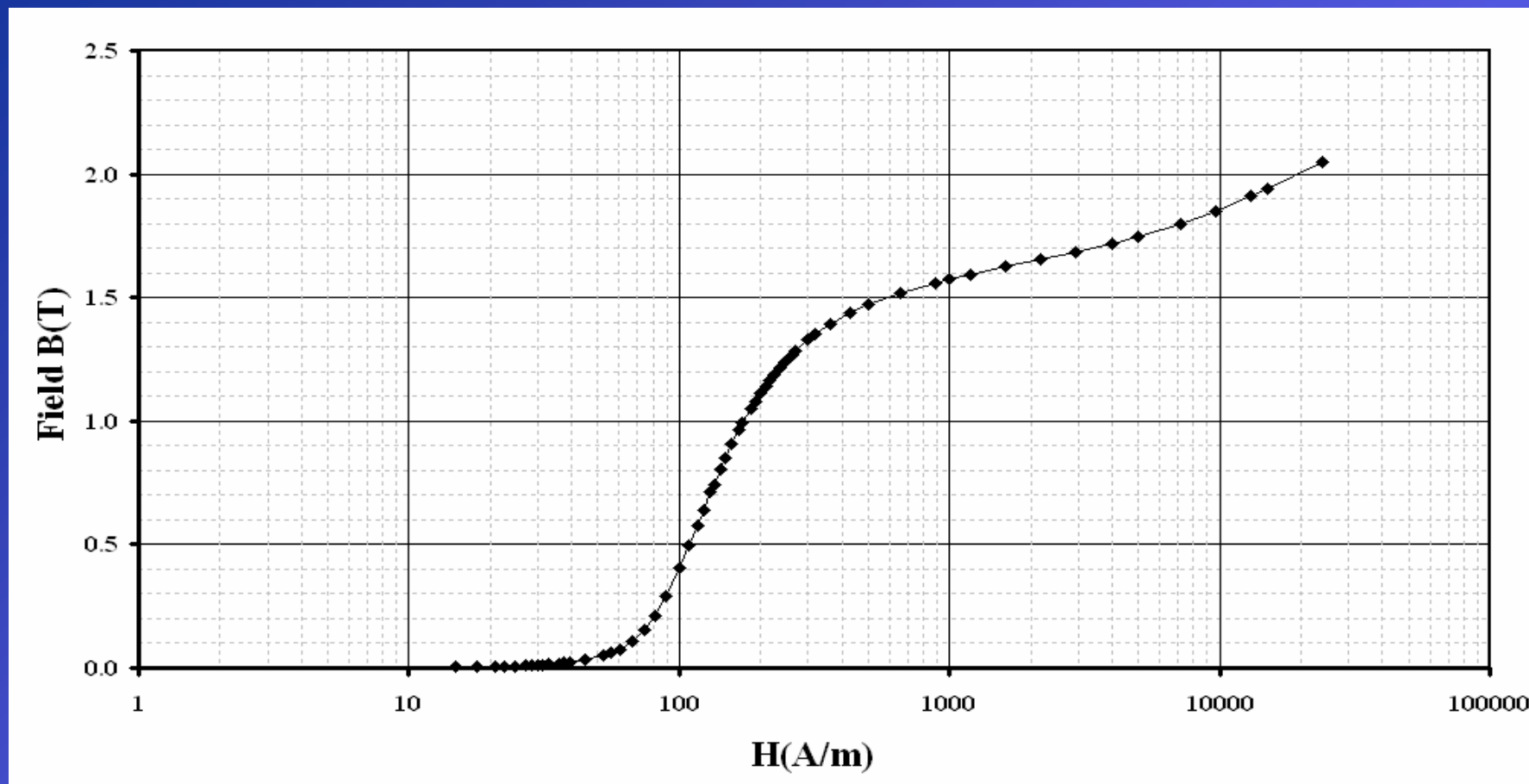
A magnetic induction is created inside the material typically up to about 2 Tesla



Split-Coil Permeameter



Split-Coil Permeameter



Coercimeters





Coercimeters

This instrument measures the coercive field H_c of sheets of magnetic material (0.5 to 6 mm thick) with a precision of the order of 3% .

The size of the hysteresis loop at zero excitation ($2 B_r$) is measured and the coercive field is then deduced from the excitation that must be applied to the material to bring the induction to zero.

The sheet to be measured is tightly held between two mumetal blocks. An induction is created in the sheet by the excitation coil. The detection coil linked to an integrating voltmeter measures its variations.



Coercimeters

The advantages of the instruments are as follows:

- Direct measurements of sheet material or of simple cut sample.
- Directional measurements to show any anisotropy of the sheet
- Rapidly. The operation that takes about 15 minutes is completely PC automated



Foerster Probe



The **FOERSTER MAGNETOSCOPI® 1.069** represent the state-of-art in permeability measurements.

Measurement of material permeabilities in the range of $\mu = 1.001$ to 2.00.

An older analogic model 1.068 is also available

Foerster Probe



Full-Scale DC Range	Resolution
Perm Range R2: $\mu = 2.000$	0.001
Perm Range R3: $\mu = 1.3000$	0.0001
Perm Range R4: $\mu = 1.1000$	0.0001
Perm Range R5: $\mu = 1.0300$	0.00001
Perm Range R6: $\mu = 1.0100$	0.00001
Perm Range R7: $\mu = 1.00300$	0.00001
Perm Range R8: $\mu = 1.00100$	0.00001

Austenitic steel permeability measuring system at 4.2K (Bld.230)

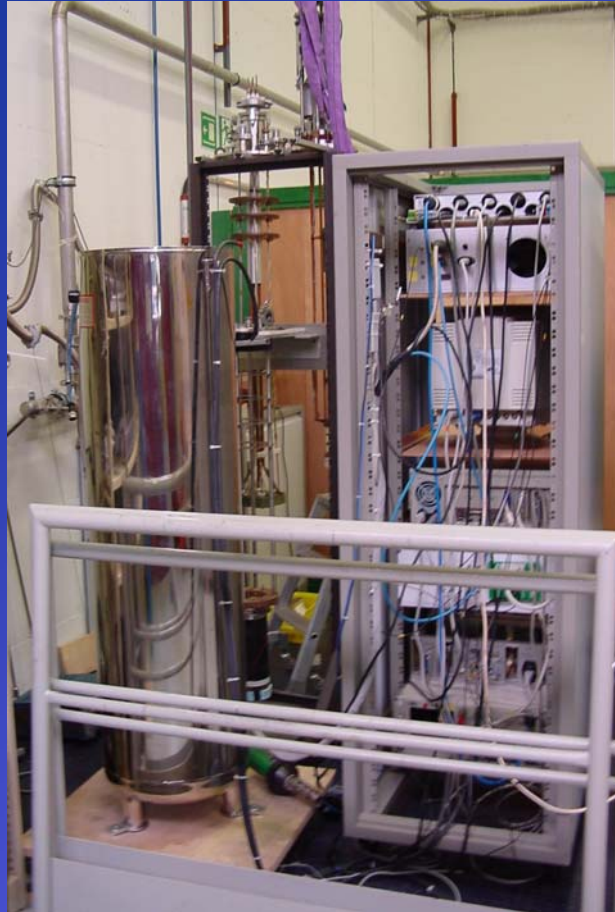
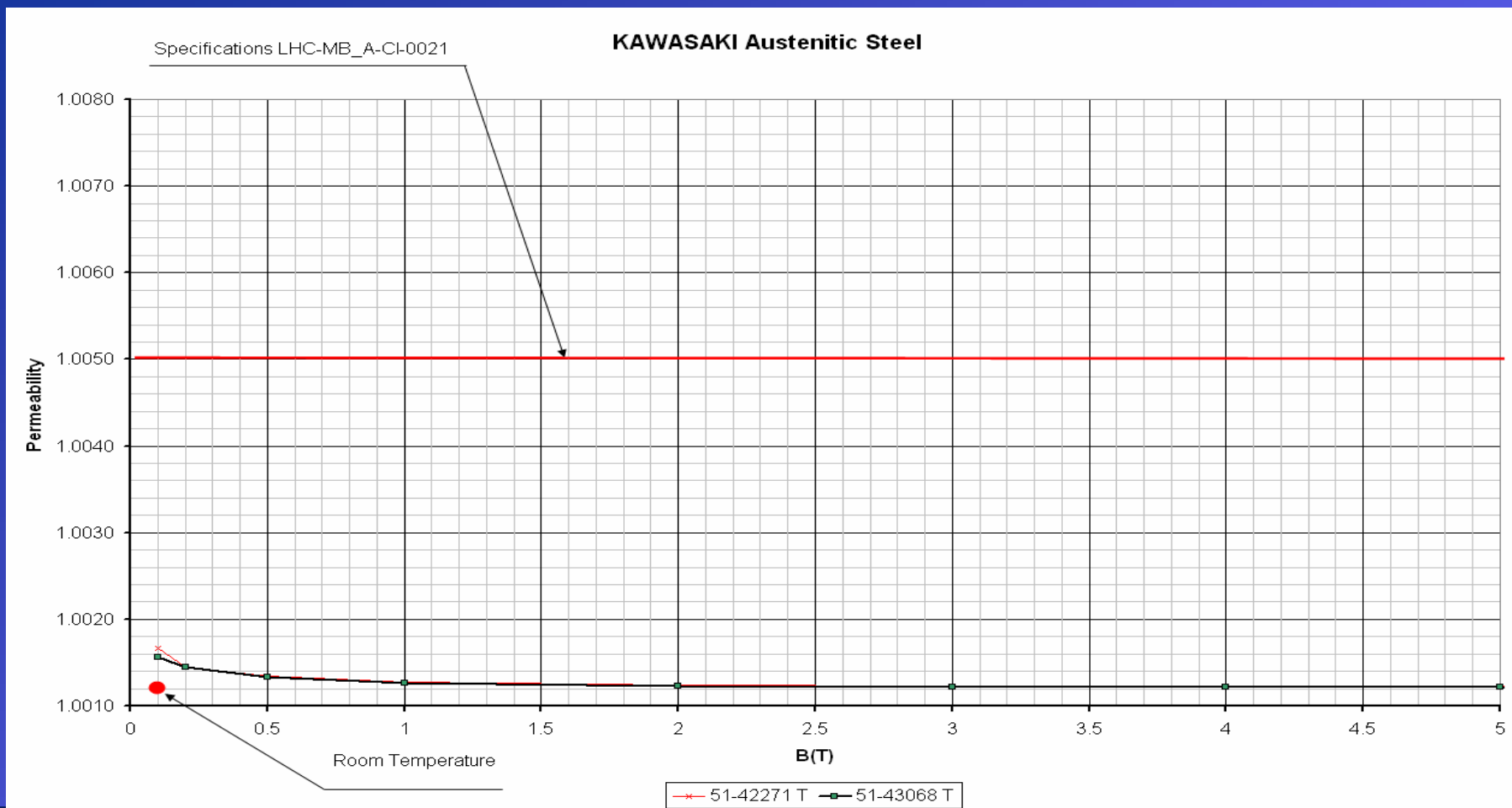


Fig. 4 Thyssen (2 mm) samples assembling



Austenitic steel permeability measuring system at 4.2K



Conclusions



CERN wide service for characterization and measurements of steel

Collaboration with external suppliers like Cockerill, Industeel etc.

Future workload estimation about 15% man-years.

A brief description of the systems is available online at:

<http://peiro.home.cern.ch/peiro/>