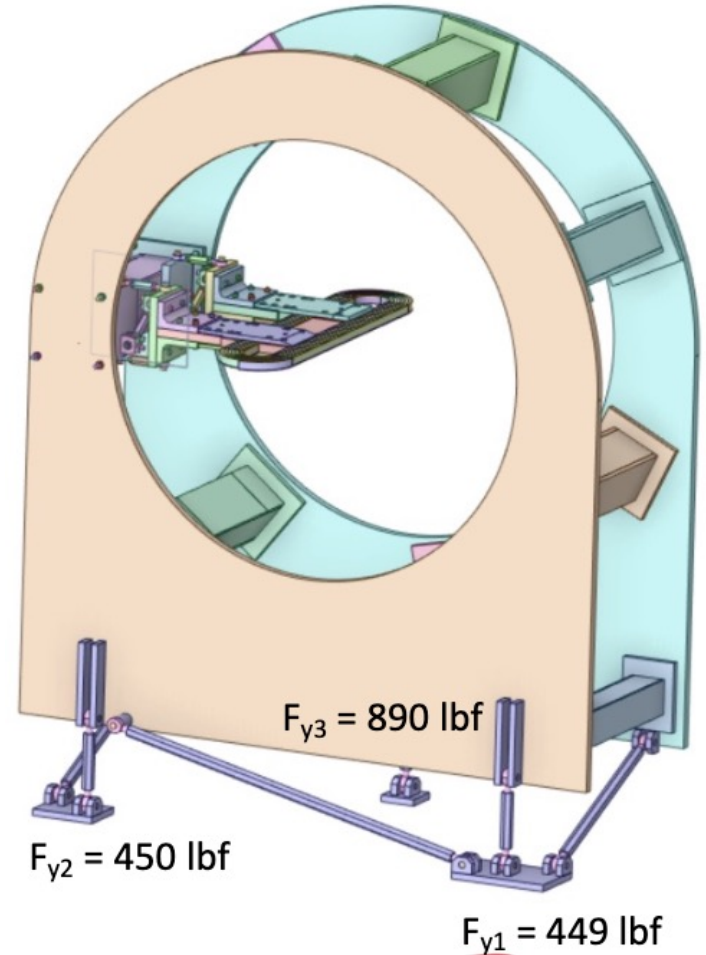


Permeability measurements

MOLLER Spectrometer
working group meeting

V. V. Berdnikov (JLab)

Feb 20 2023

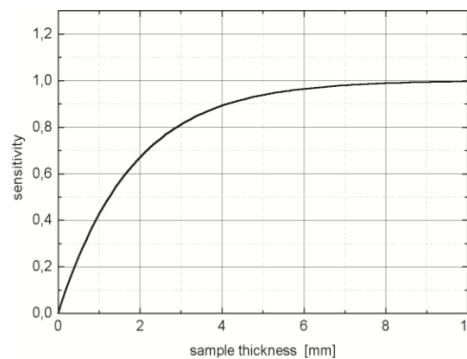
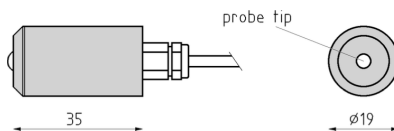



Ferromaster instrument

- Designed to measure the relative magnetic permeability μ_r of feebly magnetic material and workpieces with μ_r between 1.001 and 1.999.
- Permeability tests carried out with the FERROMASTER are compliant with the standards ASTM A342 test method 4 and EN 60404-15 method 6.
- The permeability is measured by touching the workpiece with the tip of the permeability probe and reading the result from the LC display
- Contains a small permanent magnet which magnetizes the sample to be investigated in the vicinity of the probe tip. Two sensitive magnetic field sensors in different connection measure the distortion of the magnetic field introduced by the magnetized sample.


6 Specifications

Measurement range	$\mu = 1.001$ to 1.999
Resolution	0.001
Calibration accuracy at 20 °C	$(\mu - 1) \times 5\%$, ref. to NPL calibration standards, can be readjusted
Operating temperature	0 to 50 °C
Field strength at probe tip	~35 kA/m
Battery	9 V (PP3, Alkaline)
Continuous operation with 1 battery	~50 h
Dimensions of electronics unit	151 × 82 × 33 mm ³
Environmental protection	IP65
Length of connection cable	1.5 m
Weight of complete instrument	280 g





List-Magnetik Dipl.-Ing. Heinrich List GmbH
D-70771 Leinfelden-Echterdingen · Max-Lang-Str. 58/2 · Telefon: +49 (711) 903631-0
 Fax: +49 (711) 903631-10 · Internet: http://www.list-magnetik.de · E-Mail: info@list-magnetik.de
 Sitz: Leinfelden-Echterdingen, Amtsgericht Stuttgart HRB 221 011 UST/VAT-ID No. DE 447 829 382
 Geschäftsführer / Management Board: Dipl.-Ing. (FH) Heinrich-Heiter List, Dipl.-Inform. (FH) Kai-Ingo Rogge



Manufacturer's Inspection certificate 3.1 according EN 10204

Certificate ID : LI-FM-210490
Certificate Object : Magnetic Permeability Meter Ferromaster

Manufacturer : List-Magnetik Dipl.-Ing. Heinrich List GmbH
Serial No. : 14633
Serial No. Calibration Standard : 2111
Customer : NDT Supply.com. Inc. US 66214 Lenexa, KS
Inventory No. : ---

Testing Commissioner : Frank Bartsch
Considered regulations : DIN EN 9934, ASTM A342 and IEC 60404-15, IATF16949:2016, Kap. 7.1.5.3.1 „Internal Laboratory“ is achieved
Date of calibration : 20.05.2021
Check Ambient List-Magnetik : Temperature : 21,5 ± 0,5 °C

Calibration procedure
 After offset adjustment the instrument's characteristic was adjusted to give accurate permeability readings for low permeability to the permeability standards 3121 and 3122 supplied by Institut Dr. Foerster GmbH & Co. KG and reference block 3118 supplied by the National Physical Laboratory (NPL, Teddington UK). The probe tip was oriented towards the center of a flat side of the reference blocks.
 The permeability value of the calibration standard which is supplied with this instrument was then measured with the calibrated instrument.


Foerster permeability standard 1,005	: Inv.No. 3121, S/N 11138
Calibration Certificate Foerster	: DM2020299 dated 24.07.2020
Foerster permeability standard 1,2	: Inv.No. 3122, S/N 11114
Calibration Certificate Foerster	: DM2020300 dated 24.07.2020
NPL reference block	: Inv.No. 3118, S/N MF112/11
Measurement Number NPL	: MT.41/20/055/EM 129.008 dated 09.06.2020

Test Certificate
 The instrument has been calibrated to give values of the permeability μ_r with an overall accuracy of 5% in $\mu_r - 1$ for samples with dimensions and magnetic properties similar to the reference blocks used for the calibration. Permeability measurements carried out with the calibrated Ferromaster permeability meter are compliant with ASTM A342 and IEC 60404-15 standards.

Standard Inventory No.	Reference value (μ_r)	Indicated Value pre-calibration		Indicated Value post-calibration	
		μ_r	% (base $\mu_r - 1$)	μ_r	% (base $\mu_r - 1$)
3121	1,0059	---	---	1,006 μ_r	1,69 %
3122	1,1601	---	---	1,161 μ_r	0,56 %
3118	1,6668	---	---	1,672 μ_r	0,78 %

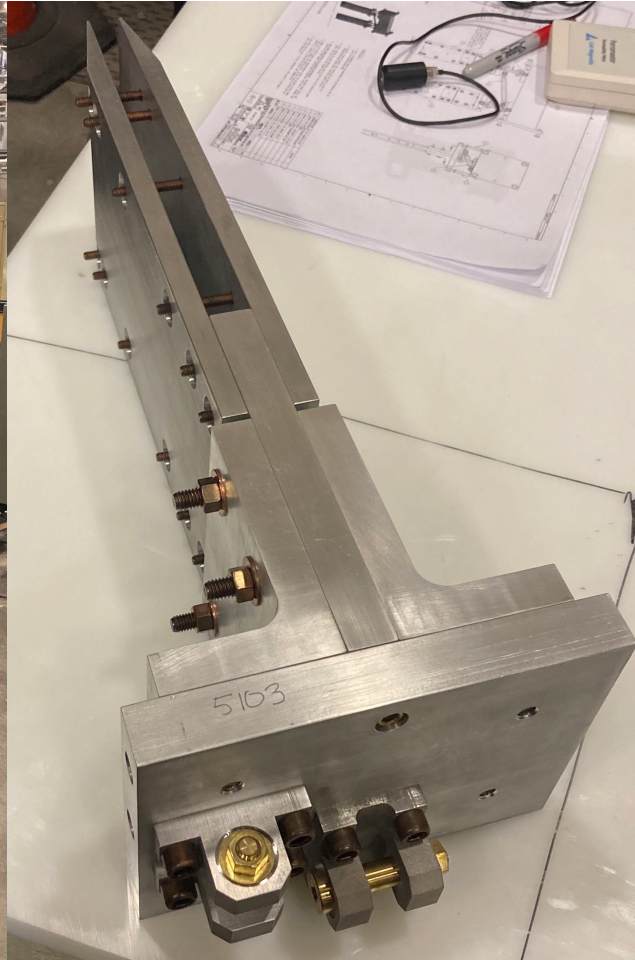
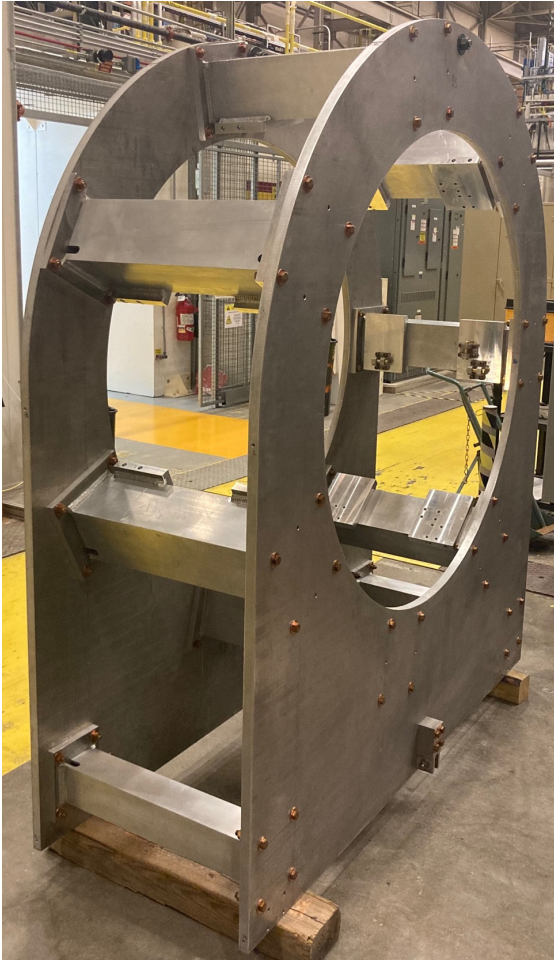
Test Result Values within tolerance acceptable ($\mu_r - 1$) ± 5 % [X] yes
[] no

LIST-MAGNETIK GmbH
 Max-Lang-Str. 58/2
 70771 Leinfelden-Echterdingen
 Telefon: +49 711 90 36 31 - 0 · Fax: -10

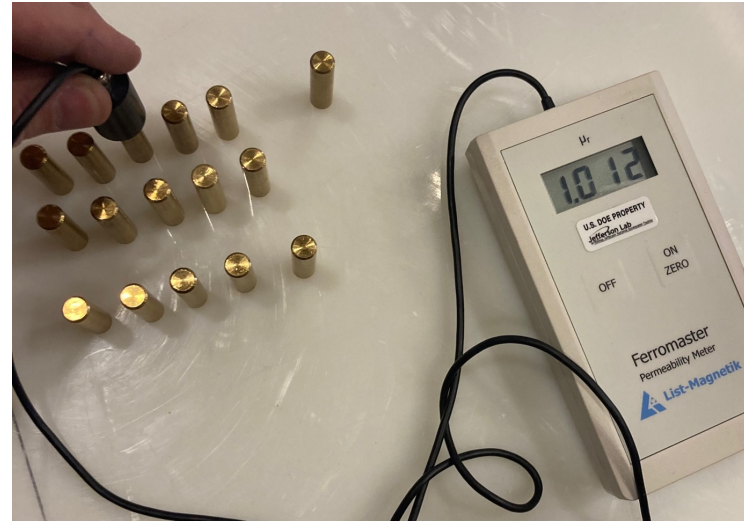


Signature Management

Testlab assembly parts



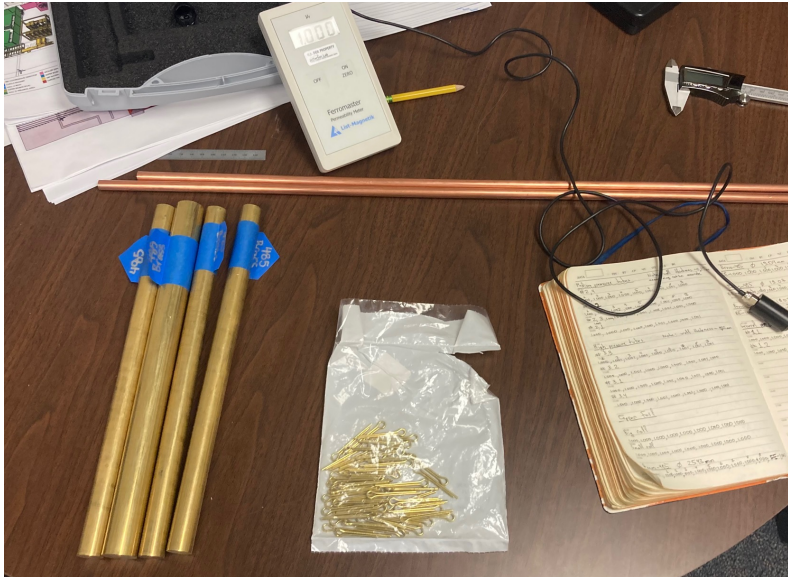
Brass-360 parts



Initial measurement results

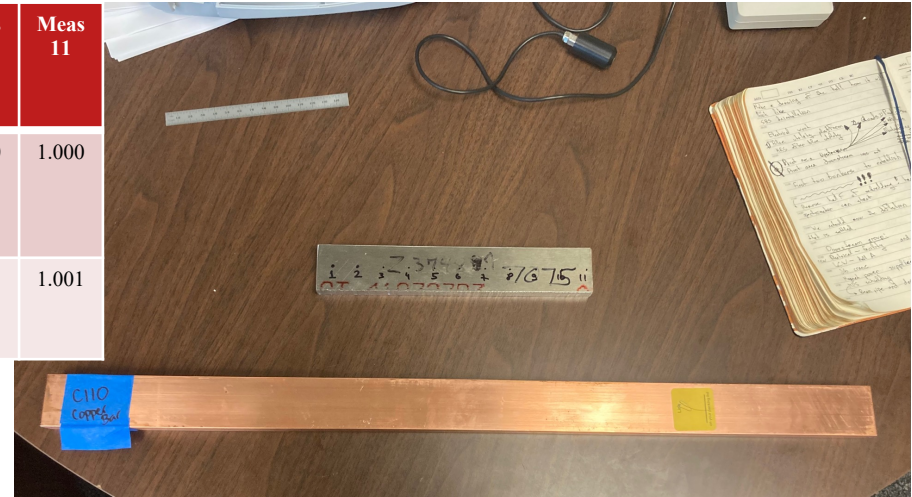
Number	Part name	Qty	Result	Comment
1	Shoulder bolt	20	?	Some bolts have (1.003 - 1.004)
2	Bulkhead assy	1	rejected	The fasteners and welded joints look good. Brass pin have elevated number up to 1.020
3	Part#A005-1503-5203	1	rejected	Brass pins have elevated numbers up to 1.020
4	Part#...-5103	1	rejected	Brass pins have elevated numbers up to 1.020
5	Part#...-5102	1	rejected	Brass pins have elevated numbers up to 1.020
6	Part# A09005-15-03-5202	1	rejected	Brass pins have elevated numbers up to 1.020 ; Small pins 1.005
7	Part# A09005-15-03-5302	1	rejected	Brass pins have elevated numbers 1.007-1.015
8	Part# A09005-15-03-5303	1	rejected	Few fasteners 1.003; brass pin 1.017; tiny pins 1.003
9	Part# A09005-15-03-5638	1	OK	Titanium(?) pin up to 1.002
10	Shoulder bolts	10	OK	
11	Painted aluminum shims	A lot	OK	measured divided in 3 stacks; one has spike 1.002;
12	Dowel pin, Brass, 5/16" Diameter	6	?	Some pins have 1.004
13	Dowel pin, Brass, 3/8" Diameter	16	rejected	One pin has number up to 1.012
14	Pins(brass)	20	rejected	Mean value 1.003 with spike 1.009

Measurement results (1)



Material	Meas 1	Meas 2	Meas 3	Meas 4	Meas 5	Meas 6	Meas 7	Meas 8	Meas 9	Meas 10
<i>Brass-485 rods</i>										
Ø25.43	1.001	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Ø19.04	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.001	1.000
Ø19.07	1.001	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Brass-485 Ø19.03	1.000	1.000	1.000	1.000	1.000	1.000	1.001	1.001	1.001	1.001

Material	Meas 1	Meas 2	Meas 3	Meas 4	Meas 5	Meas 6	Meas 7	Meas 8	Meas 9	Meas 10	Meas 11
7075Al	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
C110 Copper Bar	1.000	1.000	1.000	1.000	1.000	1.001	1.000	1.001	1.001	1.001	1.001



Measurement results (2)

Material	Meas 1	Meas 2	Meas 3	Meas 4	Meas 5	Meas 6	Meas 7	Meas 8	Meas 9	Meas 10	Meas 11	Notes
Brass-485 rods												
∅12.8	1.001	1.002	1.002	1.001	1.001	1.001	1.001	1.001	1.002	1.002	1.001	
∅9.5	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	
∅7.94	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	
Brass-464 rods												
∅9.7	1.001	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.001	1.001	
∅8.01	1.001	1.001	1.001	1.001	1.001	1.000	1.001	1.001	1.000	1.000		

Measurement results (3)

Material	Meas 1	Meas 2	Meas 3	Meas 4	Meas 5	Meas 6	Meas 7	Meas 8	Meas 9	Meas 10	Notes
<i>General purpose pipes</i>											
#1.1	1.000	1.000	1.000	1.000	1.000	1.000	1.001	1.001	1.000	1.000	Wall thickness small result may be not accurate
#1.2	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	Wall thickness small result may be not accurate
Brass pins	1.000	1.000	1.000	1.000	1.000	1.000					Pins are small. During measurements I combined ~20 pins
<i>Medium pressure tubes</i>											
#2.4	1.000	1.000	1.000	1.000	1.000	1.001	1.001	1.001	1.000		Wall thickness small results may be not accurate
#2.2	1.000	1.001	1.002	1.000	1.000	1.000	1.001	1.000	1.000		Wall thickness small results may be not accurate
#2.3	1.000	1.000	1.000	1.000	1.001	1.002	1.001	1.001	1.000		Wall thickness small results may be not accurate
#2.1	1.000	1.000	1.000	1.000	1.000	1.001	1.000	1.001	1.000		Wall thickness small results may be not accurate

Measurement results (4)

Material	Meas1	Meas 2	Meas 3	Meas 4	Meas 5	Meas 6	Meas 7	Meas 8	Meas 9	Notes
<i>High pressure tubes</i>										
#3.3	1.000	1.001	1.001	1.001	1.000	1.000	1.000	1.000	1.001	Wall thickness small results may be not accurate
#3.2	1.000	1.000	1.001	1.000	1.000	1.000	1.001	1.001	1.000	Wall thickness small results may be not accurate
#3.1	1.000	1.000	1.000	1.000	1.001	1.000	1.001	1.000	1.000	Wall thickness small results may be not accurate
#3.4	1.000	1.000	1.000	1.001	1.000	1.001	1.000	1.001	1.001	Wall thickness small results may be not accurate
<i>Copper foils</i>										
Big roll	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
Small roll	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	

Permeability measurement setup

- Reuse the old height gage tool
- Probe scope holder 3D printed
- The detailed procedure is under development
- Move to Testlab assembly space and train a dedicated person(s) how to use and document results



Summary

- Material selection is the responsibility of the sub-system delivering the component for installation
- The installation team will have to pay attention to what materials are being used
- The permeability measurements of prototype parts found that Brass-360 alloy will not work for MOLLER spectrometer
- Brass-464 and Brass-485 are under consideration and measurements ongoing
- We need to continue to control all assembly parts
- The exact threshold values for permeability in the particle envelope need to be determined and documented