The notes for MagneticMethods_Report.pdf

S2DS : October 2020

Team : EPRI

Week 1 task : Finding micro structures

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Introduction

- Applying high/low frequency magnetic field ---- Material Magnetic properties are probed
  (BH curve , MBN) (Hardness, dislocation density, microstructures)

- **Point of interest :** (Magnetic Response VS Material properties)

Inspection techniques:

Magnetic Hysteresis (BH curve)
Incremental permeability
Magnetic Barkhausen Noise (MBN)

Hardness, Thickness,
Microstructure,
dislocation density

- **Goal :** Assessment of imperfections (through material properties)

- **Samples :** Pipes and tubes (made of Steel)

There is small confusion when comparing Table -1 MBN frequency data and second paragraph of `Introduction' in the page 2.

Magnetic response Vs Material properties

Magnetic Hysteresis (BH curve)

Material flux density (B)
Vs
Applied Magnetic field (H)

remanence, coercive field (Hc)
(derived from **major** BH loop)

Material Hardness,
dislocation density

Incremental permeability
(derived from **minor** BH loop)

Lattice defects

Other details: Coercive field (Hc)

- Low frequency (<= 1 Hz),
- High Amplitude
- Measurement depth (<= 10mm for Grade 91 steel)
- Long measurement time (tens of sec)

Other details: Incremental permeability

- High frequency ,
- Measurement depth (<= 10mm for Grade 91 steel)
- small measurement time

Magnetic Barkhausen Noise (MBN)

Dislocations, grain boundaries, impurities and precipitates

Other details: (MBN)

- Low frequency (<= 1 Hz),
- Measurement depth (<= 1mm)
- sensitive to lattice defects
- Sensitive to surface conditions

Sample Preparation

- Not exposed to mechanical loading, heating , cutting or machining.
- No surface preparation was carried out.
- All **pipe** samples had areas where surface is subjected to grinding ()

- Two sets of measurements were performed on each **pipe** sample
  (**set one:** Nine measurements from ground area
  set two: Nine measurements from un-ground area)

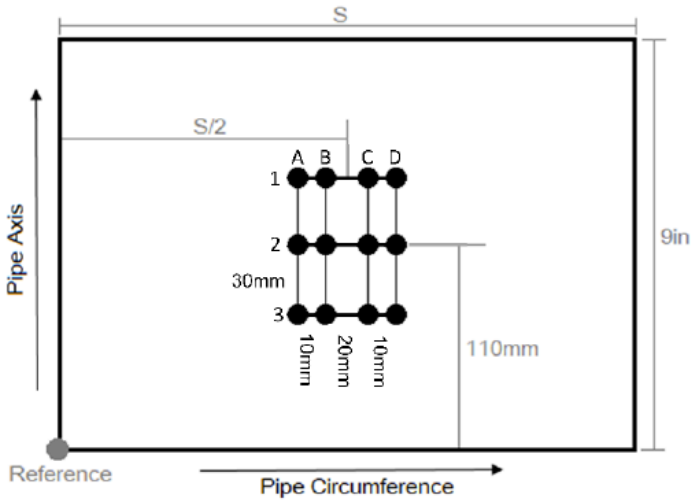
Table 2. Sample short names and hardness reference

Condition	Pipe short name	Tube short name	Target Hardness (HV 5.0)	Actual Median Hardness
Fully Ferritic	**P91_FF**	**T91_FF**	160	**147**
HAZ + Tempered	**P91_HAZ_T**	**T91_HAZ_T**	215	**170**
Over-Tempered	**P91_OT**	**T91_OT**	185	**198**
Tempered	**P91_T**	**T91_T**	195	**207**
Normalized + Tempered	**P91_N_T**	**T91_N_T**	215	**208**
As received	**P91_AR**	**T91_AR**	215	**220**
HAZ	**P91_HAZ**	**T91_HAZ**	300	**405**
Normalized	**P91_N**	**T91_N**	425	**428**

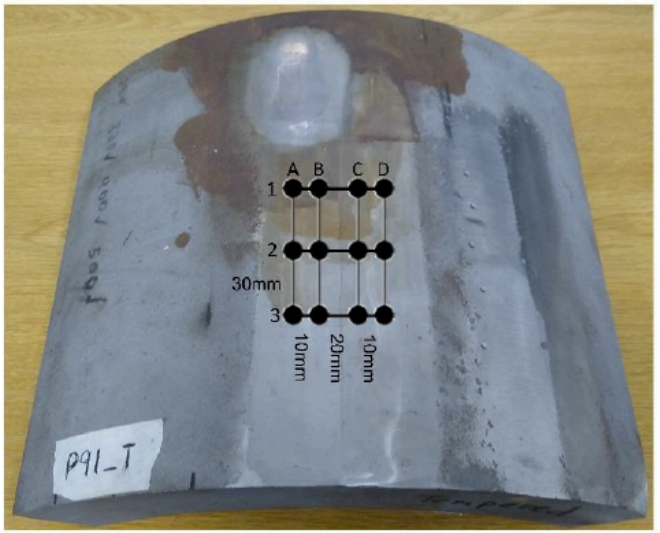
Grounded Pipe samples data

set one: Nine measurements from ground area

Pipe short name
P91_FF
P91_HAZ_T
P91_OT
P91_T
P91_N_T
P91_AR
P91_HAZ
P91_N



Scan positions for 'ground' measurements



Scan positions for 'ground' measurements

Coercive Field data

Table 4. Coercive field (kA/m) for ground areas on pipe samples

	Measurement position											
Sample	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	D3
P91_FF	0.503	0.547	0.553	0.542	0.540	0.549				0.577	0.535	0.537
P91_HAZ_T	0.794	0.762	0.743	0.813	0.784	0.752				0.804	0.801	0.750
P91_OT	0.839	0.860	0.885				0.948	0.918	0.938	0.910	0.889	0.876
P91_T	0.879	0.926	0.938				0.848	0.904	0.935	0.846	0.889	0.921
P91_N_T	0.879	0.885	0.884	0.912	0.934	0.956				0.824	0.940	0.926
P91_AR	1.035	1.111	1.097	1.024	1.031	1.099				1.060	1.080	1.030
P91_HAZ	1.281	1.388	1.258	1.255	1.351	1.260				1.238	1.267	1.294
P91_N	1.717	1.657	1.669	1.791	1.634	1.636				1.707	1.492	1.564

Grounded Pipe samples data (continued)

Incremental permeability data

Table 6. Incremental permeability values for ground areas on pipe samples

Sample	Measurement position											
	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	D3
P91_FF	151.1	144.7	150.0	154.8	141.2	154.3				150.9	137.8	144.6
P91_HAZ_T	128.2	131.5	133.6	129.9	134.6	136.1				133.0	139.0	139.0
P91_OT	132.9	126.3	122.8				129.5	123.4	120.8	127.1	121.8	120.7
P91_T	115.5	120.8	120.7				120.3	120.8	121.3	121.5	124.1	125.8
P91_N_T	113.3	116.9	124.8	124.9	116.9	123.6				117.9	120.2	123.6
P91_AR	117.8	116.4	118.8	113.6	117.8	115.3				119.7	122.1	120.5
P91_HAZ	100.7	102.8	99.1	99.4	103.7	96.7				110.6	109.5	97.7
P91_N	82.1	80.3	83.3	78.5	78.3	82.9				83.8	79.5	83.6

MBN Data

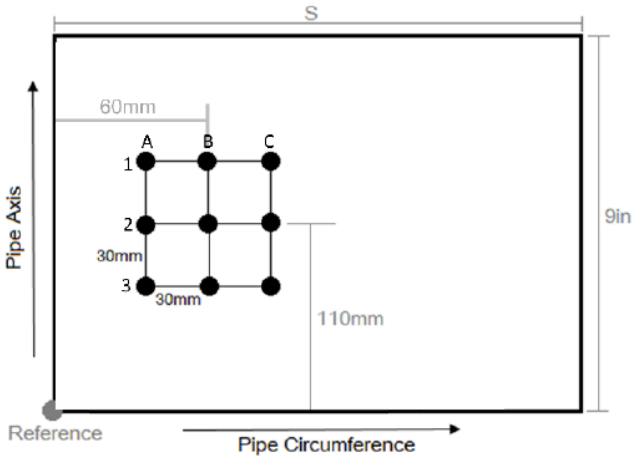
Table 8. Peak MBN (mV) for ground areas on pipe samples

Sample	Measurement position											
	A1	A2	A3	B1	B2	B3	C1	C2	C3	D1	D2	D3
P91_FF	0.510	0.616	0.634	0.657	0.585	0.472				0.696	0.618	0.602
P91_HAZ_T	1.086	0.975	0.957	0.705	0.682	0.690				0.649	0.635	0.660
P91_OT	0.958	0.803	0.733				0.654	0.702	0.611	0.783	0.766	0.706
P91_T	0.973	1.040	1.032				0.813	0.904	0.915	0.770	0.891	0.852
P91_N_T	0.922	1.059	1.100	1.012	1.071	1.060				0.957	1.064	1.027
P91_AR	0.821	0.740	0.721	0.975	0.719	0.515				0.944	0.643	0.548
P91_HAZ	0.402	0.369	0.343	0.370	0.314	0.243				0.461	0.452	0.338
P91_N	0.115	0.115	0.116	0.108	0.109	0.106				0.122	0.091	0.103

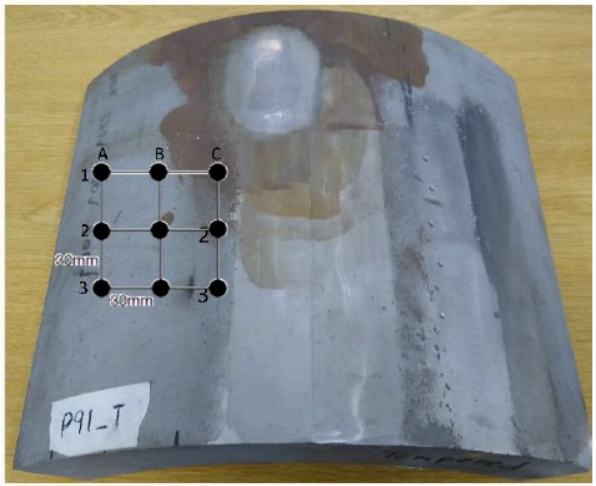
Ungrounded Pipe samples data

set two: Nine measurements from un-ground area

Pipe short name
P91_FF
P91_HAZ_T
P91_OT
P91_T
P91_N_T
P91_AR
P91_HAZ
P91_N



Scan positions for 'unground' measurements



Scan positions for 'unground' measurements

Coercive Field data

Table 5. Coercive field (kA/m) for unground areas on pipe samples

	Measurement position								
	A1	A2	A3	B1	B2	B3	C1	C2	C3
P91_FF	0.611	0.648	0.736	0.589	0.616	0.668	0.570	0.604	0.631
P91_HAZ_T	0.918	0.950	0.922	0.907	0.921	0.875	0.889	0.891	0.856
P91_OT	0.937	0.957	0.974	0.942	0.957	0.955	0.944	0.973	0.971
P91_T	0.961	1.003	0.989	0.946	0.968	0.963	0.946	0.964	0.972
P91_N_T	0.990	0.989	1.016	0.957	0.977	0.972	0.959	0.970	0.976
P91_AR	1.066	1.035	1.120	1.092	1.129	1.082	1.059	1.055	1.114
P91_HAZ	1.639	1.678	1.572	1.463	1.522	1.645	1.397	1.457	1.568
P91_N	2.081	2.071	2.114	1.959	1.942	1.960	1.949	1.922	1.891

Ungrounded Pipe samples data (continued)

Incremental permeability data

Table 7. Incremental permeability values for unground areas on pipe samples

	Measurement position								
	A1	A2	A3	B1	B2	B3	C1	C2	C3
P91_FF	138.3	132.3	127.4	138.0	133.6	128.6	141.2	134.8	131.3
P91_HAZ_T	114.2	119.1	121.4	113.7	117.7	119.2	114.2	119.1	121.8
P91_OT	117.3	115.8	116.5	118.2	112.5	115.5	117.5	114.5	117.1
P91_T	115.7	114.2	113.5	114.5	112.8	112.3	112.7	112.1	111.7
P91_N_T	115.7	113.3	114.1	113.9	111.8	112.4	111.2	111.3	111.5
P91_AR	106.8	108.2	111.6	105.8	107.0	108.6	103.4	106.1	108.1
P91_HAZ	88.2	85.5	84.8	91.3	86.9	85.6	92.9	91.1	86.1
P91_N	76.7	76.9	78.1	77.0	76.2	77.1	75.5	75.1	77.7

MBN Data

Table 9. Peak MBN (mV) for unground areas on pipe samples

	Measurement position								
	A1	A2	A3	B1	B2	B3	C1	C2	C3
P91_FF	0.507	0.473	0.528	0.461	0.490	0.572	0.446	0.459	0.533
P91_HAZ_T	0.413	0.432	0.432	0.363	0.402	0.382	0.370	0.367	0.354
P91_OT	0.463	0.384	0.376	0.464	0.446	0.430	0.447	0.404	0.318
P91_T	0.348	0.345	0.334	0.318	0.288	0.305	0.309	0.308	0.295
P91_N_T	0.314	0.300	0.301	0.314	0.305	0.301	0.288	0.290	0.293
P91_AR	0.237	0.366	0.453	0.252	0.332	0.328	0.236	0.267	0.311
P91_HAZ	0.446	0.449	0.427	0.394	0.399	0.395	0.401	0.416	0.388
P91_N	0.430	0.415	0.404	0.426	0.418	0.403	0.417	0.402	0.411

Pipe samples Results

Coercive Field results (Pipe)

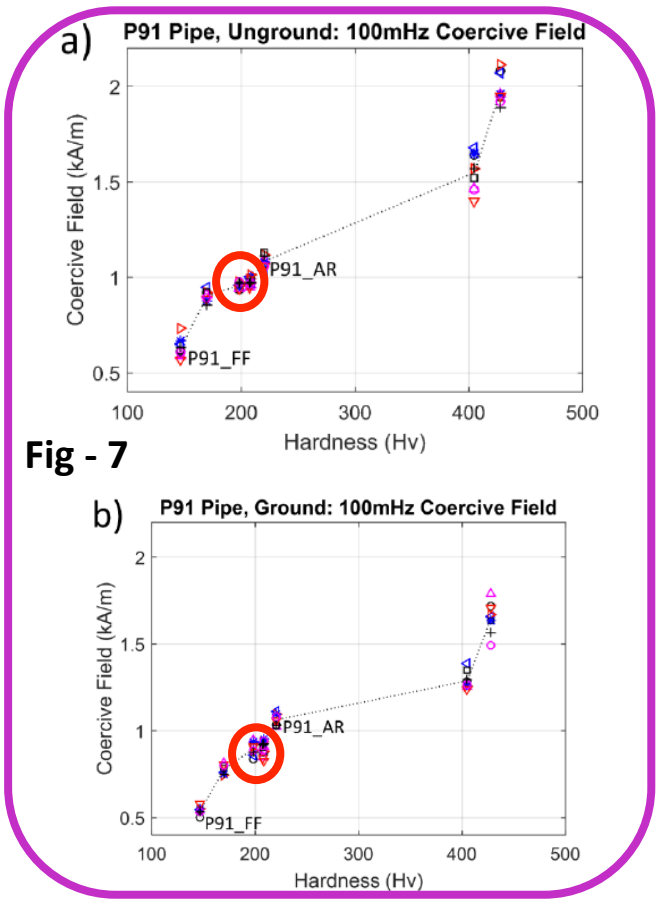


Fig - 7

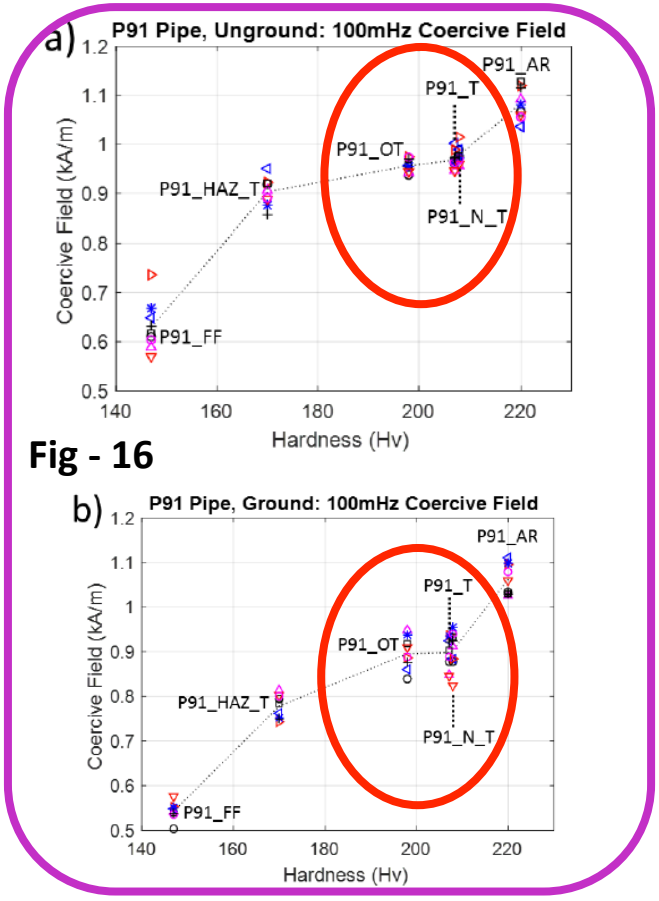


Fig - 16

Source data

- Table – 4 (Fig. 7b, 16b) (For ground areas)
- Table – 5 (Fig. 7a, 16a) (For unground areas)

- **Increase** in material hardness (Hv) plotted along x-axis results in **increase** in magnetic hardness (kA/m) plotted along y-axis. Also, coercive field is high for unground sample.
  P.S.: Don't confuse 'thickness' with 'hardness'
- P91FF, P91_HAZ_T, P91_AR, P91_HAZ, P91_N are easily distinguishable
- P91_OT, P91_T, P91_N_T are very close (not easily distinguishable)

Pipe samples Results (continued)

Incremental permeability results (Pipe) :

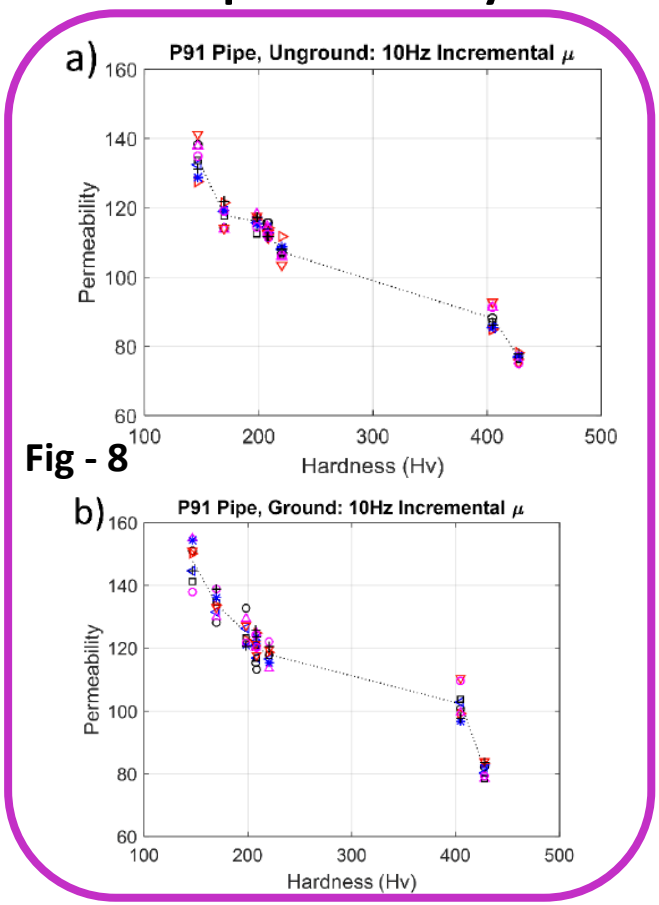


Fig - 8

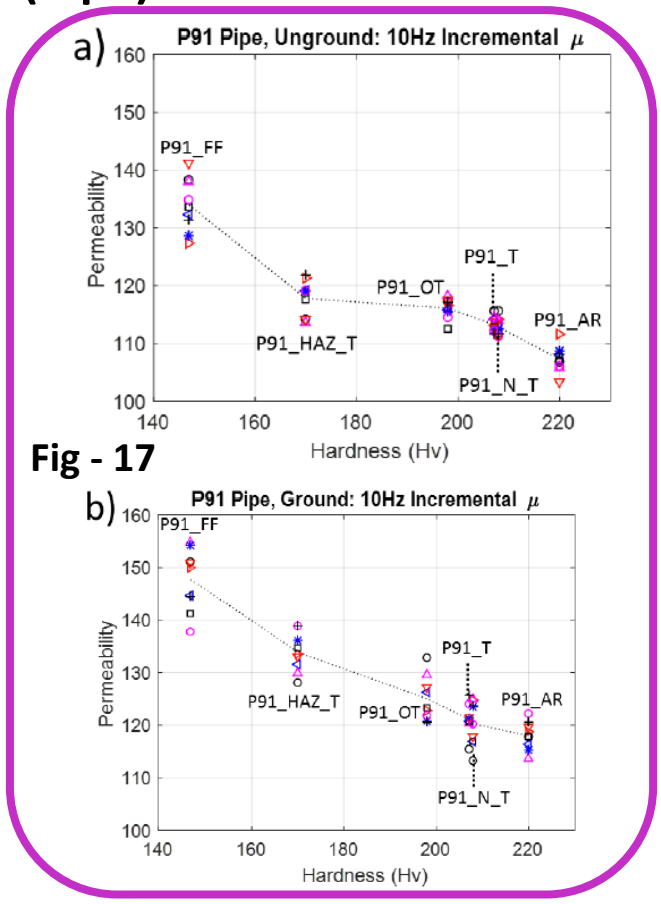


Fig - 17

Source data

- Table – 6 (Fig. 8b, 17b) (For ground areas)
- Table – 7 (Fig. 8a, 17a) (For unground areas)

- **Increase** in material hardness (Hv) plotted along x-axis results in **decrease** in the permeability of the material plotted along y-axis. Also, the ground sample has higher level of permeability.
  P.S.: Don't confuse 'thickness' with 'hardness'
- Sensitive to surface conditions

Pipe samples Results

MBN peak results (Pipe)

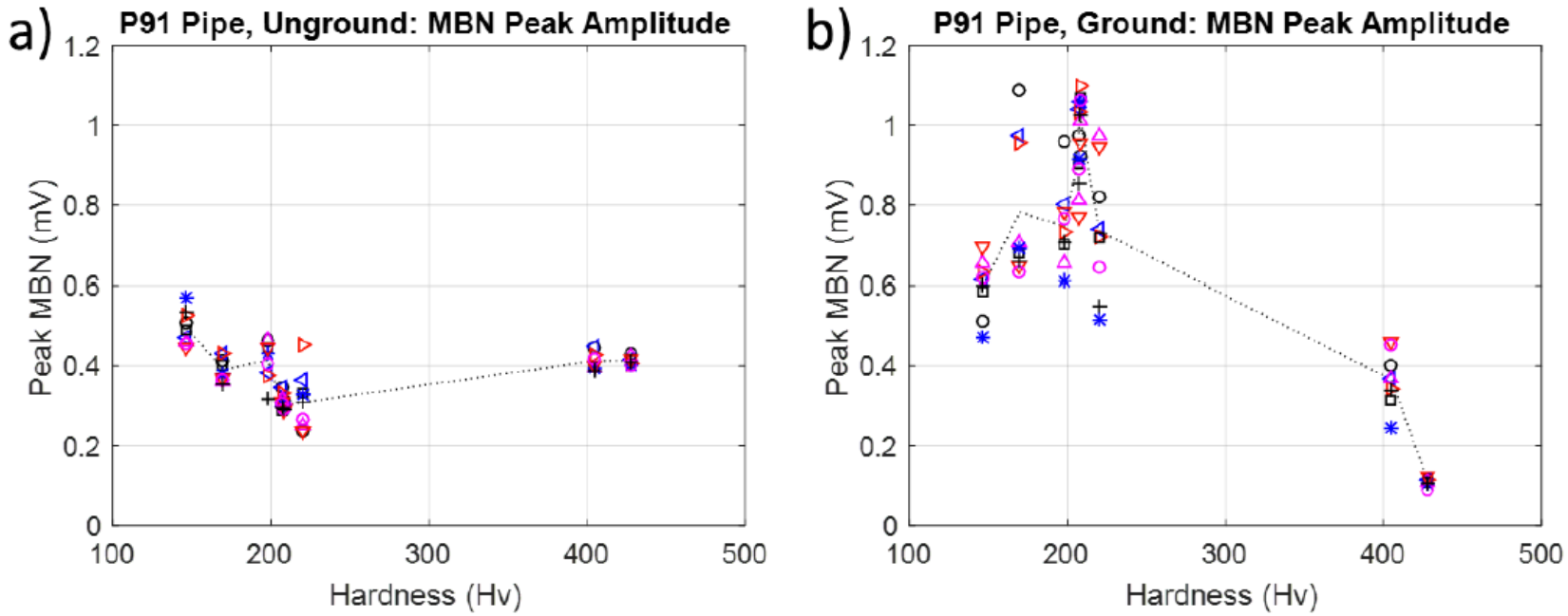


Figure 9. Plots of MBN peak amplitude extracted from MBN profiles measured on pipe sections; a) Measurements from unground area, b) Measurements from ground area

- Both the plots are highly scattered. On comparison, the graph of 9a is better than 9b (only if the last two points in 9a is disregarded).

Source data

- Table – 8 (Fig. 9b) (For ground areas)

Source data

- Table – 9 (Fig. 9a) (For unground areas)

Tube samples data Set - A

Here there is a mistake the Tube names are not consistent in the data. It has to be corrected

Tube short name
T91_FF
T91_HAZ_T
T91_OT
T91_T
T91_N_T
T91_AR
T91_HAZ
T91_N

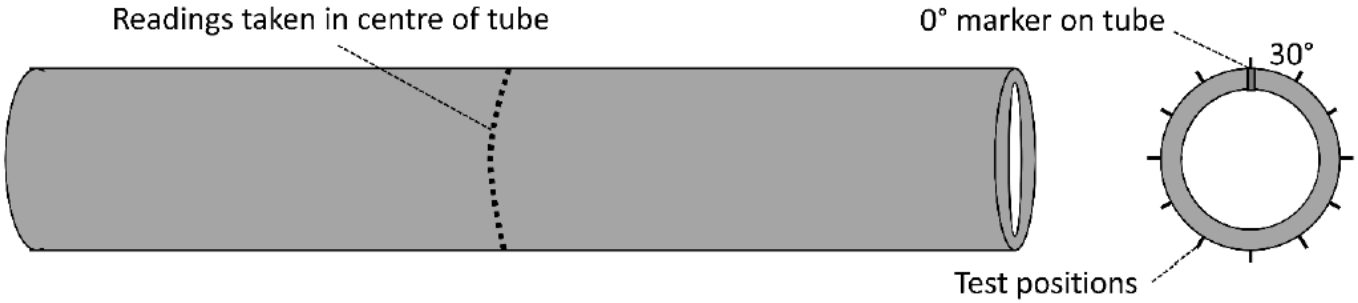


Figure 5. Measurement positions for tube samples

Coercive Field data

Table 10. Coercive field (kA/m) for identified tube samples

Sample	Measurement position											
	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
P91_FF	0.678	0.681	0.668	0.647	0.633	0.678	0.699	0.718	0.719	0.659	0.626	0.641
P91_HAZ_T	1.080	1.107	1.093	1.096	1.113	1.111	1.093	1.108	1.098	1.092	1.088	1.094
P91_OT	1.459	1.542	1.751	2.070	2.452	2.542	2.337	2.067	1.833	1.678	1.576	1.455
P91_T	1.074	1.100	1.101	1.112	1.112	1.091	1.071	1.131	1.279	1.296	1.155	1.051
P91_N_T	1.079	1.091	1.102	1.139	1.117	1.108	1.106	1.123	1.100	1.118	1.118	1.117
P91_AR	1.244	1.228	1.220	1.223	1.243	1.210	1.186	1.222	1.259	1.273	1.266	1.270
P91_HAZ	4.707	4.763	4.769	4.799	4.836	4.734	4.714	4.722	4.692	4.705	4.714	4.711
P91_N	4.405	4.460	4.476	4.466	4.525	4.559	4.546	4.525	4.493	4.479	4.509	4.499

Tube samples data Set A (continued)

Incremental permeability data

Table 11. Incremental permeability for identified tube samples

Sample	Measurement position											
	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
P91_FF	104.3	102.8	102.8	103.9	104.4	102.5	99.0	96.4	98.1	102.4	105.2	104.3
P91_HAZ_T	70.7	71.3	70.7	70.6	70.8	70.2	69.4	68.4	68.9	68.2	67.6	68.3
P91_OT	64.8	63.1	60.3	56.8	53.7	52.9	54.9	57.7	60.6	62.7	63.2	64.4
P91_T	66.9	67.3	66.8	68.0	69.0	68.1	67.6	67.6	66.3	65.7	65.5	66.0
P91_N_T	68.1	67.0	66.9	66.4	65.9	66.7	67.4	67.8	67.4	68.6	67.5	67.0
P91_AR	62.6	62.5	62.6	61.9	61.7	61.7	61.8	61.8	61.4	61.6	62.1	62.7
P91_HAZ	34.1	33.7	33.2	32.9	33.0	33.0	33.6	33.9	34.3	34.3	34.2	34.1
P91_N	33.8	33.5	33.5	33.2	32.8	33.0	33.0	33.1	33.5	33.7	33.6	33.3

MBN Data

Table 12. Peak MBN (mV) for identified tube samples

Sample	Measurement position											
	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
P91_FF	1.287	1.297	1.114	1.238	1.296	1.107	0.649	0.445	0.619	0.724	0.665	0.798
P91_HAZ_T	0.528	0.522	0.603	0.375	0.743	1.051	0.857	0.467	0.410	0.367	0.342	0.457
P91_OT	0.562	0.473	0.378	0.326	0.297	0.259	0.277	0.394	1.135	1.284	1.327	1.260
P91_T	0.564	0.426	0.460	0.677	1.104	0.632	0.493	0.541	0.464	0.467	0.738	0.814
P91_N_T	0.627	0.819	0.822	0.602	0.998	1.216	1.068	1.124	1.212	1.072	0.520	0.476
P91_AR	0.562	0.594	0.594	0.482	0.554	0.532	0.718	0.721	0.472	0.623	0.613	0.638
P91_HAZ	0.318	0.307	0.311	0.346	0.352	0.356	0.349	0.289	0.291	0.361	0.330	0.303
P91_N	0.720	0.674	0.676	0.691	0.597	0.496	0.527	0.499	0.541	0.586	0.569	0.612

Tube samples data Set - B

Coercive Field data

Table 13. Coercive field (kA/m) for unidentified tube samples

Sample	Measurement position											
	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
B1	1.092	1.093	1.113	1.106	1.092	1.076	1.085	1.121	1.114	1.100	1.107	1.100
B2	1.077	1.105	1.110	1.116	1.113	1.111	1.109	1.131	1.129	1.093	1.079	1.090
B3	1.074	1.087	1.062	1.058	1.062	1.099	1.100	1.079	1.080	1.102	1.086	1.064
B4	4.494	4.480	4.472	4.516	4.512	4.520	4.548	4.534	4.531	4.548	4.492	4.446
B5	1.424	1.433	1.458	1.453	1.454	1.413	1.411	1.425	1.437	1.412	1.442	1.421
B6	4.652	4.649	4.625	4.635	4.669	4.675	4.658	4.758	4.820	4.802	4.761	4.699
B7	0.651	0.621	0.653	0.734	0.762	0.782	0.707	0.620	0.607	0.647	0.663	0.671
B8	1.622	1.803	2.107	2.416	2.630	2.586	2.398	2.184	1.973	1.784	1.642	1.593

Incremental permeability data

Table 14. Incremental permeability for unidentified tube samples

Sample	Measurement position											
	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
B1	69.4	69.6	69.6	69.7	69.2	68.8	68.2	67.6	67.1	66.8	67.2	67.5
B2	68.0	67.8	67.3	66.4	65.5	65.2	65.2	65.7	66.0	66.5	67.1	67.0
B3	69.4	69.5	69.3	69.3	68.9	68.4	68.4	68.1	67.9	67.5	67.3	67.7
B4	33.5	33.4	33.6	33.4	33.2	32.8	32.6	32.4	32.4	32.5	32.7	33.0
B5	64.3	64.3	64.0	63.6	63.9	64.9	65.8	66.6	66.9	66.5	65.7	65.0
B6	34.9	34.9	35.2	34.9	34.6	34.2	33.6	33.1	32.8	32.8	33.3	33.9
B7	104.7	104.5	100.6	92.7	90.2	91.4	98.2	104.7	106.7	104.8	103.8	103.3
B8	62.3	59.7	56.2	53.2	51.8	52.3	54.1	56.6	59.0	60.9	62.2	62.4

Tube samples data Set - B

MBN Data

Table 15. Peak MBN (mV) for unidentified tube samples

Sample	Measurement position											
	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
B1	0.717	0.490	0.320	0.370	0.697	0.712	0.435	0.351	0.461	0.485	0.459	0.543
B2	0.509	0.648	0.646	0.484	0.510	0.644	0.681	0.495	0.438	0.635	0.820	0.626
B3	0.623	0.433	0.579	0.574	0.462	0.408	0.660	0.977	0.718	0.430	0.493	0.782
B4	0.473	0.542	0.544	0.481	0.441	0.451	0.460	0.481	0.573	0.589	0.563	0.520
B5	0.561	0.558	0.514	0.480	0.484	0.532	0.550	0.544	0.623	0.581	0.515	0.503
B6	0.301	0.304	0.279	0.278	0.301	0.332	0.375	0.334	0.294	0.317	0.282	0.277
B7	0.652	0.702	0.672	0.602	0.643	0.640	0.546	0.550	0.613	0.553	0.577	0.573
B8	0.392	0.357	0.297	0.247	0.223	0.236	0.280	0.464	0.959	0.678	0.402	0.404

- Set B is unidentified tube dataset

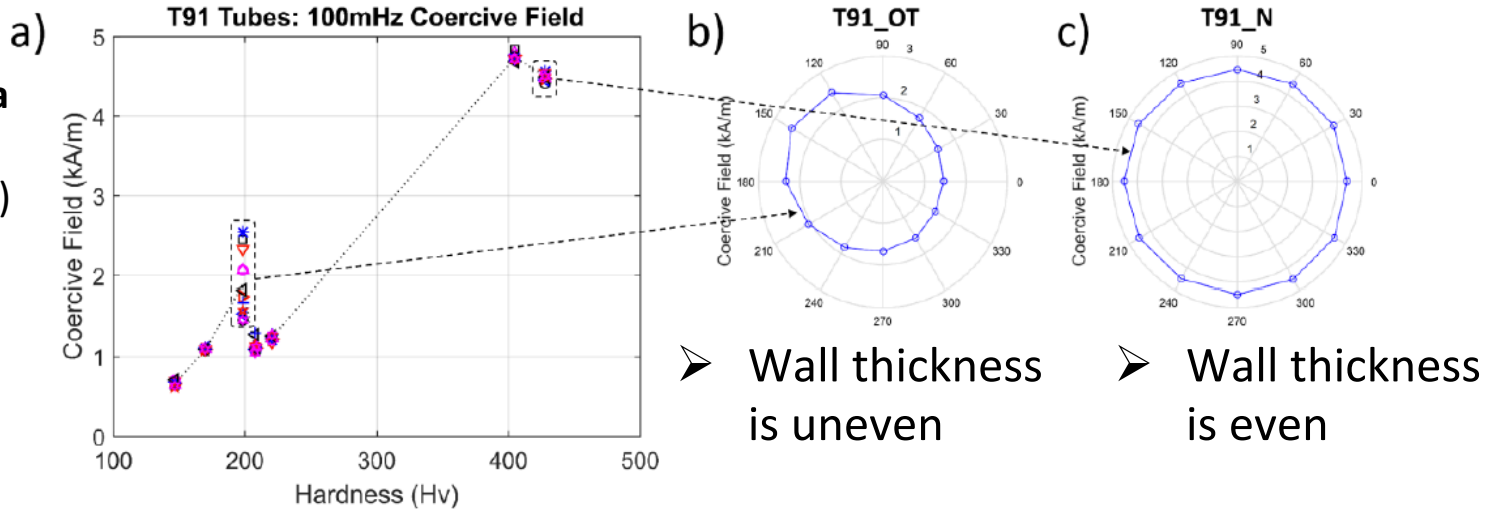
Identified tube (Set A) samples Results

Table 3. Average coercive field and incremental permeability values from identified (set A) and unidentified (set B) tube samples. Columns for 'B' samples represent best guess for sample identification. Grey columns too close to identify with confidence

	Samples							
	T91_FF	**T91_HAZ_T**	**T91_OT**	**T91_T**	**T91_N_T**	**T91_AR**	**T91_HAZ**	**T91_N**
Coercive Field (kA/m)	0.671	1.098	1.810	1.131	1.110	1.237	4.739	4.495
Incremental Permeability	102.18	69.58	59.60	67.05	67.21	62.04	33.68	33.33
	B7	**B1**	**B8**	**B3**	**B2**	**B5**	**B6**	**B4**
Coercive Field (kA/m)	0.676	1.099	2.062	1.079	1.1052	1.432	4.700	4.508
Incremental Permeability	100.48	68.40	57.55	66.47	68.47	65.12	34.01	32.97

Coercive Field results (Tube)

Source data
Table – 10
(Fig. 10 a, b)
(For Set-A)



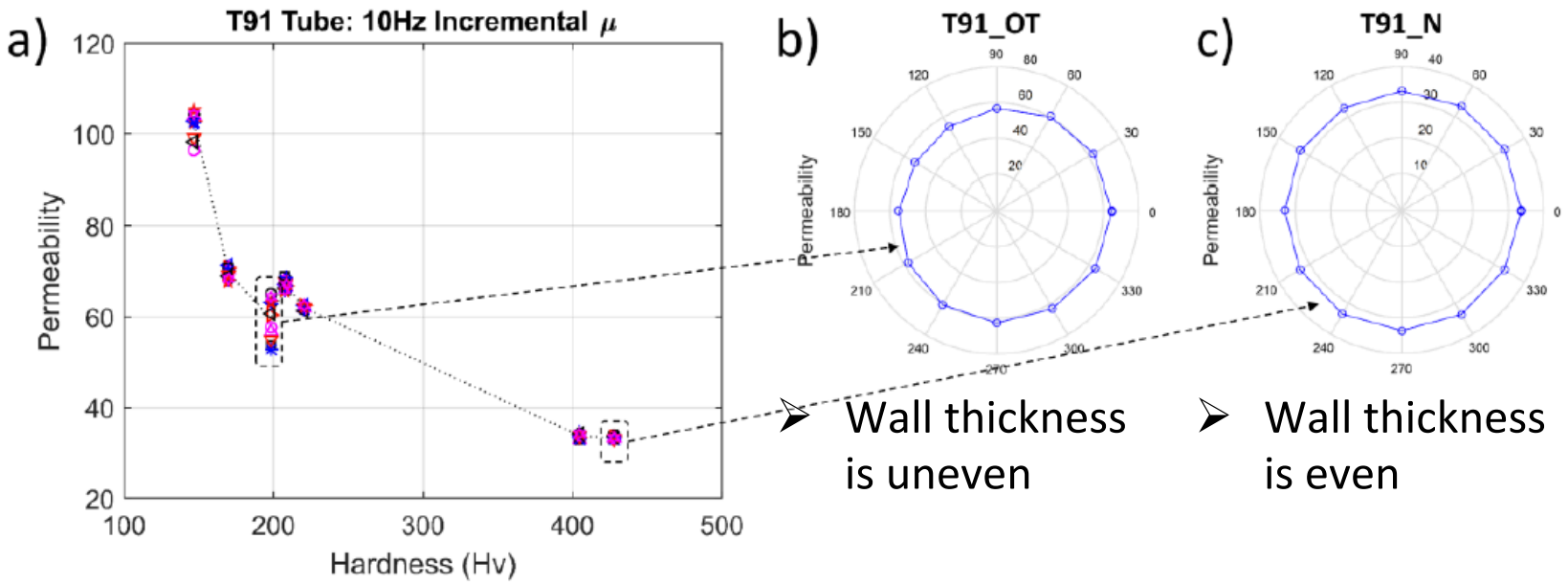
- Wall thickness is uneven
- Wall thickness is even

Figure 10. a) Plot of coercive field extracted from major loops measured on tube set A, b) Polar plot of coercive field from T91_OT, b) Polar plot of coercive field from T91_N

- Maximum Coercive field for tube is much greater than pipe samples.
- The skewed polar plot is due to uneven will thickness or uneven heat treatment

Identified tube (Set A) samples Results

Incremental permeability results (Tube) :



- Wall thickness is uneven
- Wall thickness is even

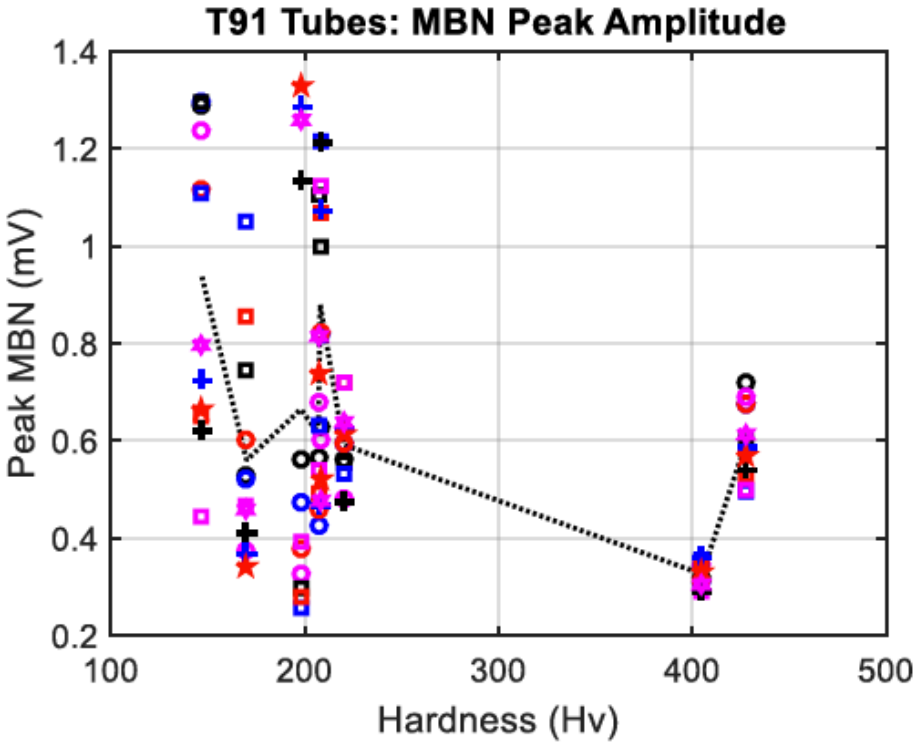
Figure 11. Plot of incremental permeability extracted from minor loops measured on tube set A, b) Polar plot of incremental permeability from T91_OT, b) Polar plot of incremental permeability from T91_N

- Coercive field and incremental permeability are inversely related.
- The reduced skewedness in polar plot is due to lower measurement depth.

Source data
Table – 11
(Fig. 11 a, b)
(For Set-A)

Identified tube samples Results

MBN peak results (Tube) :



Source data
Table – 12
(Fig. 12 a, b)
(For Set-A)

Figure 12. Plot of MBN peak amplitude measured on tube set A

- Greater scatter for soft samples.
- No correlation to hardness can be drawn.

Tube samples Results (Set A and B)

Coercive Field results (Tube)

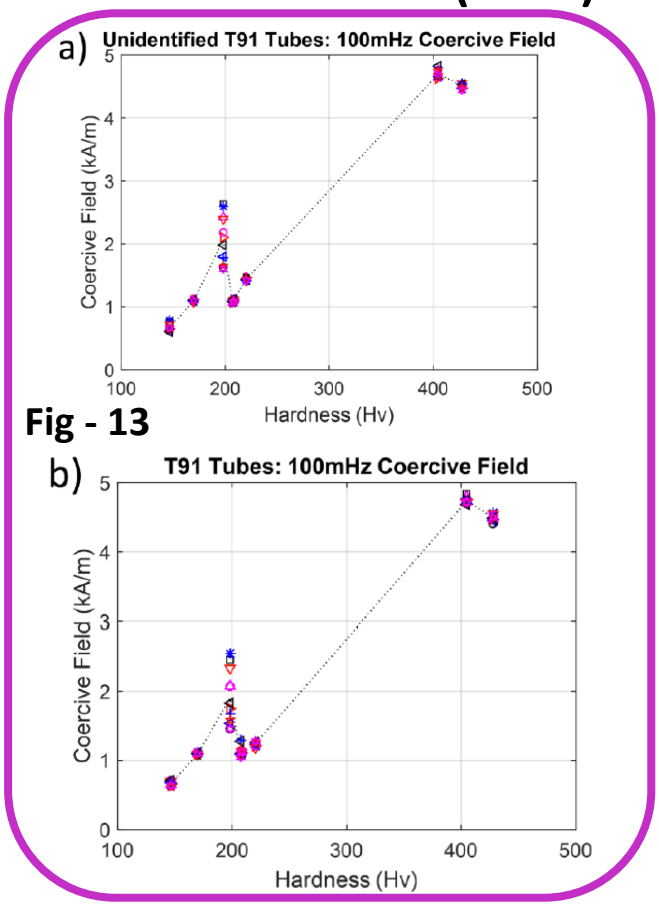


Fig - 13

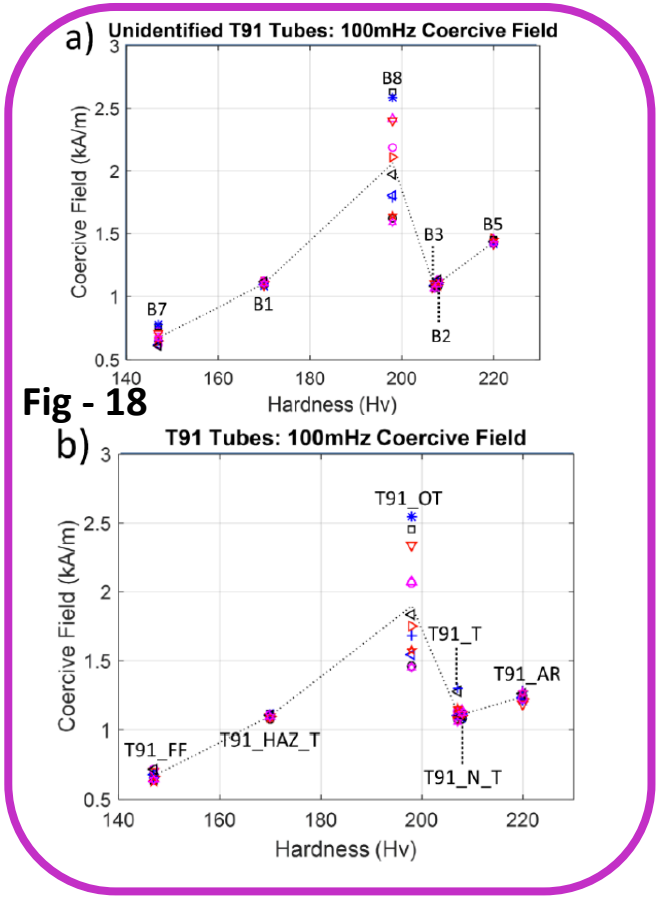


Fig - 18

Source data

- Table – 10 (Fig. 13b, 18b) (For identified tube)
- Table – 13 (Fig. 13a, 18a) (For unidentified tube)

- Fig :13 a) and 13 b) are largely comparable with only exception T91_OT and B8
- T91_OT and B8 are same tubes but different heat treatment

There is an error in '5th line of Pg No: 9 (just above Figure 13). The source data should be (Table 10 and Table 13). It is given as (Table 10 and Table 14)

Tube samples Results (Set A and B)

Incremental permeability results (Tube) :

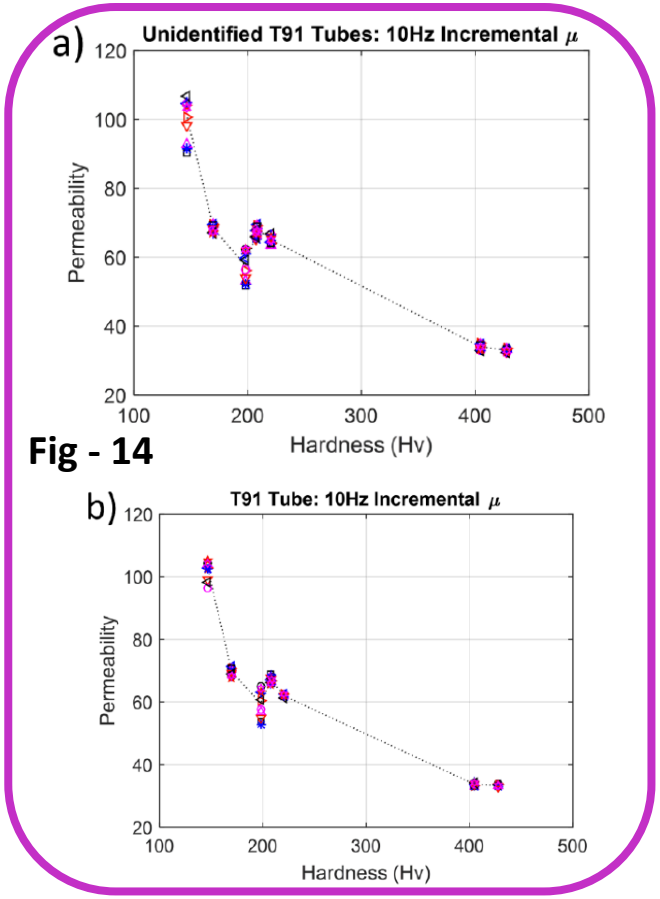


Fig - 14

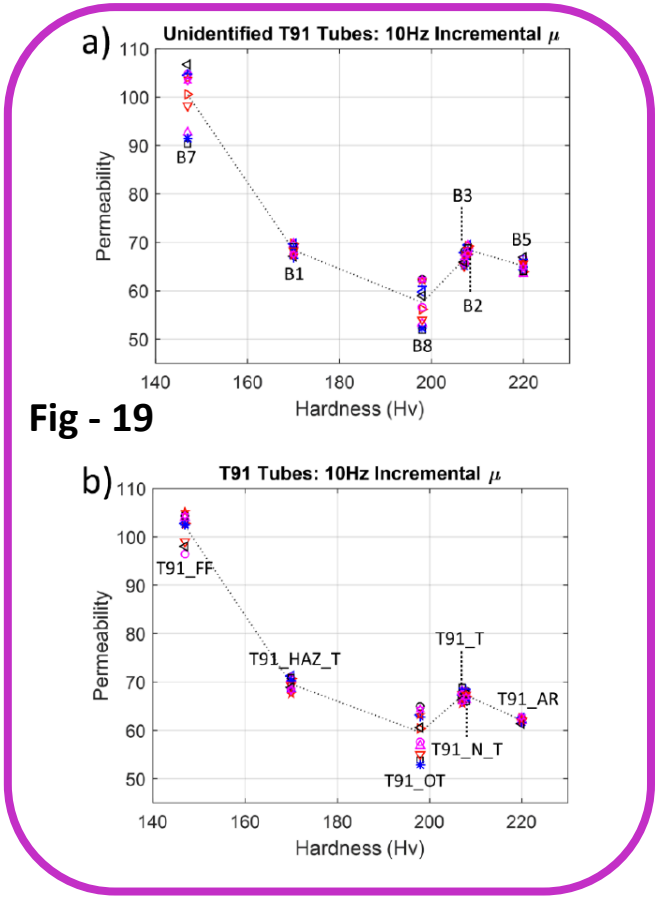


Fig - 19

Source data

- Table – 11 (Fig. 14b, 19b) (For identified tube)
- Table – 14 (Fig. 14a, 19a) (For unidentified tube)

- Fig :14 a) and 14 b) having a good match

Tube samples Results (Set A and B)

MBN peak results (Tube) :

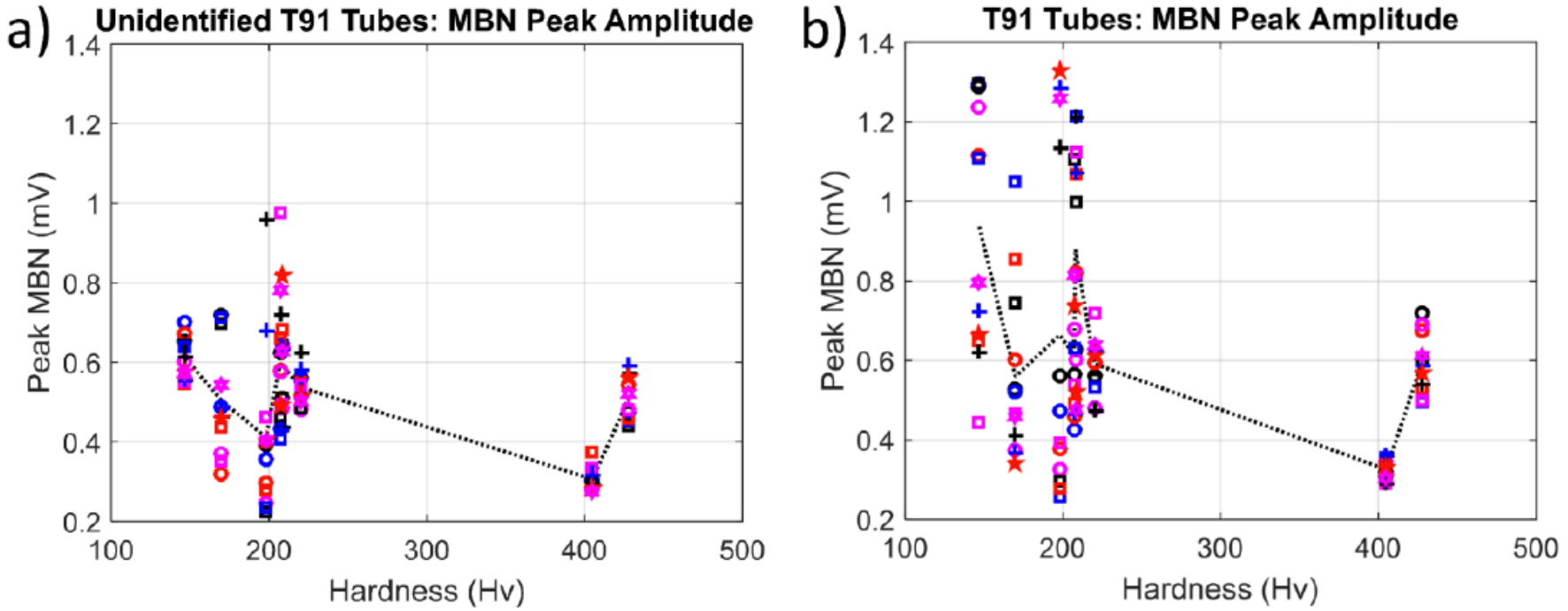


Figure 15. Plots of MBN peak amplitude extracted from MBN profiles measured on tubes; a) Unidentified 'B' tubes as labelled in Table 3, b) Identified 'A' tubes

- Dependent on surface effects
- Set- A has large areas of grinding
- Set – B is untouched

Source data

- Table – 12 (Fig. 15b) (For identified tubes)

Source data

- Table – 15 (Fig. 15a) (For unidentified tubes)

Mapping of Set – A and Set –B

Identification is not certain for the columns in grey

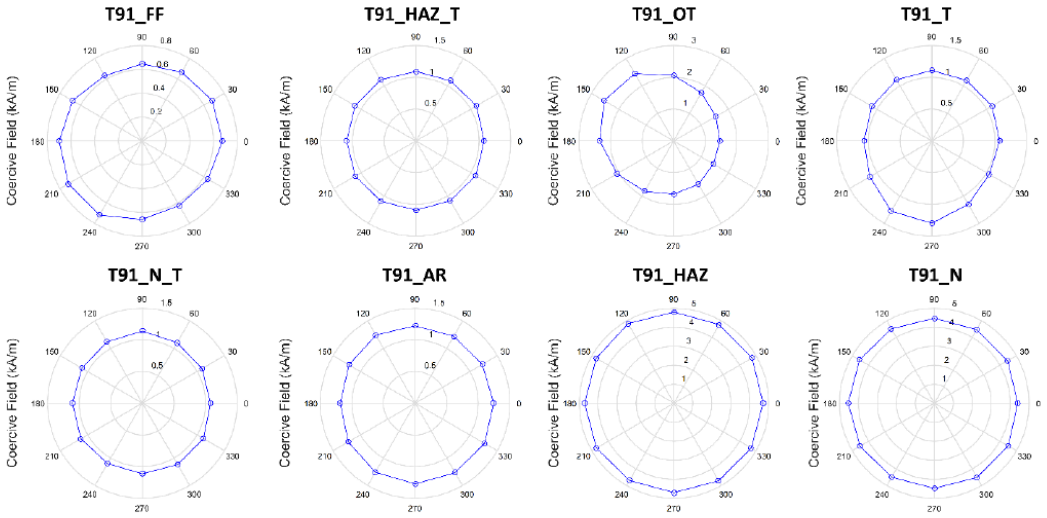


Figure 20. Polar plots of coercive field for identified tube samples

	Samples							
	T91_FF	**T91_HAZ_T**	**T91_OT**	**T91_T**	**T91_N_T**	**T91_AR**	**T91_HAZ**	**T91_N**
Coercive Field (kA/m)	0.671	1.098	1.810	1.131	1.110	1.237	4.739	4.495
Incremental Permeability	102.18	69.58	59.60	67.05	67.21	62.04	33.68	33.33
	B7	**B1**	**B8**	**B3**	**B2**	**B5**	**B6**	**B4**
Coercive Field (kA/m)	0.676	1.099	2.062	1.079	1.1052	1.432	4.700	4.508
Incremental Permeability	100.48	68.40	57.55	66.47	68.47	65.12	34.01	32.97

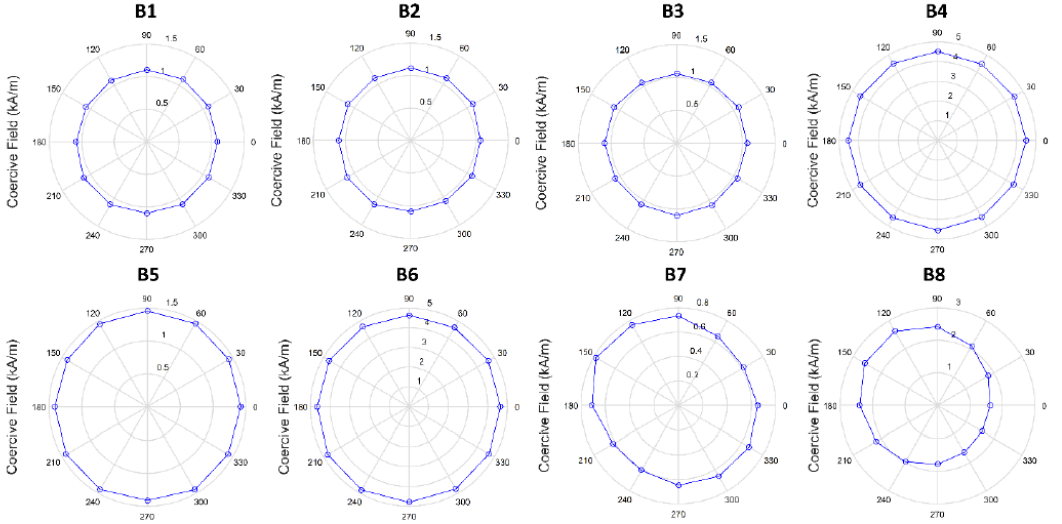


Figure 21. Polar plots of coercive field for unidentified tube samples

Mapping of Set – A and Set –B

Identification is not certain for the columns in grey

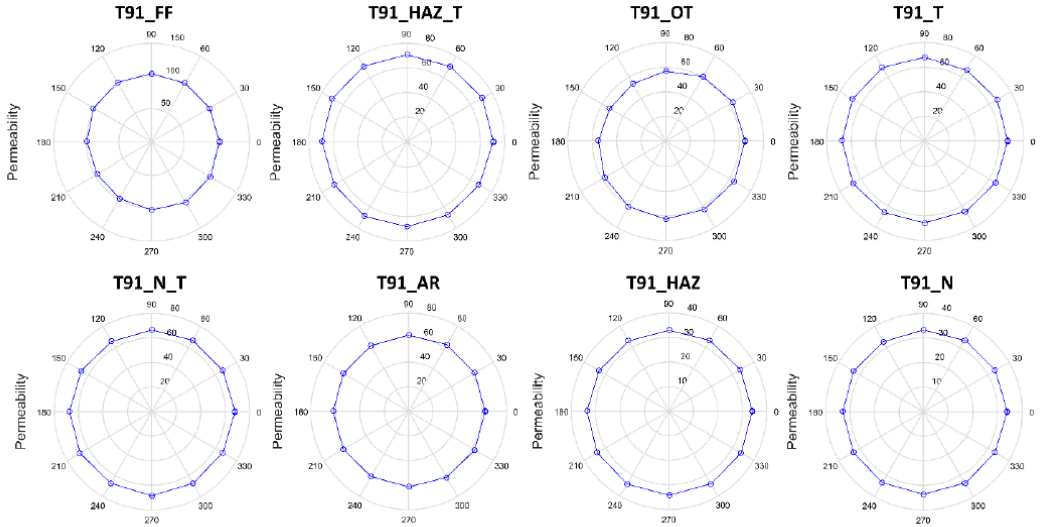


Figure 22. Polar plots of permeability for identified tube samples

	Samples							
	T91_FF	**T91_HAZ_T**	**T91_OT**	**T91_T**	**T91_N_T**	**T91_AR**	**T91_HAZ**	**T91_N**
Coercive Field (kA/m)	0.671	1.098	1.810	1.131	1.110	1.237	4.739	4.495
Incremental Permeability	102.18	69.58	59.60	67.05	67.21	62.04	33.68	33.33
	B7	**B1**	**B8**	**B3**	**B2**	**B5**	**B6**	**B4**
Coercive Field (kA/m)	0.676	1.099	2.062	1.079	1.1052	1.432	4.700	4.508
Incremental Permeability	100.48	68.40	57.55	66.47	68.47	65.12	34.01	32.97

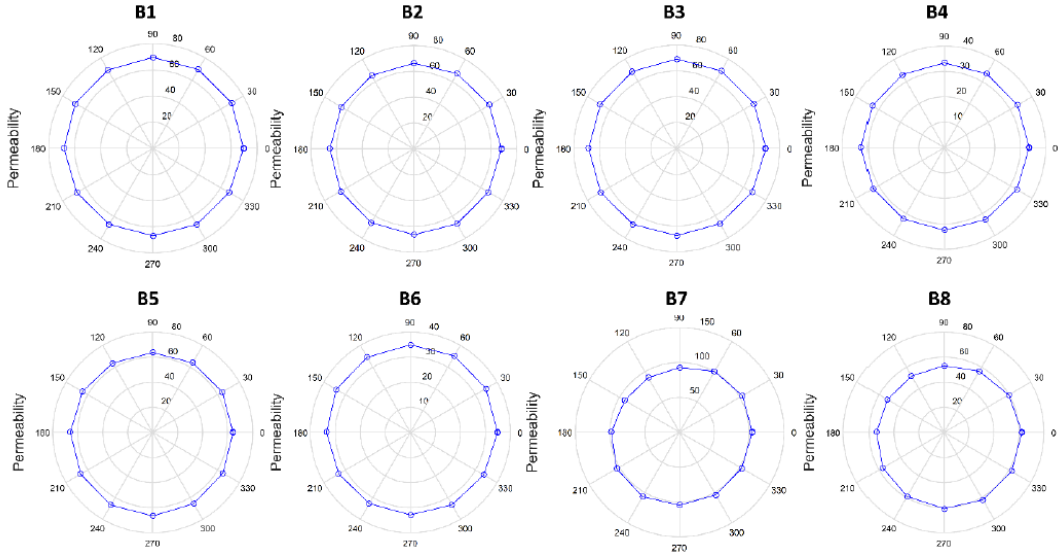


Figure 23. Polar plots of permeability for unidentified tube samples

Suggesstions

1. Since we have a lot of tables, I believe that it would be nice to have a folder that contains the csv data files of all the 15 tables individually stored in a folder

2. The folder can be named as “MagneticMethods_Report”

3. An individual csv file is created for each table. Since we have 14 tables that contain data “MagneticMethods_Report” folder should contain 14 csv data files each named uniquely.

4. The program should source the read_csv from this location. In this way, in future if there is any change in any one table or any individual entity we can individually change that one file and the rest of the calculation remains the same. If not, we have to read from different sources

Suggesstions for csv file name

Table - 2 : mm_sample_hardness.csv
Table - 3 : mm_tube_match.csv
Table - 4 : mm_gpipe_cf.csv
Table - 5 : mm_ugpipe_cf.csv
Table - 6 : mm_gpipe_ip.csv
Table - 7 : mm_ugpipe_ip.csv
Table − 8 : mm_gpipe_mbn.csv
Table - 9 : mm_ugpipe_mbn.csv
Table - 10 : mm_idtube_cf.csv
Table - 11 : mm_idtube_ip.csv
Table - 12 : mm_idtube_mbn.csv
Table - 13 : mm_uidtube_cf.csv
Table - 14 : mm_uidtube_ip.csv
Table − 15 :mm_uidtube_mbn.csv

Do let me know if there are any correction required in this document