MAGNETIC DATA FORMAT

Each BH files stores magnetic material information in magnetization and permeability curves as well as in rows and columns of an excel file. A sample BH file for an Grain Oriented Electrical Steel 23PH90 from Posco, Korea is enclosed. This note shows how the magnetic data is arranged using this file as an example.

Material Name. This name is identical to the Name of the Excel file. The material name can include following:

- Thickness (in mils or thousandths of an inch). e.g., 14 mil means 0.014 inch thickness
- Frequency. For example, 2000 Hz means B-H data is at 2000 Hz.
- Heat treatment. For example
    - o "Fully Processed": steel is delivered as fully annealed by the steel manufacturer.
    - o "Semi-Processed": steel is delivered partially annealed. stress annealing needed
    - o "732C anneal": data when annealed at 732 C anneal schedule on source website.

1.1. B-H Curve

The file includes magnetization and permeability curves shown below. It shows these curves on a common x-axis of magnetic field intensity. The left vertical axis shows flux density B in tesla, while the right vertical axis shows relative permeability which is dimensionless. Note the high nonlinearly and sharp peaks in permeability for this material. The permeability peak occurs at very low H.

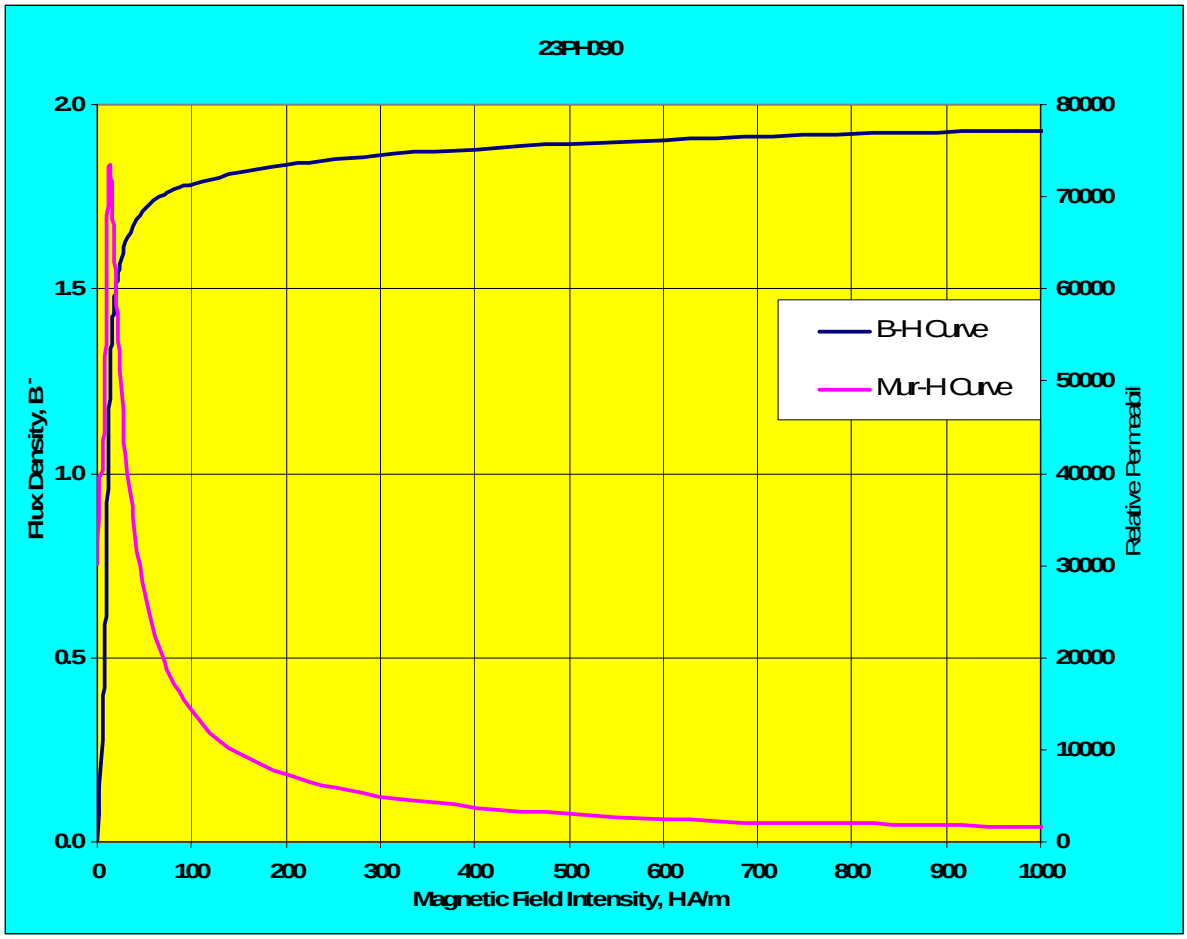


Figure 1 BH Curve for an electrical Steel 23PH90

1.2. Header

All B-H data is headed by 2 rows, with row 1 contains data while row 2 contains descriptors of the data. For a typical 23PH90 material. these two and respective 11 columns are shown below.

C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
Electrical Steel GO	Posco, South Korea	Posco		0.009	0.23	Fully Processed	DC	2.020	2.083	B002
	Manufacturer	***Brand***	***gage***	***inch***	***mm***	***Annealing***	***Hz***	***Bsat***	***MS/m***	*Curve*

The information in 11 Columns C1 to C11 is described below.

C1 - *Material Category.* It is identical to those listed in the home page. The magnetic properties are greatly influenced by the material category.

C2 - Manufacturer of the material

C3 - Brand name of the material given by the manufacturer

C4, C5, C6 - *Thickness* in gage, inches and mm respectively. Generally provided if the steel is a thin lamination. For Non-laminated materials it lists available forms such as slabs, billets, rounds etc.

C7 - Annealing condition as described under material name.

C8 -frequency at which B-H curve is obtained

C9 - Saturation Flux Density Bsat of the material in Tesla

C10 - *Electrical Conductivity in* Ms/m.

C11 -B-H Curve number. It is a unique number assigned to each curve. It is given in Xyyy format where X is the symbol for the material category and yyy is a serial number.

For highly permeable materials such as Metglas or nanocrystalline, only hysteresis loop is sometimes available instead of magnetization curve. The B-H curve is then extracted from it by the Elenbass rule, as explained in Bozorth, Ferromagnetic Materials, Fig. 11-27 and p. 511. This rule states that, for a specific H, the B on the normal magnetization curve equals average of vertical ordinates of the hysteresis loop.

1.3. B-H Data

The BH files store B, H, μ_r as numbers with 8-decimal digits. But for simplicity, it shows only 3 decimal digits of B and none for H and mur. Flux density B is expressed in Tesla, Magnetic Field Intensity H is expressed in A/m and the relative permeability μ_r is dimensionless.
The user can convert the B-H curve into other units using following relations: 1 Tesla = 1 N/Am = 1 Weber/m^2 = 1 volt-sec/m^2 = 10,000 gauss = 64.52 kilo-lines/in^2. 1 A/m = 1/79.577 oersted = 0.01 A/cm = 0.025 A/in.

The B-H data is headed by third row with H, B, mur data labels in columns C1, C2, C3:

C1 *H A/m*. It refers to column 1 label for Magnetic Field Intensity H in A/m, usually expressed as round numbers.

C2 B *Tesla*. It refers to column 2 label for Magnetic Flux Density B in Tesla, usually shown to 3 decimal digits.

C3 *Mur.* It refers to column 3 label for relative permeability (μ_r) .

The data points on the magnetization and permeability curves are presented from row 4. Each row defines a (H, B, mur) data point The numbers refer to DC or peak values (not rms). Each B-H curve is digitized with more than 100 data points. Such large number of data points results in high data density. As B-H curve is highly nonlinear, a B-H data with high data density is essential for convergence of nonlinear field equations.

The B-H data is contained in Col. A and B. The units refer to DC or peak values (not rms). The μ-H data is contained in Col. A and C. The μ-B data is contained in Col. B and C. Data in a row corresponds to one data point of B-H curve.

1.4. Sample BH File

Next few pages include a sample BH File for an electrical steel 23PH090.

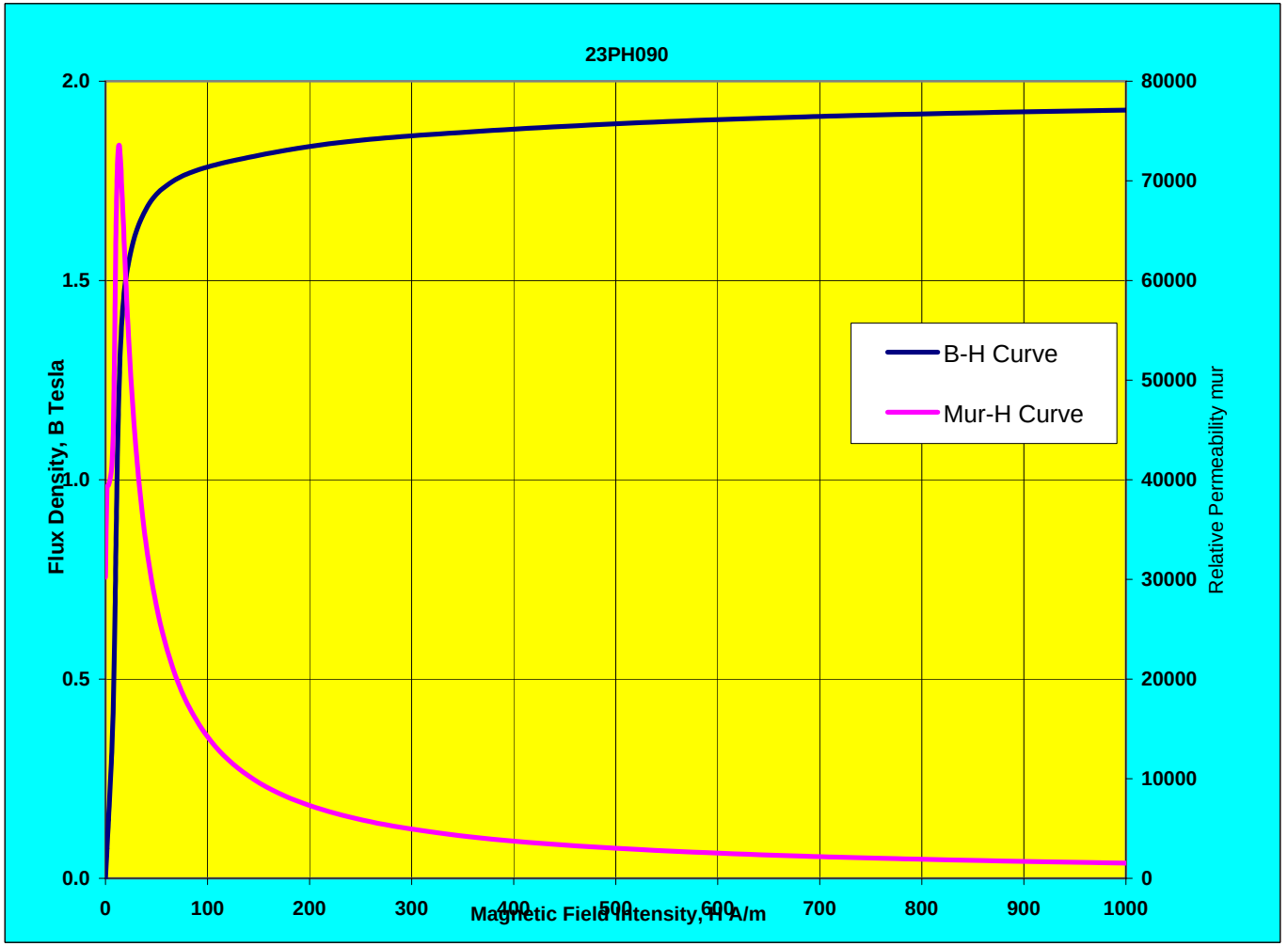
MagWeb
Magnetic Material Data

23PH090

Electrical Steel GO

Manufacturer	Brand	gage	inch	mm	Annealing	Hz	Bsat	MS/m	Curve
Posco, South Korea	Posco	0.009	0.23		Fully Processed	DC	2.020	2.083	B002

H A/m	B Tesla	Mur
0	0.000	30221
2	0.075	39221
3	0.147	39479
4	0.215	39935
5	0.276	40635
6	0.328	41626
7	0.374	42866
7	0.415	44319
8	0.453	45950
8	0.491	47724
8	0.529	49654
9	0.569	51756
9	0.611	54036
9	0.657	56481
10	0.706	59045
10	0.761	61663
10	0.821	64264
11	0.887	66751
11	0.955	68982
12	1.024	70838
12	1.089	72233
13	1.149	73125
13	1.202	73551
14	1.248	73561



14	1.288	73194
15	1.321	72501
15	1.349	71569
16	1.373	70488
16	1.394	69336
17	1.413	68170
17	1.431	67001
18	1.448	65825
18	1.462	64641
19	1.475	63434
19	1.487	62147
20	1.499	60724
20	1.511	59125
21	1.524	57340
22	1.537	55403
23	1.552	53357
24	1.567	51239
26	1.582	49075
27	1.597	46853
29	1.612	44564
31	1.627	42215
33	1.641	39840
35	1.655	37538
38	1.668	35385
40	1.680	33423
43	1.691	31645
45	1.701	29949

48	1.711	28249
52	1.721	26501
56	1.730	24704
60	1.739	22910
66	1.748	21168
72	1.757	19512
78	1.766	17925
87	1.774	16290
97	1.783	14560
112	1.793	12775
130	1.803	11047
151	1.815	9535
175	1.826	8295
200	1.836	7306
225	1.845	6517
252	1.852	5847
282	1.859	5246
317	1.866	4689
357	1.873	4175
402	1.880	3721
450	1.887	3335
500	1.893	3013
550	1.899	2746
602	1.904	2516
657	1.908	2311
717	1.913	2124
784	1.917	1946

867	1.922	1764
974	1.926	1573
1117	1.932	1377
1299	1.937	1187
1515	1.944	1021
1752	1.950	886
2000	1.955	778
2253	1.960	692
2521	1.964	620
2820	1.968	555
3167	1.972	495
3568	1.976	441
4000	1.980	394
4432	1.983	356
4833	1.987	327
5188	1.989	305
5542	1.992	286
5958	1.994	266
6500	1.996	244
7203	1.999	221
8000	2.002	199
8797	2.005	181
9500	2.007	168
10086	2.008	158
10813	2.010	148
12008	2.011	133
14000	2.014	114

17016	2.018	94
20875	2.022	77
25297	2.028	64
30000	2.034	54