IS 648 : 1994

भारतीय मानक

(Reaffirmed 1998)

चुम्बकीय सर्किट के लिए गैर-दिशात्मक विद्युत-इस्पात की चद्दरें एवं पत्तियाँ — विशिष्टि

(चौथा पुनरीक्षण)

Indian Standard

NON-ORIENTED ELECTRICAL STEEL SHEETS AND STRIPS FOR MAGNETIC CIRCUITS — SPECIFICATION

(Fourth Revision)

UDC 669·14·018·54-41 : 621·3·042

BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

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Price Group

FOREWORD

This Indian Standard (Fourth Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Wrought Steel Products Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard was first published in 1955 and subsequently revised in 1962, 1970 and 1980. As a result of the experience gained during these years it has been decided to revise this standard. In this revision the following main modifications have been made:

a) Silicon and silicon free electrical steel sheets and strips in hot rolled/cold rolled conditions and fully processed/semi processed condition have been covered.

b) Grades have been modified.

c) Guaranteed maximum core losses have been specified at 1·5 Tesla and values for maximum core loss at 1·0 Tesla have also been given for guidance.

With a view to facilitate the supply of electrical steel sheets and strips of the exact requirements to the consumers, certain detailed information has to be provided along with each inquiry and order. The information is given in Annex A.

A conversion factor table is given in Annex D for information.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values *(revised)*'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

NON-ORIENTED ELECTRICAL STEEL SHEETS AND STRIPS FOR MAGNETIC CIRCUITS — SPECIFICATION

(Fourth Revision)

1 SCOPE

1.1 This standard covers the requirements for non-oriented either silicon free or with silicon content up to 3·5%, hot rolled uninsulated and cold rolled, both insulated and uninsulated, fully processed or semi-processed electrical steel sheet and strip primarily intended for static and rotating machines operating at power frequencies.

1.2 If required and agreed to between the purchaser and the manufacturer, the typical physical and mechanical properties of the steel sheets/strips shall be supplied by the manufacturer to the purchaser.

2 REFERENCES

The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
649 : 1963	Methods of testing steel sheets for magnetic circuits of power electrical apparatus (*revised*)
1885 (Part 1) : 1961	Electrotechnical vocubulary : Part 1 Fundamental definition
8910 : 1978	General technical delivery requirements for steel and steel products

3 TERMINOLOGY

3.0 For the purpose of this standard, the following definitions in addition to those given in IS 1885 (Part 1) : 1961 shall apply.

3.1 Electrical Steel Sheet/Strip

Electrical steel sheet/strip is a material used for making cores for rotating electric machines and static apparatus.

3.2 Non-oriented Electrical Steel Sheet/Strip

Steel sheet/strip having substantially the same magnetic and electrical characteristics in all directions in the plane of the sheet.

3.3 Hot Rolled Electrical Steel Sheet/Strip

Electrical steel sheet/strip which is reduced to final gauge entirely by hot rolling.

3.4 Cold Rolled Electrical Steel Sheet/Strip

Electrical steel sheet/strip which is reduced to final gauge by cold rolling.

3.5 Silicon Steel

Electrical steel made with deliberate alloying addition of silicon.

3.6 Silicon Free Steel

Electrical steel made without deliberate alloying addition of silicon.

3.7 Fully Processed Material

Material which does not require further processing by the purchaser to give the specified properties.

3.8 Semi-Processed Material

Material which requires a further processing (annealing treatment) by the purchaser, in accordance witth the manufacturer's published recommendation in order to develop the specified magnetic properties.

3.9 Sheet

A hot or cold-rolled flat product, and rolled in rectangular section of thickness below 5 mm and supplied in straight lengths. The width is at least 100 times the thickness and the edges can be mill, trimmed, sheared or flame cut. A sheet can also be obtained by cutting of strips.

3.10 Strip

A hot/cold rolled flat product and rolled approximately in rectangular cross section of thickness normally 12 mm and below with mill, rolled, trimmed or sheared edges and supplied in coil form.

3.10.1 *Wide Strip*

Hot/cold rolled strip of width normally equal to or greater than 600 mm.

3.10.2 *Narrow Strip*

Hot/cold rolled strip of width normally less than 600 mm.

3.11 Coil Interleaves

Laps at the junctions between sub-coils for the purpose of building up larger continuous coils.

3.12 Coil Butt Welds

Butt welds at the junction between sub-coils for the purpose of building up larger continuous coils.

3.13 Batch

A single charge of the product of one or more cast heat treated together with similar quality grading.

3.14 Stacking Factor

The ratio of the calculated volume of a stack of laminations (based on density) to the measured solid volume of stack under testing load.

3.15 Flatness

The flatness shall mean the height of the wave or bulge of a steel sheet/strip in its original form laid on a surface plate and deducting the nominal thickness of the sheet from the height above surface plate.

3.16 Insulated Sheet

Insulated sheet shall mean electrical sheets in sheet/strip form coated on both sides with organic or inorganic or combined organic and inorganic materials to provide interlaminar insulation resistance.

3.17 Density

The ratio of the mass to the volume of a magnetic material kg/dm^3.

3.18 The Anisotropy of Losses

The anisotropy of losses is the difference between the total specific loss measured at right angles and parallel to the direction of the rolling expressed as percentage to the sum of two total specific losses measured at right angle and parallel to the direction of rolling.

$$P\% = \frac{P_a - P_i}{P_a + P_i} \times 100$$

where

P is the anisotropy of losses;

P_a is the total specific loss P at 1·5 Tesla perpendicular to the direction of rolling; and

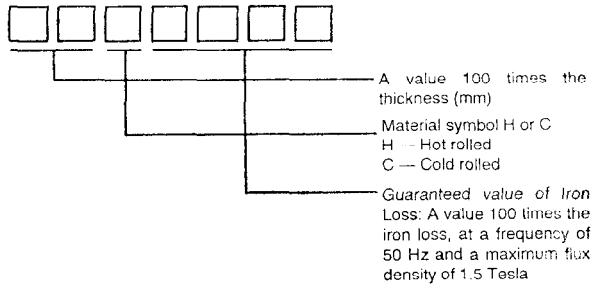
P_i is the total loss P at 1·5 Tesla parallel to the direction of rolling.

4 CLASSIFICATION OF GRADES

This standard covers the grades listed in Table 1, with the forms and condition of supply as specified in IS 8910: 1978. The grades are classified according to the maximum value of total specific loss at a polarization of 1·5 T and according to the nominal thickness (0·35, 0·50, 0·65 and 1·00 mm).

5 DESIGNATION

The complete symbol for grade of magnetic sheet and strip shall consist of the following:



Example:

i) Designation of Hot Rolled, finally annealed magnetic strip of grade symbolized by 35H330 (Thickness 0·35 mm, Total specific loss at 1·5 T not exceeding 3·30 W/kg),

ii) Designation of Cold Rolled, Non-oriented, finally annealed magnetic strip of a grade symbolized by 50C470 (Thickness 0·50 mm. Total Specific Loss at 1·5 T not exceeding 4·70 W/kg).

6 CONDITION OF DELIVERY

6.1 The product shall be supplied in the fully processed condition or in semi-processed condition as agreed between the manufacturer and the purchaser.

6.2 The cold rolled sheet/strip may be supplied with or without insulation coating on both sides. In this case, the nature of the insulation, its properties and their variation shall be as per **10.**

7 CHEMICAL COMPOSITION

The chemical composition of steel is left to the manufacturer's discretion. However, the chemical composition may be provided, if agreed to between the manufacturer and the purchaser at the time of placing the order.

8 MAGNETIC CHARACTERISTICS

8.1 Permeability Test

8.1.1 *A. C. Permeability Test*

The A. C. permeability test shall be carried out as specified in IS 649 : 1963.

8.1.2 The minimum values for various grades to be guaranteed are given in Table 1.

Table 1 Designation of Electrical Steel Grades

(*Clauses* 8.1.2, 8.2.1, 9.2, 12.1)

Sl No.	Thickness	Designation		No. of Bends	Assumed Density	Maximum Core Loss W/kg at		Anisotropy of Total Specific Loss at 1·5 T% *Max*		A. C. Magnetisation (50 Hz) Minimum Values of B *Max* (Tesla)						D. C. Magnetisation Minimum Values of B *Max* (Tesla)					
		Hot Rolled	Cold Rolled							Hot Rolled Sheets A/M			Cold Rolled Sheets A/M			Hot Rolled Sheets A/M			Cold Rolled Sheets A/M		
	mm				kg/dm³	1T	1·5T	HR	CR	2 500	5 000	10 000	2 500	5 000	10 000	1 600	2 500	10 000	1 600	2 500	10 000
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
1	0·35	35H250	35C250	2	7·60	1·00	2·50	± 8	± 18	1·47	1·59	1·70	1·49	1·60	1·71	1·33	1·45	1·69	1·35	1·46	1·70
2	0·35	35H270	35C270	2	7·65	1·00	2·70	± 8	± 18	1·47	1·59	1·70	1·49	1·60	1·71	1·33	1·45	1·69	1·35	1·46	1·70
3	0·35	35H300	35C300	3	7·65	1·20	3·00	± 8	± 18	1·47	1·59	1·70	1·49	1·60	1·71	1·33	1·45	1·69	1·35	1·46	1·70
4	0·35	35H330	35C330	3	7·65	1·30	3·30	± 8	± 18	1·47	1·59	1·70	1·49	1·60	1·71	1·33	1·45	1·69	1·35	1·46	1·70
5	0·35	35H360	35C360	3	7·65	1·40	3·60	± 8	± 18	1·47	1·59	1·70	1·49	1·60	1·71	1·33	1·45	1·69	1·35	1·46	1·70
6	0·50	50H270	50C270	2	7·60	1·10	2·70	± 8	± 18	1·47	1·59	1·70	1·49	1·60	1·70	1·33	1·45	1·69	1·35	1·46	1·70
7	0·50	50H290	50C290	2	7·60	1·15	2·90	± 8	± 18	1·47	1·59	1·70	1·49	1·60	1·71	1·33	1·45	1·69	1·35	1·46	1·70
8	0·50	50H330	50C330	3	7·60	1·35	3·30	± 8	± 14	1·47	1·59	1·70	1·49	1·60	1·70	1·33	1·45	1·69	1·35	1·46	1·70
9	0·50	50H350	50C350	5	7·65	1·50	3·50	± 8	± 12	1·47	1·59	1·70	1·50	1·60	1·71	1·33	1·45	1·69	1·35	1·46	1·70
10	0·50	50H400	50C400	5	7·65	1·70	4·00	± 8	± 12	1·48	1·60	1·70	1·51	1·61	1·71	1·33	1·45	1·69	1·35	1·47	1·70
11	0·50	50H470	50C470	10	7·70	2·00	4·70	± 6	± 10	1·49	1·61	1·71	1·52	1·62	1·72	1·33	1·45	1·70	1·35	1·46	1·71
12	0·50	50H530	50C530	10	7·70	2·30	5·30	± 6	± 10	1·51	1·63	1·74	1·54	1·64	1·74	1·35	1·47	1·71	1·36	1·48	1·72
13	0·50	50H560	50C560	10	7·75	2·40	5·60	± 6	± 10	1·51	1·63	1·74	1·54	1·64	1·75	1·35	1·49	1·71	1·36	1·48	1·73
14	0·50	50H600	50C600	10	7·75	2·60	6·00	± 6	± 10	1·53	1·64	1·75	1·55	1·65	1·75	1·38	1·50	1·72	1·39	1·51	1·74
15	0·50	50H630	50C630	10	7·75	2·80	6·30	± 6	± 10	1·53	1·64	1·75	1·55	1·65	1·76	1·38	1·50	1·72	1·39	1·51	1·74
16	0·50	50H700	50C700	10	7·80	3·00	7·00	± 6	± 10	1·54	1·65	1·76	1·58	1·68	1·76	1·41	1·51	1·74	1·42	1·53	1·76
17	0·50	50H800	50C800	10	7·80	3·60	8·00	± 6	± 10	1·56	1·66	1·77	1·58	1·68	1·77	1·45	1·52	1·76	1·46	1·53	1·77
18	0·50	50H900	50C900	10	7·80	3·80	9·00	± 6	± 10	1·56	1·66	1·77	1·58	1·68	1·77	1·45	1·53	1·80	1·46	1·54	1·81
19	0·50	50H1000	50C1000	10	7·85	4·40	10·00	± 6	± 10	1·57	1·68	1·79	1·59	1·69	1·79	1·45	1·53	1·80	1·46	1·54	1·81
20	0·50	50H1300	50C1300	10	7·85	6·00	13·00	± 6	± 10	1·57	1·68	1·79	1·59	1·69	1·79	1·45	1·54	1·80	1·46	1·55	1·82
21	0·50	50H1600	50C1600	10	7·85	7·00	16·00	± 6	± 10	1·58	1·69	1·80	1·60	1·70	1·80	1·46	1·54	1·81	1·47	1·55	1·82
22	0·65	65H330	65C330	2	7·60	1·35	3·30	± 8	± 14	1·46	1·57	1·67	1·49	1·60	1·70	1·33	1·45	1·69	1·35	1·46	1·70
23	0·65	65H350	65C350	2	7·60	1·50	3·50	± 8	± 14	1·46	1·57	1·67	1·49	1·60	1·70	1·33	1·45	1·69	1·35	1·46	1·70
24	0·65	65H400	65C400	2	7·65	1·70	4·00	± 8	± 14	1·49	1·59	1·69	1·50	1·60	1·70	1·53	1·60	1·80	1·54	1·61	1·81
25	0·65	65H470	65C470	5	7·65	2·00	4·70	± 8	± 14	1·50	1·60	1·70	1·51	1·60	1·71	1·53	1·59	1·80	1·55	1·60	1·81
26	0·65	65H530	65C530	5	7·70	2·30	5·00	± 8	± 12	1·50	1·60	1·70	1·51	1·61	1·71	1·53	1·59	1·80	1·55	1·60	1·81
27	0·65	65H600	65C600	10	7·70	2·60	6·00	± 6	± 10	1·52	1·63	1·73	1·54	1·64	1·74	1·53	1·61	1·80	1·55	1·62	1·81
28	0·65	65H700	65C700	10	7·75	3·00	7·00	± 6	± 10	1·52	1·64	1·74	1·55	1·65	1·75	1·56	1·62	1·80	1·57	1·63	1·82
29	0·65	65H800	65C800	10	7·80	3·00	8·00	± 6	± 10	1·54	1·66	1·75	1·56	1·66	1·76	1·56	1·62	1·80	1·57	1·63	1·82
30	0·65	65H940	65C940	10	7·75	4·20	9·40	± 6	± 10	1·56	1·67	1·76	1·58	1·68	1·77	1·57	1·63	1·84	1·59	1·65	1·86
31	0·65	65H1000	65C1000	10	7·85	4·50	10·00	± 6	± 10	1·56	1·67	1·76	1·58	1·68	1·77	1·57	1·63	1·84	1·59	1·65	1·86
32	0·65	65H1200	65C1200	10	7·85	5·40	12·00	± 6	± 10	1·57	1·68	1·79	1·59	1·69	1·79	1·58	1·64	1·85	1·59	1·65	1·86
33	0·65	65H1580	65C1580	10	7·85	7·10	15·80	± 6	± 10	1·57	1·68	1·79	1·59	1·69	1·79	1·58	1·64	1·85	1·59	1·65	1·86
34	0·65	65H1900	65C1900	10	7·85	8·60	19·00	± 6	± 10	1·58	1·69	1·80	1·60	1·70	1·80	1·58	1·64	1·85	1·59	1·65	1·86
35	1·00	100H1120	100C1120	10	7·85	4·90	11·20	± 6	± 10	1·56	1·66	1·77	1·58	1·68	1·78	1·45	1·54	1·80	1·46	1·55	1·80

8.1.3 *D. C. Permeability Test*

If in special case the magnetic permeability is to be determined in the direct field, the minimum values to be agreed between the manufacturer and the purchaser.

8.2 Total Specific Loss

8.2.1 The maximum values of total specific loss to be guaranteed at 1·5 *T* are as per Table 1. The values apply for the thickness of 0·35 and 0·50 mm to the aged sample and for 0·65 and 1·00 mm to non-aged samples. The values of total specific loss at 1·0 Telsa given in Table 1 are for information only.

8.2.2 The test samples shall be prepared and tested as described in IS 649 : 1963 at a peak magnetic flux density of 1·5 *T* at 50 Hz. Wherever relevant, the samples shall be annealed in accordance with the manufacturer's recommendations before testing.

8.2.3 The ageing shall be carried out as specified in IS 649 : 1963 or this may be replaced by an accelerated ageing with a duration of 24 h at a temperature of 225°C.

8.2.4 *Anisotropy of Losses*

8.2.4.1 If required by the purchaser, the anisotropy of losses (for testing, *see* Annex B) should be tested. The maximum values of Table 1 should be guaranteed (*see* **8.2.1**).

8.2.5 If agreed to between the purchaser and the manufacturer, the manufacturer shall supply characteristic curves for the following properties to the purchaser on request:

a) Core Loss at 50 Hz
b) A. C. Magnetization
c) A. C. Permeability
d) D. C. Magnetization
e) D. C. Permeability
f) Hysteresis Loop D. C.
g) Exciting Power
h) High Frequency Core Loss
k) High Frequency Permeability

8.2.6 If agreed to between the purchaser and the manufacturer, the manufacturer should also give information for the following properties to the purchaser on request.

a) Typical Electrical Resistivity values for each grade.
b) Typical Thermal Conductivity values for each grade.

9 PHYSICAL PROPERTIES

9.1 Stacking Factor

The surface quality of the uninsulated Hot Rolled/Cold Rolled sheet/strip and insulated Cold Rolled sheet/strip when measured in terms of Stacking Factor as specified in IS 649 : 1963 shall comply with minimum values given in Table 2.

9.2 Bend Test

The bend test shall be carried out as specified in IS 649 : 1963. The test piece shall withstand the number of bends as given in Table 1. The radius of jaws shall be 5·0 mm.

10 SURFACE INSULATION CHARACTERISTICS

10.1 Unless otherwise specified, fully processed cold rolled electrical sheets shall be supplied without coating. In the case of coating, they shall be coated with either organic or inorganic materials, as specified by the purchaser. The description of the coatings is given at Annex D.

10.2 The coating should have uniform colour throughout the surface of the coil tightly adherent to both sides.

10.3 If insulated material is required for subsequent annealing, this should be stated by purchaser on his inquiry and order. The coating supplied shall withstand annealing under condition specified by the supplier.

10.4 The thickness of insulation coating shall be as agreed between the manufacturer and the purchaser.

10.5 The minimum values for Insulation Resistance on both types of coatings shall be as given below:

Average of 10 Non-Overlapping Readings of IR (5 on Either Side of Sheet)	*Individual Min Value of IR*
Ohm-cm²	Ohm-cm²
2·5	1
5·0	1
10·0	1
15·0	2
20	2
30	10
50	10
100	20

10.6 Method of measurement of insulation resistance shall be as described in Annex C.

10.7 Thermal Effect on Coating

If agreed between the purchaser and the manufacturer, twelve specimens of the coated strip shall be clamped together under a pressure of 1 N/mm² approximately and heated in a labora-

Table 2 Stacking Factor

(*Clause* 9.1)

Nominal Thickness	Uninsulated		Insulated Cold Rolled
	Hot Rolled	Cold Rolled	
mm	%	%	%
0·35	93	95	93
0·50	95	97	95
0·65	95	97	95
1·00	96	98	96

tory oven at a temperature of 150°C for a period of 7 days. After cooling to the room temperature the insulation surface resistance (two side coated) shall be not less than the minimum specified values mentioned in **10.4** above.

10.8 Resistance to Solvents and Cleanliness

If agreed between the user and the manufacturer, the specimens shall be kept in a container filled with boiling Trichloroethylene or xyline for 5 min. After removal and cooling to room temperature, the film should not get soft enough so that it can be wiped off.

11 RETESTS

11.1 Should a test sample fail, two further samples shall be selected at random from the same batch of material and tested in the same manner.

11.2 If either of both of the retest samples on testing indicate that the core loss is greater than the maximum loss specified for the respective grade, the batch represented by these samples shall be taken as not complying with the requirements of that grade.

12 NOMINAL THICKNESS

12.1 The nominal thickness for each grade are given in Table 1.

12.1.1 If the material is required in thicknesses other than those specified in Table.1, these may be supplied as per the properties mutually agreed between the purchaser and the manufacturer.

13 SIZES

13.1 The sizes of strips and sheets supplied in coil or in cut lengths shall be subject to mutual agreement between the purchaser and the manufacturer.

13.2 The following sizes of sheets in cut lengths shall be considered as preferred sizes for all the grades specified in this standard:

Length	*Width*
mm	mm
3 000	1 000
3 000	1 200
3 000	800
2 745	915
2 500	1 000
2 500	900
2 000	1 000
2 000	915
2 000	800
1 720	860
1 500	750

13.3 When the material is supplied in coils, the following shall be considered as preferred dimensions of coils for all the grades specified in this standard:

Internal Diameter

400/430/450/510/610

13.3.1 When supplied in cut length form, the packet mass shall not be more than 3·5 tonnes.

13.3.2 *Interleaves and Welds*

If a coil is not in one continuous length, the interleaves shall be clearly marked for the benefit of operators unwinding the coils.

13.3.2.1 Small coils may be joined together by butt welding to form larger continuous coils in which case the welds shall be marked as for interleaves. The supplier shall ensure that the welds are made in such a manner as not to damage areas of the coils adjacent to the weld.

13.3.2.2 No coil shall contain more than 3 butt welds or interleaves. If either welds only or interleaves only are required, this should be stated by the purchaser on the inquiry and order. If less than 3 butt welds or interleaves are required this shall be the subject of an agreement between the purchaser and the manufacturer.

13.3.3 *Stability*

Coils shall be sufficiently tightly wound to prevent collapse to an extent that would preclude their being mounted on a mandrel appropriate to the ordered internal diameter.

14 TOLERANCES

14.1 Hot Rolled Sheet and Strip

14.1.1 Tolerance on thickness and width of hot rolled sheet and strip.

14.1.2 The tolerance on thickness at any point on any sheet, or strip measured by contact

micrometer at a point not less than 25 mm from any edge shall not exceed the following limits:

± 15 percent of nominal thickness.

14.1.3 The maximum range of thickness variation for an individual sheet in general shall be less than those given below:

Nominal Thickness	*Range*
mm	mm
Less than 0·5	0·08
0·5 to 0·65	0·10
More than 0·65	0·15

14.1.4 The permissible tolerances on the sizes specified under **13.2** shall be as follows:

Tolerance on width, mm $^{+10}_{-0}$

14.2 Cold Rolled Sheet and Strip

14.2.1 Tolerance on thickness measured as in **14.1.2** and width on Cold rolled insulated sheet and strip shall be as given in Table 3.

Table 3 Tolerances

Width	Thickness	Thickness Tolerance	Width* Tolerances for Trimmed Sheets
mm	mm	%	mm
Up to 150	0·35	± 10	+ 0·3
	0·50	± 8	− 0
	0·65	± 8	
	1·00	± 8	
Over 150 and up to 500	0·35	± 10	+ 0·5
	0·50	± 8	− 0
	0·65	± 8	
	1·00	± 8	
Over 500	0·35	± 10	+ 1·5
	0·50	± 8	− 0
	0·65	± 8	
	1·00	± 8	

*The height of edge burr shall not exceed 50 microns.

14.2.2 The deviation of thickness in trnsverse direction measured as in **14.1.2** on cold rolled material in coil form shall not exceed 0·03 mm for a nominal thickness of 0·35 mm, 0·50 mm, 0·65 mm and 1·00 mm.

14.2.3 The tolerance on the width of mill run sheet shall be as per **14.1.4**.

14.3 Tolerance on length on the sizes specified under **13.2** shall be as follows:

Hot Rolled (mm)	*Cold Rolled* (mm)
+ 20	+ 10
− 0	− 0

14.3.1 Tolerance on sizes other than those covered under **13.2** and **13.3** shall be subject to an agreement between the purchaser and the manufacturer.

14.4 Tolerance on Shape

Out of square, tolerance shall not be more than 1 percent of the length and width (*see* Fig. 1).

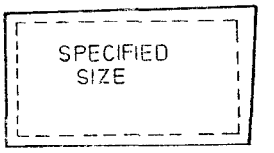


FIG. 1 SHAPE TOLERANCES

14.4.1 The tolerance on edge camber of strip in coil shall not exceed 4 mm in 2 000 mm measured against a straight edge using a 2 000 mm length cut from a coil (*see* Fig. 2).

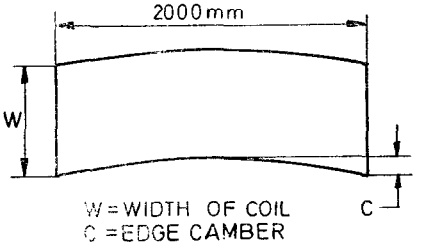


FIG. 2 EDGE CAMBER

14.4.2 *Bowing*

Strip unwound from coil shall exhibit a minimum amount of residual curvature in the longitudinal direction (bowing) and the distance shall not exceed 10 mm.

14.5 Tolerance on Flatness

Flatness shall be measured by placing a specimen of sheet or strip 2·000 mm long on a flat surface with convex side up. The deviation at a free edge from the flat surface shall not exceed 4 mm for cold rolled material and 25 mm for hot rolled material (*see* Fig. 3).

d=DEVIATION

FIG. 3 FLATNESS TOLERANCES

14.6 Sheet and Strip for Specific Purposes

Material required to tolerances other than those specified in **14.1** to **14.5** shall be subject to agreement between the purchaser and the manufacturer.

15 SURFACE CONDITION

15.1 Uninsulated Material

15.1.1 The material shall be as free from rust, loose scale, dents, surface defects, residues resulting from pickling of neutralizing liquor, dust and internal stresses as is commercially practicable at the time of despatch.

15.1.2 If oil is used as a rust preventive it shall not inhibit the subsequent insulating process. The residual scale, if present, should be adherent and shall not be detachable in subsequent processing by shearing or stamping.

15.1.3 The Surface Roughness, R_a, value of the cold rolled material shall not exceed 2·5 micron.

15.2 Insulated Material

15.2.1 The material shall be as free from rust, scale, dents and surface defects as is commercially practicable.

15.2.2 The coating shall be smooth and reasonably free from dust.

15.2.3 The coating shall be sufficiently adherent, so that it does not become detached during shearing or stamping.

15.2.4 The Surface Roughness, R_a, value of the material shall be between 0·2 micron to 0·75 micron.

16 PACKING

16.1 The sheets/strips shall be suitably packed in metal protected containers lined with waterproof material lining to avoid any damage and to ensure protection from rust during transit. The method of packing shall be subject to the approval by the purchaser before shipment from manufacturer's works.

16.2 Some typical methods of packing are given in Fig. 4 to 8.

17 MARKING

17.1 Every bundle/coil of sheet/strip shall be legibly marked with the following:

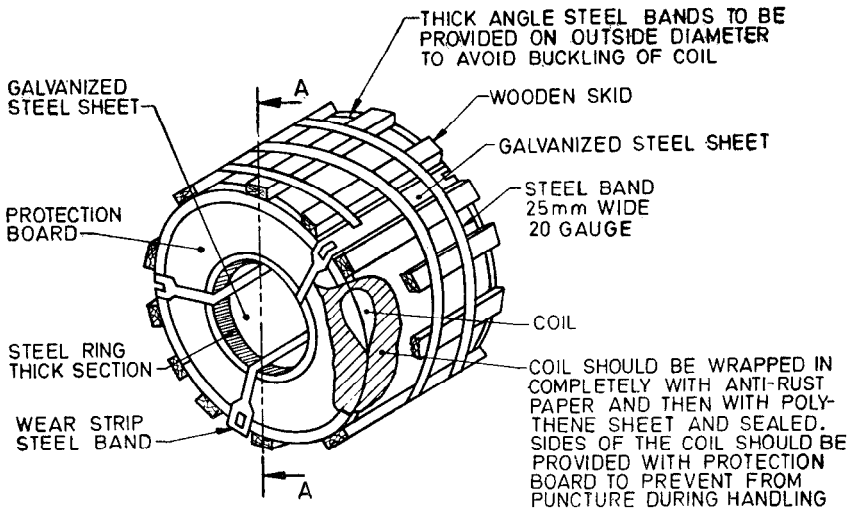
a) Manufacturer's name or trade-mark;
b) Grade and thickness;
c) Gross and net mass (at the top of bundle);
d) Cast number or identification mark by which the sheets/strips may be traced to the cast from which they were made;
e) Whether silicon-steel (SI) or silicon-free steel (SIF);
f) Whether fully processed (FP) or semi-processed (SP); and
g) Type of coating; if coated.

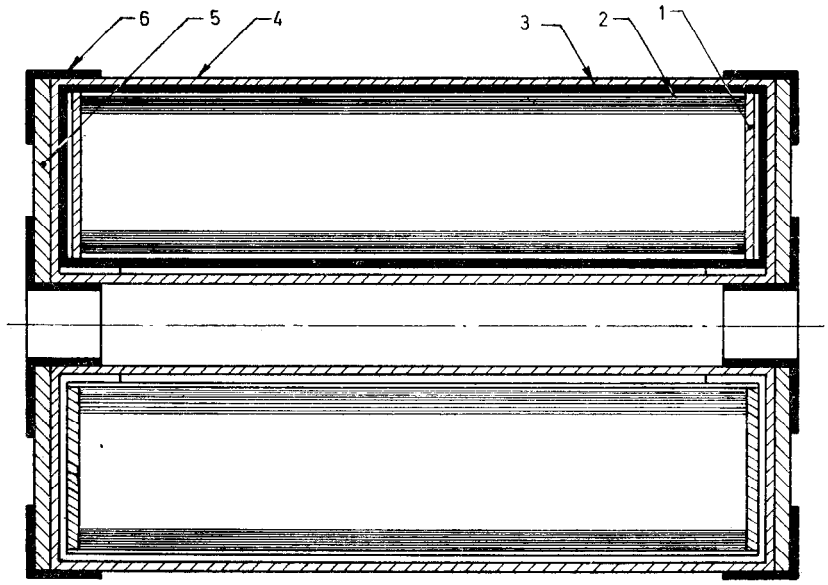
17.1.1 The material may also be marked with the Standard Mark.

18 TEST CERTIFICATE

The manufacturer shall provide with each consignment, a test certificate giving the following as per the agreement between the manufacturer and the purchaser at the time of placing the order:

a) Grade/Thickness;
b) Specific total loss for each coil/packet;
c) Chemical composition;
d) Insulation resistance, if coated;
e) No. of bends;
f) Stacking factor;
g) Density;
h) Anisotropy;
j) Insulation thickness;
k) Adherence;
m) Resistance to solvent;
n) Thermal effect; and
p) Dimensions.

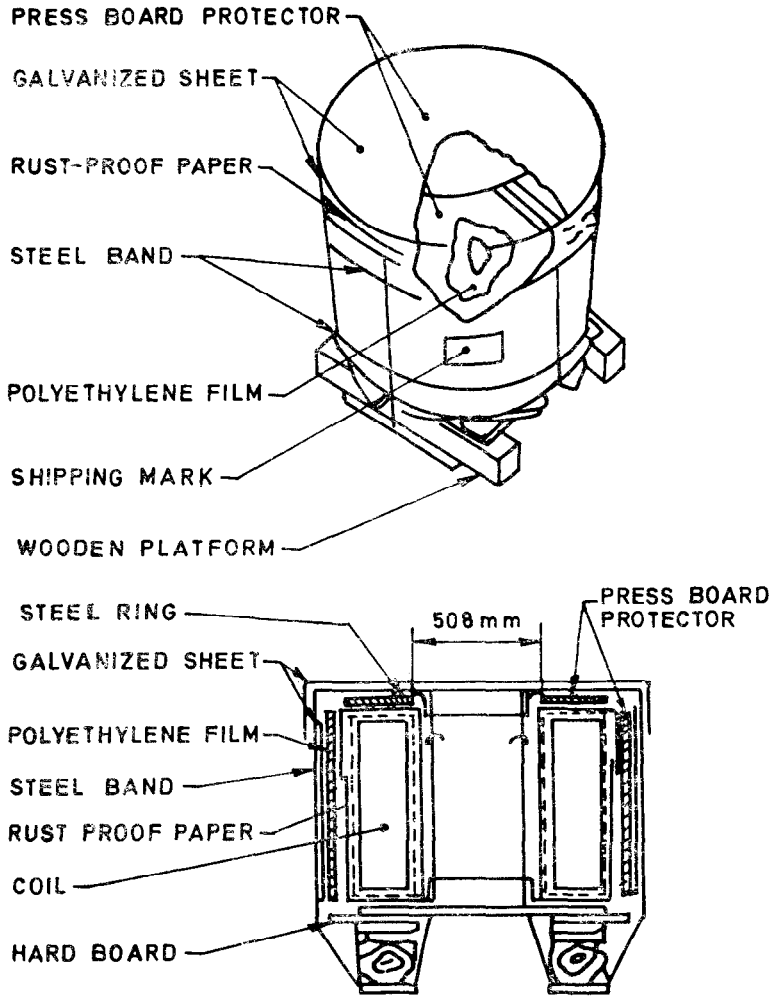




SECTION-AA

1. Protection board
2. Anti-rust paper
3. Polythene sheet
4. Galvanized sheet
5. Protection board
6. Steel ring both inside and outside

FIG. 4 DETAILS OF PACKING FOR ELECTRICAL STEEL SHEET AND STRIP IN COIL FORM (HORIZONTAL)



STEP I — An annular protection board should be placed at either end of the coil.

STEP II — The coil should then be wrapped with waterproof anti-rust crape kraft paper by lapping axially all around the circumference.

STEP III — The coil shall then be covered by polythelene sheet or waterproof kraft paper and the ends sealed properly.

STEP IV — A galvanized sheet should be wrapped on the outside of the coil and the two ends. Care should be taken to ensure that the ends extend sufficiently over the inside diameter of the coil.

STEP V — A galvanised sheet should be wrapped on the inside of the coil; care should be taken that it overlaps sufficiently over the ends of the sheet mentioned in (IV) above.

STEP VI — Steel rings made from thick angle sheet should be placed on the rims of the inner and outer diameters at both ends of the coil. The rings should be held at either ends at four points by steel bands.

STEP VII — The coil should then be mounted on wooden skids held together by steel bands.

STEP VIII — The packing should ensure that there is no seepage of moisture and the sheets reach BHEL in completely rust free condition. It should be strong enough to withstand handling at the docks, at sea and on the road.

STEP IX — Coils should be sufficiently tight wound to prevent collapse to an extent that would preclude their being mounted on a mandrel appropriate to the ordered internal diameter.

STEP X — The strip shall be of constant width and wound in such a way that the edges are superimposed in a regular manner and that the side faces of the coil are substantially flat.

FIG. 5 DETAILS OF PACKING FOR ELECTRICAL SHEET AND STRIP IN COIL FORM (VERTICAL)

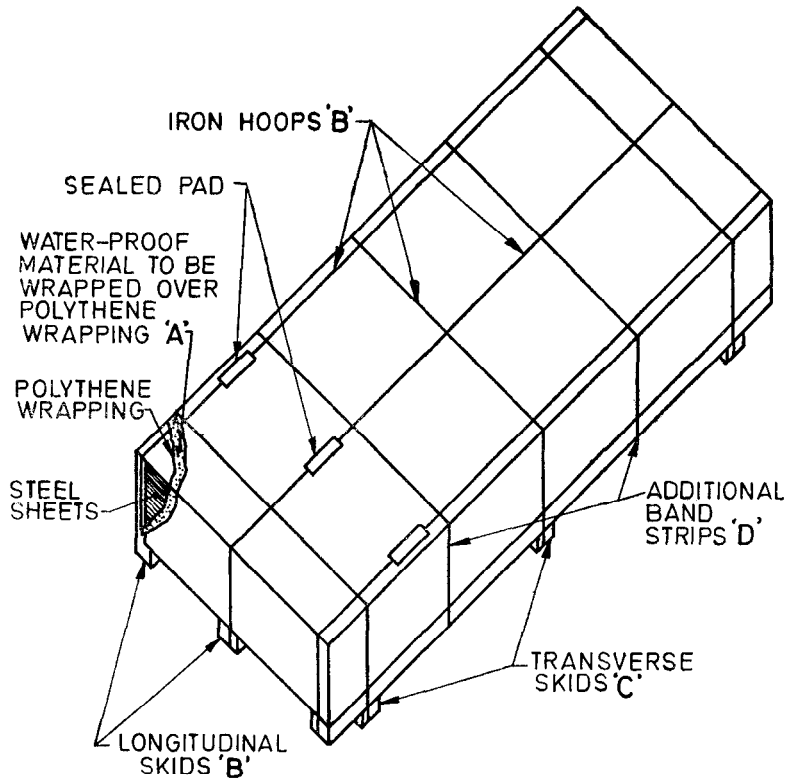
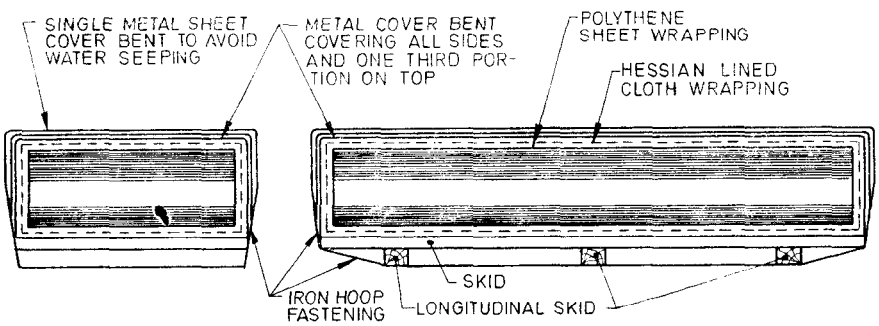


FIG. 6 DETAILS OF ELECTRICAL STEEL SHEET PACKINGS IN CUT LENGTHS
(For Details *see* Fig. 7A and 7B)



(Read this matter alongwith Fig. 6)

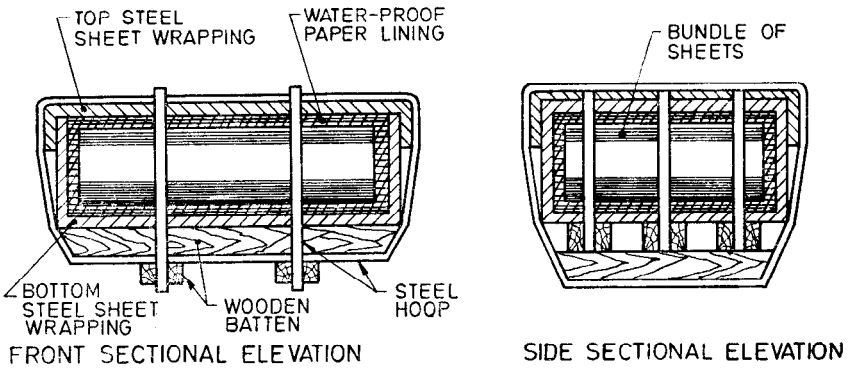
STEP I — Wrap the pack all round with polythene sheet and then with water proof hessian cloth as shown at '*A*'.

STEP II — Wrap the pack in metal sheet and bend metal sheet on the sides on top to cover one-third portion of the top. Cover the top with single metal cover bent over the sides. (A box type cover on top if possible is preferred to avoid water seeping inside). Care has to be taken to ensure that top sheet is not made up of a number of sheets from which water may seep inside the back.

STEP III — Keep assembled back on three longitudinal wooden skids approximately 75 mm × 75 mm cross section and fasten with 32 mm wide × 20 gauge iron hoop as shown at '*B*'.

STEP IV — Mail three transverse skids to the longitudinal skids and fasten with strips band as shown at '*D*'.

FIG. 7 DETAILS OF ELECTRICAL STEEL SHEET PACKINGS IN CUT LENGTHS



NOTES

1 Water-proof paper lining shall be preferably Volatile Corrosion Inhibitor (V. C. I.) coated paper with an additional polythene (100 micron) envelope.

2 Approximate weight of each bundle shall be 2 in 3 metric tonnes. Bundles weighing 2 metric tonnes are, however, preferred.

FIG. 8 DETAILS OF PACKING ELECTRICAL STEEL SHEET IN CUT LENGTHS

ANNEX A

(*Foreword*)

INFORMATION TO BE SUPPLIED ALONG WITH EACH ENQUIRY AND ORDER BY THE PURCHASER

A-1 Grade of electrical steel sheet/strip required (*see* Table 1).

A-2 Whether the sheet/strip is to be supplied hot rolled or cold rolled.

A-3 Whether the sheet/strip to be supplied is with silicon or silicon free.

A-4 Whether the sheet/strip to be supplied is fully processed or semi-processed.

A-5 The length, width and thickness of sheets or the width, thickness, maximum and minimum acceptable mass and internal diameter of coils required (*see* Table 1, **13.2** and **13.3**).

A-6 The number of interleaves and/or butt welds acceptable in a coil (**13.3.2**).

A-7 Type of coating and nominal thickness.

A-8 Any optional tests required.

A-9 Any special requirements (*see* **4, 13.1, 14.3.1, 14.6** and **16.1**).

ANNEX B

(*Clause* 8.2.4)

METHOD FOR DETERMINING ANISOTROPY AND LOSSES

For determining the anisotropy of losses, the total specific loss shall be measured separately on sample strips taken parallel and perpendicular to the direction of rolling. The anisotropy of losses is to be calculated from the formula

$$P\% = \frac{P_a - P_i}{P_a + P_i} \times 100$$

where

P is the anisotropy of losses;

P_a is the total specific loss P at 1·5 T perpendicular to the direction of rolling; and

P_i is the total loss P at 1·5 T parallel to the direction of rolling.

ANNEX C

(*Clause* 10.6)

INSULATION RESISTANCE TEST METHOD BASED ON FRANKLIN TEST METHOD

This method covers testing of single strips or punchings of flat rolled electrical steel for surface insulation resistance under predetermined conditions of voltage, pressure and temperature. An average current from multiple contacts, through one insulating coating to the metal core of the lamination is measured at the contact pressure desired. The test range is found zero to 1·0A. This current can be converted into an equivalent surface resistance by proper consideration of the test voltage and circuit resistance. This method is particularly suitable for quality control in the application if insulating coatings.

NOTE — When conducting a test in accordance with this method, single readings should not be considered significant since the nature of the test device and specimen are such that successive measurements of a specimen often yield different values. The minimum average of 10 known overlapping resistance measurements (five on each side of sheet) should be taken.

This method applies ten metallic contacts of fixed area to the coated surface under specified load and temperature conditions. The effectiveness of the coating insulation between the surface of these contacts and the base metal may then be evaluated on the basis of a current measurement.

ANNEX D

(*Foreword*)

CONVERSION FACTOR

Unit	*Multiply*	*By*	*To Obtain*
Megnetizing Force	Oersted (Oe)	$7{\cdot}958 \times 10$	Ampere per meter (A/m)
	Oersted (Oe)	2·021	Ampere per inch (A/in)
	Ampere per meter (A/m)	$1{\cdot}257 \times 10^{-2}$	Oersted (Oe)
	Ampere per meter (A/m)	$2{\cdot}540 \times 10^{-2}$	Ampere per inch (A/in)
	Ampere per inch (A/in)	$4{\cdot}947 \times 10^{-1}$	Oersted (Oe)
	Ampere per inch (A/in)	$3{\cdot}937 \times 10$	Ampere per meter (A/m)
	Ampere per centemeter (A/cm)	10^{2}	Ampere per meter (A/m)
Magnetic Induction	Tesla (T)	10^{4}	Gauss (G)
	Tesla (T)	1	Weber per square meter (Wb/m^2)
	Gauss (G)	10^{-4}	Weber per square meter (Wb/m^2)
	Gauss (G)	6·452	Lines per square inch ($Line/in^2$)
	Weber per square meter (Wb/m^2)	10^{-4}	Gauss (G)
	Weber per square meter (Wb/m^2)	1	Tesla (T)

	Weber per square meter (Wb/m^2)	$6{\cdot}452 \times 10^{4}$	Lines per square inch ($Line/in^2$)
	Lines per square inch ($Line/in^2$)	$1{\cdot}550 \times 10^{-1}$	Gauss (G)
	Lines per square inch ($Lines/in^2$)	$1{\cdot}550 \times 10^{-5}$	Weber per square meter (Wb/m^2)
Core Loss	Watt per kilogram (W/kg)	$4{\cdot}536 \times 10^{-1}$	Watt per pound (W/lb)
	Watt per pound (W/lb)	2·204	Watt per kilogram (W/kg)
Permeability	CGS electro-magnetic unit (emu)	1	Gauss per Oersted (G/Oe)
	OGS electro-magnetic unit (emu)	$1{\cdot}257 \times 10^{-4}$	Henry per meter (H/m)
	CGS electro-magnetic unit (emu)	$1{\cdot}257 \times 10^{-6}$	Weber per Ampere-meter (Wb/A-m)
	CGS electro-magnetic unit (emu)	$3{\cdot}192 \times 10^{-8}$	Weber per Ampere-inch (Wb/A-in)
	CGS electro-magnetic unit (emu)	3·192	Lines per Ampere-inch (Line/A-in)
	Henry per meter (H/m)	$7{\cdot}958 \times 10^{5}$	CGS electro-magnetic unit (emu)
	Henry per meter (H/m)	$7{\cdot}958 \times 10^{5}$	Gauss per Oersted (G/Oe)
	Henry per meter (H/m)	$2{\cdot}540 \times 10^{-2}$	Weber per Ampere-inch (Wb/A-in)
	Henry per meter (H/m)	$2{\cdot}540 \times 10^{4}$	Lines per Ampere-inch (Line/A-in)
Length	Meter (m)	$3{\cdot}937 \times 10^{6}$	inch (in)
	Inch (in)	$2{\cdot}540 \times 10^{-2}$	Meter (m)
	Meter (m)	3·281	Feet (ft)
	Feet (ft)	$3{\cdot}048\ 10^{-1}$	Meter (m)
Weight	Kilogram (kg)	2·204	Pound (lb)
	Pound (lb)	$4{\cdot}536\ 10^{-1}$	Kilogram (kg)

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Amendments Issued Since Publication

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AMENDMENT NO. 1 MAY 1996
TO
IS 648 : 1994 NON-ORIENTED ELECTRICAL STEEL SHEETS AND STRIPS FOR MAGNETIC CIRCUITS — SPECIFICATION

(Fourth Revision)

(*Page* 2, *clause* **8.1.2**) — Substitute the following for the existing clause:

'**8.1.2** The minimum values of A.C. permeability for various grades of cold rolled sheet/strip to be guaranteed are given in Table 1. For hot rolled sheets, the test shall be carried out only if mutually agreed upon by the supplier and the purchaser. The acceptance values for the test shall be agreed between the supplier and the purchaser.'

(*Page* 4, *clause* **10.1**, *last sentence*) — Delete.

(*Page* 6, *clause* **14.2.2**, *line* 1) — Substitute the word 'transverse' *for* 'trnsverse'.

(MTD 4)

Reprography Unit, BIS, New Delhi, India

AMENDMENT NO. 2 AUGUST 2000
TO
IS 648 : 1994 NON-ORIENTED ELECTRICAL STEEL SHEETS AND STRIPS FOR MAGNETIC CIRCUITS — SPECIFICATION

(Fourth Revision)

(*Page* 9, *Fig.* 5, *Step VIII*) — Substitute 'purchaser' *for* 'BHEL'.

(MTD 4)

Reprography Unit, BIS, New Delhi, India

AMENDMENT NO. 3 MARCH 2002
TO
IS 648 : 1994 NON-ORIENTED ELECTRICAL STEEL SHEETS AND STRIPS FOR MAGNETIC CIRCUITS — SPECIFICATION

(Fourth Revision)

(*Page* 3, *Table* 1) — Delete the grades mentioned at Sl No. 19, 20, 32, 33, 34 and 35.

(*Page* 4, *clause* **8.2.1**, *second sentence*) — Substitute following for the existing sentence:

'The values apply for the thickness of 0.35 and 0.50 mm to the aged sample and for 0.65 mm to non-aged sample.'

(*Page* 12, *Annex* C, *Note*, *line* 6) — Substitute ' non' *for* 'known'.

(MTD 4)

Reprography Unit, BIS, New Delhi, India