Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

IS 3024 (2006): Grain oriented electrical steel sheets and strips [MTD 4: Wrought Steel Products]
Indian Standard
GRAIN ORIENTED ELECTRICAL STEEL SHEET AND STRIP
(Second Revision)

ICS 77.140.40
FOREWORD

This Indian Standard (Second 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 Division Council.

This standard was first published in 1965 and revised in 1997. While reviewing this standard in the light of experience gained during these years, the Committee decided to revise it to bring in line with the present practices being followed by the Indian industry and overseas standards of cold rolled grain oriented electrical steels.

Grain oriented electrical steels are low carbon, silicon-iron alloys with a silicon contents of approximately 3 percent in which low core loss and high permeability in the direction of rolling are achieved by appropriate metallurgical processing. These steel sheets and strips are coated on both sides as part of its manufacturing process with an inorganic insulation to withstand desired stress relief annealing treatment which is necessary to attain the specified magnetic properties. These steels are used primarily in transformer cores operating at moderate to high induction at commercial power frequencies.

In this revision, the following changes have been made:

a) The material symbols G & P have been modified to CG & HP for conventional grain oriented (CGO) and for high permeability grain oriented (HGPO) electrical steels to align with International Standard.

b) Maximum specific core loss for conventional grain oriented (CGO) electrical steels has now been specified at 1.7 Tesla.

In formulation of this standard, assistance has been derived from the following overseas standards:


d) BS EN 10107 (1996) ‘Grain oriented electrical steel sheet and strip delivered in the fully processed state’.

e) ASTM A 876 M-98 ‘Flat rolled, grain oriented, silicon-iron, electrical steel, fully processed types (metric)’.

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 numbers of significant places retained in the rounded off values should be the same as that of the specified value in this standard.
AMENDMENT NO. 1 FEBRUARY 2009
TO
IS 3024: 2006 GRAIN ORIENTED ELECTRICAL STEEL
SHEET AND STRIP
(Second Revision)

(Page 3, clause 7.4) — Insert the following in the end:

'Dispersed defects such as scratches, blisters, cracks, discoloration, aesthetic type, physical damages, etc, are permitted if they are within the limit of thickness tolerance, not detrimental to method of working or correct use of supplied material. The limit, classification and disposition shall be subject to agreement between the purchaser and the manufacturer.'

(Page 3, Table 1, col 1, twelfth line) — Substitute '35CG165' for '35CG155'.

(Page 4, Table 2, col 1) — Substitute the following for the existing:

<table>
<thead>
<tr>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
</tr>
<tr>
<td>23HP90</td>
</tr>
<tr>
<td>23HP95</td>
</tr>
<tr>
<td>23HP100</td>
</tr>
<tr>
<td>27HP100</td>
</tr>
<tr>
<td>27HP110</td>
</tr>
<tr>
<td>30HP110</td>
</tr>
<tr>
<td>30HP120</td>
</tr>
<tr>
<td>35HP125</td>
</tr>
<tr>
<td>35HP135</td>
</tr>
</tbody>
</table>

(MTD 4)

Reprography Unit, BIS, New Delhi, India
(Page 1, clause 3.14) — Substitute the following for the existing:

‘Side Trimmed Coil — Material is side trimmed on both edges condition in the range of widths produced by suppliers’ manufacturing process.’

[Page 2, clause 5.2(a)] — Substitute the following for the existing:

‘a) Conventional grain oriented electrical steel tested at 1.7 Tesla values of maximum specific core losses are given in Table 1 and the values of maximum specific core losses at 1.5 Tesla given in Table 1 are for information only.’

[Page 3, Table 1 (see also Amendment No. 1)] — Substitute the following for the existing table:

Price Group 2
### Table 1 Magnetic Properties of Conventional Grain Oriented (CGO) Electrical Steel

*(Clauses 4.2, 5.2, 8.1 and 8.2)*

<table>
<thead>
<tr>
<th>Grade</th>
<th>Nominal Thickness mm</th>
<th>Maximum Specific Core Loss (W/kg) Polarization at 1.5 T and 50 Hz</th>
<th>Maximum Specific Core Loss (W/kg) Polarization at 1.7 T and 50 Hz</th>
<th>Minimum Polarization in Tesla at a Field Strength of 800 A/m</th>
<th>Minimum Stacking Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>23CG110</td>
<td>0.23</td>
<td>0.73</td>
<td>1.10</td>
<td>1.78</td>
<td>0.945</td>
</tr>
<tr>
<td>23CG120</td>
<td>0.23</td>
<td>0.77</td>
<td>1.20</td>
<td>1.78</td>
<td>0.945</td>
</tr>
<tr>
<td>23CG127</td>
<td>0.23</td>
<td>0.80</td>
<td>1.27</td>
<td>1.75</td>
<td>0.945</td>
</tr>
<tr>
<td>27CG120</td>
<td>0.27</td>
<td>0.80</td>
<td>1.20</td>
<td>1.78</td>
<td>0.950</td>
</tr>
<tr>
<td>27CG130</td>
<td>0.27</td>
<td>0.85</td>
<td>1.30</td>
<td>1.78</td>
<td>0.950</td>
</tr>
<tr>
<td>27CG140</td>
<td>0.27</td>
<td>0.89</td>
<td>1.40</td>
<td>1.75</td>
<td>0.950</td>
</tr>
<tr>
<td>30CG130</td>
<td>0.30</td>
<td>0.85</td>
<td>1.30</td>
<td>1.78</td>
<td>0.955</td>
</tr>
<tr>
<td>30CG140</td>
<td>0.30</td>
<td>0.92</td>
<td>1.40</td>
<td>1.78</td>
<td>0.955</td>
</tr>
<tr>
<td>30CG150</td>
<td>0.30</td>
<td>0.97</td>
<td>1.50</td>
<td>1.75</td>
<td>0.955</td>
</tr>
<tr>
<td>35CG145</td>
<td>0.35</td>
<td>1.03</td>
<td>1.45</td>
<td>1.78</td>
<td>0.960</td>
</tr>
<tr>
<td>35CG155</td>
<td>0.35</td>
<td>1.07</td>
<td>1.55</td>
<td>1.78</td>
<td>0.960</td>
</tr>
<tr>
<td>35CG165</td>
<td>0.35</td>
<td>1.11</td>
<td>1.65</td>
<td>1.75</td>
<td>0.960</td>
</tr>
</tbody>
</table>

**NOTES**

1. The above samples are sheared longitudinal to the rolling direction and then stress relief annealed in a neutral or reducing atmosphere to develop magnetic property at 780°C to 820°C.

2. The values of Maximum Specific Core Loss (W/kg) at 1.5 T are for information only.
(Page 4, Table 2) — Substitute the following for the existing table:

### Table 2 Magnetic Properties of High Permeability Grain Oriented (HPGO) Electrical Steel

*(Clauses 5.2, 8.1 and 8.2)*

<table>
<thead>
<tr>
<th>Grade</th>
<th>Nominal Thickness mm</th>
<th>Maximum Specific Core Loss (W/kg) Polarization at 1.7 T and 50 Hz</th>
<th>Minimum Polarization in Tesla at a Field Strength of 800 A/m</th>
<th>Minimum Stacking Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>23HP85 d</td>
<td>0.23</td>
<td>0.85</td>
<td>1.85</td>
<td>0.945</td>
</tr>
<tr>
<td>23HP90 d</td>
<td>0.23</td>
<td>0.90</td>
<td>1.85</td>
<td>0.945</td>
</tr>
<tr>
<td>27HP90 d</td>
<td>0.27</td>
<td>0.90</td>
<td>1.85</td>
<td>0.950</td>
</tr>
<tr>
<td>27HP95 d</td>
<td>0.27</td>
<td>0.95</td>
<td>1.85</td>
<td>0.950</td>
</tr>
<tr>
<td>27HP100</td>
<td>0.27</td>
<td>1.00</td>
<td>1.88</td>
<td>0.950</td>
</tr>
<tr>
<td>27HP110</td>
<td>0.27</td>
<td>1.10</td>
<td>1.88</td>
<td>0.950</td>
</tr>
<tr>
<td>30HP105</td>
<td>0.30</td>
<td>1.05</td>
<td>1.88</td>
<td>0.955</td>
</tr>
<tr>
<td>30HP110</td>
<td>0.30</td>
<td>1.10</td>
<td>1.88</td>
<td>0.955</td>
</tr>
<tr>
<td>35HP115</td>
<td>0.35</td>
<td>1.15</td>
<td>1.88</td>
<td>0.960</td>
</tr>
<tr>
<td>35HP125</td>
<td>0.35</td>
<td>1.25</td>
<td>1.88</td>
<td>0.960</td>
</tr>
<tr>
<td>35HP135</td>
<td>0.35</td>
<td>1.35</td>
<td>1.88</td>
<td>0.960</td>
</tr>
</tbody>
</table>

**NOTES**

1. This grade may be delivered in domain refined condition. The magnetic properties of some domain refined material may deteriorate when the material is subjected to heat treatment.

2. The domain refined grades need to be checked by single sheet method as in clause 14.3.

(Page 4, Table 3, col heading 4) — Substitute ‘ohm–cm² / Lamination’ for ‘ohm–cm’.  

(Page 5, clause 10.2) — Substitute the following for the existing
10.2 Ductility

This test can be carried out by one of two methods described below.

10.2.1 The ductility shall be as high as practicable, when the application requires forming around a sharp radius during fabrication, an evaluation of the ductility is required. The ductility rating shall be determined in accordance with the test method described in IS 649. Ductility in following classes is typical for grain-oriented material in any thickness and surface type when tested at the room temperature with a bend transverse to the rolling direction with following sheared specimens:

<table>
<thead>
<tr>
<th>Ductility Class</th>
<th>Permissible Number of Fractures on Steel Base at Bend (see Note)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 total length not over 8 mm</td>
</tr>
<tr>
<td>2</td>
<td>2 total length not over 15 mm</td>
</tr>
<tr>
<td>3</td>
<td>≥ 3</td>
</tr>
</tbody>
</table>

NOTE — Based on 610 to 910 mm width of material. For widths less than 610 mm the number of permissible fractures should be reduced in proportion to the ratio of the width to 610 mm.

10.2.2 This alternate ductility test method is as described in IS 649 (Section 8, clauses 49 and 50).

The minimum number of bends is one. The value applies to the parallel to the direction of rolling.’

(Page 5, clause 11.2) — Insert the following at the end:

‘, for widths up to and including 1 000 mm. For materials supplied with as rolled edges and/or widths above 1 000 mm the tolerances on nominal width should be the subject of agreement while ordering.’

(Page 6, Table 5) — Substitute the following for the existing table
Table 5 Width Tolerance  
*(Clause 11.2)*

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Nominal Width, <em>l</em>, mm</th>
<th>Tolerances</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>i)</td>
<td><em>l</em> ≤ 150</td>
<td>+0.2</td>
</tr>
<tr>
<td>ii)</td>
<td>150 &lt; <em>l</em> ≤ 300</td>
<td>+0.3</td>
</tr>
<tr>
<td>iii)</td>
<td>300 &lt; <em>l</em> ≤ 600</td>
<td>+0.5</td>
</tr>
<tr>
<td>iv)</td>
<td>600 &lt; <em>l</em> ≤ 1,000</td>
<td>+1.0</td>
</tr>
<tr>
<td>v)</td>
<td><em>l</em> &gt; 1,000</td>
<td>+1.5</td>
</tr>
</tbody>
</table>

NOTE — As per agreement, width Tolerance can be –ve or +ve or both –ve and +ve subject to tolerance band as given in above table.

*(Page 6, clause 14)* — Insert the following as new subclauses at the end:

*14.3 In the case where the measurement of magnetic polarization and specific core loss shall be made using single sheet method as specified in IS 649, the test specimen for the single sheet tester shall consist of one sheet having the following dimensions:

- Length 500 mm to 530 mm  
  NOTE — The value of 500 mm is recommended.
- Width 500 mm ± 0 / – 5 mm.

All the test specimens shall be cut parallel to the direction of rolling. The permitted tolerance for the angle between the direction of rolling and the direction of cutting is ±1 degree.

14.4 In case of measurements of specific core loss on aged test pieces, these shall be aged by heating at 225°C ± 5°C for duration of 24 hours and shall be cooled to ambient temperature.*
Amend No. 2 IS 3024 : 2006

(Page 6, clause 15) — Insert the following as new subclause at the end:

‘15.4 The required tests for domain refined grades, core loss to determine the core loss type (and for exciting current and peak permeability, when determined) shall be made in accordance with the test method described in IS 649, by means of a single sheet tester.’
AMENDMENT No. 3 NOVEMBER 2012
TO
IS 3024 : 2006 GRAIN ORIENTED ELECTRICAL STEEL SHEET AND STRIP
(Second Revision)

[Page 2, clause 5.2 (a) and (b) (see also Amendment No. 2)] — Substitute the following for the existing:

‘a) Conventional grain oriented electrical steel tested at 1.7 Tesla and 50 Hz values, maximum specific core losses are given in Table 1. The values of maximum specific core losses at 1.5 Tesla and 50 Hz; at 1.5 Tesla and 60 Hz and at 1.7 Tesla and 60 Hz given in Table 1 are for information only.

b) High permeability grain oriented tested at 1.7 Tesla and 50 Hz, maximum specific core losses are given in Table 2. Maximum specific core losses at 1.7 Tesla and 60 Hz given in Table 2 are for information only.’

(Page 2, clause 7.2) — Insert the following at the end of clause:

‘The additional thickness due to welds with respect to measured thickness of the steel sheet or strip shall not exceed 0.05 mm.’

[Page 3, Table 1 (see also Amendment No. 1 and 2)] — Substitute the following table for the existing table:

---

1
Table 1 Magnetic Properties of Conventional Grain Oriented (CGO) Electrical Steel
(Clauses 4.2, 5.2, 8.1 and 8.2)

NOTES

1 The above samples are sheared longitudinal to the rolling direction and then stress relief annealed in a neutral or reducing atmosphere to develop magnetic property at between 780°C to 840°C, as recommended by the manufacturer.

2 The values of Maximum Specific Core Loss (W/kg) at 1.5 T are for information only.

3 The values of Maximum Specific Core Loss (W/kg) at 1.7 T and 60Hz are for information only.
Table 2 Magnetic Properties of High Permeability Grain Oriented (HPGO) Electrical Steel
(Clauses 5.2, 8.1 and 8.2)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Nominal Thickness mm</th>
<th>Maximum Specific Core Loss (W/kg) Polarization at 1.7 T</th>
<th>Minimum Polarization in Tesla at a Field Strength of 800 A/m</th>
<th>Minimum Stacking Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>50 Hz</td>
<td>60 Hz</td>
<td>(5)</td>
</tr>
<tr>
<td>23HP85</td>
<td>0.23</td>
<td>0.85</td>
<td>1.12</td>
<td>1.85</td>
</tr>
<tr>
<td>23HP90</td>
<td>0.23</td>
<td>0.90</td>
<td>1.19</td>
<td>1.85</td>
</tr>
<tr>
<td>23HP95</td>
<td>0.23</td>
<td>0.95</td>
<td>1.25</td>
<td>1.85</td>
</tr>
<tr>
<td>23HP100</td>
<td>0.23</td>
<td>1.00</td>
<td>1.32</td>
<td>1.85</td>
</tr>
<tr>
<td>27HP90</td>
<td>0.27</td>
<td>0.90</td>
<td>1.19</td>
<td>1.85</td>
</tr>
<tr>
<td>27HP95</td>
<td>0.27</td>
<td>0.95</td>
<td>1.25</td>
<td>1.85</td>
</tr>
<tr>
<td>27HP100</td>
<td>0.27</td>
<td>1.00</td>
<td>1.32</td>
<td>1.88</td>
</tr>
<tr>
<td>27HP110</td>
<td>0.27</td>
<td>1.10</td>
<td>1.45</td>
<td>1.88</td>
</tr>
<tr>
<td>30HP105</td>
<td>0.30</td>
<td>1.05</td>
<td>1.38</td>
<td>1.88</td>
</tr>
<tr>
<td>30HP110</td>
<td>0.30</td>
<td>1.10</td>
<td>1.46</td>
<td>1.88</td>
</tr>
<tr>
<td>30HP120</td>
<td>0.30</td>
<td>1.20</td>
<td>1.58</td>
<td>1.88</td>
</tr>
<tr>
<td>35HP115</td>
<td>0.35</td>
<td>1.15</td>
<td>1.51</td>
<td>1.88</td>
</tr>
<tr>
<td>35HP125</td>
<td>0.35</td>
<td>1.25</td>
<td>1.64</td>
<td>1.88</td>
</tr>
<tr>
<td>35HP135</td>
<td>0.35</td>
<td>1.35</td>
<td>1.77</td>
<td>1.88</td>
</tr>
</tbody>
</table>

NOTES
1. This grade may be delivered in domain refined condition. The magnetic properties of some domain refined material may get deteriorate when material is subjected to heat treatment.
2. In cases where material gets deteriorated when subjected to heat treatment, the domain refined grades need to be checked by Single sheet method as given in 14.3. For other grades/other type of domain refined grades which do not deteriorate when subjected to heat treatment, the test method remains as per EPSTEIN method as given in IS 649.
3. The values of Maximum Specific Core loss (W/kg) at 60 Hz are for information only.
Amend No. 3 to IS 3024 : 2006

(Page 4, clause 9.1, line 5) — Delete ‘and approximately’.

(Page 5, clause 11.1) — Insert the following Note at the end of clause:

‘NOTE — Unless otherwise agreed the thickness tolerance for grade 23CG110 shall be
+0.025
-0.04 mm.’

(Page 6 clause 14.2, line 4) — Substitute ’780°C to 840°C for ’780°C to
820°C’. 
Indian Standard
GRAIN ORIENTED ELECTRICAL STEEL SHEET AND STRIP
(Second Revision)

1 SCOPE

1.1 This standard covers the requirements of flat rolled, fully processed (in final annealed condition) grain-oriented, electrical steel sheets or strips and intended for the construction of transformer cores operating at moderate to high inductions at commercial power frequencies and other magnetic circuits.

1.2 The electrical steel grades described in this standard include conventional and high permeability grain oriented electrical steel tested at 1.7 Tesla.

1.3 These sheets and strips shall be coated on both sides with inorganic insulation capable of withstanding stress relief annealing treatment.

2 REFERENCES

The following standards contain provisions, which through reference in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

<table>
<thead>
<tr>
<th>IS No.</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>649 : 1996</td>
<td>Methods of testing steel sheets for magnetic circuits of power electrical apparatus (second revision)</td>
</tr>
<tr>
<td>8910 : 1978</td>
<td>General technical delivery requirements for steel and steel products</td>
</tr>
<tr>
<td>13795 (Part 1) : 1993</td>
<td>Glossary of terms relating to special alloys: Part 1 Soft magnetic materials</td>
</tr>
</tbody>
</table>

3 TERMINOLOGY

For the purpose of this standard, the following definitions in addition to those given in IS 13795 (Part 1) shall apply.

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

3.2 Coil — A rolled flat strip product which is wound regularly superimposed laps so as to form a coil with almost flat side.

3.3 Coil Butt Welds — Butt welds at the junctions between sub-coils for the purpose of building-up larger continuous coils.

3.4 Coil Interleaves — Laps at the junction between sub-coil for the purpose of building-up larger continuous coils.

3.5 Cold Rolled Electrical Steel Sheet/Strip — Electrical steel sheet/strip, which is reduced to final gauge by cold rolling.

3.6 Density — The ratio of the mass to the volume of a magnetic material in kg/dm³.

3.7 Edge Camber — The edge camber is characterized by the greatest distance between a longitudinal edge of the product and a straight line joining the two ends of the gauge length.

3.8 Electrical Steel Sheet/Strip — A term used commercially to designate a flat rolled non-silicon alloy used in magnetic circuits of electrical apparatus for its magnetic properties.

3.9 Flatness (Wave Factor) — The property of a sheet or of a length of strip which is characterized by the wave factor, that is by the relation of the height of the wave to its length.

3.10 Internal Stress — Stresses, which are characterized by a deviation in the relation to the line of cutting.

3.11 Grain Oriented Electrical Steel — Steel sheet or strip which has been processes so that magnetic properties when magnetized parallel to the rolling direction are substantially better that those when magnetized at the right angles to the rolling direction.

3.12 Nominal Width Coil — Coil of the width specified on the order.

3.13 Silicon Steel — Electrical steel made with deliberate alloying addition of silicon.

3.14 Side Trimmed Coil — Material in the side trimmed condition in the range of widths produced by the suppliers’ manufacturing process.
3.15 Stacking Factor — Ratio of the uniform solid height 'h' of the magnetic material in a laminated core to the actual height 'h' (core build up) when measured under a specified pressure 'S' is thus equal to the ratio of the volume of magnetic material in a uniform laminated core to the overall geometric volume in the core.

4 SUPPLY OF MATERIAL

4.1 General requirements relating to the supply of grain oriented electrical steel sheets and strips shall conform to IS 8910.

4.2 Order shall include the following information, as applicable:
   a) Core loss type designations (see Table 1 and Table 2),
   b) Material condition (form and surface type) designation (see 7.3),
   c) Ductility class (when required),
   d) Sheet or strip width,
   e) Length (only when cut lengths are specified),
   f) Total weight of each ordered item,
   g) Limitations of lift weight,
   h) Limitations on coil size requirements, and
   j) End use.

5 CLASSIFICATIONS OF GRADES

5.1 The grades covered by this standard are classified according to the value of maximum specific total loss in watts per kilogram and according to the nominal thickness of the material (0.23, 0.27, 0.30 and 0.35 mm).

5.2 The standard covers the grades listed in Tables 1 and 2 with the forms and condition of supply as specified in 4. Sheet steel and strip made of the grades specified in Tables 1 and 2 are classified according to specific total loss, as follows:
   a) Conventional grain oriented electrical steel tested at 1.7 Tesla, and
   b) High permeability grain oriented electrical steel tested at 1.7 Tesla.

5.3 The grades are sub-classified according to the peak value of specific total loss at maximum flux density of 1.7 Tesla and according to the nominal product thickness.

6 DESIGNATION

The designation of a magnetic steel sheet or strip as specified shall comprise the following in order given and those values shall conform to the following figure:

\[
\begin{array}{cccc}
A & B & C \\
\hline
\end{array}
\]

\[\text{One hundred times the nominal thickness of material, in mm}\]
\[\text{Material symbol CG or HP}\]
\[\text{Guaranteed value of iron loss: A value 100 times the iron loss, at a frequency 50 Hz and a maximum flux density of 1.7 Tesla}\]

NOTES:
1. One hundred times the nominal thickness of the product, in mm.
2. The letter symbol:
   i) CG, for conventional grain oriented electrical steel tested at 1.7 Tesla, and
   ii) HP, for high permeability grain oriented electrical steel tested at 1.7 Tesla.
3. One hundred times the maximum value of specific total loss in W/kg.

Examples
1) A sheet or strip of 0.23 mm thickness, tested at 1.7 Tesla and specific total loss 1.20 W/kg shall be designated as 23CG120.
2) A sheet or strip of 0.27 mm thickness, tested at 1.7 Tesla and specific total loss 1.00 W/kg shall be designated as 27HP100.

7 GENERAL REQUIREMENTS

7.1 Steel Making Process

The production process of the steel and its chemical composition are left to the discretion of the manufacturer. However, the chemical composition of the material may be provided, if agreed to between the manufacturer and the purchaser at the time of placing the order.

7.2 Forms of Supply
   a) Material is supplied in bundles in the case of sheets and in coils in the case of strips.
   b) Mass of bundles of sheets or coils shall be agreed at the time of ordering.
   c) Sheets which make-up each bundle shall be agreed so that the side faces are substantially flat and approximately perpendicular to the top face.
   d) Strips shall be of constant width and wound in such a manner that the side faces of the coil are substantially flat.
   e) Coils shall be sufficiently tightly wound in order that they do not collapse under their own weight.
   f) Strips can occasionally exhibit welds or interleaves resulting from the removal of defective zones, if agreed at the time of inquiry. If necessary, the marking of welds or interleaves may be agreed at the time of ordering.
g) For coils containing repair welds or interleaves, each part of the strip shall be of the same grade.

h) The edges of parts welded together shall not be so much out of alignment as to affect the further processing of the material.

7.3 Delivery Condition
Grain oriented materials are usually supplied with an insulating coating on both sides. These may be purchased in any of the following combinations (which are combinations of material form and surface type or treatment) as desired for the expected end use:

a) **Condition NF** — An annealed coil form having an inorganic vitrified surface coating composed essentially of silicates of magnesium, Type C-2. This material is not flattened and so exhibits appreciable coil curvature.

b) **Condition F** — Thermally flattened sheet or coil strip having an inorganic surface coating. Type C-2, plus an inorganic coating Type C-5, applied over the inherent C-2 coating to provide extra surface insulation resistance.

c) **Condition PQ** — Thermally flattened sheet or coiled strip (also known as punching quality) with the inherent C-2 coating removed and an inorganic coating Type C-5, applied for insulation purpose.

7.4 Surface Condition
The material shall be reasonably free from surface defects such as holes, scabs, blisters, silvers, dents, rust and other harmful defects. The coating shall be smooth and uniform and free from dust. It shall be sufficiently adherent so that it does not become detached during further processing. If the products are intended to be immersed in liquids in service, the customer may request compatibility of liquid and coating.

7.5 Suitability for Cutting
The material shall be suitable for cutting accurately into the usual shapes when appropriate cutting tools are used.

8. MAGNETIC PROPERTIES
The properties defined in 8.1 and 8.2 shall apply to materials in the delivery condition as given in 7.3.

8.1 Core Loss
Maximum permissible core losses at 1.7 Tesla and 50 Hz, are guaranteed and are listed in Tables 1 and 2. The sampling, specimen preparation and testing practices are given in 13, 14 and 15. Materials that conform to both the core loss and thickness limits of this standard shall be

<table>
<thead>
<tr>
<th>Grade</th>
<th>Nominal Thickness</th>
<th>Maximum Specific Core Loss (W/kg) at 1.7 T and 50 Hz</th>
<th>Minimum Polarization in Tesla at a Field Strength of 800 A/m</th>
<th>Minimum Stacking Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>23CG110</td>
<td>0.23</td>
<td>1.10</td>
<td>1.78</td>
<td>0.945</td>
</tr>
<tr>
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<td>1.20</td>
<td>1.78</td>
<td>0.945</td>
</tr>
<tr>
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<td>1.27</td>
<td>1.78</td>
<td>0.945</td>
</tr>
<tr>
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<td>1.20</td>
<td>1.78</td>
<td>0.950</td>
</tr>
<tr>
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<td>1.30</td>
<td>1.78</td>
<td>0.950</td>
</tr>
<tr>
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<td>1.78</td>
<td>0.955</td>
</tr>
<tr>
<td>30CG130</td>
<td>0.30</td>
<td>1.30</td>
<td>1.78</td>
<td>0.955</td>
</tr>
<tr>
<td>30CG140</td>
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<td>1.40</td>
<td>1.78</td>
<td>0.955</td>
</tr>
<tr>
<td>30CG150</td>
<td>0.30</td>
<td>1.50</td>
<td>1.75</td>
<td>0.955</td>
</tr>
<tr>
<td>35CG145</td>
<td>0.35</td>
<td>1.45</td>
<td>1.78</td>
<td>0.960</td>
</tr>
<tr>
<td>35CG155</td>
<td>0.35</td>
<td>1.55</td>
<td>1.78</td>
<td>0.960</td>
</tr>
<tr>
<td>35CG155</td>
<td>0.35</td>
<td>1.65</td>
<td>1.75</td>
<td>0.960</td>
</tr>
</tbody>
</table>

NOTE — The above samples are sheared longitudinal to the rolling direction and then stress relief annealed in a neutral or reducing atmosphere to develop magnetic property at 780°C to 820°C (see 14.2).
Table 2  Magnetic Properties of High Permeability Grain Oriented (HPGO) Electrical Steel Tested at 1.7 Tesla and 50 Hz
(Clauses 5.2, 8.1 and 8.2)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Nominal Thickness (mm)</th>
<th>Maximum Specific Core Loss (W/kg) at 1.7 T and 50 Hz</th>
<th>Minimum Polarization in Tesla at a Field Strength of 800 A/m</th>
<th>Minimum Stacking Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>23HP90</td>
<td>0.23</td>
<td>0.90</td>
<td>1.85</td>
<td>0.945</td>
</tr>
<tr>
<td>23HP95</td>
<td>0.23</td>
<td>0.95</td>
<td>1.85</td>
<td>0.945</td>
</tr>
<tr>
<td>23HP100</td>
<td>0.27</td>
<td>1.00</td>
<td>1.85</td>
<td>0.945</td>
</tr>
<tr>
<td>23HP100</td>
<td>0.27</td>
<td>1.00</td>
<td>1.85</td>
<td>0.950</td>
</tr>
<tr>
<td>23HP110</td>
<td>0.27</td>
<td>1.10</td>
<td>1.85</td>
<td>0.950</td>
</tr>
<tr>
<td>23HP110</td>
<td>0.30</td>
<td>1.10</td>
<td>1.85</td>
<td>0.950</td>
</tr>
<tr>
<td>23HP120</td>
<td>0.30</td>
<td>1.20</td>
<td>1.85</td>
<td>0.955</td>
</tr>
<tr>
<td>23HP125</td>
<td>0.35</td>
<td>1.25</td>
<td>1.85</td>
<td>0.960</td>
</tr>
<tr>
<td>23HP135</td>
<td>0.35</td>
<td>1.35</td>
<td>1.85</td>
<td>0.960</td>
</tr>
</tbody>
</table>

NOTE — The above samples are sheared longitudinal to the rolling direction and then stress relief annealed in a neutral or reducing atmosphere to develop magnetic property at 780°C to 820°C (see 14.2).

identified by the specification number and the appropriate core loss designation.

8.2 Magnetic Polarization

The specified minimum values of magnetic polarization for magnetic field strength of 800 A/m (peak value) shall be as given in Table 1 and Table 2. The magnetic polarization shall be determined in an alternating magnetic field (expressed as a peak value) at 50Hz.

9 SURFACE INSULATION CHARACTERISTICS

9.1 The surface produced in each of the material condition of 7.3 normally have different levels for insulation quality for specimens as sheared from the coated material, the typical insulation characteristics are measure by test method described in IS 649 and approximately as shown in Table 3.

9.2 When insulation characteristics are substantially different than those listed in Table 3 are necessary, the specific requirements and the procedure for evaluating them shall be mutually agreed to between the purchaser and the manufacturer.

9.2.1 A minimum value of insulation coating resistance measured before or after the possible application of a stress relief heat treatment shall be as agreed to between the purchaser and the manufacturer. The stress relief heat treatment, when applied, shall be carried out under conditions specified by the manufacturer. The insulation coating resistance expresses as ohm-cm² represents the electrical resistance offered to the passage of current through the coating.

10 PHYSICAL AND MECHANICAL PROPERTIES

10.1 Stacking Factor

The stacking or lamination or space factor shall be as high as practicable consistent with the surface type and material

Table 3 Typical Insulation Characteristics as Sheared
(Clauses 9.1)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Surface Type</th>
<th>Surface Insulation Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>Ampere, Max</td>
</tr>
<tr>
<td>NF</td>
<td>C-2</td>
<td>0.8</td>
</tr>
<tr>
<td>F</td>
<td>C-5 Over</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>C-2</td>
<td></td>
</tr>
<tr>
<td>PQ</td>
<td>C-5 Only</td>
<td>0.85</td>
</tr>
</tbody>
</table>
## Table 4 Typical Stacking Factor
(Clause 10.1)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Surface Type</th>
<th>Stacking Factor, Percent at Nominal Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0.23 mm</td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>NF</td>
<td>C-2</td>
<td>95.5</td>
</tr>
<tr>
<td>F</td>
<td>C-5 Over</td>
<td>94.5</td>
</tr>
<tr>
<td></td>
<td>C-2</td>
<td></td>
</tr>
<tr>
<td>PQ</td>
<td>C-5 Only</td>
<td>95.5</td>
</tr>
</tbody>
</table>

thickness desired. The typical stacking factor values for the various material thickness and surface types, as determined by quality control tests made in accordance with test method described in IS 649, are shown in Table 4.

### 10.2 Ductility

The ductility shall be as high as practicable, when the application requires forming around a sharp radius during fabrication, an evaluation of the ductility is required. The ductility rating shall be determined in accordance with test method described in IS 649. Ductility in following classes is typical for grain-oriented material in any thickness and surface type when tested at the room temperature with a bend transverse to the rolling direction with following sheared specimens:

*Ductility Class  Permissible Number of Fractures on Steel Base at Bend (see Note)*

(1)  
1 1 total length not over 8 mm
2 2 total length not over 15 mm
3 ≥ 3

**NOTE** — Based on 610 to 910 mm width of material. For widths less than 610 mm the number of permissible fractures should be reduced in proportion to the ratio of the width to 610 mm.

### 11 DIMENSIONS AND TOLERANCES

#### 11.1 Thickness Tolerance

The nominal thickness of the material are 0.23, 0.27, 0.30 and 0.35 mm. For thickness tolerance, a distinction is made between:

a) The allowable tolerance on the nominal thickness within the same acceptance unit.

b) The difference in thickness in a sheet or in a length of strip in a direction parallel to the direction of rolling.

c) The difference in thickness in a direction perpendicular to the direction of rolling. This tolerance applies only to materials width a greater than 150 mm.

d) At any point, the allowable tolerance on the nominal thickness within the same acceptance unit shall not exceed ±0.030 mm except for the 0.23 mm thickness for which the tolerance shall not exceed ±0.025 mm. The additional thickness due to welds with respect to measured thickness of the steel sheet or strip shall not exceed 0.050 mm.

e) The difference in thickness in a sheet or in a length of strip of 2 m in a direction parallel to the direction of rolling shall not exceed 0.030 mm.

f) In addition, for material with a width greater than 150 mm, the difference in thickness in a direction perpendicular to the direction of rolling shall not exceed 0.020 mm, the measurement being made at least 40 mm from the edges. For narrow strips, other agreements may be needed.

#### 11.2 Width Tolerance

The width of material supplied, either as coils or cut lengths shall be as close as possible to the ordered width. The supplied width shall not exceed the width tolerance given in Table 5.

#### 11.3 Length Tolerance

The tolerance on length of sheets ordered shall be +0.5 percentage subject to maximum value of 6 mm. −0

#### 11.4 Edge Camber (Full Width Coils)

The verification of edge camber does not apply to material of width less than or equal to 150 mm. The edge camber shall not exceed 0.9 mm for a measuring length of 2 m.

#### 11.5 Flatness (Wave Factor)

The verification of flatness does not apply to material of width less than or equal to 150 mm. The wave factor expressed as a percentage shall not exceed 1.5 percent.

#### 11.6 Burr Height

The determination of the burr height applies only to the
material delivered in the width in which it will finally be used. The measured burr height shall not exceed 0.025 mm.

12 WORKMANSHIP, FINISH AND APPEARANCE

12.1 Flatness

12.1.1 Sharp, short waves and buckles are detrimental to the effective use of grain oriented electrical steels in flat lamination and shall be avoided in the delivered product.

12.1.2 The purchaser shall inform the manufacturer of any requirements for a degree of flatness more critical than that provided by the usual commercial practices. Procedure for judging or evaluating the degree of flatness in such cases shall be subject to negotiation between the purchaser and the producer.

13 SAMPLING

13.1 The manufacturer shall conduct test with one representative sample drawn from each mother coil of 10 MT maximum weight. In case the weight of the mother coil exceeds 10 MT, additional samples shall be taken for testing on prorate basis.

13.2 Test samples shall be obtained from either end of the full widths coils after the final heat treatment.

14 SPECIMEN PREPARATION

14.1 Individual Epstein

Test specimens representing each annealed coil shall be prepared in accordance with method described in IS 649. All test strips shall be cut with the long dimension parallel to the rolling direction. The permitted tolerance for the angle between the direction of rolling and the direction of cutting is ± 1°.

14.2 Each Epstein test specimen shall be stress relief annealed prior to testing. The stress relief anneal shall be made conditions that ensure that the specimen strips reach a temperature of 780°C to 820°C for 1 h or more, in an atmosphere which is slightly reducing or neutral in nature.

15 TEST METHODS

15.1 The required tests core loss to determine the core loss type (and for exciting current and peak permeability, when determined) shall be made in accordance with test method described in IS 649.

15.2 The test for all other magnetic mechanical properties, when desired, shall be made in accordance with appropriate procedures given in IS 649.

15.3 In all testing of materials, the density shall be pressured to be 7.65 kg/dm³.

16 TEST REPORT

16.1 The manufacturer shall submit to the purchaser a certified report of the core loss value for each test lot as measured in accordance with 13 through 15 to show that the material conforms to the standard. The report also shall carry the shipping lot identification, purchase order number, and such other information as may be needed to identify the test values with the proper shipment and shipping lot.

16.2 The test value shall apply to all portions of the test lot whether shipped as a full width coil, cut lengths or narrow width coil cut from the wide coil.

16.3 When a shipping lot is comprised of two or more tests lots, the assigned core loss of all tests lots be made in compliance with 13 through 15.

17 PACKAGING

The steel sheet and strip shall also be placed as not to be deformed nor deteriorated during transit and handling. The individual method of packing and weight shall be
subject to mutual agreement between the manufacturer and the purchaser.

18 MARKING

18.1 The following particulars shall be indicated on one end of each coil and on the package of steel sheet and strip. Moreover on the other end of each coil, shall be indicated the symbol of classification. Part of the following items, however, may be omitted by agreement between the parties concerned.

Moreover in the case of a coil with more than two strips, the location of the cut end shall be marked with the following:

- Symbol of classification;
- Thickness;
- Width;

- Height;
- Number of strips (in case of more than two strips);
- Test number;
- Date of manufacturer (year, month); and
- Manufacturer's name or its trade-mark.

18.2 BIS Certification Marking

The material may also be marked with the Standard Mark.

18.2.1 The use of Standard Mark is governed by the provisions of Bureau of Indian Standards Act, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

ANNEX A
(Clause 7.3)

DESCRIPTION OF CORE PLATE COATING
APPLICABLE FOR GRAIN ORIENTED STEELS

<table>
<thead>
<tr>
<th>Core Plate Designation</th>
<th>Description</th>
<th>Core Plate Designation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-2</td>
<td>An organic insulation consisting of a glass like film former during the high temperature annealing of electrical sheet, particularly grain oriented electrical steel, this insulation is intended for air coated or oil immersed cores. It will withstand stress relief annealing and has sufficient insulation resistance for wound cores of narrow width strip such as in the distribution transformers. It is not intended for stamped laminations because it is abrasive to dies.</td>
<td>C-4</td>
<td>Consists for a chemically treated or phosphate surface useful for air-cooled or oil immersed cores. It will withstand stress relief annealing in relatively neutral atmosphere.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C-5</td>
<td>An inorganic insulation similar top C-4 but with ceramic fillers added to increase the electrical insulation properties. C-5 can be used in air cooled or oil immersed cores and will endure stress relief annealing in neutral atmosphere.</td>
</tr>
</tbody>
</table>

7
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This Indian Standard has been developed from Doc : No. MTD 4 (4433).

Amendments Issued Since Publication

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