

JIS

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JAPANESE INDUSTRIAL STANDARD

Methods of Test for Magnetic Steel Sheet and Strip

JIS C 2550—1986



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standard in Japanese is to be evidence

1. Scope

This Japanese Industrial Standard specifies methods of sampling and testing the magnetic steel sheet and strip, hereinafter referred to as the "steel sheet and strip" in relation to measurements of size, cutting burr, flatness, and of transverse bend; tests for a.c. magnetization characteristics, iron loss, and apparent power at commercial frequency; d.c. magnetization characteristics test; audio frequency iron loss test; space factor test; coated layer resistance test; tension test; and repeated bending test.

Remark: The numerical values and units given in { } in this Standard are based on customary unit and are currently the criteria in force.

2. Terms and Symbols

Main definitions of terms and symbols concerning d.c. magnetization characteristics test, a.c. magnetization characteristics test, iron loss test and apparent power test shall conform to the following.

- (1) magnetizing force H The intensity of magnetic field for magnetizing a specimen which is expressed in the unit of ampere per meter (A/m) and obtained from the following formula (1).

$$\int H dl = NI \quad \dots\dots\dots (1)$$

where N : number of turns of coil wound on magnetic path
 I : intensity of current (A)
 l : length of magnetic path (m)

The magnetizing force H is expressed by formula (2), where the effective length of magnetic path is assumed l_e (m) and the magnetizing force H is regarded as uniform over the whole magnetic path in an Epstein frame.

$$H = \frac{NI}{l_e} \quad \dots\dots\dots (2)$$

- (2) magnetic flux density B The magnetic flux per unit sectional area of uniformly magnetized specimen, which is expressed in tesla (T).
- (3) magnetization curve $B-H$ Where a demagnetized specimen is magnetized again, the curve which shows the maximum a.c. magnetic flux density or the d.c. magnetic flux density as a function of magnetizing force, when the maximum a.c. magnetizing force or the d.c. magnetizing force is increased from zero.

Applicable Standards and Corresponding International Standard: See page 34.

- (4) magnetization characteristics The characteristic of magnetization which is shown by the magnetic flux density corresponding to a certain magnetizing force H (A/m) on the magnetization curve, and expressed by $B_{0.01H}$ ⁽¹⁾.

Note ⁽¹⁾ For example, magnetic flux density at the magnetizing force of 5000 A/m is called be B_{5000} .

- (5) iron loss W The electric power consumed in the specimen when it is magnetized by a.c. magnetizing force.
- (6) iron loss per kg W_s The iron loss per kg of specimen, when it is magnetized under sinusoidal magnetic flux. When magnetized under the conditions of frequency f (Hz), and maximum magnetic flux density B_m (T), it is specially symbolized as $W_{10Bm/f}$ ⁽²⁾.

Note ⁽²⁾ For example, $W_{15/50}$ means the iron loss per kg under the conditions of maximum magnetic flux density 1.5 T and frequency 50 Hz.

- (7) apparent power S The product of r.m.s. value of induced voltage and a.m.s. value of exciting current when a specimen is magnetized by a.c. magnetizing force.
- (8) apparent power per kg S_s The apparent power per kg of specimen when magnetized under sinusoidal magnetic flux. When magnetized under the conditions of frequency f (Hz) and maximum magnetic flux density B_m (T), it is specially symbolized as $S_{10Bm/f}$ ⁽³⁾.

Note ⁽³⁾ For example, $S_{15/50}$ means the apparent power per kg under the conditions of maximum flux density 1.5 T and frequency 50 Hz.

3. Test Items

The test shall be made for the following items in conformity with the provisions of 4. to 10. However, for magnetic tests when using the tester other than specified in 4. and 7., the accuracy of that tester shall be confirmed by the test held by the competent testing institution as agreed on by the purchaser and the manufacturer.

(1) Size and shape measurement (6.)

- (a) Size measurement (6.1)
- (b) Cutting burr measurement (6.2)
- (c) Flatness measurement (6.3)
- (d) Transverse bend measurement (6.4)

(2) Magnetic Test (7.)

- (a) A.C. magnetization characteristics test, iron loss test, and apparent power tests at commercial frequency (7.1)
- (b) D.C. magnetization characteristics test (7.2)
- (c) Audio frequency iron loss test (7.3)

- (3) Space factor test (8.)
- (4) Coated layer resistance test (9.)
- (5) Mechanical test (10.)
 - (a) Tension test (10.1)
 - (b) Repeated bending test (10.2)

4. Testing Conditions

4.1 Temperature Principally, magnetic tests shall be carried out at a temperature of $23 \pm 5^{\circ}\text{C}$.

4.2 Power Supply Power supply for tests shall conform to the following.

- (1) For a.c. tests, an a.c. power supply capable of satisfying the magnetizing condition in 4.3 (refer to 1. of Appendix) shall be used. The stability of voltage and frequency while testing shall be within $\pm 0.2\%$.
- (2) For d.c. tests, a d.c. power supply having ripple of 0.1% or less shall be used. The stability of current while testing shall be within 0.2% .

4.3 Magnetization Condition After demagnetizing the specimen, magnetization shall be conducted by applying magnetizing force to it, so that both the positive and negative maximum magnetic flux density induced in the specimen become identical. On a.c. test, the discrepancy between the form factors of secondary induced voltage and sine wave shall be within $\pm 5\%$.

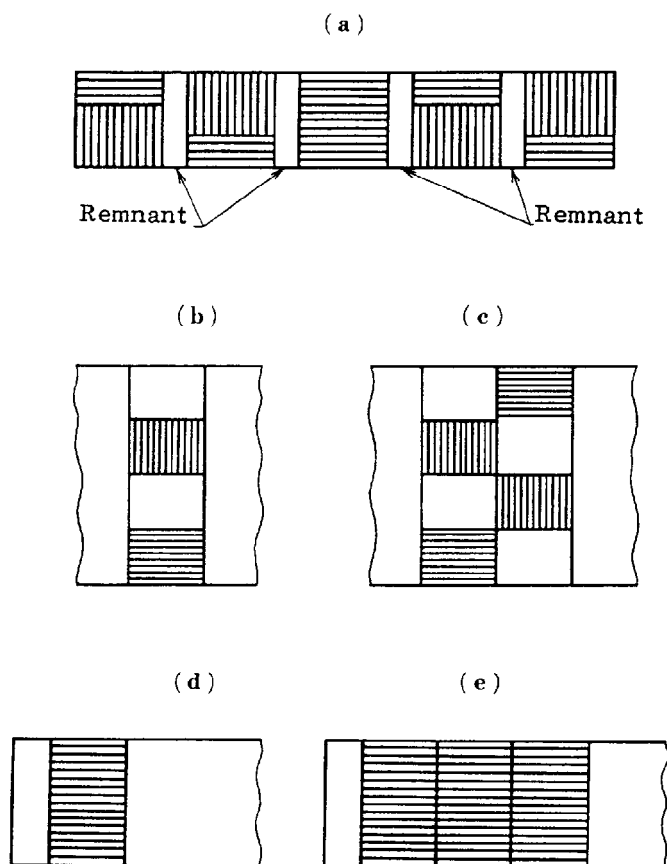
5. Specimen

Specimens used for tests other than coated layer resistance test, and size and shape measurement shall conform to the following.

- (1) Sampling The specimens shall be sampled according to the relevant material specifications based on this standard.
- (2) Cutting Method of Test Piece The cutting machine used for cutting the test pieces (steel sheet pieces to be assembled into a specimen or used as a specimen as it is) shall be sharp-edged and shall not produce remarkable cutting burrs. Test pieces shall be sampled, unless otherwise specified, as shown in (a) to (c) of Fig. 1, half of them in parallel to rolling direction (lengthwise) and the other half in perpendicular (crosswise) so as to make them represent the characteristics of the steel sheet and strip.

If specifically designated or determined by the agreement between the purchaser and the manufacturer for a certain material, only the test pieces of parallel to the rolling direction may be used, and the sampling shall conform to Fig. 1 (d) or (e). When sampled by another method, the cutting method of test pieces shall be mentioned clearly in the test report.

Examples of Cutting Method of Test Piece

6. Measurement of Size and Shape6.1 Size Measurement

6.1.1 In the Case of Steel Strip Measurement of steel strip shall conform to the following.

- (1) Measure thickness in the portion except the areas 15 mm wide along both edges of steel strip.
- (2) Deviation of thickness in transverse direction is defined as the difference of the maximum value and the minimum value in the thickness (excluding the portions from edges of steel strip by 15 mm) measured in transverse direction. The measuring instrument shall be the external micrometer specified in JIS B 7502.
- (3) Measure width at location about 3 m apart from an end of steel tape.

6.1.2 In the Case of Steel Sheet Measurement of steel sheet shall conform to the following.

- (1) Measure thickness as shown in Fig. 2, at 8 points about 15 mm apart from the edge of steel sheet per one steel sheet. The measuring instrument shall be the external micrometer specified in JIS B 7502.

Fig. 2. Measuring Points of Thickness

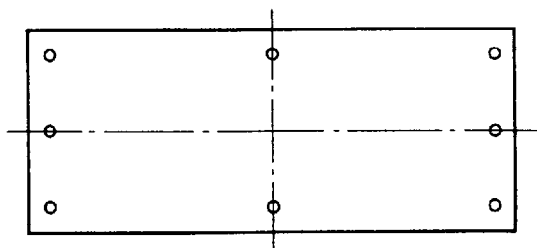
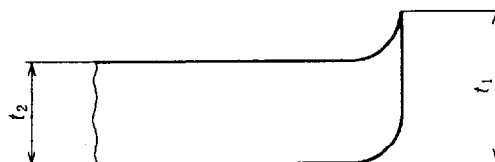


Fig. 3. Cutting Burr



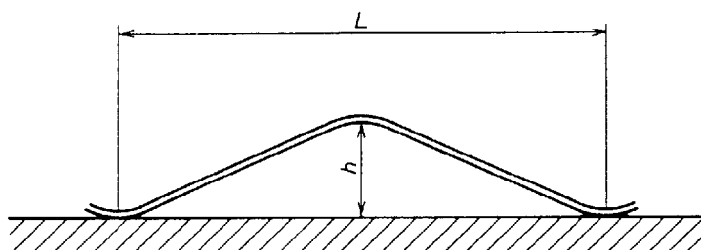
$$\text{Cutting burr } (t) = t_1 - t_2$$

- (2) Width and length shall be measured at arbitrary locations.

6.2 Cutting Burr Measurement Place an external micrometer specified in JIS B 7502 on a cut part, take the reading (t_1) when the ratchet sound once, next, remove the micrometer from the cut part and place on a portion nearby and take the reading (t_2). Take the difference (t) of above two readings as the cutting burr (refer to Fig. 3).

6.3 Flatness Measurement Place a steel sheet or strip on a surface plate, measure the height of side wave (h) and wavelength (L) using a surface gauge and scale, and calculate the flatness by the formula (3) (refer to Fig. 4).

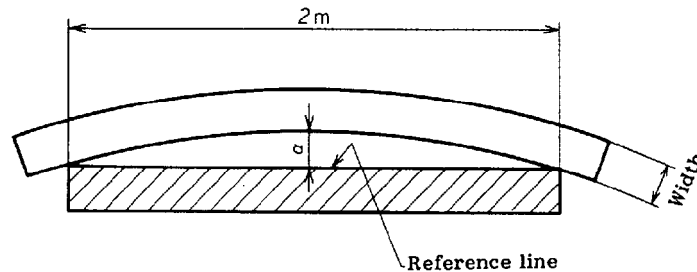
Fig. 4. Side Wave



$$\text{Flatness} = \frac{h}{L} \dots\dots\dots (3)$$

6.4 Transverse Bend Measurement Stretch one end of steel strip, place an edge of the steel strip on the reference line as shown in Fig. 5, and measure the maximum gap (α) with a scale.

Fig. 5. Measuring Method of Transverse Bend



7. Magnetic Tests

7.1 A.C. Magnetization Characteristics Test, Iron Loss Test, and Apparent Power Test at Commercial Frequency

7.1.1 Specimen The specimen for a.c. magnetization characteristics test, iron loss test and apparent power test shall conform to the following in addition to 5.

- (1) The test pieces to form a specimen (magnetic path in Epstein frame) shall be rectangular form of width 30 mm and length 280 to 320 mm. The tolerances on width shall be within ± 0.2 mm and on length ± 0.5 mm.
- (2) The angular difference between lengthwise direction of a test piece and rolling direction of steel sheet or strip shall be within the tolerance of $\pm 1^\circ$ for grain-oriented steel sheet, and $\pm 5^\circ$ for non-oriented sheet.
- (3) Test pieces shall be, unless specified in material specifications composed of a half part of lengthwise ones and the other half part of crosswise ones, and each shall be in a even number. The total number of test pieces shall be not less than 12 and preferably be as shown in Table 1.

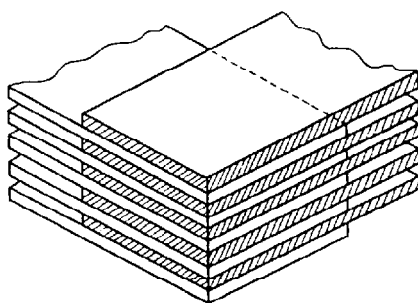
Table 1. Number of Test Pieces

Thickness mm	Number of pieces		
	About 2 kg	About 1 kg	About 0.5 kg
0.27	116	56	28
0.30	104	52	28
0.35	88	44	24
0.50	64	32	16
0.65	48	24	12

7.1.2 Measuring Apparatus The measuring apparatus used for a.c. magnetization characteristics test, iron loss test and apparent power test shall be 25 cm Epstein frame (refer to Appendix 2.), and the connection shall be as shown in Figs. 7 to 10.

7.1.3 Magnetic Circuit Divide the test pieces cut in the same direction according to 7.1.1 into 2 groups i.e. 4 groups in total, and insert them into an Epstein frame so that each group forms each arm of square magnetic path. Form the square magnetic path to have an inside member of 220^{+1}_0 mm each. Use the test pieces cut in the same direction for opposing arms. Stack one piece in one group on top of one piece in another group adjoining at a corner of the frame alternately so that double lapped joints are formed at all corners (refer to Fig. 6).

Fig. 6. Piling Method of Test Pieces at Corner (In the Case of Length 280 mm)

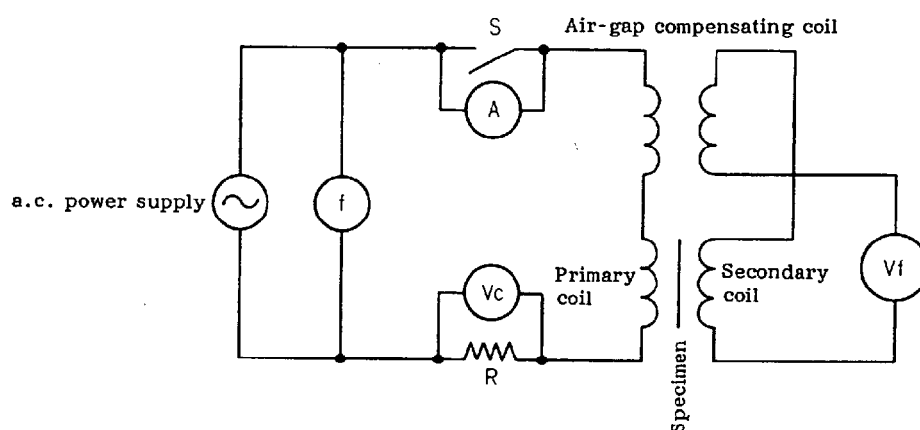


- Remarks
1. Take care in handling not to give strain on the specimen.
 2. Not insert insulation other than the original coatings between layers.
 3. Take care on the double lapped joints at corners to minimize the magnetic reluctance (minimum value of ammeter reading at constant voltage).

7.1.4 Measuring Method for A.C. Magnetization Characteristics Measure a.c. magnetization characteristics in accordance with either of the 1st method or the 2nd method.

- (1) The 1st Method The measurement by the 1st method shall be as follows:

Fig. 7. Measuring Circuit for A.C. Magnetization Characteristics by 1st Method



f frequency meter

A r.m.s. ammeter

V_f flux voltmeter

V_c crest voltmeter

R shunt

S switch

In Fig. 7, demagnetize the specimen, close switch S, adjust the power supply voltage so that reading E_c of crest voltmeter becomes the value corresponding to the magnetizing force determined previously. Keep the frequency at a specified value. Calculate the crest value of magnetizing force by formula (4).

$$H = \frac{N_1 \cdot I_c}{l} \dots\dots\dots (4)$$

where H : crest value of magnetizing force (A/m)

N_1 : number of turns of primary coil

l : effective length of magnetic path (m) = 0.94

I_c : crest value of exciting current (A) = E_c/R

E_c : reading of crest voltmeter due to voltage drop of shunt (V)

R : resistance of shunt (Ω)

In the next place, at the state as it is, obtain reading E_f of flux voltmeter. Calculate crest value of magnetic flux density by the formula (5).

$$B = \frac{E_f}{4.44fN_2A} \dots\dots\dots (5)$$

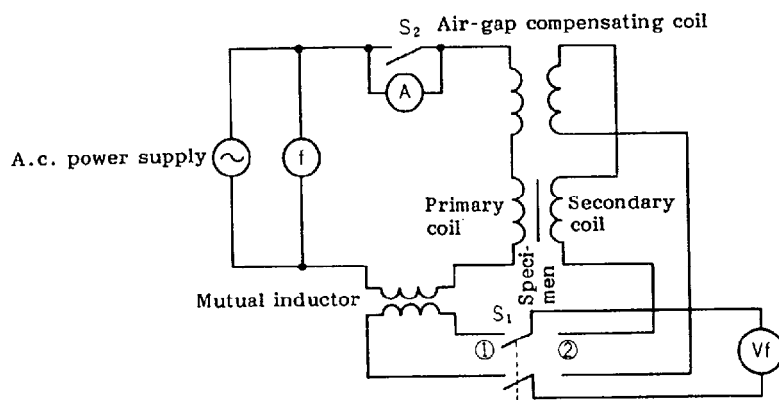
where B : crest value of magnetic flux density (T)
 E_f : reading of flux voltmeter due to induced voltage of secondary coil (V)
 f : frequency (Hz)
 N_2 : number of turns of secondary coil
 A : sectional area of specimen (m^2) ($=m/4lD$)
 m : mass of specimen (kg)
 l : length of specimen (m)
 D : density of specimen (kg/m^3)

Remark: Adjust the coefficient of mutual induction of air-gap compensating coil by changing the number of turns of its secondary coil within one turn, so that the deflection of flux voltmeter connected as shown in Fig. 7, becomes zero. The specimen being not inserted.

Reference : As for magnetic flux density, the compensating term $\mu_0 H$ [μ_0 means permeability in vacuum: $4\pi \times 10^{-7}$ (H/m)] should be inserted, but it is omitted because its rate is small.

(2) The 2nd Method The measurement by the 2nd method shall be as follows:

Fig. 8. Measuring Circuit for A.C. Magnetization Characteristics by 2nd Method



① frequency meter

② flux voltmeter

S_2 switch

Ⓐ r.m.s. ammeter

S_1 change-over switch

In Fig. 8, demagnetize the specimen, close the switch S_2 , turn the change-over switch S_1 to ① side, and then adjust the power supply voltage so that reading E_{rh} of magnetic flux voltmeter becomes the value corresponding to the magnetizing force determined previously.

Keep the frequency at a specified value.

Calculate the crest value of magnetizing force by the formula (6).

$$H = \frac{N_1 \cdot I_c}{l_1} = \frac{N_1 E_{rh}}{4.17 f M} \quad \dots\dots\dots (6)$$

where H : crest value of magnetizing force (A/m)

N_1 : number of turns of primary coil

I_c : crest value of exciting current (A) = E_c/R

l_1 : effective length of magnetic path (m)=0.94

E_{rh} : reading of flux voltmeter due to the secondary induced voltage of mutual inductor (V)

f : frequency (Hz)

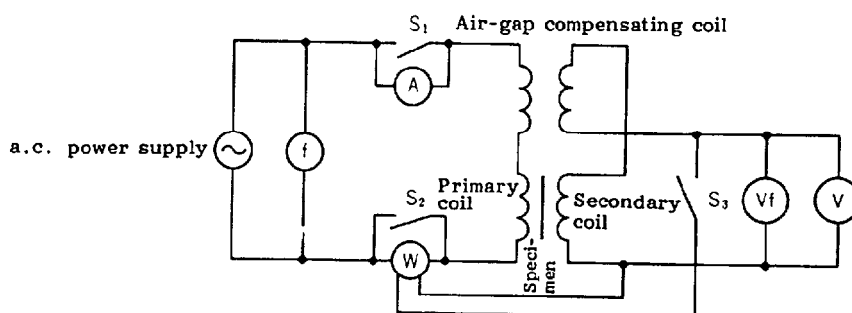
M : mutual inductance of mutual inductor (H)

Remark: In advance, obtain E_{rh} corresponding to H that has been decided using the relation curve between H or I_c and E_{rh} . (refer to the Reference and Remark in 3. of Appendix).

Then, at the state as it is, turn the change-over switch to ② side, and find reading E_r of the flux voltmeter E_r . Calculate the crest value of magnetic flux density by using the formula (5).

7.1.5 Measuring Method for Iron Loss The measurement of iron loss shall be as follows:

Fig. 9. Measuring Circuit for Iron Loss



① frequency meter

② flux voltmeter

S_1 , S_2 and S_3 switches

Ⓐ r.m.s ammeter

Ⓥ r.m.s. voltmeter

Ⓦ wattmeter