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Indian Standard

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(दूसरा पुनरीक्षण)

Acceptance Standards for Magnetic Particle Inspection of Steel Castings — Specification

(Second Revision)

ICS 77.140.80

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Foundry and Steel Castings Sectional, MTD 14

FOREWORD

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

This standard was first published in 1983 and subsequently revised in 1990. This revision has been brought out to bring the standard in the latest style and format of the Indian Standards.

In addition, the following changes have been made:

a) Reference clause is modified; and
b) False indication and magnetic anomalies are included in Table 2.

Magnetic particle inspection is a non-destructive test method for detecting discontinuities on or near the surface in suitably magnetised materials, which employs finely divided magnetic particles that tend to congregate in regions of leakage fields. This method has found widespread application and is an inspection tool of major importance for detection of cracks, seams, laps, laminations, inclusions, etc, found in magnetic ferrous materials.

The composition of the Committee responsible for formulation of this standard is given in Annex B.

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 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be same as that of the specified value in this standard.

Indian Standard

ACCEPTANCE STANDARDS FOR MAGNETIC PARTICLE INSPECTION OF STEEL CASTINGS — SPECIFICATION

(Second Revision)

1 SCOPE

1.1 This standard deals with the acceptance standard for discontinuities at or near the surface, detected by magnetic particle inspection for steel castings. The procedure adopted for this examination is as specified in IS 3703.

1.2 A steel shall be considered to be magnetic if the magnetic induction is greater than 1 tesla for a magnetic field equal to 2.4 kA/m. This standard does not apply to the testing of nonmagnetic or feebly magnetic material such as austenitic steel.

2 REFERENCE

The standards given below contain provisions which through reference in this text, constitute provision 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 edition of these standards:

IS No.	*Title*
IS 3415 : 1998	Glossary of terms used in magnetic particle flaw detection (*second revision*)
IS 3703 : 2023	Recommended practice for magnetic particle flaw detection (*third revision*)
IS 5334 : 2014	Magnetic particle flaw detection of welds — Code of practice (*third revision*)
IS 6410 : 2013	Magnetic flaw detection inks and powders — Specification (*second revision*)
IS 8780 : 2004	Non-destructive testing of steel castings — Code of practice (*first revision*)

3 TERMNOLOGY

For the purpose of this standard, definitions given in IS 3415 shall apply.

4 EQUIPMENT

4.1 Magnetizing Current

Alternating, direct or rectified magnetizing current shall be used. Unless specified in the enquiry and order, the type of magnetizing current to be used and whether the wet or the dry method is to be followed shall be at the discretion of the manufacturer. An average magnetizing current according to the section thickness and prod spacing as shown in Table 1 shall be applied. If a source of magnetizing current with an open circuit voltage of over 25 V is used. Lead, steel or aluminium, rather than copper, tipped prods are recommended to avoid copper penetration.

4.2 Prods shall be kept free of iron pick-up by frequent filing. Areas subjected to arcing shall be ground to clean metal wherever necessary.

5 CALIBRATION OF EQUIPMENT

5.1 Frequency of Calibration

Each piece of magnetizing equipment shall be calibrated at least once a year or after each time it has been subjected to major electrical repair, periodic overhaul or damage whichever is sooner.

5.2 Equipment with Ammeters

5.2.1 *Procedure*

The units meter readings shall be compared to those of a control test meter with shunt or current transformer arrangement, connected so as to monitor the output current. The accuracy of the entire control test meter arrangement shall be verified annually. Comparative readings shall be taken at a minimum of three output levels encompassing the useable range.

Table 1 Average Magnetizing Current for Magnetic Particle Inspection for Steel Castings

(*Clause* 4.1)

Sl No.	Prod Spacing mm	Magnetizing Current to be Applied	
		Section thickness below 20 mm (in amperes)	Section thickness 20 mm and over (in amperes)
(1)	(2)	(3)	(4)
i)	50 to 100	200 to 300	300 to 400
ii)	100 to 150	300 to 400	400 to 600
iii)	150 to 200	400 to 600	600 to 800

NOTE — Prod spacing less than 75 mm usually is not advisable due to banding of the particles around. By agreement between the manufacturer and the purchaser a higher prod spacing than is shown above together with a correspondingly higher current may be employed.

5.2.2 *Tolerance*

The unit's meter reading shall not deviate by more than ± 10 percent of full scale, relative to the actual current values as shown by the test meter.

NOTE — When half-wave current is involved, the direct current test meter current readings shall be doubled for the calibration.

5.3 Materials for Magnetic Particle Inspection

The defect indications may be obtained by means of the following media, any one of which may be used at the discretion of the manufacturer unless otherwise specified in the enquiry and order.

a) Dry magnetic powder stables up to 350 °C (for normal magnetic particle inspection and at elevated temperatures);
b) Dry magnetic powder with coloured pigment;
c) Magnetic powder suspended in an aqueous or hydrocarbon liquid; and
d) Fluorescent magnetic powder suspended in an aqueous or hydrocarbon liquid.

NOTE — The materials mentioned in b, c & d may be used only at ambient temperature.

5.3.1 For aqueous suspensions, the liquid shall contain an anti-rust additive and a surface active additive.

5.3.2 The powder shall be of a size, shape and colour such that it will ensure a suitable sensitivity and contrast when used in the intended manner.

5.3.3 Verification of the quality of magnetic particle material is very important. It is to be ensured before test that all the powder or particles are attracted to the magnet.

5.3.4 In order to verify the purity of the particles contained in the liquid, a sample of the material may be allowed to settle after shaking, deposit collected, cleaned, dried, weighed and ensured that all of it gets attracted to the magnet.

5.3.5 Bath concentration for wet magnetic particle inspection may be checked before use of red or black indicating material, the recommended concentration for a 100 ml sample is 1.2 ml to 2.4 ml. For fluorescent paste, the recommended concentration is 0.7 ml to 1.0 ml.

6 TYPES OF INDICATIONS

6.1 Circular Indications

Circular indications are those more or less elliptical with major axis not more than three times the minor axis.

6.2 Liner Indications

Linear indications are those having the largest dimension equal to at least 3 times the smallest.

6.3 In-Line-Indications

In-line-indications are those found in a group of three or more indications.

6.4 The type of casting/weld defects and the corresponding likely indications are listed in Table 2.

Table 2 Defects and the Corresponding Indicators

(*Foreword and Clause* 6.4)

Sl No.	Type	Type of Defect	Likely Indication
(1)	(2)	(3)	(4)
i)	Type I	Linear discontinuities	Ragged lines of variable width may appear as a single jagged line or exist in groups. They may or may not have a definite line continuity. They usually originate at the casting surface and generally becomes smaller as they go deeper.
ii)	Type II	Shrinkage	Appears as a jagged area irregular patches, shrinkage is a sub-surface discontinuity that may be brought to the surface by machining or other methods of metal removal.
iii)	Type III	Inclusions	Isolated, irregular or elongated indications of magnetic particles occurring singly in a linear distribution or scattered at random in feathery streaks. The indications are the result of the present of sand, slag or oxides in the surface metal.
iv)	Type IV	Internal chills and unfused chaplets	A uniform line or band outlining the object- and indicating lack of fusion between the metal object and the casting.
v)	Type V	Porosity	Appears as rounded and elongated clusters of magnetic particles, of various sizes scattered at random,
vi)	Type VI	Welds	Incomplete fusion and penetration appears as a straight continuous or intermittent linear indication.
			Porosity inclusions and linear discontinuities in welds appear as described above. For example: Weld porosity, incomplete penetration, undercutting, inclusions in weld, crater cracking.
vii)	Type VII	False indication	Example: Prod pattern, powder lodged in surface depression, particles dropped from cables, chisel marks, wrinkles.
viii)	Type VIII	Magnetic anomalies	Example: Adhering scale, magnetic writing, high external magnetic field, junction of materials of different permeability, powder build up at sharp fillet.

6.5 Detection of the discontinuities is connected with the direction of the magnetic flux in the casting. Therefore, it is essential to carry out a check in two directions which are essentially perpendicular, to make sure that the discontinuity lies across the flux in at least one direction.

7 EVALUATION OF INDICATIONS

7.1 Prior to evaluation, it is necessary to confirm that the discontinuities as revealed are true defects and not a result of localized surface irregularities due to machining marks or other surface conditions as they may produce false indications**.**

7.2 In case any indication is suspected to be non-relevant, it is to be considered, relevant until it is proved otherwise**.**

7.3 The surface of the casting shall be smooth enough to facilitate effective examination and to prevent broad areas of particles accumulation which could mask significant indications of discontinuities. Ordinarily the surface finish shall be equal to or better than 25 μm.

7.4 All indications of size under 1.5 mm shall be ignored as not significant.

7.5 All significant indications shall be evaluated as indicated in Table 3.

7.6 It is to be considered that the magnetic particle inspection, like all methods of non-destructive inspection forms a part of an overall assessment of the quality of a casting and may not ordinarily be treated as the sole criterion of acceptance.

7.7 The area to be examined shall be suitably illuminated to permit satisfactory evaluation of the indications revealed on the test surface. Examination is carried out visually in suitable lighting conditions. The minimum value of luminance is 500 flux in day light. In case artificial light is used, a minimum luminosity of 8 W/m^2 is to be provided**.**

8 ACCEPTANCE LIMITS

8.1 Castings are classified into five quality levels namely 1, 2, 3, 4 and 5 as given in Table 3, according to the maximum permissible size and quantity of defects recorded. The special quality level 1 A is applicable only to the specified regions of certain types of castings, as stated in **8.2**.

8.2 The maximum permissible discontinuities relate to the quality levels as indicated in the enquiry and order (or drawing).

8.3 Unless otherwise agreed upon in advance, quality level 1 A is applicable only to castings used for creep resistant applications (that is exposure to high temperatures and fluid pressures), at the fabrication weld zone that is, the region representing weld preparation plus the adjoining 40 mm length of the casting as shown in Fig. 1.

9 DEMAGNETIZATION

When so specified in the enquiry and order the castings may be demagnetized after carrying out the inspection. The demagnetization may be carried out as specified in IS 3703.

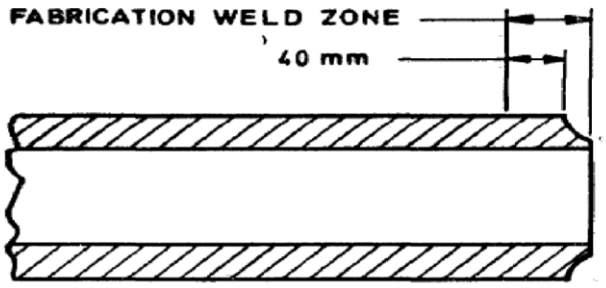

FIG. 1 FABRICATION WELD ZONE

Table 3 Maximum Permissible Size and Quantity of Discontinuities or Defects as Detected by Magnetic Particle Inspection

(*Clauses* 7.5 *and* 8.1)

Sl No.	Type of Discontinuities		Maximum Permissible Discontinuity/Indication Sizes							
			Quality Level	Quality Level 1		Quality Level 2		Quality Level 3	Quality Level 4	Quality Level 5
			1 A [Applicable to fabrication weld zone (*see* Fig 1 and **8.2**)]	Wall thickness 50 mm and below	Wall thickness above 50 mm	Wall thickness 50 mm and below	Wall thickness above 50 mm			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
i)	LINEAR (*see* **6.2**)	On surface exposed after machining or on inner as cast surface directly subjected to fluid pressure	None	3 mm	5 mm	3 mm	5 mm	1-3 a to 1-3 c	1-4 a to 1-4 c	1-5 a to 1-5 c
		Number of indication permissible in an area of 10 cm × 10 cm wherein the shortest discontinuities is not less than 3 times the extent of larger discontinuity	None	10	10	10	10	10	10	10
		Number of indications permissible in an area of 5 cm × 5 cm having a distance of minimum 2 mm between adjoining indications	None	10	10	10	10	10	15	15
		On other ‘as cast’ surface	None	1-1 a to 1-1 c	1-1 a to 1-1 c	1-2 a to 1-2 c	1-2 a to 1-2 c	—	—	—
ii)	Porosity (applicable to all surfaces) surface shrink hotels	Maximum permissible size of an individual indications (mm)	None	3 mm	5 mm	3 mm	5 mm	5 mm	5 mm	5 mm
		No. of indications permissible in an area of 5 cm × 5 cm	None	10	10	10	10	10	10	10

Table 3 (*Concluded*)

Sl No.	Type of Discontinuities	Maximum Permissible Discontinuity/Indication Sizes							
		Quality Level	Quality Level 1		Quality Level 2		Quality Level 3	Quality Level 4	Quality Level 5
		1 A [Applicable to fabrication weld zone (*see* Fig 1 and **8.2**)]	Wall thickness 50 mm and below	Wall thickness above 50 mm	Wall thickness 50 mm and below	Wall thickness above 50 mm			
(1)	(2) (3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	On surface exposed after machining or inner 'as cast' surface directly subjected to fluid pressure	None	II-1	—	II-1	—	II-2	II-3	II-3
	On other 'as cast' surface	None	II-2	—	II-3	—	II-3	II-4	II-5
iii)	Inclusions (non-metallic) (applicable to all surfaces)	—	III-2	—	III-3	—	III-3	III-4	III-5
iv)	Chills and unfused chaplets (applicable to all surfaces)	—	IV-1	—	IV-2	—	IV-3	IV-4	IV-5

NOTES

1 The evaluation and designation of discontinuities or defects shall be as specified in ASTM-E-125-63 (1980) — Standard reference for magnetic particle indications on ferrous castings. These reference photographs are available in four charts arranged for each charts are available from American Society of Testing and Materials, 1916, Race Street, Philadelphia 19103 USA.

2 The numbers I - 1 a, I - 2 a, II - 1, etc. shown above refer to the number of corresponding standard reference photographs in the ASTM.

3 Quality levels 3, 4 & 5 are applicable to all thicknesses and to all surfaces.

ANNEX B

(*Foreword*)

COMMITTEE COMPOSITION

Foundry and Steel Castings Sectional Committee, MTD 14

Organization	*Representative(s)*
BHEL (CFFP), Haridwar	SHRI V. K. RAIZADA **(*Chairperson*)**
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