



CORPORATE STANDARD

AA 085 01 33

Rev. No. 02

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PROCEDURE FOR MAGNETIC PARTICLE EXAMINATION

1.0 SCOPE:

- 1.1 This standard outlines the procedure for magnetic particle examination of ferro-magnetic materials.
- 1.2 Typical surface and subsurface discontinuities detectable by this method are cracks, seams, laps, cold shut, inclusions, etc.
- 1.3 This shall be applied to all forms of ferromagnetic material as formed and semifinished as well as, finished state, such as welds, forgings, castings, etc.
- 1.4 This standard is generally based on ASTM E 709.

2.0 PERSONNEL REQUIREMENT:

Personnel performing non-destructive examination and evaluation shall be qualified to the recommended practice SNT-TC-1A or any other recognised practice.

3.0 TEST METHOD:

Finely divided magnetic particles are applied to the surface of a part which has been suitably magnetised. The particles are attracted to regions of magnetic non-uniformity associated with defects and discontinuities, thus producing indications which are observed visually. The magnetic particle is applied either as dry powder or in a wet suspension in a liquid medium.

4.0 SURFACE CONDITION/PREPARATION:

The surface being inspected shall be clean and dry. It shall be free from dirt, oil, grease, sand, rust or loose scale. As cast or as welded surfaces are generally satisfactory if clean. A pressure blast is useful for this purpose. Thin paint does not interfere with the formation of indications but must be removed at points where electrical contact is to be made. If the surface is unusually rough, such as with burned in sand or very rough weld bead, interpretation may be difficult because the particle is being trapped mechanically. In case of doubt, light grinding may be necessary to determine if actual indications are present.

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5.0 SEQUENCE OF OPERATION:

5.1 Method Of Examination:

Examination shall be generally carried out by the continuous method, i.e., the magnetising current remains on, while the examination medium is being applied and excess being removed.

5.2 Magnetisation:

Any suitable and appropriate means for establishing the necessary magnetic flux may be employed, such as passing current through the material (e.g. 'Prod' method) using magnetic yoke, or wrapping the part with a coil through which a magnetising current is passed.

5.3 Examination Medium:

5.3.1 The finely divided ferromagnetic particles used for detection of discontinuities shall be of fine grain and the same shall be of high permeability and low retentivity. It shall be of dry powders (Fluorescent and nonfluorescent) ready for use, as supplied or powder concentrates (Fluorescent and non-fluorescent) for dispersion in water or suspending light petroleum distillates.

5.3.2 Dry Particles:

When dry particles are used, they shall be sprayed either by a low pressure pneumatic instrument or hand operated bulb blower. Colour of the powder shall be such as to provide adequate visual contrast with the back ground of the surface being examined. The temperature of the surface of the part under examination shall not exceed 315°C (600°F). Adequate lighting should be provided for easy observation of the indication. Some coloured organic coatings applied to dry particles to improve contrast lose their colour at higher temperatures. Fluorescent dry particles shall not be used at this high temperature. Manufacturer's recommendations for temperature limitation shall be followed.

5.3.3 Wet Particles:

When wet particles are used, the solid magnetic particles shall be suspended in a suitable liquid medium. The concentration of the particles in the liquid medium shall be 0.2 to 0.4 ml in a 100ml sample for fluorescent particles and from 1.2 to 2.4 ml in a 100 ml for non-fluorescent particles unless otherwise specified by the particle manufacturer.

5.3.4 Fluorescent Particles:

5.3.4.1 The fluorescent particle examination shall be performed using a black light in a darkened area.

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5.3.4.2 The black light used for fluorescent particle testing shall be capable of developing the wave length of 365nm., in any case the wave length should be in the range of 330 to 390nm. with an intensity of not less than 1000 uw/cm² on the surface of the part.

5.3.4.3 The black light shall be allowed to warm up for a minimum of 5 min. prior to its use or measurement of the intensity of the ultraviolet light emission.

5.3.4.4 The examiner shall be in the darkened area for atleast 5 min. prior to examining the parts using black light so that his eyes will adopt to dark viewing. Photochromic or permanently tinted lenses shall not be worn during examination.

5.3.4.5 The black light intensity shall be measured with a black light meter at least once every 8 hours and whenever the work station is changed.

5.4 Orientation of Discontinuities And Examination Coverage:

Examination shall be conducted with sufficient overlap to ensure cent percent coverage at established test sensivity. To ensure most effective detection of discontinuities each area shall be examined at least twice with the lines of flux approximately perpendicular to each other.

5.5 Demagnetisation:

Demagnetisation following examination shall be carried out where residual magnetism can interfere with subsequent process or usage. Demagnetisation is not normally required on the type of parts where the dry powder Prod magnetisation is used.

6.0 METHODS OF MAGNETISATION:

6.1 Prod Method:

6.1.1 Magnetising Technique:

6.1.1.1 Magnetisation shall be accomplished by portable Prod type electrical contacts pressed against the surface in the area to be examined. To avoid arcing, a remote control switch may be provided to permit the current to be turned on after the prods have been properly positioned and turned off before they are removed.

6.1.2 Prod Spacing:

Prod Spacing shall be maximum of 200 mm. Shorter spacing may be used to meet the limitation of geometry or dimensions of the area being examined, or to increase the sensitivity, but prod spacing less than 75 mm usually is not recommended owing to banding of the particles around the prods.



6.1.3 Magnetising Current:

Alternating, direct or rectified magnetising current shall be used. The current shall be 90 to 110 A per 25mm. of prod spacing for sections less than 19mm. thick and 110 to 125 A per 25mm. prod spacing for sections 19mm. and greater.

6.1.4 Prod shall be kept free of iron pick up by frequent filing. Local areas of metal being tested which have been subjected to arcing shall be ground to clean metal wherever necessary.

6.2 Coil Method:

6.2.1 Magnetising Technique:

Magnetisation shall be accomplished by pressing current through a multiturn coil looped around the part or section of the part to be examined to produce a magnetic field parallel to the axis of the coil.

6.2.2 Magnetising Current:

6.2.2.1 Encircling Coils:

There are four empirical longitudinal magnetization formulas for using encircling coils, the formula to be used depending on the fill factor.

6.2.2.1.1 Low Fill Factor Coils:

In this case, the cross sectional area of the fixed encircling coil greatly exceed the cross sectional area of the part (Less than 10% coil inside diameter). The part shall be placed well within the coils and close to the inside wall of the coil. For parts with length over diameter ratio (L/D) between 3 and 15 is calculated from the following equations.

- (1) Parts with low fill factor positioned closed to the inside wall of the coil:

$$= \frac{45,000}{L/D} \text{ Ampere Turns } (\pm 10\%)$$

- (2) Parts with a low fill factor positioned in the center of the coil:

$$= \frac{43,000 \times R}{(6 L/D) - 5} \text{ Ampere Turns } (\pm 10\%)$$



6.2.2.1.2 Intermediate Fill Factor Coils:

When the cross section of the coil is greater than twice and less than ten times the cross section of part being examined.
$$= (NI)_{hf} (10-4) + (NI)_{lf} (4-2)/8$$

Where

NI_{hf} = Value calculated for high fill factor coils using
$$\frac{35000}{(L/D) + 2} \quad (10\%)$$

NI_{lf} = Value Calculated for low fill factor coils using
$$\frac{43,000 \times R}{(L/D) - 5} \quad (10\%)$$

Where R = Coil Radius

Y = Ratio of the cross sectional area of the coil to the cross section of the part.

For example if the coil has an inside diameter of 24 cm. and part (a bar) has outside diameter of 12 cm.

$$Y = \frac{n(12)^2}{n(6)^2} = 4$$

6.2.2.1.3 High Fill Factor Coils:

In this case, when fixed coils or cable wraps used and the cross sectional area of the coil is less than twice the cross sectional area (Including hollow portions) of the part, the coil has a high fill factor.

For parts with in a high fill factor positional coil and for parts with L/D ratio equal or greater than 3.

$$= \frac{35,000}{(L/D)+2} \quad \text{Ampere turns } (\pm 10\%)$$

L/D ratio for a hollow piece: When calculating L/D ratio for a hollow piece, D shall be replaced with an effective diameter D_{eff} . Calculated using.

$$D_{eff} = [(A_t - A_h)/n]^{\frac{1}{2}}$$

Where

A_t = Total cross section area of part

A_h = Cross sectional area of hollow portion(s) of the part.

For a cylindrical piece this is equivalent to

$$D_{eff} = [(OD)^2 - (ID)^2]^{\frac{1}{2}}$$

Where

OD = Outside diameter of cylinder

ID = Inside diameter of cylinder.

**6.2.2.2 Through Coils:**

For through coils the current specified in para 6.3.2 divided by number of turns shall be used.

6.3 Direct Contact Method:**6.3.1 Magnetising Technique:**

Magnetising shall be accomplished by passing current end to end through the part to be tested to produce a circular magnetic field perpendicular to the current flow through the part.

6.3.2 Magnetising Current:

Direct or rectified current shall be used at 280 to 360 amperes per centimeter of part for diameter upto 125 mm; 200 to 280 amperes per centimeter of part for diameter grater than 250mm.

(Note: A different means of magnetising shall be used for the second examination to fulfil the requirements specified in Cl.5.4).

6.4 Yoke Method:**6.4.1 Application:**

This method shall be used only to detect surface discontinuities which actually come to the surface.

6.4.2 Magnetising Technique:

6.4.2.1 Alternating current electromagnetic yoke shall be used to magnetise, provided the yoke has a lifting power of at least 4.5 Kg and a pole spacing of 75 to 150 mm.

6.4.2.2 Alternatively direct current electromagnetic or permanent magnetic yoke shall be used to magnetise, provided the yoke has a lifting power of at least 18 kg and a pole spacing of 75 to 150 mm.

6.5 Threading Bar and Coil Technique:

6.5.1 If the part is hollow, flaws in a longitudinal direction may be detected by passing the magnetising current through a bar or cable held within the bore of the part. Alternatively a threading coil may be used.

6.5.2 The current strength shall be equivalent to not less than 10500 ampere turns (a.c; r.m.s value) or 15000 ampere turns (d.c.) per metre of the maximum distance of the bar cable from the surface of the bore of the part.



6.5.3 Because of limitations of the equipment, it may be necessary to magnetise the part at several positions within the bore, with the bar or cable lying on the bore surface, in which case the distance between spacing of the conductor or coil for successive checks shall not be greater than 100 mm.

Note: Magnetising particle field indicator shall be used to establish adequacy of the magnetic field.

7.0 CALIBRATION:

Calibration of the ammeter shall be done as per BHEL Standard AA 085 01 59.

8.0 EVALUATION OF INDICATIONS & INTERPRETATION:

8.1 If the indication is caused by the surface discontinuity the particles are usually tightly held to the surface by a relatively strong magnetic leakage field. The line of particles will be sharp and well defined.

8.2 If the indication is caused by surface discontinuity, the particles are held in a broad fuzzy accumulation rather than being sharp and well-defined.

8.3 Non-relevant indications are caused by distortion of magnetic field resulting from magnetic writing, cold working, hard and soft spots, boundaries of heat affected zone, abrupt change of section, etc. Care shall be taken to identify and eliminate them as they may mask the actual defect.

8.4 Relevant indications are those which result from mechanical discontinuities. Linear indications are those in which the length is more than three times the width. Rounded indications are indications in which are circular or elliptical with the length less than three times the width.

9.0 REFERRED STANDARDS (Latest Publication Including Amendments):

1. ASTM E 70

2. BHEL CS AA 085 01 59