




QUALITY CONTROL DEPARTMENT
MAGNETIC PARTICLE EXAMINATION
PROCEDURE


Procedure No. 4DSD 0341
Revision No. 0
Date 23.11.2007
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1. SCOPE

This procedure describes the requirement and methodology to be adopted for the Magnetic Particle Examination of ferromagnetic materials to detect discontinuities at or near the surface (sub surface) up to 0.5mm to 1 mm.

The examination procedure shall be applied to raw materials semi finished or finished machined products and welds.

Type of discontinuities detected are cracks , laps, seams , cold shuts, lamination and shrinkage porosity.


This procedure does not cover the demagnetization procedure.

2. TECHNIQUE

- (a) **Method of Examination** - Examination shall be done by the continuous method, that is the magnetizing current remains ON, while the examination medium is being applied .
- (b) **Magnetization** - Any suitable and appropriate means for establishing the necessary magnetic flux will be employed such as prod technique, longitudinal magnetization technique, circular magnetization technique, yoke technique.
- (c) **Examination Medium** - (i) Dry (ii) Wet - Visible or Fluorescent . 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 will be such as to provide adequate visual contrast with the background of the specimen.

When wet particles are used the solid magnetic particles shall be suspended in a suitable liquid medium eg. Water or kerosene oil. The concentration of the particle in the liquid medium shall generally be 1.2 to 2.4% by volume. The colour of the particle shall be such as to provide sufficient contrast with the back ground of the surface being examined. The suspension shall be stirred well before application.

Magnetic particles (powder) should be approved by BPCL. .

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3. REFERENCE

- ASME Sec. V Article – 7
- ASTM E 709
- ASME Sec. VIII Div. 1 Appendix 6 & 7
- ASME Sec. II Part A, SA 613, SA, 614, SA-654
- ASME Sec. III Sub Sec.- NC

4. EQUIPMENT, ACCESSORIES & MATERIALS

4.1 EQUIPMENT

Equipment Make	Model	Brand Equipment	Type
ORMS PAVAN, INDIA	MS – 1AHD	Magna Spray Equipment	Portable
-DO -	ST - 603AHD	-DO-	Stationary
-DO-	MS – Y7	Battery Eleminator	Portable

4.2 ACCESSORIES.

ASME Field Indicator, Centrifuge Tube, Puffer Bulb, Test Ring etc.

4.3 MATERIALS

Following Magnetic particle shall be used.


MAKE	DESIGNATION	TYPE	ALLOWABLE TEMP. LIMIT
Magna flux	7C Black	Wet	10 – 93 deg.centigrade
P – Met	MP – 71	Dry	10 - 100 -Do-
Or other BPCL approved Materials			

5. NDT PERSONNEL :

The test shall be carried out by trained / ASNT Level – I & Interpretation shall be done by ASNT Level – II.

6. SURFACE PREPARATION

The surface being inspected and the adjoining area up to 25 mm² shall be clean and dry and it shall be free from dirt, oil, grease, sand, rust, spatter or loose scales . A pressure blast is useful, however surface preparation by grinding or machining is necessary, where surface irregularities could mask indications due to discontinuities. When coatings are applied temporarily to uncoated surfaces only in amounts sufficient to enhance particle contrast, it must be demonstrated that indication can be detected through the enhancement coating.

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7. SEQUENCE OF OPERATION

8. MAGNETISATION :

- 8.1 Prod. Technique** - Magnetisation shall be accomplished by a portable Prod Type electrical contacts pressed against the surface in the area to be examined. To avoid arcing, a remote control switch which may be built into the Prod Handles, shall be provided to permit the current to be turned on, after the prods have been properly positioned. The prods shall be kept clean and dressed.

Prod. Spacing shall not exceed 200 mm. Shorter spacing may be used to meet the geometric limitation of the area being examined or to increase sensitivity but prod spacing of less than 75 mm are not practical due to banding of particles around the prod.

Direct or rectified magnetic current shall be used. The current shall be minimum 100 to maximum 125 Amperes per 25 mm of prod spacing for section 19 mm thick or greater. For section less than 19 mm in thickness the current shall be 90 to 110 Amp. Per 25 mm of prod spacing. Field adequacy shall be demonstrated by using Magnetic Particle field indicator.

- 8.2 Longitudinal Magnetisation** - Longitudinal magnetisation is produced by passing a current through a multiturn coil or cable wrapped around the job.

The magnetic field is produced longitudinally parallel to the axis of coil.

The required field strength shall be determined based on length and diameter of the cylindrical part.

For non - cylindrical part, the length and cross sectional diagonal shall be basis for determining the required field strength. Long parts shall be examined in section not to exceed 18 inches. 18 inch shall be considered as length for calculating the required field strength.

The number of Ampere - Turn required to produce adequate magnetising force to magnetise the job is related to length over diameter ratio as under.


- I. Parts with length over diameter ratios equal to or greater than

$$\text{Ampere - Turn (NI)} = 35000 / (L / D) + 2$$

- II. Parts with length over diameter ratios less than 4 but not less than 2

$$\text{Ampere - Turn (NI)} = 45000 / L / D$$

Where L = Length of the part

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D = Diameter of the part

N = Number of Turn in the coil

I = Ampere

The magnetising current shall be with in $\pm 10\%$ as determined with the above formula.

For long part the magnetising current used for examination shall be 1200 to 4500 Amp. Turn and part shall be examined in section by moving the coil or part to cover entire length.

The adequacy of magnetic field shall be established using a magnetic field indicator.

Magnetising Current (Amperes) = Ampere – Turn / Turn


8.3 Circular Magnetisation (Indirect Method)- In this technique current is passed through a central conductor through the hollow job, the inside or outside surface can be examined.

Where the job dia is large, the central conductor shall be close to the internal surface. The central conductor or cable may be single turn or multiturn.

The current requirements are the same as for a solid round job. In case of a central conductor, current requirement shall be proportionally on the number of turn of the coil. If job diameter is large the examination shall be in increments.

Approximate current requirement for hollow job where magnetising is through a central conductor is as under :-

<u>Central Conductor</u> <u>Dia in mm.</u>	<u>Section wall thickness</u> <u>In mm</u>	<u>Amperage</u>
12.7 mm	3.18	500
	6.35	750
	9.50	1000
	12.7	1250
25.4 mm	3.18	750
	6.35	1000
	9.50	1250
	12.70	1500
38 mm	3.18	1000

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	6.35	1250
	9.50	1500
	12.70	1750
50mm	3.18	1000
	6.35	1500
	9.50	1750
	12.70	2000

For wall thickness greater than 12.7 mm add 250 Amp \pm 10 for each addition of 3.18 mm.

8.4 Circular Magnetisation (Direct Method)

In this technique the current is passed through the job, setting up a circular magnetic field, right angle to direction of current flow.

The part is held between the contact heads on a stationary equipment and current is passed through heads to generate a circular field in the job. Discontinuities parallel to the current are detected.

At least two separate examination of the area shall be carried out. The magnetic field direction shall be perpendicular to each others. This can be delivered by shifting the contact point ninety degree to first contact or by generating a longitudinal field.

The suggested amperage shall be as under :-


<u>Job dia</u>	<u>Suggested Amperage</u>
Upto 5" (125 mm)	- 700 - 900 A, per inch dia of job
Over 5" to 10 " (125-250mm)	- 500 - 700 Amps. Per inch dia of job
Over 10" to 15" (250-375mm)	- 300 - 500 - do-
Over 15" (375 mm)	- 100 - 300 Amps per inch dia of job

This technique is usefull for examination of small job of light weight which can be clamped on the test equipment are generally round in shape.

Job other than round , the greatest cross – sectional diagonal in a plane at a right angle to the current flow shall determine the current requirement per inch of dia.

8.5 Yoke Technique - In yoke technique permanent magnet, AC or DC electromagnetic yoke are employed to detect surface discontinuities.

The requirement for yoke magnetisation are as under :-

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- (a) AC electromagnetic yoke shall be capable of lifting 10 pounds at the maximum pole spacing.
- (b) DC electromagnetic yoke or permanent magnetic yoke shall be capable of lifting 40 pounds at the maximum pole spacing.

In yoke technique a longitudinal magnetic field is generated between the pole. Mostly dry magnetic particles are used for examination.

9. EVALUATION OF INDICATION

There are two types of indications related to magnetic particle examination. They are (a) Relevant and (b) Non-relevant.

9.1 Relevant Indication

Relevant indications are those indications produced by magnetic field leakage in the product, due to presence of discontinuities.

Only indications which have any dimension greater than 1.6mm shall be considered relevant. A linear indication is one having a length greater than 3 times the width. A rounded indication is one of circular or elliptical shape with length equal to or less than 3 times the width.

9.2. Non – Relevant Indication

Non relevant indications are those produced by magnetic field leakage on the product surface, due to cavity and irregular surface conditions like sharp ridges.

Gradually reduce the current till indication disappear. Disappearance confirms that the indication was non-relevant.


If the indication appear at the lower magnetising current the presence of relevant indication is confirmed.

10. ACCEPTANCE STANDARDS

10.1 Acceptance Standards for steel casting

As per ASME Sec.VIII Div 1 Appendix – 7

Surface indications determined by magnetic particle examination shall be compared with those indicated in ASTM E 125. Standard reference photographs for Magnetic particle indications on Ferrous Castings and shall be removed if they exceed the following limits.

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<u>Type</u>	<u>Degree</u>
1. Linear discontinuity (Hot tears & cracks)	- All
2. Shrinkage	- 2
3. Inclusion	- 3
4. Chills and Chaplets	- 1
5. Porosity	- 1

10.2. Acceptance Standards for forgings, rolled bars , welds

As per ASME Sec.VIII Div.1 Appendix – 6
All surfaces to be examined shall be free of ;

- a) Relevant Linear Indications
- b) Relevant rounded indications greater than 5 mm
- c) Four or more relevant rounded indications in a line separated by 1.6 mm or less edge to edge.

11. ACCEPTANCE STANDARDS FOR NUCLEAR ITEMS


11.1 Acceptance standards for steel castings, forging & bars

As per ASME Sec.III NC- 2545, NC- 2577, SA-613 & SA - 614

- a) Only indications with major dimensions greater than 1.6 mm shall be considered relevant.
- b) The relevant indications (i) through (iv) below are unacceptable
 - i) Any linear indications greater than 1.6 mm long for material less than 16 mm thick, greater than 3.2 mm long for material from 16 mm thick to under 51mm thick and 4.8 mm long for material 51 mm thick and greater.
 - ii) Rounded indications with dimensions greater than 3.2mm for thickness less than 16 mm and greater than 4.8mm for thickness 16 mm and greater.
 - iii) Four or more indications in a line separated by 1.6 mm or less edge to edge.
 - iv) Ten or more indications in any 3870mm² of area whose major dimension is no more than 152 mm with dimensions taken in the most unfavourable location relative to the indications being evaluated.

11.2 Acceptance Standards for bolts & studs greater than 1 inch (25 mm) (Nominal bolt size)

As per SA - 614

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- i) Linear non- axial indications are unacceptable
- ii) Linear axial indications greater than 25mm long are unacceptable.

11.3. Acceptance Standards for Ferrous Castings other than Steel castings

Degree 2 of ASTM E 125

12. REPAIR REQUIREMENT

unacceptable imperfections shall be removed or reduced to an imperfection of acceptable size and re-examination made to ensure complete removal or reduction to acceptable size.

13. DEMAGNETISATION

The demagnetization will be carried out only when required by the drg. or by the parts specimen, which should also indicate the minimum acceptable level of residual magnetism.

14. EXAMINATION CERTIFICATE

The magnetic particle examination certificate shall contain at least the following information.


- a) Manufacturer
- b) Job order, drawing, denomination, serial number of the unit examined
- c) Customer, inspection authority
- d) Stage of examination
- e) Result of examination
- f) Signature of operator or Level II personnel

15. POST CLEANING

Surface examined shall be cleaned after evaluation with dry or wet cotton rag

16. REPORTING

The reporting of test results shall be made on the test proforma as given in annexure-1.

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Annexure - 1

CUSTOMER;		BHARAT PUMPS & COMPRESSORS LTD.				F- 44003 F -02	
		RECORD OF NON DESTRUCTIVE EXAMINATION				Ref.. No.	
						Date	
Reference :							
Sales Order No	Name of Article	Material	Identification	Heat No	Qty	Drg..No.	Specification
Dye Penetrant Examination		Magnetic Particle Examination		Ultrasonic Examination		Sketch / Remarks	
Inspection Stage.		Inspection Stage		Inspection Stage.			
Area Examined		Area Examined		Area Examined			
Penetrant.		Surface Condition		Surface Condition			
Cleaner		Apparatus		Apparatus			
Developer		Magnetizing Method		Method			
Dwell Time		Powder		Probe Dia-& Freq.			
Examination Temp.		Magnetizing Current		Couplant			
Result		Magnetizing Time		Gain	Reject	Damp	Date of Examination
		Result		Pulse Height		DY.MGR. QC	Witnessed By