



**Blue Sheet  
Engineering Division**

**DCN:**

<p><b>This Blue Sheet applies to:</b>  <input checked="" type="checkbox"/> Individual Policy/Procedure Listed Below</p>		
<p><b>LANL review date:</b> 12/1/08</p>		
<p><b>Policy/Procedure No:</b> # KSL – MT - Procedure- 16-30-005</p>	<p><b>Rev. No.:</b> 3</p>	<p><b>Date:</b> 3/7/07</p>
<p><b>Manual, Policy or Procedure Title:</b> Magnetic Particle Inspection</p>		
<p><b>Reason for Revision</b> (if complete revision is checked above) Roll over of SSS contractor activities and work to LANL/LANS</p>		
<p><b>Documents listed above will be reviewed and conformed to by:</b> All qualified personnel to perform Magnetic Particle Inspection for acceptance of welding &amp; related fabrications.</p>		
<p><b>Description of Change:</b></p> <p>1.0 Purpose – delete - "(QC) Department"</p> <p>2.0 Scope – delete – "by QC personnel" and "by KSL"</p> <p>3.0 Definitions –                      Modify "QC" – to read – Test &amp; Inspection personnel qualified in accordance with Engineering Standards Manual (ESM), Chapter 13 – Welding &amp; Joining, Volume 1, GWS 1-11 Attachment 3, Qualification and Certification of NDE Personnel.</p> <p>4.0 Responsibilities – Delete "QC Manager responsibilities paragraph                      Add - Personnel performing inspections shall be qualified and certified in accordance with ESM, Chapter 13 – Welding &amp; Joining, Volume 1, GWS 1-11 Attachment 3, Qualification and Certification of NDE Personnel.</p> <p>5.0 Methodology - No Changes</p> <p>6.0 Records – Modify to read                      Recordable indications shall be reported as to length, width and location and recorded on LANL MT Inspection Report Form. (XXXXXXXXXXXX)                      Delete - QC is to perform a final review for completeness and accuracy and sign the form.                      Modify to read - The original report shall be given to the customer with a copy placed in inspectors file for a period of 1 year unless instructed by the customer to retain copies longer.</p> <p>7.0 References – Delete –                      16-00-012, Control of Special Processes <a href="http://intranet.ksl.lanl.gov/crypt/ap/16-00-012.pdf">http://intranet.ksl.lanl.gov/crypt/ap/16-00-012.pdf</a>                      16-30-001 Procedure for Qualification and Certification of NDE Personnel  <a href="http://intranet.ksl.lanl.gov/crypt/dept_ap/16-30-001.pdf">http://intranet.ksl.lanl.gov/crypt/dept_ap/16-30-001.pdf</a></p>		

**KSL Procedures/Work Instructions**

Add –

ESM, Chapter 13 – Welding & Joining, Volume 1, GWS 1-11 Attachment 3, Qualification and Certification of NDE Personnel.

Implementation Support Document ISD 330-5.0 – Special Processes

1.0 Attachments:

Delete – “Form 16-30-005.1 NDE Inspection Report”

Add – NDE Inspection Report Form – GWS 1-11 Attachment 4

**Date Revision Required: 12/1/10**

**Changes as marked**

**Reviewed by:**

Kelly Bingham  Date:  12-2-08   
LANL Welding Program Administrator

**Approved by:**

Signature on File   Date:  3/31/09    Signature on File   Date:  3/31/09   
ES - DE Group Leader ES - DE Division Leader

**MSS Policy/Procedures Review Team please forward original Blue Sheet to Luci Chavez upon approval**



## MAGNETIC PARTICLE INSPECTION

16-30-005

### IMPLEMENTATION

**Affected Personnel:** PERSONNEL PERFORMING MAGNETIC PARTICLE INSPECTION AT KSL

**Training Determination:** Required Reading

**Procedure Owner:** Test and Inspection Department

<b>Release Date:</b> 3/7/07	<b>Next Revision Date:</b> 3/7/2010
<b>Procedure Type:</b> Operational Procedure	<b>Revision Number:</b> 3
<b>Procedure Level:</b> Department	<b>Effective Date:</b>

### DOCUMENT MODIFICATION HISTORY

Rev No.	Description of Modification
1	Format changes and transfer to KSL
2	Change format to KSL and change content
3	Minor changes to content

## DOCUMENT REVIEW AND APPROVAL

Function	Name	Position Title	Date	Signature
Prepared by	Gerald Woodson	Subject Matter Expert	3/8/07	Signature on file
	Melissa Vigil	Technical Writer	3/7/07	Signature on file
Reviewed and approved by	Gerald Woodson	Quality Control Department Manager	3/8/07	Signature on file
Final approval by	Dan Gibson	Performance Assurance Director	3/8/07	R. Maestas for D. Gibson Signature on file

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## 1.0 PURPOSE

This procedure delineates the requirements for the performance of Magnetic Particle (MT) Inspection by Test and Inspection (QC) Department personnel who are qualified and certified to perform MT inspections, and to ensure that inspected items comply with specified codes, standards laws, specifications, procurement document, requirements, instructions or criteria.

## 2.0 SCOPE

This procedure applies to Magnetic Particle inspection activities performed by QC personnel on items examined by KSL unless specified under a specific code or procedure.

## 3.0 DEFINITIONS/ACRONYMS

**Inspection** – A phase of quality control, which by means of examination, testing, observation, or measurement determines the conformance of materials, supplies parts, components, appurtenances, systems, processes, or structures to predetermined quality requirements.

**Magnetic Particle (MT) Examination** – A Non-Destructive Examination (NDE) method utilizing magnetic leakage fields and suitable indicating materials to disclose surface and near-surface discontinuity indications.

**Testing**- The determination or verification of the capability of an item to meet specified requirements by subjecting the item to a set of physical, chemical, environmental, operating conditions.

**AC** – Alternating current (AC)

**ASTM** – American Society for Testing and Materials

**IWD** – Integrated Work Document

**NDE** – Non-Destructive Examination

**QC**- Test and Inspection Department under the Performance Assurance Division

## 4.0 RESPONSIBILITIES

**QC Manager** - It is the responsibility of the QC Manager to ensure only those personnel who meet the requirements of this procedure are permitted to perform inspections/activities covered by this procedure. Personnel performing inspections shall be qualified and certified in accordance with KSL Procedure 16-30-001, Qualification and Certification of NDE Personnel.

**MT Inspection Personnel** - Personnel certified to Level I, II, or III may perform the examination described herein and record the results of that examination.

Personnel certified to Level II or III shall supervise the examination, when performed by a Level I, and evaluate the results of this examination.

Personnel performing MT testing shall wear appropriate safety and protective equipment during field-testing. Inspection personnel shall be familiar with all cognizant Integrated Work Documents (IWD) which are facility or job specific. In some cases the inspectors will need to prepare IWDs for a specific project or job.

## **5.0 METHODOLOGY**

### **5.1 EQUIPMENT AND MATERIALS**

1. Magnetizing equipment may be horizontal bench type, portable AC/DC or AC electromagnetic yoke.
2. Magnetizing equipment must be calibrated once a year or whenever a malfunction is suspected. Yokes shall be qualified 6 months or before use per magnetic field strength requirements.
3. Yoke qualification: Alternating current (AC) electromagnetic yokes shall have a lifting power of at least 10 lbs at a pole spacing of 2-6 inches. Direct current electromagnet yokes shall have a lifting power of at least 30 lbs. at a spacing of 2 to 4 inches or 50 lbs. at a spacing of 4 to 6 inches.
4. Magnetic particles: The inspection medium shall consist of finely divided ferromagnetic particles, suspended in a liquid medium or used in dry powder form. The color used shall be chosen to give maximum contrast.
5. Fluorescent particle inspection shall be performed in an area that is darkened. The black light intensity shall be measured with a black light meter. A minimum reading of 1000  $\mu\text{W}/\text{cm}^2$  on the surface of the part is required daily.

### **5.2 SURFACE PREPARATION**

1. The surface of the part to be examined shall be essentially clean, dry, and free of contaminants such as oil, grease, loose rust, loose sand, loose scale, lint, thick paint, welding flux, and weld spatter. Thin nonconductive coatings, such as paint of 1-2 mils, will not normally interfere with the formation of indications.
2. When using dry powder it is recommended that the area to be inspected be coated with penetrant developer to provide a contrasting background. The surface temperature of the part being inspected shall not exceed 600°F.
3. When using wet particles the surface temperature of the part being inspected shall not exceed 135°F.
4. Cleaning may be accomplished using detergents, organic solvents, de-scaling solutions, paint removers, vapor degreasing, sand or grit blasting, ultrasonic cleaning or wire brushing.

(Note: sand or grit blasting shall have an NDT Level III approval.)

### **5.3 MAGNETIZATION PROCESS**

1. The magnetizing process will be wet or dry continuous method.
2. The residual method requires a special technique and will be approved by the Level III.

### **5.4 MAGNETIZING CURRENT**

The current can be AC, DC, Half-Wave Rectified AC or Full-Wave Rectified AC.

### **5.5 MAGNETIZING TECHNIQUE**

1. Longitudinal fields can be produced using a yoke, or coil.
2. Circular fields can be produced using prods or direct contact.

## **5.6 MAGNETIC FIELD DIRECTION**

1. Each part shall be inspected using two magnetic fields approximately perpendicular to each other.
2. Field direction should be verified using a Magnetic Field Indicator (PIE Gage).

## **5.7 MAGNETIC FIELD STRENGTH**

1. Field Strength shall be verified by one of the following methods:
  - a. Known discontinuities – Similar parts having known discontinuities
  - b. Artificial discontinuities – Slotted shims and pie field indicators
  - c. Measured with a Hall Effect probe/sensor
2. Empirical Formulas
  - a. Central conductor – 300 to 800 A/inch of part diameter (for large diameters up to 4 times the diameter of the central should be examined at one time and then the part rotated to give full coverage; minimum of 10% overlap)
  - b. Prods – 90 to 110 A/inch of spacing (Prod spacing 3 – 8 inches)
  - c. Yokes – lifting power (10 lbs. AC, 30 lbs. DC at appropriate spacing)
  - d. Air-Core Coil (see Attachment 1)

## **5.8 ACCEPTANCE**

1. Acceptance criteria shall be established by the Magnetic Particle requester and shall be documented on the NDE Inspection form 16-30-005.1.
2. Items not meeting acceptance criteria as established by the client or requester shall be documented on the NDE inspection form.

## **5.9 INTERPRETATION OF MAGNETIC PARTICLE INDICATIONS**

1. Any indication of an imperfection which is believed to be non-relevant shall be regarded as a discontinuity until the indication is either eliminated by surface conditioning or is shown by re-examination to be non-relevant by the same method or another nondestructive method.
2. After surface conditioning, the area shall be re-examined using the magnetic particle method or another suitable nondestructive examination method.

## **5.10 POST CLEANING**

1. Post cleaning is necessary in those cases where residual powder or suspension would interfere with subsequent processing or with service requirements.
2. It is particularly important where residual magnetic materials might combine with other factors in service to produce corrosion.

## **5.11 DEMAGNETIZATION**

1. When required by the customer, specification or when residual magnetism will affect the part, subsequent machining operations or operation of sensitive instruments, de-magnetized the part by a suitable method (i.e. use of an AC coil or a DC reversing method) and verify by the use of a Gauss meter.

2. A part may retain a strong residual field after having been circularly magnetized and show little or no external evidence of this field. Therefore circular magnetization should be performed before longitudinal magnetization if complete demagnetization is required.

## 6.0 RECORDS

Recordable indications shall be reported as to length, width and location and recorded on NDE Inspection Report Form 16-30-005.1.

QC is to perform a final review for completeness and accuracy and sign the form.

The original report shall be given to the customer with a copy placed in a QC file for a period of 1 year unless instructed by the customer to retain copies longer.

## 7.0 REFERENCES

ASME (American Society for Mechanical Engineers) Boiler and Pressure Vessel Code, 2001, Section V, Article 7, Non-destructive Examination

ASTM (American Society for Testing and Materials) E1316-99a, Standard Terminology for Nondestructive Examinations (Sections A & G)

ASTM E709-95, Standard Guide for Magnetic Particle Examination

ASTM E1444-01, Standard Practice for Magnetic Particle Examination

ASTM E-1316, Standard Terminology for Nondestructive Examinations (Sections A & G)

16-00-012, Control of Special Processes <http://intranet.ksl.lanl.gov/crypt/ap/16-00-012.pdf>

16-30-001 Procedure for Qualification and Certification of NDE Personnel  
[http://intranet.ksl.lanl.gov/crypt/dept\\_ap/16-30-001.pdf](http://intranet.ksl.lanl.gov/crypt/dept_ap/16-30-001.pdf)

## 8.0 ATTACHMENTS

Attachment 1, Air Coil Formulas

16-30-005.1 NDE Inspection Report Form



## AIR COIL FORMULAS

EQ1 1. Parts with low fill-factor positioned close to inside wall of coil:

$$NI = K/(L/D)(\pm 10\%)$$

When          N = 8          L = 20          D = 2

N	8	Equals	Number of Turns in Coil
I	562.5	Equals	Coil Current to be used, Amperes (A)
K	45000	Equals	45,000 (empirically derived constant)
L	20	Equals	Part in Length, inches
D	2	Equals	Part Diameter, inches: for hollow parts see below
NI	4500	Equal	Ampere Turns
A	56.25	Equals	10%

Example: A part 15 inches long with a 5-inch outside diameter as a L/D ratio of 15/5 or 3. According to the amp turn requirement  $NI = 45000/3$ . To provide adequate field strength in the part would be 15000 ampere turns. If a five-turn coil were used then the coil amperage requirement would be  $(I = 15000/5) = 3000 \text{ A } (\pm 10\%)$ .

Calculation for a Hollow Piece:

D shall be replaced with effective diameter calculation using

$$D_{\text{eff}} = [(A_1 - A_h)/3.14]^{1/2}$$

Where:

A<sub>1</sub> equals the total cross sectional area

A<sub>h</sub> equals the cross-sectional area of the hollow portions of the part for a cylindrical piece this is:

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

### AIR COIL FORMULAS

EQ2 2. Parts with a low fill-factor positioned in the center of the coil:

$$NI = LR/[(6L/D)-5](\pm 10\%)$$

When            N = 5            L = 15            D = 5            R = 12

N	5	Equals Number of Turns in Coil
I	7938.462	Equals Coil Current to be used, Amperes (A)
K	43000	Equals 43,000 (empirically derived constant)
R	12	Equals coil radius, inch
L	15	Equals part, length, inch
D	5	Equals part diameter, inch: for hollow parts, see below
NI	39692.31	Equals Ampere Turns
A	793.8462	Equal 10%

Example: A part 15 inches long with a 5-inch outside diameter as a L/D ratio of 15/5 or 3. If a five-turn twelve-inch diameter (6-inch radius) coil or cable were used, (1) Ampere-Turns would be as follows:

$$NI = (4300 * 6)/(6*3) - 5 \text{ or } 19846$$

and the coil amperage requirement would as follows:

$$19846/5 \text{ or } 3969 \text{ A } (\pm 10\%)$$

EQ3 Intermediate fill – factor coils – When the cross section of the coil is greater than twice and less than ten times the cross section of the part being examined.

$$NI = (NI)_{hf} (10 - Y) + (NI)_{lf} (Y-2)/8$$

Where

NI<sub>hf</sub> = value of NI calculated for high fill-factors coils using EQ4

NI<sub>lf</sub> = value of NI calculated for low fill factor coils using EQ1 or EQ2 and Y + ratio of cross-sectional area of the coil to the cross section of the part.

For Example, if the coil has an inside diameter of 10 inches and part (a bar) has an outside diameter of 5 inches.

$$Y = [(5)^2]/[(2.5)^2] = 4$$

## AIR COIL FORMULAS

EQ4 High Fill-Factor Coils – In this case, when fixed coils or cable wraps are 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.

(1) For parts within a high fill-factor positioned coil and for parts with an L/D ratio equal to or greater than 3.

$$NI = K/[(L/D) + 2] (\pm 10\%)$$

When            N = 5            L = 15            D = 5

N	5	Equals Number of Turns in Coil
I	1400	Equals Coil Current to be used, Amperes (A)
K	35000	Equals 35,000 (empirically derived constant)
L	15	Equals Part, Length, inches
D	5	Equals Part, Diameter, inches: for hollow parts see below
N	7000	Equals Ampere Turns
A	140	Equals 10%

For example the application of EQ4 can be illustrated as follows:

A part 10 inches long with 2 inch outside diameter would have a L/D ratio of 5 and an ampere turn requirement of  $NI = 35000/(5 + 2)$  or 5000

If a 5 turn coil or cable wrap is used, the amperage required is  $5000/5$  or 1000 A

