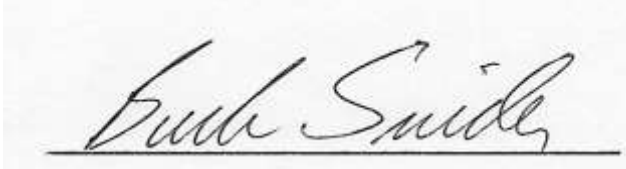
PB-2000

MAGNETIC PARTICLE TESTING

REVISION A03

SEPTEMBER 12, 2018

Reviewed By:	
Buck Snider Quality Manager Date: September 12th, 2018	
Approved By:	
Scott Powers ASNT NDT Level III 53325 Date: September 12th, 2018	

REVISION HISTORY

Revision	Date	Description of Changes	Revised by
A0	01/01/96	Original Issue	N/A
A01	12/30/99	Minor revision in various paragraphs as noted	Scott Powers
A02	08/18/08	Major revision	Scott Powers
A03	09/12/18	Reformatted and updated procedure	Scott Powers

TABLE OF CONTENTS

1.0 PURPOSE

1.1 This specification defines the requirements for the wet and dry magnetic particle examination technique and procedure for inspection of specified welds, material and components.

1.2 This specification is established to give instructions for inspection, detection and evaluation of surface or slightly subsurface discontinuities in ferromagnetic materials using the MT method.

2.0 PERSONNEL/PROCEDURE QUALIFICATION

2.1 Personnel performing inspection, evaluation and interpreting results in accordance with this specification, applicable codes, standards, and customer acceptance criteria shall have a minimum of NDE Level II certification. NDE personnel qualification and certifications shall be in accordance with the requirements of P&B Testing, Inc written practice PB-4000 which meets the requirements of ASNT SNT-TC-1A as a minimum.

2.2 NDE Level I may perform inspections and calibration of equipment if under direct supervision of NDE Level II or Level III personnel, but shall not evaluate results with respect to applicable codes, standards and customer acceptance criteria.

2.3 All third party inspection personnel shall adhere to this procedure for magnetic particle examinations of Aker Solution's products, unless customer contractual requirements mandate the use of customer procedures or P&B Testing, Inc Quality Assurance Manager and ASNT NDT Level III approve the use of a third party procedure in writing.

2.4 Quality Assurance Manager shall be responsible for all tests being performed in accordance to this procedure.

2.5 Personnel qualifications, valid eye exams and certification shall be maintained on file.

3.0 REFERENCED DOCUMENTS

The following documents have been referenced in preparation of this procedure and are considered part of it as applicable when required by contractual agreement or listed in the purchase order.

ASTM E 709	Standard Guide for Magnetic Particle Examination
ASTM E 1444	Standard Practice for Magnetic Particle Examination
ASTM A 275	Standard Test Method for Magnetic Particle Examination of Steel Forgings
ANSI/Z540-1	Calibration Laboratories and Measuring and Test Equipment Examination
RP- SNT-TC-1A	Recommended Practice for Personnel Qualification and Certification in Non-destructive Testing
API 6A	Specification for Wellhead and Christmas Tree Equipment
API 17D	Specifications for Subsea Wellhead and Christmas Tree Equipment
AWS D1.1	Structural Weld Code-Steel
ASME V-Article 7	Magnetic Particle Examination
PB-4000	Written Practice

4.0 EQUIPMENT

4.1 Magnetizing Equipment

4.1.1 Magnetizing equipment shall be capable of inducing a sufficient magnetic field in two (2) directions approximately ninety degrees (90) apart from each other using either circular or longitudinal method or both. Equipment may produce direct current, alternating current, half wave direct, full wave direct, or half wave rectified alternating current (HWAC).

4.1.2 Each piece of magnetizing equipment shall be calibrated at a minimum of once every six (6) months or whenever there is reason to believe the equipment is malfunctioning or repairs that could affect output have been made. Calibration shall be done prior to its use.

- Handheld yokes may be AC, DC or HWAC.
- Cables may be copper or aluminium.
- Coils shall consist of 3 turns minimum.
- Clamps may be lead, copper or brass.
- Prods are prohibited without written approval from Quality Assurance.
- White Contrast Paint.
- Wet or dry visible or fluorescent particles.

4.2 Yoke Equipment

4.2.1 Portable electromagnetic yokes (AC, DC or HWAC) maybe used as a magnetizing apparatus, provided AC yokes lift a calibrated weight of at least 10lbs and the DC/HWAC lift a 40 lb weight minimum at the maximum pole spaces to be used. If DC yoke poles are spaced four (4) to six (6) inches apart, a 50lb weight shall be used for calibration prior to the exam.

Note: When using DC or HWAC, 40lb weight is necessary to comply with ASTM Section V Article 7 and 50lb weight is necessary for compliance to ASTM E 709-01 as applicable.

Note: The use of Yoke Equipment on API Product is limited to localized areas i.e. weld repair, spot-checking.

4.3 Field Indicator Equipment

4.3.1 To verify the adequacy of magnetic field strength, one or more of the following three methods shall be used. When using a pie-shaped magnetic field indicator or artificial flaw shim and the magnetic lines of flux can be clearly observed in the desired direction, the field shall be considered sufficient to conduct the examination. Only table three (3) is applicable for yokes, item one (1) and two (2) below are not necessary when using the yoke technique.

- Pie-Shaped Magnetic Particle Field Indicator.
- Artificial Flaw Shims.
- Hall Effect Probe Gauss-meter.

4.4 Magnetic Particle Materials and Vehicle

4.4.1 Particles used for the examination shall meet the following requirements.

(a) Particle Types. The particles shall be treated to impart color (fluorescent pigments, nonfluorescent pigments, or both) in order to make them highly visible (contrasting) against the background of the surface being examined.
(b) Wet Particles requirements: the particles shall show indications as listed in Table 2 on the ketose test ring specimen per ASTM E 1444. The suspension vehicle for the wet method shall be a light petroleum distillate or water based and particle concentrations shall be from 0.1 to 0.4 ml in a 100-ml centrifuge tube for fluorescent particles, and 1.2 to 2.4 ml for visible.
(c) Temperature Limitations; Examination surface shall not exceed125°F for wet particles and 350°F for dry particles as measured with a suitable device.

4.5 Lighting

Visible Light – Visible light shall be used when examining with non-fluorescent particle indications or evaluating fluorescent indications. The intensity of the visible light at the surface of the part undergoing examination shall be maintained at a minimum of 100 ftc (1000 1x).

Ambient Visible Light – Fluorescent magnetic particle examinations shall be performed in a darkened area with a maximum ambient visible light level of 2 ftc (20 1x) measured at the part.

Black Lights – All black lights shall be checked at the intervals specified in Table 1, and after bulb replacement. The minimum acceptable intensity is 1000 $\mu W/cm^2$ at the part surface being examined after the bulb has warmed up for a minimum of five (5) minutes. Black light reflectors and filters shall be checked daily for cleanliness and integrity. Damaged or dirty reflectors or filters shall be replaced or otherwise corrected as appropriate.

4.6 Calibration of Equipment

All the above mentioned items shall be verified and checked per the interval as stated in Table 1.

TABLE 1 Required System / Equipment Verification Intervals

Item	Maximum Time Between Verification	Verification Requirements
Lighting		
Black Light Intensity *	1 Each Day	1000µW/cm²
Ambient Light Intensity *	1 Each Day	2 ft candles
Visible Light Intensity *	1 Each Day	100 ft candles
Particle Concentration (Fluorescent)*	1 Each Day	0.1 to 0.4 ml in 100-ml
Particle Concentration (Visible)*	1 Each Day	1.2 to 2.4 ml in 100-ml
System performance test piece or "Ketos Ring" *	1 Each Day	Refer to Table 2
Equipment Calibration Checks		
Gauss Meter (Teslameter) Zero	Prior to use	Zeroed
AC Yoke	Prior to use	10lbs Lift Test
DC/HWDC Yoke	Prior to use	50lbs Lift Test
Equipment Accuracy Calibration		
Gauss Meter (Teslameter) **	6 Months	Performed by Outside Vendor
Ammeter Accuracy **	6 Months	Performed by Outside Vendor

Timer Control **	6 Months	Performed by Outside Vendor
Quick Break **	6 Months	Performed by Outside Vendor
* Results of Verification Shall be recorded on a "Daily Verification Log" Form-MT3		
** The Maximum time between verifications may be reduced or extended when substantiated by actual technical/reliability data.		

5.0 TECHNIQUE

5.1 Direct Circular Magnetization

5.1.1 When magnetizing by passing current directly through the part (that is, using head-shots), the current shall be from 300 to 800 A/in. of part diameter (12 to 32 A/mm). The diameter of the part shall be taken as the greatest distance between any two points on the outside circumference of the part. Currents will normally be 500 A/in. or higher currents (up to 800 A/in.) being used to inspect low-permeability alloys such as precipitation-hardened steels.

5.2 Central Conductor Circular Magnetization

5.2.1 Circular magnetization may be provided by passing current through a conductor that passes through the inside of the part. Alternating current shall be used to inspect for surface or slight subsurface discontinuities on the inside surface of the part. If only the inside of the part is to be inspected, the diameter shall be the greatest distance between two points, 180 degrees apart on the inside circumference. Otherwise, the diameter is determined as in 6.3.5. The following two paragraphs cover centrally located and offset central conductors:

Centrally Located Conductor - When the axis of the central conductor is located near the central axis of the part, the same current levels as given in 6.3.4 shall apply.

Offset Central Conductor - When the conductor is passing through the inside of the part is placed against an inside wall of the part, the current levels as given in 6.3.5 shall apply. Except that the diameter shall be considered the sum of the diameter of the central conductor and twice the wall thickness. The distance along the part circumference (interior) that is effectively magnetized shall be taken as four times the diameter of the central conductor, as illustrated in Fig. 3. Rotating the part on the conductor, allowing for approximately a 10% magnetic field overlap shall inspect the entire circumference.

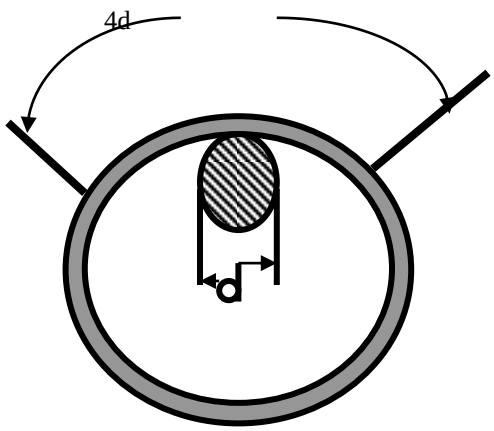


Figure 1 Approximate Effective Region of Examination when Using an Offset Central Conductor

5.3 Longitudinal Magnetization

5.3.1 Longitudinal magnetization is often accomplished by passing current through a coil encircling the part, or section of the part, to be tested (that is, by using a coil shot). This produces a magnetic field parallel to the axis of the coil. For low or intermediate fill factor coils, the effective field extends a distance on either side of the coil center approximately equal to the radius of the coil. For a high-fill factor coils, the effective distance of magnetization is 9 in. (230 mm) on either side of the coil center (see Fig. 2). For parts longer than these effective distances, repositioning the part with the coil, allowing for approximately 10% effective magnetic field overlap shall inspect the entire length.

5.4 Effective Region of Inspection

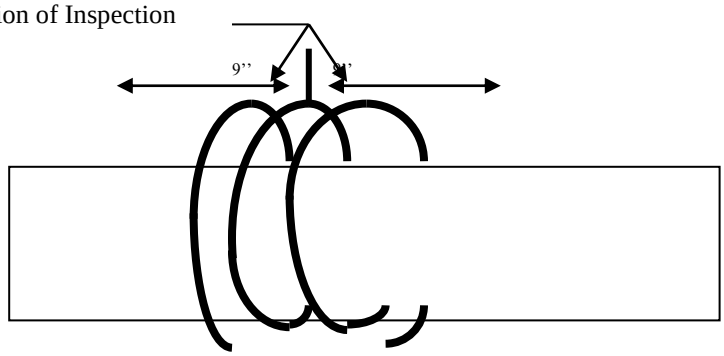


Figure 2 Effective Region of Inspection for a High Fill-Factor

5.4.1 Longitudinal Magnetization with Low-Fill Factor Coils
When the cross-sectional area of the coil is ten or more times the cross-sectional area of the part being inspected, the product of the number of coil turns, N, and the current in amperes through the coil, I, shall be as follows:

For parts positioned to the side of the coil:

$$NI = K/(L/D) \quad (+/- 10\%)$$

where:
N = number of turns in the coil,
I = coil current to be used, amperes (A),
K = 45 000 (empirically derived constant),
L = part, length
D = part diameter, (measured in the same units as the length)
NI = ampere turns.

For parts positioned in the center of the coil:

$$NI=KR/((6L/D)-5) (\square\ 10\%)$$

where:
N = number of turns in the coil,
I = coil current to be used, A,
K = 43 000 A turns per inch if R is measured in inches (1690 A turns per mm)
R = coil radius,
L = part length,
D = part diameter, (measured in the same unit as the length) *NI* = ampere turns.

5.5 Hollow parts:

If the part has hollow portions, replace D with D_{eff} as given in Sec. 4.1.3.4. These formulas hold only if L/D is greater than 2 and less than 15. If L/D is less than 2, pole pieces (pieces of ferromagnetic material with the same diameter as the part being tested) shall be placed on each end of the part to effectively increase the L/D to 2 or greater. If the L/D is greater than 15, the value of 15 shall be substituted for L/D.

Longitudinal Magnetization with High-Fill Factor Coils

When the cross-sectional area of the coil is less than twice the cross-sectional area (including hollow portions) of the part under testing, the product of the number of coil turns, N, and the current in amperes through the coil, I shall be as follows:

$$NI = K/\{(L/D) + 2\} \ (+/- 10\%)$$

Where:
K = 35 000 A turns,
L = length of the part,
D = diameter of the part (measured in the same units as the length).

If the part has hollow portions, replace D with D_{eff} as given in Sec. 4.13.4.These formulas hold only if L/D is greater than 2 and less than 15. If L/D is less than 2, pole pieces (pieces of ferromagnetic material with the same diameter as the part being tested) shall be placed on each end of the part to effectively increase the L/D to 2 or greater. If the L/D is greater than 15, the value of 15 shall be substituted for L/D

5.6 Longitudinal Magnetization for Intermediate-Fill Factor Coils
When the cross-sectional area of the coil is between two and ten times the cross-sectional area of the part being inspected, the product of the number of turns, N, and the current through the coil, I, shall be as follows:

$$NI = (NI)_h(10-\tau)/8 + (NI)_l(\tau-2)/8$$

Where:
$(NI)_l$ = value of NI calculated for low-fill factor coils using 4.1.3.1,
$(NI)_h$= value of NI calculated for high-fill factor coils using 4.1.3.2, and t = ratio of the cross-sectional area of the coil to the cross-sectional area of the part (for example, if the coil is 10 in. in diameter and the part is a rod 5" in diameter, $\tau = (\pi \times 2.5^2) = 4$)

5.7 Calculating the L/D Ratio for a Hollow or Cylindrical Part
When calculating the L/D ratio for a hollow or cylindrical part, D shall be replaced with an effective diameter, D_{eff}, calculated using the following:

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

where:
A_t = total cross-sectional area of the part, and
A_h = cross-sectional area of the hollow portions of the part.

For cylindrical parts, this is equal to the following:

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

where:
OD = outside diameter of the cylinder, and
ID = inside diameter of the cylinder.

6.0 EXAMINATION

6.1 All testings shall be examined in accordance with the requirements of this specification and the normative references unless otherwise specified. In case of conflict between this procedure, customer requirements, or normative references, the more stringent shall apply. Interpretations should be channelled through P&B Testing, Inc NDT Level III.

6.2 The continuous method shall be used for all magnetic particle examinations.

6.3 When any API specification is applicable, the continuous wet fluorescent method shall be used.

6.4 All examinations shall be conducted in a manner that will ensure 100% coverage with sufficient overlap.

The area(s) to be examined shall be determined by any one or more of the following; router, PO, ITP, QP, drawing, engineering specification or contract.

7.0 PRE-EXAMINATION AND TIMING

7.1 When MT is specified, it shall be performed after the completion of operations that could cause a surface or near-surface discontinuity. These operations include, but are not limited to, forging, heat treating, cold forming, welding, grinding, straightening, machining and proof loading.

For certain operations that may increase the parts susceptibility of delayed cracking, MT shall be performed not less than 48 hours after the completion of the operations. These shall be noted in one or more of the following; router, PO, ITP, QP, drawing, engineering specification or contract.

8.0 DE-MAGNETIZATION

8.1 The part shall be demagnetized before examination if prior operations have produced a residual magnetic field that may interfere with the examination. A residual field of three (3) gauss or less is considered demagnetized.

9.0 SURFACE CLEANLINESS AND FINISH

9.1 The surface of the part to be examined, including adjacent areas within at least 1" (25mm) of the examination area, shall be essentially smooth, clean, dry, and free of oil, scale, machining marks, or other contaminants or conditions that might interfere with the efficiency of the inspection.

9.2 All surfaces subject to MT shall have been found acceptable by visual inspection in accordance with the applicable criteria. As rolled, as welded, as cast, as forged and as machined conditions usually produce and acceptable surface for MT.

10.0 COATINGS

10.1 With written customer approval, MT may be conducted over some coatings if the procedure is qualified under similar conditions and the below requirements are met.

10.2 MT examination shall not be performed with coatings in place that could prevent the detection of a surface discontinuity in ferromagnetic substrate. Such coatings normally include paint or chrome plate greater than 0.002 in. (0.05 mm) in thickness, and ferromagnetic coatings, such as electroplated nickel greater than 0.0008 in. (0.02 mm) in thickness. When such coatings are nonconductive, they must be removed where electrical contact is to be made. In high stress applications when detection of fine discontinuity such as grinding cracks and non-metallic stringers is required, the coating shall be removed.

10.3 No coating is allowed when a yoke is being used.

10.4 Thin layers of contrast paint may be applied to improve contrast between background and magnetic particles except when prohibited by the customer.

11.0 EXAMINATION METHOD

11.1 Magnetization

11.2 Types of Magnetization: The types of current used for MT are rectified alternating (full or half wave), direct current and alternating current.

11.3 When current is passed through the part itself, the equipment shall consist of contacting or clamping elements with sufficient surface area and clamping pressure to allow the required current to flow without damaging (burning) the part being examined.

11.4 Caution: Prod shall not be used.

11.5 Direction of Magnetization: Discontinuities are difficult to detect by the magnetic particle method when they make an angle less than 45° to the direction of magnetization. To ensure the detection of discontinuities in any direction, each part must be magnetized in at least two directions. During the second examination, the lines of magnetic flux shall be approximately perpendicular to those used during the first examination. Depending on part geometry, this may consist of circular magnetization in two or more directions, of both circular and longitudinal magnetization, or of longitudinal magnetization in two or more directions.

12.0 MAGNETIC FIELD STRENGTH

12.1 The applied magnetic field applied magnetic field shall have sufficient strength to produce satisfactory indications, but it must not be so strong that it causes the masking of relevant indications by non-relevant accumulations of magnetic particles. Factors that determine the required field strength include the size, shape, and material permeability of the part, technique of magnetization, the method of particle application, and the type of discontinuities sought.

12.2 Adequate field strength shall be demonstrated by the use of a field indicator as defined in 4.2 or applicable weight lift for yoke methods.

12.3 Excessive magnetic saturation may prove to leave an undesirable magnetic field that can be very difficult to demagnetize.

13.0 PARTICLE APPLICATION

13.1 **Wet Continuous Magnetic Particle Method**

13.1.1 The magnetic particles suspension at the required concentration, shall be applied by spraying or flowing the suspension over the area to effectively cover all part surfaces. Perform MT with sufficient magnetization to ensure that discontinuities having axes in any direction will be detected. The magnetizing current shall be applied for duration of at least ½ second for each application, with a minimum of two shots being used and the last one applied immediately after the suspension has been diverted.

13.2 **Dry Magnetic Particle Continuous Method**

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13.2.1 Apply a light, uniform, dust-like coating of dry powder to the examination area with a gentle air stream while magnetizing. Remove excess particles with a gentle air stream and evaluate the magnetic particle indications. Repeat steps approximately ninety (90) degrees from the original directions while ensuring sufficient overlap.

14.0 EVALUATION

14.1 All indications shall be evaluated as relevant or non-relevant. Relevant indications are produced by leakage fields which are the result of discontinuities. Non-relevant indications can occur singly or in patterns as a result of leakage fields created by conditions that require no evaluation such as changes in section (like keyways and drilled holes), inherent material properties (like the edge of a bimetallic weld), magnetic writing, etc. Relevant indications will be compared to applicable acceptance criteria and the results will be recorded.

- An indication whose length is equal to or greater than three times its width shall be considered as linear.
- An indication whose length is equal to or greater than three times its width shall be considered as rounded.
- Only indications with major dimensions greater than 1/16 inch shall be considered relevant.

14.2 Any questionable or doubtful indications shall be re-examined to determine whether or not they are relevant. If the indication is no longer present after re-examination, it shall be considered nonrelevant.

14.3 Minor surface conditioning is an acceptable practice when conducting MT. Inherent indications such as magnetic permeability variations and non-metallic stringers not associated with surface rupture can be examined by liquid penetrant examination in accordance with P&B Testing, Inc PT procedure PB-3000 to prove their relevancy or removed by minor surface conditioning. In these cases, liquid penetrant results shall be recorded and if significant material removal has occurred, a dimensional inspection shall be conducted in accordance with applicable drawings. If indications do not bleed out with liquid penetrant examination, they shall be considered nonrelevant.

15.0 PROCESS FOR WET PARTICLES

A. Surface preparation in accordance with this procedure.
B. Place the magnetizing unit on the examination surface.
C. Energize the unit creating the magnetic field. Maintain good contact with the examination surface.

D. Apply the wet magnetic particles using an aerosol can or mixture, which has been properly agitated. Magnetization shall be applied throughout the duration of this process to ensure particle mobility.
E. The wet particles may be applied just prior to or during the energizing of the magnetizing unit. Care shall be taken to prevent high velocity flow over critical surfaces, and to cease application of the wet suspension prior to removing the magnetizing force. The application and evaluation of fluorescent particles shall be performed while the examination surface is illuminated by ultraviolet light. The current can be terminated immediately after the wet particles have been diverted.
F. Reposition the unit approximately 90 degrees to the initial direction of magnetization and repeat steps 2 through 5.
G. Mark all indications exceeding the relevant acceptance standards.

16.0 REFERENCE ACCEPTANCE CRITERIA

The below is only for reference as applicable as it would be nearly impossible to list all of the codes applicable to every part inspected by P&B Testing, Inc. True acceptance criteria shall be determined by any one or more of the following; router, PO, ITP, QP, drawing, engineering specification or contract. When adherence to a specific code or standard is required, verification of the applicable revision level is mandatory. When the Level II is not certain which acceptance criteria to apply to a specific part, he/she shall consult their Quality Manager for clarification.

16.1 Reference Criteria for Materials

For API 6A/API 17D, PSL 2, 3, and 4 materials:

- No relevant linear indications.
- No relevant rounded indication with a major dimension equal to or greater than 3/16".
- No more than 10 relevant indications in any continuous 6-square inch area.
- Four (4) or more relevant (linear or rounded) indications in a line separated by less than 1/16" (edge to edge) are unacceptable.
- No relevant indications in pressure contact sealing surfaces.

16.2 Criteria for Welds

16.2.1 Pressure containing welds per ASME X III code

All of the following shall be considered unacceptable:

- Relevant linear indications 1/16 inch or greater.
- Relevant round indications greater than 3/16 inch diameter (edge-to-edge).
- Four or more relevant rounded indications in a line separated by 1/16 inch (1.6 mm) or less (edge-to-edge).
- Sealing surface shall be free of all relevant indications.

16.2.2 Structural welds per AWS D1.1 code

Evaluations shall be based on the AWS D1.1 requirements for visual inspection, and the welds shall be acceptable if the criteria of ASW D1.1 Table 6.1 (or corresponding part in the latest edition) are satisfied, which include:

- Crack Prohibition
- Weld/Base-metal Fusion
- Crater Cross Section
- Weld Profiles
- Time of Inspection

- Underrun
- Undercut
- Porosity

16.2.3 Welds produced per API 17 D, API 6A

For welds produced under the requirements of API 17D, API 6A/ISO10423 - PSL 2, 3 and 4 (Overlays only) shall meet the requirements found in acceptance criteria for material. For item B above, the following shall be adhered to:

- No rounded indications greater than 1/8" for welds whose depth is 5/8" or less.
- No rounded indications greater than 3/16" for welds whose depth are greater than 5/8".

17.0 RECORDING OF INDICATIONS

17.1 The location of all relevant and unacceptable indications shall be marked on the part, and permanent records of the location, direction, and frequency of indications shall be made by one or more of the following methods:

A. Written Description: By recording the location, length, direction, and number of indications in sketch or tabular form.

B. Any indication not meeting the acceptance criteria of, or deviating from referencing specification or this specification shall be considered non-conforming and unacceptable.

18.0 NON-CONFORMANCE

18.1 In the event an unacceptable indication is observed and it's obvious it cannot be removed by minor surface conditioning, an NCR shall be generated and forwarded to either or all as documented in P&B Testing, Inc. facility procedures; cognizant engineer, customer, quality manager or whomever else has been designated for disposition of non-conformances of the part in question.

18.2 Nonconforming parts shall be identified and segregated until disposition has been established by the appropriate personnel.

18.3 Non-conformance reports shall contain as much information as practical to assist with the best disposition (e.g. size, shape, orientation, quantity, length, location, etc.). Furthermore, the disposition NCR shall have sufficient instructions regarding repairs (e.g. WPS #, method of indication removal, etc.).

19.0 DEMAGNETIZATION

19.1 Parts shall be carefully demagnetized between successive magnetizing operations whenever the residual magnetization would interfere with the direction and strength of the magnetic field in the next operation. After inspection, moving the part through a demagnetizing AC coil or equivalent demagnetizing current method shall demagnetize the parts The amount of magnetism remaining in a part after demagnetization shall not exceed 3 Gauss (240 $A \cdot m^{-1}$), as determined by a field indicator or a Hall-effect probe gauss-meter.

19.2 When using ac demagnetization, the part shall be subjected to a field with a peak value greater than, and in nearly the same direction as, the field used during examination. This ac field is then decreased gradually to zero. When using an ac demagnetizing coil, hold the part approximately 1 ft (30 cm) in front of the coil and then move it slowly and steadily through the coil and at least 3 ft (100 cm) beyond the end of the coil. Repeat

this process as necessary. Rotate and tumble parts of complex configuration while passing through the field of the coil.

19.3 When using dc magnetization, the initial field shall be higher than, and in nearly the same direction as, the field reached during examination. The field shall then be reversed, decreased in magnitude, and the process repeated (cycled) until an acceptably low value of residual field is reached.

20.0 POST TEST CLEANING

20.1 After completion of the examination, interpretation, reporting and demagnetization, the parts shall be thoroughly cleaned. Parts shall be protected from any possible corrosion or damage during the cleaning process and shall be treated to prevent the occurrence of corrosion after final inspection.

21.0 QUALITY CONTROL & SYSTEM PERFORMANCE

21.1 The overall performance of the magnetic particle examination system, including the equipment, materials, and the lighting environment being used, shall be verified initially and at regular intervals thereafter using Form-MT1 in the Appendix. The required verification intervals are stated in Table 1. Records of the verification results shall be maintained and retained for the time period specified in the contract. Frequency of calibration used in the verification shall comply with the requirements of Table 1, Calibrated using equipment traceable to NIST or equivalent standard, at least once every (6) six months.

21.2 When using of test parts with discontinuities, a reliable method for inspection system verification is to use the Ketos Ring, and the required indications are stated in Table 2. The required verification intervals are stated in Table 1. If correct magnetic particle indications can be produced and identified in the Ketos Ring, the overall system and inspection procedure is verified. Demagnetize, clean and check under black light, to ensure that residual indications do not remain.

TABLE 2 Required Indications when Using the Ring Specimen

Particles Used	Central Conductor FWDC Amperage	Minimum Number of Holes Indicated
Fluorescent, Visible Wet	1400	3
	2500	5
	3400	6
Reference Ketos ring per ASTM E 1444		

22.0 SUSPENSION VEHICLE TESTS

Note: Not required for aerosol cans solution.

Particle concentration and contamination shall be determined upon start up, at regular intervals thereafter, and whenever the bath is changed or adjusted. The required testing intervals are stated in Table 1.

A. *Determination of Wet Particle Concentration*: Agitate the particle suspension a minimum of 30 min. to ensure uniform distribution of particles throughout the bath.

Place a 100-mL sample of the agitated suspension in a pear-shaped centrifuge tube. Demagnetize the sample and allow the tube to stand undisturbed for at least 60 min. for Oil Based Carriers and 30 min. for Water Based Carriers. Read the volume of settled particles. If the concentration is out of the tolerance stated in the written procedure, add the particles or suspension vehicle, as required, and predetermine the particle concentration. If the settled particles appear to be loose agglomerates rather than a solid layer, take a second sample. If the second sample also appears agglomerated, replace the entire suspension.

B. *Determination of Wet Particle Contamination*: Perform the tests specified in the Paragraph above (Sec.1). In addition, for fluorescent baths, examine the liquid above the precipitate with black light. The liquid shall be comparable to the fluorescence of the original solution. Examine the graduated portion of the tube, under both black light (for fluorescent baths only) and visible light fluorescent, for striations or bands, different in color or appearance. Bands or striations may indicate contamination. If the total volume of the contaminants, including bands or striations, exceeds 30% of the volume of magnetic particles, or if the liquid is noticeably fluorescent, the bath must be replaced.

23.0 MARKING OF INSPECTED PARTS

23.1 Parts that have been accepted using magnetic particle examination shall be marked. The marking shall be applied in such a manner and location as to be harmless to the part. The identification shall not be obliterated or smeared by subsequent handling and, when practicable, placed in a location that will be visible after assembly. When subsequent processing would remove the identification, the applicable marking shall be affixed to the record accompanying the finished parts or assembly. The letter "M" with a circle around it will be employed to indicate a 100% acceptable inspection.

23.2 Records of calibration for the equipment, system test, material, technique, and procedure checks shall be maintained and retained in the Quality Assurance files for traceability purpose during the time period specified in the contract.

24.0 EYE GLASSES

When using fluorescent materials, inspectors shall not wear eyeglasses that are photo chromic or that have permanently darkened lenses. Inspectors shall wear prescription eye glasses when noted on their eye exam certificate.

25.0 SAFETY

25.1 Always use proper eye protection and clothing, safe handling practices of magnetic particles/chemicals according to the supplied Material Safety Data Sheet (MSDS), proper operating of equipment shall be always kept in mind.

26.0 DARK EYE ADAPTATION

26.1 Personnel must wait at least 1 min. after entering a darkened area for their eyes to adjust to the low-level lighting before performing fluorescent magnetic particle examination.

27.0 REPAIRS

27.1 Unacceptable discontinuity shall be removed prior to the repair. Whenever an indication is removed and subsequent repair by welding is required, the excavated area shall be re-examined to assure complete removal of the indication prior to welding.

28.0 DOCUMENTATION

28.1 The results of all magnetic particle inspection shall be recorded. All recorded results shall be identified, filed, and made available for review by the customer upon request. The following shall be recorded and maintained, in a traceable manner in Quality Assurance files:

- Procedure Number and Revision Level
- Equipment and Calibration Date of Equipment
- Magnetic Particle Report Number
- Materials Type
- Current Level/Type of Field Indication (Yoke) Used
- Particle Type and Color
- Technique Used
- Job Number
- Part Number
- Serial Number
- Date Performed
- Evaluation and Disposition
- Technician's NDE Level Certification, Signature and Date

Form-MT1: Daily Inspection Log (System Performance)

DATE:	BATH STRENGTH .1 TO .5 (PER 100 ML)	BATH CONTAMINATION <30% (PER E1444)		BLACK LIGHT INTENSITY >1000 Uw/CM² (READINGX10)	WHITE LIGHT READING <2fc		KETOS RING NO. HOLES OBSERVED APPLIED AMPS						TECH	NOTES
							1400 AMPS 5 HOLES		2300 AMPS 5 HOLES		3400 AMPS 6 HOLES			
RECORD	RECORD	OK	OUT	RECORD	OK	OUT	OK	OUT	OK	OUT	OK	OUT		