The Engineering Society
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INTERNATIONAL

400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE STANDARD

AS7114/2

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Superseding AS7100/1A

Submitted for recognition as an American National Standard

NADCAP
REQUIREMENTS FOR NONDESTRUCTIVE TESTING
MAGNETIC PARTICLE SURVEY

1. **SCOPE:**

This Aerospace Standard is to be used as a supplement to SAE AS7114. In addition to the requirements contained in AS7114, the requirements contained herein shall apply to suppliers seeking NADCAP accreditation for Magnetic Particle Inspection.

When customer requirements differ from those specified herein, the customer requirements shall take precedence.

2. **REFERENCES:**

2.1 SAE Publications

Available from Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15086-0001.

AS7003	National Aerospace and Defense Contractors Accreditation Program (NADCAP) - Program Operation
AS7114	National Aerospace and Defense Contractors Accreditation Program (NADCAP) - Nondestructive Testing
AMS 2641	Vehicle, Magnetic Particle Inspection, Petroleum Base

2.2 U.S. Government Publications

Available from DODSSP Subscription Service Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-410	Nondestructive Testing Personnel Qualification and Certification
MIL-STD-1949	Inspection, Magnetic Particle
DOD-F-87935	Fluid, Magnetic Particle Inspection, Suspension Medium (Metric)

2.3 ASTM Publications

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM E 1444	Standard Practice for Magnetic Particle Examination

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3. **MATERIALS AND EQUIPMENT:**

3.1 All magnetic particles used shall be in accordance with MIL-STD-1949/ASTM E 1444.

3.1.1 Material certification required.

3.2 Suspension vehicles shall meet requirements of MIL-STD-1949/ASTM E 1444.

3.2.1 Material certification required, except for water based.

3.3 All equipment shall include a control to vary the current from 10% to 100% of full rated output of last calibration.

4. **PROCEDURES:**

4.1 There shall be a statement in the procedure or quality manual requiring that as a minimum customer requirements shall be met.

4.2 Magnetic particle inspection shall be performed in accordance with a written procedure. The written procedure may be general in nature if it applies to all the parts being tested and meets the requirements specified herein.

4.2.1 The written procedure, general or specific, shall contain the following information as a minimum:

a. Procedure I.D. number, applicable program (if program specific), and the date the procedure was approved.
b. Identification part number, material and alloy type, shape and dimensions significant to the part to be examined.
c. Equipment to be used for magnetization, including manufacturer and model number.
d. Type of current used (e.g., single phase, half wave rectified, three phase, single phase AC, etc.).
e. Type and direction of magnetization to be used, the order in which they are applied, and any demagnetization between shots.
f. Pulse duration, type (AC, DC), and quantity (pulses/shot).
g. Magnitude of current, direction of all magnetic fields, the magnetic field strengths and the types of magnetic field strength indicators, ampere turns, etc.
h. Sketches or a chart indicating coverage and/or orientation of the part with respect to current conductors and/or contact points.
i. Details of demagnetization procedure including use of magnetic field indicator.
j. Area of parts to be examined and acceptance classes or requirements for evaluating indications.
k. Reporting of results and method of marking parts after inspection.

4.2.1 Continued:

l. Surface preparation required before and after testing.
m. Identification of test parts used for system performance.
n. Sequence of the magnetic particle inspection relative to manufacturing operations.
o. Ferromagnetic particles to be used by manufacturer, color, wet or dry, fluorescent or non-fluorescent, and suspension vehicle.
p. Contrast media or other special materials, when used.
q. A statement to the effect that all personnel are qualified and certified to MIL-STD-410 or the applicable contract requirements.
r. A statement that personnel performing inspections are prohibited from wearing glasses with photochromic lenses.
s. All process control requirements addressed in this standard.
t. Requirement to report to the customer occurrences of arcing.

4.2.2 The procedure, general or specific, shall be approved by the Level III in magnetic particle inspection.

4.3 The procedures/techniques shall provide a means to ensure that the appropriate work instructions/ routing/travelers (including sequence of operations, processing parameters, technique information, unique requirements) are available to inspection personnel on the shop floor.

4.4 When applicable, the procedure shall address inspection of hardware which has coating or plating applied in accordance with customer requirements.

4.4.1 When coatings are nonconductive, the procedure shall require removal where electrical contact is made.

5. **PROCESS CONTROLS:**

5.1 Suspension Concentration/Contamination Checks:

Determination of wet particle (petroleum based) concentration and contamination shall be made at shift change or every eight (8) hours and whenever the bath is changed or adjusted. Results shall be documented.

a. The suspension vehicle shall be agitated a minimum of 30 minutes prior to performing the suspension concentration check.
b. The sample of agitated suspension shall be demagnetized and allowed to settle undisturbed for at least 60 minutes for petroleum based suspension or at least 30 minutes for conditioned water suspension.
c. The volume of settled magnetic particles shall conform to the following ranges as applicable:

Fluorescent particles - 0.1 - 0.4 mL per 100 mL sample.
Non-fluorescent particles - 1.2 - 2.4 mL per 100 mL sample

5.1 Continued:

d. The fluorescent sample shall be examined with a black light for background fluorescence of the suspension liquid above the particle precipitate.
e. The brilliance of fluorescent suspensions shall be checked by comparison with a fresh sample in accordance with the applicable customer's frequency requirements.
f. If the sample shows reduced fluorescence and/or loose agglomeration rather than a solid layer of particles, the suspension shall be drained, the machine cleaned and refilled with fresh suspension.
g. The suspension shall be tested for contamination at the applicable customer's frequency requirements.
h. The maximum acceptable volume of contaminate shall not exceed 30% of the volume of magnetic particles.
i. If the suspension shows background fluorescence and/or bands or striations of contamination exceeding 30% of the volume of magnetic particles, the suspension shall be drained, the machine cleaned and refilled with fresh suspension.
j. Records of the checks shall be on file and provide acceptable results.
k. The facility shall be able to properly demonstrate the required suspension concentration/ contamination checks.
l. A sample of new solution shall be saved each time a new batch is made up.

5.2 Water Break Test (Water Based Vehicles):

a. If applicable, the water break test of water based vehicles shall be performed.
b. The frequency of the check shall be in accordance with customer requirements.
c. The test procedure used shall be in accordance with MIL-STD-1949.
d. The acceptance criteria utilized shall meet customer requirements.
e. Records of this test shall be on file and shall provide acceptable results.
f. The facility shall be able to demonstrate the water break test.

5.3 Viscosity Check:

a. When required by customer, the viscosity of in-use nonaqueous inspection suspensions shall be tested.
b. The frequency of the check shall be in accordance with customer requirements.
c. The test procedure used shall be in accordance with ASTM D445, or per customer requirements.
d. The maximum acceptance limit shall be 5 centistokes, or in accordance with customer requirements.
e. Records of this test shall be on file and shall provide acceptable results.
f. The facility shall be able to demonstrate the viscosity check or provide evidence that a qualified outside laboratory has performed the test.

5.4 Black Light Measurements:

a. Black light intensity shall be measured daily using a calibrated meter intended for such purpose.
b. Minimum intensity is 1000 μw/cm^2 at a distance of 15 inches.
c. Records of this test shall be on file and they shall indicate acceptable results.
d. Records of black light meter calibration shall be available for review. Calibration frequency shall be semi-annual or in accordance with customer requirements.
e. The black light meter shall have a current and proper calibration sticker affixed.

5.5 White Light Measurements:

a. The type and model of white light meter(s) shall be in accordance with customer requirements.
b. Calibration of the meter shall be performed at least semi-annually unless a stricter customer requirement is applicable.
c. The tolerance for calibration shall be documented and shall be in accordance with customer requirements.
d. The white light meter shall have a current calibration sticker.
e. There shall be a means documented to ensure that ambient white light is controlled a maximum 2 ft-candles, unless a stricter customer requirement is applicable.
f. The check for ambient white light shall be performed weekly, unless a stricter customer requirement is applicable.
g. Records of this check indicating acceptable results shall be maintained on file.
h. The facility shall be able to demonstrate this check.
i. A white light shall be available in the undarkened inspection area for visual verification.
j. A minimum of 100 foot-candles shall be available at the part surface for visual verification of penetrant indications
k. There shall be documentation indicating that available light at the part surface is checked weekly.
l. The facility shall be able to demonstrate this check.

5.6 Test Standards Physical Requirements:

a. The Ketos ring shall be serialized for traceability.
b. The Ketos ring shall be certified that it meets the requirements of ASTM E 1444 or MIL-STD-1949.
c. The Ketos ring should be free of damage or corrosion which would affect its use.
d. Other devices used shall meet customer requirements.

5.7 Adequate magnetic field strength shall be determined by one or a combination of three methods:

a. By testing parts having known or artificial defects of the type, size, and location specified in the acceptance requirements.
b. By using a Hall-effect probe gauss meter capable of measuring the peak values of the tagential field.
c. By use of the formulas given in the applicable specification.

5.7.1 Referee method for determining actual applied field strength will be the Hall-effect probe and the Hall-effect probe shall be calibrated.

5.8 Calibrated field indicators, with an accuracy of ±.5 gauss, shall be used to verify demagnetization.

5.9 Ammeter Accuracy - The ammeter shall be calibrated at intervals not to exceed 6 months unless specified otherwise by customer requirements. Calibration shall be traceable to NIST with results documented.

5.10 If an ammeter shunt combination is used to calibrate the magnetic particle machine's ammeter, the ammeter shunt combination shall be calibrated at the applicable customer's interval requirements. The calibration shall be traceable to NIST and records of the calibration shall be on file.

5.11 An internal shorting test shall be performed at the applicable customer's interval requirements. Results shall be documented.

5.12 The maximum certified output of the machine (head and coil) shall be checked at the applicable customer's interval requirements.

5.13 Current Pulse Duration - The pulse duration shall be a minimum of 0.5 second, unless otherwise specified by the customer. The actual duration shall be specified. The pulse timer shall be checked to within ± 0.1 second and shall be measured at intervals not to exceed 6 months.

5.13.1 The timing device that is used to measure the pulse timer shall be calibrated at the applicable customer's interval requirements. The calibration shall be traceable to NIST.

5.14 Quick Break - The quick break feature shall be tested at 6 months maximum intervals and results documented. (Longitudinal Magnetization)

6. **PROCESSING AREA:**

6.1 The inspection shall be performed following all processes that could adversely affect the part (heat treat, forming, machining, welding, etc.).

6.2 All parts shall be cleaned prior to inspection as applicable to remove paint, scale, oil, dirt and other foreign materials that may interfere with the inspection process.

6.3 Parts shall be masked if required.

6.4 When required, small openings leading to internal cavities shall be properly plugged.

6.5 Technique cards (written procedures) for all parts to be inspected shall be available to inspectors.

6.6 Yoke equipment shall be used only when applicable and in accordance with approved written procedures.

6.7 Clamps, leaches and other similar devices, when used according to approved written procedures, shall be equipped with copper braid to prevent arcing of part surfaces.

6.8 Aids such as magnifiers, mirrors, borescopes and high intensity lights shall be available for evaluating indications in interior areas of parts not readily accessible with standard lighting equipment.

6.9 Magnetization Process - Circular:

6.9.1 A central conductor shall be used in all cases where inspection of inside surfaces is required.

6.9.2 When current is passed through the part, care shall be exercised to prevent burning at the contact areas.

6.9.3 If arcing occurs, the procedure shall address reporting of the event.

6.9.4 If flexible cables are used to induce circular magnetic fields, a specific written procedure shall be available and this procedure shall have been approved by authorized customer personnel.

6.10 Demagnetization:

6.10.1 Coil and/or box type demag units shall have AC or DC reversing step down capabilities.

6.11 If required, all parts shall be cleaned after magnetic particle inspection. The method of cleaning shall be in accordance with customer requirements.

6.12 If required, after inspection and appropriate cleaning, all parts shall be coated with preservative oil (or anti-seize compound as required) to prevent rusting.

7. **EQUIPMENT AND MATERIALS PERFORMANCE:**

7.1 AC, DC, and Permanent Magnetic Yokes, shall be identified as applicable.

7.1.1 AC yokes shall lift a minimum of 10 lbs with yoke spacing of 2 to 4 in.

a. AC yokes shall be tested at a defined frequency that is in accordance with customer requirements.
b. Records of this test shall be on file and they shall indicate acceptable results.

7.2 DC yokes or permanent magnet yokes shall lift 30 lbs with yoke spacing of 2 to 4 in, or 50 lbs with spacing of 4 to 6 in.

a. DC yokes or permanent magnet yokes shall be tested at a frequency that is in accordance with customer requirements.
b. Records of this test shall be on file and they shall indicate acceptable results.

7.3 The magnetic particle system effectiveness shall be checked by testing the Ketos Ring (or known defect standard) showing the required holes per amperage setting for the particular type of particles being used. The number of holes per amperage setting for the particular type of particles being used shall be in accordance with customer requirements.

a. Interval shall be defined and in accordance with customer requirements
b. Records of this test shall be on file and they shall indicate acceptance results.

7.3.1 If another known defect standard is used to verify the system effectiveness on a daily basis, the method and specified results shall be documented. Records of this test shall be on file and they shall indicate acceptance results.

7.4 A sample of new solution shall be saved each time a new batch is made up.

8. **COMPLIANCE:**

Compliance audits of representative inspections from current production shall be conducted to determine compliance with these requirements. Parts should be selected to represent a variety of customer requirements and different types of processing equipment if more than one magnetic particle line is in use at this facility. Purchase order specifications shall be investigated to identify any unique acceptance, process control, or procedure requirements applicable to these parts. The facility's ability to perform these inspections in accordance with customer requirements shall be verified.

8.1 The following forms for parts being tested shall be provided: (Copies for one part only)

a. Copy of completed traveler or work order
b. Copy of completed technique card or procedure
c. Copy of completed NDT Report
d. Copy of customer specification cover page.
e. Copy of acceptance criteria or drawing data.