SAE Aerospace
An SAE International Group

AEROSPACE STANDARD

SAE AS4787

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Eddy Current Inspection of Circular Holes in Nonferrous Metallic Aircraft Engine Hardware

RATIONALE

AS4787 has been reaffirmed to comply with the SAE five-year review policy.

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1. SCOPE:

1.1 Purpose:
This SAE Aerospace Standard (AS) establishes minimum requirements for eddy current inspection of circular holes in nonferrous, metallic, aircraft engine hardware with fasteners removed. The inspection is intended to be performed at maintenance and overhaul facilities on engine run hardware.

1.2 Application:

This standard has been typically used to inspect for service-induced surface and near surface cracks, but usage is not limited to such applications.

1.3 Definitions:

1.3.1 PURCHASER: The organization that issued the procurement document invoking this specification.

1.3.2 SUPPLIER: Source, other than the purchaser, who provides inspection services.

1.3.3 INSPECTION PROCEDURE: Document written by the purchaser detailing inspection requirements.

1.3.4 QUALITY ASSURANCE PLAN: Document written by the supplier outlining specific requirements unique to his/her facility in accordance with inspection procedure.

2. APPLICABLE DOCUMENTS:
The following publications form a part of this specification to the extent specified herein. The applicable issue of referenced publications shall be the issue in effect on the date of the purchase order.

2.1 U.S. Government Publications:

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

MIL-I-23594	Insulation Tape, Electrical, High Temperature, Polytetrafluoroethylene, Pressure Sensitive
MIL-STD-410	Nondestructive Testing Personnel Qualification and Certification (Eddy Current, Liquid Penetrant, Magnetic Particle, Radiographic, and Ultrasonic)
MIL-STD-45662	Calibration System Requirements

2.2 ASNT Publications:

Available from ASNT, 1711 Arlington Lane, P.O. Box 28518, Columbus, OH 43228.

SNT-TC-1A Recommended Practice, Personnel Qualification and Certification in Nondestructive Testing

2.3 ATA Publications:

Available from Air Transport Association of America, 1301 Pennsylvania Avenue, N.W., Suite 1100, Washington, DC 20006.

ATA 105 Guidelines for Training and Qualifying Personnel in Nondestructive Testing Methods

3. TECHNICAL REQUIREMENTS:

3.1 Materials:

The high temperature, high speed environment in which many aircraft engine components operate results in an increased sensitivity to mechanical or chemical damage during maintenance activities. Personnel performing eddy current inspections must be aware of the need to ensure that the materials they use which come in contact with the hardware must be carefully chosen to avoid introducing chemical contamination or causing physical damage. Engine manufacturers can provide information regarding the suitability of specific materials or procedures for use on their hardware.

3.1.1 Tape: MIL-I-23594, Type I, 0.003 to 0.005 in (0.08 to 0.13 mm) thick. Alternate tapes may be used if specified in the appropriate inspection procedure.

3.1.2 Cleaning Materials: Mild abrasive cleaning products may be used, if allowed by the purchaser, for the removal of surface contamination. Such products shall not be aggressive enough to remove the base metal or otherwise alter or damage the part. If allowed, mild, nonmetallic abrasive cleaning pads can be torn in strips or circular nonmetallic brushes may be used to clean the inside diameter of holes. These materials shall be specified in the inspection procedure.

3.1.3 Marking Devices: Approved marking device for numbering part features and identifying the locations of suspect test indications that are acceptable to the purchaser.

3.2 Equipment:

3.2.1 Eddy Current Probes:

3.2.1.1 Select probes based on the minimum diameter of the holes to be inspected. The hole diameter and appropriate probe for any particular inspection shall be as specified in the inspection procedure. Depending on the type of probe, it is recommended that the purchaser consider the hole diameter range for the probe being specified.

3.2.1.2 Absolute (single coil), differential (dual coil), and reflection (driver-pickup) coil configurations, with or without magnetic shielding, shall be used as specified in the inspection procedure.

3.2.1.3 Probes shall be designed to maintain contact with the inspection surface at all times during the inspection. Noncontact probes which operate with a gap between the probe and the inspection surface are not acceptable.

3.2.1.4 Probes with operating frequencies of 500 KHz or higher shall be used, unless otherwise specified by the appropriate inspection procedure.

3.2.1.5 All probes shall be identified with the manufacturer's name, frequency or frequency range, and a unique serial number (reference Figure 1).

3.2.1.6 Eddy current probe sensing coils shall be prevented from directly contacting the surface of the part being inspected. This may be accomplished by covering the coil surface with low-friction tape, by recessing the coil from the surface of the probe, by manufacturing the probe with a suitable wear surface over the coil, or by other means specified in the inspection procedure.

3.2.1.7 Precautions shall be taken to protect the part being inspected from wear or abrasion from contact with any metallic portion of the probe or test equipment.

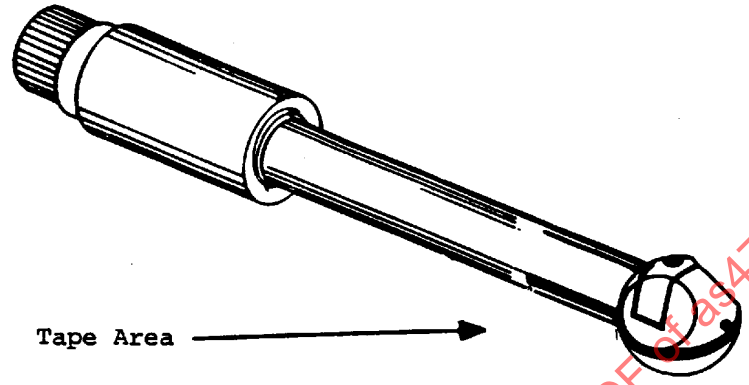
3.2.1.8 Probes shall not give interfering responses from handling pressures, manipulation, or normal operating pressure variations on the sensing coil.

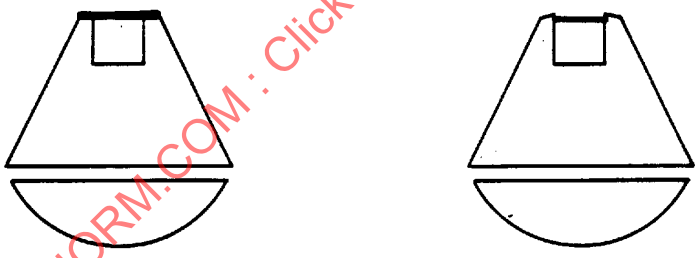
3.2.2 Eddy Current Instruments: Eddy current instruments are available which have a wide range of capabilities. The features required for any particular inspection shall be specified in the inspection procedure.

3.2.2.1 Display: Eddy current instruments can be classified into two basic categories according to the manner in which they display eddy current information. These categories are specified in 3.2.2.1.1 and 3.2.2.1.2. Either type of instrument may be acceptable for a particular inspection unless a specific type is required in the inspection procedure (reference Figures 2 and 3).

3.2.2.1.1 Instruments which use a one-dimensional meter display.

3.2.2.1.2 Instruments which use a two-dimensional impedance plane display. The "impedance plane" refers to an orthogonal display of both the inductive reactance and resistance components of the complex impedance of the eddy current probe. This type of display may be accomplished using a cathode ray tube (CRT), liquid crystal display (LCD), or other suitable method. Some instruments of this type also have the ability to produce a time-based display where one dimension of the eddy current signal is displayed as a function of time.



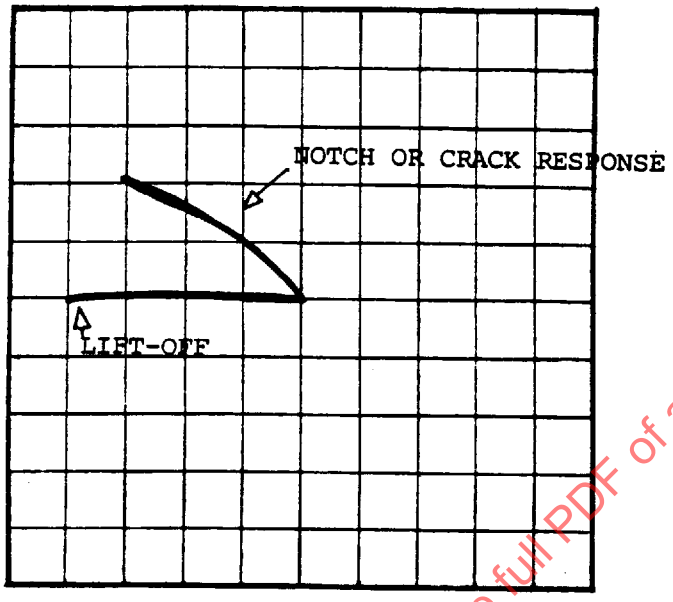


COMMENTS:

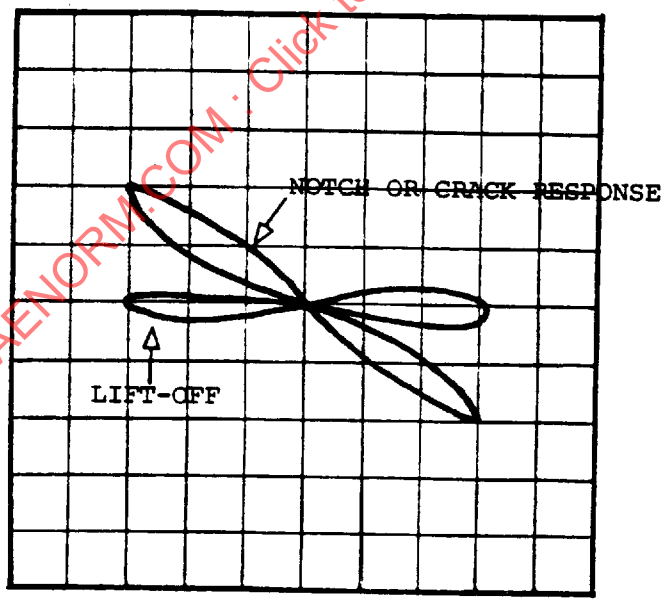
Probes shall be identified as in 3.2.1.5.

The probe total including runout, tape area, coating thickness, and recessed depth shall be detailed in the appropriate inspection procedure.

FIGURE 1 - Typical Eddy Current Probe

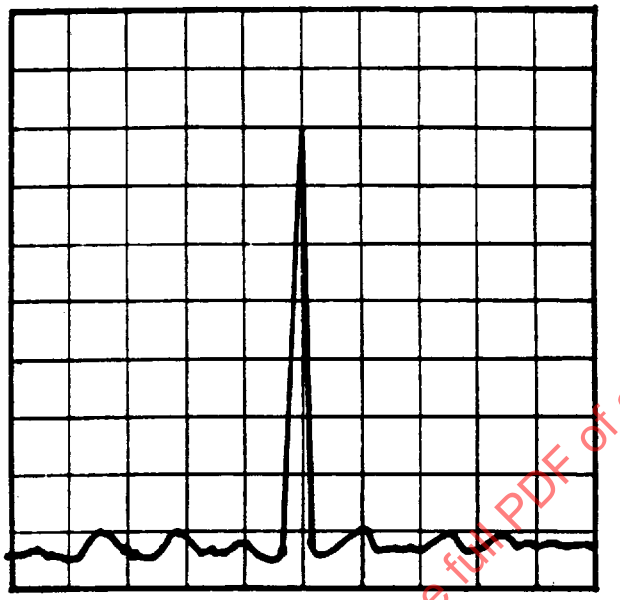


IMPEDANCE PLANE - NON-FILTERED DISPLAY
AND ABSOLUTE DISPLAY

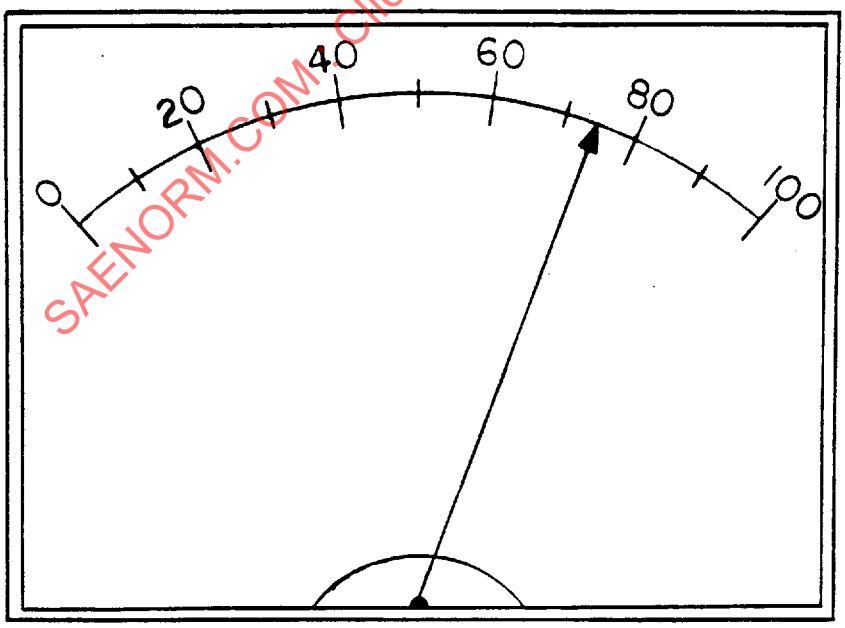


IMPEDANCE PLANE - FILTERED DISPLAY OR
DIFFERENTIAL DISPLAY

FIGURE 2 - Eddy Current Displays



IMPEDANCE PLANE - TIME BASE DISPLAY



METER DISPLAY

FIGURE 3 - Eddy Current and Meter Displays

3.2.2.2 Frequency: Instruments with variable probe excitation frequencies shall be operated at 500 KHz or higher for maximum crack detection sensitivity in materials which are typically used for aircraft engine components, unless otherwise specified in the inspection procedure.

3.2.2.3 Filters: Electronic filters are frequently useful for reducing noise or spurious geometric signals and improving the signal to noise ratio of an inspection. Some inspections may be dependent upon the use of appropriate filters for their success. Such requirements will be specified in the appropriate inspection procedure. Three general types of filters are described as follows:

3.2.2.3.1 High Pass Filters: Eliminates or reduces the amplitude of signals which have a frequency below the frequency setting of the filter.

3.2.2.3.2 Low Pass Filters: Eliminates or reduces the amplitude of signals which have a frequency above the frequency setting of the filter.

3.2.2.3.3 Band Pass Filters: A combination of a high pass and a low pass filter which acts to eliminate or reduce the amplitude of signals which have a frequency above or below the frequency settings of the filter.

3.2.2.4 Analog Signal Output: Inspections which specify external recording or monitoring of the test signals may require the use of an instrument which has provisions for the output of analog voltages which are proportional to the eddy current signals displayed on the instrument.

3.2.3 Mechanical Probe Manipulation Devices: Eddy current inspections of holes may be greatly facilitated by the use of a mechanical device to rotate the probe and translate it axially through the hole. Such devices can reduce the time required to perform an inspection and ensure that complete coverage of the hole inside diameter is obtained. Before using a mechanical manipulator the user shall verify that the rotational and axial motion speeds are appropriate for the inspection procedure.

3.2.4 Data Recording Devices: Inspections which require the recording or documentation of some or all of the test signals produced during the inspection may utilize recording devices. Such devices may be incorporated into the eddy current instrument or in a separate instrument. Such devices may consist of paper chart recorders, magnetic tape recorders, digital data acquisition instruments, or similar device. The recording device used shall be appropriate for the type and quantity of data to be recorded. Specific details regarding recording device requirements shall be contained in the inspection procedure.

3.2.5 Calibration Standards:

3.2.5.1 Calibration standards are required to establish equipment sensitivity prior to performing an inspection. Unless otherwise specified by the purchaser, standards shall be fabricated from the same material as the component to be inspected.

3.2.5.2 Notches or similar artificial defects shall be created in the standards to provide a uniform, repeatable source of an eddy current indication during equipment calibration. The size of artificial defect needed for an inspection shall depend on the requirements of the particular inspection and will be specified in the inspection procedure.

3.2.5.3 Calibration standards shall be identified with the material, part number, hole size, unique serial number, and notch size (reference Figure 4).

3.2.5.4 Calibration standard dimensions, including hole sizes and notch sizes, shall be measured and documented. Tolerances shall be specified in the inspection procedure. Certification and traceability of these measurements may be required by the purchaser.

3.2.5.5 The electrical conductivity of calibration standards shall be similar to that of the part to be inspected. The tolerance in conductivity variation between calibration standards and test parts shall be specified in the inspection procedure. It may be acceptable to use calibration standards with electrical conductivities different from that of the part to be inspected if this is specifically approved by the purchaser and appropriate correction factors are provided.

3.3 Personnel Qualification:

Personnel performing eddy current hole inspections shall be qualified and certified in accordance with MIL STD-410 or SNT-TC-1A. Other procedures (ATA 105, etc) may be used with prior approval of the purchaser.

3.4 Inspection Procedure Requirements:

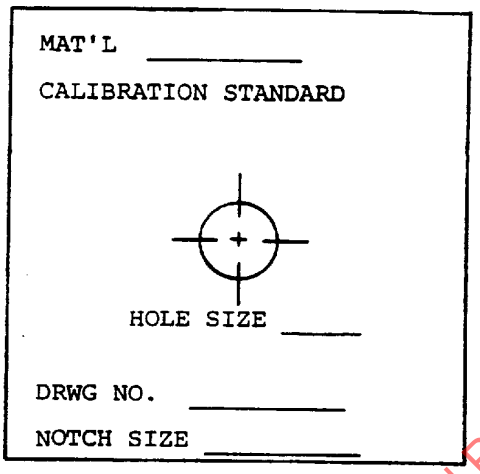
Eddy current hole inspections shall be performed in accordance with a detailed inspection procedure for the component to be tested. Each procedure shall be prepared and verified by the purchaser or his designee. A copy of each applicable procedure shall be readily available to all inspection personnel for reference and use while performing the inspection. Procedures shall comply with the general requirements of this specification and shall provide all of the specific information required to set up the equipment and perform the test. Each procedure shall include not less than the following information:

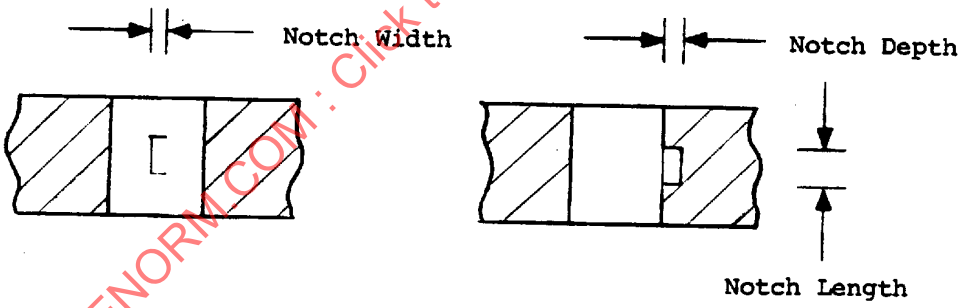
3.4.1 Name and part number to which the procedure applies (include serial number if applicable)

3.4.2 A description and sketch identifying the holes to be inspected, if this is not readily apparent.

3.4.3 Part cleaning and preparation instructions

3.4.4 A description and/or sketch of the manner in which the holes are numbered or referenced from the geometry of the part for identification purposes.





COMMENTS:

Calibration standards shall be identified as in 3.2.5.3.

Standards may contain multiple calibration areas (i.e., holes, surface notches, etc.).

The surface finish, notch dimensions/tolerances and conductivity shall be detailed in the appropriate inspection procedure.

FIGURE 4 - Typical Calibration Standard

3.4.5 Inspector training and qualification requirements

3.4.6 Inspection equipment, probe and fixture requirements, including manufacturer and model number where appropriate

3.4.7 Calibration standard to be used

3.4.8 Inspection equipment setup and operation parameters

3.4.9 Pretest calibration procedure

3.4.10 Part inspection procedure

3.4.11 Post-test calibration procedure and calibration check intervals

3.4.12 Instructions regarding the evaluation of suspect eddy current indications

3.4.13 Acceptance criteria

3.4.14 Instructions regarding inspection records which shall be completed and maintained

3.4.15 Part disposition

3.4.16 It is recommended that there is a method of marking parts that have been inspected and accepted.

3.5 Part Preparation for Inspection:

3.5.1 Verify that the inspection procedure is applicable to the part to be inspected.

3.5.2 Identify the location, number, and size of holes to be inspected.

3.5.3 Visually inspect the holes under a white light [recommended 100 ft-c (10762x)] for evidence of burrs, out of round condition, dirt, rubbing, fretting, foreign material, or other contamination which would interfere with the inspection process. Borescopes or other optical aids may be used to enhance the visual inspection.

3.5.4 Use approved cleaning materials to clean the holes or contact cognizant engineering activity for corrective action if the holes cannot be cleaned.

3.5.5 Number the holes for identification.

3.6 Equipment Calibration - Manual Probe Manipulation:

3.6.1 Connect the probe and instrumentation according to the manufacturer’s directions.

3.6.2 Adjust the initial equipment settings as specified by the inspection procedure or quality assurance plan.