METRIC

DOD-STD-2142(SH)
1 June 1983

MILITARY STANDARD

MAGNETIC SILENCING CHARACTERISTICS, MEASUREMENT OF (METRIC)

FSC 1905

DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND

Washington, DC 20362

Magnetic Silencing Characteristics, Measurement of (Metric).

DOD-STD-2142(SH)

1. This Military Standard is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to Commander, Naval Sea Systems Command, SEA 55Z3, Department of the Navy, Washington, DC 20362, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FOREWORD

1. The testing of materials and equipment in accordance with the requirements of this standard will ensure that magnetic characteristics have been considered and incorporated into the manufacture of materials and design of equipment. This will result in compatibility of materials and operation of equipment in a complex magnetic environment.

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1. SCOPE

1.1 Scope. This standard establishes requirements for methods of measuring and determining the magnetic characteristics (permeability; electrical conductivity; ferrous, stray and eddy current magnetic field strengths) of materials and equipment.

1.1.1 Application. The requirements of this standard shall be applied for the acquisition of materials and equipment to be used on nonmagnetic mine warfare ships and craft, as specified in the individual material and equipment specifications or in the contract.

1.2 Classification. Classification is applicable to the type of magnetic field source and the test method for tests established by this standard.

1.2.1 Field sources. Magnetic field sources shall be classified as follows:

Class 1. Ferrous magnetic field.

Class 2. Eddy current magnetic field.

Class 3. Stray magnetic field.

1.2.2 Test methods. Test methods are designated by a series of numbers in accordance with the following system:

(a) Electrical conductivity tests are designated by "C--".
(b) Eddy current magnetic field tests are designated by "EF--".
(c) Ferrous magnetic field tests are designated by "FF--".
(d) Permeability tests are designated by "P--".
(e) Stray magnetic field tests are designated by "SF--".

Where:

C = electrical conductivity

EF = eddy current magnetic field

FF = ferrous magnetic field

P = permeability

SF = stray magnetic field

and "--" indicates the numerical order of tests from 01 to 99.

1.3 Method of reference. When a specific test method is required for measuring a magnetic characteristic of a material or equipment, the test methods contained herein shall be referenced in the applicable document by specifying this standard and the test number.

2. REFERENCED DOCUMENTS

2.1 Issues of documents. The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein.

SPECIFICATIONS

MILITARY

MIL-I-17214 - Indicator, Permeability; Low-mu (Go-No-Go).

STANDARDS

MILITARY

DOD-STD-2141 - Definitions and Systems of Units, Magnetic Silencing (Metric).

DOD-STD-2143 - Magnetic Silencing Requirements for the Construction of Nonmagnetic Ships and Craft (Metric).

MIL-STD-45662 - Calibration Systems Requirements.

(Copies of specifications, standards, handbooks, drawings, and publications required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this standard to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

A 342 - Permeability of Feebly Magnetic Materials.
B 193 - Resistivity of Electrical Conductor Material.
B 342 - Electrical Conductivity by Use of Eddy Currents.

(Application for copies should be addressed to the American Society for Testing and Materials 1916 Race Street, Philadelphia, PA 19103.)

(Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

3. DEFINITIONS

3.1 General magnetic silencing terms. The meanings of general magnetic silencing terms used in this standard are in accordance with DOD-STD-2141.

3.1.1 Test sample. Test sample is used in this standard as an arbitrary definition of equipment which is to be tested in accordance with test methods EF, FF or SF and material which is to be tested in accordance with test methods EF and FF of this standard.

3.1.2 Test specimen. Test specimen is used as an arbitrary definition of material which is to be tested in accordance with test methods C or P of this standard. The specimen could be a sample of the material of which the item is made or the entire item itself, depending upon its physical size.

4. GENERAL REQUIREMENTS

4.1 Government furnished material and equipment. Material and equipment furnished by the Government to a contractor shall, unless the test data is furnished by the Government, require testing in accordance with the requirements of this standard by the contractor for conformance to individual material and equipment specifications, or to the contract or purchase order, or to the requirements of DOD-STD-2143.

4.2 Material or equipment tested in accordance with procedures not specified in this standard. If the material or equipment has been previously tested for magnetic characteristics by procedures not included in this standard, the test procedures and report shall be submitted for evaluation by the contracting activity as evidence of meeting equivalent portions of this standard.

4.3 Variations in test methods EF, FF or SF. Proposed variations in test methods EF, FF or SF of this standard (that is, rotating the test sample in lieu of the magnetometer mounting ring for magnetic field measurements or rolling the test sample in lieu of the test coil for EF test measurements) shall be presented to the contracting activity for approval in the test plan of 5.1.

4.4. Testing of identical material and equipment. Material and equipment produced by a manufacturer, which are identical to those previously produced by the manufacturer, tested in accordance with this standard and found satisfactory, shall require minimal testing as indicated in the approved test plan, to ascertain conformance with this standard. A copy of the previous test report shall be forwarded with the new test report for comparison and evaluation.

5. DETAILED REQUIREMENTS

5.1 Test plan. When required by the contract or order, a test procedure shall be prepared by the contractor (see appendix). The test procedure shall detail the means of implementation and application of the test procedures to be performed to verify compliance with the applicable magnetic requirements of the individual material or equipment specification, the contract or purchase order, or the requirements of DOD-STD-2143. Approval of the test plan by the contracting activity shall precede the start of formal testing. The test plan shall include but need not be limited to the following:

(a) Nomenclature, serial numbers and general characteristics of test equipment (for example, sensitivity and dynamic range of magnetometers).
(b) Methods and dates of last calibration of measuring equipment for magnetic characteristics and calculations to show expected accuracy of each.
(c) Dummy loads for test samples (for SF test methods) and similar items to be used and their description.

(d) Readout and detector functions to be used in measuring equipment, where applicable.
(e) Nomenclature, description, and modes of operation of the test sample (for SF test methods).
(f) Control settings, monitored points and sequence of operation of the test sample (for SF test methods).
(g) Description and magnetic ambient profile of test site (open space) for EF, FF and SF test methods.
(h) Detailed step-by-step test procedures and test setups, with maximum use of photographs, drawings, and diagrams.
(i) Expected overall accuracy of measurements.
(j) Personnel required, both designated Government representatives and the contractor.
(k) Considerations and regulations regarding the operation of test samples tested (for SF test methods) and measuring equipment in open areas (for example, FCC or FAA regulations).

5.2 Test conditions. Detail test conditions shall be as specified in section 6 for each particular type of test. In addition, the general test conditions of 5.2.1 through 5.2.4 shall apply.

5.2.1 Accessory equipment precaution. Accessory equipment (for example, chart recorders), used in conjunction with equipment measuring magnetic characteristics, shall not affect measurement integrity.

5.2.2 Excess personnel and equipment. The test area shall be kept free of unnecessary equipment and material. Only equipment essential to the test being performed shall be in the test area. Unauthorized personnel shall not be permitted in the test area.

5.2.3 Test coils (EF and FF test methods). Test coils, either a Helmholtz coil or an equivalent coil array acceptable to the contracting activity, shall be capable of producing applied magnetic fields in the three orthogonal directions (triaxial). The magnetic field gradient caused by the coil's field and any magnetic field distortions, from the immediate environment over the volume occupied by the test sample, shall not exceed 0.1 percent of the applied field per meter or 0.0016 amperes per meter (A/m) (flux density is 2 nanotesla (nT)), whichever is greater. The coil shall generate magnetic fields to an accuracy of at least 0.05 percent of the applied field or 0.0002 A/m (flux density is 0.25 nT), whichever is greater.

5.2.4 Power supply characteristics (SF test methods). Power supplies for equipment to be tested (SF test methods) and not supplied as part of the equipment shall have characteristics and tolerances as specified in the equipment's detailed specification.

5.3 Arrangement and operation of equipment to be tested (SF test methods). Detailed test arrangements and conditions of equipment operation for SF test methods shall be as specified in section 6 for each particular type of test. In addition, the general arrangement and conditions of operation in 5.3.1 through 5.3.5 shall apply.

5.3.1 Control adjustment. For all modes of operation, controls on the equipment to be tested shall be operated and adjusted as prescribed in the instruction manual, or as required by the equipment specification, to obtain optimum design performance.

5.3.2 Signal inputs. Actual or simulated inputs required to activate, utilize, or operate all circuits shall be used.

5.3.3 Arrangement and operating conditions. Interconnecting cable assemblies and supporting structures shall simulate actual installation and usage. Shielded leads shall not be used in the test setup, unless they have been specified for use in the intended installation. Cables shall be checked against the installation requirements to verify that no extra shielded wires have been used. Cables and equipment shall be so arranged that there is no shielding interposed between the test sample's cables and the measuring equipment.

5.3.4 Mounting and grounding. Test samples shall be mounted and grounded as when installed aboard ship.

5.3.5 Loads. The equipment under test shall be loaded with the full mechanical and electrical load, or equivalent, for which it is designed. This requirement specifically includes electrical loading of the contacts of mechanisms which are designed to control electrical loads, even though such loads are physically separate from the equipment under test. Operation of voltage regulators and other circuits that function intermittently is required during testing. The loads used shall simulate the resistance, inductance, and capacitance of the actual load. Mechanical devices shall also be operated under load. The device under test shall be actuated by the same means as it will be when installed.

5.4 Measuring equipment. Measuring equipment shall be as specified in section 6 for each particular test method. Unless otherwise specified, all laboratory equipment shall be operated as prescribed by the respective instruction manuals. This standard shall take precedence in the event of conflict with instruction manuals or other such documents issued by industry.

5.4.1 Identification of spurious responses in measuring equipment. Measurement equipment shall be checked for spurious responses. False data caused by such spurious responses shall be identified on data sheets.

5.4.2 Calibration of measuring equipment. Measuring instruments and accessories used in determining compliance with the requirements of this standard shall be calibrated under an approved program in accordance with MIL-STD-45662.

5.5 Test report. A test report, which details the testing procedures, facilities, instrumentation, and data recorded, shall be prepared by the contractor (see appendix). The test report shall be prepared immediately after the performance of the tests. A reproducible copy of the test procedures may be used as a test data log for recording test data taken during performance of the tests. The data shall be entered in the test report from the test data log. Data shall not be transferred from other copies or records, refined, edited, or typed. After the tests are completed, the test report shall be completed by incorporating a test summary, all appendices, and certifications in accordance with 5.5.1 and 5.5.2. The test sample or test specimen shall not be accepted until the final test report is reviewed by the contracting activity.

5.5.1 Classification markings. Security classification markings shall be provided in accordance with the requirements of the contracting activity.

5.5.2 Content.

5.5.2.1 Title page. The title page shall include a complete identification of the equipment or material used as the test sample or test specimen, including, as applicable, part numbers, serial numbers, name of manufacturer, name of prime contractor, Government acquisition agency, contract number and date.

5.5.2.2 Results of tests; summations and analyses. The report shall include a summary, which shall give a brief resume of the test results. The resume shall contain a statement certifying that the equipment used as the test sample or test specimen meets or does not meet the requirements of the applicable equipment or material specification, the contract or purchase order, or DOD-STD-2143, and that the tests were conducted in accordance with accepted test procedures. If the equipment or material fails, the resume shall contain a list of all points where the test sample or test specimen does not meet the requirements of the applicable equipment or material specification, the contract or purchase order, or DOD-STD-2143. Any adjustments, repairs, fuse replacements, failures, or unusual phenomenon encountered during the test shall also be described, or a positive statement, to the effect that no adjustments, fuse blowing, or failures occurred during tests, shall be included. Space shall be provided for the signatures of the test engineer, equipment or material manufacturer, prime contractor and Defense Contract Administration Services Officer (DCASO) to certify the content of the summary.

5.5.2.3 Main body of report. The objective is to have the details of what was tested, how it was tested, what results were obtained and what results should have been obtained, recorded in a manner such that information can be reviewed without searching through the report to correlate data with procedures. The main body of the report shall include, as a minimum, the information specified in section 6 for each particular type of test, and the following information:

(a) Nomenclature of measuring equipment.
(b) Serial numbers of measuring equipment.
(c) Date of last calibration of measuring equipment.
(d) Descriptions of procedures used (including methods of loading and operating and control settings for test sample for SF test methods).
(e) Measured line voltages to test sample for SF test methods.
(f) Photographs or diagrams of the test setup and test specimen or test sample with identification.
(g) Sample calculations showing how equivalent meter reading was calculated.
(h) Description and size of test facilities.
(i) Ambient magnetic profile of test site and ambient levels with each detector function energized (for EF, FF and SF test methods only).

(j) Methods and criteria for monitoring for degradation of performance of test samples for SF test methods.
(k) Explanation of special terms and abbreviations used in the report.
(l) Settings of control functions for test samples during the tests for SF test methods.

5.5.2.4 Appendices. Appendices shall be included as required to incorporate data which are of a form and content not feasible to include in the body of the report. Oscillograms are examples of data which are not feasible to include in the body of the report. Appendices shall also be used to incorporate test reports submitted by other testing activities that perform some of the tests. Each appendix shall be preceded by a title page indicating content (including number of pages) of the appendix and applicable references to the body of the report.

6. MEASUREMENT PROCEDURES

6.1 Measurement procedures. This section contains the measurement procedures to be used in determining compliance with the individual material or equipment specifications, the contract or purchase order, or DOD-STD-2143. Unless otherwise specified in the applicable document, any applicable test method may be used for the testing of a selected magnetic characteristic.

6.2 Index of measurement procedures. Table I is an index of test measurement methods by method number and title.

TABLE I. Index of test measurement methods.

Test method no.	Test method title
C01	Percent IACS electrical conductivity by electrical resistivity measurement
C02	Percent IACS electrical conductivity by eddy current measurement
P01	Relative magnetic permeability with go-no-go permeability indicator
P02	Relative magnetic permeability using a modified Fahy low-mu permeameter
P03	Relative magnetic permeability using a Fahy low-mu permeameter
P04	Relative magnetic permeability by null method
P05	Relative reversible magnetic permeability
FF01	Ferrous magnetic field from a class 1 source measured at a distance in an ambient magnetic environment

TABLE I. Index of test measurement methods. - Continued

Test method no.	Test method title
FF02	Ferrous magnetic field from a class 1 source measured at a distance in a controlled magnetic environment
FF03	Ferrous magnetic field from a class 1 source measured on a horizontal plane in an ambient magnetic environment
FF04	Ferrous magnetic field from a class 1 source measured on a horizontal plane in a controlled magnetic environment
FF05	Ferrous magnetic field from a class 1 source caused by linear motion in a ambient magnetic environment
EF01	Eddy current magnetic field from a class 2 source measured at a distance in a controlled magnetic environment
EF02	Eddy current magnetic field from a class 2 source measured on a horizontal plane in a controlled magnetic environment
EF03	Eddy current magnetic field from a class 2 source caused by oscillatory motion in an ambient magnetic field
SF01	Stray magnetic field from a class 3 source measured at a distance in an ambient magnetic environment
SF02	Stray magnetic field from a class 3 source measured on a horizontal plane in an ambient magnetic environment

Preparing activity:
Navy - SH
(Project 1905-N010)

TEST METHOD C01

PERCENT IACS ELECTRICAL CONDUCTIVITY BY ELECTRICAL RESISTIVITY MEASUREMENT

1. Scope. This method is used for determining the electrical conductivity of electrically conductive material in accordance with the standard test method of ASTM B 193. Percent IACS conductivity is determined by measuring the resistivity of the material in accordance with ASTM B 193 and then converting the resistivity into percent IACS conductivity by using the appropriate conversion factor in ASTM B 193. The conductivity may be calculated on a volume or weight basis. This method provides accuracy of plus or minus 0.30 percent on test specimens having a resistance of 0.00001 ohm.

2. Apparatus. The basic test apparatus shall consist of a Kelvin-type double bridge, a potentiometer, a Wheatstone bridge, or a Hoopes conductivity bridge as appropriate.

3. Test specimen. The test specimen shall be in the form of a wire, strip, rod, bar, or tube, or shape.

4. Procedure. The procedure of the test shall consist of measuring the electrical resistivity of the test specimen and converting the measured results to electrical conductivity.

5. Test report. The test report shall include all of the information described in ASTM B 193 and the calculated value of electrical conductivity.

TEST METHOD C02

PERCENT IACS ELECTRICAL CONDUCTIVITY
BY EDDY CURRENT MEASUREMENT

1. Scope. This method is used for determining the electrical conductivity of nonmagnetic metals and alloys in accordance with the standard test method of ASTM B 342. Percent IACS conductivity is determined by measuring the resistance of a material to the flow of eddy current and converting this resistance to conductivity. This method provides a convenient and rapid means for determining the conductivity of materials, but it is less accurate than test method C01 described herein. The value obtained can be significantly affected by the flatness and smoothness of the surface and the nonuniformities within the material being measured.

2. Apparatus. The basic test apparatus consists of a coil in a detector tip.

3. Test specimen. The test specimen shall have a flat surface. The degree of flatness and smoothness can affect the test results significantly.

4. Procedure. The procedure shall consist of measuring the resistance that test specimen presents to the flow of eddy currents in the test specimen, and then converting this resistance to conductivity.

5. Test report. The test report shall include the following information:

(a) Description of test specimen.
(b) Test temperature.
(c) Thickness of test specimen.
(d) Location of test areas on specimen.
(e) Identification of measuring instruments, including manufacturer's serial numbers.
(f) Warm-up adjustments of measuring instrument.
(g) Electrical conductivity and how it was obtained from the measurements (by calculation or directly; if by calculation, identify calculations).

TEST METHOD P01

RELATIVE MAGNETIC PERMEABILITY WITH GO-NO-GO PERMEABILITY INDICATOR

1. Scope. This method is used for determining whether the relative magnetic permeability of a feebly magnetic material exceeds a specific value (1.2, 1.6, 2.0 or 2.5). This is accomplished by using permeability inserts or standards that have known relative magnetic permeabilities with a permeability indicator. The test is a convenient and rapid method of identifying suspect material with a limited degree of accuracy.

2. Apparatus. Test apparatus shall be a low-mu (go-no-go) permeability indicator in accordance with MIL-I-17214 and associated permeability inserts of 1.2, 1.6, 2.0 and 2.5 relative magnetic permeability (see figure P01-1). The tip of the indicator's magnet shall be free of any adhering particles.

3. Test specimen. The test specimen may be a plate, sheet, bar, rod or irregular-shaped object. The test area of the specimen shall be clean and free from oxide scale.

4. Procedure. Refer to figure P01-1.

4.1 Select a permeability insert and place it into the seat of the permeability indicator.

4.2 While holding the end of the indicator opposite the insert and magnet in one hand, place the projecting end of the indicator's magnet in contact with the test area of the specimen.

4.3 Move the indicator in a direction normal to the contact surface of the test area of the specimen.

4.4. If the indicator's magnet breaks contact with the insert, the test specimen has a higher relative magnetic permeability than that of the insert. If the magnet breaks contact with the test area of the specimen, the test specimen has a lower relative magnetic permeability than that of the magnet.

4.5 Repeat 4.1 through 4.4 with other appropriate permeability inserts so that the relative magnetic permeability of the test specimen can be bracketed between that of two inserts or be established as higher than 2.5 or lower than 1.2.

5. Test report. The test report shall include the following information:

(a) Identification of test specimen.
(b) Kind of material.
(c) Serial number of the permeability indicator.
(d) Relative magnetic permeability of the test specimen with respect to the relative magnetic permeabilities of the inserts used in the test procedure.

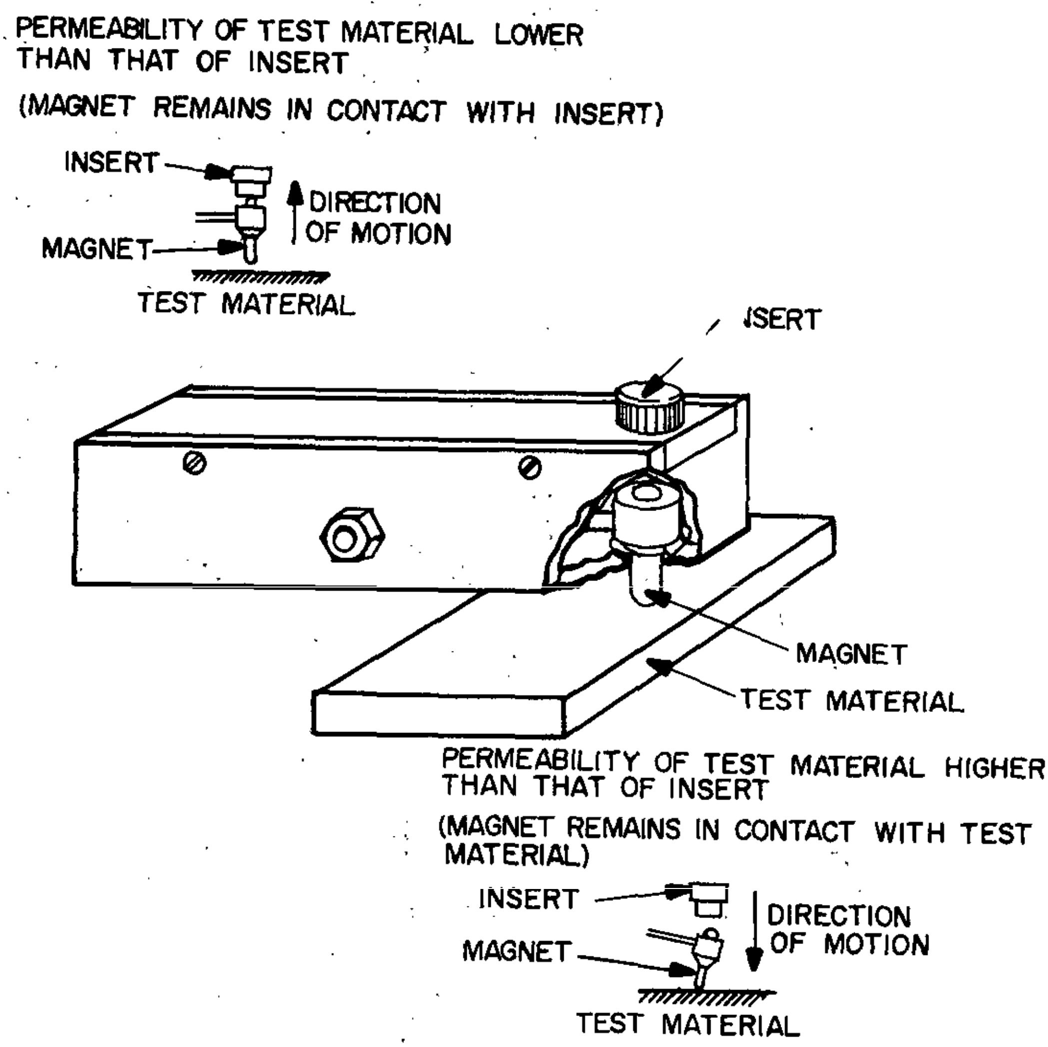


FIGURE P01-1. Use of low-mu (go-no-go) permeability indicator.

TEST METHOD P02

RELATIVE MAGNETIC PERMEABILITY USING A MODIFIED FAHY LOW-MU PERMEAMETER

1. Scope. This method is used for determining the relative magnetic permeability of materials having a permeability not exceeding 4.0 in accordance with standard test method number 1 of ASTM A 342.

2. Apparatus. The basic test apparatus shall consist of a direct current power supply and a modified Fahy low-mu permeameter.

3. Test specimen. The test specimen shall consist of straight bars, rods, wires, or strips of uniform cross section.

4. Procedure. The procedure shall consist of measuring the magnetic flux density in the test specimen for a given magnetizing force, and then calculating the permeability.

5. Test report. The test report shall include the following information:

(a) Description of the test specimen.
(b) Identification of test apparatus used, including manufacturer's and identification numbers, where appropriate.
(c) Calculated value of magnetic permeability and the identification of the utilized formulas.

TEST METHOD P03

RELATIVE MAGNETIC PERMEABILITY USING A
FAHY LOW-MU PERMEAMETER

1. Scope. This method is used for determining the relative magnetic permeability of materials having a permeability not exceeding 4.0 in accordance with standard test method number 2 of ASTM A 342.

2. Apparatus. The basic test apparatus shall consist of a direct current power supply and a Fahy low-mu permeameter.

3. Test specimen. The test specimen shall consist of straight bars, rods, wires, or strips of uniform cross section.

4. Procedure. The procedure shall consist of measuring the magnetic flux density in the test specimen for a given magnetizing force, and then calculating the magnetic permeability.

5. Test report. The test report shall include the following information:

(a) Description of the test specimen.
(b) Identification of test apparatus, including manufacturer's and identification numbers, where appropriate.
(c) Calculated value of magnetic permeability and the identification of the utilized formulas.

TEST METHOD P04

RELATIVE MAGNETIC PERMEABILITY BY NULL METHOD

1. Scope. This method is used for determining the relative permeability of materials having a permeability not exceeding 4.0 in accordance with standard test method number 3 of ASTM A 342. This method utilizes a permeameter with a nulling circuit that can provide accurate permeability measurements to within 2 percent.

2. Apparatus. The basic test apparatus shall consist of a direct current power supply, and a selection of solenoids, coils, and inductors.

3. Test specimen. The test specimen shall consist of straight bars, rods, wires, or strips of uniform cross section.

4. Procedure. The procedure shall consist of measuring the inductance of an inductor due to the presence of the test specimen, and then calculating the permeability.

5. Test report. The test report shall include the following information:

(a) Description of the test specimen.
(b) Identification of test apparatus, including manufacturer's and identification numbers, where appropriate.
(c) Calculated value of magnetic permeability and the identification of the utilized formulas.

TEST METHOD P05

RELATIVE REVERSIBLE MAGNETIC PERMEABILITY

1. Scope. This method is used for determining the relative reversible magnetic permeability of feebly magnetic materials. An alternating current (a.c.) is applied to a sense coil in which the test specimen is placed. A direct current (d.c.) is applied to a reference coil surrounding the sense coil. The voltage drop across the sense coil reflects the coil's inductance. In turn, the inductance is proportional to the permeability of the sense coil's core, which consists of air and the test specimen. Consequently, knowing the geometry of both the sense coil and core, as well as the coil's electrical response, the core's relative reversible permeability at selected frequencies of the a.c. driving the sense coil can be determined by calculation. This method should result in a permeability measurement with a plus or minus 2 percent accuracy.

2. Reversible permeability. Reversible permeability is the limit of the incremental permeability as the change in magnetizing force approaches zero.

3. Apparatus.

3.1 Direct current (d.c.) power supply. A source of steady d.c. power with constant output voltage, V, for the electrical circuit shown in figure P05-1. The constant voltage, V, shall be determined from the following equation:

$$V = \frac{100 \times R_o}{N_o \times \pi \times \ell_o} \cdot \sqrt{D_o^2 + \ell_o^2} \text{ volts}$$

where:

R_o = d.c. resistance of the reference coil in ohms.
N_o = number of turns on the reference coil.
D_o = mean diameter of the reference coil in meters.
ℓ_o = length of the reference coil in meters.
π = 3.143.

3.2 Alternating current power supply. A source of alternating power of approximate sine wave voltage form with a frequency of f_o hertz (Hz) and a root mean square (rms) voltage of V_d volts for the electrical circuit shown in figure P05-1.

3.3 Sense coil. A multilayered, solenoidal inductance coil which contains the test specimen. The sense coil length, ℓ_1, must be very short relative to the length of the test specimen in order to achieve good resolution of permeability versus length. The coil diameter, D_1, should be made as small as possible to maximize the percentage of coil core area occupied by the test specimen. An adequate number of turns, N_1, should be used to ensure a reasonable change in a.c. voltage for the smallest permeability change to be measured.

3.4 Reference coil. A solenoidal inductance coil which provides a d.c. reference magnetic field for conducting the test.

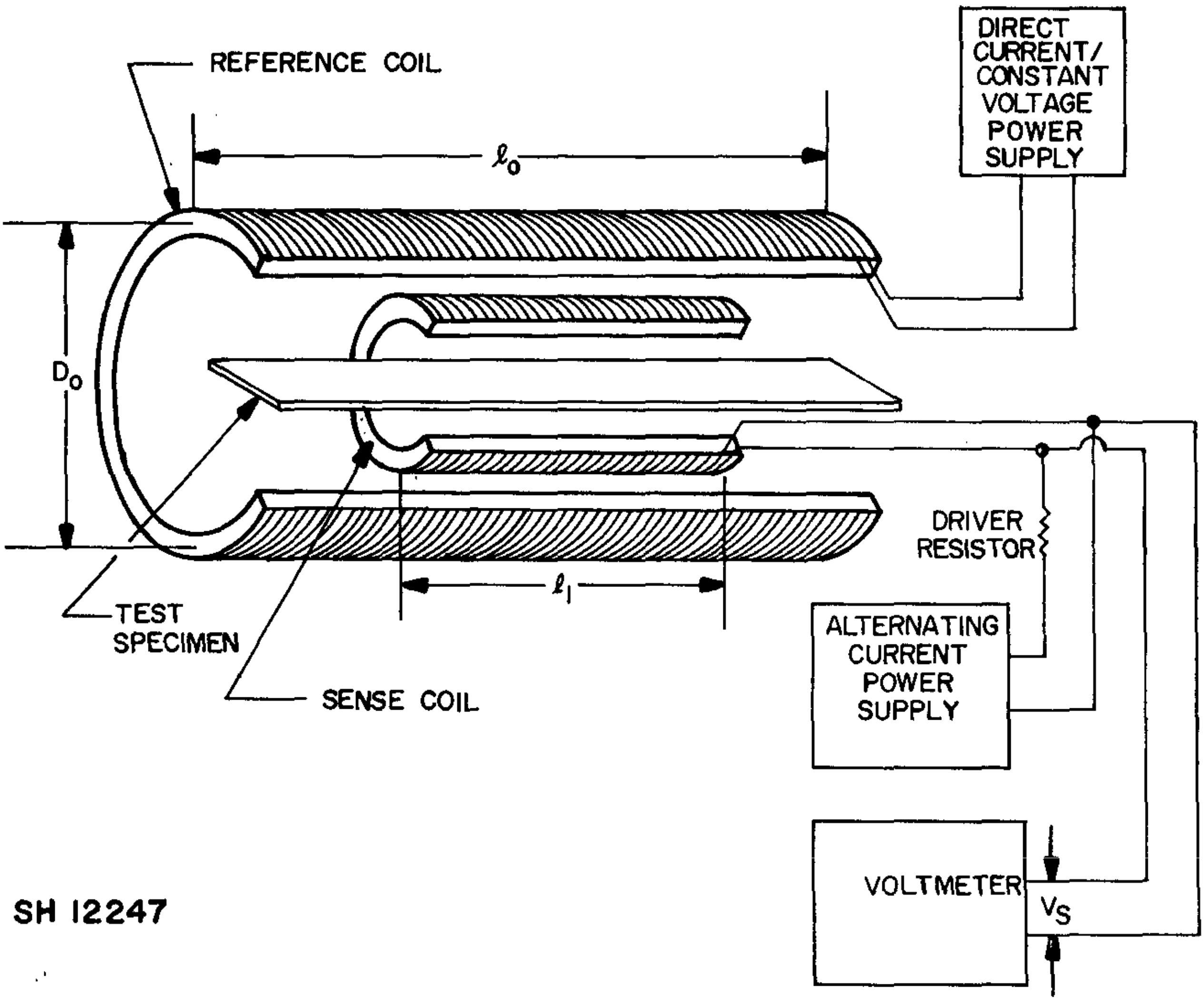


FIGURE P05-1. Typical test setup for measurement of relative reversible magnetic permeability.

3.5 Driver resistor. Resistor, R_d, in series with the sense coil and the d.c. power supply. The resistance shall be 1000 times, or greater, than the impedance of the sense coil. This will minimize current deviations caused by changes in the magnitude of the sense coil's impedance.

3.6 Voltmeter. A voltmeter with range scale as required to measure the a.c. rms voltage drop, V_s, across the sense coil.

4. Test specimen. The test specimen shall consist of a straight bar, rod, wire, or strip of uniform cross section. The length shall be not less than ten times the sense coil's length and not greater than the reference coil's length.

5. Procedure.

5.1 Apply and maintain the constant voltage V from the d.c. power supply across the leads to the reference coil.

5.2 Apply and maintain the a.c. power supply with rms voltage of V_d volts and f_o Hz to the sense coil and series driver resistor.

5.3 Before inserting the test specimen in the sense coil, obtain a reading of V_s from the voltmeter. Calculate the permeability with no test specimen present in the sense coil from the formula in section 6. If the test setup has been properly accomplished, this relative permeability should be that for air (approximately 1.0).

5.4 Insert the test specimen in the sense coil and measure from the voltmeter and record the a.c. voltage drop V_s across the sense coil.

5.5 Adjust the frequency of the a.c. power supply and repeat 5.4.

5.6 Repeat 5.5 as required to measure the permeability over the selected frequency range.

5.7 The voltmeter may be supplemented by voltage recording equipment for future data reduction, or a computer which will continuously output permeability data based upon the current value of V_s and the formula in section 6. A swept frequency spectrum analyzer may be used to measure permeability versus frequency of the a.c. power supply over a continuous range.

6. Calculation.

6.1 Calculate the relative reversible permeability (μ_r) as follows:

$$\mu_r = \frac{1}{2 \times A} \cdot \left[\frac{\ell_1 \sqrt{(V_s^2 \times R_d^2) - R_1^2 \times (V_d - V_s)^2}}{\mu_o \times N_1^2 \times \pi \times f_o \times K \times (V_d - V_s)} - \frac{\pi \times D_1^2 - 4A}{2} \right]$$

where:

N_i = number of turns on the sense coil.
D_i = mean diameter of the sense coil in meters.
ℓ_i = length of the sense coil in meters.
V_s = a.c. voltage drop across the inside solenoid in rms volts.
R_d = resistance of the driver resistor in ohms.
R_i = d.c. resistance of the sense coil in ohms.
V_d = amplitude of the a.c. power supply in rms V.
μ_o = magnetic permeability of free space ($4\pi \times 10^{-7}$ Henry/meter).
f_o = frequency of the sinusoidal a.c. power supply in Hz.
A = cross-sectional area of the test specimen perpendicular to the sense coil axis in square meters.

$$K = \left[1 + 0.45 \left(\frac{D_i}{\ell_i}\right) + 0.64 \left(\frac{t}{D_i}\right) + 0.84 \left(\frac{t}{\ell_i}\right)\right]^{-1}$$

t = radial difference between the outermost and innermost coil layer of the sense coil in meters.
π = 3.143.

5. Test report. The test report shall include the following information:

(a) Identification of the test specimen.
(b) Kind of material.
(c) Identification of test apparatus, including manufacturer's and identification numbers, where appropriate.
(d) Calculated value of permeability with no test specimen in the sense coil.
(e) Calculated value of permeability with test specimen in the sense coil at selected frequencies of the a.c. power supply.

TEST METHOD FF01

FERROUS MAGNETIC FIELD FROM A CLASS 1 SOURCE
MEASURED AT A DISTANCE
IN AN AMBIENT MAGNETIC ENVIRONMENT

1. Scope. A ferrous field (class 1) source is an item on or part of a ship or craft, which uses a material in its construction that exhibits a relative magnetic permeability different than 1.0 (the relative permeability of air). A ferrous field source emanates a ferrous magnetic field which is composed of an induced and permanent magnetic field. The ferrous magnetic field can be compensated for by a degaussing system if the magnitude and direction of the field is known. This test method is used to determine the magnitude of the normal component of the ferrous magnetic field at a number of measurement points that are equidistant from the center of the test sample. This test is accomplished in an ambient (earth's) field environment. Consequently, if the earth's field at the test site varies significantly with time during the performance of the test and is not automatically compensated for, this method will lead to less accurate results than those achievable in a controlled magnetic environment (see test method FF02). However, since a controlled magnetic environment requires a complicated test coil and control system, this method provides a rapid and convenient means for measuring the ferrous magnetic field at a fixed distance from the center of the test sample. Required information from the specifications for the test sample for this test method is the distance from the center of the test sample at which the ferrous magnetic field is to be measured.

2. Center of the test sample. Center of the test sample refers to the geometric center of the sample.

3. Apparatus.

3.1 Magnetometer. A monoaxial fluxgate magnetometer consisting of a sensor unit and an electronic unit with a minimum sensitivity of 0.0002 A/m (flux density is 0.25 nT) and a dynamic range of $\pm$ 90 A/m ($\pm$ 113 μT) shall be used. The electronic unit shall include as a minimum a meter to measure the field magnitude. A chart recorder may be utilized to facilitate data collection.

3.2 Gimbal fixture. A nonferrous gimbal fixture, with a circular ring, shall be used for the mounting of the magnetometer's sensor (see figure FF01-1). The ring shall have a radius equal to the distance from the center of the test sample at which the field is to be measured. The magnetometer's sensor shall be mounted on the ring in a manner that will allow sensing at the specified distance. The ring shall lie on a horizontal plane so that it is centered about the center of the test sample within plus or minus 10 cm and can be rotated in 45 degree increments in the plane of the ring and in the plane perpendicular to the plane of the ring (see figures FF01-1 and FF01-2). Multiple magnetometers may be used to decrease the number of rotations required for a full set of readings.

3.3 Mounting structure. A nonferrous mounting structure shall be used for positioning the test sample within the gimbal fixture.

4. Test sample. Volume of the test sample is limited by the size of the gimbal fixture and access to the mounting structure within the fixture. Mass of the test sample is limited by the loading limitations of the mounting structure. The test sample shall be identical in composition to the item to be installed and shall be oriented with respect to the vertical component of the earth's magnetic field as it would be in the intended installation.

5. Procedure.

5.1 Prior to measuring the ferrous magnetic field of the test sample, measure the earth's magnetic field with the gimbal fixture and mounting structure in place as they would be for the ferrous field measurements. Start with position 1 (see figure FF01-2) for the magnetometer's sensor. Utilize the position designators in figure FF01-2, record this data and all subsequent data.

5.1.1 With the magnetometer's sensor in position 1, measure the field magnitude.

5.1.2 Rotate the ring of the gimbal fixture + 45 degrees in the plane of the ring (position 2); measure and record the field magnitude.

5.1.3 Repeat 5.1.2 six times (positions 3 through 8).

5.1.4 Rotate the gimbal fixture + 45 degrees in the plane of the fixture and then + 45 degrees in the plane containing the magnetometer's sensor and the point on the fixture 180 degrees from the sensor.

5.1.5 Measure and record the field magnitude (position 9); repeat 5.1.2 and 5.1.3 with the exception that positions + 90 degrees and + 270 degrees are eliminated (positions 10 through 14).

5.1.6 Repeat 5.1.4 and 5.1.5 two times (positions 15 through 26).

5.2 Place the test sample on the mounting structure within the gimbal fixture and record the position of the test sample with respect to the gimbal fixture and magnetic north-south and east-west. Measure the ferrous magnetic field of the test sample at all test points by repeating 5.1.1 through 5.1.6.

5.3 Remove the test sample from within the gimbal fixture and remeasure the earth's magnetic field at all test points by repeating 5.1.1 through 5.1.6. If this final measurement of the earth's field at any point differs from the initial measurement at that point by more than 1 nT, the test results are not valid.

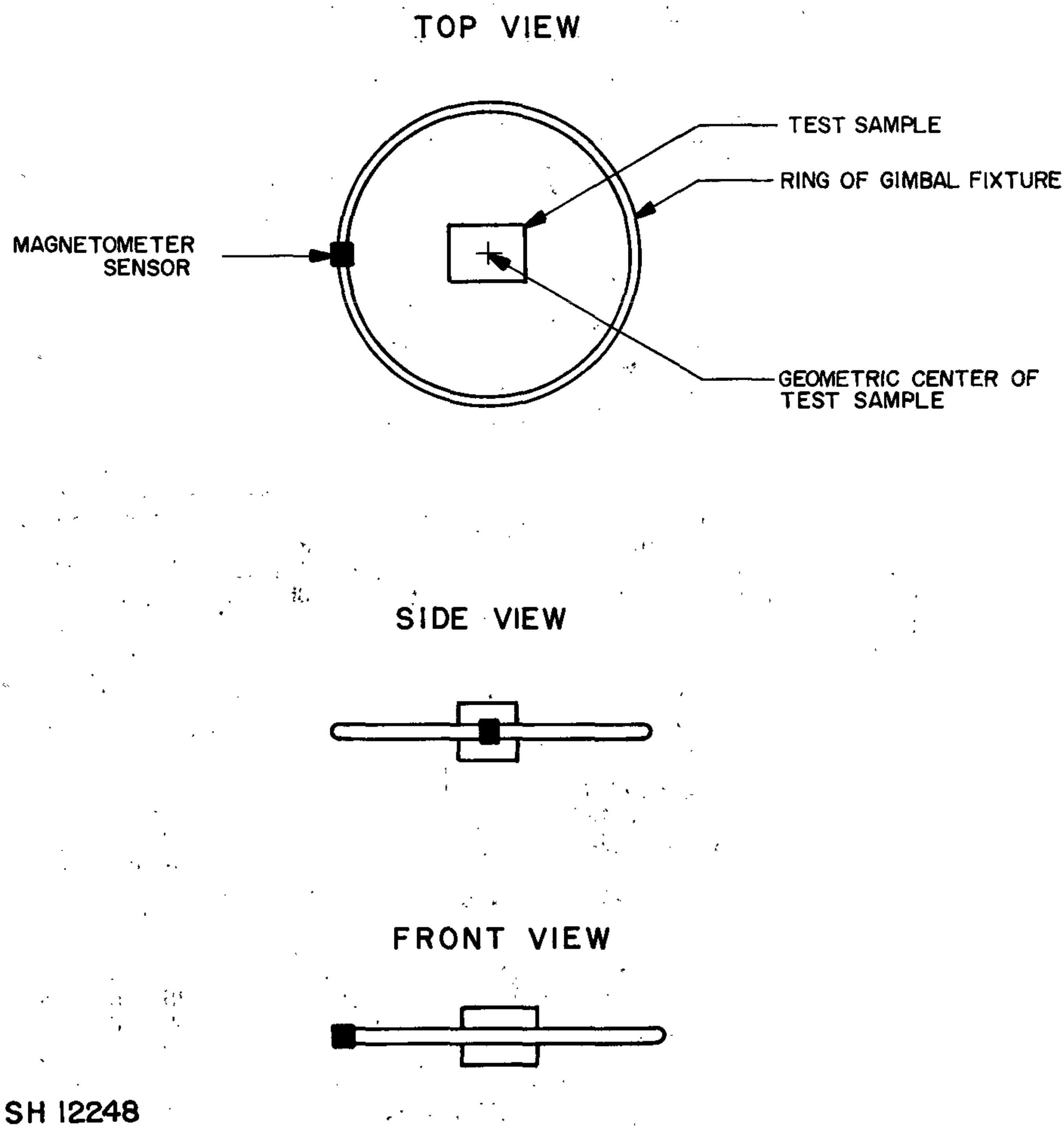
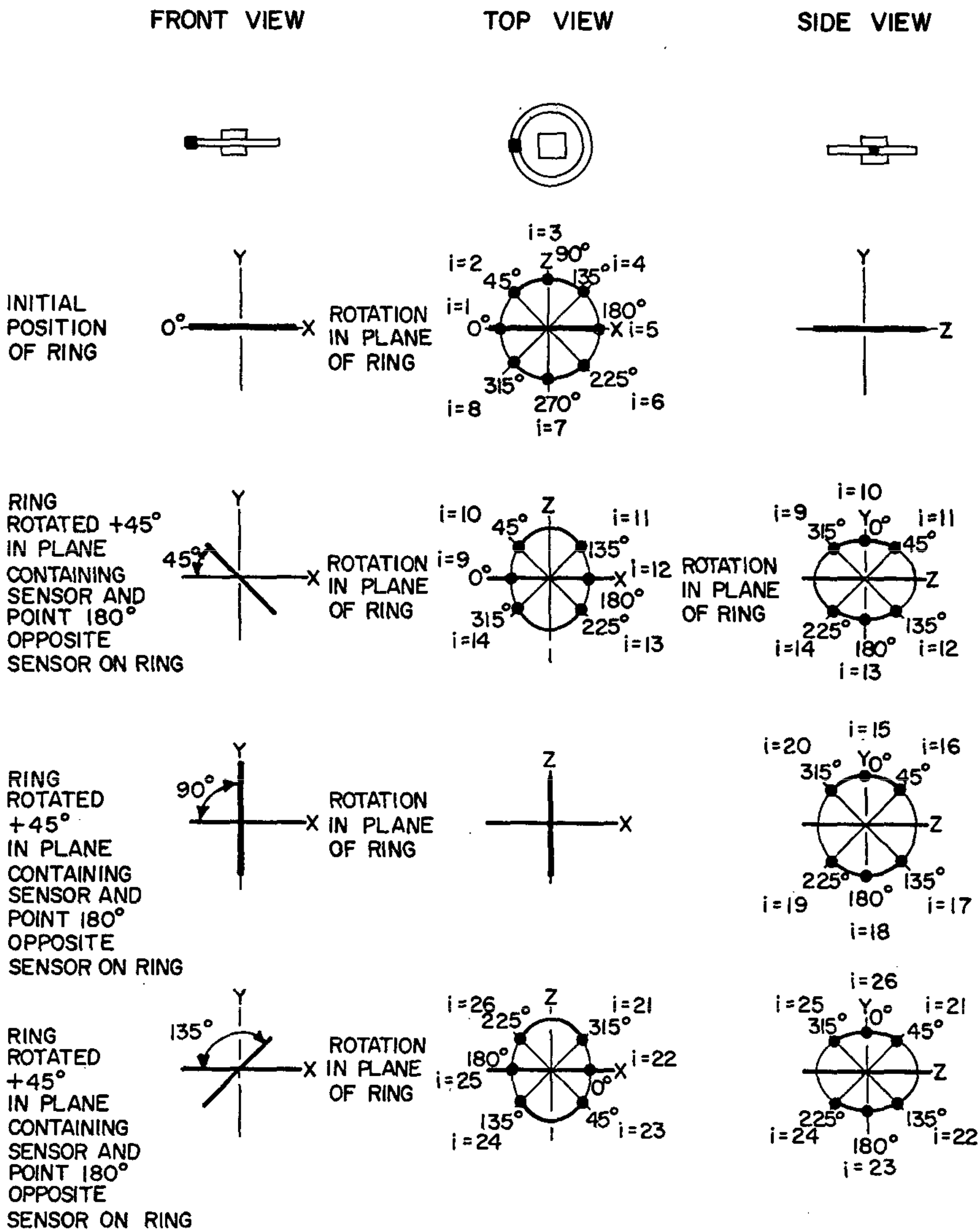


FIGURE FF01-1. Configuration of ring for gimbal fixture.



SH 12249

FIGURE FF01-2. Magnetometer position designators (i).

6. Calculations. Calculate the difference between the magnetic field with the test sample present within the gimbal fixture and the test sample removed from within the gimbal fixture for each position measured as follows:

$$H_p(i) - H_a(i) = H_t(i);\ i = 1 \text{ to } 26$$

where:

H_p = measured magnetic field with the test sample present within the gimbal fixture.
H_a = measured magnetic field with the test sample removed from within the gimbal fixture.
H_t = ferrous magnetic field emanating from the test sample.
i = position designator of the magnetometer for each of the positions measured; $i = 1$ to 26.

7. Test report. The test report shall include the following information:

(a) Identification of the test sample.
(b) Identification of the magnetometer used, including manufacturer's and identification number.
(c) Identification of the gimbal fixture and mounting structure for the test sample.
(d) Position of the test sample with respect to the gimbal structure and magnetic north-south and east-west.
(e) All recorded and calculated field values.

TEST METHOD FF02

FERROUS MAGNETIC FIELD FROM A CLASS 1 SOURCE MEASURED AT A DISTANCE IN A CONTROLLED MAGNETIC ENVIRONMENT

1. Scope. A ferrous field (class 1) source is an item on or part of a ship or craft, which uses a material in its construction that exhibits a relative magnetic permeability different than 1.0 (the relative permeability of air). A ferrous field source emanates a ferrous magnetic field which is composed of an induced and permanent magnetic field. The ferrous magnetic field can be compensated for by a degaussing system if the magnitude and direction of the field is known. This test method is used to determine the magnitude of the normal component of the ferrous magnetic field at a number of measurement points that are equidistant from the center of the test sample. This test is accomplished in a controlled magnetic environment which is created by a test coil system. Consequently, it is more accurate than the similar ambient magnetic field environment test method FF01. Required information from the specifications for the test sample for this test method is the distance from the center of the test sample, at which the ferrous magnetic field is to be measured.

2. Center of the test sample. Center of the test sample refers to the geometric center of the sample.

3. Apparatus.

3.1 Test coil system. The test coil system shall consist of the test coil, its power supply and control system. The test coil, either a Helmholtz coil or an equivalent coil array, shall produce applied magnetic fields in the three orthogonal directions (triaxial). The magnetic field gradient caused by the coil's field and any magnetic field distortion from the immediate environment over the volume occupied by the test sample shall not exceed 0.1 percent of the applied field per meter or 0.0016 A/m (flux density is 2 nT) per meter, whichever is greater. The coil shall generate magnetic fields to a maximum of 43 A/m (54 μT) with an accuracy of at least 0.05 percent of the applied field or 0.0002 A/m (flux density is 0.25 nT), whichever is greater. The power supply shall supply the current required for adequately long periods without drift or fluctuation. A storage battery of adequate capacity is a satisfactory power source. A direct current generator may be used, but may require a voltage regulator to maintain a constant output. An alternating current source with a rectifier can be used, provided the output is well filtered and the voltage is regulated and free of excessive switching transients. The power source should not be used for any other test or load simultaneous with this test.

3.2 Magnetometer. A monoaxial fluxgate magnetometer consisting of a sensor unit and an electronic unit with a minimum sensitivity of 0.0002 A/m (flux density is 0.25 nT) and a dynamic range of ± 90 A/m (± 113 μT) shall be used. The electronic unit shall include as a minimum a meter to measure the field magnitude. A chart recorder may be utilized to facilitate data collection.

3.3 Gimbal fixture. A nonferrous gimbal fixture, with a circular ring, shall be used for the mounting of the magnetometer's sensor (see figure FF02-1). The ring shall have a radius equal to the distance from the center of the test sample at which the field is to be measured. The magnetometer's sensor shall be mounted on the ring in a manner that will allow sensing at the specified distance. The ring shall lie on a horizontal plane so that it is centered about the center of the test coil within plus or minus 10 centimeters (cm) and can be rotated in 45 degree increments in the plane of the ring and in the plane perpendicular to the plane of the ring (see figure FF01-2). Multiple magnetometers may be used to decrease the number of rotations required for a full set of readings.

3.4 Mounting structure. A nonferrous mounting structure shall be used for positioning the test sample within the test coil and gimbal fixture.

4. Test sample. Volume of the test sample is limited by the size of the test coil and gimbal fixture, and access to the mounting structure within them. Mass of the test sample is limited by the loading limitations of the mounting structure. The test sample shall be identical in composition to the item to be installed and shall be oriented with respect to the horizontal and vertical components of the test coil as it would be in its intended installation.

5. Procedure.

5.1 Energize the test coil system such that the air core volume to be occupied by the test sample is subjected to a vertical magnetic field of 43 A/m (54 μT) and a horizontal magnetic field of 12 A/m (15 μT).

5.2 Place the test sample in position and record the position of the test sample with respect to the test coil. The test sample shall coincide with the center of the test coil within plus or minus 10 cm.

5.3 With the magnetometer's sensor in position 1 (see figure FF02-1), measure the field magnitude.

5.4 Rotate the ring of the gimbal fixture + 45 degrees in the plane of the ring (position 2); measure and record the field magnitude.

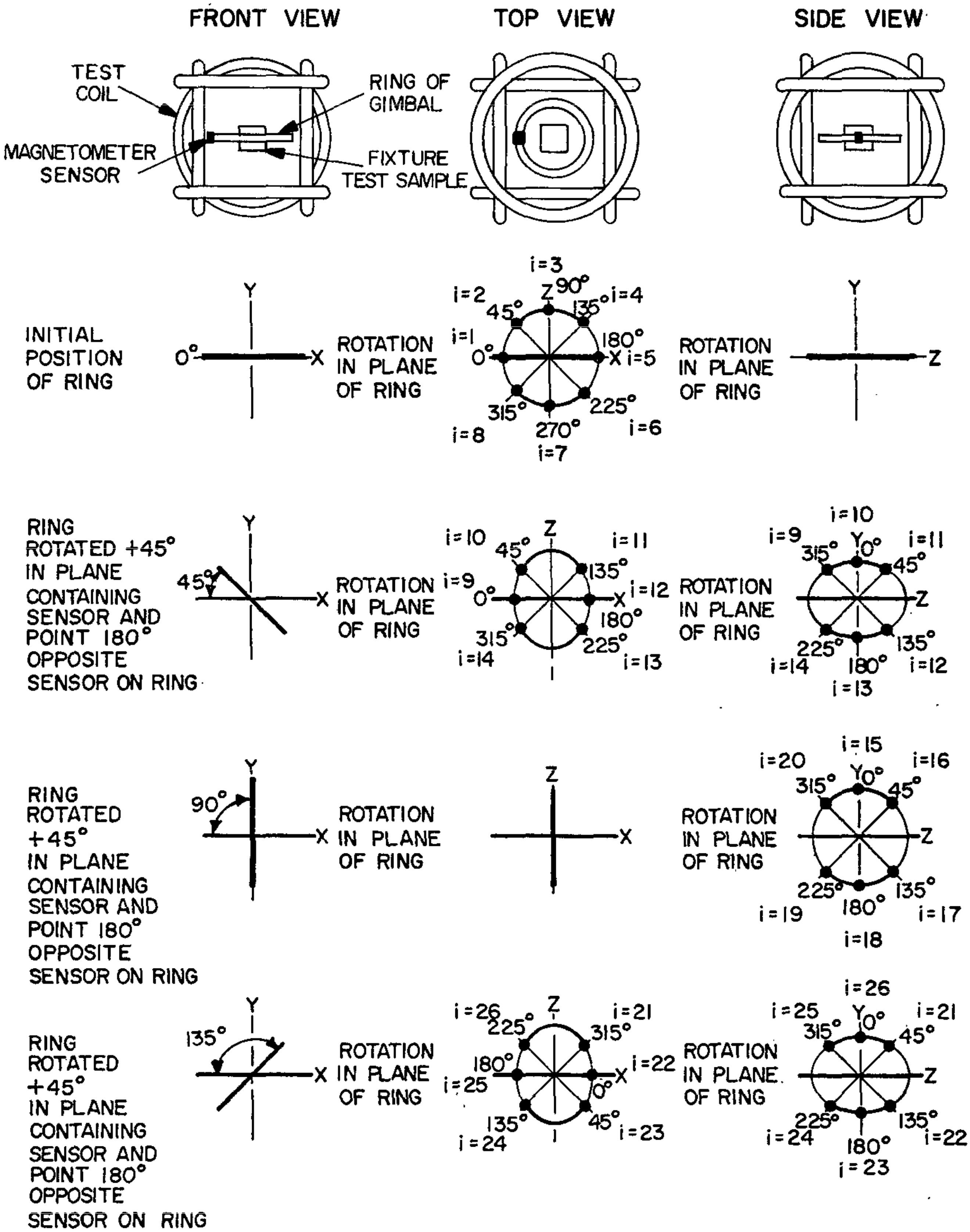
5.5 Repeat 5.4 six times (positions 3 through 8).

5.6 Rotate the ring of the gimbal fixture + 45 degrees in the plane of the ring and then + 45 degrees in the plane containing the magnetometer's sensor and the point on the ring 180 degrees from the sensor.

5.7 Measure and record the field magnitude (position 9); repeat 5.4 and 5.5 with the exception that positions + 90 degrees and + 270 degrees are eliminated (positions 10 through 14).

5.8 Repeat 5.6 and 5.7 two times (positions 15 through 26).

5.9 Remove the test sample from within the test coil and repeat 5.3 through 5.8.



SH 12250 FIGURE FF02-1. Magnetometer position designators (i).

5.10 Adjust the test coil system so that the air core volume to be occupied by the test sample is subjected to a vertical magnetic field component of 10 A/m (12.6 μT) and a horizontal magnetic field component of 34 A/m (42.7 μT).

5.11 Reinsert the test sample from within the test coil and record the position of the test sample with respect to the test coil.

5.12 Repeat 5.3 through 5.9.

6. Calculations. Calculate the difference between the magnetic field with the test sample present within the test coil and the test sample removed from within the test coil for each position measured as follows:

$$H_p\ (i,j) - H_a\ (i,j) = H_t\ (i,j);\ i = 1 \text{ to } 26,\ j = 1,2$$

where:

- H_p = measured magnetic field with the test sample present within the test coil.
- H_a = measured magnetic field with the test sample removed from within the test coil.
- H_t = ferrous magnetic field emanating from the test sample.
- i = position designator of the magnetometer for each of the positions measured; $i = 1$ to 26.
- j = designator for air core magnetic field condition; $j = 1$ corresponds to the field of 43 A/m vertical and 12 A/m horizontal; $j = 2$ corresponds to the field of 10 A/m vertical and 34 A/m horizontal.

7. Test report. The test report shall include the following information:

(a) Identification of the test sample.
(b) Identification of the test coil system used, including manufacturer's and identification numbers.
(c) Identification of the gimbal fixture and mounting structure for the test sample.
(d) Position of the test sample with respect to the test coil.
(e) All recorded and calculated field values.

TEST METHOD FF03

FERROUS MAGNETIC FIELD FROM A CLASS 1 SOURCE
MEASURED ON A HORIZONTAL PLANE
IN AN AMBIENT MAGNETIC ENVIRONMENT

1. Scope. A ferrous field (class 1) source is an item on or part of a ship or craft, which uses a material in its construction that exhibits a relative magnetic permeability different than 1.0 (the relative permeability of air). A ferrous field source emanates a ferrous magnetic field, which is composed of an induced and permanent magnetic field. The ferrous magnetic field can be compensated for by a degaussing system if the magnitude and direction of the field is known. In minesweeper applications, the vertical component of the ferrous magnetic field emanated in a horizontal plane beneath the surface of the water is usually the most critical component of the ferrous magnetic field. This test method is used to determine the magnitude of the vertical component of the ferrous magnetic field on a horizontal plane that is a distance below the center of the test sample. This method is distinguished from test method FF01 which measures the field at points that are equidistant from the center of the test sample. This test method, like test method FF01, is accomplished in an ambient (earth's) field environment. Consequently, if the earth's field at the test site varies significantly with time during the performance of the test and is not automatically compensated for, this method will lead to less accurate results than those achievable in a controlled magnetic environment (see test method FF04). However, since a controlled magnetic environment requires a complicated test coil and control system, this method provides a rapid and convenient means for measuring the ferrous magnetic field on a horizontal plane at a distance below the center of the test sample. Sensors of the magnetometers may be buried in the earth, which could eliminate the need for special mounting of the test sample. Required information from the specifications for the test sample for this test method is the distance from the center of the test sample to the horizontal plane at which the ferrous magnetic field is to be measured.

2. Center of the test sample. Center of the test sample refers to the geometric center of the sample.

3. Apparatus.

3.1 Magnetometers. Monoaxial fluxgate magnetometers consisting of a sensor unit and an electronic unit with a minimum sensitivity of 0.0002 A/m (flux density is 0.25 nT) and a dynamic range of $\pm$ 90 A/m ($\pm$ 113 μT) shall be used for the horizontal array of magnetometers. Each electronic unit shall include as a minimum a meter to measure the field magnitude, unless automatic data collection equipment is utilized. The sensors may be mutiplexed into a limited number of electronic units which automatically record the field measured by each scanned sensor.

3.2 Mounting frame for the array of magnetometers' sensors. Unless the array of magnetometers' sensors are buried in the earth, a nonferrous, rectangular frame for the mounting of the sensors shall be provided (see figure FF03-1). The sensors mounted on the frame shall be located on a horizontal plane at the specified distance below the center of the test sample. One sensor shall be located directly below the center of the test sample (center sensor). The remainder of the sensors in the array shall be located at spacings equal to 0.25 of the vertical distance from the center sensor to the center of the test sample. The periphery of the array shall be no closer to the center sensor than twice the vertical distance from the center sensor to the center of the test sample. Each sensor shall be vertical within 0.5 degree.

3.3 Mounting structure. A nonferrous mounting structure shall be used for positioning the test sample with respect to the mounting frame, if required by the location of the magnetometer array.

4. Test sample. Length and width of the test sample is limited by the dimensions of the array of sensors. Mass of the test sample is limited by the loading limitations imposed by the surface on which the sample is located. The test sample shall be identical in composition to the item to be installed and shall be oriented with respect to the vertical components of the earth's magnetic field, as it would be in the intended installation.

5. Procedure.

5.1 Prior to measuring the ferrous magnetic field of the test sample, measure the earth's magnetic field with the mounting frame for the array of magnetometer's sensors and mounting structure for the test sample in place as they would be for the ferrous field measurements.

5.1.1 Record the position of and the magnetic field measured by each sensor.

5.2 Place the test sample in position and record the position of the test sample with respect to the mounting frame for the array of magnetometers' sensors and magnetic north-south and east-west.

5.3 Record the position of and the magnetic field measured by each sensor.

5.4 Remove the test sample from the test setup and remeasure the earth's magnetic field at all test points by repeating 5.1.1. If this final measurement of the earth's field at any point differs from the initial measurement by more than 1 nT, the test results are not valid.

6. Calculations. Calculate the difference between the vertical component of the magnetic field with the test sample present and the test sample removed for each position measured as follows:

$$H_p(i) - H_a(i) = H_v(i);\ i = 1 \text{ to } n$$

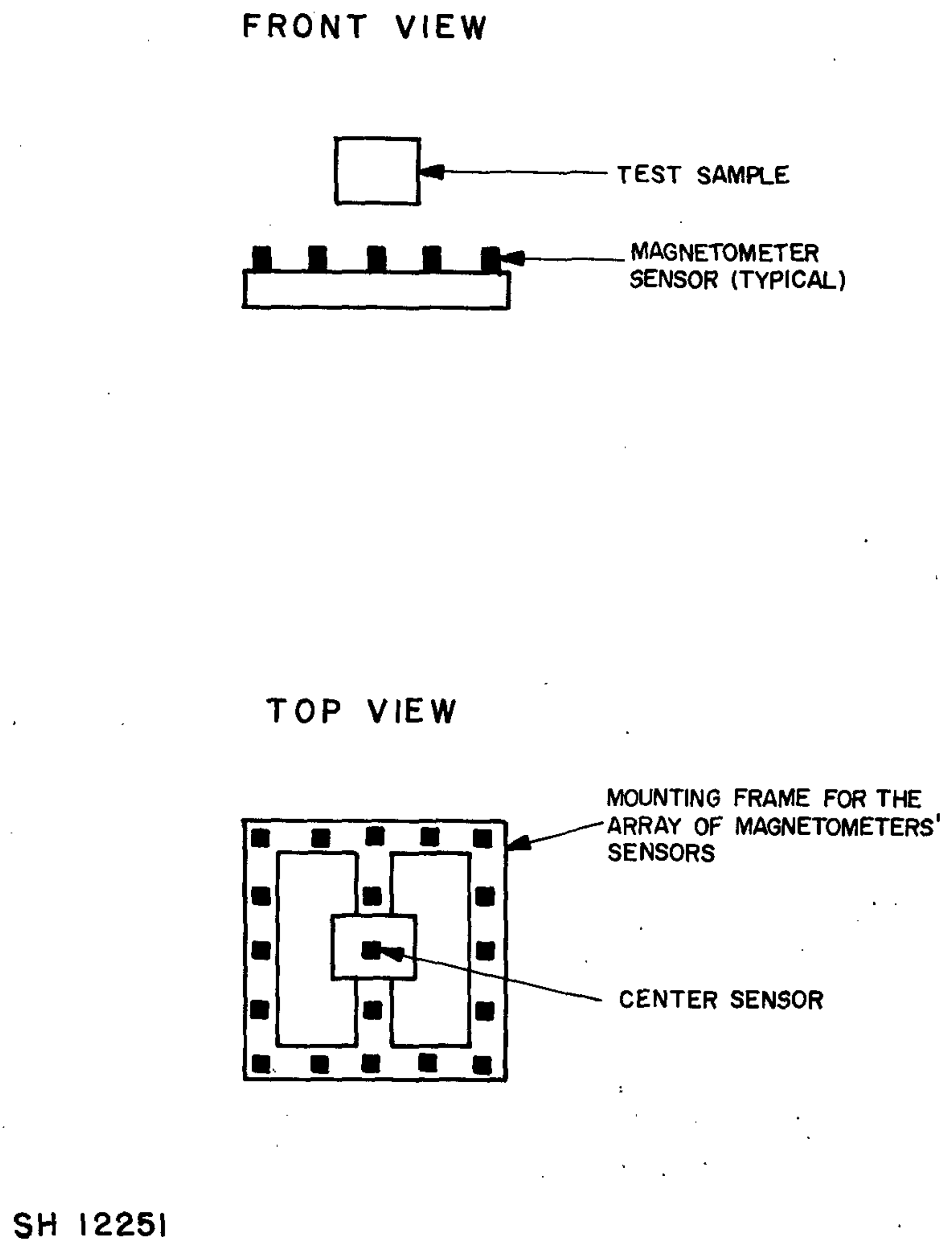


FIGURE FF03-1. Configuration of magnetometers' sensors.

where:

H_p = measured magnetic field with the test sample present.
H_a = measured magnetic field with the test sample removed.
H_v = ferrous magnetic field emanating from the test sample.
i = position designator of the magnetometer for each of the positions measured; $i = 1$ to n.
n = total number of magnetometers.

7. Test report. The test report shall include the following information:

(a) Identification of the test sample.
(b) Identification of the magnetometers used, including manufacturer's and identification number.
(c) Identification of the mounting frame for the array of the mageto-meters' sensors and the mounting structure for the test sample.
(d) Position of the test sample with respect to the mounting frame of the magnetometers' sensors and magnetic north-south and east-west.
(e) All recorded and calculated field values.

TEST METHOD FF04

FERROUS MAGNETIC FIELD FROM A CLASS 1 SOURCE MEASURED ON A HORIZONTAL PLANE IN A CONTROLLED MAGNETIC ENVIRONMENT

1. Scope. A ferrous field (class 1) source is an item on or part of a ship or craft, which uses a material in its construction that exhibits a relative magnetic permeability different than 1.0 (the relative permeability of air). A ferrous field source emanates a ferrous magnetic field which is composed of an induced and permanent magnetic field. The ferrous magnetic field can be compensated for by a degaussing system if the magnitude and direction of the field is known. In minesweeper applications, the vertical component of the ferrous magnetic field emanated in a horizontal plane beneath the surface of the water is usually the most critical component of the ferrous magnetic field. This test method is used to determine the magnitude of the vertical component of the ferrous magnetic field on a horizontal plane that is a distance below the center of the test sample. This method is distinguished from test method FF02, which measures the field at points that are equidistant from the center of the test sample. This test method, like test method FF02, is accomplished in a controlled magnetic environment which is created by a test coil system. Consequently, it is more accurate than the similar ambient magnetic field environment test method FF03. Required information from the specifications for the test sample for this test method is the distance from the center of the test sample to the horizontal plane at which the ferrous magnetic field is to be measured.

2. Center of the test sample. Center of the test sample refers to the geometric center of the sample.

3. Apparatus.

3.1 Test coil system. The test coil system shall consist of the test coil, its power supply, and control system. The test coil, either a Helmholtz coil or an equivalent coil array, shall produce applied magnetic fields in the three orthogonal directions (triaxial). The magnetic field gradient caused by the coil's field and any magnetic field distortion from the immediate environment over the volume occupied by the test sample shall not exceed 0.1 percent of the applied field per meter or 0.0016 A/m (flux density is 2 nT) per meter, whichever is greater. The coil shall generate magnetic fields to a maximum of 43 A/m (54 μT) with an accuracy of at least 0.05 percent of the applied field or 0.0002 A/m (flux density is 0.25 nT), whichever is greater. The power supply shall supply the current required for adequately long periods without drift or fluctuation. A storage battery of adequate capacity is a satisfactory power source. A direct current generator may be used, but may require a voltage regulator to maintain a constant output. An alternating current source with a rectifier can be used, provided the output is well filtered and the voltage is regulated and free of excessive switching transients. The power source should not be used for any other test or load simultaneous with this test.

3.2 Magnetometers. Monoaxial fluxgate magnetometers consisting of a sensor unit and an electronic unit with a minimum sensitivity of 0.0002 A/m (flux density is 0.25 nT) and a dynamic range of ± 90 A/m (± 113 μT) shall be used for the horizontal array of magnetometers. Each electronic unit shall include as a minimum a meter to measure the field magnitude, unless automatic data collection equipment is utilized. The sensors may be mutiplexed into a limited number of electronic units, which automatically record the field measured by each scanned sensor.

3.3 Mounting frame for the array of magnetometers' sensors. A nonferrous, rectangular frame for the mounting of magnetometers' sensors shall be provided (see figure FF04-1). The sensors mounted in the frame shall be located on a horizontal plane at the specified distance below the center of the test sample. One sensor shall be located directly below the center of the test sample (center sensor). The remainder of the sensors in the array shall be located at spacings equal to 0.25 of the vertical distance from the center sensor to the center of the test sample. The periphery of the array shall be no closer to the center sensor than twice the vertical distance from the center sensor to the center of the test sample. Each sensor shall be vertical within 0.5 degree.

3.4 Mounting structure. A nonferrous mounting structure shall be used for positioning the test sample within the test coil and over the mounting frame for the array of magnetometers' sensors.

4. Test sample. Volume of the test sample is limited by the size of the test coil and mounting frame for the array of magnetometers' sensors, and access to the mounting structure within them. Mass of the test sample is limited by the loading limitations of the mounting structure. The test sample shall be identical in composition to the item to be installed and shall be oriented with respect to the vertical components of the test coil as it would be in its intended installation.

5. Procedure.

5.1 Energize the test coil system such that the air core volume to be occupied by the test sample is subjected to a vertical magnetic field of 43 A/m (54 μT) and a horizontal magnetic field of 12 A/m (15 μT).

5.2 Place the test sample in position and record the position of the test sample with respect to the test coil. The test sample shall coincide with the center of the test coil within plus or minus 10 cm.

5.3 Record the positions and the magnetic field measured by each sensor.

5.4 Remove the test sample from the test coil and repeat 5.3.

5.5 Adjust the test coil system so that the air core volume to be occupied by the test sample is subjected to a vertical magnetic field component of 10 A/m (12.6 μT) and horizontal magnetic field component of 34 A/m (42.7 μT).

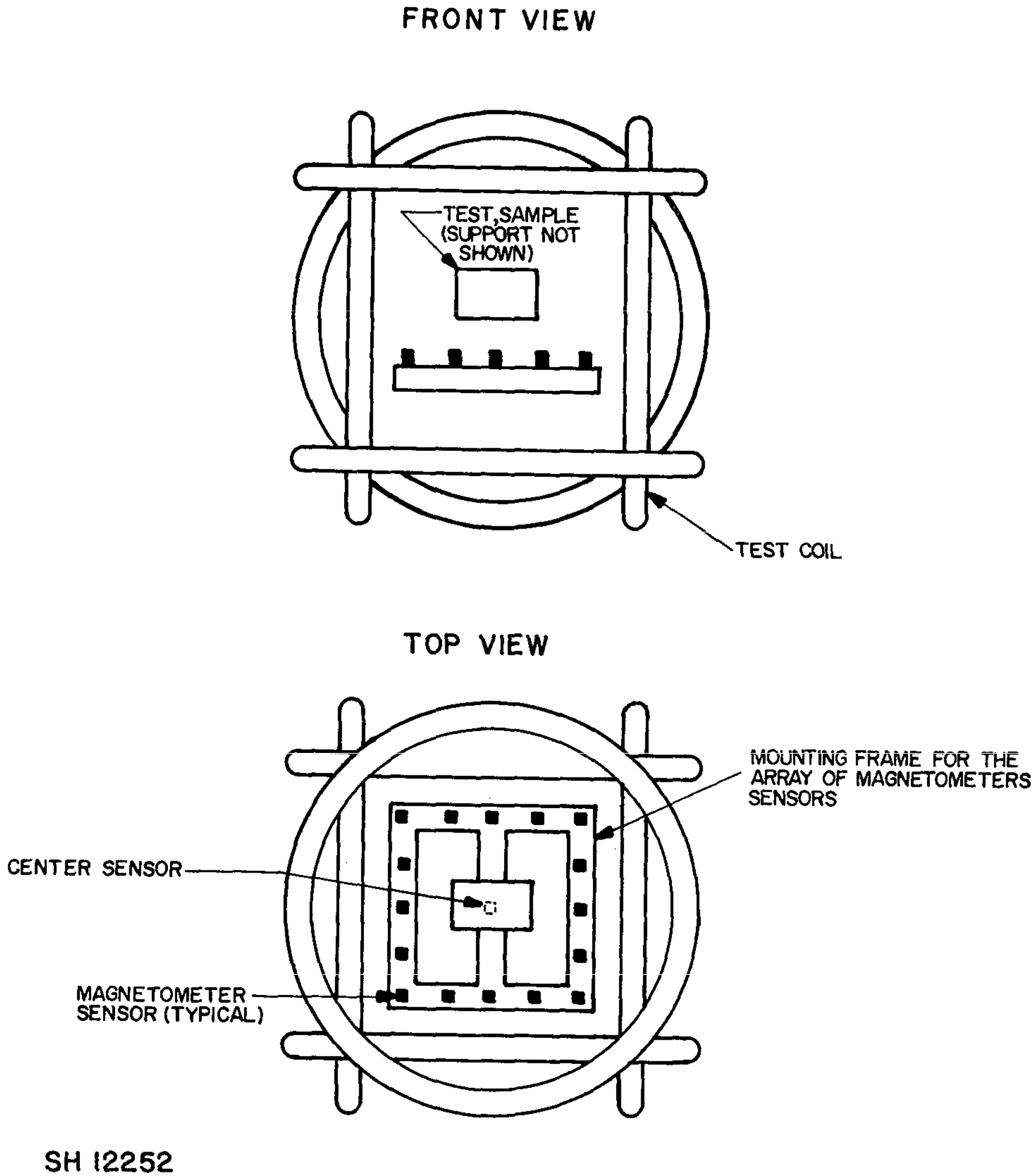


FIGURE FF04-1. Configuration of magnetometers' sensors array.

5.6 Reinsert the test sample within the test coil and record the position of the test sample with respect to the test coil.

5.7 Repeat 5.3 and 5.4.

6. Calculations. Calculate the difference between the vertical component of the magnetic field with the test sample present within the test coil and the test sample removed from within the test coil for each position measured as follows:

$$H_p\ (i,j) - H_a\ (i,j) = H_v\ (i,j);\ i = 1 \text{ to } n,\ j = 1,2$$

where:

H_p = measured magnetic field with the test sample present.
H_a = measured magnetic field with the test sample removed.
H_v = ferrous magnetic field emanating from the test sample.
i = position designator of the magnetometer for each of the positions measured; $i = 1$ to n.
n = total number of magnetometers.
j = designator for air core magnetic field condition; $j = 1$ corresponds to the field of 43 A/m vertical and 12 A/m horizontal; $j = 2$ corresponds to the field of 10 A/m vertical and 34 A/m horizontal.

7. Test report. The test report shall include the following information:

(a) Identification of the test sample.
(b) Identification of the magnetometers used, including manufacturer's and identification number.
(c) Identification of the mounting frame for the array of magnetometers' sensors and the mounting structure for the test sample.
(d) Position of the test sample with respect to the test coil.
(e) All recorded and calculated field values.

TEST METHOD FF05

FERROUS MAGNETIC FIELD FROM A CLASS 1 SOURCE CAUSED BY LINEAR MOTION IN AN AMBIENT MAGNETIC ENVIRONMENT

1. Scope. A ferrous field (class 1) source is an item on or part of a ship or craft, which uses a material in its construction that exhibits a relative magnetic permeability different from 1.0 (the relative permeability of air). A ferrous field source emanates a ferrous magnetic field which is composed of an induced and permanent magnetic field. The ferrous magnetic field can be compensated for by a degaussing system if the magnitude and direction of the field is known. This test method is used to determine the magnitude of the vertical component of the ferrous magnetic field at a fixed distance below the center of the test sample, as the test sample is moved in a linear direction over the measured point. This test is accomplished in an ambient (earth's) magnetic environment. Required information from the specifications for the test sample for this test method is the distance below the center of the test sample at which the ferrous magnetic field is to be measured.

2. Center of the test sample. Center of the test sample refers to the geometric center of the sample.

3. Apparatus.

3.1 Track. 450 meters of nonferrous, non-electrically conductive track for the test sample's cart shall be installed in a straight line along magnetic north-south and magnetic east-west with intersection at their midpoints (225 meters).

3.2 Cart. A nonferrous, non-electrically conductive cart shall be provided for mounting of the test sample so that it can travel along the test track at constant speeds between 1.0 meters per second (2 knots) and 4.1 meters per second (8 knots).

3.3 Magnetometer. A monoaxial fluxgate magnetometer consisting of a sensor unit and an electronic unit with a minimum sensitivity of 0.0002 A/m (flux density is 0.25 nT) and a dynamic range of $\pm$ 90 A/m ($\pm$ 113 μT) shall be used. The electronic unit shall include, as a minimum, a manually controllable field neutralization subsystem to null out the earth's field magnitude and a continuous recording instrument so that the magnitude of the absolute field is continuously read as the test sample is moved. The magnetometer shall be located at the intersection of the two tracks at the specified distance below the test sample (see figure EF01-1).

4. Test sample. Volume of the test sample is limited by the size of the cart. Mass of the test sample is limited by the loading limitations of the cart and track. The test sample shall be identical in composition to the item to be installed and shall be oriented with respect to the vertical component of the earth's magnetic field as it would be in its intended installation.

5. Procedure.

5.1 With the test sample removed from the test site, measure the earth's magnetic field at the magnetometer's sensor and null it out with the magnetometer's control circuit.

5.2 Mount the test sample on the cart and record its position with respect to the cart.

5.3 Operate the cart with the test sample on it at a constant speed of 1.0 meters per second along the entire length of the magnetic north-south track. Record the magnitude of the field at the sensor on the continuous recording equipment, as the cart is moved along the track.

5.4 Repeat 5.3 at speeds of 2.6 meters per second and 4.1 meters per second.

5.5 Relocate the cart with the test sample on it to the magnetic east-west track and operate it at a constant speed of 2.6 meters per second along the entire length of the track. Record the magnitude of the field at the sensor on the continuous recording equipment as the cart is moved along the track.

5.6 Repeat 5.5 at speeds of 2.6 meters per second and 4.1 meters per second.

5.7 Remove the test sample from the test site and remeasure the earth's magnetic field at the magnetometer's sensor. If this final measurement of the earth's field differs from the initial measurement at that point by more than 1 nT, the test results are not valid.

6. Test report. The test report shall include the following information:

(a) Identification of the test sample.
(b) Identification of the magnetometer used, including manufacturer's and identification number.
(c) Identification of the track and cart used.
(d) All recorded field values.

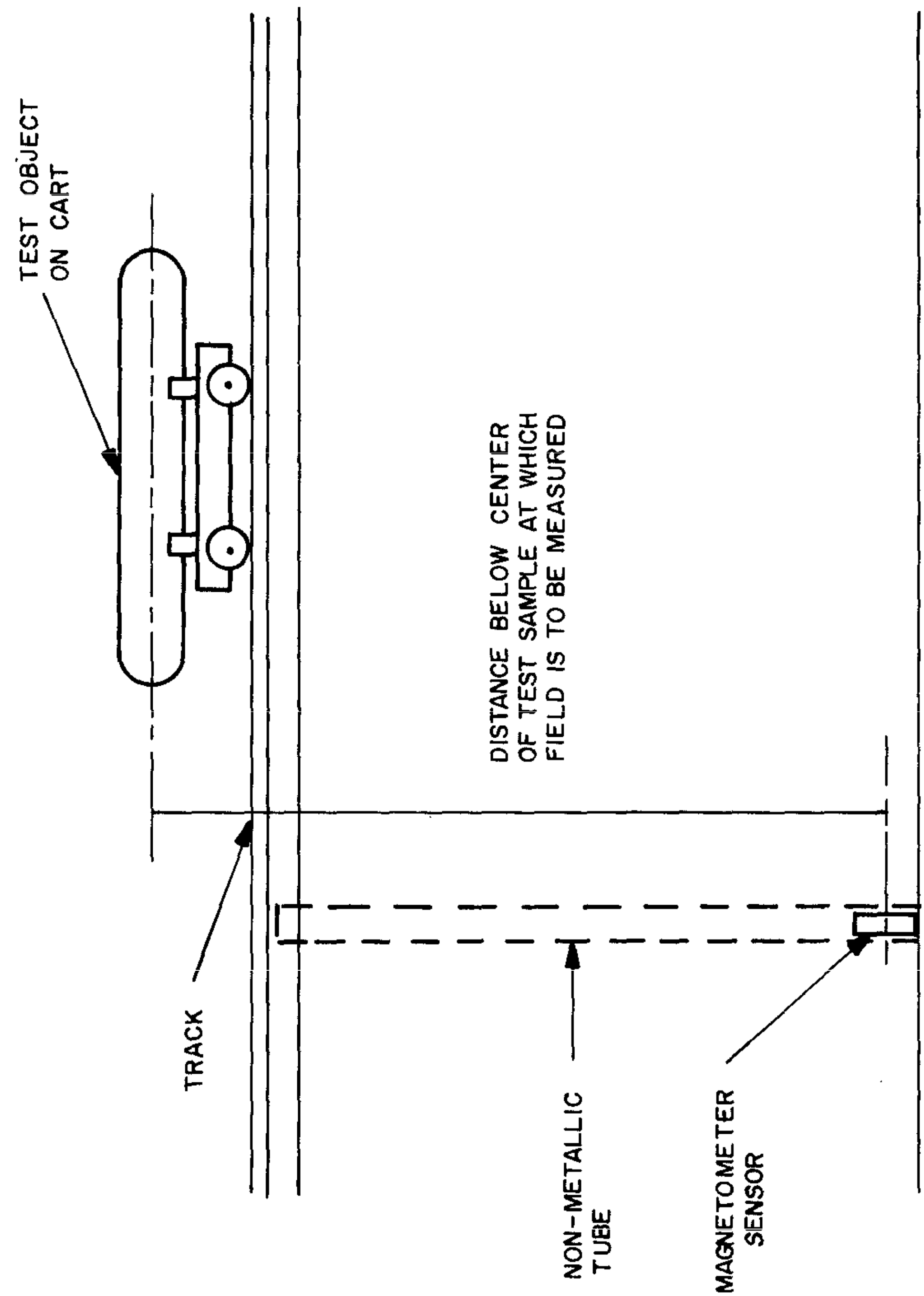


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FIGURE FF05-1. Configuration of test, cart, track and sensor.

TEST METHOD EF01

EDDY CURRENT MAGNETIC FIELD FROM A CLASS 2 SOURCE
MEASURED AT A DISTANCE
IN A CONTROLLED MAGNETIC ENVIRONMENT

1. Scope. An electrically conductive material will generate within itself eddy currents when it is oscillated in a magnetic field. These eddy currents, in turn, will create an eddy current magnetic field. Eddy current field (class 2) sources aboard a ship or craft will emanate eddy current magnetic fields as they roll and pitch in the earth's magnetic field. Consequently, the magnitude of eddy current magnetic fields needs to be controlled aboard minesweepers that sweep for magnetic-influence mines. This test method is used to determine the magnitude of the normal component of the eddy current magnetic field at a number of measurement points that are equidistant from the center of the test sample. This test is accomplished in a controlled magnetic environment which is created by a test coil system, which is rotated about the test sample of the eddy current field source. Alternatively, the test sample could be rotated in the magnetic field created by the test coil system. Required information from the specifications for the test sample for this test method is the distance from the center of the test sample of which the eddy current magnetic field is to be measured.

2. Center of the test sample. Center of the test sample refers to the geometric center of the sample.

3. Apparatus.

3.1 Test coil system. The test coil system shall consist of the test coil, its power supply and control system. The test coil, either a Helmholtz coil or an equivalent coil array, shall produce applied magnetic fields in the three orthogonal directions (triaxial). The magnetic field gradient caused by the coil's field and any magnetic field distortion from the immediate environment over the volume occupied by the test sample shall not exceed 0.1 percent of the applied field per meter or 0.0016 A/m (flux density is 2 nT) per meter, whichever is greater. The coil shall generate magnetic fields to a maximum of 43 A/m (54 µT) with an accuracy of at least 0.05 percent of the applied field or 0.0002 A/m (flux density is 0.25 nT), whichever is greater. The power supply shall supply the current required for adequately long periods, without drift or fluctuation. A storage battery of adequate capacity is a satisfactory power source. A direct current generator may be used, but may require a voltage regulator to maintain a constant output. An alternating current source with a rectifier can be used, provided the output is well filtered and the voltage is regulated and free of excessive switching transients. The power source should not be used for any other test or load simultaneously with this test.

3.2 Roll mounting fixture for test coil. The test coil shall be mounted on a roll mounting fixture which shall roll the test coil at a rate of 5 to 7 cycles per minute in one plane to angles of 45 degrees on either side of the vertical in increments of 15 degrees. The magnitude of the vertical and horizontal components of the magnetic field occupied by the air core volume specified in the test procedures shall rotate as the test coil rotates and shall be maintained at the same values and tolerances throughout the rotation.

3.3 Magnetometer. A monoaxial fluxgate magnetometer consisting of a sensor unit and an electronic unit with a minimum sensitivity of 0.0002 A/m (flux density is 0.25 nT) and a dynamic range of $\pm$ 90 A/m ($\pm$ 113 μT) shall be used. The electronic unit shall include a continuous reading instrument to measure the field magnitude as the test coil rotates through its roll angle.

3.4 Gimbal fixture. A nonferrous, non-electrically conductive gimbal fixture, with a circular ring, shall be used for the mounting of the magnetometers' sensor (see figure EF01-1). The ring shall have a radius equal to the distance from the center of the test sample at which the field is to be measured. The magnetometer's sensor shall be mounted on the ring in a manner that will allow sensing at the specified distance. The ring shall lie on a horizontal plane so that it is centered about the center of the test coil within plus or minus 10 cm and can be rotated in 45 degree increments in the plane of the ring and in the plane perpendicular to the plane of the ring (see figure EF01-1). Multiple magnetometers may be used to decrese the number of rotations required for a full set of readings.

3.5 Mounting structure. A nonferrous, non-electrically conductive mounting structure shall be used for positioning the test sample within the test coil and gimbal fixture.

4. Test sample. Volume of the test sample is limited by the size of the test coil and gimbal structure, access to the mounting structure within them, and clearance distances for the roll of the test coil. Mass of the test sample is limited by the loading limitations of the mounting structure. The test sample shall be identical in composition to the item to be installed and shall be oriented with respect to the horizontal and vertical components of the test coil, as it would be in its intended installation.

5. Procedure.

5.1 Energize the test coil system such that the air core volume to be occupied by the test sample is subjected to a vertical magnetic field of 43 A/m (54 μT) and a horizontal magnetic field of 12 A/m (15 μT).

5.2 Place the test sample in position, so that it is orientated with respect to the roll plane of the coil as it would be orientated to the athwartship direction aboard the ship or craft. Record the position of the test sample with respect to the test coil. The center of the test sample shall coincide with the center of the test coil at 0 degrees roll angle within plus or minus 10 cm.

5.3 Place the magnetometer's sensor in position 2 (see figure EF01-1).

5.4 Rotate the test coil in its roll plane through an angle of 15 degrees from one side of the vertical to the other side (starboard orientation plus (+) degrees and port orientation (-) degrees) at a rate between 5 to 7 cycles (0 to 15 degrees or 0 to -15 degrees) per minute.

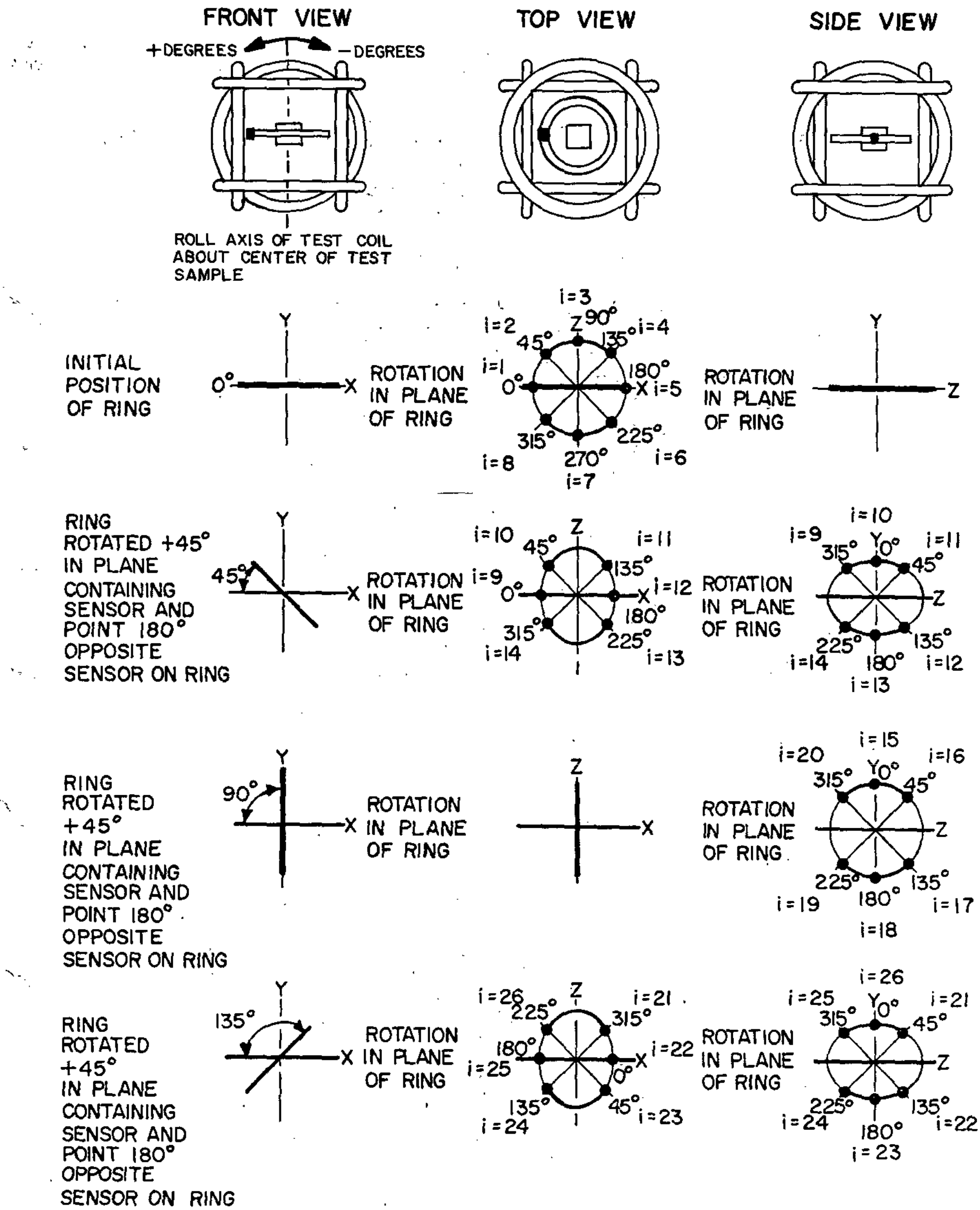

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FIGURE EF01-1. Magnetometer position designators (i).

5.5 Record the test coil roll angle and rate. Record the position of the magnetometer's sensor. Measure the maximum field magnitude during the roll from the continuous recording instrument.

5.6 Repeat 5.4 and 5.5 for 30 degrees and 45 degrees roll angles.

5.7 Rotate the ring of the gimbal fixture + 45 degrees in the plane of the ring; repeat 5.4 through 5.6 (position 2).

5.8 Repeat 5.7 six times (positions 3 through 8).

5.9 Rotate the ring of the gimbal fixture + 45 degrees in the plane of the ring and then + 45 degrees in the plane containing the magnetometer's sensor and the point on the ring 180 degrees from the sensor.

5.10 Repeat 5.4 through 5.7 with the exception that positions + 90 degrees and + 270 degrees are eliminated (positions 9 through 14).

5.11 Repeat 5.9 and 5.10 two times (positions 15 through 26).

5.12 Remove the test sample from within the test coil and repeat 5.4 through 5.11.

5.13 Reinsert the test sample within the test coil so that it is orientated with respect to the roll plane of the coil as it would be orientated to the forward-aft direction aboard the ship or craft. Record the position of the test sample with respect to the test coil. The center of the test sample shall coincide with the center of the test coil at 0 degrees roll angle within $\pm$ 10 cm.

5.14 Repeat 5.4 through 5.12. Test coil roll plane angles are plus (+) degrees for forward pitch and minus (-) degrees for aft pitch.

5.15 Adjust the test coil system so that the air core volume to be occupied by the test sample is subjected to a vertical magnetic field component of 10 A/m (12.6 μT) and a horizontal magnetic field component of 34 A/m (42.7 μT).

5.16 Repeat 5.2 through 5.14.

6. <u>Calculations</u>. Calculate the difference between the magnetic field with the test sample present within the test coil and the test sample removed from within the test coil for each position measured as follows:

$$H_p\ (k,j,k) - H_a\ (i,j,k) = H_t\ (i,j,k);\ i = 1 \text{ to } 26,\ j = 1,2,\ k = 1,2,3.$$

where:

H_p = measured magnetic field with the test sample present within the test coil.
H_a = measured magnetic field with the test sample removed from within the test coil.
H_t = eddy current magnetic field emanating from the test sample.

i = position designator of the magnetometer for each of the positions measured; i = 1 to 26.
j = designator for air core magnetic field condition; j = 1 corresponds to the field of 43 A/m vertical and 12 A/m horizontal; j = 2 corresponds to the field of 10 A/m vertical and 34 A/m horizontal.
k = designator for test coil, roll angle; k = 1 corresponds to a roll angle of 15 degrees; k = 2 corresponds to a roll angle of 45 degrees.

7. Test report. The test report shall include the following information:

(a) Identification of the test sample.
(b) Identification of the test coil system used, including manufacturer's and identification numbers.
(c) Identification of the roll mounting fixture, gimbal fixture and mounting structure for the test sample.
(d) Position of the test sample with respect to the test coil at 0 degrees roll.
(e) All recorded and calculated field values.

TEST METHOD EF02

EDDY CURRENT MAGNETIC FIELD FROM A CLASS 2 SOURCE MEASURED ON A HORIZONTAL PLANE IN A CONTROLLED MAGNETIC ENVIRONMENT

1. Scope. An electrically conductive material will generate within itself eddy currents when it is moved in a magnetic field. These eddy currents, in turn, will create an eddy current magnetic field. Eddy current field (class 2) sources aboard a ship or craft will emanate eddy current magnetic fields as they roll and pitch in the earth's magnetic field. Consequently, the magnitude of eddy current magnetic fields needs to be controlled aboard minesweepers that sweep for magnetic-influence mines. The vertical component of the eddy current magnetic field emanated in a horizontal plane beneath the surface of the water is usually the most critical component of the eddy current magnetic field. This test method is used to determine the magnitude of the vertical component of the eddy current magnetic field on a horizontal plane that is a distance below the center of the test sample. This method is distinguished from test method EF01 which measures the field at points that are equidistant from the center of the test sample. This test method, like test method EF01, is accomplished in a controlled magnetic environment which is created by a test coil system, which is rotated about the test sample of the eddy current field source. Alternatively, the test sample could be rotated in the magnetic field created by the test coil system. Required information from the specifications for the test sample for this test method is the distance from the center of the test sample to the horizontal plane at which the eddy current magnetic field is to be measured.

2. Center of the test sample. Center of the test sample refers to the geometric center of the sample.

3. Apparatus.

3.1 Test coil system. The test coil system shall consist of the test coil, its power supply and control system. The test coil, either a Helmholtz coil or an equivalent coil array, shall produce applied magnetic fields in the three orthogonal directions (triaxial). The magnetic field gradient caused by the coil's field and any magnetic field distortion from the immediate environment over the volume occupied by the test sample shall not exceed 0.1 percent of the applied field per meter or 0.0016 A/m (flux density is 2 nT) per meter, whichever is greater. The coil shall generate magnetic fields to a maximum of 43 A/m (54 μT) with an accuracy of at least 0.05 percent of the applied field or 0.0002 A/m (flux density is 0.25 nT), whichever is greater. The power supply shall supply the current required for adequately long periods without drift or fluctuation. A storage battery of adequate capacity is a satisfactory power source. A direct current generator may be used, but may require a voltage regulator to maintain a constant output. An alternating current source with a rectifier can be used, provided the output is well filtered and the voltage is regulated and free of excessive switching transients. The power source should not be used for any other test or load simultaneously with this test.

3.2 Roll mounting fixture for test coil. The test coil shall be mounted on a roll mounting fixture which shall roll the test coil at a rate of 5 to 7 cycles per minute in one plane to angles of 45 degrees on either side of the vertical in increments of 15 degrees. The magnitude of the vertical and horizontal components of the magnetic field occupied by the air core volume specified in the test procedures shall rotate as the test coil rotates and shall be maintained at the same values and tolerances throughout the rotation.

3.3 Magnetometers. Monoaxial fluxgate magnetometers consisting of a sensor unit and an electronic unit with a minimum sensitivity of 0.0002 A/m (flux density is 0.25 nT) and a dynamic range of $\pm$ 90 A/m ($\pm$ 113 μT) shall be used for the horizontal array of magnetometers. Each electronic unit shall include as a minimum a continuous reading instrument to measure the field magnitude, as the test coil rotates through its roll angle.

3.4 Mounting frame for the array of magnetometers' sensors. A nonferrous, non-electrically conductive rectangular frame for the mounting of magnetometers' sensors shall be provided (see figure EF02-1). The sensors mounted on the frame shall be located on a horizontal plane at the specified distance below the center of the test sample. One sensor shall be located directly below the center of the test sample (center sensor). The remainder of the sensors in the array shall be located at spacings equal to 0.25 of the vertical distance from the center sensor to the center of the test sample. The periphery of the array shall be no closer to the center sensor than twice the vertical distance from the center sensor to the center of the test sample. Each sensor shall be vertical within 0.5 degree.

3.5 Mounting structure. A nonferrous, non-electrically conductive mounting structure shall be used for positioning the test sample within the test coil and over the mounting frame for the array of magnetometer's sensors.

4. Test sample. Volume of the test sample is limited by the size of the test coil and mounting frame for the array of magnetometer's sensors, access to the mounting structure within them, and clearance distances for the roll of the test core. Mass of the test sample is limited by the loading limitations of the mounting structure. The test sample shall be identical in composition to the item to be installed and shall be oriented with respect to the horizontal and vertical components of the test coil, as it would be in its intended installation.

5. Procedure.

5.1 Energize the test coil system such that the air core volume to be occupied by the test sample is subjected to a vertical magnetic field of 43 A/m (54 μT) and a horizontal magnetic field of 12 A/m (15 μT).

5.2 Place the test sample in position, so that it is orientated with respect to the roll plane of the coil as it would be orientated to the athwartship direction aboard the ship or craft. Record the position of the test sample with respect to the test coil and the array of magnetometers' sensors. The center of the test sample shall coincide with the center of the test coil at 0 degrees roll within plus or minus 10 cm.

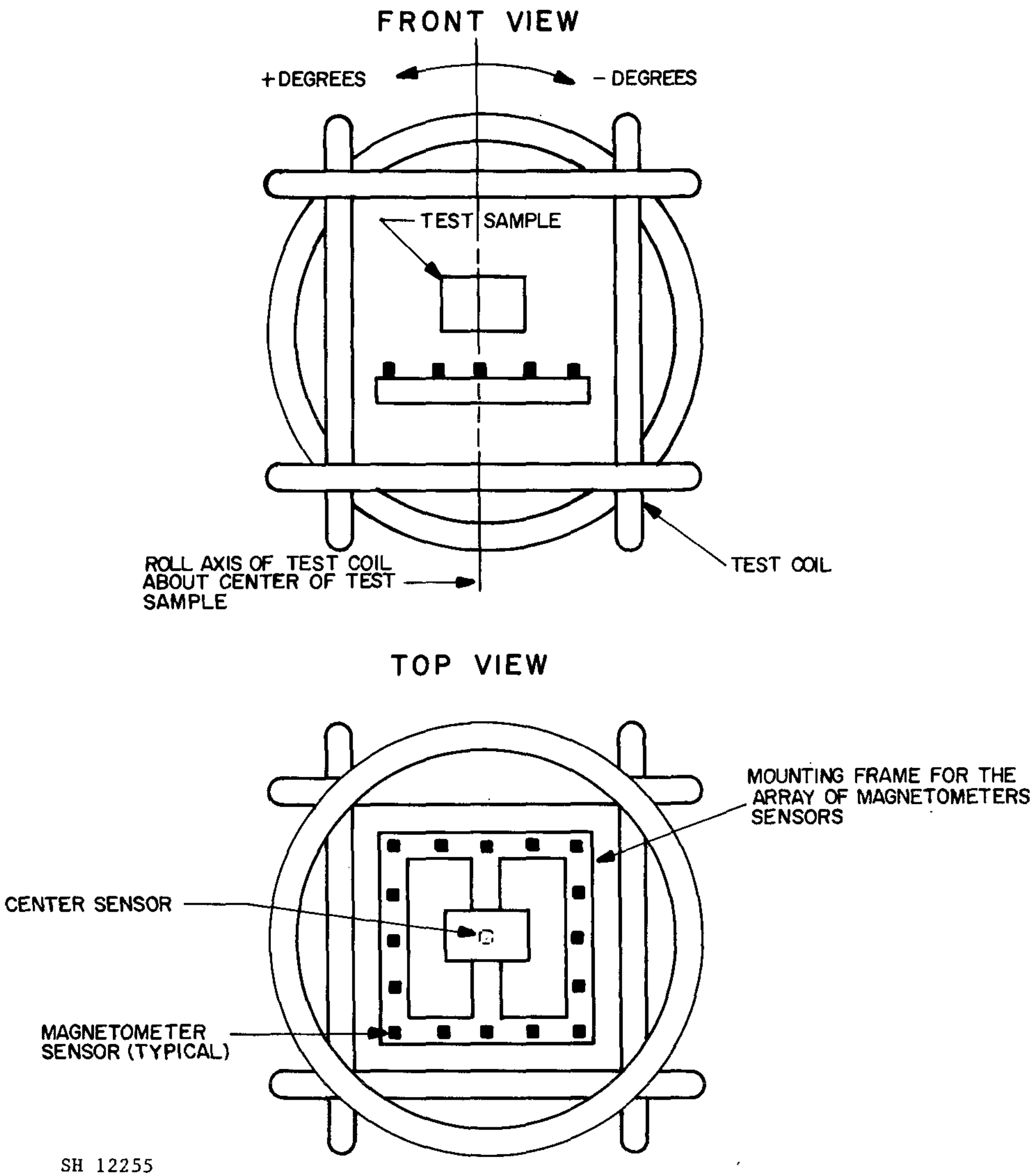


FIGURE EF02-1. Configuration of mounting frame for sensors.

5.3 Rotate the test coil in its roll plane through an angle of 15 degrees from one side of the vertical to the other side (starboard orientation plus (+) degrees and port orientation (-) degrees) at a rate between 5 to 7 cycles (0 to +15 degrees or 0 to -15 degrees) per minute.

5.4 Record the test coil roll angle and rate. Measure the maximum field magnitude during the roll from the continuous reading instrument.

5.5 Repeat 5.3 and 5.4 for 30 degrees and 45 degrees roll angles.

5.6 Remove the test sample from within the test coil and repeat 5.3 through 5.5.

5.7 Reinsert the test sample within the coil, so that it is oriented with respect to the roll plane of the coil as it would be oriented to the forward-aft direction aboard the ship or craft. Record the position of the test sample with respect to the test coil. The center of the test sample shall coincide with the center of the test coil at 0 degrees roll angle within plus or minus 10 cm.

5.8 Repeat 5.3 through 5.6. Test coil roll plane angles are plus (+) degrees for forward pitch and minus (-) degrees for aft pitch.

5.9 Adjust the test coil system so that the air core volume to be occupied by the test sample is subjected to a vertical magnetic field component of 10 A/m (12.6 µT) and a horizontal magnetic field component of 34 A/m (42.7 µT).

5.10 Repeat 5.2 through 5.8.

6. Calculations. Calculate the difference between the vertical component of the magnetic field with the test sample present within the test coil and the test sample removed from within the test coil for each position measured for the three test coil roll angles, as follows:

$$H_p\ (i,j,k) - H_a\ (i,j,k) = H_v\ (i,j,k);\ i = 1 \text{ to } n,\ j = 1, 2,\ k = 1, 2, 3$$

where:

H_p = measured magnetic field with the test sample present.
H_a = measured magnetic field with the test sample removed.
H_v = eddy current magnetic field emanating from the test sample.
i = position designator of the magnetometer for each of the positions measured; $i = 1$ to n.
n = total number of magnetometers in the array.
j = designator for air core magnetic field condition; $j = 1$ corresponds to the field of 43 A/m vertical and 12 A/m horizontal; $j = 2$ corresponds to the field of 10 A/m vertical and 34 A/m horizontal.
k = designator for test coil, roll angle; $k = 1$ corresponds to a roll angle of 15 degrees; $k = 2$ corresponds to a roll angle of 45 degrees.

7. Test report. The test report shall include the following information:

(a) Identification of the test sample.
(b) Identification of the magnetometers used, including manufacturer's and identification number.
(c) Identification of the roll mounting fixture, mounting frame for the array of magnetometers' sensors and the mounting structure for the test sample.
(d) Position of the test sample with respect to the test coil at 0 degree roll angle.
(e) All recorded and calculated field values.

TEST METHOD EF03

EDDY CURRENT MAGNETIC FIELD FROM A CLASS 2 SOURCE
CAUSED BY OSCILLATORY MOTION
IN AN AMBIENT MAGNETIC ENVIRONMENT

1. Scope. An electrically conductive material will generate within itself eddy currents when it is moved in a magnetic field. These eddy currents, in turn, will create an eddy current magnetic field. Eddy current magnetic field (class 2) sources aboard a ship or craft will emanate eddy current magnetic fields as they roll and pitch in the earth's magnetic field. Consequently, the magnitude of eddy current magnetic fields needs to be controlled aboard minesweepers that sweep for magnetic-influence mines. This test method is used to determine the magnitude of the vertical component of the eddy current magnetic field at a fixed distance below the center of the test sample, as the test sample is moved in an oscillatory manner over the measured point. This test is accomplished in an ambient (earth's) magnetic environment. Required information from the specifications for the test sample for this test method is the distance below the center of the test sample at which the eddy current magnetic field is to be measured.

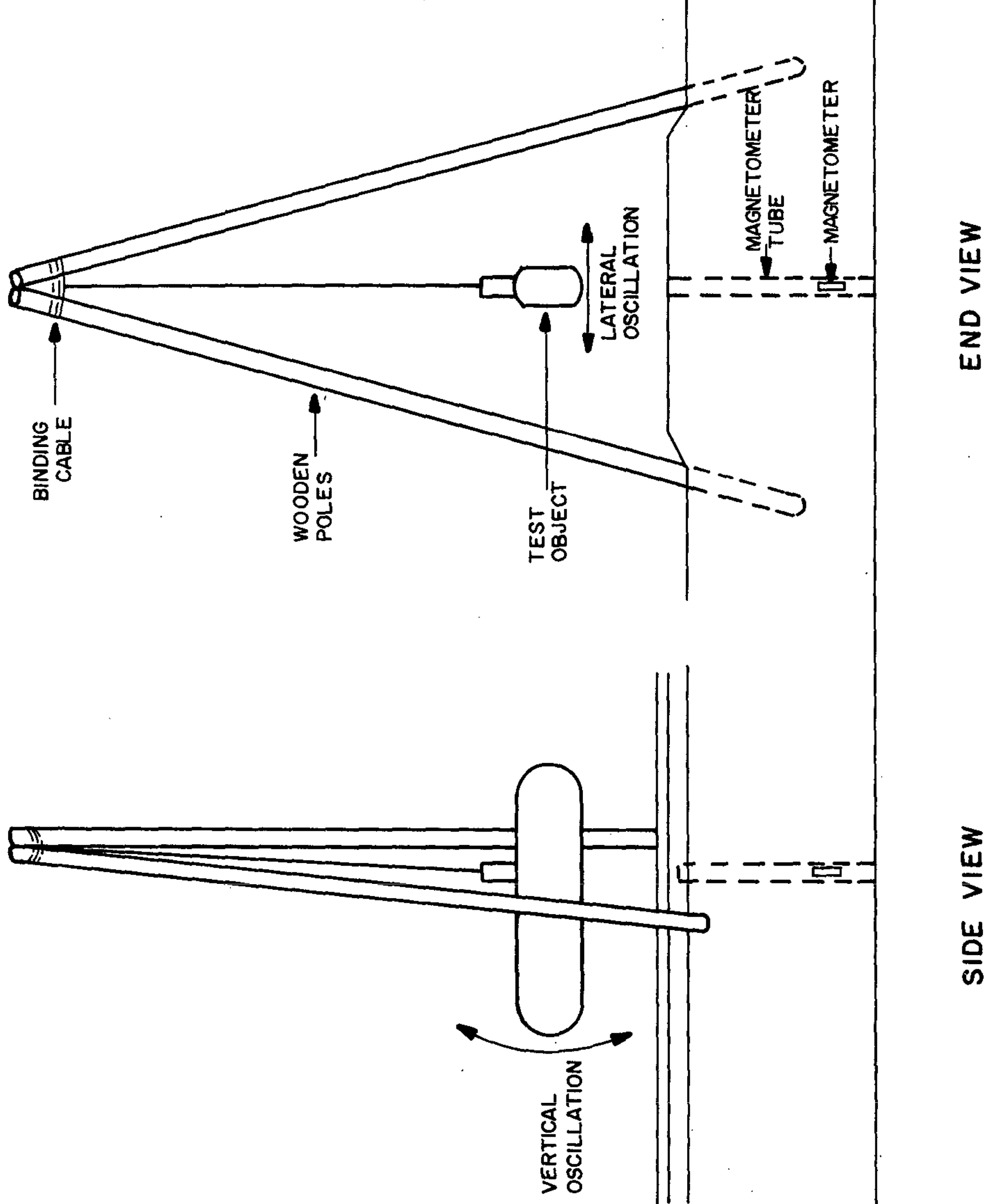
2. Center of the test sample. Center of the test sample refers to the geometric center of the sample.

3. Apparatus.

3.1 Pendulum support structure. A pendulum support structure shall be constructed of wooden poles, binding cable and test sample support cable (see figure EF03-1). The height and breadth of the structure shall allow a 45 degree movement from the vertical of the test sample support cable with the test sample attached in the vertical and lateral oscillatory directions.

3.2 Magnetometer. A monoaxial fluxgate magnetometer consisting of a sensor unit and an electronic unit with a minimum sensitivity of 0.0002 A/m (0.25) and a dynamic range of $\pm$ 90 A/m ($\pm$ 113 μT) shall be used. The electronic unit shall include, as a minimum, a manually controllable field neutralization subsystem to null out the earth's field magnitude and a continuous recording instrument so that the magnitude of the absolute field is continuously read as the test sample is moved. The magnetometer shall be located directly below the center of the test sample when the test sample support cable is at 0 degree with the vertical at the distance specified (see figure EF02-1).

4. Test sample. Volume of the test sample is limited by the dimensions of the pendulum support structure. Mass of the test sample is limited by the loading limitations on the pendulum support structure. The test sample shall be identical in composition to the item to be installed and shall be oriented with respect to the vertical component of the earth's magnetic field, as it would be in the intended installation.



SH 12256

FIGURE EF03-1. Configuration of test sample, structure and sensor.

5. Procedure.

5.1 With the test sample removed from the test site, measure the earth's magnetic field at the magnetometer's sensor and null it out with the magnetometer's control circuit.

5.2 Mount the test sample on the pendulum support structure and record its position with respect to the structure.

5.3 Raise the test sample in the vertical direction so that the test sample support cable is at an angle of 15 degrees with the vertical. Release the test sample and record the magnitude of the field at the sensor on the continuous recording equipment, as the test sample oscillates in the vertical direction.

5.4 Repeat 5.3 for 30 degrees and 60 degrees.

5.5 Raise the test sample in the lateral direction so that the test sample support cable is at an angle of 15 degrees with the vertical. Release the test sample and record the magnitude of the field at the sensor on the continuous recording equipment, as the test sample oscillates in the lateral direction.

5.6 Repeat 5.5 for 30 degrees and 60 degrees.

5.7 Remove the test sample from the pendulum support structure and remeasure the earth's magnetic field at the magnetometer's sensor. If this final measurement of the earth's field differs from the initial measurement at that point by more than 1 nT, the test results are not valid.

6. Test report. The test report shall include the following information:

(a) Identification of the test sample.
(b) Identification of the magnetometer used, including manufacturer's and identification number.
(c) Identification of the pendulum support structure for the test sample.
(d) Position of the test sample with respect to the pendulum support structure.
(e) All recorded field values.

TEST METHOD SF01

STRAY MAGNETIC FIELD FROM A CLASS 3 SOURCE MEASURED AT A DISTANCE IN AN AMBIENT MAGNETIC ENVIRONMENT

1. Scope. Minesweepers are carefully built of nonmagnetic materials wherever possible. When magnetic materials are necessary, their magnetic field is accurately compensated for by a degaussing system. However, the stray magnetic field caused by direct current carrying conductors of ship machinery, such as those found in the generators which produce the large currents for the minesweeping cables, cannot be compensated for by the usual degaussing techniques, since they are not constant nor as predictable a source of magnetic fields as the sources which consist primarily of magnetic materials. The stray magnetic field caused by these stray magnetic field (class 3) sources must be measured, to ensure that they are minimized in accordance with their specifications. This test method is used to determine the magnitude of the normal component of the stray magnetic field at a number of measurement points that are equidistant from the center of the test sample. This test is accomplished in an ambient (earth's) field environment. Consequently, variations in the earth's field at the test site must be automatically compensated for so that accurate results can be achieved. Required information from the specifications for the test sample for this test method is the distance from the center of the test sample at which the stray magnetic field is to be measured.

2. Center of the test sample. Center of the test sample refers to the geometric center of the test sample.

3. Apparatus.

3.1 Magnetometer. A monoaxial fluxgate magnetometer consisting of a sensor unit and an electronic unit with a minimum sensitivity of 0.0002 A/m (flux density is 0.25 nT) and a dynamic range of $\pm$ 90 A/m ($\pm$ 113 μT) shall be used. The electronic unit shall include as a minimum an automatically controllable field neutralization subsystem to null out the earth's field magnitude and a meter to measure the absolute field magnitude. A chart recorder may be utilized to facilitate data collection.

3.2 Gimbal fixture. A nonferrous gimbal fixture, with a circular ring, shall be used for the mounting of the magnetometers' sensor (see figure SF01-1). The ring shall have a radius equal to the distance from the center of the test sample at which the field is to be measured. The magnetometer's sensor shall be mounted on the ring in a manner that will allow sensing at the specified distance. The ring shall lie on a horizontal plane so that it is centered about the center of the test sample within plus or minus 10 cm and can be rotated in 45 degree increments in the plane of the ring and in the plane perpendicular to the plane of the ring (see figures SF01-1 and SF01-2). Multiple magnetometers may be used to decrease the number of rotations required for a full set of readings.

3.3 Mounting structure. A nonferrous mounting structure shall be used for positioning the test sample within the gimbal fixture.

3.4 Power supplies. Electrical power supplies shall be provided as required to operate the test sample over its full operating range.

3.5 Loads. Mechanical and electrical loads shall be provided as required to operate the test sample over its full operating range.

4. Test sample. Volume of the test sample is limited by the size of the gimbal fixture and access to the mounting structure within the fixture. Mass of the test sample is limited by the loading limitations of the mounting structure. The test sample shall be identical to the equipment to be installed and shall be oriented with respect to the vertical component of the earth's magnetic field, as it would be in its intended installation. The test sample shall operate over its full operating range, including overload conditions.

5. Procedure.

5.1 Place the test sample in position and record the position of the test sample with respect to the gimbal fixture.

5.2 Connect all power and control circuits as they would be connected in the actual installation.

5.3 Energize all power and control circuits to rated output and as further specified in the test plan approved by the contracting activity.

5.4 Place the magnetometer's sensor in position 1 (see figure SF01-2); measure and record the field magnitude.

5.5 Rotate the ring of the gimbal fixture + 45 degrees in the plane of the ring; measure and record the field magnitude (position 2).

5.6 Repeat 5.5 six times (positions 3 through 8).

5.7 Rotate the ring of the gimbal fixture + 45 degrees in the plane of the ring and then + 45 degrees in the plane containing the magnetometer's sensor and the point on the ring 180 degrees from the sensor.

5.8 Measure and record the field magnitude (position 9). Repeat 5.5 and 5.6 with the exception that positions + 90 degrees and + 270 degrees are eliminated (positions 10 through 14).

5.9 Repeat 5.7 and 5.8 two times (positions 15 through 26).

5.10 Conduct addtional test cycles consisting of 5.3 through 5.9 in accordance with the requirements of the contracting activity.

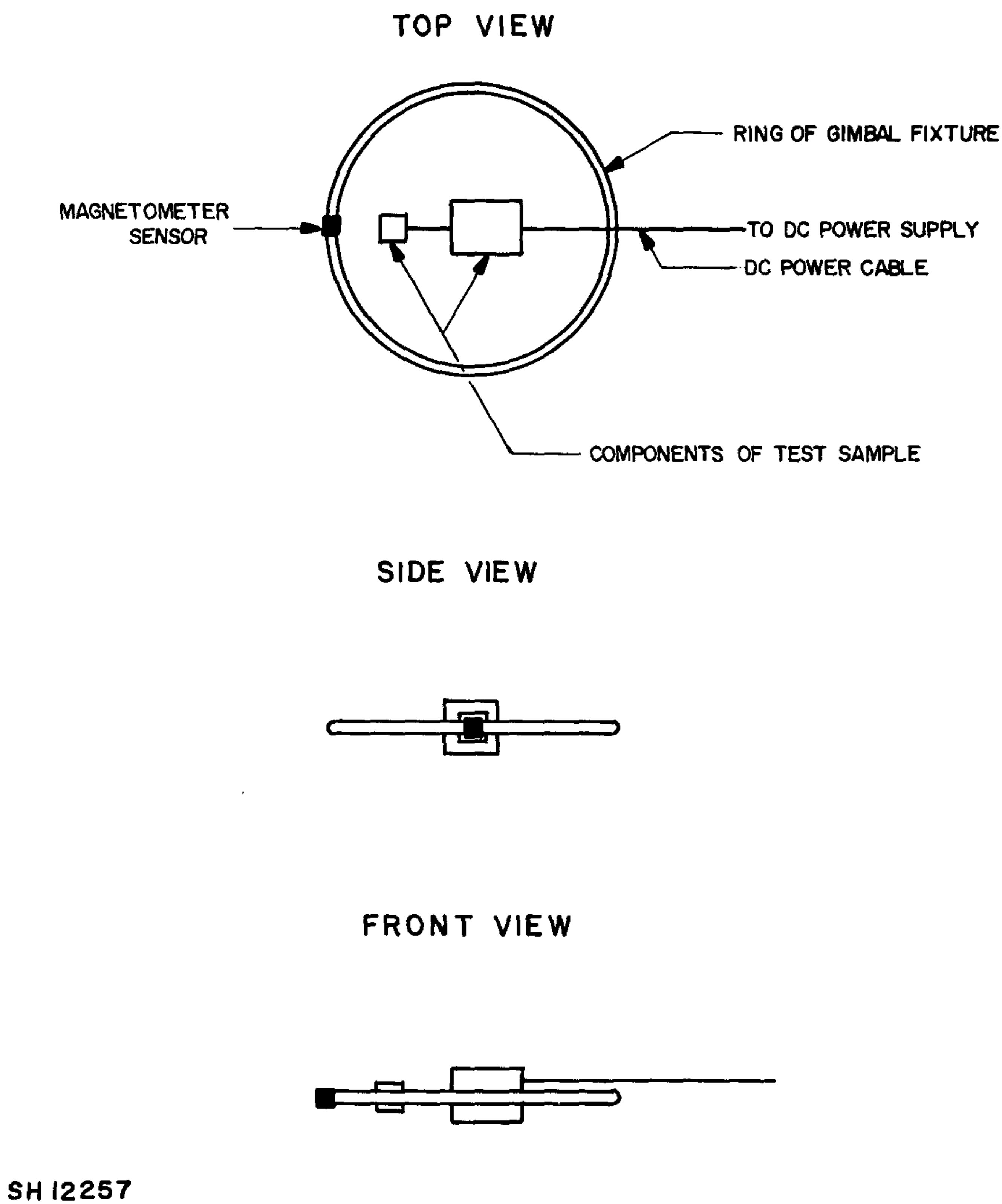
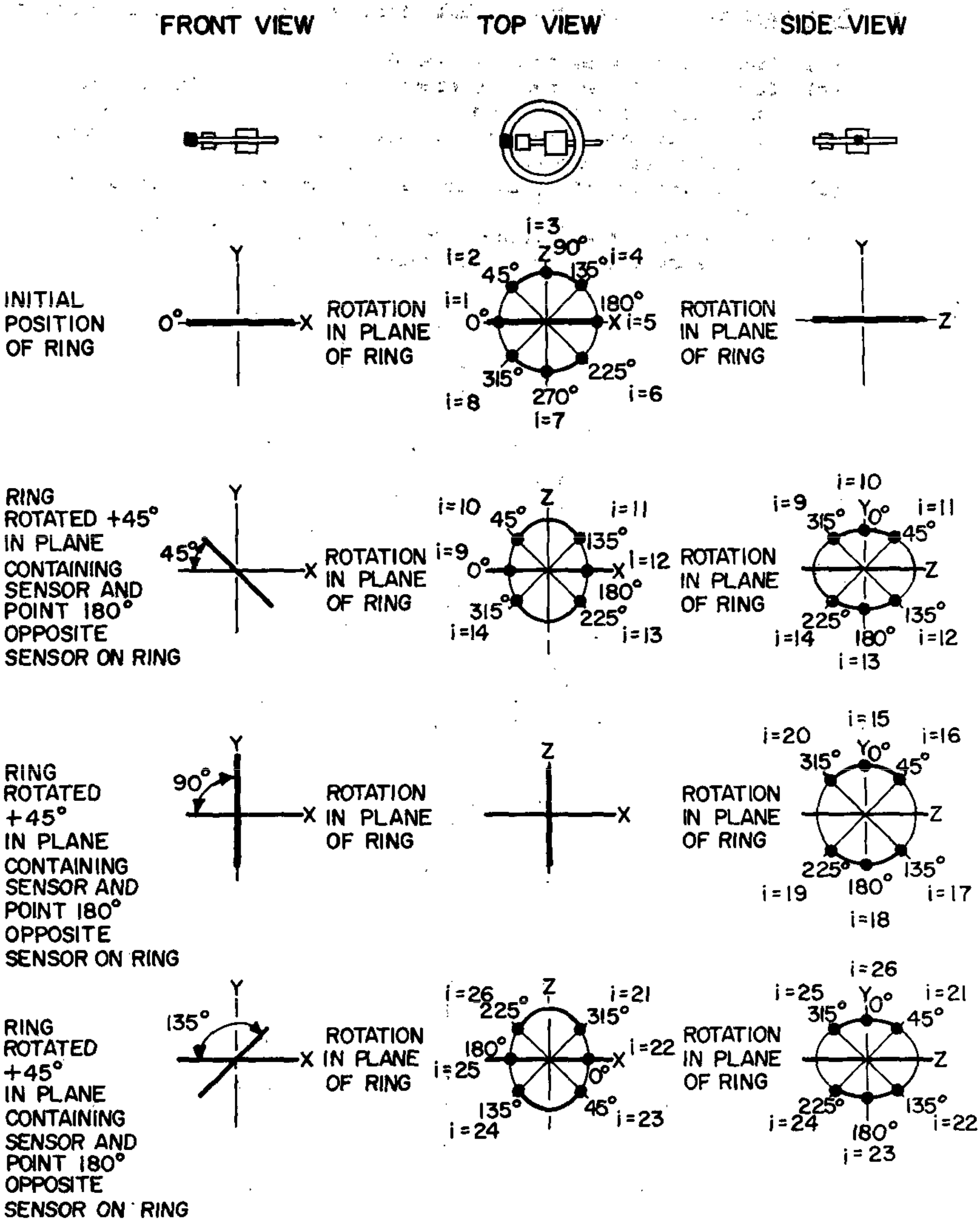


FIGURE SF01-1. Configuration of ring for gimbal fixture.



SH 12258

FIGURE SF01-2. Magnetometer position designators (i).

6. Test report. The test report shall include the following information:

(a) Identification of the test sample.
(b) Identification of the magnetometer used, including manufacturer's and identification number.
(c) Identification of the gimbal fixture and mounting structure for the test sample.
(d) Identification of power supplies and loads used with the test sample.
(e) All recorded field values and the operating conditions of the test sample when they were recorded.

TEST METHOD SF02

STRAY MAGNETIC FIELD FROM A CLASS 3 SOURCE
MEASURED ON A HORIZONTAL PLANE
IN AN AMBIENT MAGNETIC ENVIRONMENT

1. Scope. Minesweepers are carefully built of nonmagnetic materials whereever possible. When magnetic materials are necessary, their magnetic field is accurately compensated for by a degaussing system. However, the stray magnetic field caused by direct current carrying conductors of ship machinery, such as those found in the generators which produce the large currents for the minesweeping cables, cannot be compensated for by the usual degaussing techniques, since they are not constant nor as predictable a source of magnetic fields as the sources which consist primarily of magnetic materials. The stray magnetic field caused by these stray magnetic field (class 3) sources must be measured, to ensure that they are minimized in accordance with their specifications. In minesweeper applications, the vertical component of the stray magnetic field emanated in a horizontal plane beneath the surface of the water is usually the most critical component of the stray magnetic field. This test method is used to determine the magnitude of the vertical component of the stray magnetic field on a horizontal plane that is a distance below the center of the sample. This method is distinguished from test method SF01, which measures the field at points that are equidistant from the center of the test sample. This test method, like test method SF01, is accomplished in an ambient (earth's) field environment. Consequently, variations in the earth's field at the test site must be automatically compensated for so that accurate results can be achieved. Required information from the specifications, for the test sample for this test method, is the distance from the center of the test sample to the horizontal plane at which the stray magnetic field is to be measured.

2. Center of the test sample. Center of the test sample refers to the geometric center of the test sample.

3. Apparatus.

3.1 Magnetometers. Monoaxial fluxgate magnetometers consisting of a sensor unit and an electronic unit with a minimum sensitivity of 0.0002 A/m (flux density is 0.25 nT) and a dynamic range of $\pm$ 90 A/m ($\pm$ 113 µT) shall be used for the horizontal array of magnetometers. Each electronic unit shall include, as a minimum, an automatically controllable field neutralization subsystem to null out the earth's field magnitude and a meter to measure the absolute field magnitude. If an automatic data collection system is used, the sensors may be multiplexed into a limited number of electronic units which automatically record the field measured by each sensor.

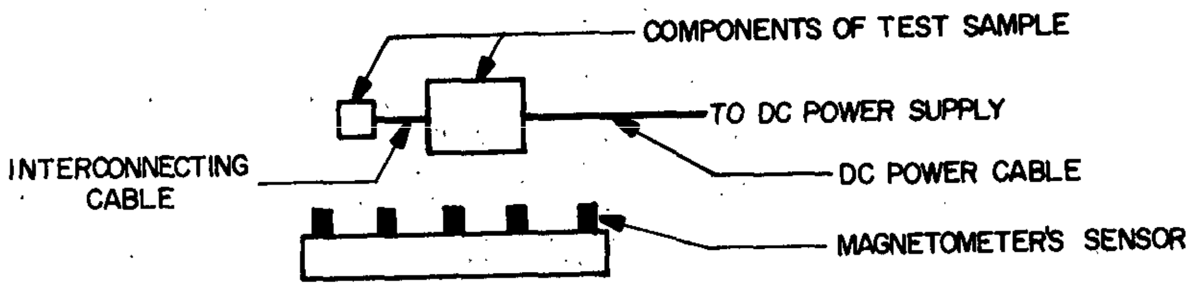
3.2 Mounting frame for the array of magnetometers. A nonferrous, rectangular frame for the mounting of the magnetometers' sensors shall be provided (see figure SF02-1). The sensors mounted on the frame shall be located on a horizontal plane at the specified distance below the center of the test sample. One sensor shall be located directly below the center of the test sample (center sensor). The remainder of the sensors in the array shall be located at spacings equal to 0.25 of the vertical distance from the center sensor to the center of the test sample. The periphery of the array shall be no closer to the center sensor than twice the vertical distance from the center sensor to the center of the test sample. Each sensor shall be vertical within 0.5 degree.

3.3 Mounting structure. A nonferrous mounting structure shall be used for positioning the test sample with respect to the mounting frame.

3.4 Power supplies. Electrical power supplies shall be provided as required, to operate the test sample over its full operating range.

3.5 Loads. Mechanical and electrical loads shall be provided as required, to operate the test sample over its full operating range.

FRONT VIEW



TOP VIEW

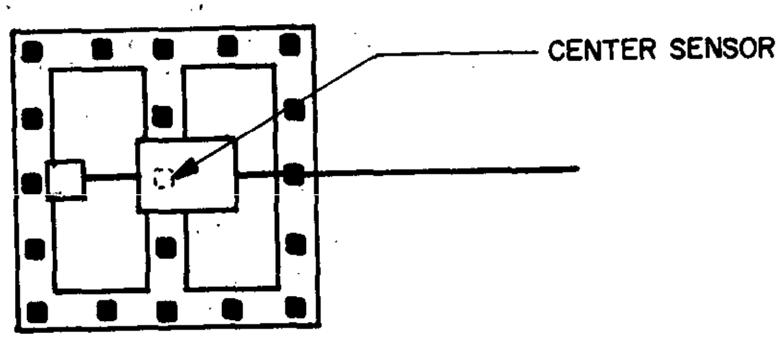


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FIGURE SF02-1. Configuration of mounting frame for sensors.

APPENDIX

DATA REQUIREMENTS

10. DATA

10.1 Data requirements. When this standard is used in a contract which incorporates a DD Form 1423 and invokes the provisions of 7-104.9(n) of the Defense Acquisition Regulation (DAR), the data requirements identified below will be developed as specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the approved Contract Data Requirements List (DD Form 1423) incorporated into the contract. When the provisions of DAR-7-104.9(n) are not invoked, the data specified below will be delivered by the contractor in accordance with the contract requirements. Deliverable data required by this standard is cited in the following paragraphs:

Paragraph no.	Data requirement title	Applicable DID no.	Option
5.1	Procedures, test	UDI-T-23732	---
5.5	Reports, test	DI-T-2072	10.1.b

(Copies of data item descriptions required by the contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

10.1.1 The data requirements of 10.1 and any task in the standard required to be performed to meet a data requirement may be waived by the contracting/acquisition activity upon certification by the offeror that identical data were submitted by the offeror and accepted by the Government under a previous contract for identical item acquired to this standard. This does not apply to specific data which may be required for each contract, regardless of whether an identical item has been supplied previously (for example, test reports).

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
DOD-STD-2142(SH)	

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
	☐ VENDOR ☐ USER ☐ MANUFACTURER ☐ OTHER *(Specify)*: ______
b. ADDRESS *(Street, City, State, ZIP Code)*	

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

DD FORM 82 MAR 1426 PREVIOUS EDITION IS OBSOLETE.

(TO DETACH THIS FORM, CUT ALONG THIS LINE.)