Designation: F2046 – 00 (Reapproved 2017)

An American National Standard

Standard Specification for Tachometers, Various[1]

This standard is issued under the fixed designation F2046; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This specification covers various tachometers capable of measuring rotational shaft speed.

1.2 Special requirements for tachometer types used in naval shipboard applications are included in Supplement S1.

1.3 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D3951 Practice for Commercial Packaging

3. Terminology

3.1 *Definitions:*

3.1.1 *SI (Le Systeme International d'Unites) Units, n*—units of measurement recognized by the Comite' International des Poids et Mesures (CIPM).

3.1.2 *tachometer, n*—an instrument capable of generating, transmitting, and indicating information or signal that can be convened into a function of rotational speed.

4. Classification

4.1 *Design Types*—The following are among the types of tachometers available:

(1) Centrifugal;
(2) Centrifugal, flexible drive;
(3) Chonometric;
(4) Electrical, alternating current (ac) voltage responsive, direct drive;
(5) Electrical reactance;
(6) Electrical, magnetovoltmeter, direct drive;
(7) Electrical, magnetovoltmeter;
(8) Frequency responsive, electrical control box and voltmeter, direct drive;
(9) Frequency sensitive, electrical, nonrotating magnetic pickup, direct drive, consists of a magnetic pickup, transducer, and indicator;
(10) Photoelectric;
(11) Digital contact;
(12) Centrifugal, flexible drive; and
(13) Vibrating resonant reed.

5. Ordering Information

5.1 The buyer shall provide the manufacturer with all of the pertinent application data in accordance with the acquisition requirements, 5.2.

5.2 *Acquisition Requirements*—Acquisition documents shall specify the following:

(1) Title, number, and date of this specification;
(2) Quantity of tachometers required;
(3) Range;
(4) Manufacturer's part number;
(5) When qualification inspection is required;
(6) Final disposition of qualification test samples;
(7) Type of electrical connection;
(8) Mounting method;
(9) Environmental requirements;
(10) Materials;
(11) Size and weight restrictions;
(12) Critical service life requirements;
(13) Performance requirements;
(14) Surface finish requirements;
(15) Cleaning requirements;
(16) When certification is required;
(17) Marking requirements;
(18) Packaging requirements; and
(19) Preservation requirements.

[1] This specification is under the jurisdiction of ASTM Committee F25 on Ships and Marine Technology and is the direct responsibility of Subcommittee F25.10 on Electrical.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

6. Materials and Manufacture

6.1 *Material Selection*—The materials for all parts shall be selected for long-term compatibility with the environment in which the tachometer will be installed or used.

6.2 *Material Inspection*—The manufacturer shall be responsible for ensuring that materials used are manufactured, examined, and tested in accordance with the specifications and standards as applicable.

7. Physical Properties

7.1 *Size and Weight*—The buyer may have intended applications where size and weight are limited. Size and weight limitations shall be specified in the acquisition requirements.

8. Performance Requirements

8.1 *Service Life*—The buyer may have a minimum specified service life requirement. Critical service life requirements shall be specified in the acquisition requirements.

8.2 *Tachometer Performance*—Performance tolerances are usually specified in percentage of range span. The following performance characteristics and environmental exposures may or may not be important to each buyer's intended application.

(1) Accuracy,
(2) Repeatability,
(3) Damping,
(4) Temperature,
(5) Humidity,
(6) Salt spray,
(7) Vibration,
(8) Shock, and
(9) Electromagnetic interference (EMI).

9. Workmanship, Finish, and Appearance

9.1 *Cleaning, Finish, and Appearance*—Any special cleaning, surface finish, and appearance requirements shall be specified in the acquisition requirements.

10. Inspection

10.1 *Classification of Inspections*—The inspection requirements specified herein are classified as follows:

(1) Qualification testing, and
(2) Quality conformance testing.

10.2 *Qualification Testing*—Qualification test requirements shall be specified, where applicable. Test methods should be identified for each design and performance characteristic specified. Test report documentation requirements should also be specified.

10.3 *Quality Conformance Testing*—Quality conformance inspection is accomplished when acceptance and qualification testing is satisfied by a previous acquisition or when the product has demonstrated reliability in similar applications. Quality conformance inspection is usually less intensive than acceptance and qualification, often verifying that samples of a production lot meet a few critical performance requirements.

11. Number of Tests and Retests

11.1 *Test Specimens*—The number of test specimens to be subjected to qualification testing shall depend on the tachometer design. If each range is covered by a separate and distinct design, a test specimen for each range will require testing. In instances in which a singular design series may cover multiple ranges and types, it is recommended that three test specimens be tested provided the electrical and mechanical similarities are approved by the buyer. In no case, however, should less than three units, one unit each representing low, medium, and high ranges, be tested, regardless of design similarity.

12. Test Methods

12.1 *Tests*—All tests shall be performed in accordance with ASTM, American Society of Mechanical Engineers (ASME), or industry standards as specified.

12.2 *Test Data*—All test data shall remain on file at the manufacturer's facility for review by the buyer upon request. It is recommended that test data be retained in the manufacturer's files for at least three years or a period of time acceptable to the buyer and manufacturer.

13. Quality Assurance Provisions

13.1 *Warranty:*

13.1.1 *Responsibility for Warranty*—Unless otherwise specified, the manufacturer is responsible for the following:

(1) All materials used to produce a unit and
(2) Manufacturer will warrant his product to be free from defect of workmanship to produce the unit.

14. Certification

14.1 When specified in the purchase order or contract, the buyer shall be furnished certification that samples representing each lot have been either tested or inspected as directed in this specification, and the requirements have been met. When specified in the purchase order or contract, a report of the test results shall be furnished.

15. Product Marking

15.1 User-specified product marking shall be listed in the acquisition requirements. The minimum data to be clearly marked on each tachometer shall include the following:

(1) Manufacturer's name,
(2) Manufacturer's part number,
(3) Serial number or lot number,
(4) Date of manufacture, and
(5) Range.

16. Packaging and Package Marking

16.1 *Packaging of Product for Delivery*—Product shall be packaged for shipment in accordance with Practice D3951.

16.2 Any special preservation, packaging, or package marking requirements for shipment or storage shall be identified in the acquisition requirements.

17. Keywords

17.1 tachometer

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements established for U.S. Naval shipboard application shall apply when specified in the contract or purchase order. When there is conflict between this standard (Specification F2046) and this supplement, the requirements of this supplement shall take precedence for equipment acquired by this supplement. This document supersedes MIL-T-16049C, *Tachometers: Electrical; Self-Generating; Mechanical, Fixed Mounting, and Hand Held; and Vibrating Reed*, for new ship construction. This document also supersedes MIL-T-24797, *Tachometers, Fiber Optic, (Naval Shipboard Use), (Metric) General Specification for*, for new ship construction.

TACHOMETERS: ELECTRIC AND FIBER OPTIC, FIXED MOUNTING

S1. Scope

S1.1 This supplement covers single-range noncontact electric and fiber-optic tachometers capable of generating, transmitting, and indicating information or signal that can be converted into a function of rotational speed. The subject tachometers may be used in shipboard systems, such as gas generators, power turbines, propulsion shafts, and gas steam turbine generators.

S1.2 Vibrating reed resonant-type tachometers are not covered in this specification.

S1.3 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

S2. Referenced Documents

S2.1 *Commercial Documents:*

S2.1.1 *ASTM Standards:*[2]

B117 Practice for Operating Salt Spray (Fog) Apparatus

D3951 Practice for Commercial Packaging

S2.1.2 *ANSI/ISA Standards:*[3]

ANSI/ISA S37.1 (R-1982) Electrical Transducer Nomenclature and Terminology

ANSI/ASQC Q9001-1994 Quality Systems—Model for Quality Assurance in Design, Development, Production, Installation, Inspection, Testing, and Servicing

S2.1.3 *Electronic Industries Association (EIA) Standards:*[4]

RS-422 Electrical Characteristics of Balanced Voltage Digital Interface Circuit

455-22 FOTP-22 Ambient Light Susceptibility of Fiber Optic Components

455-34 FOTP-34 Interconnection Device Insertion Loss Test

S2.2 *Government Documents:*

S2.2.1 *Military Standards:*[5]

MIL-STD-461 Electromagnetic Interference Characteristics of Subsystems and Equipment, Requirements for the Control of

MIL-STD-167-1 Mechanical Vibrations of Shipboard Equipment (Type I—Environmental and Type II—Internally Excited)

S2.2.1 *Military Specifications:*[5]

MS3452 Connector, Receptacle, Electric, Box Mounting, Rear Release, Crimp Contact, AN Type

MS3456 Connector, Plug, Electrical, Rear Release, Crimp Contact, AN Type

MIL-C-5015 Connectors, Electrical, Circular Threaded, AN Type General Specification for

MIL-M-24794 Material, Index Matching, Fiber Optics

MIL-F-49291 Fiber, Optical, (Metric), General Specifications for

MIL-C-83522 Connectors, Fiber Optic, Single Terminus, General Specification for

MIL-C-83522/16 Connector, Fiber Optic, Single Terminus, Plug, Adapter Style, 2.5 mm Bayonet Coupling, Epoxy

MIL-C-83522/17 Connector, Fiber Optic, Single Terminus, Adapter, 2.5 mm Bayonet Coupling, Bulkhead Panel Mount

MIL-C-83522/18 Connector Fiber Optic, Single Terminus, Adapter, 2.5 mm Bayonet Coupling, PC Mount

MIL-C-85045 Cables, Fiber Optic, (Metric), General Specification for

MIL-S-901 Shock Tests, H.I. (High Impact), Shipboard Machinery, Equipment, and Systems, Requirements for

S3. Terminology

S3.1 *Definitions*—Terms marked with "ANSI/ISA S37.1" are taken directly from ANSI/ISA S37.1 (R-1982) and are included for the convenience of the reader.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from IHS Markit Ltd, https://www.ihs.com/products/eia-standards.html.

[5] Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, http://quicksearch.dla.mil.

S3.1.1 *ambient conditions, n*—conditions, such as pressure and temperature, of the medium surrounding the case of a sensor.

ANSI/ISA S37.1

S3.1.2 *calibration, n*—test during which known values of measurands are applied to the sensor and corresponding output readings are recorded under specific conditions.

ANSI/ISA S37.1

S3.1.3 *environmental conditions, n*—specified external conditions, such as shock, vibration, and temperature, to which a sensor may be exposed during shipping, storage, handling, and operation.

ANSI/ISA S37.1

S3.1.4 *error, n*—the error for a given value of the input variable (measurand) is the difference between the measured value of the output signal and the expected value of the output signal. The expected value of the output signal for any value of the measurand shall be represented by a straight line whose end points are given by:

S3.1.4.1 The specified value of the output signal at the minimum input value of the measurand (for example, 4 mA at the minimum specified rotational speed).

S3.1.4.2 The specified value of the output signal at the maximum input value of the measurand (for example, 20 mA at the maximum specified rotational speed).

S3.1.5 *noncontact tachometer, n*—any type of tachometer that senses or responds to rotational speed without physical contact or mechanical connection to the shaft being measured.

S3.1.6 *operating environmental conditions, n*—environmental conditions during exposure to which a sensor must perform in some specified manner.

ANSI/ISA S37.1

S3.1.7 *optical, adj*—involving the use of light-sensitive devices to acquire information.

S3.1.8 *optical fiber*—a very thin filament or fiber, made of dielectric materials, that is enclosed by material of lower index of refraction and transmits light throughout its length by internal reflections.

S3.1.9 *optoelectronics module, n*—a component of the fiber optic tachometer that contains the optical source and detector, and signal conditioner devices necessary to convert the sensed rotational speed to a specified output signal.

S3.1.10 *output, n*—electrical or numerical quantity, produced by a sensor or measurement system, that is a function of the applied measurand.

S3.1.11 *range, n*—measurand values, over which a sensor is intended to measure, specified by their upper and lower limits.

ANSI/ISA S37.1

S3.1.12 *repeatability, n*—ability of a sensor to reproduce output readings when the same measurand value is applied to it consecutively, under the same conditions, and in the same direction.

ANSI/ISA S37.1

S3.1.13 *sensor element, n*—that part of the sensor that responds directly to the measurand.

ANSI/ISA S37.1

S3.1.14 *sensor head, n*—the transduction element of a fiber optic tachometer that detects rotational speed by means of changes in optical properties.

S3.1.15 *sheath, n*—the protective covering of a sensor element.

S3.1.16 *signal conditioner, n*—an electronic device that makes the output signal from a transduction element compatible with a readout system.

S3.1.17 *span, n*—the algebraic difference between the limits of the measurement range.

S3.1.18 *static error band, n*—the maximum deviation from a straight line drawn through the coordinates of the lower range limit at specified sensor output, and the upper range limit at specified output expressed in percentage of sensor span.

S3.1.19 *supporting surface, n*—surface on which the equipment is placed.

S3.1.20 *tachometer, n*—an instrument capable of generating, transmitting, and indicating information or signal that can be converted into a function of rotational speed.

S3.1.21 *target, n*—description including items such as material, size, multiple reflectors, and surface features shall be as specified in the acquisition requirements.

S3.1.22 *warm-up time, n*—the time required for a sensor to operate within specified accuracy, repeatability, and other critical parameters after being energized from a cold (ambient) state.

S4. Design Classification

S4.1 *Electric Types*:

S4.1.1 *Designation*—Tachometers shall be classified by a series of designations which shall be assigned and listed in the format following.

Example: F2046-20M-BK-A

F2046	20M	BK	A
Specification	Range (see S4.1.2)	Mounting (see S4.1.3)	Indicator (see S4.1.4)

S4.1.2 *Range*—Electric tachometer ranges shall be selected from the standard ranges listed in Table S4.1.

S4.1.3 *Mounting*—Tachometer indicators shall be either bulkhead mounted (designator—BK) or panel (designator—PL) mounted.

S4.1.4 *Indicator*—Tachometer indicators shall be either analog (designator—A) or digital (designator—D).

S4.2 *Fiber-Optic Type*:

S4.2.1 *Designation*—The sensor classification shall consist of a series of designations which shall be assigned and listed in the form following.

Example: F2046-DC-A-1

F2046	dc	A	1
Specification	Input power S4.2.2	Optoelectronics module type S4.2.3	Sensor mounting configuration S4.2.4

S4.2.2 *Input Power*—The input power required to operate the optoelectronics module shall be designated as follows:

dc—28-V direct current (Vdc)
ac—115-V alternating current (Vac)

S4.2.3 *Optoelectronics Module*—The mounting of the tachometer's optoelectronics module type shall be designated as follows:

TABLE S4.1 Standard Ranges for Electric Tachometers

Range, RPM	Designation
0–100	10A
0–200	20A
0–500	50A
50–500	50M
0–1000	10B
100–1000	10M
0–2000	20B
200–2000	20M
0–3000	30B
300–3000	30M
0–4000	40B
0–5000	50B
500–5000	50N
0–10 000	10C
1000–10 000	10N
0–20 000	20C
1000–20 000	20N
0–30 000	30C
0–50 000	50C
5000–50 000	50P
0–100 000	10D
500–100 000	10P
1000–100 000	10R
5000–100 000	10T

Type A—Bulkhead mounted (see S7.3.1)
Type B—Console mounted (see S7.3.2)

S4.2.4 *Sensor Mounting Configuration*—The tachometer's sensor shall be mounted according to the following mount requirement type. The mass per unit length of the sensor mount configuration shall be no greater than 0.02 kg/mm. The dimensions of the tachometer's sensor head shall be in accordance with Fig. S4.1.

S4.2.4.1 *Mass*—Unless otherwise specified, the mass of the optoelectronics module shall be not greater than 5 kg.

S4.2.4.2 *Target*—The target description including items such as material, size, multiple reflectors, and surface features shall be as specified in the acquisition requirements.

S4.2.5 *Range*—The fiber-optic tachometer range is an internal selection within the optoelectronics module with the following ranges:

0—1000 RPM
0—5000 RPM
0—10 000 RPM
0—20 000 RPM

S5. Ordering Information

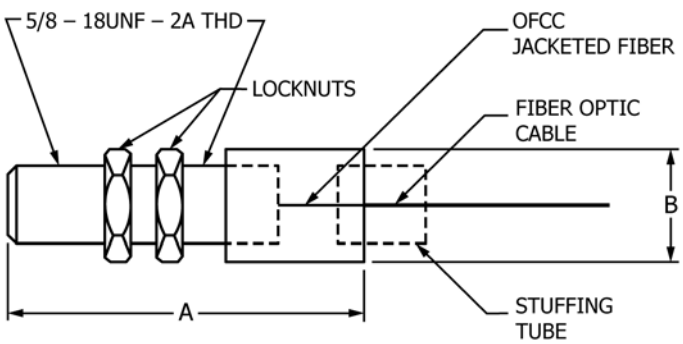
S5.1 The buyer shall provide the manufacturer with all of the pertinent application data shown in S5.2. If special application operating conditions exist that are not shown in the acquisition requirements, they shall also be described.

S5.2 *Acquisition Requirements*—Acquisition documents shall specify the following:

(1) Title, number, and date of this specification;
(2) Type and quantity required;
(3) Whether panel or bulkhead mounting is required;
(4) Range required;
(5) National Stock Numbers (NSNs) if available;
(6) When self-contained red illumination is required;
(7) Whether tachometer, control box, and indicator should be other than drip-proof construction;
(8) Number of additional indicators, if required;
(9) When qualification testing is required;
(10) Disposition of qualification test samples;
(11) Analog or digital indicator requirement;
(12) Special levels of preservation-packaging and packing required; and
(13) Product marking and labeling required.

S5.2.1 *Fiber-Optic Requirements*—In addition to the requirements outlined in S5.2, acquisition documents for fiber-optic tachometers should specify the following:

(1) Classification (see S4.2.1):
(a) Input power,
(b) Optoelectronics module,
(c) Signal output, and
(d) Range.
(2) Whether bulkhead or console mounting is required.
(3) Type and quantity of indicator(s) required.
(4) Whether junction box should be other than drip-proof construction.



SENSOR HEAD DIMENSIONS (mm)	
A	200.0 MAX
B	50.0 MAX

FIG. S4.1 Sensor Head Construction

S6. Materials and Manufacture

S6.1 *Metals*—Unless otherwise specified herein, all metals used in the construction of the tachometer shall be corrosion resistant. Dissimilar metals shall not be used in close physical contact with each other unless suitably finished to prevent electrolytic corrosion.

S6.2 *Flammable Materials*—Materials used in the construction of the tachometer shall, in the end configuration, be noncombustible or retardant in the most hazardous conditions of atmosphere, pressure, and temperature to be expected in the application.

S6.3 *Fungus-Resistant Materials*—Materials used in the construction of the tachometer shall be fungus-inert materials.

S6.4 *Solvents, Adhesives, and Cleaning Agents*—If any chemicals or cements are used in bonding of internal tachometer components, no degradation of these components shall result during in-service use.

S6.5 *Refractive Index Matching Gels, Fluids, or Compounds*—Refractive index matching gels, fluids, or compounds for fiber-optic tachometers shall be in accordance with MIL-M-24794.

S7. Physical Properties

S7.1 *Electric Tachometers*—Electric tachometers shall be a noncontact design and shall provide an output proportional to the continuous instantaneous shaft speed. Tachometers shall be for fixed mounted type of installations in which ranges from 100 to 100 000 RPM are encountered. Unless otherwise specified, the sensor, control box, and indicator shall be of drip-proof construction.

S7.1.1 *Sensor*—The sensor shall produce a signal by magnetic pulse, light pulse, or other noncontact method for input to the control box. The method of mounting or adapting the sensor may be varied to suit the machinery details.

S7.1.2 *Control Box*—The control box shall include the necessary electronics to process the sensor signal for driving the indicator. The sensor and control box may be combined in a single unit.

S7.1.3 *Indicator*—The indicator shall be capable of panel or bulkhead mounting. The indicator shall be analog or digital, as specified in the acquisition requirements. The analog indicator shall be a nominal 4½- or 6-in. round scale with a 250° minimum arc. The digital indicator may be a round or rectangular liquid crystal or light-emitting diode display with readout numerals a minimum of 1 cm in height. A stop shall be provided in analog indicators to prevent the indicating pointer from going past full-scale reading. Analog indicators shall have self-contained red illumination.

S7.1.3.1 *Dial and Pointer for Analog Indicators*—The dial shall be of a corrosion-resistant material that will not warp at 90°C. The dial shall have a dull white finish with scale markings, numerals, and pointer a dull black. Dial and pointer assembly shall be of commercial design.

S7.1.3.2 *Display or Indicator Windows*—The display shall be protected by a window of high-quality plastic, free from flaws and defects, that does not cause parallax error.

S7.1.4 *Dimensions and Weights (Maximum)*—Dimensions and weights of the indicator shall be as shown in Table S7.1.

TABLE S7.1 Dimensions and Weight (Indicators)

Nominal Scale Length Min, in.	Height Max, in.	Width Max, in.	Depth Max, in.	Weight Max, lbs
4½	5½	5½	5	5
6	7½	7½	6	6

S7.1.5 *Mounting*—The indicator shall be designed for panel or bulkhead mounting.

S7.1.6 *Operating Characteristics*—The tachometers shall instantaneously and continuously indicate information or a signal that can be converted into a function of the speed of rotation in RPM of the rotating part being measured. The tachometers shall indicate, without change or adjustment, regardless of the direction of rotation of the driving part on the same scale.

S7.2 *Fiber-Optic Tachometers*—The fiber-optic tachometer shall be a noncontact device capable of converting a rotational speed to a continuous output signal throughout a specified measurement range. A fiber-optic tachometer shall consist of a sensor head, optoelectronics module, and fiber-optic cable connector at both ends. The optoelectronics module translates the optical input from the sensor head to a continuous linear proportional analog electrical signal or other output signal such as optical and digital.

S7.2.1 *Sensor Head*—The sensor head(s) shall be passive and detect shaft rotation through change in optical properties. The beam interruption sensing mechanism shall consist of two sensor heads. One sensor head shall be used to transmit, and one sensor head shall be used to receive an optical signal (generated from the optoelectronics module) across an air gap. Neither electrical nor electronic components shall be used in the construction of the sensor head. The configuration and physical dimensions of the sensor head(s) shall be as specified.

S7.2.2 *Optoelectronics Module Mounting*—The optoelectronics module mounting shall be either bulkhead or console mounted as specified.

S7.2.2.1 *Bulkhead Mounted (Type A)*—The optoelectronics module shall be housed in a junction box.

S7.2.2.2 *Console Mounted (Type B)*—The optoelectronics module shall be packaged in a circuit card that is a modular subassembly of a control console. Design and test requirements for the optoelectronics module shall be as specified.

S7.2.3 *Fiber-Optic Cable*—For integrity, the cable shall have an outer diameter of a four–fiber cable in accordance with MIL-C-85045. In the cable, there shall be no less than two times the number of fibers needed for operation of the sensor. The cable shall be supplied with a stuffing tube, packing assembly, and an O-ring, installed on each end of the cable to accomplish watertight penetration into the sensor head and optoelectronics module. Exposed single-fiber OFCC shall not be used over distances greater than 1 m. The length of cable shall be as specified.

S7.2.3.1 *Optical Fiber*—Optical fiber used to transmit light between the optoelectronics unit and the sensor head shall be in accordance with MIL-F-49291.

S7.2.3.2 *Fiber-Optic Connectors, Receptacles, and Bulkhead Adapters*—Fiber-optic connectors, receptacles, or bulkhead adapters used shall be in accordance with MIL-C-83522

and MIL-C-83522/16,17,18, respectively. Connectors shall be assembled at both ends of the fiber-optic cable between the sensor head and the optoelectronics module. The connectors and receptacles shall be mounted inside the sensor head or optoelectronics module.

S7.2.4 *Electrical Input Power Requirements*—Nominal steady-state power supply requirements for ac shall be 115 ± 8 V, 60 ± 2 Hz, single phase. Nominal steady-state power supply requirements for dc shall be 28 ± 4.5 V. The tachometer shall meet all performance requirements specified herein while operating with specified power supply voltages and their tolerances.

S7.2.5 *Output Signal*—The output signal of the tachometer shall be directly proportional to the speed being measured. A means shall be provided for internal selection (within the optoelectronics module) between the following output signals: true current source of 4 to 20 mA, 0 to 1 mA, 0 to 2 mA, 0 to 5 mA; true voltage source of 0- to 5-V or 0- to 10-V dc, and frequency (including TTL compatibility). A means shall also be provided for internal indication of the output signal selected. The complexity of this adjustment shall be such that one individual working alone is capable of performing this adjustment. The adjustment shall not require electrical disconnection.

S7.2.5.1 *Current Output*—The 0– or 4–mA output shall correspond to the lower speed range value and the 1–, 2–, 5–, or 20–mA output shall correspond to the upper speed range value. The current output shall remain accurate regardless of external load resistance variations over a range of 0 to 250 Ω.

S7.2.5.2 *Voltage Output*—The 0–Vdc output shall correspond to the lower speed range value, and the 5– or 10–Vdc output shall correspond to the upper speed range value. The voltage output shall remain accurate regardless of external load resistances greater than 100 000 Ω.

S7.2.5.3 *Optical Output*—When an optical output is required, all requirements shall be as specified.

S7.2.5.4 *Digital Output*—When an electrical digital output is required, all requirements shall be as specified. The electrical characteristics shall be in accordance with EIA Standard RS-422 for balanced voltage digital interface circuitry or as specified. The data format shall be as specified.

S7.2.6 *Electrical Connectors*—A single electrical connector and mating plug in accordance with MIL-C-5015 shall be used to interface the input power and linear output signal to the optoelectronics module. The appropriate connector assembly and pin designations for each of the possible tachometer configurations shall be as follows:

S7.2.6.1 *dc Input and Current or Voltage Output*—The receptacle mounted to the optoelectronics module shall be Classification MS3452W14S-5PX in accordance with MS3452. Receptacle Pin "A" shall be +28–Vdc power input, Pin "B" shall be −28–Vdc power input, Pin "C" shall because ground, Pin "D" shall be a +mA or Vdc signal output, and Pin "E" shall be a −mA or Vdc signal output. The mating plug shall be Classification MS3456W14S-SSX in accordance with MS3456.

S7.2.6.2 *dc Input and Frequency Output*—The receptacle mounted to the optoelectronics module shall be Classification MS3452W14S-5PX in accordance with MS3452. Receptacle Pin "A" shall be +28–Vdc power input, Pin "B" shall be −28–Vdc power input, Pin "C" shall be case ground, and Pins "D" and "E" shall be frequency signal outputs. The mating plug shall be Classification MS3456WI4S-5SX in accordance with MS3456.

S7.2.6.3 *ac Input and Current or Voltage Output*—The receptacle mounted to the optoelectronics module shall be Classification MS3452W14S-5PX in accordance with MS3452. Receptacle Pins "A" and "B" shall be 115–Vac power input, Pin "C" shall be case ground, Pin "D" shall be a +mA or Vdc signal output, and Pin "E" shall be a −mA or Vdc signal output. The mating plug shall be Classification MS3456W14S-5SX in accordance with MS3456.

S7.2.6.4 *ac Input and Frequency Output*—The receptacle mounted to the optoelectronics module shall be Classification MS3452W14S-5PX in accordance with MS3452. Receptacle Pins "A" and "B" shall be 115–Vac power input, Pin "C" shall be case ground, Pins "D" and "E" shall be frequency signal outputs. The mating plug shall be Classification MS3456W14S-5SX in accordance with MS3456.

S7.2.6.5 *Digital Output*—The connector assembly for a digital output signal shall be as specified.

S7.2.7 *RPM Range Selection*—A means shall be provided for internal selection (within the optoelectronics module) between the following rpm ranges: 0 to 1000, 0 to 5000, 0 to 10 000, and 0 to 20 000. A means shall also be provided for internal indication of the rpm range selected. The complexity of this adjustment shall be such that one individual working alone is capable of performing this adjustment. The adjustment shall not require electrical disconnection.

S7.2.8 *Low-Intensity Alarm Indication*—The optoelectronics module shall have a red LED which shall light when the intensity of the tachometer's optical signal falls below a preset level. The LED shall be located on either the top or front of the module as it would be mounted during typical usage. The LED shall be visible in typical fluorescent room lighting. The optoelectronics alarm will allow for an indication that maintenance is required before a false output signal from the tachometer.

S7.2.8.1 *Low-Intensity Alarm Set Point Adjustment*—A means shall be provided for adjusting the low-intensity alarm set point over no less than one half of the dynamic range of the tachometer. A means of securing this adjustment shall be provided. The low-intensity alarm set point shall be capable of adjustment by one individual without the necessity for any electrical disconnection. Alarm set point adjustments shall be labeled and shall be accessible when the optoelectronics enclosure cover is removed.

S7.2.9 *Sensitivity Adjustment*—The tachometer shall have a sensitivity adjustment for increasing or decreasing the electrical pulse height of the optical signal over the dynamic range of the tachometer. The tachometer's sensitivity shall be adjustable by one individual without the necessity for any electrical disconnection. Sensitivity adjustments shall be labeled and shall be accessible when the optoelectronics enclosure cover is removed.

S7.2.10 *Fuses*—The optoelectronics module shall not be fused.

S8. Performance Requirements

S8.1 *Accuracy, Repeatability, and Damping*—The accuracy of the tachometer shall be no less than 1 % of full-scale reading at any part of the scale at any ambient temperature between 5 and 65°C. The accuracy requirement shall be met during three calibration cycles to demonstrate repeatability. The accuracy requirements shall be met within 2 s of the sensor receiving an input signal and at any temperature between 5 and 65°C to demonstrate damping requirements.

S8.2 *Reference Measurement*—The referenced accuracy of each of the output signals of the fiber optic tachometer shall be within ±1.0 % of the output span. Measurements shall be made at 10, 50, and 90 % intervals of span without any alignments or adjustments.

S8.3 *Magnetizing*—The materials used in the construction of the tachometers shall have such characteristics that no error, either temporary or permanent, in excess of the errors permitted under the accuracy requirements specified for the applicable type will be introduced when the tachometer is tested as specified in S12.2.3. Posttest reference measurements shall meet the requirements of S8.2.

S8.4 *Accelerated Life*—The tachometers shall be capable of demonstrating reliable operation within the accuracy requirements when subjected to the conditions within the performance parameters yet configured to induce accelerated life conditions (see S12.2.4).

S8.5 *Sensitivity (Fiber Optic Only)*—The ratio of the tachometer output in percent change of span to speed input in percentage change of span shall not be less than 0.75 or more than 1.25.

S8.6 *Response Time (Fiber Optic Only)*—The time for the tachometer output signal to indicate a steady-state speed (that is, 5000, 10 000, or 20 000 rpm) shall not be greater than 2 s after the test standard attains a steady-state speed.

S8.7 *Warm-Up Time (Fiber Optic Only)*—The tachometer shall attain an output value within ±1 % of the output span. Output shall reach this band in no more than 1 min after the tachometer is energized and shall remain in this band.

S8.8 *Dynamic Range (Fiber Optic Only)*—The dynamic range of the tachometer shall be no less than 35 dB for tachometers using the beam interruption sensing mechanism. The dynamic range of the tachometer shall be no less than 16 dB for tachometers using the reflection and magneto-optic sensing mechanism.

S8.9 *Ambient Light Susceptibility (Fiber Optic Only)*—This test is applicable for tachometers using the reflection and beam interruption sensing mechanism only. Monitored tachometer output during the ambient light susceptibility test shall show no deviation greater than ±1 % of the output span.

S8.10 *Steady-State Supply Voltage and Frequency (ac) or Supply Voltage (dc) (Fiber Optic Only)*—The tachometer shall exhibit no damage and shall be in accordance with the requirements of S8.2 during each of the specified test conditions.

S8.11 *Transient Voltage and Frequency (ac) or Voltage (dc) (Fiber Optic Only)*—The tachometer shall exhibit no damage and reference measurements shall be in accordance with the requirements of S8.2 following each of the transient conditions.

S8.12 *Insulation Resistance (Fiber Optic Only)*—The insulation resistance of the optoelectronics module shall not be less than 10 MΩ.

S8.13 *Power Interruption (Fiber Optic Only)*—The tachometer shall exhibit no damage and shall be in accordance with the requirements of S8.2 when power is reapplied following each of the power interruption intervals.

S8.14 *Short Circuit (Fiber Optic Only)*—The tachometer shall exhibit no damage and shall be in accordance with the requirements of S8.2 following the short-circuit test.

S8.15 *Line Voltage Reversal (dc Input) (Fiber Optic Only)*—The tachometer shall exhibit no damage and shall be in accordance with the requirements of S8.2 following the line voltage reversal test.

S8.16 *Temperature (Fiber Optic Only)*—During the temperature test, monitored tachometer output shall show no deviation greater than ±1 % of the output span. Following this test, the tachometer shall be in accordance with the requirements of S8.2.

S8.17 *Humidity (Fiber Optic Only)*—The tachometer shall be in accordance with the requirements of S8.2 without any alignments or adjustments. After testing is completed, there shall be no evidence of physical degradation, such as corrosion of metal parts or distortion of plastic parts.

S8.18 *Enclosure (Fiber Optic Only)*—There shall be no evidence of water penetration into the tachometer components either during or at the conclusion of the enclosure test. During the enclosure test, monitored tachometer output shall show no deviation greater than ±1 % of the output span. The tachometer shall be in accordance with the requirements of S8.2 following the enclosure test.

S8.19 *Salt Spray (Fiber Optic Only)*—Following this test, the tachometer shall show no appreciable corrosion or other damage, either optical, mechanical, or electrical that will affect its operation, and it shall be in accordance with the requirements of S8.2.

S8.20 *Vibration*—Tachometers shall conform to the vibration requirements of MIL-STD-167-1 (see S12.2.20). Monitored tachometer output during all phases of the vibration test shall show no deviation greater than ±1 % of the output span. Pretest and posttest reference measurements shall be in accordance with the requirements of S8.2. The tachometer shall show no evidence of physical damage that impairs its operation as a result of the vibration test.

S8.21 *Shock*—Tachometers shall conform to the shock requirements of Type A, Class I, Grade A for lightweight equipment of MIL-S-901. Monitored tachometer output during all phases of the shock test shall show no evidence of physical damage greater than ±1 % of the output span. Pretest and posttest reference measurements shall be in accordance with

the requirements of S8.2. The tachometer shall show no evidence of physical damage that impairs its operation as a result of the shock test.

S8.22 *Electromagnetic Interference (EMI) Emission and Susceptibility*—Tachometers shall conform to the electromagnetic interference requirements of MIL-STD-461 (see S12.2.22). The tachometers shall be in accordance with MIL-STD-461 requirements CE101, CE102, CS101, CS114, CS116, RE101, RS101, RS103, and RS105. Monitored tachometer output during all phases of the EMI test shall show no deviation greater than ±1 % of the output span. Pretest and posttest reference measurements shall be in accordance with the requirements of S8.2.

S9. Workmanship, Finish, and Appearance

S9.1 *Cleaning and Surface Finishes*—Surfaces of castings, forgings, molded parts, stampings, and machined and welded parts shall be free of defects such as cracks, porosity, undercuts, voids, and gaps as well as sand, dirt, fins, sharp edges, scale, flux, and other harmful or extraneous materials. External surfaces shall be smooth and edges shall be either rounded or beveled. There shall be no burn-through. There shall be no warpage or dimensional change as a result of heat from welding operation.

S10. Inspection

S10.1 *Inspection System*—The manufacturer shall provide and maintain an inspection system acceptable to the buyer for supplies and services covered by this specification. The testing set forth in this specification shall become a part of the manufacturer's overall inspection system or quality program. The manufacturer's quality system shall comply with the requirements of ANSI/ASQC 9001-1994. Certification and registration is highly desired but not required.

S10.2 *Classification of Inspections*—The inspection requirements specified herein are classified as follows:

(1) Qualification testing and

(2) Quality conformance testing.

S10.3 *Qualification Testing*—One sample tachometer shall be subjected to the examination and tests specified in Table S10.1. Failure of any tachometer to meet the requirements of this specification shall be cause for rejection.

S10.4 *Quality Conformance Testing*—Each tachometer shall be subjected to the tests specified in Table S10.2. The results of each examination and test shall be compared to the requirements of this specification. If any tachometer fails in the examination or in any test, it shall be rejected.

S10.5 *Order of Inspection*—The sample tachometers shall be subjected to the inspections specified in Table S10.1 and Table S10.2 in the order listed except that the steady-state supply voltage and frequency inspection may be performed concurrently with the temperature inspection.

S10.6 *General Examination*—Each tachometer shall be given a thorough examination to determine conformance to the requirements of this specification with respect to material, finish, workmanship, construction, assembly, dimensions, weight, and marking of identification. Examination shall be limited to the examinations that may be performed without disassembling the units. Examination shall also include a check of all adjustments. The manufacturer shall be responsible for ensuring that materials used are manufactured, examined, and tested in accordance with the specifications and standards as applicable.

TABLE S10.1 Qualification Testing

Examination and Test	Electrical Tachometers	Fiber-Optic Tachometers	Require-ments	Test
General examination	X	X	S10.6	
Accuracy and repeatability	X	X	S8.1	S12.2.1
Damping	X		S8.1	S12.2.1
Reference measurement	X	X	S8.2	S12.2.2
Magnetizing	X	X	S8.3	S12.2.3
Accelerated life	X		S8.4	S12.2.4
Sensitivity		X	S8.5	S12.2.5
Response time		X	S8.6	S12.2.6
Warm-up time		X	S8.7	S12.2.7
Dynamic range		X	S8.8	S12.2.8
Ambient light susceptibility		X	S8.9	S12.2.9
Steady-state voltage frequency		X	S8.10	S12.2.10
Transient voltage frequency		X	S8.11	S12.2.11
Insulation resistance		X	S8.12	S12.2.12
Power interruption		X	S8.13	S12.2.13
Short circuit		X	S8.14	S12.2.14
Line voltage reversal		X	S8.15	S12.2.15
Temperature		X	S8.16	S12.2.16
Humidity		X	S8.17	S12.2.17
Enclosure		X	S8.18	S12.2.18
Salt spray		X	S8.19	S12.2.19
Vibration	X	X	S8.20	S12.2.20
Shock	X	X	S8.21	S12.2.21
Electromagnetic interference	X	X	S8.22	S12.2.22

TABLE S10.2 Qualification Conformance Testing

Examination and Test	Electrical Tachometers	Fiber-Optic Tachometers	Require-ments	Test
General examination	X	X	S10.6	
Accuracy and repeatability	X	X	S8.1	S12.2.1
Damping	X		S8.1	S12.2.1
Dynamic range		X	S8.8	S12.2.8
Insulation resistance		X	S8.12	S12.2.12
Temperature		X	S8.16	S12.2.16
Enclosure		X	S8.18	S12.2.18

S11. Number of Tests and Retests

S11.1 The number of tests and retests, if any, shall be specified in the acquisition requirements.

S12. Test Methods

S12.1 *Test Conditions*—Unless otherwise specified herein, the fiber-optic tachometer(s) shall be fully assembled and energized throughout the duration of each test procedure. Except where the following factors are the variables, the tests specified in S10.2 shall be conducted with the equipment under the following operating environmental conditions:

(1) Ambient temperature shall be 25 ± 5°C,

(2) Relative humidity shall be ambient,

(3) Supply voltage shall be 115 V (nominal) for input power designation ac or 28 V (nominal) for input power designation dc,

(4) Supply frequency shall be 60 Hz (nominal) for input power designation ac or dc for input power designation dc,

(5) Distance from sensor head to target shall be 10 mm for fiber-optic tachometers using reflection and beam interruption sensing mechanisms, and

(6) Distance from sensor head to target shall be 2 mm for fiber-optic tachometers using magno-optic sensing mechanism.

S12.2 *Test Methods*:

S12.2.1 *Accuracy*—The tachometer shall first be operated over its full speed range by slowly increasing and decreasing the applied speed in four continuous cycles. The calibration measurements shall be made at a minimum often equally spaced intervals over the full range. This calibration procedure shall be applied three successive times to determine repeatability. The fiber optic tachometer shall be energized and operational at a speed range setting of 0 to 20 000 rpm. A measurement of each of the outputs of the optoelectronics module shall be performed at the following speeds: 5000, 10 000, 15 000, and 20 000 rpm. This measurement shall be performed three successive times for each of the optoelectronics module outputs (see S8.2). The maximum difference between any two output values at the same speed for each of the optoelectronics module output signal selections shall determine repeatability. Accuracy, repeatability, and damping shall meet the requirements of S8.1.

S12.2.1.1 *Temperature*—Accuracy tests shall be conducted at 5, 25, and 65°C. The accuracy shall be checked at a minimum of five equally spaced operating speeds over the range of the tachometer. The tachometer shall conform to the accuracy requirements of S8.1.

S12.2.2 *Reference Measurement*—The tachometer shall be energized and operational. A measurement shall be made at 10, 50, and 90 % intervals of span both upscale and downscale. The accuracy at all points of measurement shall meet the requirements of S12.2.1.

S12.2.3 *Magnetizing*—While operating at a constant speed of approximately 50 % of full-scale range, the tachometer shall be placed in varying positions in a unidirectional, magnetic field having a flux density in free air of approximately 5 gausses. The error of tachometers shall be within the requirements specified in S8.2.

S12.2.4 *Accelerated Life*—Tachometers shall be operated at a constant speed approximately equal to the midpoint of their range for four periods. The periods shall be as follows:

Period 1	25 h at 25°C
Period 2	25 h at 5°C
Period 3	25 h at 65°C
Period 4	25 h at 25°C

Relative humidity shall be varied during Periods 2 and 3 between approximately 50 and 90 % in alternate hour periods. All tachometers shall operate satisfactorily during these tests within their required accuracy as specified in S8.1.

S12.2.5 *Sensitivity (Fiber Optic Only)*—The sensitivity factor shall be determined using the following procedure:

(1) The tachometer shall be energized and operational at an output signal, of the 0- to 10-V setting corresponding to a speed of 3000 rpm. The tachometer's speed range setting shall be 0 to 10 000 rpm.

(2) Measure both the shaft speed and the optoelectronics module output signal.

(3) Increase the shaft speed by an amount not greater than 1 % of the output span.

(4) Measure both the new shaft speed and the optoelectronics module output signal.

(5) Calculate the change in both shaft speed and the optoelectronics module output signal as a percentage of the output span.

(6) Determine the ration of the output percentage change to applied shaft speed percentage change in terms of the output span.

(7) Repeat this procedure for shaft speed decrease not greater than 1 % of the output span.

S12.2.6 *Response Time (Fiber Optic Only)*—The response time shall be determined by the following procedure:

(1) Energize the fiber optic tachometer and set the position of the sensor head.

(2) Adjust the tachometer's output signal to the 0- to 10–V setting and the rpm setting to the 0- to 10 000-rpm range.

(3) Energize the test standard and increase the speed of its rotating target to 5000 rpm. The test standard shall reach 5000 rpm within 2 s.

(4) Monitor the output signal of the tachometer and the test standard during the test.

S12.2.7 *Warm-Up Time*—The warm-up time shall be determined by the following procedure:

(1) Allow the tachometer output signal to stabilize at a value, of the 0- to 5–V setting, corresponding to a measurand operating speed of 800 rpm. The tachometer's speed range setting shall be 0 to 1000 rpm.

(2) Deenergize the tachometer for no less than 2 h.

(3) Reenergize the tachometer and monitor the optoelectronics module output as necessary to ensure tachometer meets the requirements of S8.7.

S12.2.8 *Dynamic Range (Fiber Optic Only)*—The dynamic range of the optoelectronics module shall be tested in accordance with the following procedures:

S12.2.8.1 *Beam Interruption*—A calibrated optical attenuator with two jumpers shall be tested for insertion loss in accordance with EIA-455-34. The attenuator shall then be connected between the optoelectronics module and the sensor head of the transmitting optical signal by means of the two jumper cables. The tachometer's sensitivity shall be adjusted to the maximum setting. The attenuation shall be increased from 0 dB (encompassing insertion loss of attenuator and jumpers) to 35 dB. The tachometer shall be operating at an output signal value, of the 0- to 5–V setting, corresponding to an operating speed of 800 rpm. The tachometer's speed range setting shall be 0 to 1000 rpm. The dynamic range will be exceeded when the output signal drops to a value equivalent to 0 rpm. Performance shall be in accordance with the requirements of S8.8.

S12.2.8.2 *Reflection and Magneto-Optic Effect*—A calibrated optical attenuator with two jumpers shall be tested for insertion loss in accordance with EIA-455-34. The attenuator shall be connected between the optoelectronics module and the sensor head via the two jumper cables. The tachometer's sensitivity shall be adjusted to the maximum setting. The attenuation shall increase from 0 dB (encompassing insertion

loss of attenuator and jumpers) to 16 dB. The tachometer shall be operating at an output signal value, of the 0- to 5–V setting, corresponding to an operating speed of 800 rpm. The tachometer's speed range setting shall be 0 to 1000 rpm. The dynamic range will be exceeded when the output signal drops to a value equivalent to 0 rpm. Performance shall be in accordance with the requirements of S8.8.

S12.2.9 *Ambient Light Susceptibility (Fiber Optic Only)*—The ambient light source and general test conditions shall be in accordance with EIA-455-22. The tachometer shall be energized and placed in the beam of the light source for a 10-min duration. During the test, the tachometer shall be energized and operational at an output signal, of the 0- to 5–V setting, corresponding to a speed of 3000 rpm. The tachometer's speed range setting shall be 0 to 10 000 rpm. This output shall be monitored during the test. Performance shall be in accordance with the requirements of S8.9.

S12.2.10 *Steady-State Supply Voltage and Frequency (ac) or Supply Voltage (dc) (Fiber Optic Only)*—This test may be performed in conjunction with the temperature test (see S12.2.16). For ac-powered tachometers, a reference measurement shall be performed at 0, 25, and 65°C for each of the conditions specified in S12.2.11.1 and S12.2.11.2. For dc-powered tachometers, a reference measurement shall be performed at 0, 25, and 65°C for each of the conditions specified in S12.2.11.3. The tachometer shall be allowed to stabilize at each testing temperature before the reference measurements are performed. Performance shall be in accordance with the requirements of S8.10.

S12.2.11 *Transient Voltage and Frequency (ac) or Voltage (dc) (Fiber Optic Only)*—Ac-powered tachometers shall be tested in accordance with S12.2.11.1 and S12.2.11.2. Dc-powered tachometers shall be tested in accordance with S12.2.11.3.

S12.2.11.1 *Transient Voltage (ac)*:

S12.2.11.1.1 *Upper Limit*—With the tachometer operating at the steady-state voltage of 123 Vac, the voltage shall be increased to 138 Vac and then decreased back to the steady-state voltage of 123 Vac in a 2–s period. A reference measurement shall then be performed at 115 Vac. The tachometer shall be in accordance with the requirements of S8.2.

S12.2.11.1.2 *Lower Limit*—With the switch operating at a steady-state voltage of 107 Vac, the voltage shall be decreased to 92 Vac and then increased back to the steady-state voltage of 107 Vac in a 2–s period. A reference measurement shall then be performed at 115 Vac. The tachometer shall be in accordance with the requirements of S8.2.

S12.2.11.2 *Transient Frequency (ac)*:

S12.2.11.2.1 *Upper Limit*—With the tachometer operating at a steady-state frequency of 62 Hz, the frequency shall be increased to 63.5 Hz and then decreased back to the steady-state frequency of 62 Hz in a 2–s period. A reference measurement shall then be performed at 60 Hz. The tachometer shall be in accordance with the requirements of S8.2.

S12.2.11.2.2 *Lower Limit*—With the tachometer operating at a steady-state frequency of 58 Hz, the frequency shall be decreased to 56.5 Hz and then increased back to the steady-state frequency of 58 Hz in a 2–s period. A reference measurement shall then be performed at 60 Hz. The tachometer shall meet the requirements of S8.2.

S12.2.11.3 *Transient Voltage (dc)*:

S12.2.11.3.1 *Upper Limit*—With the tachometer operating at a steady-state voltage of 32.5 Vdc, the voltage shall be increased to 34.5 Vdc and then decreased back to the steady-state voltage of 32.5 Vdc in a 2–s period. A reference measurement shall then be performed at 28 Vdc. The tachometer shall be in accordance with the requirements of S8.2.

S12.2.11.3.2 *Lower Limit*—With the tachometer operating at a steady-state voltage of 23.5 Vdc, the voltage shall be decreased to 21.5 Vdc and then increased back to the steady-state voltage of 23.5 Vdc in a 2–s period. A reference measurement shall then be performed at 28 Vdc. The tachometer shall be in accordance with the requirements of S8.2.

S12.2.12 *Insulation Resistance (Fiber Optic Only)*—The insulation resistance of the optoelectronics module shall be determined by applying 50 Vdc between electrical input and output circuits and between these circuits and ground. The temperature shall be 25 ± 5°C and the relative humidity shall be 50 ± 10 %. The insulation resistance measurement shall be made immediately after a 2–min period of uninterrupted test voltage application. If the indication of insulation resistance meets the specified limit and is steady or increasing, the test may be terminated before the end of the 2–min period. The tachometer shall be in accordance with the requirements of S8.12.

S12.2.13 *Power Interruption (Fiber Optic Only)*—With the tachometer operating within the steady-state tolerances of voltage and frequency, the external power supply shall be suddenly interrupted. After an interval of between 3 and 4 s, the power supply, within the steady-state tolerances, shall be reapplied. After the tachometer has been operated long enough to detect any major performance degradation, the power shall be interrupted for an interval of no less than 30 s. This cycle, (3- to 4-s interruption, monitor, then an interruption of no less than 30 s) shall be repeated three times (four total cycles). Following each of the power interruption intervals, a reference measurement shall be made. The tachometer shall be in accordance with the requirements of S8.13.

S12.2.14 *Short Circuit (Fiber Optic Only)*—The tachometer shall be deenergized and the positive and negative electrical output leads or terminals of the optoelectronics module shall be connected directly together with no load resistance. The tachometer shall be energized for 5 min, then deenergized, and the short circuit removed. The tachometer shall be energized and a reference measurement shall be made at ambient temperature. The tachometer shall meet the requirements of S8.14.

S12.2.15 *Line Voltage Reversal (for dc Powered Tachometers) (Fiber Optic Only)*—A positive 28-Vdc signal shall be applied to connector Pin "B." The dc reference signal shall be applied to connector Pin "A." The power supply shall be energized for a period of 10 min and then shall be disconnected. The power supply shall then be correctly applied (Pin A positive, Pin B negative) and a reference measurement shall be made. The tachometer shall be in accordance with the requirements of S8.15.

S12.2.16 *Temperature (Fiber Optic Only)*—The tachometer shall be positioned in an environmental chamber in an energized state and shall be subjected to the following test procedure. Performance shall meet the requirements of S8.16.

(1) Hold test temperature at 0°C for no less than 24 h.

(2) Increase test temperature in steps of 10° each, at 30 min for each step, until plus 65 ± 2°C is reached. Hold at that temperature for no less than 24 h.

(3) Reduce test temperature in steps of 10° each, at 30 min for each step, until plus 25 ± 2°C is reached. Hold at that temperature for no less than 24 h.

During the last hour of operation at each temperature plateau (0, 65, and 25°C) the tachometer electrical output signal, of the 0- to 5–V setting, shall be measured corresponding to a speed of 3000 rpm. The tachometer's speed range setting shall be 0 to 10 000 rpm. After the temperature test, a reference measurement shall be made. Performance shall be in accordance with the requirements of S8.16.

S12.2.17 *Humidity (Fiber Optic Only)*—The tachometer shall be subjected to the conditioning and tests specified in S12.2.17.1 through S12.2.17.5. The tachometer shall be energized throughout the test. Performance shall be in accordance with the requirements of S8.17.

S12.2.17.1 *Conditioning*—To establish a reference condition for the measurement of operating parameters and a valid basis for comparison of the effects of the conditioning to follow, the complete equipment shall be dried at a temperature no less than 40°C or more than 500°C for no less than 2 h.

S12.2.17.2 *Reference Measurements*—Following the conditioning, a reference measurement shall be made at 25 ± 5°C and 50 ± 5 % relative humidity. Performance shall be in accordance with the requirements of S8.17.

S12.2.17.3 *Temperature Cycling*—The tachometer shall then be subjected to four 24-h cycles of temperature variation consisting of 18 h at 65 ± 5°C and 6 h at 25 ± 5°C. The relative humidity shall be maintained at 90 to 95 % (noncondensing) during the steady-state conditions. The transitions between temperatures shall be accomplished within the 6-h period so that the time at the high temperature is 18 h. Each transition shall be not greater than 1 h if the tachometer remains in the chamber or 15 min if a two chamber method is used. The relative humidity need not be controlled during the transition periods.

S12.2.17.4 *Measurement During Cycling*—During the second cycle, a reference measurement shall be made at the end of the high temperature period with the tachometer remaining in the chamber at 65 ± 5°C. The tachometer shall be energized for as brief a period as required to complete the measurements.

S12.2.17.5 *Measurements After Temperature Cycling*—After the four complete cycles, a reference measurement shall be made at 25 ± 5°C with the tachometer remaining in the chamber. Performance shall meet the requirements of S8.17.

S12.2.18 *Enclosure (Fiber Optic Only)*—The tachometer shall be placed or mounted in a position typical of that for which it was designed. The surface upon which the equipment is placed or mounted (supporting surface) shall extend no less than 1 m beyond the equipment on all sides so that splashing may be produced by directing the water stream on the supporting surface. The water stream shall be a coarse spray with a flow rate of no less than 55 L/min and a head pressure of no less than 3 m. A head pressure of 3 m is defined as sufficient water pressure so that if directed straight up, the stream of water shall rise to a height of 3 m. The distance from the nozzle to the enclosure under test shall be approximately 2 m. The time of the test shall be no less than 5 min with approximately equal portions of time for spray on each surface, including joints of the enclosure and at the supporting surface. During the test, the tachometer shall be energized and operational at an output signal, of the 0- to 5-V setting, corresponding to a speed of 3000 rpm. The tachometer's speed range setting shall be 0 to 10 000 rpm. This output signal shall be monitored during the test. The equipment shall be in accordance with the requirements of S8.18.

S12.2.19 *Salt Spray (Fiber Optic Only)*—Before exposure to salt spray, a reference measurement shall be made. The fiber-optic tachometer shall be deenergized and tested in accordance with Practice B117. Duration of the test shall be 96 h. The tachometer's major components shall be disassembled at the immediate conclusion of the test and examined for corrosion and moisture penetration. After exposure to salt spray, the tachometer shall be energized and a reference measurement shall be made. Performance shall be in accordance with the requirements of S8.19.

S12.2.20 *Vibration*—Before exposure to vibration, a reference measurement shall be made. The tachometer shall be exposed to Type I vibration in accordance with MIL-STD-167-1. During vibration, the electric tachometer shall be energized and operational at a speed corresponding to the midpoint of full scale. During vibration, the fiber-optic tachometer shall be energized and operational at an output signal, of the 0- to 5-V setting, corresponding to a speed of 3000 rpm. The tachometer's speed range setting shall be 0 to 10 000 rpm. This output signal shall be monitored during the test. After exposure to vibration, a reference measurement shall be made. Performance shall be in accordance with the requirements of S8.20.

S12.2.21 *Shock*—Before shock, a reference measurement shall be made. Electric tachometers shall be subjected to the Type A, Grade A, Class I, lightweight equipment test of MIL-S-901. During shock, electric tachometers shall be energized and operational at a speed corresponding to the midpoint of full scale. The fiber-optic tachometer equipment shall be exposed to shock in accordance with MIL-S-901, Grade A, Type C, Class I. The equipment shall be mounted on Fixture 4A simulating shipboard installation. During shock, the tachometer shall be energized and operational at an output signal, of the 0- to 5-V setting, corresponding to a speed of 3000 rpm. The tachometer's speed range setting shall be 0 to 10 000 rpm. This output signal shall be monitored during shock. After exposure to shock, a reference measurement shall be made. Performance shall be in accordance with the requirements of S8.21.

S12.2.22 *Electromagnetic Interference (EMI) Emission and Susceptibility*—The tachometers shall be exposed to EMI in accordance with MIL-STD-461. During exposure to EMI, the electric tachometer shall be energized and operational at a

speed corresponding to the midpoint of full scale. During exposure to EMI, the fiber-optic tachometer shall be energized and operational at an output signal, of the 0- to 5-V setting, corresponding to a speed of 3000 rpm. The tachometer s speed range setting shall be 0 to 10 000 rpm. This output signal shall be monitored during exposure to EMI. After exposure to EMI, a reference measurement shall be made. Performance shall be in accordance with the requirements of S8.22.

S13. Quality Assurance Provisions

S13.1 *Warranty*—Special warranty requirements shall be specified in the acquisition requirements. Otherwise, the standard commercial warranty applies.

S14. Certification

S14.1 When specified in the purchase order or contract, the buyer shall be furnished certification that samples representing each lot have been either tested or inspected as directed in this specification, and the requirements have been met. When specified in the purchase order or contract, a report of the test result shall be furnished. It is recommended that all test data remain on file for three years at the manufacturer's facility for review by buyer upon request.

S15. Product Marking

S15.1 Unique product marking requirements shall be specified in the acquisition requirements.

S15.2 *Fiber-Optic Tachometers*:

S15.2.1 *Optoelectronics Module*—Each optoelectronics module shall be permanently and legibly marked. The following minimum information shall be provided:

(1) Nomenclature,
(2) Design classification,
(3) National Stock Number (NSN) if available,
(4) Manufacturer's name and model number,
(5) Technical manual number,
(6) Contract number, and
(7) A unique serial number from the manufacturer.

S15.2.2 *Sensor Head*—Each sensor head shall be permanently and legibly marked in accordance with Practice D3951. The following minimum information shall be provided:

(1) Nomenclature,
(2) Design classification,
(3) National Stock Number (NSN) if available,
(4) Manufacturer's name and model number, and
(5) A unique serial number from the manufacturer.

S15.2.3 *Labeling*—If laser radiation is used, a visible label shall be affixed to the outside of the optoelectronics module cover and shall contain the following:

NOTICE
UNTERMINATED OPTICAL CONNECTIONS MAY EMIT LASER RADIATION. DO NOT VIEW BEAM WITH OPTICAL INSTRUMENTS AND AVOID DIRECT EXPOSURE TO THE BEAM.

A visible label with yellow lettering on a black background shall be affixed to the sensor head and the inside of the optoelectronics module and shall contain the following:

WARNING
INVISIBLE LASER RADIATION
AVOID EXPOSURE TO THE BEAM

S15.2.3.1 *Alternating Current*—Optoelectronics modules with input power designation ac shall be permanently and legibly marked with the following label:

"WARNING 115VAC"

S16. Packaging and Package Marking

S16.1 *Packing Requirements*—Tachometer equipment shall be preserved, packaged, and marked in accordance with Practice D3951. Bar codes and other applicable packing acquisition options shall be specified.