Designation: F 2071 – 00

An American National Standard

Standard Specification for Switch, Position Proximity (Noncontact) or Limit (Mechanical Contact), Fiber-Optic[1]

This standard is issued under the fixed designation F 2071; 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.

1. Scope

1.1 This specification covers the requirements for fiber-optic position switches (proximity and limit). This specification does not include switches that transfer an optical signal from one path to another by an external force or energy applied to the switch.

1.2 The values stated in SI units are to regarded as the standard. The values given in parentheses are for information only. Where information is to be specified, it shall be stated in SI units.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.4 Special requirements for naval shipboard applications are included in the Supplement.

2. Referenced Documents

2.1 *ASTM Standards:*

D 3951 Practice for Commercial Packaging[2]

2.2 *ISO Standards:*

ISO 9001 Quality System—Model for Quality Assurance in Design/Development, Production, Installation, and Servicing[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *closed switch*—the light path is complete; signal from transmitter to receiver is complete.

3.1.2 *closed switch with positive alarm*—the light path is complete. Signal level indicates that the end faces of the sensing element are dirty and require maintenance for continued proper operation.

3.1.3 *fiber-optic position switch*—a device that converts measured position, via changes in fiber-optic properties, to an output that is a function of the applied measurand. The fiber-optic position switch normally consists of a sensor head, optoelectronics module, and connectorized fiber-optic cable.

3.1.4 *limit switch*—a switch that senses a change in position via mechanical contact.

3.1.5 *open switch*—the light path is blocked; signal from transmitter to receiver is not complete.

3.1.6 *optical transmittance change*—the change in optical power level introduced by an environmental, mechanical, or other induced stress.

3.1.7 *optoelectronics module*—unit of the fiber-optic position switch that contains the optical transmitter and receiver, and signal conditioning electronics, necessary to convert the sensed position to the specified output signal. The optoelectronics module may be an expansion card for a microprocessor-based system, or a stand-alone unit.

3.1.8 *proximity switch*—a switch that senses a change in position via noncontact means.

3.1.9 *sensor head*—unit of the fiber-optic position switch that detects position via changes in optical properties. The optoelectronics module interrogates the sensor head to determine the position of the measurand. An optical signal is transmitted from the optoelectronics module to the sensor head. The optical path is either complete or blocked, depending on the status of the item being measured, giving an indication of the position or status of the item back to the optoelectronics module.

3.1.10 *steady-state supply voltage*—an input voltage that does not deviate from a specified nominal tolerance (ex: ±5 %).

3.1.11 *tether valve limit switch*—a limit switch used to detect valve position via a tether line connected to the valve handle.

3.1.12 *transient supply voltage*—a voltage superimposed on the steady-state supply voltage that is greater than the specified steady-state tolerance and has a very rapid rise and fall.

4. Classification

4.1 *Designation*—Most switch manufacturers use designations, systematic numbering or identifying codes. Once understood, these designations could aid the purchaser in quickly identifying the switch type, electrical power ratings, and other characteristics.

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[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.

Current edition approved Dec. 10, 2000. Published March 2001.

[2] *Annual Book of ASTM Standards*, Vol 15.09.

[3] Available from International Organization for Standardization, Case Postale 56, Geneve, Switzerland CH-1211.

4.2 *Design*—Fiber-optic position switches typically consist of an assembly with three major components: optical sensor head, fiber-optic cables, and optoelectronics module. The optoelectronics module shall be interchangeable between any of the sensor types.

4.3 *Types*—The following are common types of fiber-optic position switches:

Proximity
Limit, pin actuated
Limit, lever actuated
Limit, lever and roller
Limit, tether valve

4.3.1 *Fiber-Optic Proximity Switches*—The fiber-optic proximity switch sensor head receives the light beam from the light source in the optoelectronics module via a fiber-optic cable. The sensor head emits the light beam to detect an object in a specific location. The sensor head also receives the light beam reflection from the object, typically via a wide angle receiving lens, and is detected by the light beam receiving device in the optoelectronics module. When the object moves into the sensing site, the light beam is reflected into the receiving lens completing the fiber-optic light path. It is important to consider contrasting light levels between reflections from background objects when no object to be detected is present and reflections from the object to be detected, when selecting a fiber-optic proximity switch.

4.3.2 *Fiber-Optic Limit Switches*—The fiber-optic limit switch sensor head houses the mechanical contact device that senses the position of the object to be detected. The mechanical contact device is typically a pin or plunger, lever, roller, lever and roller, or tether valve. The fiber-optic limit switch sensor head receives the light beam from the light source in the optoelectronics module via a fiber-optic cable. The same fiber-optic cable allows completion of the light path to a fiber-optic receiver in the optoelectronics module. Dependent upon the configuration of the switch, the mechanical contact device either completes or breaks the light path upon detection of the object.

5. Ordering Information

5.1 The purchaser should provide the manufacturer with all of the pertinent application data. Recommended data is shown in 5.2. If special application operating conditions exist that are not shown in the acquisition requirements, they should also be described.

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

(a) Title, number, and date of this specification,
(b) Manufacturer's part number,
(c) Switch type required (see 4.3),
(d) Unique or special enclosure requirements (see 7.1),
(e) Type of optoelectronics module (see 7.2). If control enclosure or console mounted, specify requirements,
(f) Length of fiber-optic cable required,
(g) Type of electrical connection (see 7.4),
(h) When the electrical connection mating plug is not to be provided (see 7.4),
(i) System operating characteristics,
(j) Materials,
(k) Environmental requirements,
(l) Quantity of switches required,
(m) Size and weight restrictions (see 7.5),
(n) Critical service life requirements (see 8.1),
(o) Performance requirements (see 8.2),
(p) Special surface finish requirements (see 9.1),
(q) Special workmanship requirements (see 9.2),
(r) When certification is required (see 13),
(s) Special marking requirements (see 14),
(t) Special packaging or package marking requirements (see 15),
(u) When ISO 9001 quality assurance system is not required (see 16.1), and
(v) Special warranty requirements (see 16.1).

6. Materials and Manufacture

6.1 *Position Switches*—Materials for the fiber-optic position switches shall be corrosion resistant and noncombustible or fire retardant.

7. Physical Properties

7.1 *Enclosure*—If case sealing is required, the mechanism, materials, and process shall be described. The same should apply to the electrical connector. Resistance to cleaning solvents should likewise be stated. Unique or special enclosure requirements shall be specified in the acquisition requirements (see 5.2).

7.2 *Optoelectronics Module*—The optoelectronics module shall contain the optical and signal conditioner devices necessary to convert the sensor head output to the specified electrical output. Optoelectronics modules shall be designed in consideration of their mounting method (type): bulkhead mounted, control enclosure mounted, or console mounted (microprocessor expansion card).

7.3 *External Configuration*—The outline drawing shall show the configuration with dimensions in SI units (inch-pound units) if they are not specified. The outline drawing shall include limiting dimensions for electrical and fiber-optic connections if they are not specified. The outline drawing shall indicate the mounting method with hole size, center location, and other pertinent dimensions. Where threaded holes are used, thread specifications shall be provided.

7.4 *Electrical Connection*—An electrical interface connector receptacle and mating plug shall be provided with each optoelectronics module of the position switch unless otherwise specified in the acquisition requirements (see 5.2). Other possible electrical interface connections include pigtails and terminal boards.

7.5 *Size and Weight*—The purchaser may have intended applications in which size and weight are limited. Size and weight restrictions shall be specified in the acquisition requirements (see 5.2).

8. Performance Requirements

8.1 *Service Life*—The purchaser may have a minimum specified service life requirement that may be critical. Critical service life requirements shall be specified in the acquisition requirements (see 5.2).

8.2 *Switch Performance*—Critical performance requirements shall be specified in the acquisition requirements (see 5.2). The following performance characteristics and environmental exposures may or may not be important to each purchaser's intended application.

(a) Warm-up time,
(b) Steady-state supply voltage and frequency (ac),
(c) Steady-state supply voltage (dc),
(d) Response time,
(e) Transient supply voltage and frequency (ac),
(f) Transient supply voltage (dc),
(g) Change in optical transmittance,
(h) Dynamic range,
(i) Ambient light susceptibility,
(j) Temperature,
(k) Humidity,
(l) Salt spray,
(m) Insulation resistance,
(n) Power interruption,
(o) Short circuit,
(p) Line voltage reversal (dc powered),
(q) Output,
(r) Mechanical life,
(s) Enclosure,
(t) Vibration,
(u) Shock,
(v) Electromagnetic interference (EMI), and
(w) Power system harmonic distortion.

9. Workmanship, Finish and Appearance

9.1 *Finish and Appearance*—Any special surface finish and appearance requirements shall be specified in the acquisition requirements (see 5.2).

9.2 *Workmanship*—Any special workmanship requirements shall be specified in the acquisition requirements (see 5.2).

10. Number of Tests and Retests

10.1 The number of test specimens to be subjected to first-article and conformance tests shall be specified and should depend on the fiber-optic position switch design. As guidance, for each switch covered by a separate and distinct design, a test specimen for each design should require testing. In instances in which a singular design series may cover multiple switch configurations, a minimum of three test specimens should be tested, provided the electrical, optical, and mechanical similarities are approved by the purchaser. It is recommended that one unit be tested for each switch configuration regardless of design similarity.

11. Inspection

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

(a) First-article tests (see 11.2)
(b) Conformance tests (see 11.3)

11.2 *First-Article Tests*—First-article test requirements shall be specified, where applicable. First-article test methods should be identified for each design and performance characteristic specified.

11.3 *Conformance Tests*—Conformance testing is accomplished when first-article tests were satisfied by a previous acquisition or the product has demonstrated reliability in similar applications. Conformance tests are usually less intensive than first-article tests, often verifying that samples of a production lot meet a few critical performance requirements.

12. Test Data

12.1 *Test Data*—Test data shall remain on file at the manufacturer's facility for review by the purchaser 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 purchaser and manufacturer.

13. Certification

13.1 When specified in the acquisition requirements (see 5.2), the purchaser 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.

14. Product Marking

14.1 Special purchaser specified product marking shall be listed in the acquisition requirements (see 5.2). The minimum data to be clearly marked on each switch shall include the following:

14.1.1 *Sensor Head*:

(a) "FIBER-OPTIC POSITIONS SWITCH—SENSOR HEAD,"
(b) Manufacturer's name,
(c) Manufacturer's serial number or lot number, and
(d) Manufacturer's part number.

14.1.2 *Optoelectronics Module*:

(a) "FIBER-OPTIC POSITION SWITCH—OPTOELECTRONICS MODULE"
(b) Manufacturer's name,
(c) Manufacturer's serial number or lot number,
(d) Manufacturer's part number, and
(e) Excitation voltage.

15. Packaging and Package Marking

15.1 *Packaging of Product for Delivery*—Product should be packaged and marked for shipment in accordance with Practice D 3951.

15.2 Special packaging or package marking requirements for shipment or storage shall be identified in the acquisition requirements (see 5.2).

16. Quality Assurance

16.1 *Quality System*—A quality assurance system in accordance with ISO 9001 shall be maintained to control the quality of the product being supplied effectively, unless otherwise specified in the acquisition requirements (see 5.2).

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

(a) All materials used to produce a unit and
(b) Workmanship to produce the unit.

Special warranty requirements shall be specified in the acquisition requirements (see 5.2).

17. Keywords

17.1 fiber-optic position switch; limit switch; optoelectronics module; position switch; proximity switch; sensor head

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 the standard F25(FOSW)M-99 and this supplement, the requirements of this supplement shall take precedence for equipment acquired by this supplement. This document supersedes MIL-S-24798, Switch, Position, Proximity (Non-Contact) or Limit (Mechanical Contact), Fiber Optic, for new ship construction.

S1. SWITCH, POSITION, PROXIMITY (NONCONTACT) OR LIMIT (MECHANICAL CONTACT), FIBER-OPTIC

S1.1 Scope

S1.1.1 This specification supplement covers the requirements for fiber-optic position switches (proximity and limit) designed to meet the requirements for use onboard naval ships. This specification does not include switches that transfer an optical signal from one path to another by an external force or energy applied to the switch.

S1.1.2 The values stated in SI units are to be regarded as the standard. Inch-pound units are provided for information only.

S1.2 Referenced Documents

S1.2.1 *ASTM Standards:*

D 542 Test Methods for Index of Refraction of Transparent Organic Plastics[4]

D 570 Test Method for Water Absorption of Plastics[4]

S1.2.2 *EIA Standards:*

455-20 FOTP-20 Measurement of Change in Optical Transmittance[5]

455-22 FOTP-22 Ambient Light Susceptibility of Fiber Optic Components[5]

455-34 FOTP-34 Interconnection Device Insertion Loss Test[5]

S1.2.3 *NEMA Standards:*

250 Enclosures for Electrical Equipment (1000 Volts Maximum)[6]

S1.2.4 *Military Standards*

MIL-C-83522 Connectors, Fiber Optic, Single Terminus, General Specification for[7]

MIL-C-83522/16 Connector, Fiber Optic, Single Terminus, Plug, Adapter Style, 2.5 Millimeter Bayonet Coupling, Epoxy[7]

MIL-C-83522/17 Connector, Fiber Optic, Single Terminus, Adapter, 2.5 Millimeter Bayonet Coupling, Bulkhead Panel Mount[7]

MIL-C-83522/18 Connector, Fiber Optic, Single Terminus, Adapter, 2.5 Millimeter Bayonet Coupling, PC Mount[7]

MIL-PRF-49291 Fiber, Optical (Metric), General Specification for[7]

MIL-S-901 Shock Tests, H.I. (High-Impact); Shipboard Machinery, Equipment and Systems, Requirements for[7]

MIL-STD-167-1 Mechanical Vibrations of Shipboard Equipment (Type I-Environmental and Type II-Internally Excited)[7]

MIL-STD-461 Electromagnetic Interference Characteristics of Subsystems and Equipment, Requirements for the Control of[7]

MIL-STD-1399, Section 300 Interface Standard for Shipboard Systems, Electric Power, Alternating Current[7]

S1.3 Terminology

S1.3.1 Terminology is consistent with that of Section 3 and the referenced documents.

S1.4 Designation

S1.4.1 *Designation*—For this specification, fiber-optic position switch designations shall be assigned as specified in S1.5.2 and listed in the format below:

Example: F25(FOSW)M-1-B-DC

F25(FOSW)M-99	1	B	DC
Specification	Type	Optoelectronics Module	Power Supply
	S1.4.2	S1.4.3	S1.4.4

S1.4.2 *Type*—The following designators have been established for the various types of fiber-optic position switches:

1—Proximity position switch sensor head,

2—Pin-actuated limit position switch sensor head,

3—Lever-actuated limit position switch sensor head,

4—Lever and roller limit position switch sensor head,

5—Tether valve limit position switch sensor head, and

6—Special (see S1.5.2).

S1.4.3 *Optoelectronics Module*—The optoelectronics module shall be designated as follows:

A—Bulkhead mounted,

B—Control enclosure mounted, and

C—Console mounted (microprocessor or programmable logic controller expansion card).

S1.4.4 *Electrical Power Supply*—The electrical interface wiring shall be determined by the power supply as follows:

[4] *Annual Book of ASTM Standards*, Vol 08.01.

[5] Available from Electronic Industries Association, 2500 Wilson Blvd., Arlington, VA 22201-3834.

[6] Available from National Electric Manufacturers Association, 1300 N. 17th St., Suite 1847, Rosslyn, VA 22209.

[7] Available from U.S. Government Standardization Documents Order Desk, 700 Robbins Ave., Philadelphia, PA 19111.

AC—Four-wire system used with a 115-V (nominal) alternating current (ac) supply.

DC—Four-wire system used with a 28-V (nominal) direct current (dc) supply.

S1.5 Ordering Information

S1.5.1 The purchaser shall provide the manufacturer with all of the pertinent application data shown in accordance with S1.5.2. If special application operating conditions exist that are not shown in the acquisition requirements, they shall also be described.

S1.5.2 *Acquisition Requirements*—Acquisition documents shall specify the following:

(a) Title, number, and date of this specification;

(b) Part designation (see S1.4.1);

(c) Special type position switch (see S1.4.2) description and unique requirements;

(d) National Stock Number (NSN) if available;

(e) Sensor head mounting requirements (see S1.7.2);

(f) Requirements when Type B or Type C optoelectronics module is specified (see S1.7.3.2 and S1.7.3.3);

(g) Optoelectronics module mounting method if other than specified herein (see S1.7.3);

(h) Type of fiber-optic connectors, receptacles, and bulkhead adapters, if other than specified herein (see S1.7.4);

(i) Fiber-optic cable length required (see S1.7.6);

(j) Critical dimensions of the switch (see S1.7.13);

(k) Quantity of switches required;

(l) When first-article tests are required (see S1.12.2);

(m) Special marking requirements (see S1.14);

(n) Special packaging or package marking requirements (see S1.15); and

(o) Special warranty requirements (see S1.16.1).

S1.5.3 *First-Article Tests*—The purchaser should include specific instructions in acquisition documents regarding arrangements for tests, approval of first-article test results and time period for approval, and disposition of first articles. Invitations for bids should provide that the purchaser reserves the right to waive the requirement for samples for first-article inspection to those manufacturers offering a product which has been previously acquired or tested by the purchaser, and that manufacturers offering such products, who wish to rely on such production or test, must furnish evidence with the bid that prior purchaser approval is presently appropriate for the pending contract. The manufacture of items before purchaser approval should be specified as the responsibility of the manufacturer.

S1.6 Materials

S1.6.1 *Metals*—Unless otherwise specified herein, all metals used in the construction of the proximity or limit position switch shall be corrosion resistant. Dissimilar metals shall not be used in contact with each other unless suitably finished to prevent electrolytic corrosion.

S1.6.2 *Flammable Materials*—Materials used in the construction of the proximity or limit position switch shall be noncombustible or fire retardant in the most hazardous conditions of atmosphere, pressure, and temperature to be expected in the application. Fire-retardant additives may be used provided they do not adversely affect the specified performance requirements of the basic materials. Fire retardance shall not be achieved by use of nonpermanent additives to the basic material.

S1.6.3 *Fungus-Resistant Materials*—Materials used in construction of the switch sensor head and optoelectronics module shall not support the growth of fungus.

S1.6.4 *Solvents, Adhesives, and Cleaning Agents*—When chemicals or cements are used in bonding of internal proximity or limit position switch components, no degradation shall result during in-service use.

S1.6.5 *Refractive Index Matching Gels, Fluids, or Compounds*—Refractive index matching gels, fluids, or compounds shall not produce toxic, corrosive, or explosive byproducts. The material is subject to a toxicological data and formulations review and inspection, for safety of material, by the purchaser. The index matching material shall be either silicone or aliphatic hydrocarbon material and shall be clear and transparent. The index matching material shall have an index of refraction of 1.46 ± 0.01 as tested in accordance with Test Methods D 542, when exposed to operating temperature extremes between −28°C and +85°C. The index matching material shall not flow at elevated temperatures. The index matching material shall remain clear and transparent when tested for water absorption in accordance with Test Method D 570. The index matching material shall have a shelf life not less than 36 months at 25°C ± 5°C. The 36-month period commences on the date of adhesive manufacture.

S1.7 Physical Properties

S1.7.1 *Design and Construction*—The switch shall consist of an assembly with three major components: optical sensor head, fiber-optic cable, and optoelectronics module. The optoelectronics module shall be interchangeable between any of the sensor head types (see S1.4.2).

S1.7.2 *Sensor Head*—The sensor head shall meet the requirements specified herein. Sensor head mounting requirements shall be as required for the switch application and specified in the acquisition requirements (see S1.5.2). It is recommended that the sensor head be installed such that sufficient clearance is provided for repair and maintenance of the unit.

S1.7.3 *Optoelectronics Module*—The optoelectronics module shall contain the optical and signal conditioner devices necessary to convert the sensor head output to the specified electrical output. The module shall be bulkhead mounted, control enclosure mounted, or console mounted as specified in the acquisition requirements (see S1.5.2).

S1.7.3.1 *Bulkhead Mounted (Type A)*—Bulkhead-mounted optoelectronics modules shall be housed in a junction box. The junction box maximum dimensions shall be 280-mm L by 205-mm W by 130-mm D (11-in. L by 8-in. W by 5-in. D). The junction box material shall be brass.The junction box shall meet all test criteria in NEMA Standard 250 for Type 4X enclosures. The optoelectronics module shall be subjected to all first-article tests as specified (see S1.12.1) before mounting in the junction box.

S1.7.3.2 *Control Enclosure Mounted (Type B)*—Control enclosure-mounted optoelectronics modules are intended for use within an environmental protective enclosure as part of a

motor controller or other system. The optoelectronics module shall be mounted in an enclosure as specified in the acquisition requirements (see S1.5.2). The optoelectronics module shall be subjected to all first-article tests as specified (see S1.12.1) before mounting in the enclosure.

S1.7.3.3 *Console Mounted (Type C)*—Console-mounted (microprocessor or programmable logic controller (PLC) expansion card) optoelectronics modules are intended for use as a plug-in card for a console control system. The optoelectronics module shall be packaged in a console-mounted circuit card as specified in the acquisition requirements (see S1.5.2). The size, weight, pinout configuration, and number of channels shall be as specified in the acquisition requirements (see S1.5.2).

S1.7.4 *Fiber-Optic Cable*—A fiber-optic cable shall be used to connect sensor head to the optoelectronics module. There shall be no less than two times the number of fibers needed for operation of the switch in the cable. Penetration of the fiber-optic cable into the sensor head and the optoelectronics module shall be watertight. The required length of cable shall be as specified in acquisition requirements (see S1.5.2).

S1.7.5 *Optical Fiber*—All optical fiber used in the construction of the fiber-optic switch shall be in accordance with MIL-PRF-49291.

S1.7.6 *Fiber-Optic Connectors, Receptacles, and Bulkhead Adapters*—All fiber-optic connectors, receptacles, and bulkhead adapters shall be in accordance with MIL-C-83522 and MIL-C-83522/16, 17, and 18, respectively, or equal. Connectors shall be assembled at both ends of the fiber-optic cable between the sensor head and the optoelectronics module.

S1.7.7 *Local Status Indication*—The switch optoelectronics module shall have three indicator light-emitting diodes (LEDs): (1) a green LED that indicates the switch is closed when illuminated, (2) a red LED that indicates the switch is open when illuminated, and (3) a yellow LED that indicates a switch is closed with alarm level condition when illuminated. The LEDs shall be located on either the top or front of the module as it would be mounted during usage. The LEDs shall be visible in fluorescent room lighting. One LED and only one LED shall be lit at all times when the optoelectronics unit is energized.

S1.7.8 *Low-Intensity Alarm Set Point Adjustment*—The switch shall provide an indication of a degradation in the intensity of the transmitted optical signal via an alarm output. The optoelectronics module shall provide a means for adjusting the low-intensity alarm set point by one individual and without the necessity for an electrical disconnection. The low-intensity alarm set point adjustments shall be labeled and shall be accessible when the optoelectronics enclosure cover (for mounting Type A and Type B) is removed. The low-intensity alarm level set point shall allow tamperproof sensitivity adjustment over the entire dynamic range of the optoelectronics module. The optoelectronics module low-intensity alarm shall allow for an indication that maintenance is required before a false open switch indication.

S1.7.9 *Electrical Overload Protection and Isolation*—The optoelectronics module shall be provided with overload and short circuit protection. As a minimum, ac switches shall be protected from continuous overloads up to 6-A rms. Interruption of the operating voltage shall be required to restore normal operation of the switch after an overload has been detected. A means of isolating the optoelectronics module from ship power shall be provided on the unit.

S1.7.10 *Wire Colors:*

S1.7.10.1 *ac Switches*—Wire colors shall be as follows:

Normally open (N.O.):	Normally Closed (N.C.):
Black = input	Black = input
White = output	White = output

S1.7.10.2 *dc Switches*—Wire colors shall be as follows:

Black	= dc power high (positive lead)
White	= normally open (N.O.) output
Red	= normally closed (N.C.) output
Green	= dc power low (negative lead)

S1.7.11 *Lubrication*—The fiber-optic position switch shall not require lubrication.

S1.7.12 *Weight*—The weight of the fiber-optic position switch shall not exceed 4.5 kg (10 lb).

S1.7.13 *Dimensions*—The critical dimensions of the fiber-optic position switch shall be as specified in the acquisition requirements (see S1.5.2).

S1.8 Performance Requirements

S1.8.1 *Reliability*—The fiber-optic position switch shall be constructed for a service life of no less than 40 000 h.

S1.8.1.1 *Switch Electrical Characteristics*—Fiber-optic position switches shall operate on either ac or dc power as specified in the part designation (see S1.5.2)

S1.8.2 *ac Switch Electrical Characteristics*—ac switches shall be two-wire devices and shall operate in series with the load. ac switches shall be selectable between normally open or normally closed configuration.

S1.8.2.1 *Operating Voltage*—The switch shall be designed to operate using 115-V, 60-Hz, single-phase, ungrounded, ac power as defined in MIL-STD-1399, Section 300. The switch shall operate with power supply variations as specified in S1.11.9 and S1.11.10. Full-time surge protection shall be provided for power supply limits.

S1.8.2.2 *Voltage Drop*—The voltage drop across each switch during the activated (ON) state shall not be greater than 4-Vac root mean square (rms) at rated load current.

S1.8.2.3 *Leakage Current*—The leakage current through each switch during the deactivated (OFF) state shall not be greater than 2-mA rms.

S1.8.2.4 *Load Ratings*—The switch load ratings shall be as specified in S1.8.2.5 through S1.8.2.7.

S1.8.2.5 *Resistive*—The switch shall have a resistive rating of 1.25.

S1.8.2.6 *Inductive*—The switch shall operate inductive loads with a power factor between 1 and 0.35. As a minimum, the switch shall have a make-current rating of 10-A rms for three cycles of the specified operating voltage and a break current rating of 1.25-A rms.

S1.8.2.7 *Minimum Load*—The switch shall operate with a minimum load of 15-mA rms.

S1.8.3 *Multiple ac Switch Operation:*

S1.8.3.1 *Series Connection*—When two ac switches of the same designation (see S1.4.1) are operated in series, the total

switch voltage drop at the load shall not be greater than 8-Vac rms at the rated load current.

S1.8.3.2 *Parallel Connection*—When two ac switches of the same designation (see S1.4.1) are operated in parallel, the total switch leakage current at the load shall not be greater than 4-mA rms.

S1.8.4 *dc Switch Electrical Characteristics*—dc switches shall be four-wire devices and shall operate as voltage sources. Switches shall be line powered and shall have solid-state outputs. Each switch shall have one normally open (N.O.) and one normally closed (N.C.) output in a complementary configuration. The total power drawn from the line shall not be greater than the sum of 50 mA plus the output load current.

S1.8.4.1 *Operating Voltage*—The switch shall be designed to operate using 28 ± 4.5 V. The switch shall operate with power supply variations as specified in S1.11.9 and S1.11.10. Full-time surge protection shall be provided for power supply limits.

S1.8.4.2 *Voltage Drop*—The voltage drop across each switch during the activated (ON) state shall not be greater than 1.5 Vdc at rated load current.

S1.8.4.3 *Leakage Current*—Leakage current from each output in the open (OFF) state shall not be greater than 300 μA with 35 Vdc applied to the switch.

S1.8.5.4 *Load Ratings*—The switch load ratings shall be as specified in S1.8.5.5 through S1.8.5.6.

S1.8.5.5 *Maximum Current*—The switches shall operate continuously and supply 250 mA to resistive and inductive loads and 100 mA into lamp loads. The inductive load shall have a decay time of not greater than 100 ms when the load is interrupted. This decay shall be measured from the 90 % level to the 10 % level.

S1.8.5.6 *Minimum Load*—The switches shall supply any load current from maximum (see S1.8.5.5) down to zero.

S1.8.5 *Multiple dc Switch Operation:*

S1.8.5.1 *Series Connection*—When two dc switches of the same designation (see S1.4.1) are operated in series, the total switch voltage drop at the load shall not be greater than 3 Vdc at the rated load current.

S1.8.5.2 *Parallel Connection*—When two dc switches of the same designation (see S1.4.1) are operated in parallel, the total switch leakage current at the load shall not be greater than 600 μA.

S1.8.6 *Switch Performance:*

S1.8.6.1 *Operation*—The switch shall operate as specified in S1.7.7, S1.7.8 and S1.8.1.1.

S1.8.6.2 *Response Time*—Response time is the time it takes to go from 10 to 90 % of full rise. The response time of the opto-electronics module shall be no greater than 100 ms closed to open and 100 ms open to closed.

S1.8.6.3 *Warm-Up Time*—The switch shall operate properly as specified in S1.7.7 and S1.8.1.1 within 1 min.

S1.8.6.4 *Change in Optical Transmittance*—Changes in optical transmittance shall not be greater than 3 dB.

S1.8.6.5 *Dynamic Range*—The dynamic range of the opto-electronics module shall not be less than 30 dB.

S1.8.6.6 *Ambient Light Susceptibility*—The switch shall not indicate a false closed condition when the switch is open nor a false open condition when the switch is closed in the presence of ambient light.

S1.8.6.7 *Steady-State Supply Voltage and Frequency (ac) or Supply Voltage (dc)*—The switch shall perform in accordance with S1.8.6.1 and shall not indicate a false open condition when the switch is closed, nor shall it indicate a false closed condition when the switch is open, when operated within the limits of steady-state voltage.

S1.8.6.8 *Transient Supply Voltage and Frequency (ac) or Supply Voltage (dc)*—The switch shall perform in accordance with S1.8.6.1 and shall not indicate an open switch condition at any time when exposed to the specified limits of transient voltage and frequency.

S1.8.6.9 *Insulation Resistance*—The insulation resistance of the optoelectronics module shall not be less than 10 mΩ.

S1.8.6.10 *Power Interruption*—The switch shall perform in accordance with S1.8.6.1 and shall not indicate an open switch condition during steady-state operation when exposed to repeated power interruptions.

S1.8.6.11 *Short Circuit*—The switch shall perform in accordance with S1.8.6.1 and the local status indication shall indicate the correct switch position when experiencing a shorted output circuit.

S1.8.6.12 *Line Voltage Reversal (dc Switch Only)*—The switch shall operate in accordance with S1.8.6.1 after the input power leads have been reversed.

S1.8.6.13 *Mechanical Life*—The switch shall operate in accordance with S1.8.6.1 and S1.8.6.4 for a minimum of 260 000 cycles. The switch shall show no evidence of physical damage.

S1.8.6.14 *Temperature*—The sensor head and optoelectronics module shall operate within the optical limits specified in S1.8.6.4 when exposed to the specified temperature limits. The switch shall show no evidence of physical damage.

S1.8.6.15 *Enclosure*—The sensor head and optoelectronics module shall meet all test criteria in NEMA Standard 250 for Type 4X enclosures.

S1.8.6.16 *Vibration*—The sensor head and optoelectronics module shall meet the requirements of S1.8.6.1 and S1.8.6.4 when exposed to vibration in accordance with MIL-STD-167-1. The switch shall show no evidence of physical damage.

S1.8.6.17 *Shock*—The switch shall operate within the requirements of S1.8.6.1 and S1.8.6.4 when exposed to shock in accordance with MIL-S-901. Minor deformation of the switch is acceptable provided the sensor operates in accordance with S1.8.6.1 after shock. The switch shall not indicate a change in state for greater than 50 ms during shock.

S1.8.6.18 *Electromagnetic Interference (EMI)*—The switch shall perform within the limits of S1.8.6.1 and S1.8.6.4 and shall not indicate a change in state at any time when exposed to EMI in accordance with MIL-STD-461 Table II, except as modified below:

CE101—The test signal shall be applied only to the ac power leads of the test sample.

CE102—The test signal shall be applied only to the ac power leads of the test sample.

CS114—Only Limit Curve No. 2 shall apply with the frequency range limited to 10 kHz to 30 MHz.

RE101—Only the limit curve for 50 cm shall apply.

RS103—The frequency range shall be limited to 10 kHz to 18 GHz with an electric field strength test level of 10 V/m.

S1.9 Workmanship, Finish, and Appearance

S1.9.1 *Surface Finish*—Surfaces of castings, forgings, molded parts, stampings, and machined and welded parts shall be free of defects such as cracks, pores, undercuts, voids, and gaps, as well as harmful or extraneous materials such as sand, dirt, fins, sharp edges, scale, and flux. External surfaces shall be smooth and edges shall be either rounded or beveled. There shall be no burn through, warpage, or dimensional change as a result of heat from welding. There shall be no damage to adjacent parts resulting from welding.

S1.10 Number of Tests and Retests

S1.10.1 *First-Article Test Sample Size*—A sample shall consist of a sensor head (Type 1 through 5), an optoelectronics module, associated fiber-optic cable, connectors, bulkhead adapters, and connector receptacles. Four samples of the same test lot (see S1.10.1.1) shall be subjected to first-article tests. Each sample shall be supplied with the length of cable required for the application (see S1.5.2) or 30 m of fiber-optic cable, whichever is greater. Note that two items will be tested at the same time: the optoelectronics module and the sensor head, whether proximity or limit. Prior testing of an optoelectronics module in conjunction with the testing of a different sensor head does not exclude the optoelectronics module from any of the testing requirements specified herein. Three samples shall be subjected to the tests of Group I and one sample shall be subjected to the tests of Group II.

S1.10.1.1 *First-Article Test Lot*—A test lot shall consist of all fiber-optic switches of the same classification (see S1.4.1), produced under essentially the same conditions, in the same facility from the same materials and offered for delivery at the same time.

S1.10.2 *Conformance Test Sample Size*—Fiber-optic switches offered for delivery shall be subjected to Group A tests listed in Table S1.1. The number of samples subjected to Group B tests shall be in accordance with Table S1.2.

S1.11 Test Methods

S1.11.1 *Test Conditions*—Except where the following factors are the variables, the tests specified in S1.11.2 shall be conducted with the equipment under the following operating environmental conditions:

TABLE S1.1 Conformance Tests

Test	*Method*	*Requirement*
Group A		
General examination	S1.12.4	S1.6.1 through S1.7.13
Operation	S1.11.3	S1.8.6.1
Response time	S1.11.4	S1.8.6.2
Dynamic range	S1.11.7	S1.8.6.5
Group B		
Supply voltage and frequency (steady-state)	S1.11.9	S1.8.6.7
Insulation resistance	S1.11.13	S1.8.6.9
Temperature	S1.11.18	S1.8.6.14
Enclosure	S1.11.19	S1.8.6.15

TABLE S1.2 Group B Tests Sample Size

Lot Size	Sample Size
2 to 8	2
9 to 15	3
16 to 25	5
26 to 50	8
51 to 90	13
91 to 150	20
151 to 280	32
281 to 500	50
501 to 1200	80
1201 to 4200	125
4201 +	3 per 100

(a) Ambient temperature shall be 23 ± 2°C.

(b) Relative humidity shall be ambient.

S1.11.2 *Tests*—Except for the warm-up time test (see S1.11.5), the switch and all associated test equipment shall be energized for a period of time sufficient to ensure complete warm-up.

S1.11.3 *Operation*—The operation of the sensor head and optoelectronics module shall be tested by manually opening and closing the switch for ten cycles. Performance shall be in accordance with S1.8.6.1.

S1.11.4 *Response Time*—The response time shall be measured by opening and closing the switch via a beam gate, controlled by a function generator. The output of the switch shall be connected to a calibrated optical oscilloscope or a calibrated electrical oscilloscope as appropriate. The output from the function generator shall be connected to the monitoring oscilloscope and the traces shall be compared to determine the response time of the system. Performance shall be in accordance with S1.8.6.2.

S1.11.5 *Warm-Up Time*—The switch shall be deenergized for a period of not less than 12 h. The switch shall then be energized. The warm-up time is the elapsed time between the application of line power and the point at which the switch output reaches the conditions specified in S1.8.6.3. Performance shall be in accordance with S1.8.6.3.

S1.11.6 *Change in Optical Transmittance*—The change in optical transmittance of the sensor head shall be performed in accordance with EIA 455-20. Performance shall be in accordance with S1.8.6.4.

S1.11.7 *Dynamic Range*—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 to the transmitter and receiver via the two jumper cables. The attenuation shall be increased from 0 dB (plus insertion loss of attenuator and jumpers) to 50 dB (plus insertion loss of attenuator and jumpers). The switch shall be left in the open position. The dynamic range will be exceeded when the switch indicates a closed switch position. The dynamic range shall be in accordance with S1.8.6.5.

S1.11.8 *Ambient Light Susceptibility*—The ambient light source and general test conditions shall be in accordance with EIA 455-22. The entire switch shall be placed in the beam of the light source and placed in a closed condition. After a period of 10 min, the switch shall be placed in an open condition by disconnecting the optical cable from the source. The switch

shall then be subjected to the ambient light source for an additional 10 min. Performance shall be in accordance with S1.8.6.6.

S1.11.9 *Steady-State Supply Voltage and Frequency (ac) and Supply Voltage (dc)*—The switch shall be operated for not less than 15 min and shall be manually opened and closed not less than ten times at conditions of nominal, maximum, and minimum steady-state voltages (dc) and all possible combinations of nominal, maximum, and minimum steady-state voltages and frequencies (ac). Each of the conditions shall be tested at 0 ± 2°C, 25 ± 2°C, and 60 ± 2°C. This test may be performed in conjunction with the temperature test (see S1.11.18). The switch shall be allowed to stabilize at each testing temperature before the steady-state voltage and frequency test shall be performed. Performance shall be in accordance with S1.8.6.7.

S1.11.10 *Transient Supply Voltage and Frequency (ac) or Supply Voltage (dc)*—The switch shall be tested to S1.11.11 (ac) or S1.11.12 (dc). The switch shall be placed in a closed switch position and the output of the switch shall be monitored throughout the test. Performance shall be in accordance with S1.8.6.8.

S1.11.11 *Transient Supply Voltage and Frequency (ac)*—The test shall be performed as follows:

(a) With the switch operating at 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.

(b) 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.

(c) With the switch 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.

(d) With the switch 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.

S1.11.12 *Transient Supply Voltage (dc)*—The test shall be performed as follows:

(a) With the switch 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.

(b) With the switch 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.

S1.11.13 *Insulation Resistance*—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 requirements (see S1.8.6.9) and is steady or increasing, the test may be terminated before the end of the 2-min period. Performance shall be in accordance with S1.8.6.9.

S1.11.14 *Power Interruption*—The switch shall be placed in a closed switch position and the output of the switch shall be monitored throughout the test. With the switch operating within the steady-state tolerances of voltage and frequency, the external power supply shall be suddenly interrupted, and after an interval between 3 and 4 s, the power supply shall be reestablished to within the steady-state tolerances. After the switch has been operated long enough to detect any major performance degradation, the power shall be interrupted for an interval of 30 s. This cycle (3- to 4-s interruption, monitor, then 30-s interruption) shall be repeated three times (total of four). Performance shall be in accordance with S1.8.6.10.

S1.11.15 *Short Circuit*—The switch shall be deenergized. The electrical output leads or terminals of the optoelectronics module shall be connected directly together with no load resistance. The switch shall be energized for 5 min. The switch shall be manually opened and closed ten times during this period. Immediately following the 5-min period, the output pins shall be unshorted. Performance shall be in accordance with S1.8.6.11.

S1.11.16 *Line Voltage Reversal (dc)*—The switch power supply shall be connected as follows: the 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 shall then be disconnected. The power supply shall then be correctly applied (Pin “A” positive, Pin “B” negative). Performance shall be in accordance with S1.8.6.12.

S1.11.17 *Mechanical Life*—The switch shall be placed in the closed switch condition. The switch shall then be operated for 260 000 cycles (open-close is one cycle). The cycle rate shall be between one cycle per s and one cycle every 2 s (1 to 0.5 Hz). A change in optical transmittance test (see S1.11.6) shall be performed at the end of the mechanical life test. Performance shall be in accordance with S1.8.6.13.

S1.11.18 *Temperature*—The mated cable to switch assemblies shall be tested at high and low temperature as specified herein. The switch shall be placed in a closed switch position and Steps 1 through 6 shall be performed. The switch shall then be placed in an open switch position and Steps 1 through 6 shall be performed. Change in optical transmittance shall be measured in accordance with S1.11.6. Visual inspection shall be performed after the test. Performance shall be in accordance with S1.8.6.14.

Step 1—Hold temperature at room ambient (25 ± 2°C) for one h.

Step 2—Decrease temperature in steps of 10°C at 30 min per step until −28 ± 2°C is achieved.

Step 3—Hold temperature at −28 ± 2°C for 24 h.

Step 4—Increase temperature in steps of 10°C at 30 min per step until 65 ± 2°C is achieved.

Step 5—Hold temperature at 65 ± 2°C for 24 h.

Step 6—Decrease temperature in steps of 10°C at 30 min per step until 25 ± 2°C is achieved.

S1.11.19 *Enclosure*—The sensor head and optoelectronics module shall be subjected to the tests in NEMA 250 for Type 4X enclosures. Change in optical transmittance shall be measured in accordance with S1.11.6. Performance shall conform to the requirements of S1.8.6.15.

S1.11.20 *Vibration*—The switch shall be placed in a closed switch position and the output of the switch shall be monitored throughout the test. The switch shall be tested in accordance with MIL-STD-167-1 Type I vibration test. Change in optical transmittance shall be measured in accordance with S1.11.6. Visual inspection shall be performed after the test. Performance shall be in accordance with S1.8.6.16.

S1.11.21 *Shock*—The switch shall be subjected to the high-impact shock test for Grade A, Type A, Class I, lightweight equipment as specified in MIL-S-901. The switch shall be placed in a closed switch position and the switch shall be monitored throughout the test. The change in optical transmittance shall be measured after each of the nine hammer blows (see S1.11.6). Performance shall be in accordance with S1.8.6.17.

S1.11.22 *Electromagnetic Effects*—The switch shall be tested in accordance with MIL-STD-461. The switch shall be placed in a closed switch position and the output of the switch shall be monitored throughout the test. Performance shall be in accordance with S1.8.6.18.

S1.12 Inspection

S1.12.1 *Classification of Inspections*—The inspection requirements specified herein are classified as follows:

(a) First-article tests (see S1.12.2).

(b) Conformance tests (see S1.12.3).

S1.12.2 *First-Article Tests*—When first-article tests are required in the acquisition requirements (see S1.5.2), first-article tests shall be performed before production. First-article tests shall be performed on samples that have been produced with equipment and procedures normally used in production. First-article tests shall consist of the tests specified in Table S1.3. Failure of any switch to meet the requirements of this specification shall be cause for rejection.

TABLE S1.3 First-Article Tests

Test	*Method*	*Requirement*
Group I		
Operation	S1.11.3	S1.8.6.1
Response time	S1.11.4	S1.8.6.2
Warm-up time	S1.11.5	S1.8.6.3
Change in optical transmittance	S1.11.6	S1.8.6.4
Dynamic range	S1.11.7	S1.8.6.5
Ambient light susceptibility	S1.11.8	S1.8.6.6
Supply voltage and frequency (steady-state)	S1.11.9	S1.8.6.7
Supply voltage and frequency (transient)	S1.11.10	S1.8.6.8
Insulation resistance	S1.11.13	S1.8.6.9
Power interruption	S1.11.14	S1.8.6.10
Short circuit	S1.11.15	S1.8.6.11
Line voltage reversal	S1.11.16	S1.8.6.12
Mechanical life	S1.11.17	S1.8.6.13
Temperature	S1.11.18	S1.8.6.14
Enclosure	S1.11.19	S1.8.6.15
Vibration	S1.11.20	S1.8.6.16
Shock	S1.11.21	S1.8.6.17
Group II		
Operation	S1.11.3	S1.8.6.1
EMI	S1.11.22	S1.8.6.18

S1.12.2.1 *Order of First-Article Tests*—Test specimens shall be subjected to the tests specified in Table S1.3 in the order listed except that the steady-state supply voltage and frequency test may be performed concurrently with the temperature test. Any deviation in the test order shall first be approved by the purchaser.

S1.12.3 *Conformance Tests*—All switches shall be subjected to conformance tests. Conformance tests shall be in accordance with Table S1.1 and S1.10.2. Failure of any switch to meet the requirements of this specification shall be cause for rejection.

S1.12.4 *General Examination*—Each fiber-optic position switch shall be examined to determine conformance to the requirements of this specification with respect to material, color, finish, workmanship, safety, construction, assembly, dimensions, weight, identification marking, and label plates. Examination shall be limited to the examinations that may be performed without disassembling the unit in such a manner that its performance, durability, or appearance would be affected. Examination shall include a check of all controls and adjustments, as applicable.

S1.13 Certification

S1.13.1 The purchase order or contract should specify whether the purchaser shall be furnished certification that samples representing each lot have been either tested or inspected as directed in this standard and the requirements have been met. The purchase order or contract should specify when a report of the test results shall be furnished. Otherwise, the purchase order or contract should specify that all test data remain on file for three years at the manufacturer's facility for review by purchaser upon request.

S1.14 Product Marking

S1.14.1 *Identification Marking*—Special purchaser specified product marking shall be listed in the acquisition requirements (see 5.2). Switches shall be permanently and legibly marked. Marking shall be located on the top or front of the sensor head (as mounted in service), and on the top or front of the optoelectronics module (as mounted in service).

S1.14.1.1 *Sensor Head*—At a minimum, the information specified in 14.1.1 in addition to the following shall be marked on the sensor head:

(a) National stock number (NSN).

S1.14.1.2 *Optoelectronics Module*—At a minimum, the information specified in 14.1.2 in addition to the following shall be marked on the module.

(a) National stock number (NSN),

(b) Technical manual number, and

(c) Contract number.

S1.14.2 *Labeling*—Labels with yellow lettering on a black background shall be provided as follows:

S1.14.2.1 *Optoelectronics Module*—A visible label shall be affixed to the outside of the optoelectronics module cover and shall contain the following:

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

S1.14.2.2 *Sensor Head and Inside of Optoelectronics Module*—A visible label 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

S1.15 Packaging and Package Marking

S1.15.1 Packaging and package marking shall be in accordance with Section 15.

S1.16 Quality Assurance

S1.16.1 *Warranty*—Special warranty requirements shall be specified in the acquisition requirements (see S1.5.2).