Designation: F2071 – 00 (Reapproved 2017)

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 F2071; 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 Special requirements for naval shipboard applications are included in the Supplement.

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. Where information is to be specified, it shall be stated in SI units.

1.4 *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.*

1.5 *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

2.2 *ISO Standards:*[3]

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

3. Terminology

3.1 *Definitions:*

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

3.1.2 *closed switch with positive alarm, n*—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, n*—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, n*—a switch that senses a change in position via mechanical contact.

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

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

3.1.7 *optoelectronics module, n*—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, n*—a switch that senses a change in position via noncontact means.

3.1.9 *sensor head, n*—unit of the fiber-optic position switch that detects position via changes in optical properties. The

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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.

[3] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

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, n*—an input voltage that does not deviate from a specified nominal tolerance (for example, ±5 %).

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

3.1.12 *transient supply voltage, n*—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.

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:

(1) Title, number, and date of this specification,
(2) Manufacturer's part number,
(3) Switch type required (see 4.3),
(4) Unique or special enclosure requirements (see 7.1),
(5) Type of optoelectronics module (see 7.2). If control enclosure or console mounted, specify requirements,
(6) Length of fiber-optic cable required,
(7) Type of electrical connection (see 7.4),
(8) When the electrical connection mating plug is not to be provided (see 7.4),
(9) System operating characteristics,
(10) Materials,
(11) Environmental requirements,
(12) Quantity of switches required,
(13) Size and weight restrictions (see 7.5),
(14) Critical service life requirements (see 8.1),
(15) Performance requirements (see 8.2),
(16) Special surface finish requirements (see 9.1),
(17) Special workmanship requirements (see 9.2),
(18) When certification is required (see 13),
(19) Special marking requirements (see 14),
(20) Special packaging or package marking requirements (see 15),
(21) When ISO 9001 quality assurance system is not required (see 16.1), and
(22) 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.

(1) Warm-up time,
(2) Steady-state supply voltage and frequency (ac),
(3) Steady-state supply voltage (dc),
(4) Response time,
(5) Transient supply voltage and frequency (ac),
(6) Transient supply voltage (dc),
(7) Change in optical transmittance,
(8) Dynamic range,
(9) Ambient light susceptibility,
(10) Temperature,
(11) Humidity,
(12) Salt spray,
(13) Insulation resistance,
(14) Power interruption,
(15) Short circuit,
(16) Line voltage reversal (dc powered),
(17) Output,
(18) Mechanical life,
(19) Enclosure,
(20) Vibration,
(21) Shock,
(22) Electromagnetic interference (EMI), and
(23) 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:

(1) First-article tests (see 11.2)
(2) 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:*

(1) "FIBER-OPTIC POSITIONS SWITCH—SENSOR HEAD,"

(2) Manufacturer's name,

(3) Manufacturer's serial number or lot number, and

(4) Manufacturer's part number.

14.1.2 *Optoelectronics Module:*

(1) "FIBER-OPTIC POSITION SWITCH—OPTOELECTRONICS MODULE,"

(2) Manufacturer's name,

(3) Manufacturer's serial number or lot number,

(4) Manufacturer's part number, and

(5) 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 D3951.

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:

(1) All materials used to produce a unit and

(2) 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 standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

S1.2 Referenced Documents

S1.2.1 *ASTM Standards:*[2]

D542 Test Methods for Index of Refraction of Transparent Organic Plastics

D570 Test Method for Water Absorption of Plastics

S1.2.2 *Electronic Industries Association (EIA) Standards:*[4]

455-20 FOTP-20 Measurement of Change in Optical Transmittance

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

455-34 FOTP-34 Interconnection Device Insertion Loss Test

S1.2.3 *NEMA Standards:*[5]

250 Enclosures for Electrical Equipment (1000 Volts Maximum)

S1.2.4 *Military Standards:*[6]

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 Millimeter Bayonet Coupling, Epoxy

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

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

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

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

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

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

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

[5] Available from National Electrical Manufacturers Association (NEMA), 1300 N. 17th St., Suite 900, Arlington, VA 22209, http://www.nema.org.

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

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

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 Specification	1 Type S1.4.2	B Optoelectronics Module S1.4.3	DC Power Supply 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:

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:

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

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

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

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

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

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

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

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

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

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

(11) Quantity of switches required;

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

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

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

(15) 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 D542, 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 D570. 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)