MILITARY SPECIFICATION

SWITCHES, AIR AND LIQUID FLOW, SENSING, GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense

1. SCOPE

1.1 Scope. This specification covers the general requirements for flow switches intended primarily for use in equipment to sense velocity and flow of air or liquid.

1.2 Classification. Switches shall be classified by the flow type, air or liquid, as specified (see 3.1).

2 APPLICABLE DOCUMENTS

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

SPECIFICATIONS

FEDERAL

ZZ-R-765 - Rubber, Silicone. Low-and-High-Temperature and Tear Resistant.

MILITARY

MIL-I-10 - Insulating Compound, Electrical, Ceramic, Class L.
MIL-M-14 - Molding Plastics and Molded Plastic Parts, Thermosetting.
MIL-S-8516 - Sealing Compound, Synthetic Rubber, Electric Connectors and Electric Systems, Accelerator Required.
MIL-I-16923 - Insulating Compound, Electrical, Embedding.
MIL-S-23586 - Sealing Compound, Electrical, Silicone Rubber, Accelerator Required.
MIL-M-24041 - Molding and Potting Compound, Chemically Cured Polyurethane (Polyether Based).
MIL-S-28786 - Switches, Preparation for Delivery of.
MIL-C-45662 - Calibration System Requirements.
MIL-I-81550 - Insulating Compound, Electrical, Embedding, Reversion Resistant Silicone.

See supplement 1 for list of associated specification sheets.

STANDARDS

FEDERAL

FED-STD-H28 - Screw-Thread Standards for Federal Services.

MILITARY

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.
MIL-STD-202 - Test Methods for Electronic and Electrical Component Parts.
MIL-STD-454 - Standard General Requirements for Electronic Equipment.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to Naval Electronic Systems Command, Department of the Navy, Washington DC 20360, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

MIL-STD-1276 - Leads, Weldable for Electronic Component Parts
MIL-STD-1285 - Marking of Electrical and Electronic Parts

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

3 REQUIREMENTS

3.1 Specification sheets. The individual item requirements shall be as specified herein and in accordance with the applicable specification sheets. In the event of any conflict between requirements of this specification and the specification sheet, the latter shall govern (see 6.1).

3.2 Switch categories. Switches furnished under this specification shall be category I or II as defined herein.

3.2.1 Category I. Switches completely defined by a military specification sheet.

3.2.2 Category II. Switches the same as category I, except for minor differences such as terminations, mounting means, or flow settings, which do not change the basic design or construction of the qualified switch. Category II shall be procured from a source listed on the applicable qualified products list for the particular similar product in category I. Category II switches are nonstandard.

3.3 Qualification. Category I switches furnished under this specification shall be products which are qualified for listing on the applicable qualified products list at the time set for opening of bids (see 4.5 and 6.2).

3.4 Material. Material shall be as specified herein. However, when a definite material is not specified, a material shall be used which will enable the switches to meet the performance requirements of this specification. Acceptance or approval of any constituent material shall not be construed as a guaranty of the acceptance of the finished product.

3.4.1 Metals. All metal parts exposed to environmental conditions shall be of a corrosion-resistant material or shall be suitably plated to resist corrosion.

3.4.1.1 Ferrous material. Ferrous material shall not be used for current-carrying parts except for feed-through terminals in headers.

3.4.1.2 Dissimilar metals. When dissimilar metals are used in intimate contact with each other, protection against electrolysis and corrosion shall be provided. The use of dissimilar metals in contact, which tend toward active electrolytic corrosion (particularly brass, copper, or steel used in contact with aluminum or aluminum alloy), is not acceptable. However, metal-spraying or metal plating of dissimilar base metals to provide similar or suitable abutting surfaces is permitted. The use of dissimilar metals separated by a suitable insulating material is also permitted. Dissimilar metals are defined in 6.3 through 6.3.4 and table IV, except that the use of corrosion-resistant steel in contact with cadmium plating shall be allowed.

3.4.2 Insulation.

3.4.2.1 Plastic. Unless otherwise specified (see 3.1 and 6.1.2), molded plastic material shall conform to MIL-M-14, except that cotton-, wood-, or cellulose-filled molding materials shall not be used.

3.4.2.1.1 Thermoplastics. Thermoplastics shall not be used.

3.4.2.2 Ceramic. Ceramic insulation shall be grade L411 or higher, in accordance with MIL-I-10.

3.4.3 Rubber. Rubber parts except media seals shall be in accordance with ZZ-R-765.

3.4.4 Weldability. Leads designed for weldability shall conform to requirements of MIL-STD-1276, type K.

3.4.5 Potting compounds. Unless otherwise specified (see 3.1), potting compounds shall be in accordance with MIL-S-8516, MIL-S-23586, MIL-I-81550, MIL-M-24041, or MIL-I-16923 within their specified temperature ranges.

3.4.6 Fungus resistant material. Unless certification is furnished, materials for fabrication of switches covered by this specification shall conform to requirement 4 of MIL-STD-454. When nutrient materials are used, they shall be treated prior to fabrication of the switches.

3.5 Design and construction. Switches shall be of the design, construction, and physical dimensions specified (see 3.1), and shall be so constructed as to ensure proper operation when mounted in any position. The electrical ratings shall be as specified (see 3.1 and 6.1.2).

3.5.1 Mounting. Mounting shall be as specified (see 3.1 and 6.1.2). Stud mounting shall have threads in accordance with FED-STD-H28.

3.5.2 Termination. Termination shall be as specified (see 3.1).

3.5.2.1 Solder terminals. Solder terminals shall be treated to facilitate soldering. The terminal design shall be such that a mechanical connection can be made prior to soldering. Acceptable solder terminal designs are turret, hook, pierced, or post type. Gold plating shall not be used.

3.5.2.2 Screw terminals. Screw terminals shall be provided with hardware as specified (see 3.1 and 6.1.2). Lockwashers shall be captive to the screw. For direct Government orders, all terminal hardware shall be assembled in proper order.

3.5.3 Screw threads. Screw threads on removable threaded parts shall be in accordance with unified thread series of FED-STD-H28. Threading of nonmetallic parts shall not be permitted. Terminal threading engagement shall be at least two full threads.

3.5.4 Tamperproof calibration. Unless otherwise specified (see 3.1 and 6.1.2), the switches shall be so sealed that any tampering with the calibration after final adjustment by the manufacturer shall require dismantling of the switch or the breaking of a seal. The seal shall not be easily broken by manual force or without the use of any device considered a tool, that is, screwdriver, pliers, soldering iron, and so forth.

3.5.5 Weight. Weight shall be as specified (see 3.1 and 6.1.2).

3.5.6 Actuating mechanism. The external actuator shall be insulated from all current-carrying parts.

3.6 Solderability (when specified, see 3.1). When switches are tested as specified in 4.7.2, 95 percent of the total length of fillet, which is between the standard wrap wire and the terminal, shall be tangent to the surface of the terminal being tested. There shall be no pinholes, voids, and so forth. A ragged or interrupted line at the point of tangency between the fillet and the terminal under test shall be considered a defect. After the test, there shall be no evidence of fracture, loosening of parts, or any other mechanical failure of the switches.

3.7 Run-in (when specified, see 3.1 and 6.1.2). When switches are tested as specified in 4.7.3, the operating points shall be within the tolerances specified (see 3.1).

3.8 Calibration (see 3.1 and 6.1.2).

3.8.1 Actuation and deactuation. When tested as specified in 4.7.4.1, switches shall actuate and deactuate at the flow rate and pressure specified (see 3.1 and 6.1.2).

3.8.2 Proof flow. When tested as specified in 4.7.4.2, switches shall be capable of passing a minimum proof flow with a maximum differential pressure (pressure drop) as specified (see 3.1 and 6.1).

3.8.3 Differential pressure (pressure drop through switches). When tested as specified in 4.7.4.3, calibration and proof flow, the total pressure drop across the switch shall not exceed the specified values (see 3.1 and 6.1).

3.8.4 Proof pressure. When tested as specified in 4.7.4.4, switches shall show no evidence of leakage. Unless otherwise specified (see 3.1), the proof pressure shall be at least 150 percent of the maximum operating pressure. The actuation and deactuation flow rate, measured before and after the proof pressure test, shall not differ by more than the tolerances specified (see 3.1 and 6.1).

3.9 Transfer time. When switches are tested as specified in 4.7.5, the contacts of a pole shall transfer within 5 milliseconds on both increasing and decreasing flow within the operating tolerances specified (see 3.1 and 6.1.2).

3.10 Coincidence of operating points (applicable to multipole switches only). When switches are tested as specified in 4.7.6, all poles shall transfer within a total operating time of 10 milliseconds on both increasing and decreasing flow within the operating tolerances specified (see 3.1 and 6.1).

3.11 High temperature. When switches are tested as specified in 4.7.7, there shall be no evidence of malfunction, internal leakage, deterioration, combustion, or any other damage that may adversely affect the operation of the switch.

3.12 Low temperature. When switches are tested as specified in 4.7.8, there shall be no evidence of malfunction, internal leakage, deterioration, combustion, or any other damage that may adversely affect the operation of the switch.

3.13 Terminal strength (when specified, see 3.1). When switches are tested as specified in 4.7.9, the terminals shall not break, loosen, crack, or affect the operation of the switch.

3.14 Connector torque (when specified, see 3.1). When switches are tested as specified in 4.7.10, there shall be no loosening, rotation, distention, short circuiting, open circuiting, or other damage of any portion of the connector-switch interface or switch itself.

3.15 Shock. Unless otherwise specified (see 3.1 and 6.1.2), when switches are tested as specified in 4.7.11, there shall be no change in operation, no evidence of broken, deformed, displaced, or loose parts, and the operating points shall be within the tolerances specified (see 3.1).

3.15.1 Method I (shock, specified pulse). When switches are tested as specified in 4.7.11.1, closing of open contacts and chatter of closed contacts shall not exceed 10 microseconds, unless otherwise specified (see 3.1 and 6.1.2).

3.15.2 Method II (when specified, see 3.1) (high-impact shock). When switches are tested as specified in 4.7.11.2, closing of open contacts and chatter of closed contacts shall not exceed 20 milliseconds, unless otherwise specified (see 3.1 and 6.1.2).

3.16 Vibration. When switches are tested as specified in 4.7.12, there shall be no opening of closed contacts, nor closing of open contacts, in excess of 250 microseconds, unless otherwise specified (see 3.1). There shall be no evidence of broken, deformed, displaced, or loose parts and the operating points shall be within the tolerances specified (see 3.1).

3.17 Thermal shock. When switches are tested as specified in 4.7.13, there shall be no mechanical or electrical damage.

3.18 Moisture resistance. When switches are tested as specified in 4.7.14, the insulation resistance immediately after conclusion of the test shall be greater than 2 megohms at 500 Vdc. At the end of the drying period, the insulation resistance shall be as specified in 3.19. At the conclusion of the test, there shall be no evidence of corrosion or mechanical damage.

3.19 Insulation resistance. When measured as specified in 4.7.15, the insulation resistance between all insulated terminals and enclosures shall be not less than 500 megohms.

3.20 Dielectric withstanding voltage. Unless otherwise specified (see 3.1 and 6.1.2), when switches are tested as specified in 4.7.16, there shall be no flashover, arcing, or current flow in excess of 500 microamperes.

3.21 Seal (when specified, see 3.1 and 6.1.2).

3.21.1 Watertight. When switches are tested as specified in 4.7.17.1, there shall be no leakage as evidenced by a continuous stream of bubbles.

3.21.2 Hermetic. When switches are tested as specified in 4.7.17.2, the leakage rate shall not exceed 1×10^{-8} standard atmospheric cubic centimeters per second (atm cc/sec).

3.22 Contact resistance. When switches are tested as specified in 4.7.18, the initial resistance shall not exceed 100 milliohms. The final resistance at completion of endurance testing shall not exceed 250 milliohms.

3.23 Endurance. When tested as specified in 4.7.19, there shall be no evidence of malfunction or damage during or after the test, and switches shall meet the requirements of 3.8.

3.24 Sand and dust (when specified, see 3.1). When switches are tested as specified in 4.7.20, the subsequent operating characteristics shall be as specified (see 3.1), and they shall be mechanically and electrically operative at the conclusion of the test.

3.25 Explosion (when specified, see 3.1). When switches are tested as specified in 4.7.21, there shall be no explosion within the test chamber, whether or not explosion occurs within the switch. Switches shall be mechanically and electrically operable at the conclusion of the test.

3.26 Flammability (when specified, see 3.1). When switches are tested as specified in 4.7.22, there shall be no residual flame from the unit under test, upon removal of the external flame source and there shall be no evidence of external leakage of the media.

3.27 Salt spray (corrosion). When tested as specified in 4.7.23, switches shall show no evidence of destructive corrosion. After the test any mounting hardware (if applicable) shall be readily removable. NOTE: Destructive corrosion shall be construed as being any type of corrosion which in any way interferes with the mechanical or electrical performance, or in the case of plated metals, corrosion which has passed through the plating and attacked the base metal.

3.28 Burst pressure. When switches are tested as specified in 4.7.24, there shall be no evidence of internal leakage (between flow and electrical chambers) or external leakage (see 3.1 and 6.1.2). Following the test, the dielectric withstanding voltage shall be as specified in 3.20.

3.29 Marking. Switches shall be marked in accordance with MIL-STD-1285 with the military part number or the manufacturer's part number (when specified, see 6.1.2), date code, and the manufacturer's trademark or code symbol. For polarized switches, the plus terminal shall be marked with a positive sign. When a military part number is not available, the flow setting and contact arrangement shall be marked on the switches.

3.30 Workmanship. Switches shall be processed in such a manner as to be uniform in quality and shall be free from cracked or displaced parts, sharp edges, burrs, and other defects which will affect life, serviceability, or appearance.

4 QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Test equipment and inspection facilities. Test and measuring equipment and inspection facilities of sufficient accuracy, quality and quantity to permit performance of the required inspection shall be established and maintained by the contractor. The establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment shall be in accordance with MIL-C-45662.

4.2 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. Materials inspection (see 4.3).
b. Qualification inspection (see 4.5).
c. Quality conformance inspection (see 4.6).
d. Packaging inspection (see 4.6.3).

4.3 Materials inspection. Materials inspection shall consist of certification supported by verifying data that the materials listed in table I, used in fabricating the switches, are in accordance with the applicable referenced specification or requirements prior to such fabrication.

TABLE I. Materials inspection.

Material	Requirement paragraph	Applicable specification
Fungus resistance - - - - - -	3.4.6	MIL-STD-454
Plastic - - - - - - - - - - -	3.4.2.1	MIL-M-14
Rubber - - - - - - - - - - -	3.4.3	ZZ-R-765
Ceramic - - - - - - - - - - -	3.4.2.2	MIL-I-10

4.4 Inspection conditions. Unless otherwise specified herein, all inspections shall be performed in accordance with the test conditions specified in the GENERAL REQUIREMENTS of MIL-STD-202.

4.5 Qualification inspection. Qualification inspection shall be performed at a laboratory acceptable to the Government (see 6.2) on sample units produced with equipment and procedures normally used in production.

4.5.1 Sample size. The number of switches to be subjected to qualification inspection shall be as specified (see 3.1 and table II).

4.5.2 Inspection routine. The sample shall be subjected to the inspections specified in table II, in the order shown. All sample units shall be subjected to the inspections of group I. The sample shall then be divided as specified in table II for groups II through V inclusive, and subjected to the inspection for their particular group.

4.5.3 Failures. One or more failures shall be cause for refusal to grant qualification approval.

4.5.4 Extent of qualification.

4.5.4.1 Single submission. Qualification shall be restricted to the switch submitted.

TABLE II Qualification inspection.

Inspection	Requirement paragraph	Test method paragraph
Group I (all sample units)		
Visual and mechanical examination	3.1, 3.4, 3.5, 3.29, and 3.30	4.7.1
Solderability (when specified)	3.6	4.7.2
Run-in (when specified)	3.7	4.7.3
Calibration	3.8	4.7.4
Transfer time	3.9	4.7.5
Coincidence of operating points (when specified)	3.10	4.7.6
Group II (4 sample units from group I)		
High temperature	3.11	4.7.7
Low temperature	3.12	4.7.8
Terminal strength (when specified)	3.13	4.7.9
Connector torque (when specified)	3.14	4.7.10
Shock	3.15	4.7.11
Vibration	3.16	4.7.12
Thermal shock	3.17	4.7.13
Moisture resistance	3.18	4.7.14
Insulation resistance	3.19	4.7.15
Dielectric withstanding voltage	3.20	4.7.16
Seal (when specified)	3.21	4.7.17
Group III (sample units from group I) 1/		
Contact resistance	3.22	4.7.18
Endurance (2 sample units per electrical load or 4 sample units minimum)	3.23	4.7.19
Contact resistance	3.22	4.7.18
Dielectric withstanding voltage	3.20	4.7.16
Seal (when specified)	3.21	4.7.17
Group IV (2 sample units from group II)		
Sand and dust (when specified)	3.24	4.7.20
Explosion (when specified)	3.25	4.7.21
Flammability (when specified)	3.26	4.7.22
Group V (4 sample units from group III)		
Salt spray (corrosion)	3.27	4.7.23
Burst pressure	3.28	4.7.24
Dielectric withstanding voltage	3.20	4.7.16

1/ Number of sample units shall depend on number of loads specified.

4.5.4.2 Group submission. The extent of qualification shall be in accordance with the applicable specification sheet (see 3.1).

4.5.5 Retention of qualification. To retain qualification, the contractor shall submit a summary of the results of the tests performed for inspection of product for delivery (group A), and a certification of compliance at yearly intervals via the Government quality assurance representative. The summary of group A shall indicate the number of inspection lots that passed and the number that failed (including the number and type of failures) together with corrective action taken to correct failures. The certification of compliance shall include verification that materials, processes, and quality control have not changed. Failure to submit the group A summary and certification of compliance shall result in loss of qualification. If the summary of the test results indicates nonconformance with the specification requirements, and corrective action acceptable to the qualifying activity has not been taken, action may be taken to remove the failing product from the qualified products list.

4.6 Quality conformance inspection.

4.6.1 Inspection of product for delivery. Inspection of product for delivery shall consist of group A inspection.

4.6.1.1 Inspection lot. An inspection lot shall consist of all switches of the same type, produced under essentially the same conditions, and offered for inspection at one time.

4.6.1.2 Group A inspection. Group A inspection shall consist of the examinations and tests specified in table III, in the order shown. Differential pressure, insulation resistance, and dielectric withstanding voltage shall be within the limits specified. Actual values need not be recorded.

TABLE III Group A inspection.

Inspection	Requirement paragraph	Test method paragraph	AQL (percent defective)	
			Major	Minor
Calibration - - - - - - -	3.8	4.7.4	100% inspection	---
Run-in (when specified) -	3.7	4.7.3		
Calibration 1/ - - - - -	3.8	4.7.4		
Dielectric withstanding voltage - - - - - - - -	3.20	4.7.16	1.0	---
Insulation resistance - -	3.19	4.7.15		
Seal (when specified) - -	3.21	4.7.17		
Visual and mechanical examination - - - - - -	3.1, 3.4, 3.5, 3.29, and 3.30	4.7.1	1.0	4.0

1/ Applicable only when run-in is required.

4.6.1.2.1 Sampling plan. Statistical sampling and inspection shall be in accordance with MIL-STD-105 for general inspection level II. The acceptable quality levels (AQL) shall be as specified in table III. Major and minor defects shall be as defined in MIL-STD-105. In-process inspection may be used to fulfill all or part of group A.

4.6.1.2.2 Rejected lots. If an inspection lot is rejected, the contractor may rework it to correct the defects, or screen out the defective units, and resubmit for reinspection. Resubmitted lots shall be inspected using tightened inspection. Such lots shall be separate from new lots, and shall be clearly identified as reinspected lots.

4.6.1.2.3 Disposition of sample units. Sample units which have passed all the group A inspection may be delivered on the contract, if the lot is accepted and the sample units are still within specified electrical tolerances.

4.6.2 Packaging inspection. The sampling and inspection of the preservation-packaging, packing and container marking shall be in accordance with the requirements of MIL-S-28786.

4.7 Methods of inspection.

4.7.1 Visual and mechanical examination. Switches shall be examined to determine that the materials, design, construction, physical dimensions, marking, and workmanship are in accordance with the applicable requirements (see 3.1, 3.4, 3.5, 3.29, and 3.30).

4.7.2 Solderability (see 3.6) Switches shall be tested in accordance with method 208 of MIL-STD-202. The following details and exception shall apply

a. Number of terminations for each part to be tested - Two.
b. Dipping device - If it cannot be used, immersion, dwell, and emersion times shall be as specified.
c Examination of terminations - Method for evaluation of lugs and tabs shall apply.

4.7.3 Run-in (see 3.7) Switches shall be mounted by their normal mounting means in equipment capable of providing the media at the flow rates specified (see 3.1) The switches shall be cycled for the number of cycles specified (see 3.1). One cycle shall consist of increasing the flow rate from 0.25 gallon per minute (GPM) or 20 percent below the minimum operating flow rate, whichever is less, to the actuation point and back to the initial flow rate.

4.7.4 Calibration (see 3.8).

4.7.4.1 Actuation and deactuation (see 3.8.1). Switches shall be mounted by their normal mounting means in equipment capable of providing the media at the flow rates and pressure specified (see 3.1). The flow rate shall be increased to within 10 percent of actuation and then increased at a flow rate gradient, not exceeding 1 percent per second, until the actuation point is reached. The point shall be recorded. The flow rate shall then be reduced to within 10 percent of deactuation and then decreased at a flow rate gradient, not exceeding 1 percent per second, until deactuation occurs. The value shall be recorded. The flow rate shall then be decreased to zero. Media other than the service media may be used during these tests if the changes in fluid properties are properly correlated and submitted for approval to the qualifying activity.

4.7.4.2 Proof flow (see 3.8.2). Switches shall be mounted in the same fixture and system utilized for calibration (see 3.8). The flow shall be increased to the proof flow value specified (see 3.1 and 6.1), and maintained for 1 minute. Proof flow may be run in conjunction with calibration (see 4.7.4.1).

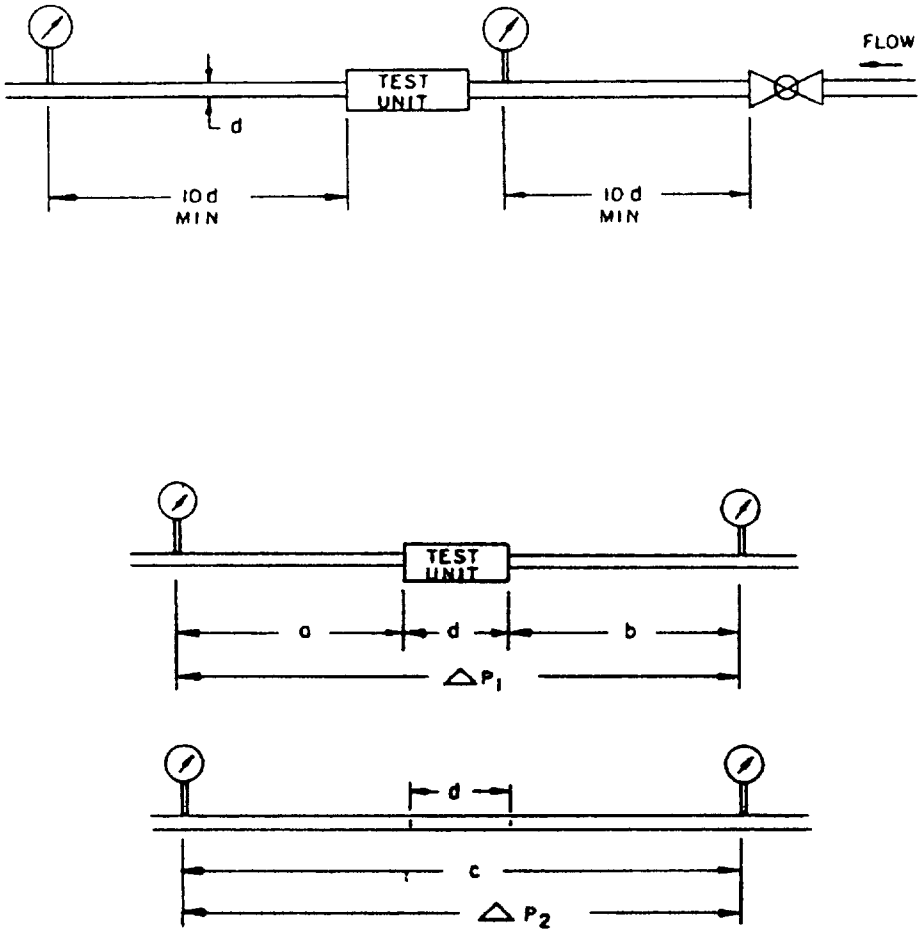
4.7.4.3 Differential pressure (see 3.8.3). Switches shall be mounted in the same fixture and system utilized for calibration (see 3.8.1). The differential pressure (pressure drop) measurements shall be taken in conjunction with calibration, at actuation flow, system flow and deactuation flow. During proof flow, differential pressure will be measured at the specified proof flow value (see 3.1 and 6.1). A differential pressure gage of at least 0.1 pounds per square inch (PSI) accuracy, shall be mounted such that it senses the pressure drop across (through) the switch, during flow conditions. The pressure pick-off points shall be as specified on figure 1.

4.7.4.4 Proof pressure (see 3.8.4). Switches shall be connected to equipment capable of supplying the specified medium at the pressure which can be varied from zero to at least the proof pressure specified (see 3.1). The downstream side of the switch may be closed. The pressure, either static or dynamic, shall be increased from zero to the specified proof pressure, maintained 1 minute, and decreased to zero.

4.7.5 Transfer time (see 3.9). Switches shall be tested using a variable flow which shall be increased and decreased slowly and uniformly, with no external vibratory influence while passing through the operating points at a rate of change not exceeding 1 percent per second.

4.7.6 Coincidence of operating points (see 3.10). When switches are tested, the variable flow shall be increased and decreased slowly and uniformly, with no external vibratory influence while passing through the operating points, at a rate of change not exceeding 1 percent per second. All poles shall transfer contacts on both increasing and decreasing flow tolerances specified (see 3.1 and 6.1), within a total operating time of 5 milliseconds.

4.7.7 High temperature (see 3.11). Switches shall be subjected to the highest nonoperating temperature specified (see 3.1 and 6.1), for a minimum of 12 hours. After this period, the temperature shall be reduced to the highest operating temperature specified and held for 2 hours. Then, while at this temperature, the switches shall be tested in accordance with 3.8, and the operating points shall be within tolerances specified.



C is a straight pipe equal in length to a + d + b.

ΔP_1 minus ΔP_2 is the amount of ΔP chargeable to the test unit.

FIGURE 1. Differential test set-up.

4.7.8 Low temperature (see 3.12). Switches shall be subjected to the lowest nonoperating temperatures specified (see 3.1), for a minimum of 12 hours. After this period, the temperature shall be changed to the lowest operating temperature specified and held for 2 hours. Then, while at this temperature, the switches shall be tested in accordance with 4.7.4, and the operating points shall be within tolerances specified.

4.7.9 Terminal strength (see 3.13). Switches shall be tested in accordance with method 211 of MIL-STD-202. The following details and exceptions shall apply.

a. Test condition - A.
b. Applied force - 4-1/2 pounds. For wire lead terminals, the applied force shall be 15 pounds.
c. Direction of force - Force shall be applied along three mutually perpendicular axes of the terminal, one direction of which shall be the one most likely to cause failure.
d. Time duration - 1 minute.
e. Examination after test - Switches shall be examined for evidence of breaking, loosening, cracking, and other damage affecting the operation of the switch. (Bending of terminals shall not be considered as damage to the switch.)

4.7.10 Connector torque (see 3.14). Switches shall be mounted by their normal mounting means on a rigid metal fixture. A torque of 5 foot-pounds shall be applied to the electrical connector, in a plane perpendicular to its central axis and in the direction which would tighten the mating part, and held for 1 minute. If the normal mounting means of the switch includes some type of strap or clamp, which would permit rotation of the entire switch in its mounting device during this test, the switch shall be held stationary by its pressure-port wrench flats, while the torque is applied. This test is intended as a verification of connector mounting suitability, and is not meant to confirm integrity of connector design or construction.

4.7.11 Shock (see 3.15). Switches shall be tested as specified in 4.7.11.1, method I, and in addition, when specified (see 3.1), switches shall also be tested as specified in 4.7.11.2, method II. The following details and exceptions shall apply to method I and method II:

a. Mounting method and accessories - Switches shall be mounted on a rigid metal panel by their normal mounting means.
b. Electrical load conditions - The electrical load shall consist of the monitor circuit only.
c. Half of the units shall be tested with the actuating means in one position and the other half of the units shall be tested with the actuating means in an alternate position. Open circuits may be connected in parallel and monitored for closing and closed circuits may be connected in series and monitored for opening. In the event of indication of opening or closing of contacts greater than that allowed, the test shall be modified by applying successive identical blows in the same plane to monitor contacts, switch by switch, to determine if a switch is defective.
d. Measurements during shock - Switch-contact stability shall be continuously monitored during shock using method 310 of MIL-STD-202.
e. Measurement after test - There shall be no evidence of broken, deformed, displaced, or loose parts and the operating points shall be within the tolerances specified.

4.7.11.1 Method I (shock, specified pulse). Switches shall be tested in accordance with method 213 of MIL-STD-202. The following detail and exception shall apply:

a. Test condition - I.
b. Contact stability - 10 microseconds.

4.7.11.2 Method II (high-impact shock) (when specified). Switches shall be tested in accordance with method 207 of MIL-STD-202. The following shall apply:

a. Contact stability - 20 milliseconds.

4 7.12 Vibration (see 3.16). Switches shall be tested for vibration grade 1, 2, or 3 (as applicable, see 3.1) in accordance with MIL-STD-202. The following details shall apply

a. Mounting of specimens - Switches shall be mounted on a rigid metal fixture by their normal mounting means.
b. Electrical load conditions - The electrical load shall consist of a monitoring circuit.
c. Test condition letter
   1 For vibration grade 1 - Method 201 (10-55 Hz).
   2. For vibration grade 2 - Method 204, test condition A (10-500 Hz).
   3. For vibration grade 3 - Method 204, test condition B (10-2,000 Hz).
d Measurements during test - All checks for contact disturbance shall be conducted with the switches being cycled between actuation and deactuation at a switching rate of no more than 10 cycles per minute, with the flow rise and decay rate not exceeding 1 percent per second, within 10 percent of the switching points. The entire frequency range shall be traversed as required by the applicable test method in MIL-STD-202. A minimum of two cycles of operation shall be recorded at each of the following frequencies. 10, 20, 40, and 55 (grade 1) or 10, 20, 40, 60, 80, 100, and every 100 Hz to and including 500 Hz or 2,000 Hz, as applicable (grades 2 and 3). Contact disturbance shall not exceed 250 microseconds when the flow pressure is within 10 percent of the switching point. At all other times, the contact disturbance shall not exceed 10 microseconds. Contact disturbance shall be monitored by any suitable means that will provide a permanent record of the contact disturbance at the above test frequencies. Approximately 50 actuations in each of the three mutually perpendicular planes shall be recorded and submitted with the test report. Following the test, switches shall be examined for evidence of broken, displaced, or loose parts, and operating points shall be within tolerances specified (see 3.1).

4.7.13 Thermal shock (see 3.17). Switches shall be tested in accordance with method 107 of MIL-STD-202. The following details and exception shall apply:

a. Test condition - A.
b. Measurement before and after cycling - Not applicable.
c. Examination after test - The flow settings shall be within the tolerances specified (see 3.1 and 6.1.2). Switches shall be examined for mechanical and electrical damage, and loosening of rivets and other fastening devices, and switches shall be within tolerances specified.

4.7.14 Moisture resistance (see 3.18). Switches shall be tested in accordance with method 106 of MIL-STD-202. The following details and exceptions shall apply:

a. Polarization voltage - During steps 1 to 6 inclusive, a polarizing voltage of 100 volts dc shall be applied between all terminals tied together and the metal panel. The negative polarity shall be applied to the metal panel.
b. Steps 7a and 7b - Not applicable.
c. Loading voltage - Not applicable.
d. Final measurements - After high humidity, insulation resistance shall be measured as specified in 4.7.15. At the end of the drying period, insulation resistance shall again be measured as specified in 4.7.15.
e. Examinations during final measurement and after test - Switches shall be examined for evidence of corrosion, breaking, cracking, and spalling.

4.7.15 Insulation resistance (see 3.19). Switches shall be tested in accordance with method 302 of MIL-STD-202. The following details shall apply:

a. Test condition - B.
b. Points of measurement - Between all terminals and frame or ground.

4.7.16 Dielectric withstanding voltage (see 3.20). Switches shall be tested in accordance with 4.7.16.2 and, when applicable (see 3.1 and 6.1.2), in accordance with 4.7.16.1. This test shall be performed with the switch in normal position, and shall then be repeated for other operating positions.

4.7.16.1 At atmospheric pressure. Switches shall be tested in accordance with method 301 of MIL-STD-202. The following details shall apply:

a. Magnitude of test voltage - 1,000 volts plus twice the working voltage.
b. Nature of potential - AC.
c. Duration of application of test voltage - 1 minute for qualification, 5 seconds for quality conformance tests, at 20 percent higher voltage.
d. Points of application of test voltage - Between all terminals and ground.
e. Maximum leakage current - 500 microamperes.
f. Examination after test - Switches shall be examined for evidence of arcing and flashover.

4.7.16.2 At reduced barometric pressure. Switches designed for operation above 10,000 feet shall be tested as specified in 4.7.16.1, and in accordance with method 105 of MIL-STD-202. The following details and exception shall apply.

a. Method of mounting - Normal mounting means.
b. Test condition - C or D, as applicable.
c. Test voltage - 500 volts, unless otherwise specified (see 3.1 and 6.1.2).

4.7.17 Seal (as applicable, see 3.21). Switches shall be tested in accordance with 4.7.17.1, or 4.7.17.2, as applicable.

4.7.17.1 Watertight. Switches shall be immersed to a depth of 2 ±1 inches in a container of water containing approximately 1/2 of 1 percent aerosol, and shall then be placed in a vacuum chamber. The absolute pressure shall be 1.3 inches of mercury and this pressure shall be maintained for a period of 1 minute. The absolute pressure shall then be increased to 2.5 inches of mercury and this pressure maintained for 2 minutes. During the 2-minute period, the switches shall be observed for evidence of a continuous stream of bubbles. Any bubbles coming from within the switches shall be considered as leakage. Bubbles which are the result of entrapped air on the exterior of the switches shall not be considered as an indication of leakage.

4.7.17.2 Hermetic. Switches shall be tested in accordance with method 112 of MIL-STD-202. The following details shall apply:

a. Test condition - C.
   1. Procedure III or IV, leakage-rate sensitivity - 1×10^{-8} atm cc/sec; for checking gross leaks, test condition B.
   2. For procedure IV.
      a. Reduced pressure of the chamber and duration of pressurization - Determination made in accordance with the type of equipment used.
b. Measurements after test - None.

4.7.18 Contact resistance (see 3.22). Switches shall be tested in accordance with method 307 of MIL-STD-202, except that the resistance measurements made shall include not only the contact resistance itself, but also the resistance of all connecting wires, solder joints, terminals, and so forth, which form the associated circuitry of the set of contacts. The following details shall apply:

a. Method of connection - The measuring apparatus shall be connected to the switch under test, utilizing the normal means by which the switch will be connected in actual use, i.e., receptacles and connectors, terminal blocks, pigtail leads, and so forth. Provision shall be made for testing each set of contacts and its associated circuitry when multicontact or multipole switches are involved.

b. Test current and maximum test voltage - The test current and test voltage may be any values compatible with the test method employed, but shall not exceed the rated values of the switch (see 3.1 and 6.1).
c. Actuations prior to measurement - Three mechanical actuations before measurement shall be allowed.
d. Number of test actuations - Three.
e. Number of measurements per actuation - One.
f. Resistance measurements shall be made before and after endurance testing, as specified in table II, and the resistance rise of each set of contacts and its associated circuitry shall not exceed 100 milliohms. The final resistance shall not exceed 250 milliohms.

4.7.19 Endurance (see 3.23). Switches shall be tested for endurance in accordance with the following. The media specified or an approved equivalent shall be used.

a. Operational cycling - Switches shall be subjected to the total number of mechanical and electrical cycles specified (see 3.1 and 6.1). One cycle shall consist of raising the flow rate from 0.25 GPM or 20 percent below the minimum actuating or deactuating flow rates, whichever is less, to the specified system flow rate plus or minus 10 percent. The flow rate shall then be reduced to the initial flow rate. Unless otherwise specified, the flow rate gradients shall be as equal as possible, and the holding times at minimum and maximum flow rates shall be as equal as possible. The cycling rate shall not exceed 30 cycles per minute.
b. Measurements during endurance cycling - Switch cycling shall be halted at the 10, 20, 30, 40, 50, 60, 70, 80, and 90 percent completion endurance stages. At each of these stages, the switches shall be subjected to the tests for calibration, proof flow, differential pressure and contact resistance, specified in 4.7.4, 4.7.4.2, 4.7.4.3, and 4.7.18, respectively. Tests shall be conducted at ambient environmental conditions, unless otherwise specified (see 3.1).
c. Measurements following endurance cycling - Switches shall be tested for all requirements specified for group A, in table III.

4.7.20 Sand and dust (see 3.24) (when specified, see 3.1 and 6.1.2). Switches shall be tested in accordance with method 110 of MIL-STD-202. The following details shall apply

a. Test condition - B.
b. Measurements - Switches shall be within tolerances specified.

4.7.21 Explosion (see 3.25) (when specified, see 3.1 and 6.1.2). Switches shall be tested in accordance with method 109 of MIL-STD-202. The following detail shall apply:

a. Mechanical and electrical load - Switches shall be operated at their maximum rated dc inductive current (see 3.1 and 6.1.2). Following the test, switches shall be within tolerances specified.

4.7.22 Flammability (see 3.26). Switches shall be tested in accordance with method 111 of MIL-STD-202. The following details shall apply:

a. Switches shall be connected to a pressure source. Both the inlet and outlet ports shall be connected in their normal manner. The outlet of the switch shall be capped off at a distance away from the switch, sufficient so not to be affected by the temperature buildup. The medium specified or an approved equivalent shall be used.
b. The point of impingement of the applied flame shall be midway between the electrical connector and the pressure flow ports.
c. The flame shall be applied for 5 minutes.
d. Immediately after removal of the external flame, there shall be no residual flame from the unit under test.
e. The flow rate shall then be increased to the actuation point plus 10 percent and maintained for a period of not less than 20 minutes during which there shall be no evidence of leakage by visual inspection.

4 7 23 Salt spray (corrosion) (see 3.27) Switches and their mounting hardware and brackets (if applicable) shall be tested in accordance with method 101 of MIL-STD-202. The following details shall apply

a. Test condition - B.
b. Measurements after exposure - Following the drying period, the switches shall meet the requirements specified in 3.27. Mounting hardware shall be removed at the end of the test.

4.7.24 Burst pressure (see 3.28). Switches shall be connected to equipment capable of supplying the specified medium (see 3.1), at a pressure which can be varied from zero to at least the burst pressure specified. The downstream side of the switch or switch test chamber may be closed. The pressure shall be increased from zero to the specified burst pressure at a rate not exceeding 1 percent per second. The specified burst pressure shall be maintained for at least 10 minutes, and the switches shall be examined for evidence of leakage. Following the burst pressure test, the switches shall be subjected to the test for dielectric withstanding voltage as specified in 4.7.16.

5. PACKAGING

5.1 Packaging requirements. The requirements for packaging shall be in accordance with MIL-S-28786.

6. NOTES

6.1 Ordering data.

6.1.1 For category I switches. Procurement documents should specify the following:

a. Title, number, and date of this specification.
b. Title, number, and date of the applicable specification sheet and the complete military part number.

6.1.2 For category II switches. Procurement documents should specify the following:

a. Title, number, and date of this specification.
b. Title, number, and date of the applicable specification sheet.
c. Military part number of qualified switch.
d. Manufacturer's part number of modified switch.
e. Details of the variations from the specification sheet.
f. Inspection requirements (to verify variations from category I switches) (see 4.5 and notes 1 and 2).
   1. Tests to be performed (if any) (see 4.5).
   2. The laboratory at which inspection is to be performed (see 4.5).
   3. Samples and submission of data, if other than that specified (see 4.5.1 and 4.5.2).

6.2 Qualification. With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids, qualified for inclusion in the applicable qualified products list, whether or not such products have actually been so listed by that date. The attention of the suppliers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the qualified products list is the Naval Electronic Systems Command, ELEX-5043, Washington, DC 20360. Information pertaining to qualification of products may be obtained from either the Naval Electronic Systems Command or the Defense Electronics Supply Center (DESC-E), Dayton, Ohio 45444.

6.2.1 Copies of "Provisions Governing Qualification" may be obtained upon application to Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

6 3 Intermetallic contact The finishing of metallic contact of dissimilar metals results in electrolytic couples which promote corrosion through galvanic action To provide the required corrosion protection, intermetallic couples are restricted to those permitted by table IV Table IV shows metals and alloys for plates) by groups which have common electromotive forces (EMF) within 0.05 volt when coupled with a saturated calomel electrode in sea-water at room ambient temperatures All members of a group are considered as completely compatible, one with the other Compatible couples between groups have been specified in table IV based on a potential difference of 0.25 volt maximum. To simplify any arithmetic involved, table IV shows, in addition to EMF against a calomel electrode, a derived "anodic index" with group 1 (gold, and so forth,) as 0 and group 18 (magnesium, and so forth,) as 175. Subtraction of a lower group anodic index gives the EMF difference in hundredths of a volt.

6 3 1 Groups. Table IV sets up 18 primary groups It may be noted that neither the metallurgical similarity nor dissimilarity of metals is the parameter for selection of compatible couples. All members within a group, regardless of metallurgical similarity, are considered inherently nonsusceptible to galvanic action when coupled with any member within the group, for example, such dissimilar metals as platinum and gold. Similarly, such basically dissimilar alloys as austenitic stainless steel, silver-solder, and low brass (all members of group 5) are inherently nonsusceptible when coupled together.

6.3.2 Compatibility graphs. Permissible couple series are shown in table IV by the graphs at the right. Members of groups connected by lines will form permissible couples. A "0" indicates the most cathodic member of each series, a "0" an anodic member, and the arrow indicates the anodic direction.

6.3.3 Selection of compatible couples. Proper selection of metals in the design of equipment will result in fewer intermetallic contact problems. For example, for sheltered exposure, neither silver nor tin require protective finishes. However, since silver has an anodic index of 15 and tin 65, the EMF generated as a couple is 0.50 volt, which is not allowable by table IV. In this case, other metals or plates will be required. It should be noted that, in intermetallic couples, the member with the higher anodic index is anodic to the member with the lower anodic index and will be susceptible to corrosion in the presence of an electrolytic medium. If the surface area of the cathodic part is significantly greater than that of the anodic part, the corrosive attack on the contact area of the anodic part may be greatly intensified. Material selection for intermetallic contact parts, therfore, should establish the smaller part as the cathodic member of the couple, whenever practicable.

6.3.4 Plating. When base metals intended for intermetallic contact form couples not allowed by table IV, they are to be plated with those metals which will reduce the potential difference to that allowed by table IV.

6.4 Definitions.

6.4.1 Enclosure. An enclosure is an auxiliary housing providing protection and means for mounting and actuating of the basic switch.

6.4.1.1 Unsealed switch. Unsealed switches are switches with contact areas open to the atmosphere.

6.4.1.2 Watertight switch. Watertight switches are switches with contact areas sealed to meet the requirements of 3.21.1.

6.4.1.3 Hermetic seal. A hermetic seal is one which has been effected by means of fusion of glass or ceramic to metal, or by bonding of metal to metal, thus providing a completely sealed, gas-tight enclosure.

6.4.2 Differential pressure. Pressure measured or expressed from some reference other than absolute zero of ambient atmospheric pressure is called differential pressure.

6.4.3 Proof pressure. The maximum pressure that can be repeatedly applied without causing rupture, leakage, permanent deformation of parts, calibration shifts, or other damage is called proof pressure.

TABLE IV Compatible couples (see 6.4.) 1/

Group No.	Metallurgical category	EMF (volt)	Anodic index (0.01 v)	Compatible couples
1	Gold, solid and plated, gold-platinum alloys, wrought platinum (most cathodic)	+ 0.15	0	
2	Rhodium plated on silver-plated copper	+ 0.05	10	
3	Silver, solid or plated, high silver alloys	0	15	
4	Nickel, solid or plated, monel metal, high nickel-copper alloys	- 0.15	30	
5	Copper, solid or plated, low brasses or bronzes, silver solder, German silver; high copper-nickel alloys; nickel-chromium alloys; austenitic corrosion-resistant steels	- 0.20	35	
6	Commercial yellow brasses and bronzes	- 0.25	40	
7	High brasses and bronzes; naval brass, Muntz metal	- 0.30	45	
8	18 percent chromium type corrosion-resistant steels	- 0.35	50	
9	Chromium, plated; tin, plated; 12 percent chromium type corrosion-resistant steels	- 0.45	60	
10	Tin-plate; terneplate; tin-lead solder	- 0.50	65	
11	Lead, solid or plated; high lead alloys	- 0.55	70	
12	Aluminum, wrought alloys of the duralumin type	- 0.60	75	
13	Iron, wrought, gray, or malleable; plain carbon and low alloy steels, armco iron	- 0.70	85	
14	Aluminum, wrought alloys other than duralumin type; aluminum, case alloys of the silicon type	- 0.75	90	
15	Aluminum, cast alloys other than silicon type; cadmium, plated and chromated	- 0.80	95	
16	Hot-dip-zinc plate; galvanized steel	- 1.05	120	
17	Zinc, wrought; zinc-base die-casting alloys; zinc, plated	- 1.10	125	
18	Magnesium and magnesium-base alloys, cast or wrought (most anodic)	- 1.60	175	

1/ Compatible couples - potential difference of 0.25 volt maximum between groups.

6 4 4 Burst pressure The maximum pressure that can be applied without causing rupture or leakage, although permanent structural deformation and calibration shifts may result, is called burst pressure.

6.5 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue, due to the extensiveness of the changes

Custodians:
Army - ER
Navy - EC
Air Force - 85

Review activities
Army - MI
Navy - OS
Air Force - 17, 99
DLA - ES

User activities:
Army - ME, AT, AV, AR
Navy - AS
Air Force - 11, 19

Preparing activity.
Navy - EC

Agent:
DLA - ES

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