INCH-POUND
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SUPERSEDING
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PERFORMANCE SPECIFICATION

SWITCHES, BUS TRANSFER, ELECTRIC POWER, AUTOMATIC AND MANUAL

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

1. SCOPE

1.1 Scope. This specification covers the Automatic Bus Transfer Switch (ABT) (see 6.4.1) and the Manual Bus Transfer Switch (MBT) (see 6.4.13), herein referred to as ABT, MBT, or switch(es), for use on surface and submarine Naval vessels. Unless otherwise specified herein, this specification applies to both ABTs and MBTs. Requirements for Static or Solid State ABTs (SABTs) are not defined in this specification. MIL-PRF-32150 specifies requirements for SABTs.

1.2 Classification. Switches have the following characteristics: (Part or identifying number (PIN) codes are provided along with the classifications to avoid unnecessary duplication of information in 1.3.)

1.2.1 Voltage. Switch voltages are as follows:

Voltage	PIN Code
120 V	1
208 V (400 Hz only)	2
240 V (DC only)	3
450 V (AC only)	4
Other	6

1.2.2 Frequency. Switch frequencies are as follows:

Frequency	PIN Code
60 Hz	A
DC	D
400 Hz	F

Comments, suggestions, or questions on this document should be addressed to: Commander, Naval Sea Systems Command, ATTN: SEA 05Q, 1333 Isaac Hull Avenue, SE, Stop 5160, Washington Navy Yard, DC 20376-5160 or emailed to CommandStandards@navy.mil, with the subject line “Document Comment”. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at http://assist.daps.dla.mil.

1.2.3 Configuration type. Switch configuration types are as follows:

Configuration Type (CT) Description	PIN Code
ABT has: (a) control circuit time delay (0.3 to 0.5 seconds) (see 6.4.5) **and** (b) single phase protection (see 3.4.2.3.12) (see 6.4.8) on normal bus **and** (c) is instantaneous (see 6.4.10) **and** (d) normal seeking.	01
ABT has: (a) control circuit time delay (0.3 to 0.5 seconds) **and** (b) full phase protection on normal bus **and** (c) is instantaneous **and** (d) normal seeking.	02
ABT has: (a) control circuit time delay (0.3 to 0.5 seconds) **and** (b) line circuit time delay (see 6.4.12) **or** in-phase monitoring (see 6.4.9) **and** (c) single phase protection on normal bus **and** (d) is normal seeking.	03
ABT has: (a) single phase protection on normal bus **and** (b) is instantaneous **and** (c) power seeking.	04
ABT has: (a) control circuit time delay (0.3 to 0.5 seconds) on voltage sensing **and** (b) single phase protection on normal bus **and** (c) instantaneous transfer (see 6.4.22) on frequency sensing **and** (d) random transfer below 25 percent voltage **and** (e) contains in-phase monitoring.	05
ABT is for DC (direct current) only and has: (a) no line circuit time delay **and** (b) single phase protection on normal bus **and** (c) is power seeking.	06
ABT has: (a) single phase protection on normal bus **and** (b) senses voltage and frequency **and** (c) has transfer stabilization time **and** (d) has an operating transfer time (see 6.4.15) of 70 milliseconds maximum upon voltage failure **and** (e) is instantaneous **and** (f) power seeking.	07

Configuration Type (CT) Description	PIN Code
ABT is similar to configuration type 07 with additional current sensing on load terminals to inhibit transfer during overload conditions.	08
ABT is the same as configuration type 03 but is: (a) three-way **and** (b) normal seeking between normal and alternate **and** (c) power seeking to emergency **and** (d) automatically signals the start of the emergency power source **and** (e) open mounting type **and** (f) facilities for dead front mounting **and** (g) automatic starting of emergency/auxiliary generator **and** (h) DC has no line circuit time delay.	09
ABT has: (a) control circuit time delay 2.5 to 3.5 seconds **and** (b) single phase protection on normal bus **and** (c) in-phase monitoring **and** (d) is normal seeking.	10
ABT is the same as configuration type 03, but is power seeking.	11
Manual Bus Transfer Switch	12
Note: 1. In-phase monitoring is not used in 400-Hz ABTs on Naval vessels.	

1.2.4 Special features. Switch special features are as follows:

Special Feature	PIN Code
Special Feature(s)	S
No Special Feature(s)	X

1.2.5 Current rating. Switch current ratings are as follows:

Current Rating	PIN Code
025 to 600 amps	XXX

1.2.6 Cabinet integrity. Switch cabinet integrities are as follows:

Cabinet Integrity	PIN Code
Drip-proof	D
Splash-proof	S
Watertight	W
Open Mounted	O

1.3 Part or identifying number (PIN). PINs to be used for switches acquired to this specification are created as follows: (see 1.2.1 through 1.2.6 for PIN Code designations)

M Prefix	Specification Number	Hyphen	Voltage	Frequency	CT	Special Feature	Current Rating (maximum)	Cabinet Integrity
M	17773	-	4	A	01	S	600	D

The example above (M17773-4A01S600D) is for a 450-V, 60-Hz, instantaneous and normal seeking, special feature, 600-amp maximum current rating, drip-proof ABT.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, or 5 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

FEDERAL STANDARDS

FED-STD-595-26307 - Colors Used in Government Procurement

DEPARTMENT OF DEFENSE SPECIFICATIONS

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

MIL-E-917 - Electric Power Equipment Basic Requirements

MIL-E-2036 - Enclosures for Electric and Electronic Equipment

MIL-DTL-2212 - Contactors and Controllers, Electric Motor AC or DC, and Associated Switching Devices

MIL-DTL-3661 - Lampholders, Indicator Lights, Indicator Light Housings, and Indicator Light Lenses, General Specification for

MIL-L-3661/38 - Housings, Indicator Light, Style LH80

MIL-L-3661/54 - Lenses, Indicator Light, Style LC40

MIL-L-3661/62 - Lampholder, Lights, Indicator (Housing), Style LH95, (for D.C. Applications)

MIL-L-3661/63 - Lampholder, Lights, Indicator (Housing), Style LH96

MIL-L-3661/64 - Lampholder, Lights, Indicator (Housing), Style LH97

MIL-L-3661/65 - Lampholder, Lights, Indicator (Housing), Style LH98

MIL-DTL-15024 - Plates, Tags, and Bands for Identification of Equipment, General Specification for

MIL-P-15024/5 - Plates, Identification

MIL-DTL-15291	-	Switches, Rotary, Snap Action and Detent/Spring Return Action, General Specification for
MIL-DTL-16036	-	Switchgear, Power, Low Voltage, Naval Shipboard
MIL-DTL-17361	-	Circuit Breaker Types AQB/NQB, Air, Electric, Low Voltage, Insulated Housing (Shipboard Use), General Specification for
MIL-C-17587	-	Circuit Breakers, Low Voltage, Electric Power, Air, Open Frame, Removable Construction
MIL-PRF-19500/519	-	Semiconductor Device, Diode, Light Emitting, Red Types, JAN1N6092, JANTX1N6092, JAN1N6609 (Clear Lens) JANTX1N6609 (Clear Lens), and Panel Mounted Assembly, Types JANM19500/51901, JANTXM19500/51902, JANM19500/51903 (Clear Lens), and JANTXM19500/51904 (Clear Lens)
MIL-PRF-19500/572	-	Semiconductor Device, Diode, Light Emitting, Types 1N6493, 1N6494, 1N6495, 1N6500, 1N6501, and 1N6502 JAN and JANTX
MIL-PRF-19500/708	-	Displays, Diode, Light Emitting, Solid State, Red, Numeric and Hexadecimal, With On Board Decoder/Driver Types 4N51, 4N52, 4N53 and 4N54 JAN and JANTX
MIL-R-19523	-	Relays, Control
MIL-DTL-23928/2	-	Panel, Electrical, Volts, Power Distribution for AQB-A50 and NQB-A50 Circuit Breakers, Dripproof, Totally Enclosed and Watertight
MIL-DTL-23928/4	-	Panel, Electrical, Power Distribution for Double AQB-A101 and NQB-A101 Circuit Breakers, 2-12 Circuits, With and Without Manual Transfer, Dripproof, Totally Enclosed and Watertight
MIL-DTL-23928/5	-	Panel, Electrical, Manual Transfer for Double NQB-A101 Circuit Breakers, Dripproof, Totally Enclosed and Watertight
MIL-DTL-23928/8	-	Panel, Electrical, Manual Transfer for Double NQB-A250 Circuit Breakers, Dripproof, Totally Enclosed and Watertight
MIL-PRF-24712	-	Coatings, Powder (Metric)

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-108	-	Definitions of and Basic Requirements for Enclosures for Electric and Electronic Equipment
MIL-STD-167-1	-	Mechanical Vibrations of Shipboard Equipment (Type I-Environmental and Type II-Internally Excited)
MIL-STD-202	-	Electronic and Electrical Component Parts
MIL-STD-461	-	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
MIL-STD-681	-	Identification Coding and Application of Hookup and Lead Wire
MIL-STD-740-2	-	Structureborne Vibratory Acceleration Measurements and Acceptance Criteria of Shipboard Equipment
MIL-STD-1310	-	Standard Practice for Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety

DOD-STD-1399-070-1	-	Interface Standard for Shipboard Systems, Section 070 - Part 1, D.C. Magnetic Field Environment (Metric)
MIL-STD-1399-300	-	Interface Standard for Shipboard Systems, Section 300A, Electric Power, Alternating Current (Metric)
MIL-STD-1474	-	Noise Limits
MIL-STD-1686	-	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)

(Copies of these documents are available online at http://assist.daps.dla.mil/quicksearch/ or http://assist.daps.dla.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

NAVAL SHIP'S TECHNICAL MANUAL (NSTM)

S9086-KC-STM-010/ 300	-	Electrical Plant, General

(Copies of this document are available by sending a request to CommandStandards@navy.mil or from Commander, Naval Sea Systems Command, ATTN: SEA 05Z9, 1333 Isaac Hull Avenue, SE, Stop 5122, Washington Navy Yard, DC 20376-5122.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC. (IEEE)

IEEE 1012	-	Standard for Software Verification and Validation
IEEE 1394	-	Standard for a High Performance Serial Bus

(Copies of these documents are available online at www.ieee.org or from the Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.)

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST SP 500-234	-	Reference Information for the Software Verification and Validation Process

(Copies of this document are available online at http://nvl.nist.gov/ or from the NIST Standards Information Center, 100 Bureau Drive, Stop 2150, Gaithersburg, MD 20899-2150.)

UNDERWRITERS LABORATORIES INC. (UL)

UL 1008	-	Standard for Transfer Switch Equipment (DoD adopted)
UL 60950	-	Safety of Information Technology Equipment

(Copies of these documents are available online at www.ul.com or from Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.)

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Qualification. Switches furnished under this specification shall be products that are authorized by the qualifying activity for listing on the applicable qualified products list before contract award (see 4.2 and 6.3).

3.2 Materials. The contractor shall select materials capable of meeting all of the operational and environmental requirements specified herein in accordance with MIL-E-917.

3.2.1 Recycled, recovered, or environmentally preferable materials. Recycled, recovered, or environmentally preferable materials should be used to the maximum extent possible, provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs.

3.2.2 Electrical insulation. Electrical insulating materials shall be in accordance with the requirements of MIL-DTL-16036 and MIL-E-917.

3.2.3 Parts. Parts shall be in accordance with the requirements of MIL-E-917.

3.2.4 Light emitting diodes. Light emitting diodes (LEDs) shall meet the requirements of MIL-PRF-19500/519, MIL-PRF-19500/572, or MIL-PRF-19500/708.

3.2.5 Indicator lights, lamps, and lenses. AC (alternating current) indicator lights shall conform to type LH98/4 for 450-VAC service and type LH98/3 for 120-VAC service in accordance with MIL-L-3661/65. DC indicator lights shall conform to style LH96/5 for 120-VDC service and type LH96/6 for 240-VDC service in accordance with MIL-L-3661/63. Lenses shall be style LC40 in accordance with MIL-L-3661/54, with lens color as specified herein.

3.2.6 Serial connection. If the ABT has embedded software (firmware) that is capable of being communicated by external means, then communications shall be by an RS-232, USB2.0, or firewire IEEE 1394 (or similar, if supported by industry standards) port for a remote computer for the purpose of controlling the ABT electrical parameters and to allow programming of setpoints. A software program shall be provided to interface with the ABT for the purpose of establishing these parameters and setpoints during shipboard installation. No infrared or RF communications are allowed.

3.2.7 Relays. If electro-mechanical relays are used, they shall meet the requirements of MIL-R-19523 and shall have operating voltages as specified in 3.4.2.3.3. Dashpots operating with oil or air as the retardant for controlling the speed of operation of a relay shall be hermetically sealed.

3.2.8 Creepage and clearance distances. Electrical creepage and clearance distances shall be in accordance with MIL-E-917.

3.2.9 Nameplates. Manufacturer identification other than that allowed for the nameplates shall not appear on the equipment. Markings shall be in accordance with MIL-DTL-15024 and MIL-P-15024/5.

3.2.9.1 Embedded software. Embedded software (firmware) that is used in ABTs shall appear on the nameplate by name and/or part number, the version number or designator. Equipment furnished with embedded software and/or calibration software shall have software certified by independent V&V (Verification and Validation) testing to NIST SP 500-234 and IEEE 1012 standards.

3.2.10 Plating. Switch bus bars shall be silver-plated in accordance with MIL-DTL-16036, in areas of current-carrying contact with lugs, terminals, bus ties, screw bolts, and so forth. The contact surfaces of bus bars shall be silver-plated up to 1 inch past the joint area. In lieu of this, the entire bus may be silver surfaced, or on each copper bus bar, an area around each hole may be silvered, provided the silvered area around the hole is not less than a 1/8-inch wide band. Threaded surfaces, used as electrical contact surfaces, shall have silver thickness of at least 0.0002 inch.

3.2.11 Cable entrance. Switches shall enable cable entry and exit from the top or the bottom of its enclosure. The cable entrance plates when provided shall be blank to facilitate terminals or stuffing tubes for passage of cables. The plates shall be sealed to the level of effectiveness of the enclosure (see 3.4.41).

3.2.12 Wire, wiring methods, and marking. Wire, wiring methods, and marking shall be in accordance with the requirements of MIL-E-917. Color-coded wire may be used in accordance with MIL-STD-681.

3.2.13 Terminal markings for supply lines and loads. Terminal markings for supply lines and loads shall be in accordance with Table I. Like phases shall be arranged in the same manner. The phase rotation shall be A, B, C, respectively, from right to left (facing the front), top to bottom, and front to back.

TABLE I. Terminal markings.

Sources and Load	AC	DC 2-Wire	DC 3-Wire
Two-way switches:			
Normal (N) source	SA, SB, SC	S+, S-	S+, S±, S-
Emergency (E) source	EA, EB, EC	E+, E-	E+, E±, E-
Load	Ll, L2, L3	L+, L-	L+, L±, L-
Normal (N) source	S1A, S1B, S1C	S1+, S1-	S1+, S1±, S1-
Alternate (A) source	S2A, S2B, S2C	S2+, S2-	S2+, S2±, S2-
Load	Ll, L2, L3	L+, L-	L+, L±, L
Three-way switches:			
Normal (N) source	S1A, S1B, S1C	S1+, S1-	S1+, S1±, S1-
Alternate (A) source	S2A, S2B, S2C	S2+, S2-	S2+, S2±, S2-
Emergency (E) source	EA, EB, EC	E+, E-	E+, E±, E-
Load	Ll, L2, L3	L+, L-	L+, L±, L-

3.2.14 Diagrams. Each switch shall include a wiring diagram and a schematic diagram. The information shall be protected in accordance with Method 1 of MIL-E-2036 and shall be attached to the inside of the enclosure door in accordance with MIL-E-2036. Wiring diagrams shall include wire numbers, component identification, and fuse size and type, if applicable.

3.2.15 Instruction sheets. As specified (see 6.2), instruction sheets for installation shall be in accordance with MIL-E-2036.

3.2.16 Configuration settings. When specified in 6.2, ABTs with adjustable settings shall include those settings affixed in or on the ABT in accordance with MIL-DTL-15024 and MIL-P-15024/5.

3.2.17 Paint. Paint used on the switch shall be in accordance with the requirements of MIL-E-917 or MIL-PRF-24712. Color shall be No. 26307 as specified by FED-STD-595.

3.3 Weight and size. Unless otherwise specified (see 6.2), the switch shall weigh not more than 300 pounds and shall be not more than 40" H x 30" W x 20" D in size. 600 amp switches shall be no more than 56" H x 30" W x 20" D and no more than 300 pounds.

3.4 Performance characteristics.

3.4.1 Special features. When applicable, special features shall be as specified (see 6.2).

3.4.2 Modes of operation. Switches shall operate manually (MBT) or automatically (ABT). Automatic transfer switches shall conform to the requirements of MIL-STD-1399-300. Automatic bus transfer switches shall be capable of manual operation.

3.4.2.1 Automatic operation. The ABT shall monitor the power supplied from both the normal power source and the alternate power source. A source shall be considered “available”:

a. When the source is within preset levels, or

b. When the source (see 6.4.14) is not within preset levels. The ABT shall transfer to the alternate source provided the alternate source is available. The ABT shall provide two automatic transfer modes: in-phase transfer and random transfer as specified by configuration type (see 1.2.3). The ABT shall allow for operation with a preferred source (see 6.4.18), in which case the unit shall preferentially power the load from that source, provided it is available. This is called Normal Seeking. However, when the ABT is Power Seeking, it shall re-transfer (see 6.4.19) to the initially active source (see 6.4.3) following restoration of the initially active source to an available status, only if the presently active source becomes unavailable.

3.4.2.1.1 In-phase transfer mode. ABTs shall be provided with in-phase monitoring in accordance with configuration type (see 1.2.3) to allow completion of transfer when two sources are within 60 electrical degrees of each other.

3.4.2.1.2 Random transfer mode. When the alternate source is available, the ABT shall initiate a transfer when the normal source voltage and/or frequency specified by configuration type (see 1.2.3) falls below the random transfer setpoint for a time period longer than that set by the control circuit time delay. Random transfer will occur regardless of the phase angle difference between the sources.

3.4.2.2 Manual operation of MBTs. A manually operated handle, lever, or wheel located on the front of the MBT shall be used to transfer power from one power source to another. A sustained off position between energized power sources/closed positions shall be incorporated. White indicator lights shall provide power available indications for each source.

3.4.2.3 Manual operation of ABTs. To ensure fail-safe mode of operation, the ABT shall have a manual mode for selecting power sources. During the manual mode of operation, the ABT automatic functions are disabled. Manual transfer shall be performed by activating a switch handle or wheel (see 3.4.8). Manual transfer of an ABT can only be initiated when both power sources are de-energized.

3.4.2.3.1 Selector switch. ABTs shall be provided with a selector switch that controls manual or automatic ABT operation (see 6.4.2).

3.4.2.3.2 Preferred source selector switch and control circuit.

3.4.2.3.2.1 Two-way switches. Two-way switches with normal (ship’s service) and alternate (ship’s service) supply sources shall be provided with a preferred source selector switch that controls the selection of the preferred source of power.

3.4.2.3.2.2 Three-way switches. Three-way switches with normal (ship’s service), alternate (ship’s service) and emergency (service) supply sources shall be provided with a preferred source selector switch that controls the selection of the preferred source of power to be either the normal (ship’s service) or alternate (ship’s service).

3.4.2.3.3 Operating voltages. Switches shall operate with tolerances in accordance with MIL-STD-1399-300 as specified (see 1.2.1 and 6.2).

3.4.2.3.4 Drop-out voltages. Drop-out voltages for configuration types (see 1.2.3) shall be in accordance with Table II. A tighter tolerance may be specified (see 6.2). For configuration types CT03, CT05, and CT10 with in-phase monitoring, the in-phase transfer shall operate between 80 and 85 percent to between 20 and 30 percent. Below 20 and 30 percent random transfer shall occur.

TABLE II. Transfer threshold drop-out voltages.

Configuration Type (CT)	Drop-out Voltage Percentage (%) (Percentage of rated voltage)
CT01	60-70%
CT02	60-70%
CT03	60-70%
CT04	75-85%
CT05	60-70%
CT06	60-70%
CT07	76-80%
CT08	76-80%
CT09	60-70%
CT10	60-70%

3.4.2.3.5 Pick-up voltages. Pick-up voltages for configuration types (see 1.2.3) shall be in accordance with Table III. A tighter tolerance may be specified (see 6.2) for CT04 and CT05.

TABLE III. Pick-up voltages.

Configuration Type (CT)	Pick-up Voltage Percentage (%) (Percentage of rated voltage)
CT01	85-95%
CT02	85-95%
CT03	85-95%
CT04	85-95%
CT05	85-95%
CT06	85-95%
CT07	86-90%
CT08	86-90%
CT09	85-95%

3.4.2.3.6 Timing. Unless otherwise specified (see 6.2), timing shall be specified by configuration type (see 1.2.3).

3.4.2.3.7 Instantaneous transfer. On types requiring instantaneous transfer, the time from initiating the transfer to the closing onto the other source shall not exceed 50 milliseconds.

3.4.2.3.8 Control circuit time delay. Control circuit time delay (CCTD) (see 6.4.5) shall be specified by configuration type (see 1.2.3).

3.4.2.3.9 Line circuit time delay (LCTD). When specified by configuration type (see 1.2.3), ABTs shall be provided with a time delay between the opening of the main line contacts and the closing of the other set of main line contacts (OFF position) as shown in Table IV. The CCTD and the LCTD may be incorporated into a single device, provided that the total time delay does not exceed 4 seconds. LCTD shall be suspended after the voltage level falls below 20 percent.

TABLE IV. Line circuit time delays.

Current Rating of Switching Mechanism	Time Delay (seconds)
50 A or less	1 to 3.5
Over 50 A	2.5 to 3.5

3.4.2.3.10 Transfer stabilization time. When specified by configuration type (see 1.2.3), re-transfer shall be inhibited for 100 to 150 milliseconds after transfer to allow for source stabilization.

3.4.2.3.11 Drop-out and pick-up frequency (60 Hz applications). Drop-out and pick-up frequency for configuration types (see 1.2.3) shall be in accordance with Table V. Tighter tolerances may be specified (see 6.2).

TABLE V. Drop-out and pick-up frequencies.

Configuration Type (CT)	Drop-out Frequency (Below rated frequency, 60 Hz)	Pick-up Frequency (Below rated frequency, 60 Hz)
CT05	2-3 Hz	1-3 Hz
CT07	4-7 Hz	1-3 Hz
CT08	4-7 Hz	1-3 Hz

3.4.2.3.12 Full phase protection. Unless otherwise specified (see 6.2), full phase protection shall be in accordance with configuration type (see 1.2.3). Full phase protection is monitoring all three phases.

3.4.2.3.13 In-phase monitoring control circuit. When specified by configuration type (see 1.2.3), ABTs with in-phase monitoring shall complete transfer when the two sources are within 60 electrical degrees of each other.

3.4.2.3.14 Transfer inhibit on overload. When specified by configuration type (see 1.2.3), transfer shall be inhibited if the load current supplied by the switch exceeds 125±5 percent of the switch ampere rating unless otherwise specified (see 6.2).

3.4.3 Transfer test. The ABT shall include an automatic mode test. The test shall simulate a power source fault to verify that the ABT transfers power to the other source.

3.4.4 Maintainability. The maintainability capability provided for the unit when combined in a target system platform shall make it possible for the assigned maintenance personnel to perform necessary unit equipment repairs at the organizational level within the mean time to repair (MTTR) criteria specified herein. The MTTR shall not exceed 30 minutes. The maximum time to repair (M_{max}) at the 95^{th} percentile shall not exceed 60 minutes. Time to repair shall be the sum of the time required for:

a. Fault localization
b. Fault isolation
c. Disassembly
d. Interchange/repair
e. Reassembly
f. Repair validation

3.4.5 Front panel. The front panel shall provide the operator with the controls and indicators necessary to monitor the status of the normal and alternate power sources. All ABT controls and indications shall be located on the front of the unit.

3.4.5.1 Indicator lights. Indicator lights shall conform to MIL-DTL-3661, MIL-L-3661/38, MIL-L-3661/62, MIL-L-3661/63, MIL-L-3661/64, MIL-L-3661/65, MIL-PRF-19500/519, MIL-PRF-19500/572, and MIL-PRF-19500/708, as applicable. Indicator lights shall be furnished with lamps or LEDs. For position indication of circuit breakers, blue indicator lights shall be used to show that the circuit breaker is closed. Other indicator lamps have color caps as specified for the particular application. The color code shall be as follows:

a. Red – danger or emergency condition requiring immediate attention or corrective action.

b. Green – normal condition.

c. White – power available or power on.

d. Blue – closed, advisory.

e. Clear (not etched) – synchronized or ground detector lights.

f. Yellow – abnormal, but not requiring immediate attention.

3.4.5.2 Controls.

3.4.5.2.1 Indicator test feature. When specified (see 6.2), the ABT shall provide a feature for indicator testing.

3.4.5.2.2 Mode. ABTs shall be provided with a selector switch that controls manual or automatic ABT mode of operation. (see 3.4.2.3.1)

3.4.5.2.3 Manual operator switch. The ABT shall provide a manual operator for the purpose of transferring power sources in manual mode.

3.4.5.2.4 Transfer test switch. The ABT shall provide a transfer test switch for the purpose of initiating a transfer test. The test switch shall be of the momentary spring return type.

3.4.5.2.5 MBT OFF position. MBTs shall have a definitive, sustained OFF position between the two energized/closed positions.

3.4.6 Fusing of control circuits and indicator circuits. Switches shall have fused control circuits (see 6.4.6) and indicator circuits as necessary to prevent damage in the event of operating component malfunction.

3.4.7 Manual operating controls. Manual operating controls shall be external to the enclosure and located in a readily accessible position.

3.4.8 Manual operating handle or lever for automatic bus transfers. Protruding manual operating handles or levers for automatic bus transfer switches may rotate when the transfer switch is on automatic operation. When on manual operation, the operating handle shall indicate by mechanical position which source of supply is connected to the load circuit. For automatic bus transfer switches which utilize an inherent double-throw transfer mechanism, a white light shall be provided with an instruction plate to define the parameters for mechanical operation when only one or both sources are not available.

3.4.9 Interlocks. Interlocks (see 6.4.11) shall be provided to prevent simultaneous operation of elements of the switching mechanism which could result in improper operation or a short-circuit condition. The interlocking mechanism shall be either electromechanical or mechanical. Electromechanical interlocks shall require power to defeat. If simultaneous operation may be caused by only electrical means, the interlocking may be electrical only. The interlocks shall prevent one set of switching elements from closing when the other set of switching elements are not fully open so that two power supply lines are not simultaneously connected to the load or cause an arc between the two supply lines.

3.4.10 Auxiliary switches. Unless otherwise specified (see 6.2), ABTs over 100 amps shall be provided with one double pole, double throw (DPDT) auxiliary switch, and ABTs 100 amps and under shall be provided with one single pole, double throw (SPDT) auxiliary switch for remote indication of the supply line connected to the load circuit or for a function limiting device, or both. The auxiliary switch contacts shall be wired to a terminal board in the ABT for connection to the remote equipment. Auxiliary switches shall have a minimum rated continuous current of 5 amps and a rated voltage of 500 VAC and 250 VDC and meet the endurance requirements as specified in Method II, Table X.

3.4.11 Switching mechanisms. Switching mechanisms of bus transfer switches shall use contactors, circuit breakers, or rotary snap switches as specified in Table VI.

TABLE VI. Circuit breaker types and contactor sizes for bus transfer switches.

Manual		Automatic	
Amperes (A)	Type 1/	Amperes (A)	Type 1/
Greater than 250	AQB	Above 600 3/	ACB
250 or less	AQB	25 to 600 2/	Transfer contactors
25 to 600	Transfer contactors	15 to 540	Contactor relays (sizes 0 to 6)
10 to 60	Rotary switch, Type SR with off		

Notes:
1/ For specific sizes of AQB circuit breakers available refer to MIL-DTL-17361.
For specific sizes of ACB circuit breakers available refer to MIL-C-17587.
For specific sizes of contactor relays available refer to MIL-DTL-2212.
For specific sizes of rotary switches available refer to MIL-DTL-15291.
2/ Standard sizes of transfer switches utilizing transfer type contactors shall be 25, 50, 100, 150, 250, 300, 400, and 600 A.
3/ Sizes above 600 A shall be as specified. (see 6.2)

3.4.12 Contactors. Contactors shall be actuated by magnetic coils or motor-driven cams and shall be mechanically held.

3.4.13 External control cable connections. Terminal boards or studs shall be provided for external control connections if more than 12 external control wires are required. Terminal boards and studs shall be accessible from the front of the enclosure with the front panel open, and the control wire connection points shall be accessible and identified.

3.4.14 Grounding. Grounding shall be in accordance with MIL-STD-1310.

3.4.14.1 Chassis grounding. All external parts capable of electrical conduction shall be at ground potential at all times in accordance with MIL-STD-1310. Each chassis within the enclosure shall be electrically bonded to minimize electromagnetic interference (EMI). The DC resistance measured from the conductive frame of any assembly receiving primary power and the unit electrical bond point shall not exceed 0.1 ohm.

3.4.14.2 Signal grounding. A single point ground (SPG) system shall be used within the ABT and shall be DC isolated from the chassis/safety ground. To achieve this SPG system, all signal circuits and secondary DC power returns shall be referenced to a single point within the unit. The signal shall be DC isolated from the chassis ground.

3.4.14.3 Line-to-ground impedance. The insulation resistance or impedance to ground shall be measured with all operating components attached and connected in the ABT's normal operational condition with no internal wiring disconnected. Insulation resistance of ABTs shall be not less than 10 megohms as specified in MIL-E-917.

3.4.15 Electrostatic discharge (ESD) protection requirements. The use of electrostatic discharge (ESD) sensitive components is discouraged. When specific parts, modules, connectors/receptacles or subassemblies sensitive to damage by ESD are used, the devices shall be clearly marked with ESD labeling in accordance with MIL-STD-1686. The symbol shall be located in a position readily visible to personnel when that assembly is incorporated into its next higher assembly.

3.4.16 Ungrounded circuits. Switches shall operate in ungrounded systems.

3.4.17 Continuous duty. Switches shall operate at continuous duty (100 percent) (see 6.4.4).

3.4.18 Electromagnetic interference (EMI). When specified (see 6.2), enclosures shall comply with MIL-STD-461.

3.4.19 Conducted emissions. The ABT shall not exceed the CE101 and CE102 limits of MIL-STD-461. Additionally, the upper limit of CE101 shall be extended to 20 KHz.

3.4.20 Conducted susceptibility. The ABT shall meet the specified performance requirements per the CS101, CS114, and CS116 limits of MIL-STD-461.

3.4.21 Conducted susceptibility spikes, power leads. The ABT shall not exhibit any malfunction, degradation of performance, or deviation from specified indications when tested in accordance with 4.6.6.

3.4.22 Radiated emissions, AC magnetic field. The ABT shall not exceed the RE101 limits of MIL-STD-461.

3.4.23 Radiated emissions, AC electric field. The ABT shall not exceed the RE102 limits of MIL-STD-461.

3.4.24 Radiated susceptibility, AC magnetic field. The ABT shall meet the specified performance requirements in an AC magnetic field in accordance with the RS101 limits of MIL-STD-461.

3.4.25 Radiated susceptibility, DC magnetic field. The ABT shall be compatible with the magnetic field environment interface constraints of DOD-STD-1399-070-1.

3.4.26 Radiated susceptibility, AC electric field. The ABT shall meet the specified performance requirements in an electric field per the RS103 limits of MIL-STD-461.

3.4.27 Radiated susceptibility, magnetic and electric fields, spikes and power frequencies. The ABT shall not exhibit any malfunction, degradation of performance or deviation from specified indications when tested in accordance with MIL-STD-461 and 4.6.11.

3.4.28 Power. Switches shall operate in accordance with MIL-STD-1399-300 and shall not introduce negative electrical characteristics to exceed the values specified therein during steady-state operation and during transfer. The ABT shall not introduce transients or noise in excess of that defined and allowed by MIL-STD-1399-300.

3.4.29 Safety. Switches shall operate in a safe manner such that two procedural errors, or the malfunction of any single hardware or software component or element, shall not result in catastrophic hazards, causing death, system loss, or severe environmental damage, or critical hazards, causing severe injury, severe occupational illness, or major system or environmental damage. Safety requirements for the equipment shall be in accordance with MIL-E-917. A safety ground shall be provided on all equipment in accordance with UL 60950.

3.4.30 Personnel electrical safety.

3.4.30.1 High voltage protection. Protection from dangerous voltages (30 to 500 Vrms or 30 to 500 VDC) shall be provided by the use of guards, grounding, and warning placards in accordance with MIL-E-917. Assemblies operating at potentials exceeding 500 Vrms or 500 VDC shall be completely enclosed. The maximum discharge time shall be ten seconds to discharge components or assemblies from their operating voltages to 30 Vrms or less.

3.4.30.2 High current protection. Protection from shock hazards that can occur from contact with current producing circuitry of 21 mA AC or 80 mA DC at a potential of greater than 30 VDC or 30 Vrms shall be provided. For high current (greater than or equal to 25 amps) power sources, positive design measure shall be incorporated by the use of guards, barriers, and warning placards.

3.4.30.3 Chassis leakage current protection. All electrical parts capable of electrical conduction shall be at ground potential in accordance with MIL-STD-1310 and shall limit leakage current for personnel safety in accordance with MIL-STD-1399-300.

3.4.30.4 Operational source-to-source impedance. The source-to-source impedance shall be no less than 1.3 megohms at 68 °F (20 °C) with a minimum load of 25 amps and 0.5 megohm at 122 °F (50 °C). If specified (see 6.2), a higher source-to-source impedance may be required.

3.4.30.5 Source-to-source leakage current for maintenance. When specified (see 6.2), leakage current to the non-energized side of the ABT shall be controlled by air gap isolation between sources to allow for safe load center maintenance.

3.4.31 Electrical bonding. Electrical bonding shall be in accordance with MIL-STD-1310.

3.4.32 Mechanical hazards. Suitable protection shall be provided to prevent contact with moving mechanical parts such as gears, fans, and belts when the equipment is operating. Sharp projections on cabinets, doors, and similar parts shall be avoided. Rack-mounted equipment shall maintain the center of gravity as low as possible to minimize tipping over. Door or hinged covers shall be rounded at the corners, provided with stops to hold them open, and shall be removable. ABT design shall include provisions to prevent accidental pulling out of drawers or rack mounted equipment components, which would cause equipment damage or injury. Equipment power switches, if used, shall be located so that accidental contact shall not place the equipment in operation, secure the equipment, or change its mode of operation.

3.4.33 Component heat removal. If forced air-cooling is used, the unit shall generate no more than the structureborne or airborne noise acceptance criteria as specified in MIL-STD-740-2. The unit shall be capable of operating normally for a period of at least 24 hours at rated load, in 122 °F (50 °C) ambient air, with a loss of one-third, minimum, of the active cooling capacity, and support the rated load for a minimum of 6 hours, in 82 °F (28 °C) ambient air, with a loss of all (100 percent) of the active cooling capacity.

3.4.34 Transfer positions. Switches shall be two-way or three-way as specified by configuration type (see 1.2.3).

3.4.35 Current ratings. The continuous duty current ratings (see 1.2.5) for switches shall be in accordance with their configuration type (see 1.2.3) and Table VI.

3.4.36 Line phases. Switches shall operate in three-phase circuits.

3.4.37 Compatibility with shipboard ground fault detector circuits. When specified (see 6.2), an ABT connected to both power sources and to the loads shall:

a. Have a source-to-source impedance as high as possible, but no less than 0.5 megohm at 122 °F (50 °C).

b. Have a minimum line-to-ground impedance of at least 10 megohms.

c. Not cause a low-impedance to a ground fault condition detected on one source to be imposed on, transferred to, or reflected on the other source.

3.4.38 Endurance and overload. Switches shall meet endurance and overload requirements when tested in accordance with 4.6.16 and Table X, unless otherwise specified (see 6.2).

3.4.39 Short-circuit withstandability. Unless otherwise specified (see 6.2) switches shall meet the short-circuit withstandability (see 6.4.20) requirements specified in Table VII.

TABLE VII. Bus transfer switch short-circuit withstandability.

Continuous Rating (A)	Short-Circuit Current (A) at pf 0.15-0.20		Duration (seconds)	
	60 Hz	400 Hz	60 Hz	400 Hz
To 50	10000	10000	0.017	0.021
100	15000	10000	.017	.021
250	20000	10000	.025	.028
400	30000	10000	.028	.033
600	50000	10000	.028	.033
Over 600 1/				

Note:
1/ Special short-circuit withstandability requirements shall be as specified (see 6.2).

3.4.40 Dielectric withstanding voltage. Switches shall meet the dielectric withstanding voltage requirements when tested in accordance with MIL-E-917.

3.4.41 Enclosures. Enclosures for the switch shall be drip-proof, watertight, splash-proof, or open-mounted as specified (see 6.2) and shall meet the performance requirements of MIL-E-2036 for Class I enclosures for electronic equipment.

3.5 Environmental conditions.

3.5.1 Ambient temperature. Switches shall operate over an ambient temperature range of 32 to 122 °F (0 to 50 °C) in accordance with MIL-E-917.

3.5.2 Humidity. Switches shall operate in a 95 percent relative humidity environment in accordance with MIL-E-917.

3.5.3 Pressure. Switches shall operate within performance limits of MIL-STD-202 while subjected to an atmospheric pressure from 24 to 36 inches of mercury.

3.5.4 Temperature rise. Switches shall operate in an ambient temperature of 122 °F (50 °C) with no more than a 59 °F (15 °C) temperature rise for surface ships and a 77 °F (25 °C) rise for submarines as specified in MIL-DTL-16036.

3.5.5 Inclined operation. Switches shall perform satisfactorily during inclined operation as specified in MIL-E-917.

3.5.6 Shock. Switches shall meet Grade A, Class I, Type A high impact shock tests as specified in MIL-S-901.

3.5.7 Vibration. Switches shall meet Type I vibration tests specified in MIL-STD-167-1.

3.5.8 Protection against arcs. The interior of enclosing cases shall be protected by insulating material selected in accordance with the requirements of MIL-E-917.

3.5.9 Airborne noise. When specified (see 6.2), airborne noise requirements shall be in accordance with MIL-STD-1474 unless otherwise specified in 6.2.

3.5.10 Structureborne noise. When specified (see 6.2), structureborne noise requirements shall be in accordance with MIL-STD-740-2 unless otherwise specified in 6.2.

4. VERIFICATION

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

a. Qualification inspection (see 4.2).

b. Conformance inspection (see 4.3).

4.2 Qualification inspection. Qualification inspection shall be performed on one complete switch of each rating and shall include the examinations and tests specified in Table VIII.

4.3 Conformance inspection. Conformance inspection shall be performed to verify that the switch meets specification requirements prior to acceptance and shall include the tests specified in Table VIII.

4.4 Inspection conditions. All inspections shall be performed in accordance with the test conditions specified in the general requirements of MIL-STD-202.

TABLE VIII. Qualification tests and conformance inspections.

Tests	Requirement Paragraph	Qualification Test	Conformance Inspection
Examination	3.2 – 3.3, 3.4.5 – 3.4.14.2, 3.4.29, 3.4.30.1, 3.4.30.2, 3.4.31 through 3.4.36	4.5	4.5
Operational	3.4.2 through 3.4.3	4.6.1.2 through 4.6.1.12	4.6.1.2 through 4.6.1.12
Line-to-Ground Impedance	3.4.14.3	4.6.2	--
EMI	3.4.18	4.6.3	--
Conducted Emissions	3.4.19	4.6.4	--
Conducted Susceptibility	3.4.20	4.6.5	--
Conducted Susceptibility, Spikes, Power Leads	3.4.21	4.6.6	--
Radiated Emissions, AC Magnetic Field	3.4.22	4.6.7	--
Radiated Emissions, AC Electric Field	3.4.23	4.6.8	--
Radiated Susceptibility, AC Magnetic Field	3.4.24	4.6.9	--
Radiated Susceptibility, DC Magnetic Field	3.4.25	4.6.10	--
Radiated Susceptibility, AC Electric Field	3.4.26	4.6.11	--

TABLE VIII. Qualification tests and conformance inspections. Continued.

Tests	Requirement Paragraph	Qualification Test	Conformance Inspection
Radiated Susceptibility, Magnetic and Electric Fields, Spikes and Power Frequencies	3.4.27	4.6.12	--
Power	3.4.28	4.6.13	--
Chassis Leakage Current Protection	3.4.30.3	4.6.14	--
Compatibility with Active Ground Fault Detector Circuit	3.4.37	4.6.15	--
Endurance and Overload	3.4.38	4.6.16	--
Short-Circuit Withstandability	3.4.39	4.6.17	--
Dielectric Withstanding Voltage	3.4.40	4.6.18	--
Degree of Enclosure	3.4.41	4.6.19	--
Ambient Temperature	3.5.1	4.6.20	--
Humidity	3.5.2	4.6.21	--
Pressure	3.5.3	4.6.22	--
Temperature Rise	3.5.4	4.6.23	--
Inclined Operation	3.5.5	4.6.24	--
Shock	3.5.6	4.6.25	--
Vibration	3.5.7	4.6.26	--
Airborne Noise	3.5.9	4.6.27	--
Structureborne Noise	3.5.10	4.6.28	--

4.5 Examination. Each switch shall be examined for compliance with the requirements specified in Table VIII. This element of inspection shall encompass all visual examinations and dimensional measurements. The examination shall be conducted using the classifications of defects as specified in Table IX as applicable. Noncompliance with any specified requirements or presence of one or more defects preventing or lessening maximum efficiency shall constitute cause for rejection.

TABLE IX. Classification of defects.

Categories	Defects	Related Requirements Paragraph
001	Prohibited materials are used.	3.2
002	Insulating material not as specified or not provided as required.	3.2.2
003	Supply line and load terminal markings not as specified.	3.2.13
004	Manual operation for ABT switch not provided as required.	3.4.2.
005	Preferred source selector switch not provided as specified.	3.4.2.3.2
006	Time delay circuits not provided as specified or instantaneous is not within maximum time limit specified.	3.4.2.3.6, 3.4.2.3.7, 3.4.2.3.8, 3.4.2.3.9

TABLE IX. Classification of defects. Continued.

Categories	Defects	Related Requirements Paragraph
007	Single or full phase protection not provided as specified.	3.4.2.3.12
008	Indicator lights not specified colors.	3.4.5.1
009	Test switch not provided for ABT switches.	3.4.5.2.4
010	Fusing of control circuits and indicator circuits not as specified.	3.4.6
011	Manual operator does not have a mechanical position indicator for supply line indication.	3.4.7
012	Transfer positions are not two-way as specified.	3.4.34
013	Number of line phases not as specified for switches.	3.4.36
101	Parts not in conformance with applicable specifications.	3.2.3 and 3.5.8
102	Light emitting diodes not as specified.	3.2.4
103	Relays not as specified.	3.2.7
104	Information plates, identification plates, and marking not as specified.	3.2.9
105	Cable entrances not as specified.	3.2.11
106	Wire, wiring methods, and marking not as specified.	3.2.12
107	Diagrams and descriptions of operation not provided as specified.	3.2.14
108	Auxiliary switches not as specified.	3.4.10
109	Terminal boards not provided or wire connection points not accessible and identifiable.	3.4.13
110	Degree of enclosure not as specified.	3.4.41
201	Creepage and clearance distances not as specified.	3.2.8
202	Painting not as specified.	3.2.17

4.6 Methods of inspection.

4.6.1 Operational tests.

4.6.1.1 Order of precedence. The following tests shall be completed in the following order and a successful completion is required to continue:

a. Shock (see 4.6.25)

b. Vibration (see 4.6.26)

c. Short circuit withstandability (see 4.6.17)

d. Dielectric withstandability (see 4.6.18)

4.6.1.2 Automatic operation. ABTs shall be operated to determine that the operating voltages are as specified in 3.4.2.3.3. Not less than five transfers and five re-transfers shall be made under conditions of constant temperature, frequency, and rate of change of voltage. Testing shall also be performed using asynchronous sources at worse case scenario of 180 degrees out of phase.

4.6.1.3 Manual operation. When manual mode has been selected (see 3.4.2.), automatic control circuit devices shall not be operable while the manual-automatic selector switch is in the manual position; the ABTs shall not automatically transfer.

4.6.1.4 Preferred source selection. The preferred source selector switch shall be switched to each position and the ABT shall transfer to that preferred source.

4.6.1.5 Timing. Timing, time delay, and operating transfer time, as specified by the bus transfer switch configuration type (see 1.2.3), shall be measured five times to determine conformance with the required time periods as specified in 3.4.2.3.6. Adjustable time delay devices shall be operated over their adjustable range to determine that the specified time range can be achieved. When instantaneous is specified, the voltage shall be reduced quickly to approximately five equal intervals from 20 percent rated voltage to specified setpoint voltage including maximum and minimum setpoint. The ABT shall pick up the non-preferred source within 0.05 seconds after initial time delay is completed. The switch shall not transfer at the maximum setpoint.

4.6.1.6 Re-transfer to normal. ABTs shall be tested for re-transfer (normal to alternate and back to normal) as specified by 3.4.2.3.9, 3.4.2.3.10, and configuration type (see 1.2.3). Normal rated power shall be adjusted to reduced and zero voltage and returned to normal at the start, middle, and end point of the test. Alternate and/or emergency power shall be maintained at rated power throughout the test. No additional delay in time other than those stated in 3.4.2.3.9 and 3.4.2.3.10 shall occur.

4.6.1.7 Test switch. The ABT's test switch shall be operated to determine that it simulates a voltage failure and a transfer action occurs.

4.6.1.8 Full phase protection. When specified (see 6.2), the ABTs shall be operated to determine the operating voltage of each phase. Not less than five transfers and five re-transfers per phase voltage test shall be made under conditions of constant temperature, frequency, and rate of change of voltage.

4.6.1.9 In-phase monitoring. ABTs furnished with in-phase monitoring shall be operated five times in each direction including the low voltage setpoint (minimum of 80 percent voltage or as specified in 3.4.2.3.13). The frequency of the two sources shall be a nominal 60 Hz. After these operations are completed the voltage shall be rapidly reduced to below random transfer setpoint for instantaneous random transfer verification. When frequency sensing is specified, the switch shall be operated five additional times in each direction. The voltage shall be set at 5 points including 114 percent or greater and 85 percent or less. These tests shall be conducted by one of the two following methods:

a. The tests shall be performed with a load consisting of a motor of sufficient size to maintain a voltage greater than 30 percent for minimum of 0.50 second after the power is suddenly disconnected.

b. The tests shall be performed with any convenient load. A calibrated phase angle sensing instrument shall be used to record the phase angle displacement between the normal and alternate sources at the completion of transfer. In each operation, except the instantaneous random transfer when voltage is reduced to below random transfer setpoint, the phase angle difference (see 6.4.16) at the completion of transfer shall not exceed 60 degrees.

4.6.1.10 Frequency sensing. The frequency as specified (see 6.2) shall be tested five times at the high and low frequency pickup points to determine compliance with the frequency requirements as specified (see 3.4.2.3.11).

4.6.1.11 Overload transfer inhibit. When transfer inhibit on overload has been specified (see 6.2), a transfer operation shall be initiated by failing voltage on the connected source to determine that transfer shall not occur if the load current is above overload inhibit value specified in 3.4.2.3.14.

4.6.1.12 Power available indicator. Switches shall be operated to determine that each power available indicator operates properly when power is supplied and removed from each supply line.

4.6.2 Line-to-ground impedance. Line-to-ground impedance tests shall be conducted in accordance with Method 302, test condition "B" of MIL-STD-202. Test conditions shall be as follows:

a. Points of measure - Between each electrically isolated circuit and all other circuits connected together to ground (frame, chassis or enclosure).

b. Electrification time - 60 seconds minimum for insulation suitability test, and only sufficient time to take resistance readings for all other tests.

c. Temperature at time of test shall be in accordance with NSTM Chapter 300.

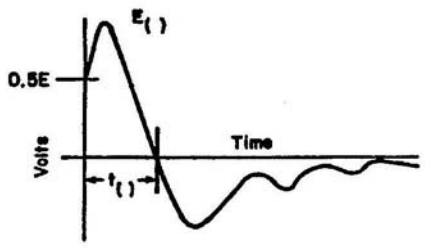
4.6.3 Electromagnetic interference. When specified (see 6.2), the switch shall be tested for electromagnetic interference (EMI) in accordance with MIL-STD-461.

4.6.4 Conducted emissions. The switch shall be tested for conducted emissions in accordance with MIL-STD-461, procedures CE101 and CE102. The upper limit of procedure CE101 shall be extended to 20 KHz.

4.6.5 Conducted susceptibility. The switch shall be tested for conducted susceptibility in accordance with MIL-STD-461, procedures CS101, CS114, and CS116.

4.6.6 Conducted susceptibility, spikes, power leads. The switch power leads, including grounds and neutrals, which are not grounded internally to the equipment, and interconnecting control leads, which provide power to the switch, shall be tested. The switch shall not exhibit any malfunction, degradation of performance, or deviation from specified indications, beyond the tolerances indicated when the test spike, having the waveform shown on Figure 1, is applied to the power leads for a period of time not less than 1 minute at each phase position and for a total test period not exceeding 15 minutes in duration. The values of $E_{(\ )}$ and $t_{(\ )}$ are given below. The spike shall be superimposed on the power line voltage waveform.

Spike E_1 = 400 volts; t_1 = 5 microseconds ±20%



NOTE: The test sample shall be subjected to the spike(s) with the waveform shown and with the specified voltage (s) and pulsewidth (s).

FIGURE 1. Acceptable wave shape for conducted susceptibility, spikes, power leads.

4.6.7 Radiated emissions, AC magnetic field. The switch shall be tested for radiated emission, AC magnetic field in accordance with MIL-STD-461, procedure RE101.

4.6.8 Radiated emissions, AC electric field. The switch shall be tested for radiated emissions, AC electric field in accordance with MIL-STD-461, procedure RE102.

4.6.9 Radiated susceptibility, AC magnetic field. The switch shall be tested for radiated susceptibility, AC magnetic field in accordance with MIL-STD-461, procedure RS101.

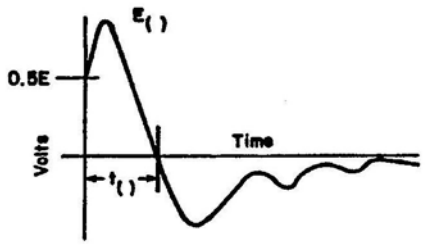
4.6.10 Radiated susceptibility, DC magnetic field. The switch shall be tested for radiated susceptibility, DC magnetic field in accordance with DOD-STD-1399-070-1.

4.6.11 Radiated susceptibility, AC electric field. The switch shall be tested for radiated susceptibility, AC electric field in accordance with MIL-STD-461, procedure RS103.

4.6.12 Radiated susceptibility, magnetic and electric fields, spikes and power frequencies.

4.6.12.1 Spike. The switch shall not exhibit any malfunction, degradation of performance, or deviation from specified indications when subjected to the test spike having a wave form as shown in Figure 2. The values of E_1 and t_1 are as follows:

Spike E_1 = 400 volts; t_1 = 5 microseconds ±20%



NOTE: The test sample shall be subjected to the spike(s) with the waveform shown and with the specified voltage(s) and pulsewidth(s).

FIGURE 2. Acceptable wave shape for radiated susceptibility, magnetic and electric fields, spikes and power frequencies.

4.6.12.2 Power frequency. The switch shall not exhibit any malfunction, degradation of performance or deviation from specified indications when 20 amperes are applied to the test wire at 60 and 400 Hz.

4.6.13 Power test. Power tests shall be conducted in both steady-state and transient modes for the following in accordance with MIL-STD-1399-300 during steady-state operation and during transfer at 180 degrees out of phase, with line capacitance to ground of 100 µf per phase and a load with a power factor of 1 at 20 amps:

a. Voltage and frequency tolerance
b. Voltage and frequency transient tolerance
c. Voltage spike
d. Emergency condition
e. Grounding
f. User equipment power profile (at no load)
g. Current waveform
h. Equipment (insulation resistance)
i. Voltage and frequency modulation

4.6.14 Chassis leakage current. The switch shall be tested for chassis leakage current in accordance with MIL-E-917.

4.6.15 Compatibility with active ground fault detector circuit. When specified (see 3.4.37 and 6.2), the bus transfer switch shall be tested with an active ground fault detector circuit utilizing a 500-VDC power supply and shall:

a. Have a source-to-source impedance as high as possible, but no less than 0.5 megohm at 122 °F (50 °C).
b. Have a minimum source-to-ground impedance of at least 10 megohms.
c. Not cause a low-impedance to ground fault condition detected on one source to be imposed on, transferred to, or reflected on the other source.

4.6.16 Endurance and overload. Bus transfer switches shall be tested for overload and endurance in accordance with Table X. Switches shall be energized for a minimum of 1/6 of a second before and after transfer. Operation cycles shall be initiated by the loss of power from either source. The ABT must be powered down between operation cycles. Unless otherwise specified (see 6.2), Method II is applicable to AC ABTs without time delay and not for switchboard service, and Method I is applicable to all other ABTs. These tests may be conducted on one set of contacts. However, in no case shall the specified operating cycles cause damage to components from excessive heating. ABTs shall fail the overload and endurance tests if they fail to perform their intended operating functions during or after the tests without adjustment, calibration, or replacement of parts, excluding a one time replacement of contacts.

TABLE X. Endurance and overload test conditions.

ABT and MBT	Overload test conditions				
	Number of cycles of operations	Test current (percent rated)	Test voltage (percent rated)	Load power factor	Time limit
AC (method I)	50	600	100	0.40-0.50	1 hour
AC (method II)	50	150	100	0.70-0.80	1 hour 40 minutes
DC	50	400	100	-	1 hour
	Endurance test conditions				
	Number of cycles of operations	Test current (percent rated)	Test voltage (percent rated)	Load power factor	Minimum make and break operating cycles
AC (method I)	6000	100	100	0.80	6 per minute
AC (method II)	6000	100	100	0.80	6 per minute
DC	6000	100	100	-	6 per minute

4.6.17 Short-circuit withstandability. ABT, MBT, and ABT auxiliary switches shall be tested for short-circuit withstandability in accordance with MIL-DTL-16036. The bus transfer switches shall be subjected to and pass the dielectric withstanding voltage test as specified in Table VII after the short-circuit withstandability tests without adjustment, calibration, or replacement of parts. The test circuit current shall be measured, instrumented, and calibrated in accordance with UL 1008. A 60-Hz comparison test may be used for DC and 400-Hz testing cases where required laboratory power supplies are not available. ABTs shall fail the short-circuit withstandability tests if one or more of the following occurs after the withstandability test:

a. Malfunction occurs that prevents one transfer and re-transfer action by manual means.

b. Malfunction occurs to prevent transfer and re-transfer automatically at rated conditions.

4.6.18 Dielectric withstanding voltage. Dielectric withstanding voltage tests shall be conducted in accordance with Method 301 of MIL-STD-202. Testing shall be performed after vibration testing. Magnitude of test voltage for circuits rated more than 60 V but not greater than 450 V, the rms test voltage shall be twice rated circuit voltage plus 1000 V.

4.6.19 Degree of enclosure. Switches shall be tested in accordance with MIL-E-2036 for Class I enclosures, as supplemented by MIL-STD-108, to determine the effectiveness of the enclosure as specified in 3.4.41. The switch enclosure shall be subjected to a water sprinkle rate of 6.9 in/hr (1000 cubic inches per hour per square foot of area covered) for a 12 minute (8 minutes operating and 4 minutes off) minimum in each of five different orientations; vertical and inclined 45 degrees forward, backward, to the right, and to the left. Failure of the equipment to operate satisfactorily or accumulation of water within the enclosure shall be cause for rejection. Additionally, the unit shall not be a hazard to personnel in case of minor water intrusion.

4.6.20 Ambient temperature. Switches shall be designed for continuous reliable operation within specified limits over an ambient temperature range of 32 to 122 °F (0 to 50 °C). The switch shall not be damaged nor shall the operational performance be degraded when restored to operating temperature range after exposure for long periods, 24-hour minimum, in a non-operating air temperature range of –13 to +140 °F (–25 to +60 °C). Test shall be conducted in accordance with MIL-STD-202.

4.6.21 Humidity. Switches shall be subjected to humidity testing in accordance with MIL-STD-202.

4.6.22 Pressure. Switches shall operate within the specified performance limits while subjected to an atmospheric pressure from 24 to 36 inches of mercury in accordance with MIL-STD-202. The ABT shall reliably operate within specified performance limits after exposure to an atmospheric overpressure of 2 atmospheres (14.7 psi positive differential on the ABT).

4.6.23 Temperature rise. Switches shall be subjected to a temperature rise test. The test shall be conducted with the switch carrying rated current, with control circuit energized. Component temperature rises shall be measured by the resistance method or by thermographic equipment. Sufficient thermocouples (or equivalent temperature sensors) shall be installed on representative current-carrying parts such as coils, contacts, and terminals. Temperature rises shall be measured at the hottest point where current-carrying parts are closest to insulating material. The test shall be conducted in accordance with MIL-E-917.

4.6.24 Inclined operation. Switches shall be tested for inclined operation in accordance with MIL-E-917.

4.6.25 Shock. Switches shall be subjected to shock tests in accordance with MIL-S-901 for Grade A, Class I, Type A equipment with weight classification as required by the weight of the equipment. The ABT shall be tested in the same mounting configuration as the one chosen for shipboard installation. The tests shall be conducted with the switch carrying current, at rated voltage and frequency. Control circuits shall be energized as in actual service. An oscillograph shall be used to check the closed contacts for excessive contact bounce and to check the open contacts for momentary closures. Switch mounting shall be as specified for standard mounting for bulkhead mounted equipment in accordance with MIL-S-901. Fuses (or other indicators which provide a positive indication) shall be connected in a manner to detect any momentary shorting between live parts or live parts and ground. The bus transfer switches being tested shall not be reconditioned or adjusted during the testing. Switches shall fail the test if it cannot perform its intended operating functions during and after such tests or if one or more of the following occurs during the tests:

a. Contact occurs between live parts and the enclosure.
b. Enclosure door opens.
c. Structural parts are damaged or loosened.
d. Functional parts are damaged or loosened.
e. Inadvertent transfer of load due to the force of shock blow.
f. Main line contacts have contact bounce in excess of 0.02 second per bounce.
g. Closed auxiliary contacts momentarily open or open auxiliary contacts momentarily close.

Note: The switches shall be thoroughly examined after the tests to determine whether there is evidence of items c and d above. The vibration test shall follow the shock test.

4.6.26 Vibration. Switches shall be subjected to Type I vibration tests in accordance with MIL-STD-167-1. The tests shall be conducted with the switch in each operating position with the switch carrying rated current at rated frequency. Control circuits shall be energized as in actual service. An oscillograph or other suitable instrument shall be used to check correct power transfer and operation of any auxiliary contacts. Fuses (or other indicators which provide a positive indication) shall be connected in a manner to detect any momentary shorting between live parts or live parts and ground.

4.6.26.1 Conditions. Switches shall retain structural integrity when the vibration exists along each of the three rectilinear orientation axis of the switch as installed on shipboard (i.e., vertical, athwartship, and fore and aft). Switches shall be tested in the same mounting configuration as the one chosen for shipboard installation (if shock or isolation mounts are utilized, these shall not cause resonance), and shall be subjected to:

a. An exploratory vibration sweep from 4 Hz to 33 Hz at 0.010-inch peak amplitude with the sweep in 1-Hz increments and held at each discrete frequency for a minimum of 15 seconds,

b. A variable frequency test with the following amplitude and frequency profile: 5-minute dwell at 1-Hz increments from 4 Hz to 15 Hz at 0.030-inch peak amplitude; 5-minute dwell at 1-Hz increments from 16 to 25 Hz at 0.020-inch peak amplitude; 5-minute dwell at 1-Hz increments from 26 to 33 Hz at 0.010-inch peak amplitude, and

c. A 2-hour endurance test at the highest frequency resonance (resonance defined as any frequency where the transmissibility is 2 to 1 or greater) and applicable 5-minute dwell amplitudes found during the exploratory sweep. If no resonance can be found, the 2-hour endurance test shall be run at 33 Hz.

4.6.26.2 Indications of failure. A switch shall fail the test if it cannot perform its intended operating functions during and after such tests, or if one or more of the following occurs during the tests:

a. Contact between live parts and the enclosure.

b. Enclosure door opens.

c. Structural parts are damaged or loosened.

d. Functional parts are damaged or loosened.

e. Inadvertent transfer of load.

f. Re-transfer operation is initiated.

g. Closed auxiliary contacts momentarily open or open auxiliary contacts momentarily close.

h. Main line contacts exhibit contact chatter.

i. The switches shall be thoroughly examined after the tests to determine whether there is evidence of items c and d above. The switches shall be subjected to and pass the dielectric withstanding voltage test (see 4.6.18) after the vibration tests.

4.6.27 Airborne noise. When specified (see 6.2), the switch shall be tested for airborne noise in accordance with MIL-STD-1474.

4.6.28 Structureborne noise. When specified (see 6.2), the switch shall be tested for structureborne noise in accordance with MIL-STD-740-2.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. Switches are intended for use in applications as devices that automatically or manually transfer power supply lines to a connected load. When accomplished automatically, control circuits determine when and in what manner the transfer will occur.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of the specification.
b. PIN (see 1.3).
c. Specific issue of the individual documents referenced, if required (see 2.2.1 and 2.3).
d. Instruction sheets (see 3.2.15).
e. Adjustable configuration settings, if required (see 3.2.16).
f. Different weight and size requirements (see 3.3).
g. Special features (see 3.4.1).
h. Operating voltage (see 3.4.2.3.3).
i. Special setpoint voltages, if required (see 3.4.2.3.4 and 3.4.2.3.5).
j. Timing or time delay, other than as specified (see 3.4.2.3.6).
k. Operating frequency (see 3.4.2.3.11).
l. Special frequency variation or time delay requirements for frequency sensing ABTs (see 3.4.2.3.11).
m. Full or single phase protection for ABTs (see 3.4.2.3.12).
n. In-phase monitoring control circuit for ABT switches (see 3.4.2.3.13).
o. Setting for inhibiting transfer on overload (see 3.4.2.3.14).
p. Indicator test feature (see 3.4.5.2.1).
q. Special auxiliary switch requirements, if necessary (see 3.4.10).
r. Type switching mechanism for ABTs greater than 600 A (see 3.4.11).
s. EMI criteria, if required (see 3.4.18).
t. Source-to-source impedance for operation (see 3.4.30.4).
u. Source-to-source leakage current for maintenance (see 3.4.30.5).
v. Active ground fault detection requirement (see 3.4.37).
w. Special endurance and overload requirements, if required (see 3.4.38).
x. Special short-circuit withstandability test, if required (see 3.4.39).
y. Degree of enclosure (see 3.4.41).
z. Airborne noise limits, if required (see 3.5.9).
aa. Structureborne noise limits, if required (see 3.5.10).
bb. Manufacturer provided written warranty.

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products, which are, at the time of award of contract, qualified for inclusion in Qualified Products List QPL-17773 whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, 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. Information pertaining to qualification of products may be obtained from Commander, Naval Sea Systems Command, ATTN: SEA 05Q, 1333 Isaac Hull Avenue, SE, Stop 5160, Washington Navy Yard, DC 20376-5160 or emailed to CommandStandards@navy.mil.

6.4 Definitions. For the purpose of the following definitions, the ABT is assumed to be in automatic mode with the normal source supplying the loads unless specifically indicated otherwise. Note that in the manual mode the ABT will remain lined up to the operator-selected power source regardless of the availability of either source.

6.4.1 Automatic bus transfer switch (ABT). The ABT is a self-acting device for transferring one or more load cable connections from one power source to another.

6.4.2 ABT operation. ABT operation is the transfer or the re-transfer of the connected load from one power source to another.

6.4.3 Active source. The active source is the source that is connected to the load. The active source is indicated on the front panel.

6.4.4 Continuous duty. Operation at substantially constant load for an unlimited period of time is considered continuous duty (100 percent).

6.4.5 Control circuit time delay. The control circuit time delay is the time a condition exists as specified by the configuration type, which must be continuously present in order for the unit to recognize a condition and initiate a transfer. (see 3.4.2.3.8)

6.4.6 Control circuits. Control circuits are solid-state (semiconductor) circuits that sense and control the transfer from normal to alternate power sources and re-transfer or otherwise control operation of the ABT.

6.4.7 Fault. A condition whereby a power source voltage or frequency falls outside its preset limits, causing it to become not available.

A fault of the type described above will always trigger a transfer or a transfer inhibit. Most faults of the type described above can be cleared when conditions external to the ABT change (i.e., restoration of a source from not available to available status).

6.4.8 Full phase protection. Full phase protection occurs when an ABT device monitors all phase voltages of one power source and initiates transfer of the connected load from the active power source to another when voltage of the active power source drops below a predetermined value. The device initiates transfer of the connected load back to the preferred power source when all voltages of the preferred source return to within specified limits.

6.4.9 In-phase monitoring. In-phase monitoring for sensing and control is a device used to sense the phase angle between the normal and alternate sources prior to load transfer. It is used with a two way instantaneous type ABT switch to initiate transfer only when the two sources are nearly synchronized thereby limiting the motor inrush current to below normal starting current levels and avoiding inadvertent circuit breaker tripping.

6.4.10 Instantaneous. A qualifying term indicating that no delay is purposely introduced in the action of the ABT switch.

6.4.11 Interlock. Interlock is a device actuated by the operation of some other device with which it is directly associated, to govern succeeding operations of the same or allied devices. An interlock system is a series of interlocks applied to associated equipment in such a manner as to prevent or allow operation of the equipment only in a prearranged sequence. Interlocks are classified into three main divisions: mechanical interlocks, electrical interlocks, and key interlocks, based on the type of interconnection between the associated devices.

6.4.12 Line circuit time delay. A designated time delay specified by configuration type (see 1.2.3) between the opening of the main contacts and the closing of the other set of main contacts.

6.4.13 Manual bus transfer switch (MBT). A manual (non-automatic) bus transfer switch is a device by which a human operator manually transfers the connected load from one power source to another.

6.4.14 Normal source. This establishes an arbitrary convention to distinguish between the two sources. Which source is normal and which is alternate depends entirely on which set of bus bars the cables from the two available power sources are connected to inside the ABT and hence is independent of which source should supply the load under normal operation. The term “normal” should therefore not be confused with “preferred”.

6.4.15 Operating transfer time. Operating transfer time is the time measured from the instant of monitored voltage source deviation to the recognition of an available alternate source, exclusive of any purposely introduced time delay.

6.4.16 Phase angle difference. Phase angle difference is monitored only if the phase angle difference feature is enabled. The phase angle difference is measured between the normal and alternate sources.

6.4.17 Pick-up voltage. The pickup voltage of a device is the minimum voltage at which the device starts to operate. Pick-up voltage is the lowest voltage of a power source at which the ABT will consider that source available, provided the other monitored parameters are specified and are also within their acceptable ranges.

6.4.18 Preferred source. The source to which the SABT will automatically re-transfer the load in the event both power sources become available. Either normal or alternate source can be selected to be preferred. If the re-transfer feature is not active, however, the term effectively has no meaning. When a source is selected as preferred, it will be so indicated on the front panel.

6.4.19 Re-transfer. The automatic switching of loads from the non-preferred to the preferred source after a transfer has occurred earlier and subsequently the preferred source has become available. If the phase angle difference feature is enabled, the re-transfer is performed only with the sources within the maximum allowed phase angle difference, otherwise it will occur regardless of phase mismatch between sources. The re-transfer feature can be disabled, in which case, there is effectively no preferred source; the ABT will not automatically re-transfer loads after the preferred source has been restored to an available state. An indicator on the front panel is lit if the re-transfer feature is enabled.

6.4.20 Short-circuit withstandability. Short-circuit withstandability is the ability of the ABT switch switching mechanism to carry the required short-circuit current without permanent damage for the period of time necessary for circuit protective devices in the system to clear the fault.

6.4.21 Time delay. Time delay is an intentionally introduced delay in the operation of a bus transfer switch.

6.4.22 Transfer. Transfer is the switching of loads from the active to the inactive source. It is triggered by the ABT upon sensing that the active source is outside preset transfer limits while the inactive source is available.

6.5 Acronyms.

ABT Automatic Bus Transfer Switch

CCTD Control Circuit Time Delay

EMI Electromagnetic Interference

ESD Electrostatic Discharge

LCTD Line Circuit Time Delay

MBT Manual Bus Transfer Switch

RMS Root Mean Square

V&V Verification and Validation

6.6 Subject term (key word) listing.

ABT

MBT

Switch gear

Switching mechanism

6.7 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

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