

INCH-POUND

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MILITARY SPECIFICATION

FUSE, CURRENT LIMITER TYPE, AIRCRAFT

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 requirements for current limiter type fuses for use in aircraft primary electrical power systems conforming to MIL-STD-704. These limiters are suitable for use in MIL-F-5373 fuse holders for operation at -54°C to 125°C.

1.2 Classification. Limiters shall be as described on the applicable military standard (MS) or specification sheet (see 6.2).

1.2.1 Style. A style of limiter shall consist of all part numbers in the same current range (0-30A and 35-60A) covered by one military standard or specification sheet. For example: all part numbers 0-30A of MS28937 shall be the same style (see 6.5 for part number example).

1.2.2 Ampere Rating. The ampere rating designator shall be a number specified on each military standard or specification sheet to indicate the ampere rating.

2 APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commanding Officer, Naval Air Warfare Center Aircraft Division Lakehurst, Systems Requirements Department, Code SR3, Lakehurst, NJ 08733-5100, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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SPECIFICATIONS

MILITARY

- MIL-M-14 - Molding Compounds, Thermosetting
- MIL-W-5086 - Wire, Electric, Polyvinyl Chloride Insulated, Copper or Copper Alloy
- MIL-F-5372/1- Fuse, Limiter Type Enclosed Link, 1-60 Amp
- MIL-F-5373 - Fuseholder, Block Type, Aircraft
- MIL-T-7928 - Terminal, Lug & Splices, Conductor, Crimp Style
- MIL-E-17555 - Electronic and Electrical Equipment; Accessories, and Provisioned Items (Repair Parts); Packaging Of

STANDARDS

MILITARY

- MIL-STD-202 - Test Methods For Electronic And Electrical Component Parts
- MIL-STD-454 - Standard General Requirements For Electronic Equipment
- MIL-STD-704 - Aircraft Electric Power Characteristics
- MIL-STD-889 - Dissimilar Metals
- MIL-STD-1285- Marking of Electrical and Electronic Parts
- MS20659 - Terminal, Lug, Crimp Style, Copper, Uninsulated Ring Tongue, Type 1, Class 1
- MS28937 - Fuse, Limiter Type, Enclosed Link, 5-60 amp, Aircraft
- MS28938 - Fuse, Limiter Type, Enclosed Link, Intermediate Rating, Aircraft
- MIL-STD-45662 - Calibration System Requirements

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the DODSSP, Standardization Document Order Desk, 700 Robbins Ave., Bldg. 4D, Philadelphia, PA 19111-5094.)

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2.2 Non-government publications. The following document forms a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

ASTM D635-88 Plastics, Self-supporting, In a Horizontal Position,
Rate of Burning and/or Extent of Time of Burning Of

(Application for copies should be addressed to the American Society of Testing and Materials, 1916 Race Street, Philadelphia, PA 19103-1137.)

(Non-government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for related associated detail specifications, specification sheets or military standards), 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 Specification sheet or military standard. The individual item requirements shall be as specified herein and in accordance with the applicable specification sheet or military standard (MS). In the event of any conflict between the requirements of this specification and the specification sheet or military standard, the latter shall govern.

3.2 Qualification. The current limiters furnished under this specification shall be products which are authorized by the qualifying activity for listing on the applicable Qualified Products List at the time of award of contract (see 4.5 and 6.3).

3.3 Materials. Materials shall be as specified herein. However, when a definite material is not specified, a suitable material shall be used that will enable the current limiters to meet the performance requirements of this specification. Recovered material shall be used to the maximum extent possible.

3.3.1 Fungus. Materials shall be used which are not nutrients for fungus, as specified in MIL-STD-454, Requirement 4.

3.3.2 Metal. All metals used in the construction of current limiters shall be corrosion resistant or shall be suitably protected to resist corrosion. The use of dissimilar metals, especially contacts between brass, copper, or steel and aluminum or magnesium alloys, shall be avoided. Where contact between dissimilar metals is unavoidable, the metals shall be protected against electrolytic corrosion. Dissimilar metals are defined in MIL-STD-889.

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3.3.3 Plastics. Plastic materials used in the limiters shall be in accordance with MIL-M-14, type MSI-30 (silicone) or Type GII-30F (diallyl isophthalate) as specified on the individual specification sheet or military standard. When other plastic materials are used, the manufacturer shall submit satisfactory evidence to the activity responsible for qualification that the materials are suitable for the purpose intended. The plastic materials used shall neither support combustion nor release noxious gases when subject to arcs, such as those arcs caused by interrupting heavy short circuit currents, or explosions of gaseous vapors to which the materials may be subjected in service. Plastic materials with cellulose fillers will not be permitted in parts that may be subjected to arcing or surface creepage. Plastic materials used shall be certified to exhibit a minimum ignition time of 90 seconds and a maximum extinguishing time of 90 seconds when tested for flammability in accordance with ASTM D635-88.

3.3.3.1 Color. The color of external plastic parts shall be as specified on the applicable military standard or specification sheet. After exposure to the temperature conditions specified in 4.8.3, there shall be no degradation of these requirements.

3.3.4 Protective coating. Protective coating shall not be used.

3.4 Design and construction. The current limiter shall conform to the requirements specified herein and in the applicable military standard or specification sheet.

3.4.1 Visual indication. An open limiter shall be self-indicating and so designed that visual indication of an open condition will not require removal from the limiter holder. The design shall be such that an energized electrical circuit will not be necessary to visually indicate an open-circuit limiter after a fault has occurred.

3.4.2 Insertion and removal. The design shall be such that the limiter can be inserted into or removed from the limiter holder without requiring use of a tool. The contour of the molding shall provide finger grips or other means to facilitate removal by hand.

3.4.3 Fuseholders. The limiter shall be designed for use with fuseholders in accordance with MIL-F-5373.

3.4.4 Mounting position. Limiter performance shall not be affected by its mounting position.

3.4.5 Terminals. Limiter terminals shall be as specified on MS20659.

3.4.6 Current rating. The rating of the limiter shall be as specified on the applicable military standard or specification sheet.

3.4.7 Dimensions. The dimensions of the limiter shall be as specified on the applicable military standard or specification sheet.

3.4.8 Weight. The weight of the limiter shall be as specified on the applicable military standard or specification sheet.

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3.5 Performance. Limiters shall pass the performance requirements of this specification and the applicable military standard or specification sheet when tested as specified in section 4.

3.5.1 Time-current characteristics. Time-current characteristics shall be as specified on the applicable military standard or specification sheet.

3.5.2 Initial loading. Loads up to 100 percent of rating may not reduce the current required to melt the limiter by more than 10 percent in any specified time (see 4.8.11).

3.5.3 Ambient temperature influence. The time-current characteristics of the limiter shall be within the tolerance limits specified on the applicable military standard or specification sheet (see 4.8.3) for the temperatures specified.

3.5.4 Overloading. The characteristics specified herein shall not be altered by overloading the limiter up to 70 percent of the current required to melt the limiter in a specified time, as shown on the applicable military standard or specification sheet (see 4.8.10).

3.5.5 Terminal voltage drop. The voltage drop across the limiter terminals, while the limiter is carrying rated current, shall not exceed the following (see 4.8.20):

Ampere rating	Terminal voltage drop
1	1.2
2, 3, and 5	0.25
10 through 60	0.1

3.5.6 Alternating current interrupting capacity. When specified, the current limiter shall be capable of interrupting prospective line-to-neutral faults on a 115/200 volt (V), three phase, 400 Hertz (Hz) system that is capable of producing a line-to-neutral fault current of 6,000 amperes (amps) during the first cycle of fault current; for a sustained fault, the current may be allowed to decrease at a gradual rate to 3,600 amps within 0.05 second after fault initiation. Two limiters, connected in series, shall be capable of interrupting line-to-line faults on a system conforming to MIL-STD-704 and capable of producing a line-to-line fault current of 4,200 amps during the first cycle of fault current and, for a sustained fault, the current may be allowed to decrease in a gradual rate of 2,500 amps within 0.05 second after fault initiation (see 4.8.14).

3.5.7 Direct current interruption capacity. When specified, the limiter shall be capable of interrupting prospective fault currents of 6,000 amps, with this value achieved in 0.01 to 0.03 second after fault initiation. The system voltage shall not be less than 28V before the fault. The transient recovery voltage at the terminals of the limiter holder shall not be less than 28V within 0.002 second after the interruption and shall maintain 28V at maximum value with the steady-state, open-circuit voltage reaching no less than 28V after the fault.

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3.5.8 Temperature rise. The temperature rise shall not exceed 90°C (194°F) when subjected to the test of 4.8.21.

3.5.9 Continuity. When tested as specified in 4.8.23, fuses shall have electrical continuity.

3.5.10 Environment. The limiter shall perform satisfactorily when subjected to any natural combination of the following environmental conditions. There shall be no breakage, malfunction, or evidence of damage that would prevent additional testing.

3.5.10.1 Temperature. Temperatures shall be from -54°C to +125° (see 4.8.2 through 4.8.5)

3.5.10.2 Altitude. Pressure altitude shall be from sea level to 60,000 feet (see 4.8.14).

3.5.10.3 Moisture resistance. Moisture resistance shall be as specified in 4.8.4.

3.5.10.4 Salt spray. There shall be no peeling, chipping, or blistering of metal or plastic surfaces, or exposure of base metal when the limiter is subjected to the test of 4.8.7.

3.5.10.5 Sand and dust. There shall be no peeling, chipping, or blistering of metal or plastic surfaces, or exposure of base metal. The indicator shall operate on the subsequent time current test when the limiter is subjected to the test of 4.8.17.

3.5.10.6 Vibration. When the limiter is tested in accordance with 4.8.12, there shall be no physical or electrical damage to the limiter and each limiter shall meet the room ambient time-current requirements of the applicable military standard at 500 percent of rated current.

3.5.10.7 Mechanical shock. Mechanical shock shall be as specified in 4.8.19. Following this test, the limiter shall withstand the time-current test of 4.8.13 for 500 percent of the rated current.

3.5.10.8 Indicator pin. The indicator pin shall be extended as the result of the current limiter opening during any overcurrent test requiring the fuse element to open.

3.5.10.9 Acceleration. The limiter shall be subjected to and pass the acceleration test as specified in 4.8.18.

3.5.10.10 Explosion proof. The limiter shall be subjected to and pass the explosion test conditions specified in 4.8.16.

3.5.11 Terminal strength. There shall be no physical damage to the limiter after the forces specified in 4.8.9 are applied.

3.5.12 Thermal shock. The limiter shall withstand the thermal shock test of 4.8.5 with no evidence of limiter cracks, delamination of finishes, obscuring of identification markings, severance of the fuse element, loosening of parts, or false indication. Following this test, the limiter shall withstand the time-current test of 4.8.13 for 500 percent of the rated current.

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3.5.13 Random drop. There shall be no physical damage and the limiter shall remain in proper position with respect to the fuseholder clips when subjected to the random drop test of 4.8.8.

3.5.14 Life test. There shall be no physical damage to the limiter when subjected to the life test specified in 4.8.2.

3.5.15 Rated current. When tested as specified in 4.8.22 there shall be no evidence of mechanical damage or failure. The temperature of the terminals shall not rise more than 90°C (194°F) above ambient temperature.

3.6 Identification of product. All current limiters shall be permanently and legibly marked as shown on the applicable military standard or specification sheet. The markings shall remain legible during and after all of the tests specified in this specification. The marking for identification shall be in accordance with MIL-STD-1285 as follows:

Part number (see 6.5)
Current rating
Manufacturer's name or trademark

3.7 Position. Current limiters shall operate satisfactorily in any position.

3.8 Workmanship. Workmanship shall be in accordance with MIL-STD-454, requirement 9.

3.8.1 Cleaning. The limiter shall be thoroughly cleaned of metal chips and other foreign material, before and after final assembly.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, 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 this specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements; however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

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TABLE I. Qualification Inspection.

TEST AND SAMPLES UNITS	REQUIREMENT PARAGRAPH	TEST PARAGRAPH	NOTE
TEST GROUP I - all samples (51) Examination of Product Voltage Drop	3.4 3.5.5	4.8.1 4.8.20	<u>1/</u>
TEST GROUP II - 2 samples Thermal Shock Moisture Resistance Time Current	3.5.12 3.5.10.3 3.5.1	4.8.5 4.8.4 4.8.13	<u>2/</u>
TEST GROUP III - 3 samples Terminal Strength Vibration Salt Spray Rated Current	3.5.11 3.5.10.6 3.5.10.4 3.5.15	4.8.9 4.8.12 4.8.7 4.6.22	<u>3/</u>
TEST GROUP IV - 3 samples Random Drop Temperature Rise Rated Current	3.5.13 3.5.8 3.5.15	4.8.8 4.8.21 4.8.22	
TEST GROUP V - 7 samples Explosion Proof	3.5.10.10	4.8.16	
TEST GROUP VI - 2 samples Acceleration Mechanical Shock Sand and Dust Time Current	3.5.10.9 3.5.10.7 3.5.10.5 3.5.1	4.8.18 4.8.19 4.8.17 4.8.13	<u>2/</u>
TEST GROUP VII - 4 samples Life Test Time Current	3.5.14 3.5.1	4.8.2 4.8.13	<u>5/</u>
TEST GROUP VIII - 8 samples Ambient Temp. Influence Time Current	3.5.3 3.5.1	4.8.3 4.8.13	<u>4/</u>
TEST GROUP IX - 6 samples Overload Damage Time Current	3.5.4 3.5.1	4.8.10 4.8.13	<u>6/</u>

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TABLE I. Qualification inspection - Continued

TEST AND SAMPLE UNITS	REQUIREMENT PARAGRAPH	TEST PARAGRAPH	NOTE
TEST GROUP X - 6 samples Initial Loading Influence Time Current	3.5.2 3.5.1	4.8.11 4.8.13	6/
TEST GROUP XI - 8 samples Alternating Current Interrupt	3.5.6	4.8.14	
TEST GROUP XII - 2 samples Direct Current Interrupt	3.5.7	4.8.15	

NOTES:

- 1/ Only 4 limiters need be measured for dimensions and for voltage drop.
- 2/ Time current shall be measured at 500% of rated current.
- 3/ Three sample limiters shall be tested in a 3 pole block. The center limiter and one other limiter shall carry 100% of rated current. The third limiter shall carry no current for the entire vibration test.
- 4/ Four sample limiters shall be conditioned at $-54^{\circ} \pm 5^{\circ}\text{C}$ and 4 sample limiters shall be conditioned at $125^{\circ} \pm 5^{\circ}\text{C}$. After stabilizing at the temperature extremes for a minimum of 4 hours. Two sample limiters from each temperature exposure shall meet the 500% rating requirements and 2 sample limiters from each temperature exposure shall meet the 1000% rating requirement.
- 5/ Time current shall be measured at 500% and 1000% of rated current (2 samples at each overload).
- 6/ Time current shall be measured at 300%, 500% and 1000% of rated current (2 samples at each overload).

4.5.1.3 Sampling instructions. Qualification inspection samples shall consist of not less than 51 limiters of each current rating. Samples shall be representative of the manufacturer's normal production and shall be identified by the manufacturer's part number.

4.5.2 Test routine. The qualification inspection samples for current limiters shall be subjected to the tests specified in table I. All sample units shall be subjected to Test Group I then divided as indicated into the various remaining tests groups.

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4.5.3 Retention of qualification. To retain qualification, the supplier shall forward at 24-month intervals to the qualifying activity, a summary of the results of Group A and Group B tests indicating, as a minimum, the number of lots that passed and the number that failed. Every 36 months, the supplier shall furnish a test report of Group C tests. Failure to submit the summary of Group A and Group B Tests or the failure to submit the Group C test report shall result in loss in qualification for the product. In addition to periodic submission and testing, the supplier shall immediately notify the qualifying activity, through the local Government representative, at any time, that the inspection data indicates failure of the qualified product to meet the requirements of the specification. In the event that no production occurred during the reporting period, a report shall be submitted to the qualifying activity certifying that the company still has the capabilities and facilities necessary to produce the item. If there has been no production during the next reporting period, the manufacturer may be required by the qualifying activity to perform Group C testing on the products in accordance with 4.6.

4.6 Quality conformance inspection.

4.6.1 Inspection of product for delivery. Inspection of product for delivery shall consist of Group A and Group B inspection. Except as specified in 4.6.2, delivery of products that passed Group A and Group B inspection shall not be delayed pending the results of Group C inspection.

4.6.1.1 Inspection lot. An inspection lot shall consist of all limiters of the same style and current rating produced under essentially the same conditions, and submitted 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 II and shall be made on all production items, in the order shown. If the manufacturer has established a statistical process control (SPC) system that is approved by the qualifying activity, and this system includes testing limiters to the Group A inspections, the Group A inspection need not be performed. The manufacturer must provide access to the information developed by his SPC system when requested by the qualifying activity.

TABLE II. Group A inspections.

TEST	SAMPLE QTY.	REQMT. PARA.	TEST PARA.	DEFECTS	
				ACCEPT	REJECT
Critical Dimensions 1/		3.4.7	4.8.1	0	1
Continuity	100%	3.5.9	4,8.23	0	1

1/ Critical dimensions are those dimensions indicated on the applicable military standard or individual specification sheet.

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4.6.1.3 Sampling. Sampling for critical dimensions shall be as follows:

First 100 limiters - 4 samples
 Each additional 250 limiters (up to 1000 limiters)
 4 samples each 250 limiters
 Over 1000 limiters - 4 samples from each additional
 1000 limiters.

4.6.2 Group B inspection. Current limiters shall be tested as specified in Table III in the order shown.

4.6.2.1 Sampling plan. Sample units shall be selected from each production lot from each ampere rating manufactured. Group B inspection shall be performed on 9 sample units which have passed Group A inspection, unless the Government considers it more practical to select a separate sample. If more than one limiter fails, reject the lot. If one limiter fails, a second sample of 6 limiters shall be tested for the failure point. If there are no additional failures, accept the lot. If there is a failure in the second sample test, reject the lot.

TABLE III. Group B inspections.

TEST	SAMPLE QTY.	REQMT. PARA.	TEST PARA.
Time Current at:		3.5.1	4.8.13
300% of rating	3		
500% of rating	3		
1000% of rating	3		

4.6.3 Periodic inspection. Periodic inspection shall consist of Group C inspection.

4.6.3.1 Group C inspection. Current limiters shall be tested as specified in Table IV. Sample units that have been subject to and have passed Group A inspections shall be used, unless the qualifying activity considers it more practical to select separate samples. The test shall be done at 36-month intervals.

4.6.3.2 Group submission. For group periodic testing of limiters with the same physical sizes and construction, the maximum and minimum ampere ratings shall be subjected to the tests specified in table IV in the order shown.

4.6.3.2.1 Intermediate ratings. Intermediate ratings shall be submitted to the following tests.

- a. Time-current measurements (4.8.13) (2 samples - each rating)
- b. Overload damage (4.8.10) Time current - 1000% (2 samples - each rating)

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TABLE IV. Group C Inspection.

TEST	REQUIREMENT PARAGRAPH	TEST PARAGRAPH	NOTE
TEST GROUP I - 2 samples Thermal Shock	3.5.12	4.8.5	
Salt spray	3.5.10.4	4.8.7	
Moisture Resistance	3.5.10.3	4.8.4	
Time Current	3.5.1	4.8.13	<u>1/</u>
TEST GROUP II - 3 samples Voltage Drop	3.5.6	4.8.20	
Temperature Rise	3.5.8	4.8.21	
Vibration	3.5.10.6	4.8.12	
Rated Current	3.5.15	4.8.22	
TEST GROUP III- 8 samples Ambient Temperature Influence	3.5.3	4.8.3	
Time Current	3.5.1	4.8.13	<u>2/</u>
TEST GROUP IV - 4 samples Life Test	3.5.14	4.8.2	
Time Current	3.5.1	4.8.13	<u>3/</u>
TEST GROUP V - 6 samples Overload Damage	3.5.4	4.8.10	
Time Current	3.5.1	4.8.13	<u>4/</u>

1/ Time current shall be measured at 500% of rated current.

2/ Four sample limiters shall be conditioned $-54^{\circ}\text{C} \pm 5^{\circ}\text{C}$ and 4 sample limiters shall be conditioned at $125^{\circ}\text{C} \pm 5^{\circ}\text{C}$ after stabilizing at the temperature extremes for a minimum of 4 hours. Two sample limiters from each temperature exposure shall meet the 500% rating requirements and 2 sample limiters from each temperature exposure shall meet the 1000% rating requirement.

3/ Time current shall be measured at 500% and 1000% of rated current (2 samples at each overload).

4/ Time current shall be measured at 300%, 500% and 1000% rated current (2 samples at each overload).

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4.6.3.3 Non-compliance. If a sample fails to pass Group C inspections, the supplier shall take corrective action on the materials or processes, or both, as warranted, and on all units or processes which can be corrected and which were manufactured under essentially the same conditions, with essentially the same materials, processes, etc., and which are considered subject to the same failure. Acceptance of the product shall be discontinued until corrective action, acceptable to the Government has been taken. After the corrective action has been taken, Group B or C inspection shall be repeated on additional sample units (all inspections, or the inspection which the original sample failed, at the option of the Government). Group A inspection may be reinstated; however, final acceptance shall be withheld until the Group B or C reinspection has shown that the corrective action was successful. In the event of failure after reinspection, information concerning the failure and the corrective action taken shall be furnished to the cognizant inspection activity and the qualifying activity.

4.6.3.4 Inspection of preparation for delivery. Sample packages or packs and the inspection of the preservation, packaging, packing and marking for shipment and storage shall be in accordance with the requirements of Section 5.

4.7 Test conditions.

4.7.1. Standard conditions. Unless otherwise specified, all load tests shall be conducted in still air at a temperature of $25 \pm 5^{\circ}\text{C}$ which shall be considered room ambient and at sea level pressure. The atmospheric pressure at the test facility may be used in lieu of sea-level pressure if the elevation of the test facility is not greater than 3,000 feet above sea level.

4.7.2 Power supply. For qualification tests, unless otherwise specified, the power source for AC current tests shall be $118 \pm 3\text{V}$ at a frequency of 400 ± 20 Hz with waveform and harmonic content in accordance with the requirements of MIL-STD-704, and for DC shall be $28 \pm 1\text{V}$. For Group B tests and Group C tests, unless otherwise specified, all AC current tests shall be $118 \pm 3\text{V}$ at a frequency of $60 \pm 1\text{Hz}$ and for DC shall be $28 \pm 1\text{V}$. Higher voltages may be used at manufacturer's option.

4.7.3 Test cables. Test cables in accordance with table V shall be used for all tests that require limiters to carry current except the tests requiring currents of fault magnitude in the rupture and explosion-proof tests. Test leads from the fuseholder to the source of power shall be a minimum of three feet in length and shall conform to MIL-W-5086/2.

4.7.4 Limiter holders. All tests requiring holders shall be performed with applicable holders as specified in MIL-F-5373.

4.8 Test methods.

4.8.1 Examination of product. All limiters shall be inspected to verify that materials, design, construction, weight, physical dimensions, marking and workmanship conform to applicable requirements (see 3.3 through 3.4.8, 3.6 and 3.7).

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TABLE V. Test leads.

Limiters Rating (Amperes)	Wire Size	Terminal Lug MIL-T-7928 Type
1 thru 10	20	MS20659-102
15	18	MS20659-102
20	16	MS20659-107 or 127
25 - 30	14	MS20659-107 or 127
35 - 40	12	MS20659-105 or 128
50	10	MS20659-105 or 128
60	8	MS20659-107 or 129

4.8.2 Life test. The limiter shall be inserted into the specified limiter holder and subjected to a 1,000-hour life test (see 3.5.14) at any convenient AC or DC voltage, consisting of 500 hours of operation at each of the ambient temperature extremes of $-54^{\circ} \pm 5^{\circ}\text{C}$ and $125^{\circ} \pm 5^{\circ}\text{C}$. While at each of these temperature extremes, the limiter shall carry rated current at any convenient AC or DC voltage continuously for 250 hours and then be subjected to 2,500 off and on cycles with each cycle consisting of 3 minutes at rated current and 3 minutes at no current. The temperature of the limiter bodies shall be monitored continuously and the temperature rise determined and recorded. The maximum temperature shall not exceed 218°C . Time-current measurements performed subsequent to this test shall be distributed evenly at 500 and 1,000 percent of current rating and shall be conducted at 28Vdc. The time-current test method shall be in accordance with 4.8.13.

4.8.3 Ambient temperature influence. Fifty percent of the limiters, as required for this test as specified in table I, shall be conditioned at the low ambient temperature extreme of $-54^{\circ} \pm 5^{\circ}\text{C}$ and the remaining 50 percent shall be conditioned at the high ambient temperature extreme of $125^{\circ} \pm 5^{\circ}\text{C}$. The limiters shall be stabilized at each temperature extreme for a minimum of 4 hours. After thermal stabilization at these temperature extremes, the time-current measurements of the limiters shall be obtained at 500 and 1,000 percent of the current rating at 28Vdc. These measurements shall be in accordance with the requirements of 4.8.13 except at the temperatures stated in this paragraph. The specified limiter holder with at least a 3-foot length of wire attached to the limiter holder terminals shall be stabilized at the same ambient temperature as the limiters (see 3.5.3).

4.8.4 Moisture resistance. The limiter shall be inserted in the specified limiter holder and subjected to the moisture resistance test in accordance with MIL-STD-202, Method 106 except that step 7B of this method shall be omitted. Subsequent to this test and immediately after a 24-hour conditioning at $25^{\circ} \pm 2^{\circ}\text{C}$ and at a relative humidity of 50 ± 5 percent, the limiter shall be tested and shall meet the time-current requirements of 4.8.13 for 500 percent of rated current (see 3.5.10.3).

4.8.5 Thermal shock. The limiter shall be inserted in the specified limiter holder and subjected to 5 thermal-shock cycles in accordance with MIL-STD-202, Method 107, test condition B except that -54°C shall be used in lieu of -65°C (see 3.5.12).

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4.8.6 Indicator pin operation. After each overcurrent test requiring the fuse element to open, verification shall be made that the indicator pin has properly extended to the "blown" position (see 3.5.10.8).

4.8.7 Salt spray. The limiter shall be inserted in the specified limiter holder and subjected to salt-spray exposure in accordance with MIL-STD-202, Method 101, test condition B using a salt solution concentration of 5 percent. After drying, residue may be removed using a brush (see 3.5.10.4).

4.8.8 Random drop. The limiter shall be inserted in the specified limiter holder which shall be rigidly mounted in a mounting fixture and subjected to the random-drop test in accordance with MIL-STD-202, Method 203. The limiters shall remain inserted in the limiter holders throughout the test (see 3.5.13).

4.8.9 Terminal strength test. The limiter shall be clamped firmly at one end and the forces specified in table VI applied to the opposite end. The test shall be done only once on a sample (3.5.11).

TABLE VI. Terminal strength test.

Direction of application of force	Ampere Ratings	
	Up to 30	Above 30
	Force in Pounds (minimum)	
To edge of blade, as inserted into clip of holder	10	25
To flat side of blade	5	10
To end of blade so as to push into limiter body	30	40

4.8.10 Overload damage. Using equipment suitable for the time-current tests of 4.8.13, with provisions added to interrupt current at predetermined times before limiter damage, apply the test current for the time shown on the applicable time-current curve for 70 percent of the melting current at 200, 500, and 1,000 percent of rated current. The test shall be conducted at 28 Vdc, or at a higher voltage at the manufacturer's option. With the limiter stabilized at the ambient temperature of $125^{\circ} \pm 5^{\circ}\text{C}$, apply each of the test currents one time, allowing a minimum of 10 minutes between applications. Stabilize the limiter at room temperature and perform the calibration test of 1,000 percent of rating. Failure will be indicated by inability of the limiter to complete the above procedure or to melt at a time outside the calibration requirement of 4.8.13 (see 3.5.4).

4.8.11 Initial loading influence. Adjust the limiter to 100 percent of rated current. Maintain this current until temperature stabilization is achieved at the limiter-holder clips. While at this condition, apply the 1,000 percent calibration current, and measure the fuse melt time by means of a transient recorder, typically a digital oscilloscope or a recording oscilloscope and a galvanometer, complete with shunts and amplifiers (3.5.2).

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4.8.12 Vibration. The vibration test shall be accomplished in accordance with of MIL-STD-202, Method 204, test condition B (see 3.5.10.6).

- a. Three similar samples of the limiter shall be inserted in the applicable MS holder and mounted on the vibration fixture. The center limiter and one other shall carry 100 percent of rated current at any convenient voltage, while the third limiter shall carry no current for the entire vibration test.
- b. The test shall be done at room ambient condition. The limiters that carry current shall have current applied for at least 30 minutes prior to the vibration test.
- c. Suitable test circuitry with indicating provisions shall be connected to the terminals of the limiter holder to establish that electrical continuity is maintained by each limiter during the entire vibration test.

4.8.13 Time-current measurements (3.5.1).

- a. Time-current measurements shall be taken at an ambient temperature of $25^{\circ} \pm 5^{\circ}\text{C}$ on two samples of each rating of each type of current limiter at 300, 500 and 1,000 percent of limiter rating.
- b. For each test current, the load bank shall be adjusted at the start to a value that will result in ± 5 percent of the current for the test.
- c. Measurements shall be taken, utilizing a high-drain battery source with a potential between 28 and 48V and connected similar to figure 1.
- d. A visual record shall be made of time-current measurements of 10 seconds or less. The limiter element melttime and fusing current shall be determined from these records and tabulated (see figure 2).
- e. The limiter shall conform to the tolerance stated on the applicable time-current curve.
- f. The percent deviation of fusing current from the curve of the applicable MS shall be calculated and recorded. The measurements shall be performed with the limiters inserted in the limiter holders as specified in the applicable MS. Percent current deviation (X) is defined as follows:

$$\% \text{ deviation} = X = (-100) \frac{I_c - I_x}{I_c}$$

where I_x is the current that melts the test limiter at the time T_x (see figure 2) and I_c is the current obtained from applicable time-current curve at time T_x .

- g. The limiter shall not suffer external physical damage as a result of this test.

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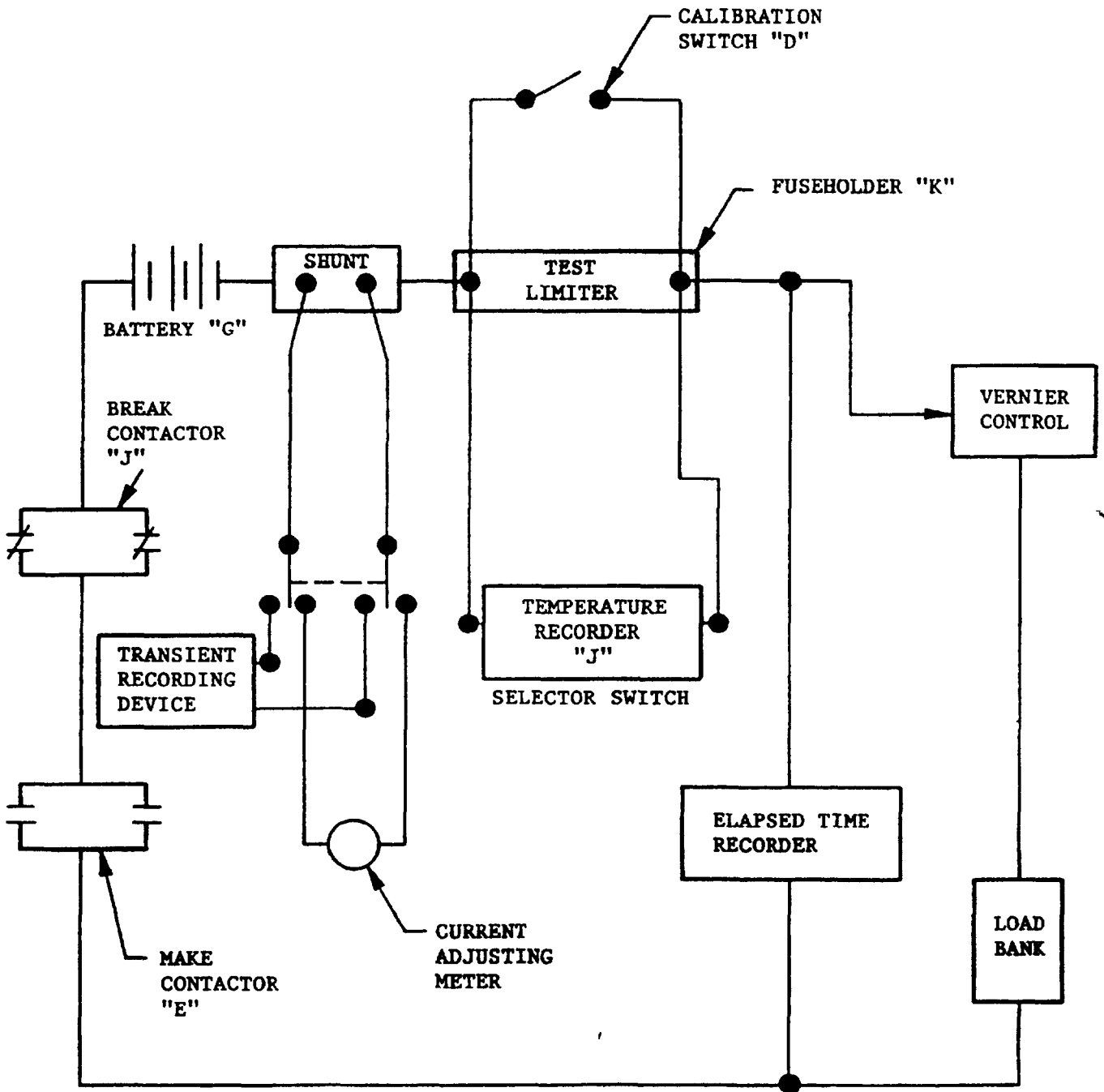


FIGURE 1. Time-current test block diagram.

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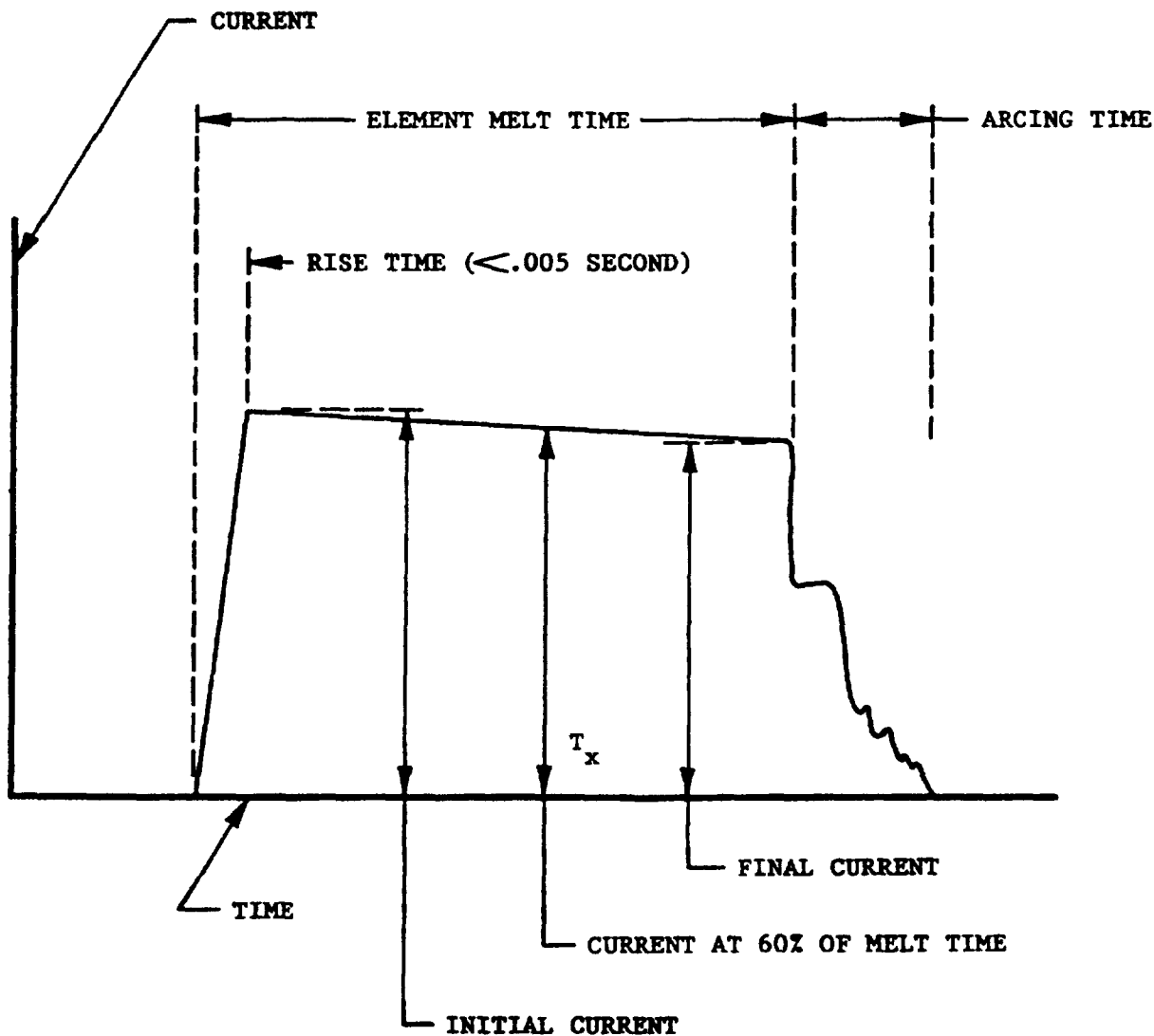


FIGURE 2. Typical time current oscillograph.

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4.8.13.1 Test apparatus. The test apparatus shall be:

- a. Load current meter, accurate to ± 0.5 percent.
- b. Transient recorders, typically a digital oscilloscope or a recording oscillograph and galvanometer, complete with shunts and amplifiers. These devices shall have a minimum frequency of 3000 Hertz, and a timing marker to allow time measurements accurate to the nearest 0.5 millisecond; and current and voltage measurements accurate to ± 2 percent.
- c. Load bank, resistive, capable of setting current flow to desired value ± 5 percent, current droop not to exceed 10 percent. Provide cooling if necessary.
- d. Switch, calibration, to be utilized for presetting desired current flow.
- e. Contactor, make, to be utilized for making current only. Contact bounce shall be negligible—less than 250 micro-seconds.
- f. Electric stop clock, calibrated to 0.01 second, accurate to ± 0.02 second, to be used for measurements exceeding 10 seconds.
- g. Battery, 28 to 48V, capable of supplying the necessary test currents for the required times with current droop limited to 10 percent and rise time to 0.005 seconds maximum.
- h. Cable, No. 4/0, capable of passing the highest test current with no appreciable voltage drop.
- i. Test enclosure, free of air drafts and capable of maintaining samples at an ambient temperature of $25^{\circ} \pm 5^{\circ}\text{C}$.
- j. Potentiometer, to monitor temperature of limiter clips.
- k. Limiter holder, as specified in MIL-F-5373.

4.8.13.2 Fuse element melt time, less than 10 seconds. On tests of less than 10 seconds element melt time, the time for the current to reach steady-state condition (rise time) shall be less than 0.005 second. The short time to reach steady-state conditions shall be achieved by using high-drain batteries and short leads to reduce the transient impedance of the circuit. All leads shall be bundled as close as possible, and shall be isolated from magnetic material. The leads shall not run in magnetic conduit. Current droop caused by the increase in limiter resistance, as the limiter temperature increases from ambient temperature to the melt temperature, shall not exceed 10 percent of the initial current value.

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4.8.13.3 Measurement of limiter element melt time. When determining melt time of a limiter element from oscillographic records, time shall be measured along a line parallel to the zero trace to the point where the current drops sharply. The sharp current drop may be caused by the indicator or the arcing element. Fusing current values shall be measured (I_x) at a point where 60 percent of the melt time has elapsed. Figure 2 depicts a typical oscillographic current trace.

4.8.13.4 Measurements greater than 10 seconds. For element melt time greater than 10 seconds, an electric stop clock may be used. The fusing current may be maintained at the correct value by varying the setting of the load bank. In melt time exceeding 10 seconds, the indicator melt time and the arcing time become insignificant in comparison with the total interrupt time, therefore, it will be permissible to discount them.

4.8.13.5 Limiter holder terminal temperature. The temperature of the limiter holder terminals shall be monitored during time-current measurements to ensure the limiter holder and attached leads return to the correct ambient temperature between tests.

4.8.14 Alternating current interrupt. The interrupt test shall be conducted with the limiter connected as shown on figure 3 for the line-to-neutral tests and as shown on figure 4 for the line-to-line test. These tests shall use the current available from the three phase-system specified in 3.5.6. Tests shall be performed in accordance with the following schedule:

Test Sample	Altitude	Line-to-Neutral	Line-to-Line
A	Sea level	X	
B	Sea level	X	
C	60,000 feet	X	
D	60,000 feet	X	
E and F	Sea level		X
G and H	60,000 feet		X

4.8.15 Direct-current interrupt. Using the circuitry specified on figure 3, test the limiter to ensure that the requirements of 3.5.7 have been met.

4.8.16 Explosion proof test. The current limiter shall be subjected to explosion test of MIL-STD-202, Method 109. The following test conditions and exceptions shall apply:

- a. The explosive atmosphere shall consist of propane gas (C_3H_8) or acetylene gas (C_2H_2) having a purity of 99 percent and air. The mixing cycle should be closely controlled to ensure repeatability of results.
- b. The test currents and circuit used shall be those specified in 3.5.6 for the interruption tests, except 60 Hz may be used in lieu of 400 Hz.

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- c. The atmosphere within the chamber shall be verified as explosive after each limiter blowing.

Test Sample	Configuration	Altitude
A	Line-to-neutral	Sea level
B	Line-to-neutral	Sea level
C	Line-to-neutral	Sea level
D	Line-to-neutral	15,000 feet
E	Line-to-neutral	25,000 feet
F and G	Line-to-line	Sea level

Failure shall be indicated by ignition of the explosive mixture resulting from limiter operation.

4.8.17 Sand and dust. While inserted in the specified limiter holder, the limiter shall be subjected to MIL-STD-202, Method 110. At the end of this test, the calibration of 500 percent of rated current shall be within the limits required by 4.8.13 (see 3.5.10.5).

4.8.18 Acceleration. With the limiter normally inserted in the specified limiter holder, the acceleration test of MIL-STD-202, Method 212, condition A, shall be conducted, except that the force shall be limited to 14g (see 3.5.10.9). At the end of this test the limiter shall meet the calibration requirements at 500 percent in accordance with 4.8.13.

4.8.19 Mechanical shock. Three limiters shall be inserted in the specified limiter holder, which shall be mounted by normal means on a mounting fixture. The specimen shall be tested in accordance with MIL-STD-202, test condition J, Method 213. The test shall consist of 18 shocks (6 shocks in each of 3 mutually perpendicular planes). The limiter shall remain in the limiter holder throughout the test (see 3.5.10.7).

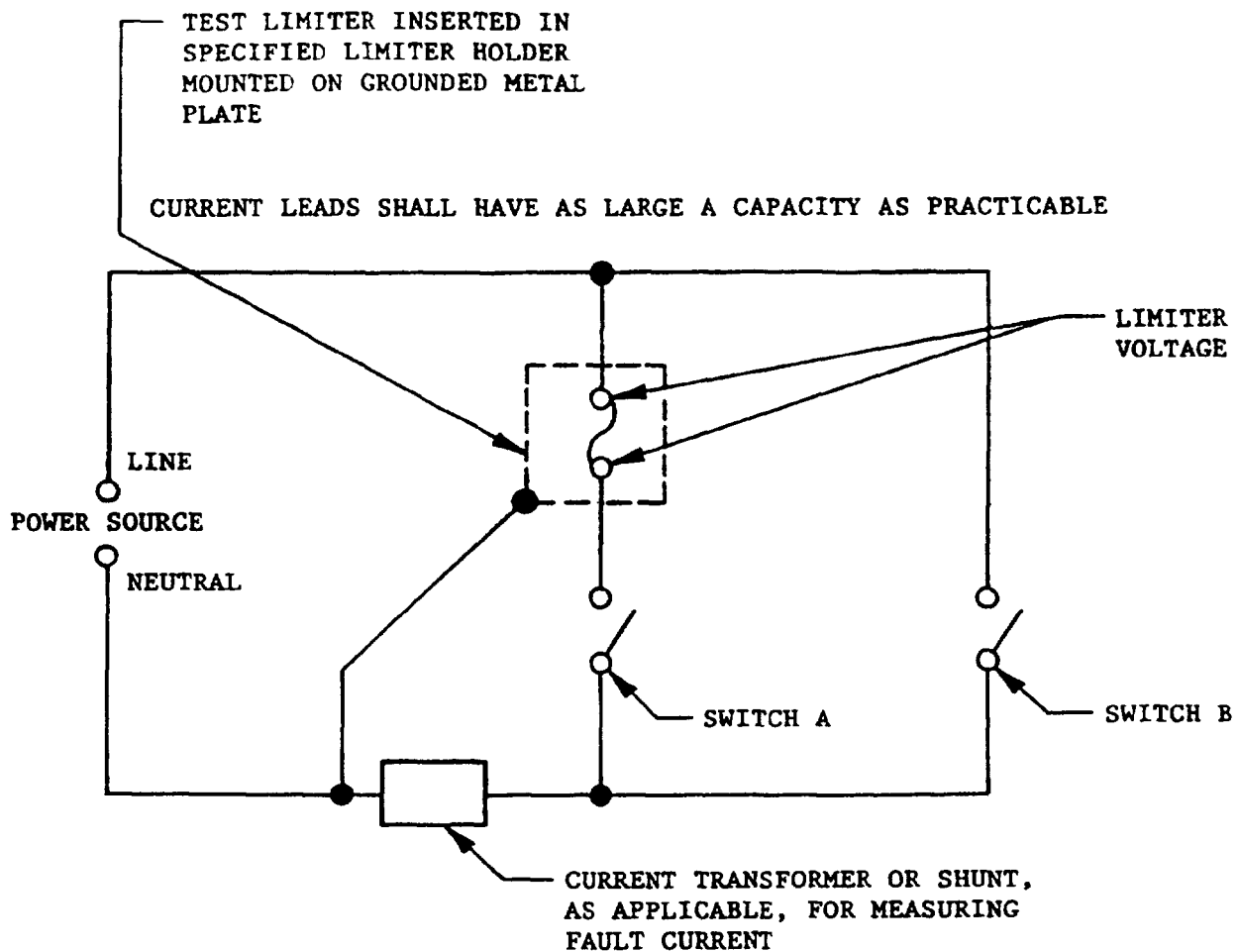
4.8.20 Terminal voltage drop. The limiter shall be inserted in the specified limiter holder and the voltage drop shall be determined with 100 percent rated current applied (see 3.5.5).

4.8.21 Temperature rise. Three limiters shall be inserted in the specified limiter holder, with leads attached suitable for calibration, and be subjected to the following duty cycle. This test shall be repeated for a total of 15 duty cycles.

Percent Load	Time in Minutes
100	30
140	1
0	29

The temperature rise shall be measured on the limiter terminal and shall not be greater than allowed in 3.5.8, with ambient temperature constant throughout the test.

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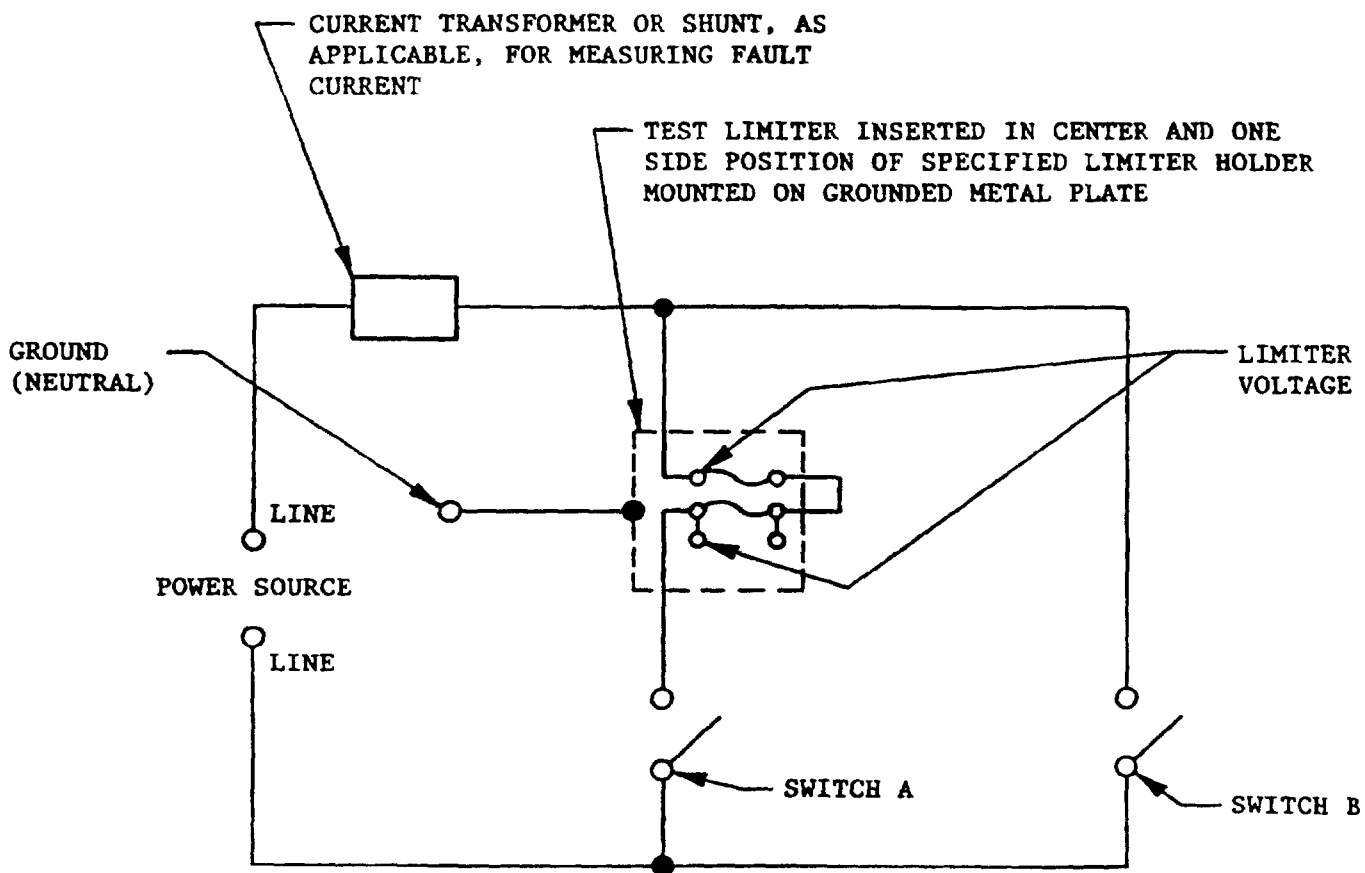
SWITCH A SHALL NOT CONTAIN BOUNCE EXCEEDING 250 MICROSECONDS. AN OSCILLOGRAPH HAVING A RESPONSE RATING OF AT LEAST 3000 HZ SHALL BE USED TO RECORD TEST CURRENT AND LIMITER VOLTAGES. TIME MEASUREMENTS SHALL BE ACCURATE TO 0.1 MILLISECOND.

PROCEDURE:

- (a) WITH SWITCH A OPEN, CLOSE SWITCH B TO DETERMINE IF THE CURRENT CAPACITY OF THE CIRCUIT IS IN ACCORDANCE WITH THE REQUIREMENT.
- (b) OPEN SWITCH B.
- (c) INSERT TEST LIMITER IN LIMITER HOLDER.
- (d) CLOSE SWITCH A.

FIGURE 3 Line-to-neutral interrupt test circuit.

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CURRENT LEADS SHALL HAVE AS LARGE A CAPACITY AS PRACTICABLE.

SWITCH A SHALL NOT CONTAIN BOUNCE EXCEEDING 250 MICROSECONDS. AN OSCILLOGRAPH HAVING A RESPONSE RATING OF AT LEAST 3000 HZ SHALL BE USED TO RECORD TEST CURRENT AND LIMITER VOLTAGE. TIME MEASUREMENTS SHALL BE ACCURATE TO 0.1 MILLISECOND.

PROCEDURE:

- (a) WITH SWITCH A OPEN, CLOSE SWITCH B TO DETERMINE IF THE CURRENT CAPACITY OF THE CIRCUIT IS IN ACCORDANCE WITH THE REQUIREMENT.
- (b) OPEN SWITCH B.
- (c) INSERT TEST LIMITER IN LIMITER HOLDER.
- (d) CLOSE SWITCH A.

FIGURE 4. Line-to-line interrupt test circuit

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4.8.22 Rated current. A test limiter shall be inserted in an applicable fuseholder and a thermocouple of No. 28 to 32 shall be placed on each limiter terminal. The limiter shall be energized at its rated current at any convenient voltage within its rating. The current shall be maintained for not less than thirty minutes after the temperature of the limiter has stabilized but shall be applied for not less than 1-1/2 hours. The temperature may be considered stabilized when 3 consecutive readings taken 10 minutes apart show no difference in temperature of more than $\pm 1^{\circ}\text{C}$.

4.8.23 Continuity. When tested at any convenient voltage, the limiters shall have electrical continuity (see 3.5.9).

4.8.24 Packaging, packing, and marking. Preparation for delivery shall be examined for conformance to Section 5.

5. PACKAGING

5.1 Preservation, packaging, packing, and marking. Unless otherwise specified, fuses shall be preserved and packaged in accordance with Method III, Level A or C of MIL-P-17555 in unit quantities of one each. They shall be packed in accordance with Level A, B, or C, as specified (see 6.2), and marked in accordance with MIL-P-17555. Unless otherwise specified, shipment marking nomenclature shall be as follows:

FUSE, CURRENT LIMITER TYPE, AIRCRAFT
MS or specification sheet part number as applicable

6. NOTES

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

6.1 Intended use. The current limiters covered by this specification are intended for use in aircraft primary electrical power systems with an alternating current rating of 115/200V at 400 Hz, and a direct current rating of 28V. The main purposes of these devices are to protect wiring from excessive current flow, and to prevent damage to electrical equipment resulting from fault conditions.

6.2 Acquisition requirements. Acquisition documents must specify the following:

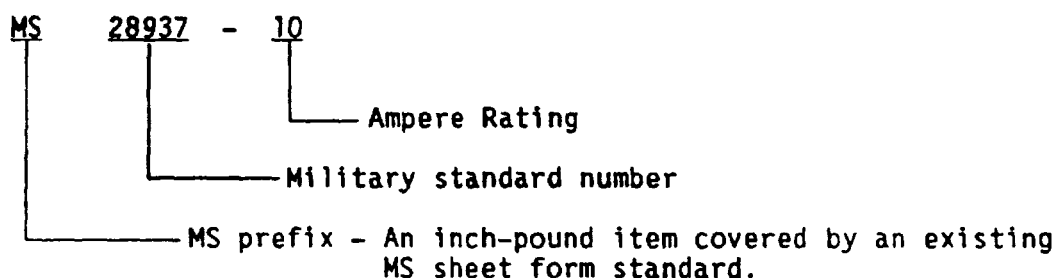
- a. Title, number, and date of the specification and applicable military standard or specification sheet.
- b. Issue of DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.1.1 and 2.2).
- c. Quantity and ampere rating conforming to the applicable military standard or specification sheet (see 1.2).
- d. Levels of preservation, packaging, and packing (see Section 5).

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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 the applicable QPL, whether or not such products have actually been so listed by that date. The attention of the suppliers 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. The activity responsible for the QPL is the Commanding Officer, Naval Air Warfare Center (Code B/714), 6000 East 21st Street, Indianapolis, IN 46219-2189, and information pertaining to qualification of products may be obtained from that activity. Copies of the "Provisions Governing Qualification" may be obtained upon application to DODSSP, Standardization Documents Order Desk, 700 Robbins Ave., Bldg. 4D, Philadelphia, PA 19111-5094.

6.4 Deleted.

6.5 Part or Identifying Number (PIN). The PIN to be used for the limiters acquired to this specification is created as follows:



6.6 Subject term (key word) listing.

Current limiter
Limiter

6.7 Definitions. The following definitions apply to terminology used in this specification.

6.7.1 Arcing time. Arcing time is the time measured from that point when element melt time ends to that point when current is interrupted and permanently becomes a zero. If a mechanical indicator is utilized which incorporates a secondary element parallel to the fusible element, arcing time will commence from the point at which indicator melt time ends.

6.7.2 Current droop. Current droop is the percentage decrease of the fusing current from the moment fusing current is initiated to the point where indicator melt time or arcing time begins. Current droop is usually caused by increase in limiter element resistance due to increased temperature caused by flow of current. Current droop can be encountered if care is not exercised in the selection of interconnecting wire, resistive loads, and battery source (see figure 3).

$$\text{Current droop} = \frac{\text{initial current} - \text{final current}}{\text{initial current}} \times 100$$

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6.7.3 Element melt time. Element melt time is the time elapsed from the moment a fusing current begins to flow to the moment the current sharply drops in value and indicator melt time or arcing commences.

6.7.4 Current limiter. A current limiter is an aircraft fuse designed specially with a high temperature melting point to provide protection for electrical power distribution systems against fault current.

6.7.5 Limiter current rating. Limiter current rating is a value of current assigned to a limiter that is below the minimum fusing current and can be carried continuously under all environmental conditions encountered by the limiter without deterioration of the element, the body, or the terminals.

6.7.6 Limiter element. That part of a limiter designed to melt by an excessive flow of current and thus interrupt a faulty condition.

6.7.7 Limiter voltage rating. Limiter voltage rating is that value assigned to a limiter denoting the maximum open-circuit voltage it can safely interrupt under specified test conditions.

6.7.8 Limiter holder. A limiter holder is a mounting device with contacts and terminals for the purpose of accepting limiters for easy connection within a circuit.

6.7.9 Fusing current. A fusing current is a current of such a magnitude that, under specified environmental conditions, the limiter element will melt.

6.7.10 Minimum fusing current. The smallest value of current that will melt the limiter element at a specified ambient temperature.

6.7.11 Prospective current. The value of short-circuit current (rms or dc) that would flow in a circuit if the limiter element were replaced by an element of negligible impedance.

6.7.12 Interrupt capacity. The largest prospective current the fuse can safely interrupt under specified conditions of voltage and of power factor or time constant.

6.7.13 Self-indicating current limiter. The type of limiter that incorporates a device to visually denote severance of the fusible element as an integral part of the limiter. Those limiters that visually display the fusible element or incorporate a mechanical indicating device are classified as self-indicating current limiters.

6.7.14 Total clearing time. Total clearing time is the total time obtained by adding element melt time, indicator melt time, and arcing time (see figure 2).

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

Custodian:
Air Force - 85

Preparing Activity:
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(Project 5920-0485)

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I RECOMMEND A CHANGE:
1. DOCUMENT NUMBER

MIL-F-5372D

2. DOCUMENT DATE (YYMMDD)

920422

3. DOCUMENT TITLE

FUSE, CURRENT LIMITER TYPE, AIRCRAFT

4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed)

5. REASON FOR RECOMMENDATION

PREPARING ACTIVITY		
a. NAME (Last, First, Middle Initial) NAME COMMANDING OFFICER, NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION LAKEHURST SYSTEMS REQUIREMENTS DEPARTMENT	b. TELEPHONE (include Area Code) (1) Commercial (2) AUTOVON (if applicable)	3. DATE SUBMITTED (YYMMDD) (2) AUTOVON
c. ADDRESS (include Zip Code) CODE SR3 LAKEHURST, NJ 08733-5100	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340	