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Superseding AIR1616

Self-Sealing Breakaway Valves for Crash-Resistant Aircraft Fuel Systems

RATIONALE

This document has been determined to contain basic and stable technology which is not dynamic in nature.

STABILIZED NOTICE

This document has been declared “Stabilized” by the AE-5 Technical Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

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1. SCOPE:

1.1 This document defines design, performance, and test criteria for self-sealing breakaway valves.

2. APPLICABLE DOCUMENTS:

2.1 Issue of Documents: The following documents of issue in effect on date of invitation for bids or request for proposal form a part of this document to the extent specified herein. In the event of conflict between these documents and the text of this document, the latter shall govern.

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http://www.sae.org/technical/standards/AIR1616A

2.1.1 Specifications:

U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19102.

Federal:

P-D-680	Dry Cleaning Solvent
QQ-A-367	Aluminum Alloy Forgings
QQ-S-763	Stainless Steel Forgings
TT-S-735	Standard Test Fluids, Hydrocarbon

Military:

MIL-A-8625	Anodic Coatings, for Aluminum and Aluminum Alloys
MIL-B-5087	Bonding, Electrical, and Lightning Protection, for Aerospace Systems
MIL-C-6021	Castings, Classification and Inspection of
MIL-C-7024	Fluids, Calibrating, for Aircraft Fuel Systems
MIL-C-45662	Calibration System Requirements
MIL-D-1000	Drawings: Engineering and Associated Lists
MIL-F-8615	Fuel System Components, General Specification for
MIL-G-5572	Gasoline, Aviation: Grades 80/87, 100/130, 115/145
MIL-I-8500	Interchangeability and Replaceability, Physical, of Component Parts for Aircraft (Including Guided Missiles)
MIL-N-25027	Nut, Self Locking, 250 Degree F, 450 Degree F, and 800 Degree F, 125 Ksi Ftu, 60 Ksi Ftu, and 30 Ksi Ftu
MIL-S-7742	Screw Threads, Standard, Optimum Selected Series, General Specification for
MIL-S-8879	Screw Threads, Controlled Radius Root with Increased Minor Diameter; General Specification for
MIL-T-5624	Turbine Fuel, Aviation, Grades JP-4 and JP-5
MIL-T-83133	Jet Fuel - Grade JP-8

2.1.2 Standards:

Federal:

No. 595	Colors

Military:

MIL-STD-129	Marking for Shipment and Storage
MIL-STD-130	Identification Marking for U.S. Military Property
MIL-STD-143	Specification and Standards, Order of Precedence for the Selection of
MIL-STD-276	Impregnation of Porous, Nonferrous Metal Castings
MIL-STD-794	Parts and Equipment, Procedures for Packaging and Packing of
MIL-STD-810	Environmental Test Methods
MIL-STD-1290	Light Fixed - and Rotary-Wing Aircraft Crashworthiness
MS20995	Wire, Lock
MS33540	Safety Wiring and Cotter Pinning, General Practices for

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2.1.2 Standards (Continued):

MS33586 Metals, Definition of Dissimilar
MS33588 Nut, Self-Locking, Aircraft Design and Usage Limitations of

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

2.1.3 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

ARP 868 Pressure Drop Test for Fuel System Components
ARP 1055 Fire Testing of Flexible Hose Tube Assemblies, Coils, Fittings & Similar System Components

3. REQUIREMENTS:

3.1 Quality Assurance: This document makes provisions for recommended qualification and quality conformance testing.

3.2 Description: The requirement of this section apply to the design of breakaway self-sealing valves including the performance and design of the self-sealing mechanism and the frangible section of the valve.

3.3 Materials: Materials and processes used by the manufacturer of fuel system components shall conform to applicable Government and Industry Documents. Materials conforming to contractor's documents may be used, provided prior approval is obtained from the procuring activity. The use of contractor's documents shall not constitute waiver of Government inspection. All materials used in the component shall be sufficiently resistant to fluids shown in paragraph 3.8.3.

3.3.1 Selection of Materials: Specifications and standards for all materials, parts, and processes which are not specifically designated herein and which are necessary for the execution of this specification shall be selected in accordance with MIL-STD-143.

3.3.2 Metals: All metals used in the construction of fuel-system components that are not of a corrosion-resistant type shall be suitably protected to resist corrosion during the normal service life of the component. Unless suitably protected against electrolytic corrosion, dissimilar metals as defined in MS33586 shall not be used in intimate contact with each other. Magnesium shall not be used in fuel system components. Cadmium plate and copper shall not be used where in contact with fuel.

3.3.3 Castings: Classification and inspection of ferrous and non-ferrous metal castings shall be in accordance with MIL-C-6021. If necessary to prevent leakage due to porosity, parts shall be treated in accordance with MIL-STD-276.

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3.3.4 Forgings: Forgings shall be in accordance with QQ-A-367 and QQ-S-763 or equivalent.

3.3.5 Fungus-Proof Materials: If possible, materials that are nutrients for fungi shall not be used.

3.4 Finish: Anodizing, plating, protective treatment, and painting of fuel system components shall be as specified in the model specification and applicable detail drawings. Paints, when used, shall not flake or chip so as to contaminate the fuel system. Surfaces normally in contact with fuel shall not be painted.

3.5 Identification of Product: Equipment, assemblies, and parts shall be marked for identification in accordance with MIL-STD-130.

3.6 Color Identification: Each fuel system component shall be marked by a red color, in approximate conformance with Federal Standard No. 595, color number 11136. The marking shall be permanent and, when applied to parts that may come in contact with fuel, shall not soften, chip, crack, or cause the fuel to be affected in any way. The marking shall consist of a band 1/4 inch wide by 1 inch long minimum on each side or around the component. A 45 degree arc 1/4 inch minimum width on both sides of the component, or the entire component may be red anodized in accordance with MIL-A-8625. In this case, the red anodic coating shall approximate color number 11136.

3.7 Parts:

3.7.1 Standard Parts: Standard parts (MS, AN or NAS) shall be used wherever they are suitable for the purpose and shall be identified on the drawing by their part number. Commercial utility parts (e.i., screws, bolts, nuts, and cotter pins) may be used, provided; (1) they possess suitable properties and are replaceable by the standard parts without alteration and (2) the corresponding standard number is referenced in the parts list and, if practicable, on the vendor's drawing. In event there are not suitable corresponding standard parts in effect on date of invitation for bids, commercial parts may be used if they conform to all requirements of this specification.

3.7.2 Threaded Parts: Threaded parts shall be in accordance with MIL-S-8879 or MIL-S-7742. The use of pipe threads is prohibited.

3.7.3 Locking of Parts: All threaded parts shall be locked by safety wiring, self-locking nuts, cotter pins, or other methods approved by the procuring activity. Safety wiring shall be installed in accordance with MS33540 and shall conform to MS20995. Self-locking nuts shall be in accordance with MIL-N-25027 and MS33588. Lockwashers or staking are not permitted. Components installed in the fuel cells shall not have safety wire.

3.8 Design and Construction: The valve frangible mechanisms shall be designed to meet all operational and service forces of the aircraft while being designed to separate at a predetermined point and load. Upon separation,

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3.8 (Continued):

internal self-sealing mechanisms in each valve section shall automatically close and seal, preventing leakage of fluids. The design shall consider visual indication of valve position and a means to prevent external leakage after separation due to foreign object contact with the sealing mechanisms. Provisions shall be designed into the valve to prevent fuel leakage in the event of a partial fracture of the frangible section before the valve closes. Spillage during separation and valve closure shall not exceed the values listed in Table I. Design of the valve shall be such that contamination and ice from the normal flow stream, shall not prevent valve closure which would cause an inadvertent failure and subsequent inability of the valve to self-seal. The design of the valve shall be such that no external power source or control is required for valve closure.

TABLE I

FLOW, PRESSURE LOSS & SPILLAGE

VALVE SIZE DIA., INCHES	FLOW RATE GPM	PRESS. LOSS @ 75°F PSIG MAX.	SPILLAGE CC
1/2	10	4.0	3
3/4	20	4.0	8
1	50	4.0	19
1 1/4	80	4.0	38
1 1/2	120	4.0	65
2	200	4.0	150
2 1/2	250	3.0	300
3	300	3.0	520

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3.8.1 Valve Configuration: The outside configuration of the valve, such as the method of mounting, the type of fluid connections, and the permissible envelope, shall be prescribed by the procuring activity to meet the specific needs of each fuel system.

3.8.2 Construction: The valves shall be constructed to withstand the strains, jars, vibrations, and other conditions as specified in MIL-STD-1290 for crashworthy fuel system. The valves shall not require, except for initial preservation, special treatment or controlled environment during storage.

3.8.3 Fluid Media: The valves shall be suitable for use with fuels conforming to specifications MIL-G-5572, MIL-T-5624, MIL-T-83133, test fluid Type II per MIL-C-7024 and P-D-680 Stoddard Solvent.

3.8.4 Bonding: Electrical continuity of 1.0 ohm maximum electrical resistance is required through the valve assemblies from one end to the other per MIL-B-5087 Type S.

3.9 Performance Characteristics:

3.9.1 Rated Pressure Range: The valve shall be designed to operate in the pressure range from -5 psig to 60 psig or the maximum anticipated fuel system operating pressure, whichever is greater.

3.9.2 Rated Temperature Range: The valve shall be designed to function normally in the fuel temperature range of -65°F to +160°F or the maximum anticipated fuel temperature, whichever is greater, and in an ambient temperature range required by MIL-F-8615.

3.9.3 Performance: The breakaway valves shall satisfy the following performance requirements when subjected to the applicable tests specified in Section 4 and in the procuring activity's specification.

3.9.3.1 Functional - Prior to Valve Separation:

3.9.3.1.1 Proof and Leakage: There shall be no external leakage when subjected to the proof and leakage tests of paragraph 4.6.2.1.

3.9.3.1.2 Negative Pressure Leakage: There shall be no measurable inward leakage when an internal pressure of -5 psi is applied for a period of 5 minutes as per paragraph 4.6.2.2.

3.9.3.1.3 Pressure Drop: The pressure drop shall meet the maximum shown in Table I unless otherwise specified by the procuring activity. The pressure drop shall be determined in accordance with ARP 868 and shall not exceed the specified pressure drop when subjected to the test of paragraph 4.6.2.3.

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3.9.3.2 Functional - After Valve Separation (Complete or Partial):

3.9.3.2.1 Proof and Leakage: External leakage shall not exceed the specified amount when each separated valve section is subjected to the leakage test of paragraph 4.6.3.

3.9.3.3 Surge Flow: The valve shall not close nor shall there be any evidence of failure or loosening of parts following the surge flow test of paragraph 4.6.4.

3.9.3.4 Fungus: The valve shall function properly and there shall be no evidence of deterioration following the fungus test of paragraph 4.6.5.

3.9.3.5 Corrosion Resistance: The valve shall function properly following the accelerated corrosion test of paragraph 4.6.6.

3.9.3.6 Contaminated Fuel Endurance: Following the contamination fuel endurance test of paragraph 4.6.7, the valves shall satisfactorily pass the Proof and External Leakage Test of paragraph 4.6.2.1.

3.9.3.7 Fuel Resistance and Extreme Temperature: There shall be no external evidence of failure, corrosion, degradation in performance, or self sealing capability when the valve is subjected to the applicable test of paragraph 4.6.8.

3.9.3.8 Vibration: The valve shall not close nor shall there be any evidence of structural failure, loosening of parts, leakage, or performance degradation either during or as a result of the vibration test of paragraph 4.6.9.

3.9.3.9 Shock: The valves shall not close nor shall there be any evidence of structural failure during or following the shock test of paragraph 4.6.10.

3.9.3.10 Icing: The valve shall function as specified when it is subjected to the icing test of paragraph 4.6.11.

3.9.3.11 Sand and Dust: The valve shall function as specified after being subjected to the sand and dust test of paragraph 4.6.12.

3.9.3.12 Disassembly and Inspection: After completion of the qualification tests, disassembly and inspection shall reveal no indication of damage or excessive wear.

3.9.3.13 Burst Pressure: There shall be no external leakage or valve actuation when the valve is subjected to the burst pressure test of paragraph 4.6.13.

3.9.3.14 Fire Test: The fire test, if required, should be performed in accordance with current standard practices and equipment as specified in ARP 1055 and by the procuring activity.

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3.9.4 Separation Criteria:

3.9.4.1 Separation Modes: The valve frangible mechanism shall be designed to separate and seal upon application of a force of 25 to 50% of the load required to fail the weakest component of the fuel system adjacent to the valve assembly, or at a level specified by the procuring activity. Separation modes may be in the form of tension, bending, shear or a combination thereof. Separation may be caused by static loads, paragraph 4.6.14 or dynamic loads, paragraph 4.6.15. During separation, spillage shall be within the limits defined in paragraph 3.8. After separation each valve section shall meet the leakage requirements of paragraph 4.6.3.

3.10 Maintainability:

3.10.1 Interchangeability: All parts having the same manufacturer's part number shall be directly and completely interchangeable with each other with respect to installation and performance in accordance with Specification MIL-I-8500. Changes in manufacturer's part numbers shall be governed by the drawing number requirements of Specification MIL-D-1000.

3.10.2 Repairability: The valve assembly shall be designed so that no adjustments, cleaning, or repairs are required during normal service life.

3.10.3 Replaceability: The valve assembly replacement shall not require special tools, facilities, or highly skilled personnel.

3.10.4 Standardization: Standard hardware shall be used except if standard hardware would inhibit design objectives.

3.10.5 Serviceability: The valve assembly shall be so designed that, except for preservation procedures, scheduled maintenance will not be required in order to maintain physical or functional capability.

3.10.6 Service Life: Service life shall be 10,000 flight hours or 10 calendar years, whichever comes first. Service life will be computed from date of manufacture to completion of calendar/flight hour schedule.

3.11 Safety: These valves are identified as a safety critical item and the design shall preclude all human error/material failure modes which could result in these hazards:

a) Inadvertent closure of the valves.

b) Inadvertent valve re-opening.

c) Leakage.

d) Failure to close when subjected to crash impact loads defined by the procuring activity.

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3.12 Drawings: Manufacturer's drawings shall conform to MIL-D-1000.

3.13 Failure and Corrective Action Reporting: Each failure detected during or following qualification or acceptance tests shall be reported to the procuring activity in the format specified by them.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. The supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, subject to approval by the procuring activity or otherwise specified in the contract or order. The procuring activity reserves the right to perform any of the inspections set forth in the specification.

4.2 Classification of Inspections: The inspection and testing of fuel valves shall be classified as follows:

	PARAGRAPH
a) Qualification tests	4.3
b) Quality conformance tests	4.4

4.3 Qualification Tests:

4.3.1 Test Samples: The qualification test samples shall be subjected to the following tests or as designated by the procuring activity. Two samples of each size shall be used as a minimum. Additional test samples may be required depending on the type of frangible section used and damage sustained during separation testing. Test samples may be repaired by replacing the frangible sections for the added separation tests. Depending on design and test methods, additional test samples may be required as agreed upon by supplier and procuring agency. Supplier assumes responsibility for reuse of a test unit after separation test and only the frangible element shall be replaced.

4.3.2 Test Sequence for the Test Samples: The qualification test sequence shall be as listed in Table II.

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TABLE II QUALIFICATION TESTS

	Requirement Para.	Qual. Test Para.	Test Sequence Test Unit #1	Test Unit #2	Test Unit #Note
Examination of Product		4.6.1	1	1	*
Fuel Resistance & Extreme Temp.	3.9.3.7	4.6.8	2	2	*
Functional, Prior to Separation	3.9.3.1	4.6.2			
Proof & External Leakage Test	3.9.3.1.1	4.6.2.1	3	3	*
Negative Pressure Leakage	3.9.3.1.2	4.6.2.2	4	4	*
Pressure Drop	3.9.3.1.3	4.6.2.3	5	5	*
Vibration	3.9.3.8	4.6.9	6		
Shock	3.9.3.9	4.6.10	7		
Corrosion Resistance	3.9.3.5	4.6.6		6	
Surge Flow	3.9.3.3	4.6.4		7	
Contaminated Fuel Endurance	3.9.3.6	4.6.7		8	
Icing	3.9.3.10	4.6.11		9	
Sand & Dust	3.9.3.11	4.6.12		10	
Fungus	3.9.3.4	4.6.5		11	
Static Load Separation	3.9.4.1	4.6.14	8		*
Dynamic Load Separation	3.9.4.1	4.6.15		12	*
Functional, After Separation	3.9.3.2	4.6.3	9	13	*
Disassembly and Inspection	3.9.3.12	4.6.16	10	14	*
Burst Pressure	3.9.3.13	4.6.13	11		

NOTE: IF ADDITIONAL TEST UNITS ARE REQUIRED THEY SHALL BE TESTED AS MARKED.*

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4.3.3 Rejection & Retest of Qualification Test Samples: In the event of a failure during qualification testing, the procuring agency shall be notified within 24 hours, testing suspended and a failure report including recommended correction be submitted as soon as possible.

Concurrence of the procuring agency shall be obtained prior to resumption of testing, indicating corrections and modifications and point of test resumption.

4.4 Quality Conformance Tests: Quality conformance tests shall consist of the acceptance tests and sampling tests.

4.4.1 Acceptance Tests - Production Lots:

Each valve assembly shall be subjected to the following:

	Paragraph
a) Examination of Product	4.6.1
b) Functional (except pressure drop)	4.6.2

4.4.2 Sampling Tests - Production Lots: Two valve samples shall be selected from each lot of 100 or fraction thereof manufactured and submitted for acceptance at the same time or as specified by the procuring activity and shall be subjected to the following:

	Paragraph
a) Examination of Product	4.6.1
b) Functional, Prior to Valve Separation	4.6.2
c) Static Load	4.6.14
d) Functional, After Valve Separation	4.6.3
e) Disassembly and Inspection	4.6.16

NOTE: One each specimen subjected to shear and one to tension load.

4.4.3 Rejection and Retest - Production Lots: Failure of any representative sample shall be cause for the rejection of the lot represented. Valve assemblies which have been rejected may be reworked to correct the defects and resubmitted for acceptance. Before resubmitting, full particulars concerning previous rejection and the action taken to correct the defects found in the original rejection shall be furnished the Procuring Activity. Valve assemblies rejected after retest shall not be submitted without the specific approval of the Procuring Activity.

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4.5 Test Conditions: Unless otherwise specified, the following test conditions shall apply during the tests performed in accordance with this specification.

4.5.1 Cleaning: Prior to testing any valve assemblies, all lubricants and preservative compounds, except permanent protective coatings such as paint, shall be removed from the external parts of the unit and from all internal parts which are normally wetted with fuel.

4.5.2 Test Fluid: Unless otherwise specified, the test fluid shall be in accordance with TT-S-735, P-D-680 Stoddard Solvent or MIL-C-7024.

4.5.3 Room Temperature and Pressure: Unless otherwise specified, all tests shall be conducted at temperatures of 60° to 90°F and at local barometric pressure.

4.5.4 Temperature Tolerance: Unless otherwise specified, the following temperature tolerances shall be maintained.

SPECIFIED TEMPERATURE	TOLERANCE
Above 100°F	± 10°F
Below 100°F	± 5°F

4.5.5 Attitude: Unless otherwise specified, all tests shall be conducted with the valve assembly mounted in the attitude specified by the procuring activity.

4.5.6 Test Equipment Calibration: Test equipment required to perform the testing described herein shall be calibrated within the specified periods established by MIL-C-45662. Ranges and accuracy of instrumentation shall be capable of providing test data within the specified tolerances.

4.6 Test Methods:

4.6.1 Examination of Product: Each valve assembly submitted for acceptance shall be carefully examined to determine its conformance to the requirements of the specification and the procuring activity requirements. This examination should include, but not necessarily be limited to, envelope dimensions, weight, materials and finishes.

4.6.2 Functional, Prior to Valve Separation:

4.6.2.1 Bonding: The valve assembly shall meet the requirements of paragraph 3.8.6.

4.6.2.2 Proof and External Leakage Test: The valve assembly with the valves open shall be pressurized to 2 psig for 1 minute, at operating pressure for 1 minute and at proof pressure (twice operating) for 1 minute. There shall be no evidence of leakage at any pressure, failure, malfunction, or permanent distortion at proof pressure.

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4.6.2.2 (Continued):

This test shall be extended to 5 minutes at each pressure for qualification testing.

4.6.2.3 Negative Pressure Leakage (as applicable): The valve shall be installed in a minimum volume test system and an internal pressure of -5 psi locked in for a period of five minutes. Temperatures shall be maintained constant within ± 2°F and the pressure observed during this period. There shall be no measurable leakage (reduction in pressure reading in excess of 0.5 psig) during this period. This is a qualification test requirement only.

4.6.2.4 Pressure Drop: With the valves in the valve assembly open, test for pressure drop in accordance with SAE ARP 868. Sufficient data shall be recorded to permit the plotting of curves. The pressure drop graph shall show the net pressure drop vs. flowrate of the valve assembly using test fluids as specified by the procuring activity. The pressure drop shall not exceed the pressure drop specified in Table I or as specified by the procuring activity.

4.6.3 Functional, After Valve Separation: Each valve section with the self-sealing mechanisms closed shall be pressurized at 2 psig for 5 minutes then gradually increased to proof pressure and held for 5 minutes. No external valve leakage in excess of 1 drop per minute is allowed. There shall be no failure, malfunction or permanent distortion at proof pressure.

4.6.4 Surge Flow: A complete valve shall be subjected to a flow of two times the rated flow in the normal flow direction for 5 seconds minimum. This surge flow pattern shall be repeated 20 times; 10 in each direction. The valve shall be examined for evidence of flow blockage, internal damage, and then subjected to the leakage test of paragraph 4.6.2.1 and the pressure drop test of paragraph 4.6.2.3.

4.6.5 Fungus: A valve assembly shall be subjected to the fungus test of MIL-STD-810, Method 508.1. If there are no fungus nutrients, this requirement may be satisfied by certification.

4.6.6 Corrosion Resistance: The external surface of the valve, with ends capped, shall be exposed to the Salt Fog Test of MIL-STD-810, Method 509.1, Procedure 1. There shall be no evidence of deterioration that might adversely affect subsequent operation.

4.6.7 Contaminated Fuel Endurance: A test fluid in accordance with TT-S-735, Type I, containing contaminant at the concentration specified in MIL-F-8615 shall be circulated through the unit for a period of 2.5 hours. Flow shall be approximately one half the rate specified in Table I. Upon completion of the tests, the unit shall be subjected to the unit leakage tests of paragraph 4.6.2.1 herein.

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4.6.8 Fuel Resistance and Extreme Temperature: The valve shall be subjected to the fuel resistance and extreme temperature test as shown in Table III.

The tests shall be conducted in a continuous manner and each period shall follow the preceding one in the order listed. The soak period for each phase shall be conducted with the connected couplings totally immersed continuously in the specified fluid with the ports open. For the dry periods, the coupled couplings shall be drained, without disconnecting, and blown dry with the ports open and placed in a test chamber having air at specified temperature (135°F) continuously circulating around the test specimen.

At the conclusion of each soak and dry period the coupling shall be subjected to the Proof and Leak Test of paragraph 4.6.2.1. The tests following Phase I and II shall be conducted at room temperature using the fluids shown in Table III. The tests following Phase III shall be conducted at the soak temperature, then repeated at room temperature.

TABLE III

FUEL RESISTANCE AND EXTREME TEMPERATURE

TEST PERIOD	PHASE I		PHASE II		PHASE III
	SOAK	DRY	SOAK	DRY	SOAK
Ambient and fluid test temperature	135°F ± 10°F	135°F ± 10°F	135°F ± 10°F	135°F ± 10°F	-65°F or colder
Test fluid * during soak					
Class A	Type III		Type III		Type I
Period Duration	96 Hours Minimum	24 Hours	18 Hours Minimum	30 Hours	18 Hours Minimum
Test fluids to be used for tests immediately after period	Type III	Type I	Type III	Type I	Type I

* TT-S-735 Type I: Iso-Octane
TT-S-735 Type III: Iso-Octane and toluene mixture

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