SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE STANDARD

SAE AS5877

Issued 2001-07

Detailed Specification for Aircraft Pressure Refueling Nozzle

1. SCOPE:

This SAE Aerospace Standard (AS) prescribes requirements for the various types of nozzles that are used for the refueling of aircraft fitted with pressure fuel servicing systems. It is to be used as a replacement for MIL-N-5877, MS29520 and for all commercial applications.

1.1 Classification:

The nozzles specified herein shall be classified in accordance with Table 1.

1.2 Field of Application:

This specification is for all nozzles that are utilized either in commercial or military applications where the aircraft system utilizes pressure fuel-servicing systems. The nozzle shall be compatible with and mate with the international aircraft adapter fitting in accordance to ISO 45 Aircraft Pressure Refueling Connections.

1.3 Nozzle Configuration:

The nozzle shall conform to the design interface envelope of Figure 1 of this document. The inlet configuration outside of the envelope is at the manufacturer's option and may be designed to have an angled or straight configuration to meet individual requirements. The envelope restrictions are mandatory to assure that aircraft fuel system manufacturers and nozzle manufacturers have a common interface with which to work. This will assure compatibility between the available nozzles and the aircraft refueling system adapters. The nozzle may be configured to include various features and be available in various inlet configurations including, but not necessarily limited to those shown in Table 2.

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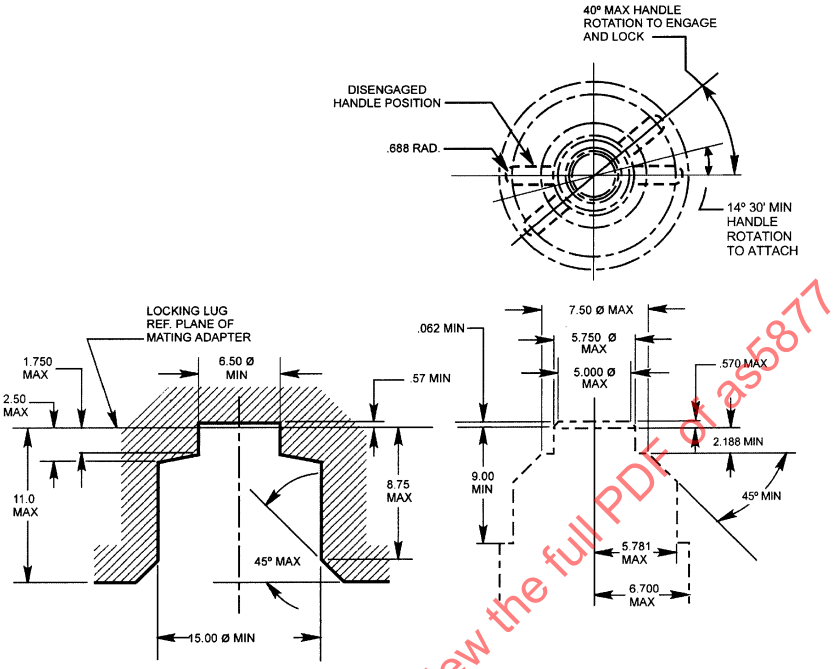
TABLE 1

TYPE	CLASS	DESCRIPTION
I	D-1	Pressure refueling nozzle with a curved body with a 6-bolt inlet flange and without a hose end control valve. All type I nozzles designed mainly for use by some branches of the U.S. Military supersede those previously specified in the MIL-N-5877. Various inlets and accessories may be added to the basic nozzle as noted herein.
I	D-1R	Same as Type I, Class D-1 except a 55-psi hose end control valve is included as an accessory.
I	D-2	Same as Type I, Class D-1 except the inlet is straight.
I	D-2R	Same as Type I, Class D-2 except a 55-psi hose end control valve is included as an accessory.
II	-	Underwing nozzle designed primarily for commercial usage with a straight body and various inlet connections and without a hose end control valve. Various inlets and accessories may be included as noted herein. Some branches of the U.S. Military use this type of nozzle in lieu of a D-2.
II	R	Same as Type II except a hose end control valve is included as an accessory. The customer shall specify the pressure setting for the hose end control valve. Some branches of the U.S. Military use this type of nozzle in lieu of a D-2R.



AIRFRAME ENVELOPE CLEARANCE REQUIREMENTS

NOZZLE MATING DIMENSION ENVELOPE REQUIREMENTS

Notes:

1. Minimum side by side installation dimensions between aircraft adapter installation shall be 10 inches.
2. Dimensions are in inches for clarity. Metric conversions for the dimensions shown above are as follows:

Inches	Millimeters	Inches	Millimeters
.062 min	1.578min	5.750 max	146.05 max
.475	12.07	5.781 max	146.84 max
.506	12.85	6.500 min	165.10 min
.570 max	14.48 max	6.700 max	170.18 max
1.375	34.93	7.500 max	190.50 max
1.438	36.53	8.750 max	222.25 max
1.750 max	44.45 max	9.000 min	228.60 min
2.188 min	55.58 min	11.000 max	279.40 max
2.500 max	63.50 max	15.000 min	381.00 min
5.000 max	127.00 max		

3. Certain provisions (dimensions required for connection with the adapter and envelope dimensions) of this standard are the subject of international standardization agreement ASCC AIR STD 25/4 and STANAG 3105. When revision of this AS5877 standard is proposed which shall affect or violate the international agreement concerned appropriate reconciliation action through international standard channels shall be taken.
4. Nozzle poppet face shall be located at .475 to .506 inches above the Adapter Locking Lug Reference Plane (adapter is located in an underwing position with the lugs on the surface away from the aircraft wing). Nozzle poppet travel shall be 1.375 min to 1.436 max inches.

FIGURE 1 - Envelope Requirements

TABLE 2 - Various Features Available on Nozzles

FEATURE	SIZE/TYPE	DESCRIPTION
Inlet Thread	2, 2½ & 3 in NPT or BSPP	Inlet configuration may be one of many including, but not limited to, the ones described in this table.
Inlet Flange	2½ in, 6-through bolt type flange for gasket seal	"Military" type tube connection (formerly MS33786-40) utilized on Type I, Class D-1, D-1R, D-2 and D-2R nozzles for military applications. The inside diameter of the inlet flange shall be 2.506 in ± 0.009 in (63.73 mm).
Handle Configuration	Various	Stick, Stirrup and Wheel type handles are available from different manufacturers. The manufacturer specifications should be checked before ordering. Note that handle selection may affect nozzle stowage and or interlock devices on refueling vehicles. Stick type handles are required for military applications.
Strainers	40-mesh 60-mesh 100-mesh	A device, normally mounted in either the inlet disconnect or ball valve, that is designed to be the last defense against and for the detection of "large" contaminants from entering the aircraft fuel system. The size of strainer mesh is at the option of the buyer (see 3.3.5 for certain restrictions). Note that the degree of filtration capability is dependent upon mesh and wire size. The manufacturer specifications should be checked before ordering.
Bonding Cable	Varies with manufacturer	An accessory part of the unit as specified in the procurement document. A relatively short cable with either a standard phone type jack plug or an alligator clip (or both) that allows for bonding the nozzle to the aircraft structure. The manufacturer specifications should be checked before ordering. The bonding of the nozzle to the aircraft, although still done in some locations is not a usual requirement. Bonding cables used on underwing nozzles for military applications are limited to Marine/Army equipment only.
Hose End Control Valves (Regulators)	Nominal 2½ in size with connections to mate the nozzle for which it is designed	Unit designed to limit nominal pressure at the outlet and to sense rapid buildup of pressure in the aircraft manifold and to control surge pressure within the aircraft system. Various pressure settings are available and must be specified in accordance with the manufacturer details. Commonly advertised spring ratings are 35, 45, 50, and 55 psig. Note that the advertised spring ratings may not produce control pressures of the same value. Manufacturer's test reports should specify the actual limits.
Inlet Type - furnished as an accessory of the nozzle.	Most will use the sizes and types noted under Inlet Thread	Quick Disconnect - Mates the nozzle to the hose and allow for quick access to a strainer and for quick replacement for repair. A swivel may or may not be present in this type of inlet. Quick Disconnect Dry Break - Same as above except the hose half of the unit is self-sealing or manually sealed to keep the fuel in the hose from draining out of the system when the nozzle is disconnected. Fuel will still be present in the nozzle body and care shall be exercised to keep from spilling this fuel. Strainer Ball Valve or similar type device - A unit incorporating a ball valve or similar type device that allows for the inspection of the strainer without removing the nozzle from the system. Provides for the minimum spillage of fuel from the system. A quick disconnect and/or swivel may or may not be included in this unit.
Swivel	-	This feature may be an integral part of the nozzle or as an added optional feature contained in either the quick disconnect, dry break, ball valve or similar device. It is needed to ease hose handling during refueling.
Vacuum Breaker	-	An optional accessory part of the unit as specified in the procurement document. A small spring-loaded valve mounted on the side of the nozzle to allow for the incursion of atmospheric pressure to the fuel system to prevent the formation of an excessive vacuum within the system. The manufacturer's specifications should be checked before ordering.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and 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.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AS24484	Pressure Refueling Adapter
ARP5298	Adapter Wear Limits

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor, West Conshohocken, PA 19428-2959.

ASTM D 910	Standard Specification for Aviation Gasoline
ASTM D 1655	Jet Fuel, Type A-1
ASTM 6227	Unleaded Aviation Gasoline

2.3 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-DTL-5624	Turbine Fuel, Aviation, Grades JP-4 and JP-5
MIL-DTL-83133	Turbine Fuel, Aviation, Kerosene Type, Grade JP-8
MIL-N-5877	Nozzle, Pressure Fuel Servicing
MIL-PRF-7024	Calibrating Fluid, Aircraft Fuel System Components.
MS29520	Envelope Dimension, Nozzle Fuel Pressure Servicing.
MOD DEF STAN 91-91 (DERD 2494)	Joint Industry Checklist AFQRJOS for Jet A-1
FED-STD-H28	Screw Thread Standards for Federal Services

2.4 ISO Publications:

Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ISO 45	Aircraft Pressure Refueling Connections
ISO 68	International Standard - General Purpose Screw Threads, Basic Profile
ISO 228/1	Standards for Pipe Threads for Tubes and Fittings

2.5 ATA Publications:

Available from ATA, Engineering and Maintenance Division, 1709 New York Avenue, Northwest, Washington, DC 20006-5206.

ATA Specification 103 Standards for Jet Fuel Quality Control at Airports

2.6 American Petroleum Institute Publications:

Available from API, 1200 L. Street, Washington, DC 20005-4070.

API 1529 Hose, Aviation Refueling

3. REQUIREMENTS:

3.1 Qualification:

3.1.1 Nozzles approved to this specification require qualification. Qualification testing shall consist of the tests specified in Section 4 and shall be performed in accordance with the provisions of 5.2.

3.1.2 Nozzles for military applications approved to this specification shall be listed or approved for listing on the qualified products list (QPL) in accordance with the provisions of 5.2. Changes in product formulation raw material, basic methods of manufacturer or design changes that affect form, fit or function for qualified nozzle listed or approved for listing on the QPL, without first notifying the responsible QPL agency, may result in the product being disqualified and removed from the QPL.

3.1.3 Nozzles for commercial applications shall be approved in accordance with the particular user requirements on approval of equipment.

3.2 Materials:

All materials used in the nozzle shall be chemically compatible with and not adversely affect the nozzle's operation or the quality of the fuel when used with fuels specified in 3.3.15. The use of magnesium, manganese, copper, zinc, cadmium or their alloys (alloys containing more than 5% of the subject materials) in parts wetted by fuel and subject to wear shall not be used. Corrosion resistant metals shall be used. Exterior surfaces susceptible to impact or contact with the airport apron or other surfaces shall be made of aluminum, stainless steel, plastic or other material that will not cause a spark when contact is made. Unless suitably protected against electrolytic corrosion, dissimilar metals shall not be used in contact with each other. Materials subject to potential corrosion must be suitably coated with a process that will not contain any of the above-restricted materials.

3.3 Design:

3.3.1 Envelope and Interface: The nozzle shall interface with ISO 45/AS24484 Pressure Refueling Adapter. The nozzle envelope shall not exceed that specified in Figure 1, Nozzle Mating Dimension Envelope Requirement.

3.3.2 Flow Rate: The nozzle shall allow a flow rate of up to 600 U.S. gpm (2271 l/min). with an operating pressure as specified in 3.3.17.1. Note: Some applications (small airports) that require flow rates less than 600 U.S. gpm (2271 l/min) may be approved to this specification upon mutual agreement between manufacturer and approving customer. All other requirements, except for the reduced flow rate shall remain the same.

3.3.3 Operation: The nozzle shall have an operating lever or other suitable means to mechanically open or close the nozzle. The lever is not intended to be utilized for control or shutting off of the flow. It is used to open or close the nozzle during no-flow conditions. This operating lever action shall be independent from the action used to attach the nozzle to the aircraft adapter. Operation of the lever will simultaneously open or close the adapter sealing unit, which will allow flow to or from the aircraft, or other vehicle to which the nozzle is attached. Removal of the nozzle from the adapter shall be impossible unless the lever is in the closed, no-flow position. It shall also be impossible to open the nozzle unless it is attached properly to a mating adapter in good repair (wear limits for the adapter are defined in ARP5298). The lever shall remain in either the full flow or no-flow position under the full range of flow rates and pressures, during fueling or defueling, without the need of maintaining a continuous manual holding force. Note: The forces within the nozzle/adapter combination is a function of the internal nozzle design and the design of the adapter as controlled by AS24484.

3.3.4 Interface Seal: The interface seal shall prevent leakage when the nozzle and adapter are connected and open. The seal shall compensate for wear on the adapter (as defined in AS24484 and/or ARP5298), wear on the nozzle, dimensional tolerances, side loading and temperature changes.

3.3.5 Strainer: All nozzles shall have provisions for the installation of a strainer as an optional feature. Strainers are commonly referred to as being 40-, 60- or 100-mesh. However the open flow area through the strainer is determined by the size of wire cloth used. The minimum open area for each size shall be as shown in Table 3:

TABLE 3

MESH DESIGNATION	MINIMUM OPEN FLOW SIZE – MICRONS
40-mesh	450
60-mesh	300
100-mesh	145

3.3.5 (Continued):

Provisions shall be made in the design to allow quick easy inspection and cleaning of the strainer by a single person with the use only of basic hand tools. The design shall be appropriate to allow routine (e.g., weekly) repeated disassembly/assembly without damage to the nozzle. Any devices designed for removal of the nozzle to check the strainer or to replace the nozzle shall be securely locked by appropriate means to prevent inadvertent disconnect during use or storage. Strainers must be robust enough to withstand 35-psi differential when fully blocked. The design of the strainer installation shall not impede the use of any other options, such as, but not limited to quick disconnect dry-breaks, pressure test devices or sampling port devices. Strainers shall be designed and used for the fueling operation only and removed or reversed for any defueling operation.

3.3.6 Accessory/Ambient Ports: Provisions for two accessory ports shall be made through the body wall of the nozzle to allow for installation of a pressure gauge, a vacuum breaker or fuel sampling tap. The ports shall have a 0.375-in NPT, 12-mm ISO straight pipe thread or 0.375-in BSPP thread. Location and configuration shall allow insertion of a sampling probe, which protrudes 0.56 in (14.2-mm), into the flow path of the nozzle body. The probe shall not interfere with the operation of the nozzle. Unless the nozzles include accessories to be mounted in these ports, they shall be closed with pressure tight plugs. If used (Class D-1R, D-2R and R only), the breather or vent port in the side of the Hose End Control Valve shall be designed to divert any leakage or flow of fuel from it away from the operator of the nozzle during an operation. The breather or vent port, when used shall have a 7/16-20 UNF-3B thread with O-ring sealing capability (old AND10050-4) to allow for in-field blocking out during the testing of other components in the system.

3.3.7 Inlet Swivel: Each nozzle shall have a swivel capable of 360° rotation included as an integral part of the nozzle or as an accessory to the nozzle to ease the connection of the unit to an aircraft or other receiving vehicle. The swivel design shall not inhibit movement while the hose is being subjected to operating pressure.

3.3.8 Handles: The nozzle shall incorporate handles that facilitate carrying and connection to the receiving vehicle. The handles can be of optional configuration, common ones being stick, stirrup and wheel. The handles shall include material of non-slip characteristics in the areas in which the operator's hands will come in contact. The handles shall be within the envelope specified in Figure 1. Length of the stick type handles is at the option of the manufacturer and or the procuring customer.

3.3.9 Bonding Cable: Provisions for the installation of a bonding cable shall be provided as a customer specified option. The connecting clip/plug and the nozzle body material shall have a maximum electrical resistance of 10 Ω.

3.3.10 Hose End Control Valve (also interchangeably called Regulator): Class D-1R, D-2R and R nozzles shall incorporate this device designed to limit delivery pressure at the outlet and to react to changing aircraft manifold pressures to prevent excessive surge pressures within the manifold. The customer specifies the pressure setting. Most common usage is 45-psig for commercial and 55-psig for military applications.

3.3.11 Maintenance: Wherever possible, industry standard seals (packings or O-rings) shall be utilized provided they meet the requirements of this specification. The overhaul of the nozzle shall be possible by maintenance personnel with a minimum of training, tools and equipment normally available commercially.

3.3.12 Protective Devices: A protective bumper of a fuel resistant material shall be provided around the outlet major diameter to protect the aircraft structure and the nozzle from accidental impact damage during use and operation. Optional self-sacrificing (of non-foreign object damage [FOD] design), brackets, pads or rings may be provided to protect certain critical parts of the nozzle from damage caused by dragging.

3.3.13 Dust Cap: A non-metallic cap shall be provided to prevent dust and other foreign debris from entering the outlet portion of the nozzle during handling and storage. When the nozzle is connected to a receiving adapter, the dust cap shall hang free so that it shall not interfere with the refueling operation. The use of springs for cap retention is not allowed. The material of the cap shall be resistant to exposure to ultra-violet, aviation fuels and the combination of high humidity and temperature.

3.3.14 Lubrication: The nozzle shall operate without the use of lubricants.

3.3.15 Fuel Compatibility: The nozzle shall not malfunction when used with fuels conforming to MIL-DTL-5624, MIL-DTL-83133, MOD DEF STRAN 91-91 (DERD 2494), Joint Industry Checklist AFQRJOS for Jet A-1, ASTM D 1655, ASTM 6227 and ASTM D 910.

3.3.16 O-rings, Packings and Seals: O-rings or packings and associated seals shall be suitable for use in hydrocarbon fuels and meet the test requirements of this specification. Special shaped seals shall be kept to a minimum.

3.3.17 Pressures:

3.3.17.1 System Operating Pressure: The nozzle shall be designed to refuel aircraft at a maximum operating pressure of 60-psi (413.7-kPa) with a surge pressure of up to 300-psi (2068.5-kPa).

3.3.17.2 Pressure Loss: The corrected gauge pressure loss across the nozzle and the mating adapter shown in Figure 4 shall be kept to a minimum. The use of the adapter in Figure 4 provides a standard of comparison for all manufacturers. Other pressure loss data using other mating adapters may also be useful to the customer.

3.3.17.2.1 Military Type I, Class D-1 or D-2 Nozzles: The pressure loss across the nozzle/adapter combination shall not exceed 15-psid at a flow rate of 600 gpm.

3.3.17.2.2 Military Type I, Class D-1R or D-2R Nozzles: The pressure loss across the nozzle/hose end control valve/adapter shall not exceed 35-psid at a flow rate of 600 gpm. The hose end control valve shall be in a full (blocked) open position for this requirement.

3.3.17.2.3 Commercial Nozzles, All Types: Due to the many commercial configurations possible no specific design parameter will be offered in this document for those nozzle configurations. Manufacturers shall determine and report the pressure loss for the various combinations of equipment offered.

3.3.17.3 Pressure Limitation (Class D-1R, D-2R & R Nozzles Only): Using the test setup specified in 4.6.3, with flow rates from 600 U.S. gpm (2271 l/min) to 25 U.S. gpm (95 l/min), the regulator shall limit the downstream pressure to a maximum of 5 psig (34.5-kPa) above the nominal spring setting. At flow rates at or near zero (less than 5 U.S. gpm [19 l/min]), the pressure shall not exceed 10 psig (68.9-kPa) above the nominal pressure setting.

3.3.17.4 Surge Pressure (Class D-1R, D-2R & R Only): With 12.5 psig (86.3-kPa) back pressure and inlet pressure from 60 to 100 psig (413.7 to 689.5-kPa), and a downstream valve closure of 0.5 s, the downstream surge pressure shall not exceed 120 psig (827.4-kPa).

3.3.17.5 Proof Pressure: The nozzle when connected to a test adapter and opened shall withstand pressures up to 300-psig (2068.5-kPa). The nozzle when closed shall withstand pressures up to 180-psig (827.4-kPa).

3.3.17.6 Burst Pressure: The nozzle when connected to a test adapter and opened shall withstand pressures up to 450 psig (3102.8-kPa) without structural failure. The nozzle when closed shall withstand pressures up to 240 psig (1654.8-kPa) without structural failure. Seal leakage at this pressure shall not be considered a structural failure

3.3.20 Operating Lever: The operating lever shall operate from the full closed to full open positions with a maximum applied torque of 40 in-lb (7.2 cm-kg) when a force of 50 lb is applied against the nozzle poppet in the direction to close the nozzle.

3.3.21 Strength: The nozzle shall withstand the loads shown on Figures 2 and 3 without leakage, distortion, or failure when tested in accordance with 4.6.7.

3.3.22 Electrical Continuity: Electrical continuity between the nozzle and aircraft adapter shall be established through the attaching lugs when the units are connected. The resistance from the nozzle inlet to the adapter-locking flange shall be no greater than 10 Ω.

3.3.23 Construction: The nozzle and accessories shall withstand the testing program outlined in Section 4. It should be understood that this testing program may not represent the normal daily operational requirements at many locations.

3.3.24 Interchangeability: All parts having the same manufacturer's part number shall be functionally and dimensionally interchangeable with the like part number regardless of the date of manufacture. Changes to detail parts of the nozzle shall be made only after such interchangeability has been proven. Possible requalification may be required if changes are made that affect interchangeability of a part(s) within the nozzle. A new manufacturer’s model (part) number for the basic nozzle shall be created to control interchangeability with nozzles in service.

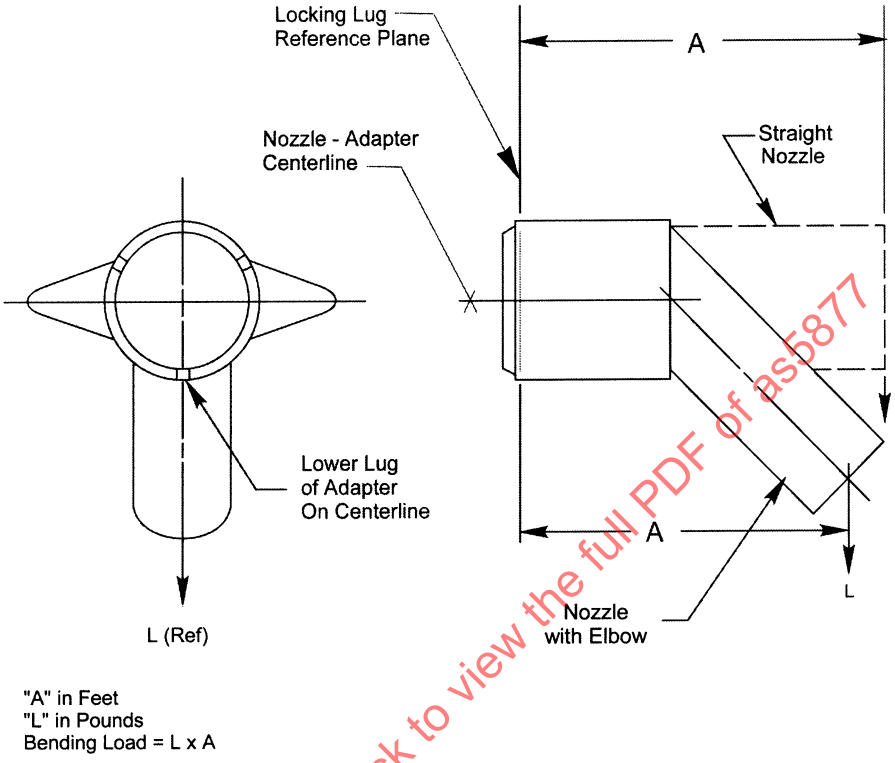


FIGURE 2 - Strength Test Setup

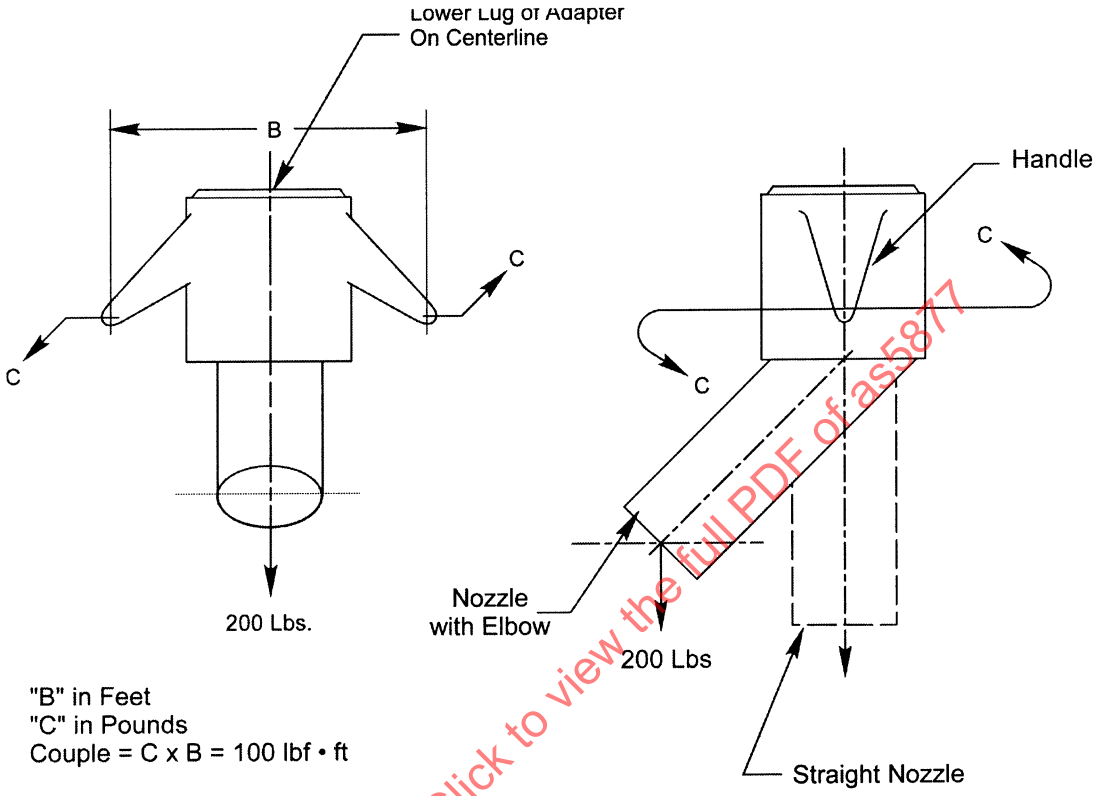


FIGURE 3 - Swivel Strength Test Setup

3.3.25 Parts Availability: Interchangeable parts or replacements for the nozzle shall be available for a minimum of 10 years after the last sale of a particular model nozzle.

3.3.26 Weight: The weight of a nozzle shall be kept to a practical minimum consistent with the anticipated required operation.

(1) Military Type I Nozzles - The weight of Class D-1 and D-2 nozzles shall not exceed 11.5 lb. The weight of Class D-1R and D-2R nozzles shall not exceed 14 lb.

(2) Commercial Nozzles - Due to the many commercial configurations possible no specific design parameter shall be offered in this document for those nozzle configurations.

3.3.27 Threads: All fastener threads shall be in accordance with FED-STD-H28, BS1580 or ISO 68.

3.3.28 Locking of Threaded Parts: All threaded parts shall be locked to prevent loosening or detachment which would result in the part entering the system being refueled or cause failure to the nozzle. The use of a locking compound shall be kept to a minimum and used only where its use is not necessary in the overhaul or maintenance procedures in the field.

3.3.29 Quality Control System: The manufacturer shall operate under an approved quality control system.

3.3.30 Operational/Maintenance Manual: A manual, which provides specific instructions for the operation, maintenance and repair requirements with exploded parts illustrations and/or section drawings and parts listing, shall be made available to all customers.

3.3.31 Identification of Product: All nozzles shall be marked with at least the manufacturer's name, model number and a unique serial number in a location that will not affect performance and will not be subject to destruction during anticipated use.

3.3.32 Failure Modes and Effects Analysis (FMEA): The manufacturer shall prepare a detailed nozzle FMEA which will at a minimum list each individual component or piece part, its purpose, each possible component failure and the effect of each failure under operating conditions.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The manufacturer is responsible for the performance of all inspection requirements specified herein. The manufacturer may use his own or any other facilities suitable for the performance of the inspection requirements specified herein.

4.1.1 Responsibility for Compliance: 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 assuring that all nozzles comply with all requirements of this specification.

4.2 Classifications of Inspections:

The inspection requirements specified herein are classified as follows:

(1) Qualification Inspection. (4.3)
(2) Acceptance Testing Inspection. (4.4)

4.3 Qualification Inspection:

Qualification inspection shall consist of the tests specified in 4.3.1 and the field evaluation program outlined in 4.3.2.

4.3.1 Qualification Tests: The qualification tests, which are listed in Table 4, shall be conducted on two sample nozzles, which are production units. The tests shall be conducted in the sequence listed in Table 4.

TABLE 4 - Qualification Testing Sequence

TEST	TEST SEQUENCE		TEST
	Sample 1	Sample 2	PARA.
Examination of Product	1	1	4.6.1
Proof Pressure	2	2	4.6.10
Calibration	-	-	4.6.2
Functional - Static	3	3	4.6.2.1
Pressure Loss	4	4	4.6.2.2 through 4.6.2.2.2
Regulator Performance (Class D-1R, D-2R and R only)	5	5	4.6.3
Leakage	6	6	4.6.4
Swivel Endurance	7	-	4.6.6
Endurance	8*	-	4.6.8.1, through 4.6.8.1.2
Regulator Endurance	9	-	4.6.8.2 through 4.6.8.2.1
Electrical Conductivity	-	7	4.6.13
Fuel Resistance & Extreme Temperature	-	8	4.6.5
Accelerated Corrosion	-	9	4.6.9
Strength	-	10	4.6.7
Drop Test	-	11	4.6.12
Endurance - Extended Operation	11	-	4.6.8.1.3
Endurance - Extended Regulator	12	-	4.6.8.2.2
Defuel Endurance	13	-	4.6.8.2.3
TEST	TEST SEQUENCE		TEST
	Sample 1	Sample 2	PARA.
Worn Adapter Test	14		4.6.16
Burst Pressure	15	-	4.6.11
Disassembly & Inspection	10 &16*	12	4.6.14
Strainer Strength	Optional	Optional	4.6.15

*Following the Endurance Test on Sample One, the nozzle shall be disassembled and inspected in accordance with 4.6.14. It shall then be reassembled and the testing program beginning with 4.6.8.1.3 shall be resumed. Disassembly & inspection shall then follow the Burst Pressure Test as noted in the sequence above.

4.3.1.1 Rejection and Retest: When a nozzle fails to meet any of the requirements of the qualification tests, the program shall be halted until the extent and cause of the failure is determined. A complete disclosure of the failure, the cause and the solution shall be included in the final qualification test report. All qualification tests, which are affected by the corrections, shall be repeated.

4.3.1.2 Test Report: The manufacturer shall provide, upon request from any customer or potential customer, a complete test report-reflecting conformance to the testing requirements herein. This report shall be complete and include, as a minimum, an outline of all tests conducted, test conditions, diagrams of all test setups, copies of test data sheets, list and descriptions of testing equipment, any failure, its analysis and corrections, and the final conclusions.

4.3.1.3 Operational/Maintenance Manual: An operational/maintenance manual in accordance with 3.3.30 shall be provided as a part of the qualification package when requesting approval for the nozzle.

4.3.1.4 Maintenance of Qualified Status: The qualification test samples shall be produced using identical manufacturing methods as those utilized or intended to be utilized in the manufacture of the production units. Any subsequent changes to materials, manufacturing processes or functional dimensions or tolerances thereof to working parts which may degrade or decrease material properties or unit performance shall be supported by appropriate requalification testing.

4.3.1.5 Qualification by Similarity: Changes to any detail part that do not affect interchangeability with the part it replaces can be made without changing the model (part) number of the nozzle. If these changes do not affect structural integrity, form, fit or function the nozzle qualification status won't be affected. Changes to any detail part, or its next assembly, of the nozzle for any reason that affect interchangeability of the part with the part it replaces will require a new model number for the nozzle. Such changes that require a new model number may be qualified by similarity to previously qualified units provided that the new design is truly similar in design, material and method of manufacturing. Evidence justifying similarity shall be included in the qualification test report. Where similarity can not be justified, certain tests, as appropriately caused by the design changes shall be repeated and a report covering such testing provided to cover the complete qualification of the nozzle. This report shall include all previous testing as well as the specific testing to justify the new design changes and the rationale for a partial qualification program in lieu of a complete requalification.

4.3.2 Field Trial and Approval: Following qualification testing and prior to the sale of production units, field trials at a minimum of four locations for a minimum of six months shall be conducted. These tests shall be at representative locations where daily use of the equipment is anticipated, i.e. international airports, military bases or other locations where a minimum of ten refueling operations are conducted daily. The trial locations will also be chosen to subject the nozzles to temperature extremes of -20 °F (-29 °C) to 100 °F (38 °C), areas of high humidity and coastal locations where corrosion potential is highest. Testing shall be conducted on nozzles installed on hose reel applications where the most potential damage is anticipated. It is anticipated that such field trials will be a requirement of receiving formal approval of the nozzle from major oil companies and other major international using organizations. Upon completion of the testing program, the nozzles shall be retrieved and a report written by the manufacturer on the results of the tests. This report shall be available to any customer upon request.

4.4 Acceptance Inspection:

Each nozzle produced shall be subjected to the following tests prior to shipment as shown in Table 5.

Test records shall be maintained by serial number by the manufacturer for a minimum of 12 months following shipment and shall be made available to any customer upon request.

4.5 Test Conditions:

Unless otherwise specified, the following test conditions shall apply.

4.5.1 Test Fluid: Odorless kerosene, commercial solvent 140, MIL-PRF-7024, Type II or another equivalent test fluid shall be used when a specific fluid is not specified. Water shall not be used for testing purposes.

4.5.2 Ambient Temperature and Pressure: All tests shall be performed with the ambient and test fluid at temperatures of 60 °F (15.6 °C) to 90 °F (32.2 °C) and at local barometric pressure.

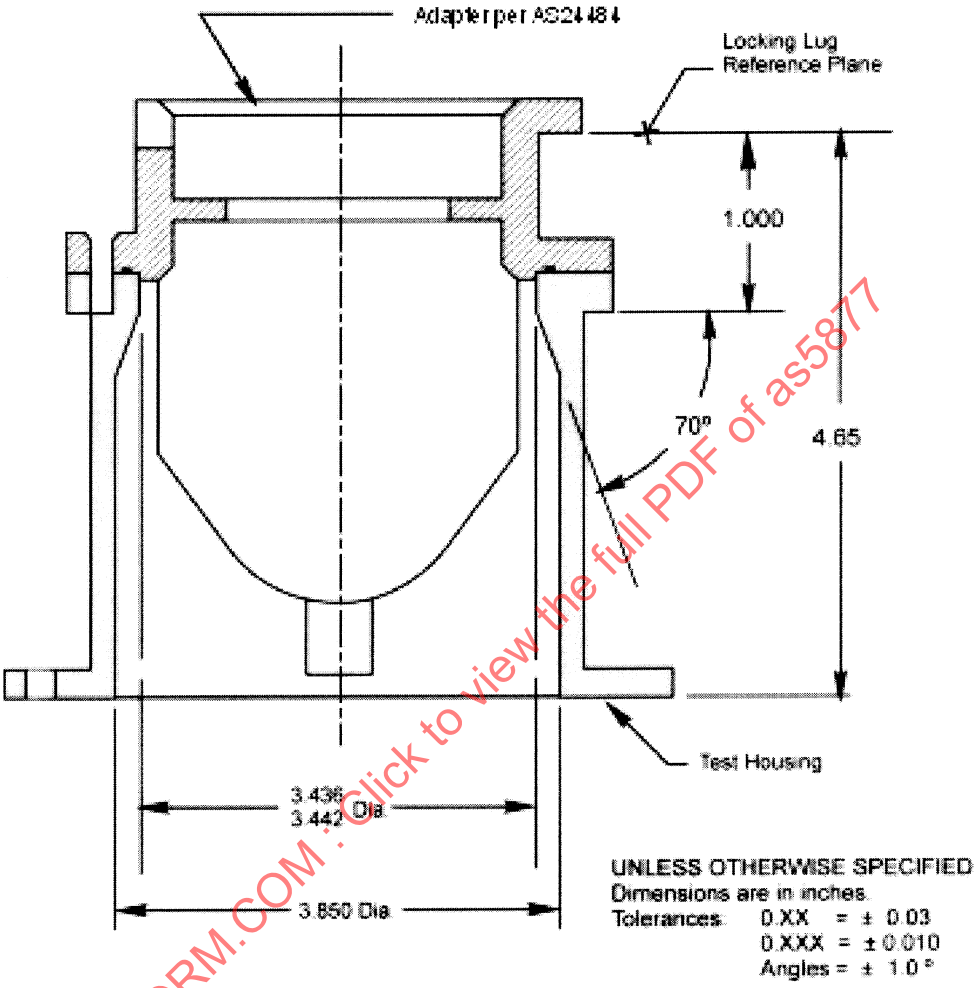
4.5.3 Test Adapter: The test adapter used shall have an interface in accordance with ISO 45 installed in the housing defined in Figure 4.

4.6 Test Methods:

4.6.1 Examination of Product: Each nozzle shall be subjected to inspection for adherence to the envelope requirements of Figure 1 of this document and to determine that the nozzle meets the requirements of 3.3. The nozzle shall also be examined to determine conformance to the requirements of this specification with respect to materials, interchangeability, construction, weight, locations of accessory ports and protective coatings. The foregoing shall be noted and recorded.

TABLE 5

TEST	PARAGRAPH
Examination of Product	4.6.1
Functional	4.6.2.1
Leakage	4.6.4
Downstream Lockout (Class D-1R, D-2R and R only)	4.6.3.2.5
Proof Pressure	4.6.10



Notes:

1. Dimensions are in inches for clarity. Metric conversions for the dimensions shown above are as follows:

Inches	Millimeters	Inches	Millimeters
.010	.25	3.442	87.43
.030	.76	3.850	97.79
1.000	25.40	4.65	118.11
3.436	87.27		

FIGURE 4 - Test Adapter Configuration

4.6.2 Calibration:

4.6.2.1 Functional - Static: The nozzle shall be attached onto the test adapter (Figure 4) and the adapter-sealing valve actuated a minimum of five times. Pressure of 60-psig (413.7-kPa) shall be applied to the inlet of the nozzle during at least three of the above cycles. There shall be no evidence of binding of the lever.

4.6.2.2 Pressure Loss Test: With a setup similar to Figure 5, and the test adapter in accordance with Figure 4, pressure loss data shall be obtained for flow rates defined in the following paragraphs. When testing Class D-1R, D-2R and R nozzles (with a regulator), it is necessary to block the regulator open to prevent regulator operation due to downstream pressure conditions while conducting these tests. Test results shall be in compliance with the fueling and defueling loss requirements in accordance with 3.3.17.2.

4.6.2.2.1 Fueling Mode: With an inlet pressure of 40-psig minimum, a pressure loss test shall be performed with fuel flow rates from 100 (378-l/min) to 600 U.S. gpm (2271-l/min), in 100 U.S. gpm (378-l/min) increments. The results of the test shall be reported.

4.6.2.2.2 Defueling Mode: A pressure loss test shall be performed with fuel flow rates from 0 to 300 U.S. gpm (1136-l/min), in 50 U.S. gpm (189-l/min) increments. The results of the test shall be reported.

4.6.3 Regulator Performance (Class D-1R, D-2R and R Nozzles Only):

4.6.3.1 Test Setup: The test setup shall have the following minimum features:

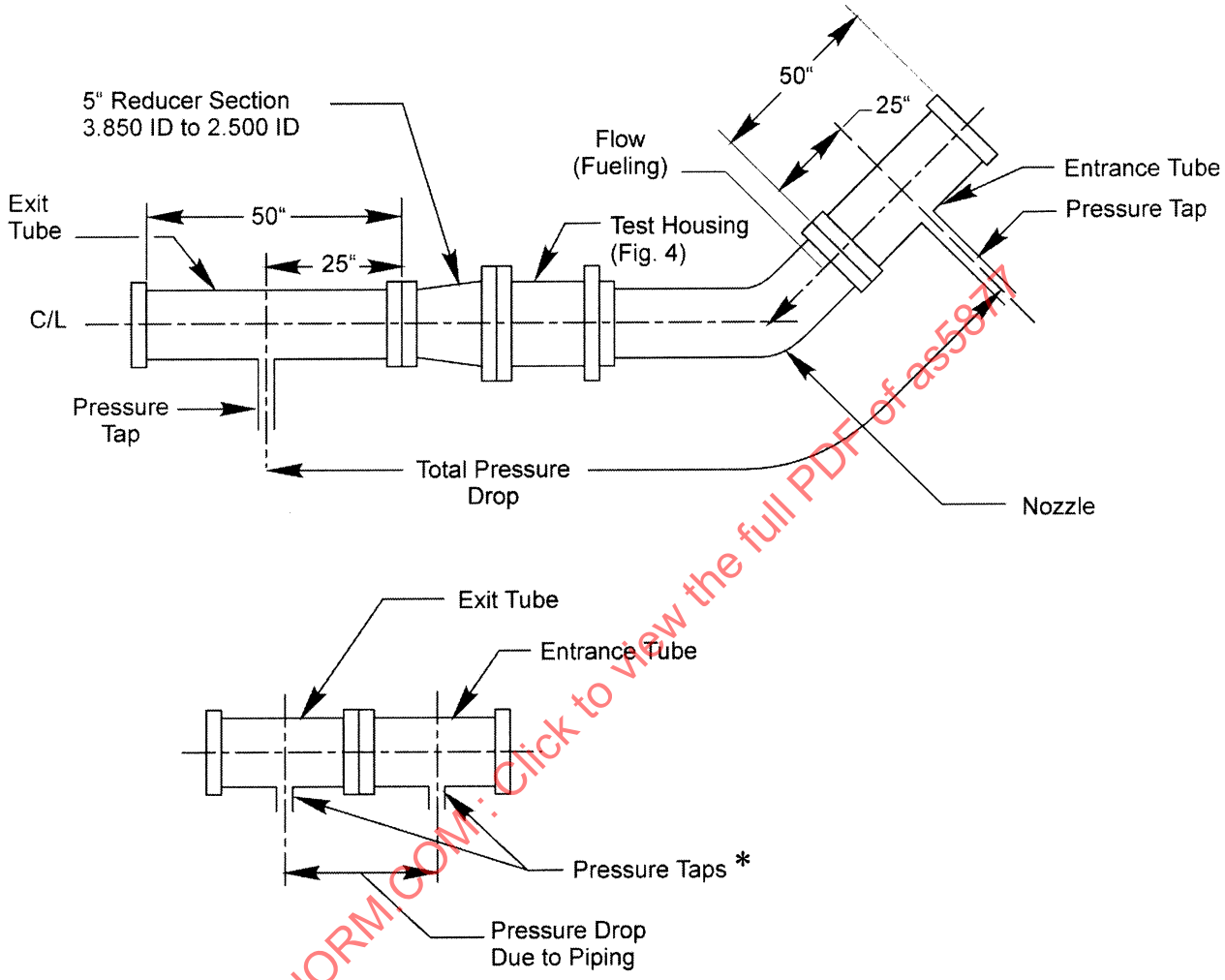
4.6.3.1.1 Capable of producing pressures downstream of the aircraft adapter of at least the regulator setting (backpressure) at rated flow rate.

4.6.3.1.2 Have a controlled shutoff valve that will close in 0.5 s at 600 U.S. gpm (2271-l/min).

4.6.3.1.3 The test nozzle shall incorporate a regulator with the appropriate setting. The regulator shall not be blocked in the open position for this test.

4.6.3.1.4 The setup in Figure 5 shall be used.

4.6.3.1.5 The system shall be instrumented with pressure transducers (sensitive enough for the data required) mounted in both pressure taps. The downstream transducer will be capable of recording the pressures generated in the line downstream of the aircraft adapter under the test conditions. A strip chart or other suitable recording device shall be used to monitor the pressures obtained during the tests.



△ P = Total Pressure Drop - Drop Due to Piping

Nominal Tube Size, Entrance and Exit Tubes = 2 ½" Schedule 40

*Include all fittings needed to connect Test Nozzle
to Entrance Tube and connect Reducer to Exit Tube.

FIGURE 5 - Pressure Drop Test Setup

4.6.3.1.6 Except for the surge test in 4.6.3.2.3, the test setup, including the test nozzle and upstream plumbing shall include a minimum of:

(1) 75 ft (19 m) of 4 in (101.6-mm) diameter pipe,

(2) 30 ft (9.2 m) of 4 in (101.6-mm) intake hose (Note: All hose referenced herein shall be aviation refueling type in accordance with API 1528),

(3) 20 ft (6 m) of 4 in (101.6-mm) rigid pipe work,

(4) And 20 ft (6 m) of 3 in (76.2-mm) aviation refueling hose connected to the test nozzle.

4.6.3.1.7 For the surge test in 4.6.3.2.3, the hose attached to the nozzle shall be 2-1/2 in (63.5-mm) diameter and 75 ft (22.8 m) long.

4.6.3.1.8 A pressure control system that does not attenuate downstream pressures shall be used to supply the appropriate inlet pressures during the testing.

4.6.3.2 Tests: The following tests shall be conducted:

4.6.3.2.1 Pressure Limitation: With the test unit inlet pressure maintained at a constant 60 psig ± 2 psig (413.7-kPa) and using the downstream control valve, the flowrate through the unit shall be adjusted to 0, 100, 200, 300, 400, 500, 600, 500, 400, 300, 200, 75, 50, 25 and 0 gpm (0-2271-l/min-0). At each flow rate the outlet pressure of the unit shall be measured and recorded.

4.6.3.2.2 The test shall be repeated with an inlet pressure of 70 (482.7-kPa), 80 (551.6-kPa), 90 (620.6-kPa), 100 (689.5-kPa), 110 (758.5-kPa) and 120-psig (827.4-kPa). The control pressure shall be within the requirements of 3.3.17.3. Sufficient measurements shall be obtained to plot the results in a curve of control pressure versus flow rate for each inlet pressure setting.

Plot the results in a curve of control pressure versus flow rate for each inlet pressure setting (7 curves).

4.6.3.2.3 Surge Control: The inlet pressure to the nozzle shall be set at approximately 60-psig (413.7-kPa). The downstream control valve shall be set to a backpressure of 12.5-psig (86.2-kPa) at 600 U.S. gpm (2271-l/min) to simulate an empty aircraft. The downstream valve shall be closed within 0.50 s and the downstream pressure surge shall be measured. Repeat the test with flow rates of 500 to 100 U.S. gpm (1893 to 378-l/min), in 100 U.S. gpm (378-l/min) increments, by adjusting the downstream control valve opening. Repeat the test at 80 (551.6-kPa) and 100-psig (689.5-kPa) inlet pressures. The surge pressure downstream of the nozzle (in the simulated aircraft adapter) shall not exceed 120-psig (827.4-kPa).

4.6.3.2.4 Surge Control - Failure Condition: The nozzle for this test shall not be modified from the original condition. The test in 4.6.3.2.1 shall be repeated at 80-psig (551.6-kPa) nozzle inlet pressure with the Hose End Control Valve vent chamber full of fuel to simulate seal failure. The surge pressure shall not exceed 120-psig (827.4-kPa).

4.6.3.2.5 Lockout: With 120-psig (689.5-kPa) inlet pressure, the flow rate through the system shall be set at 300 gpm (1135-l/min) and then reduced slowly to zero using the shut-off valve downstream of the nozzle. The outlet pressure shall be observed for 1 min after the flow rate has been reduced to zero. The outlet pressure shall not increase by more than 10-psig (68.9-kPa) above the applicable spring setting.

4.6.3.2.6 Pressure Relief: The outlet of the open nozzle shall be attached to a pressure source of 80-psig (551.6-kPa). The inlet of the nozzle shall be plugged and a pressure gauge shall be installed in the plug. Upon application of the pressure the inlet pressure gauge shall increase to a minimum of 70-psig (482.7-kPa) within 60 s.

4.6.3.2.7 Stability: The test in 4.6.3.2.1 shall be repeated using a valve that will increase the inlet pressure from 60-psig (413.7-kPa) to 100-psig (689.5-kPa) in less than 1.0 s. Repeat by decreasing the inlet pressure back to the starting point in the same time frame after flow rate has been stabilized at the higher pressure. Repeat the test with 100-psig (689.5-kPa) inlet and rapidly increase the backpressure from 20-psig (137.9-kPa) to 50-psig (344.8-kPa) in less than 1.0 s. There shall be no evidence of instability of the Hose End Control Valve during these tests.

4.6.4 Leakage:

4.6.4.1 Connected: With the nozzle connected to the test adapter and the nozzle operation lever in the full open position, the leakage test shall be conducted over a range from 10 to 60-psig (68.9 to 413.7-kPa) in 10-psig (68.9-kPa) increments. The pressure shall be maintained at each increment for at least 1 min. There shall be no evidence of external fuel leakage from the nozzle and air leakage inward into the nozzle shall not exceed 50 scc per minute during any part of the leakage tests. Acceptance Inspection testing shall be conducted only at pressures of 5 and 60-psig (34.5 and 413.7-kPa).

4.6.4.2 Disconnected: With the nozzle disconnected from the adapter, fuel pressures of from 0 to 60-psig (0 to 413.7-kPa) in 10-psig (68.9-kPa) increments, and then air at pressures from -12 to 0 psig (-82.74 to 0-kPa) shall be applied to the nozzle inlet. The pressure shall be maintained at each increment for at least 1 min. There shall be no evidence of external fuel leakage from the nozzle and air leakage inward into the nozzle shall not exceed 50 scc per minute during any part of the leakage tests. Acceptance Inspection testing shall be conducted only at pressures of 5 and 60-psig (34.5 and 413.7-kPa).

4.6.4.3 Regulator (Class D-1R, D-2R and R Only): With the nozzle disconnected from the adapter, fuel pressures of from 0 to 60-psig (0 to 413.7-kPa) in 10-psig (68.9-kPa) increments shall be applied to the nozzle inlet. The pressure shall be maintained at each increment for at least 5 min. The nozzle shall be positioned such that the axis of the unit is parallel to the ground and the ambient vent port on the regulator is pointed in a downward position. The breather plug of the regulator shall be removed for this test. There shall be no evidence of leakage in the form of a free falling drop from the ambient sense port. Upon initial calibration, there shall be no evidence of wetting during the test. Acceptance Inspection testing shall be conducted only at pressures of 5 and 60-psig (34.5 and 413.7-kPa). No wetting or leakage shall be allowed during Acceptance Inspection testing.

4.6.5 Fuel Resistance and Extreme Temperature: A fuel resistance and low temperature test shall be conducted in accordance with Table 6.

4.6.6 Swivel Endurance: The nozzle swivel shall be wear-tested by loading the nozzle with a 100 ft-lb-bending load (Figure 2) and turning the swivel 2000 times through at least a 45° arc. During this test, the nozzle shall be pressurized with test fluid to 55-psig (379.2-kPa). Following this loading, the nozzle shall successfully complete the proof pressure test of 4.6.10.

4.6.7 Strength: The test adapter shall be mounted to a fluid container capable of sustaining any pressure applied. The nozzle shall be connected and the operating handle actuated to the flow position. The nozzle shall be filled with test fluid. There shall be no evidence of leakage, deterioration, deformation, fracture or malfunction when the following loads are applied to the nozzle (Figures 2 and 3).

4.6.7.1 25 applications of a 600 ft-lb bending load, applied as shown on Figure 2.

4.6.7.2 950 applications of a 350 ft-lb bending load, applied as shown on Figure 2.

4.6.7.3 25 applications of a 200 ft-lb bending load, applied as shown on Figure 2, with a fluid pressure of 240-psig (1241.1-kPa) applied to the adapter-nozzle combination.

4.6.7.4 100 applications of a combined load of a 100 ft-lb couple applied to the nozzle handles and an axial load of 200 lb applied to the nozzle inlet flange in accordance with Figure 3, with a fluid pressure of 240-psig (1241.1-kPa) applied to the adapter-nozzle combination.

4.6.8 Endurance:

4.6.8.1 Nozzle Endurance: There shall be no evidence of binding, instability, or leakage during the tests below.

TABLE 6 - Fuel Resistance and Low Temperature Test Schedule

Test Period (1)	Fuel Resistance				Low Temperature
	Phase I, Soak	Phase I, Dry	Phase II, Soak	Phase II, Dry	
Component configuration	Nozzle closed during first 72 hours and open during last 24 h (2)	Drained, nozzle closed, inlet port open	Nozzle closed during first 12 h and open during last 6 h (2)	Drained, nozzle closed, inlet port open	Nozzle closed (2)
Test Fluid	(4)	None	(4)	None	(5)
Period duration	96 h (4 days)	24 h	18 h	30 h	18 h
Ambient air or test fluid temperature	158 °F ± 2 °F (70 °C ± 1°C)	Circulating air at 158 °F ± 2 °F (70 °C ± 1 °C)	158 °F ± 2 °F (70 °C ± 1 °C)	Circulating air at 158 °F ± 2 °F (70 °C ± 1 °C)	Lower the fluid temperature to -35 °F ± 2 °F (-37 °C ± 1 °C), then maintain the fluid at that temperature for a minimum of 18 h
Operation or tests during period	Connect and disconnect nozzle and actuate it a minimum of 4 times during each 24 h period	None	Connect and disconnect nozzle and actuate it a minimum of 6 times with a minimum of 1 h between cycles	None	None
Operation or tests immediately after period.	Conduct leakage test (4.6.4), using Test fluid per (4) at positive pressures only.	Connect and disconnect nozzle and actuate it once in dry condition. Conduct leakage test (4.6.4) using Test fluid per (5) at positive pressures only.	Conduct leakage test (4.6.4), using Test fluid per (4) at positive pressures only.	Connect and disconnect nozzle and actuate it once in dry condition. Conduct leakage test (4.6.4) using Test fluid per (5) at positive pressures only	With ambient temperature and test fluid at -35 °F (-37 °C) - (a) operate the nozzle through 10 complete cycles. (b) Conduct leakage test (4.6.4) using Test fluid per (5) at positive pressures only.

(1) Each period shall be continuous and follow immediate after the preceding one in the order listed.
(2) The nozzle shall be maintained in such a manner as to insure complete contact of all non-metallic parts with the fluid as would be expected under normal service conditions. The test adapter shall be utilized when the nozzle is to be opened or actuated. No connection shall be made during the soak period when the nozzle is closed, except for test purposes.
(3) For the low temperature test the leakage limits - Static - 0-4-psig - no leakage; 4-60-psig - 2 cc/min; During actuation - 0-60-psig - 2 cc/min per actuation.
(4) Test fluid to be 2,2,4-Trimethylepentane and Toluene mixed 70-30% by volume.
(5) Test fluid to be 2,2,4-Trimethylepentane.