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MILITARY SPECIFICATION

FUEL SYSTEMS: AIRCRAFT, INSTALLATION AND TEST OF

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

1. SCOPE

1.1 This specification covers the general requirements for functional operation, installation, and testing of fuel systems for all piloted aircraft, target drones and guided missiles, and shall be followed except as otherwise authorized by the procuring activity for each design.

2. APPLICABLE DOCUMENTS

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

SPECIFICATIONS

MILITARY

MIL-N-4180 — Nozzles, Fuel and Oil Servicing.

MIL-E-5007 — Engines, Aircraft, Turbojet, General Specification for.

MIL-B-5087 — Bonding, Electrical (for Aircraft).

MIL-G-5572 — Gasoline, Aviation, Grades 80/87, 91/96, 100/130, 115/145.

MIL-T-5578 — Tanks; Fuel, Aircraft, Self-Sealing.

MIL-J-5624 — Jet Fuel, Grades JP-4 and JP-5.

MIL-N-5877 — Nozzle, Pressure Fuel Servicing, Locking, Type D-1.

MIL-T-6396 — Tank, Fuel, Oil, Water-Alcohol, Coolant Fluid, Aircraft, Non-Self-Sealing, Removable, Internal.

MIL-L-6730 — Lighting Equipment, Exterior, Installation of Aircraft (General Specification).

MIL-C-7244 — Cap and Adapter Unit, Filler, Tank.

MIL-C-8605 — Cap, Pressure Fuel Servicing.

MIL-F-8615 — Fuel System Components, General Specification for.

MIL-D-8706 — Data and Tests, Engineering, Contract Requirements for Aircraft Weapon Systems.

MIL-D-8708 — Demonstration Requirements for Airplanes.

MIL-S-8710 — Strainer, Aircraft Fuel System, General Specification for.

FSC 2915

MIL-F-18802 —Fuel and Oil Lines, Aircraft, Installation of.

MIL-T-18847 —Tank, Fuel, Aircraft, Auxiliary External, Design and Installation of.

MIL-A-19736 —Air Refueling Systems, General Specification for.

MIL-A-25896 —Adapter, Pressure Fuel Servicing, Aircraft, Nominal 2½ Inch Diameter.

MIL-D-70327 —Drawings, Engineering and Associated Lists.

STANDARDS

MILITARY

MS 29514 —Flange, Adapter Locking, Pressure Fuel Servicing.

MS 33502 —Knob, Control, Fuel Selector — Standard Shape for.

AIR FORCE - NAVY AERONAUTICAL

AN2555 Nozzle — Aircraft Fueling.

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

2.2 **Other publications.** The following document forms a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply:

U.S. COMMITTEE ON EXTENSION TO THE STANDARD ATMOSPHERE

U. S. Standard Atmosphere, 1962

(Application for copies of the above publication should be addressed to the Superintendent of Documents, Government Printing Office, Washington, D. C. 20402.)

3. REQUIREMENTS

3.1 **Components.** The approval and installation of components under the requirements of this specification applies to functional components as distinguished from such other components as lines, fittings, and tanks. Functional components will generally include but not be limited to the following: Pumps, valves, strainers, filters, filler units, filler caps, fuel center of gravity (cg) control units, fuel transfer pressure regulators, fuel tank pressure control units. For logistic reasons interchangeable components shall be utilized to a maximum extent throughout the fuel system.

3.1.1 *Components approval.* All functional components employed in the fuel system shall have passed the qualification tests required in the applicable specifications. A list of all functional components and their respective qualification test reports shall be submitted as required by MIL-D-8706 for review and approval prior to installation of the components in a production configured aircraft. Components listed for approval shall include sufficient identifying data, including the following, as applicable.

(a) Name of component.

(b) Vendor's part number and/or drawing number.

(c) Applicable Government specifications and drawings (and deviations, if any).

(d) Present qualification or approval status.

(e) Aircraft manufacturer's drawing and part number.

(f) Aircraft manufacturer's procurement specification.

(g) Weight.

3.1.1.1 *Standard components.* Components in this category are those which are covered by applicable Qualified Products Lists (QPL), Government specifications, and drawings.

Those components which are listed on an applicable QPL or other Government approved lists will be approved. Those components currently undergoing Government qualification tests may be approved subject to satisfactory completion of the tests. In the case of components which are qualified or are undergoing qualification, but which are being applied to special installations not adequately covered by applicable specifications, approval may be granted subject to satisfactory service and subject to completion of special qualification tests pertinent to the particular installation. In the case of those components which are not listed on an applicable Government approval list and which have not been submitted for Government qualification tests, the submittal of samples for such tests will normally be required; approval, in this instance may be granted subject to satisfactory completion of such qualification tests.

3.1.1.2 *Nonstandard components.* Components in this category will be considered those which do not apply under a specific Government specification or drawing but which are commercially available. Approval may be granted on the basis of prior satisfactory service experience and subject to satisfactory service in the particular application.

3.1.1.3 *New development components.* Components in this category will generally be considered those which must be designed for the specific aircraft application. Those components will require the submission by the aircraft manufacturer of detailed procurement specifications and envelope drawings in accordance with MIL-D-70327 for release by the Government. Procurement specifications shall be based upon the applicable requirements of MIL-F-8615, and shall be prepared in accordance with the appendix thereto.

3.1.2 *Components installation.* All components shall be designed to permit ease of installation and removal. Components requiring frequent servicing shall be installed so as to be easily accessible. Quick-opening access doors in the aircraft skin shall be provided where necessary.

3.2 Materials. All materials shall be suitable for the purpose intended. Magnesium parts shall not be used in the fuel system.

3.3 Design and construction.

3.3.1 *Fuel.* The fuel system for reciprocating engine aircraft shall be suitable for use with all grades of fuel conforming to MIL-G-5572. The fuel system for gas turbine, ram jet and pulse jet engine aircraft, unless otherwise specified in the aircraft detail specification, shall be suitable for normal operation with fuel conforming to MIL-J-5624, grades JP-4 and JP-5.

3.3.2 *Piping.* Piping shall be installed in accordance with MIL-F-18802.

3.3.2.1 *Line sizes.* Line sizes shall be chosen to meet the requirements of 3.3.5. In addition, line sizes shall be adequate for satisfactory normal fuel system operation down to — 65° F. ambient air temperature for both JP-4 and JP-5 fuel, provided the —65°F. air temperature does not drop the fuel temperature below the freezing point of the fuel.

3.3.3 *Tanks.* Internal fuel tanks, except self-sealing and integral, shall be in accordance with MIL-T-6396. Self-sealing tanks shall be in accordance with MIL-T-5578. All fuel tanks shall be securely anchored to the aircraft structure to prevent movement of the tank in any direction with respect to the aircraft. Each individual cell shall be capable of installation and removal without requiring removal of any other cell or major component of the structure. The installation shall not be such as to require jacking of the wings or nacelle to allow replacement of any cell. It is desirable for the cell to be removable through a nonstressed panel, involving an absolute minimum of bolts and attaching screws. External auxiliary fuel tanks shall be in accordance with MIL-T-18847. Integral tanks shall be in accordance with the following:

(a) Integral tanks shall normally be of clad aluminum alloy construction and shall be either anodized or chemically surface treated. Where it is not practicable to have internal tank surfaces so clad, they shall be protected against corrosion by means approved by the procuring activity.

(b) Closed section stiffeners shall not be used inside integral fuel tanks. Stiffeners shall not be continuous through fuel-tight bulkheads, unless the compartments on both sides of the bulkhead are intended to contain fuel.

(c) Single rows of fasteners shall not be used in fuel-tight joints unless the thickness of both pieces of material to be joined is adequate to prevent interfastener buckling under the critical design ultimate load for the joint.

(d) Tank design features shall allow complete and free drainage of fuel, water, and sediment to the lowest point(s) in the tank with the aircraft in the normal attitude on the ground, afloat, or on beaching gear. A spring-loaded-to-close drain valve of approved type shall be provided at each low point and such valves shall be readily accessible and convenient to operate. The low point(s) shall permit the drainage of all water and sediment with a minimum of fuel loss.

(e) The tanks shall be capable of being sealed and maintained fuel-tight throughout in service. Sealing shall be in accordance with the contractor's process specification approved by the procuring activity. Where sealing systems dependent on the use of sealants are employed, they shall be of the channel type and shall provide for sealant injection from the exterior of the aircraft, unless otherwise approved by the procuring activity.

3.3.4 *Fuel availability.* The outlet in the fuel feed tank(s) and the fuel boost pumps shall be designed to provide uninterrupted fuel flow to the engine(s) under the conditions listed.

3.3.4.1 *Maneuvering requirements.* Fuel availability during maneuvering shall be as listed in table I.

3.3.4.2 *Landing requirements.* Fuel availability during landing shall be as listed in table II.

3.3.4.3 *Transfer fuel availability.* Where fuel transfer systems are used, fuel delivery to the engine(s) feed tank(s) shall be at a rate not less than the rate of fuel consumption of the engine(s) in the maximum thrust (power) condition for all altitudes. Fuel shall be available for transfer under the conditions listed in table III. A single functional failure shall not make transfer fuel unavailable.

3.3.4.4 *Fuel availability warning.* A low fuel level warning shall be provided in all piloted aircraft and helicopters. In reciprocating engine aircraft, the low fuel level warning should indicate approximately 30 minutes of fuel remaining in the engine feed tank at the maximum range cruise power. In gas turbine engine aircraft, the low level warning should indicate approximately 25 percent of internal fuel capacity remaining, or 30 minutes of fuel remaining in the engine(s) feed tank(s) at maximum range cruise power at 10,000 feet, whichever is less. The low level warning system shall be entirely independent of the fuel gaging system.

3.3.5 *Engine inlet fuel feed conditions.* The condition of the fuel with regard to pressure, temperature, and associated parameters which affect engine operation, shall satisfy the conditions listed in the applicable engine model specification and as noted herein.

3.3.5.1 *Normal fuel system operation.* The condition of fuel at the engine inlet "customer's" connection shall satisfy the applicable requirements of table IV.

3.3.5.2 *Fuel feed under extreme aircraft operating conditions.* Under transient extreme conditions of aircraft operation, the fuel system need not necessarily provide fuel pressures at the "customer's" connection within the prescribed fuel pressure limits for normal operation. Within allowable engine operating limits of air speed, altitude, and ambient air temperature, the fuel system shall not limit the performance of the aircraft, or cause engine malfunction under such conditions. As noted in table IV, where aircraft pumping capacity may be marginal and engine inlet fuel pressure may be below the engine manufacturer's prescribed limits, a detailed analysis and/or test of the condition will be required for specific approval by the procuring activity.

3.3.5.3 *Takeoff with functional failure in fuel feed system.* With any single failure of a functional component of the fuel feed system, or auxiliary system necessary to the proper functioning of the fuel system, during takeoff and attainment of normal flight altitude, it shall be possible to complete the attainment of normal flight altitude and execute a safe return to carrier or base. The condition of fuel at the "customers" connection shall satisfy the applicable requirements of table IV.

3.3.5.4 *Functional failure in fuel feed system during aerobatic maneuvers in multiengine aircraft.* In multi-engine aircraft, any single failure of a functional component of the fuel system, or other system necessary to the proper functioning of the fuel system, shall not result in an unsafe condition of asymmetric power or thrust.

3.3.5.5 *Catapulting and arrestment with partial fuel load.* In all aircraft designed for catapulting and arrestment, the fuel system shall provide for satisfactory engine fuel feed at all fuel loadings down to and including the lowest of the following quantities:

(a) The quantity of fuel for one catapult, go-around and arrested landing, including adequate reserve for one wave-off, representing routine carrier qualification training operations.

(b) Design mission minimum fuel loading.

(c) Twenty-five percent internal fuel capacity, representing an operational procedure of catapulting from small carriers in light loading conditions.

3.3.5.6 *Maximum fuel pressure.* From engine fuel control considerations, the maximum fuel pressure at the "customers" connection shall not exceed that prescribed by the engine model specification under any conditions of aircraft and fuel system operation without review by the engine manufacturer and specific approval by the procuring activity.

3.3.5.7 *Maximum and minimum fuel temperatures.* Fuel shall be supplied at the "customers" connection at temperatures which are not outside the range of the values given in the engine model specification.

3.3.6 *Fuel system arrangement.* Maximum simplicity of the fuel system consistent with (1) weapon system requirements, and (2) functional requirements of 3.3.5 is mandatory. The fuel system shall require minimum pilot (or flight engineer) attention during normal operation. For single and twin engine aircraft, the system shall be so designed that the aircraft cg travel is automatically maintained within prescribed limits during air refueling and normal flight. For aircraft using three or more engines, a crew-controlled cg system may be used, subject to approval by the procuring activity. For aircraft with a design internal fuel loading of 4,500 gallons or less, the servicing provisions shall be so designed and located that an expansion space of 5 percent, by volume, remains in each tank when the tanks are filled to useable capacity. For aircraft having a design internal fuel loading of greater than 4,500 gallons, only 3 percent expansion space need be provided. Positive shutdown of each engine, by its associated engine feed line shutoff valve, shall not exceed 3 seconds at sea level take-off power. Feed line collapse shall not be permitted for this emergency condition. Insofar as practical, all fuel feed shutoff valves shall be manually operated by mechanical push-pull from aircrew stations. In fuel systems where plumbing or functional components are used for more than one function, i.e., fueling, transfer, dumping, etc., the performance of each individual system or the aircraft fuel system as a whole shall not be compromised.

3.3.6.1 *Multi-engine fuel system arrangement.* It shall be possible to cutoff the fuel to any engine or combination of engines without adversely affecting the fuel flow to the remaining engines. When the fuel flow to any engine or combination of engines is cut off, it shall be possible to use fuel from any fuel feed tank for the remaining engine or combination of engines. For aircraft with three or more engines, each engine shall be supplied from a separate feed tank and system. For two-engine aircraft, a single feed tank may be employed if the engine feed systems are designed such that a failure of one feed system will not affect the operation of the other.

3.3.6.2 *Transfer system arrangement.* Where transfer systems are used, they shall be so designed that the immediate attention or immediate action of the pilot (or flight engineer) for safety of flight during normal fuel system operation is not required. Electric transfer pumps need not be shut off automatically when the tank is empty. Where fuel jettisoning of transfer tank fuel is provided, the pilot shall be provided with a means of transferring in normal sequence or delaying fuel transfer to permit jettisoning the maximum amount of fuel in an emergency. In multiple transfer tank installations, failure of the transfer system arrangement for any one tank shall not prevent the transfer of fuel from other tanks. Where failure of any single functional component of the fuel transfer system may result in lateral or longitudinal unbalance, an indicating system and adequate control shall be provided to permit the pilot to minimize the adverse condition. In aircraft designed for use with auxiliary (drop) tanks, this fuel shall be transferred directly to the engine feed tanks. Fuel transfer may be accomplished by: (1) gravity, (2) pumping systems, or (3) air/gas pressure. The failure of a single functional component of the transfer system shall not cause loss of availability of the affected fuel.

3.3.6.2.1 *Transfer at altitude.* Fuel transfer systems shall be designed to prevent fuel slugging and foaming at all altitudes.

3.3.6.2.2 *Air pressure transfer systems.* In air pressure transfer systems which utilize the same air source as is used for cabin pressurization and other functions where fuel vapor contamination of the air source cannot be tolerated, the air source shall be positively isolated from such contamination by no less than two series-mounted, zero-leak check valves. All pressure regulators shall be designed to have a tendency to fail to the position which provides tank pressurization. Failure of a pressure regulator to full-open position shall not result in excessive tank pressurization. For dual-level pressure regulators, the unit shall fail to the lowest level of pressurization which ensures normal fuel transfer. A single failure of any pressure relief valve shall not cause structural damage to the aircraft or fuel and vent system and shall not affect the transfer rate of the affected tank and systems. Depressurization of tanks shall be accomplished by pressure relief. Complete fuel transfer shutoff may be accomplished by depressurization, valving, or both, and shall be accomplished in not more than 10 seconds. All air pressure systems shall provide a ground service connection (type and size to be approved by the procuring activity) for use of shop or ship air when defueling. An accessible line-mounted, field-cleanable filter shall be installed so as to filter contaminant from all air used to pressurize the fuel system for either fuel transfer or defueling.

3.3.6.2.2.1 In air pressure transfer systems, means shall be provided to protect automatically against subjecting the fuel tanks to pressure on the ground and during takeoff and for relieving the fuel tanks of pressure prior to landings. Means shall be provided to override the automatic feature and thereby provide continuous pressurization to ensure continuous fuel transfer for gear down operation. Means shall also be provided for stopping the passage of air through the fuel transfer system after fuel is exhausted from the transfer tanks.

3.3.7 *Vents.* All vents shall lead outside the aircraft. Vent lines shall not be attached to the filler unit or to the filler cap. Vent systems shall be designed to prevent loss of fuel during any possible flight maneuver including catapulting, arrested landing, and taxiing with full or partially full tank. The aircraft tank vent(s) shall not weep or discharge fuel under any operational ground attitude and fuel loading. Vent outlets shall be located so that fumes or liquid cannot enter any part of the aircraft, water cannot enter the vent system, and fuel siphoning or tank collapse will not occur. Mud, dirt, dust, etc., thrown up during takeoff and taxi shall not enter the vent system. Vent outlets of aircraft capable of continuous operation in icing conditions shall have adequate nonicing provisions; vent outlets of aircraft not capable of prolonged operation in icing shall not be more critical to ice accumulation than the basic airplane (primarily the airplane flight surfaces). In boat type seaplanes and amphibians, all fuel tank vents shall terminate above the maximum gross weight water line and shall prevent sea water spray during takeoff and landing from entering the vent system. Vent systems shall contain no traps or low points which may collect condensate which could freeze, unless the traps are completely drained. For aviation gas fueled aircraft, vents shall be so designed that the vapor within the tanks is not diluted with air to bring it toward the lean mixture range, except as required to prevent tank collapse.

3.3.7.1 *Extreme fuel temperature venting.* In addition to design of tank vents for reduction of fuel loss at altitude, the vents shall provide adequate venting or pressure relief consistent with tank strength and structural integrity under extreme hot fuel conditions. Temperatures shall be as specified in the aircraft model specification.

3.3.7.2 *Vent monitoring system.* All aircraft utilizing pressure fueling systems shall include provisions for monitoring vent system or fuel cell pressure during ground refueling operations. The system to measure and display this pressure shall require the specific approval of the procuring activity.

3.3.7.3 *Vent line size.* Vent line sizes shall be consistent with climbing, diving, fueling, and defueling requirements. To prevent overpressurization in the event of failure of a fueling control component, vent lines shall be capable of flowing the fuel flow rate of the largest refueling shutoff valve in the fuel system and the venting air flow requirements of the remaining tank(s).

3.3.8 *Fuel loss at altitude.* A fuel tank pressure system shall be provided where necessary to prevent fuel loss due to vaporization, foaming, or boiling. The maximum combined fuel loss, for these conditions shall not exceed 2 percent, by weight, of the total fuel capacity for any one fueling for jet fuels and 5 percent for aviation gas. Where provisions are required, unless otherwise specified in the aircraft detail specification, the method of fuel loss control shall be a tank pressure system. Determination of and control of fuel loss shall be based on fuel specified for normal operation in 3.3.1 and initial fuel temperature of 110° F.

3.3.9 *Fueling and defueling.*

3.3.9.1 *Fueling rates.* The fueling system shall permit fueling all tanks, both internal and external, to design capacity within the time requirements specified on figure 7, when fueled from the facility designated for primary design (see footnote 1, figure 7). Time required to gain access to, remove and replace filler caps, move the fueling nozzle from one filler to another, and for pressure or gravity fueling (as applicable), and the decrease in flow rate which may be required to permit topping shallow tanks without spillage when gravity fueling, shall be included in determining total time required to fuel the aircraft.

3.3.9.2 *Fueling system selection.* The type of fueling system provided shall be determined as follows:

(a) Pressure fueling provisions shall be incorporated in all: (1) seaplanes using aviation gas and (2) jet fueled aircraft.

(b) Gravity fueling shall be incorporated in all aviation gas fueled aircraft, except as noted in (a).

3.3.9.3 *Pressure fueling.* Pressure fueling systems shall provide for fueling all tanks, both internal and external. For aircraft with folding or tilting wings, the arrangement shall provide for fueling to design conditions with wings both spread, folded, and tilted. For maximum safety during ground operation, means shall be provided to supply power only to those electrical components needed during fueling and defueling of external tanks. Electrical power shall not be required to refuel the internal fuel tanks or to precheck the refueling system operation without approval of the procuring activity.

3.3.9.3.1 *Pressure fueling adapter arrangements.* Pressure fueling adapters shall be in accordance with MIL-A-25896. Except for seaplanes, their location shall permit fuel servicing with a MIL-N-5877 pressure fueling nozzle by an average height attendant while standing on the ground or deck. An optimum location is considered to be between 3 and 5 feet above the deck; more extreme locations will depend upon filler adapter orientation and shall require procuring activity approval prior to adoption. Additional pressure fueling/defueling connections, or other accessible apertures, shall be installed such that the aircraft can be readily defueled through the unit(s) in case of a wheels-up landing without lifting the aircraft. For carrier-based aircraft, particular consideration shall be given to access while the aircraft is parked close to the edge of the deck and with wings folded. For seaplanes, the adapters shall be located at one fueling station, as close to the bow as practical but not more than 40 feet aft of the bow, located for receiving, handling and operation of nozzles by personnel within the seaplane at sea and also located for convenient fueling, while docked, by an operation standing along side. The mounting alignment of the adapters shall be with respect to normal approach with the fueling nozzle. Adjacent location of adapters shall provide adequate clearance for multiple coupling of MIL-N-5877 nozzles in sequence (minimum spacing of 15 inches between centers for side-by-side mounting). The number of pressure fueling adapters shall be as required to satisfy the fueling and defueling times in table V for the various types of aircraft. All pressure fueling adapters shall be bonded to aircraft structure in accordance with MIL-B-5087. Grounding jacks shall be provided at every tank or fuel cell filler opening for grounding the pressure and gravity fueling nozzles to the aircraft. All pressure fuel filler units which are recessed behind access doors shall incorporate positive provisions whereby the access doors may not be physically secured unless the safety cap is properly installed. Conventional, 3-inch nominal diameter, filler units consisting of MIL-C-8605 pressure fueling adapter safety caps and adapters conforming to the bayonet locking design detail of MS29514 shall be used. Unless specifically authorized, all filler units shall be sealed to the exterior of the aircraft to prevent the entrance of fuel or fuel vapors into the interior parts of the aircraft.

3.3.9.3.2 *Maximum fueling pressure.* The pressure fueling system and each individual tank to be fueled, shall be capable of receiving fuel without adverse effect upon the aircraft from each of the fueling facilities listed in footnote 1 to figures 7, 8, and 9 for all aircraft. Maximum fueling pressure shall not exceed 55 psig for any flow rate and the maximum surge for any shutoff condition shall not exceed 120 psig, unless it can be shown that a 180-psig surge limit can be safely utilized without an increase in weight over the 120-psig system.

3.3.9.3.3 *Fuel level control.* The aircraft pressure fueling system shall provide, within the aircraft, for automatic control of fuel level to design capacity or capacities and for automatic fueling flow shutoff for safety of tanks and aircraft when fueling at any rate up to the maximum rate provided by 3.3.9.1. Where any single component, subcomponent, or auxiliary system failure may result in failure to shut off the fueling flow with attendant possible rupture of tanks and aircraft structure, or failure to transfer fuel to the feed tank, a secondary system of shutoff involving a secondary component, subcomponent, or basic system, as appropriate, shall be provided. The secondary shutoff provision shall provide for the same shutoff level as the primary system. Single-seat, single-diaphragm valves may be used for fuel level control for pressure fueling where a failure of any one of these units will not cause failure of any tank(s), or other component(s) of or in the fuel system. If single-seat, single-diaphragm valves are not utilized as described above, dual-seat (in series) or dual-diaphragm, single-seat valves shall be used. Shutoff valves shall be designed to fail closed. The pilot control systems for both single- and dual-seat valves shall be of the dual float, or equivalent type.

3.3.9.3.3.1 The fuel system shall incorporate provisions to limit surge to 120 psig. However, a 180-psig surge limit may be used if it can be shown that the system weight does not increase over the weight required by a system designed for 120-psig peak surges. The surge prevention or arresting device shall be designed such that its failure will not cause the main valve to fail to operate and shall be as approved by the procuring activity.

3.3.9.3.3.2 Where any single failure in the fueling system may not be readily evident to the fueling operator, means shall be provided at the fueling station for the operator to check for any single failure prior to or during fueling. The pressure fueling precheck system shall not utilize electrical power without approval of the procuring activity. Float switches shall not be used to control transfer fuel flow into the feed tank(s).

3.3.9.3.4 *Selective loading.* Means shall be provided for selective fuel loading, either inflight or ground, to any of the fuel loading conditions specified under useful loads in the aircraft detail specification. Internal transfer of fuel shall not be utilized to meet this requirement. Where one filler installation is utilized to fill several tanks, the arrangement shall be such that repeated topping-off is not required to fill the affected tanks to design capacity.

3.3.9.3.5 *Mass loading.* The pressure fueling system shall provide for level control to the design maximum weight fuel loadings specified in the aircraft detail specification and for any intermediate loading from empty fuel tanks to the maximum fuel loading. The level control system shall also satisfy the requirements of 3.3.9.3.3.

3.3.9.4 *Gravity fueling.* All gravity-fueled tank installations shall be capable of receiving fuel from a MIL-N-4180 or an AN2555 2-inch nozzle at a fueling rate up to 150 gpm without blow-back. All gravity fuel filler units which are recessed behind access doors, shall incorporate positive provisions whereby the access doors may not be physically secured unless the filler cap is properly installed. Unless specifically authorized, all filler units shall be sealed to the exterior of the aircraft to prevent the entrance of fuel or fuel vapors into the interior parts of the aircraft. Gravity fuel filler caps shall be 3 inches in accordance with MIL-C-7244.

3.3.9.5 *Air refueling.* Provisions shall be incorporated or the system shall be arranged to permit the later incorporation of air refueling only if specified in the aircraft detail specification. If air refueling is required, the receiver probe need not be retractable if it can be shown that icing will not affect probe nozzle operation and hence wartime mission (in other than perfect weather) requirements. The probe shall be installed such that the probe nozzle will, when extended, be well ahead of the pilot and in his general line of sight between the 12 and 2 o'clock positions. For fixed installations, the probe location shall be such that the nozzle appears below the horizon in the pilot's field of view during cruise and high speed flight. Boom and receptacle air refueling systems shall be as specified by the procuring activity. For further information refer to MIL-L-6730 and MIL-A-19736.

3.3.9.6 *Defueling.* All pressure-fueled aircraft shall provide for defueling, through a standard pressure fueling connection, of all tanks including external droppable tanks. Where this defueling connection is not also a pressure fueling point and the aircraft can be damaged by pressure fueling at the defueling point, means shall be provided to prevent pressure fueling through this point. All gravity-fueled aircraft shall be capable of being defueled by: (1) hose inserted through the gravity filler opening, (2) two-inch drain valves at the system low point or points, or (3) both. For aircraft with folding or tilting wings the arrangement shall provide for defueling to the design conditions with wings both spread and folded or tilted in ground operational position.

3.3.9.6.1 *Defueling rates.* For all aircraft, it shall be possible to perform an operational defueling procedure of rapidly defueling the representative remaining fuel load, using the standard pressure fueling equipment in accordance with figure 8, immediately after landing the aircraft. The aircraft pumps and transfer system may be used for defueling, when approved by the procuring activity.

3.3.9.6.1.1 *Emergency defueling.* All types of aircraft shall be capable of being completely defueled of maximum capability fuel load within the defueling times shown on figure 9. External electrical power and other methods approved by the procuring activity may be used in this instance. Suction defueling equipment will not generally be available for seaplanes and defueling will be accomplished utilizing the airplane internal power system, except in special instances specifically approved by the procuring activity.

3.3.9.7 *Fuel jettisoning.* Fuel jettisoning shall be provided for all aircraft in accordance with the following:

(a) Fixed and variable wing: The design rate shall be based on exhaustion of 98 percent of all jettisonable fuel at a minimum rate of 300 gpm, with the total dump not to exceed 5 minutes, or as specified in the detail aircraft specification. Fuel shall jettison clear of all parts of the aircraft and no fire or explosion hazards shall result from fuel jettisoning. Tests shall be conducted in accordance with

4.10(a) to determine compliance with the above design requirements.

(b) Rotary wing: The design rate shall be based on exhaustion of 98 percent of all jettisonable fuel at a minimum rate of 200 gpm with the total dump time not to exceed 5 minutes, or as specified in the detail aircraft specification. Fuel impingement is allowed in noncritical areas; however, no fire, explosion hazards, or safety of flight shall result from fuel jettison. Entrance of fuel into the interior of the helicopter, impingement of fuel in the area of engine inlet, engine, or exhaust is not permitted. Tests shall be conducted in accordance with 4.10(b) to determine compliance with the above design requirements.

3.3.10 *Strainers and filters.*

3.3.10.1 *Tank outlet strainers.* Number 8-mesh strainers shall be provided on all tank fuel transfer and engine fuel feed outlets except that separate strainers are not required in addition to those normally provided on tank mounted pump inlets.

3.3.10.2 *Reciprocating engine feed line strainers.* Strainers in accordance with MIL–S–8710 shall be installed in the engine feed line of all reciprocating engine installations. The strainer shall be located upstream of any vane type line-mounted auxiliary pump. The strainer capacity shall be based on sea level intermediate power fuel consumption.

3.3.10.3 *Gas turbine engine feed line strainers.* A cleanable and reusable strainer or filter designed in accordance with MIL–S–8710 shall be provided for each engine of the weapons system. It shall be capable of permitting a cumulative fuel flow equivalent to a minimum of 10 hours of continuous operation of the particular airframe power plant combination at maximum continuous rated sea level thrust, with fuel contaminated as specified in paragraph titled "Fuel contamination" of MIL–E–5007, without actuating the impending by-pass warning device. An additional 1½ ±½ hours shall be accumulated prior to operation of the by-pass valve. Pilot or crew warning of impending by-pass valve operation shall be provided. The minimum area of the element shall be 0.06 square inches per 1.0 pound of fuel flow per hour at maximum fuel flow. A nonicing by-pass valve shall be provided. Strainer capacity shall be increased over the above listed minimum as necessary for satisfactory engine inlet pressure requirements.

3.3.10.3.1 *Filter strainer anti-icing.* The weapons system airframe-furnished fuel filter (or strainer) shall be protected against ice. If a heater is used, formation of ice in the heater shall not affect aircraft and engine fuel system performance and not cause by-pass of the heater core. By-pass around the heater core, in event of contaminant clogging, shall be provided and shall be indicated by a nonresettable visual indicator.

3.3.11 *Vent and drain lines.*

3.3.11.1 *General.* Unless otherwise authorized by the procuring activity, all vents and drains which are a possible source of discharge of combustible fuel or vapor overboard shall be arranged in such a manner that there shall be no impingement on the aircraft under any normal conditions of the aircraft operation. Where impingement is authorized, there shall be no re-entry of the combustible fuel or vapor into aircraft spaces occupied by crew, or where a possible source of ignition and explosion or fire hazard may exist, or through seams which will "open" during the normal operation of the aircraft, throughout the service life of the aircraft. Fuel tank vents shall be installed such that fluids discharged will not contact ground equipment normally parked about the aircraft, when fueling the aircraft. No drains shall be manifolded together except at the point of overboard discharge. All drains shall be readily identified and easily accessible.

3.3.11.2 *Drains.* Sufficient approved type drain valves, spring loaded to the closed position, shall be provided to permit draining of all fluid from all low points in the fuel tanks and fuel system with the aircraft in the normal ground attitude, ±5 degrees, or in the case of seaplanes and amphibians, on the water, landing gear, and beaching gear attitudes. Where fuel tank drains cannot remove all fluid, inert fillings (or some other means) shall be used to insure complete drainage. Installation shall be such, that entrance into fuel tank, shall not be required for replacement of the drain valve.

3.3.11.2.1 *Fuel tank compartment drains.* All areas surrounding fuel tanks shall be drained and ventilated to: (1) remove the fire hazard resulting from any fuel spillage or leakage, and (2) prevent prolonged contact of fuel with external tank surfaces, which could result in outside activation of nonmetallic fuel cells. The drainage and ventilation openings shall remain at all times. There shall be no trapped fluid.

3.3.11.2.2 *Engine fuel system components drains.* Overboard drains from engine fuel system components shall not be combined, except as approved by the procuring activity.

3.3.11.3 *Fuel system component vent lines.* Vent lines shall be installed on all fuel system components which incorporate vent connections which may discharge fuel in case of diaphragm or bellows failures. The vent lines shall conduct fuel overboard in accordance with 3.3.11.1.

3.3.11.3.1 *Fuel pump vent lines.* Positive-displacement fuel pumps shall be provided with a vent line fitted to the relief valve housing and routed overboard, or to the carburetor air inlet duct, as applicable. The vent line fitting at the pump shall incorporate a number 60 (.040) restrictor to damp out pressure fluctuations and to limit fuel loss in event of a relief valve diaphragm failure. Pump relief valve vent lines shall not be interconnected with other vent or drain lines. A sufficient length of flexible hose shall be employed in vent lines to permit interchangeability of standard pumps of the same capacity with slightly different vent fitting locations.

3.3.11.4 *Fuel system component seal drains.* Drain lines shall be installed on all fuel system components which incorporate seal drain connections. The drain lines shall conduct leakage overboard to a location free of possible fire hazard and shall provide a negative pressure at the drain connection.

3.3.11.5 *Scupper drains.* All filler unit scuppers, which can collect spilled fuel during filling, shall be provided with adequate drains which lead clear of the aircraft.

3.3.12 *Fuel system controls.*

3.3.12.1 *Arrangement.* In all large multi-engine, multi-tank installations the fuel system controls in the pilot's cockpit or at the flight engineer's station shall be arranged on a fuel control panel by visual functional presentation. In smaller aircraft a visual functional arrangement of fuel system control shall be provided wherever practical.

3.3.12.2 *Control handles.* All fuel system fuel control handles in the aircraft, except electrical toggle switches, shall conform to the shape of MS33502. In addition, control handles for manually operated valves within the aircraft shall conform to the dimensions on figure 1.

3.3.12.3 *Control linkages.* Manual fuel system control linkages shall be as simple as practicable, with the minimum number of universal joints, gear boxes, etc. Cable controls shall be designed to avoid transmittal of rigging loads to fuel valve shafts. The control system backlash shall not exceed one degree. Friction in the control system shall not increase the turning torque or force required to operate the equipment by more than 20 percent. Controls shall be designed so that they cannot be incorrectly rigged in service. Positive means shall be provided to identify the correct setting of the equipment being controlled. Torque type control handles for electrically operated valves shall provide for adequate torque to ensure against inadvertent turning and shall provide appropriate "running torque" for positive indexing "feel". As a guide, the indexing torque shall be based upon 20 ±5 pound-inches for a handle the size shown on figure 1. The indexing torque shall decrease proportionally for handles of smaller size and the "running torque" should be between 30 percent and 60 percent of the indexing torque.

3.3.13 *Warning lights and indicators.* The following warning lights and indicators shall be provided in the pilot's cockpit, if such warning will provide the pilot information which may affect the satisfactory and safe completion of the mission. Otherwise, these indicators shall be provided at the pressure fueling precheck panel.

(a) Boost pump pressure (indicators)
(b) Transfer system or pump pressure (indicators)
(c) Impending by-pass of the weapon system fuel filter (warning light)
(d) Low level fuel warning (warning light)

Indicators, as distinguished from warning lights, will normally be installed for functions which do not require the immediate attention of the pilot for safety of flight but are required for normal fuel system management such as indication of empty auxiliary tanks in the fuel transfer system. All pressure switches shall be chatter-free at and near the "make" and "break" points during vibration tests for slowly increasing and decreasing pressures (in effect, if a test lamp is used, there shall be no observable flicker). All pressure switches shall be mounted at an elevation above that where the pressure source is located. The sensing line between the source and the switch shall not contain any traps.

3.3.14 *Fuel system operating and maximum surge pressures.* The normal operating pressures for the aircraft fuel system shall not exceed 60 psig in any portion of the fuel system. Surge pressures during pressure fueling and fuel transfer due to level control shutoff valve action and trapped system pressure due to thermal expansion, shall not exceed 120 psig, unless it can be shown that a 180-psig surge limit can safely be utilized without weight increase or sacrifice in system performance. A summary of all operating conditions in which the fuel system pressures will exceed 60 psig shall be submitted to the procuring activity for review and approval. All fuel system components shall be tested for satisfactory performance, under maximum anticipated normal operating pressures, and nonfailure when subjected to maximum anticipated surge and trapped fuel pressure. Surge relief provisions incorporated in valves shall be designed such, that failure will cause the shutoff valve to fail closed or shall be as approved by the procuring activity. Thermal relief provisions shall be designed such, that pressure buildup will not cause any functional component to fail to operate.

3.3.15 *Fuel gaging.* All internal and external fuel, except for external tanker packages, shall be continuously gaged. For fuel systems incorporating less than three tanks, the presentation may be provided by independent quantity indicators. For fuel systems incorporating three or more tanks, the cockpit presentation shall provide continuous indication of: (1) total fuel, (2) main or feed tank fuel, and (3) any other tank so selected.

3.3.16 *Fuel system icing.* The entire fuel system shall be tested in accordance with

4.17. System operation shall not be affected by ice or icing conditions.

4. QUALITY ASSURANCE PROVISIONS

4.1 **Sampling.** Not available.

4.2 **Inspection.** All fuel systems shall be inspected for conformance to the applicable requirements of this specification.

4.3 **Tests.** The following tests shall be conducted and a report thereon shall be submitted in accordance with MIL-D-8706, except:

(a) The fuel system analysis report, and final fuel system schematic shall be submitted to the procuring activity for review and approval not later than 8 months after awarding the aircraft contract.

(b) The fuel system test rig report shall be submitted to the procuring activity for review and approval at least 1 month prior to first flight.

(c) The production aircraft fuel system test report shall be submitted prior to procuring activity acceptance of the 10th production aircraft.

(d) The flight test report shall be submitted to the procuring activity for review and approval as soon as available but not later than 1 year after the first flight.

Tests under this specification include computation and analysis as well as physical tests as noted. The report shall include, for information and reference purposes, a complete schematic arrangement of the aircraft fuel system together with a listing by manufacturer and part number of all functional components as defined in 3.1 and a fuel system reliability analysis. Since tests are reported separately, they shall be submitted as addenda or amendments to the basic fuel system report rather than by separate report title. Tests listed in this specification which are not applicable to an aircraft shall be listed by title with appropriate notation rather than omitted from reference in the fuel system test report.

4.3.1 Table V contains a summary of tests required for demonstration of compliance with requirements of this specification.

4.3.2 Figures 2, 3, and 4 show pages of a typical test report. These figures represent the type of presentation desired.

4.3.3 Revisions of, and addenda to, fuel system reports and drawings shall be provided to the procuring activity within 90 days after completion of testing or incorporation of the modified fuel system into the aircraft or test rig. In reports, the changes or revisions shall be underlined. On drawings, the revisions or changes shall be specifically noted by an appropriate symbol and a separate note, on the same drawing, giving date and aircraft effectivity.

4.4 **Fuel availability.**

4.4.1 *Unavailable fuel.* Unavailable fuel for transfer and landing shall be demonstrated by filling the fuel tanks of the test vehicle with a measured quantity of fuel and pumping or transferring the fuel in normal operating manner. Unavailable fuel in the transfer system is that remaining when the transfer rate drops to zero for the specified aircraft attitude. Unavailable fuel in the feed system is that remaining when the fuel flow and pressure drops below that required for engine operation for the specified aircraft maneuver. Fuel unavailable for landing is the fuel trapped in the feed tank or tanks. Unavailable fuel shall be demonstrated on both the fuel system test rig and a production configured aircraft.

4.4.2 *Maneuvering availability.* Fuel available for maneuvering shall be established by calculation or other suitable means adaptable to valid engineering analysis. Fuel unavailable for maneuvering is the fuel trapped in the feed tank or tanks for the various maneuvers.

4.5 Engine inlet fuel feed. Fuel feed tests shall be conducted on the fuel system test rig and a production configured aircraft with the fuel system in normal operation, over the range of normal fuel flows to establish engine fuel inlet pressures and temperatures. The test shall be extended over the entire range of fuel feed capacity to establish extreme limits of operation. Fuel feed tests shall be conducted under all abnormal conditions of fuel system operation including alternate methods of normal fuel feed as well as emergency fuel feed under all possible conditions of a single functional failure in the fuel system. The contractor will perform such ground tests as necessary to permit the predication of engine-flameout, for the condition of airframe boost pump(s) not operating, at intermediate rated, maximum continuous rated, and maximum range fuel flows. Extrapolate test data to design conditions. Engine shutdown time shall be demonstrated.

4.6 Center of gravity travel. It shall be shown by engineering analysis for both normal and emergency fuel transfer and feed condition that, the aircraft cg is maintained within prescribed aerodynamic limits. If the fuel transfer and feed system arrangement includes mechanical or other control of cg travel, test rig and aircraft tests are required.

4.7 Fuel transfer rate. Fuel transfer tests shall be conducted on the test rig and a production configured aircraft to demonstrate compliance with design fuel transfer rates. Emergency transfer or fuel feed conditions pertinent to any condition of possible failure of the fuel transfer system shall be included.

4.8 Fuel tank venting tests.

4.8.1 *Ground taxi.* With the production configured aircraft fuel tanks filled to design capacity, taxi or towing tests shall be conducted at normal ground handling speeds including acceleration, braking, and right and left turns on a smooth surface. Low speed taxi or towing tests shall be conducted on a simulated rough surface producing a two inch sharp edge drop of port and starboard gear alternately to provide two complete cycles of lateral oscillation in a 15-second interval. This test shall be repeated for alternate drops of main and nose or tail gear as applicable to obtain two complete cycles of longitudinal oscillation. One complete 360-degree turn to the right followed by one to the left, as fast as possible, shall be performed without spillage. There shall be no venting of fuel overboard through the vent system.

4.8.1.1 *Ground static.* Fill the fuel system test rig fuel tanks to design capacity with fuel at a temperature of 50° F. The fuel temperature shall then be increased from 50° to 110° F. There shall be no venting of fuel overboard through the vent system.

4.8.2 *Climb and dive venting.* A climb shall be made by a production configured aircraft to combat ceiling at maximum rate of climb with normal fuel load or with all internal fuel tanks filled to design capacity and with fuel as warm as practical up to design hot fuel temperature but not less than 110° F. The aircraft shall then be accelerated from V cruise to V max. (max. Mach No.) by level flight acceleration or shallow dive to altitude for V max., as appropriate, to obtain tank venting pressures over the entire range of design air speed (Mach No.) With minimum required fuel remaining for safe landing, and starting from stabilized conditions in level flight, at service ceiling, a dive at maximum rate of descent to minimum safe pull-out altitude shall be conducted. Fuel slugging and loss during climb shall be checked by direct observation and computation between estimated fuel consumed during climb and fuel remaining at end of climb. Fuel tank differential pressure shall be recorded during the aircraft flight test.

4.8.3 *Catapult and arrested landing.* An engineering analysis shall be made of fuel distribution under transient conditions of catapult and arrested landing to ensure that fuel slugging and siphoning will not be encountered in service.

4.9 Fueling and defueling.

4.9.1 *Pressure fueling.* Fueling tests shall be conducted on the fuel system test rig and a production configured aircraft to verify design filling rates, design fuel tank capacities, and compliance with 3.3.9.3. Tests shall be conducted with the wings spread and folded or tilted as applicable.

4.9.1.1 *Pressure fueling system test equipment.* The aircraft pressure fueling and air refueling systems shall be tested using a ground refueling system which has a flow capability of not less than 600 gpm at a nozzle pressure of 65 psig.

4.9.2 *Maximum rate fueling.* Tests shall be conducted under applicable maximum fueling rate conditions to demonstrate that the fuel system and each individual tank is capable of receiving fuel at the maximum rate without attendant hazard.

4.9.3 *Defueling rates.* On all aircraft and helicopters, operational and emergency defueling tests shall be conducted to verify compliance with 3.3.9.6.

4.9.4 *Fuel level control.* Tests shall be conducted as appropriate to establish satisfactory fuel level control in the pressure fueling system.

4.9.5 *Gravity fueling.* Tests shall be conducted to establish satisfactory fueling characteristics of each filler unit to demonstrate compliance with 3.3.9.4.

4.9.6 *Air refueling.* Ground air refueling tests shall be conducted on the fuel system test rig and a production configured aircraft to determine the maximum air refueling rate and to determine compliance with 3.3.9.3.2, 3.3.9.3.3, and 3.3.14.

4.10 Fuel jettisoning. To determine compliance with 3.3.9.7, tests shall be conducted as follows:

(a) Fixed or variable wing: Fuel jettisoning tests shall be conducted:
  (1) In level flight at 5,000 feet altitude at 250-300 knots indicated airspeed.
  (2) Flight corresponding to operational carrier approach altitude, attitude, and airspeed, including descent from a marshal point.
  (3) Flight corresponding to partial power loss during takeoff and subsequent return for landing. Partial loss of power is defined as single engine operation of a twin-engine aircraft and 90 percent rotor speed for single-engine jet aircraft.

(b) Rotary wing: Fuel jettisoning tests shall be conducted:
  (1) Level flight at speeds of 10 knots to maximum cruise speed at sea level. Tests shall be conducted between 200 and 5,000 feet.
  (2) Hover at an altitude of 50 to 200 feet.
  (3) Autorotation from 5,000 feet.

The jettisoned fluid need not necessarily be fuel, provided appropriate allowance is made in the analysis for difference in pertinent fluid parameters. In addition, a sufficient quantity of suitable fluid having a volatility comparable with moderately low temperature fuel for low evaporation shall be jettisoned. These tests shall be recorded by motion pictures during flight and by photographs immediately upon landing.

4.11 Vent and drain line discharge. To determine compliance with the design requirements of 3.3.11, provisions shall be incorporated in the test aircraft for the discharge of suitable fluid dye from all vent and drain line discharge points such as tank vents, pump seal drains, and pressure switch vents and drains, etc., where there may be a possibility of fuel discharge in flight with attendant impingement on the aircraft. At an altitude between 5,000 and 15,000 feet in level flight at cruise power, dye shall be discharged from each applicable source. The test shall be repeated with flaps extended, bomb bay open, etc., for each source which may be influenced by changes in the air flow and pressure distribution due to such aircraft configuration. Results shall be recorded by photograph immediately upon landing. In reporting this test, all sources of fuel discharge on the aircraft shall be listed regardless of whether or not they were subjected to the dye test. For those not subjected to test, substantiating data shall be furnished pertinent to the locations and type of discharge justifying the omissions.

4.12 Surge and trapped fuel pressure. To determine compliance with 3.3.14, maximum surge pressure and trapped fuel pressure tests shall be conducted on the test rig, on the fueling, simulated air refueling, if applicable, fuel feed, and fuel transfer systems to demonstrate safe maximum pressures. Surge pressure measurements shall be made with equipment capable of reflecting as closely as practical actual peak surge pressures. Fuel system shutoffs including: (1) all possible shutoff combinations, (2) insuring reproducible data which guarantees that the maximum surge limits will not be exceeded shall be performed.

4.13 Drains. Fuel tank and system drains shall be checked on the actual aircraft to insure contractor compliance with 3.3.11. Comments shall be tabulated on the functional suitability of arrangement and ease of accessibility of the following items:

(a) Scupper drains
(b) Fuel or fuel vapor entrance to interior of aircraft from filler units during over-side fueling
(c) Fuel system component drains
(d) Water drains

4.14 Vent icing. Comments on the suitability of the fuel tank vents under icing conditions shall be tabulated. Anti-icing system design details shall be described where applicable.

4.15 Filler unit security. Comments on the suitability of provisions against closure of filler unit access doors, including both pressure fueling and gravity fueling units with the filler cap improperly secured shall be tabulated.

4.16 Fuel system controls. Comments on all fuel system controls, except toggle switches, with regard to conformance with standard shape and adequacy of running and indexing torque shall be tabulated.

4.17 Fuel system icing. Comments on all fuel system components (pumps, valves, filters, screens, etc.) with regard to susceptibility to icing shall be tabulated. Tests on fuel systems should be conducted at 28° ± 2° F., at the lowest fuel temperature experienced in flight, and at 15° F. The most critical temperature from the icing standpoint occurs at about 15° F. according to the best information available to date. All surfaces of fuel system components in contact with fuel shall be at, or below, the normal surface temperatures which will be encountered in operational use. All systems shall be capable of winter operation with fuel conditioned in accordance with 4.17.1. Ice will build up on components from flight to flight under winter operating conditions. When running tests, the conditions of the apparatus should be such that ice from previous tests is not destroyed between test runs.

4.17.1 Evaluate aircraft fuel systems to ensure that icing does not adversely affect the operation of any of the aircraft fuel system components. All aircraft fuel systems shall be capable of continuous operation with fuel saturated at 80° F. and cooled to test temperature. Tests of components and systems shall be conducted to demonstrate their capability of satisfactory operation for the design mission plus one in-flight fueling. Test temperatures shall be dictated by actual measurements from the aircraft during operation with fuel preconditioned in accordance with the following procedures (see figure 6):

Conditioning procedure for saturated fuel at 80° +10°, —0° F. Use the primary jet fuel of the procuring activity, JP-4 or JP-5 with 10 +15, —0 percent aromatics.

(a) Circulate fuel from storage tank through the facility heat exchanger and back to the storage tank until fuel has been heated to approximately 90° F.

(b) Establish a fuel flow from the storage tank through a transfer pump rig with a by-pass around the filter/water separator open, and return flow to the storage tank.

(c) With flow established through storage tank, atomize, with a pneumatic atomizing nozzle, 1 gallon of water per 1,000 gallons of fuel at a rate of approximately 50 cc per minute.

(d) After all water has been atomized into the fuel in the storage tank, continue circulation for approximately 5 minutes. Then close bypass valve and direct fuel flow through filter/water separator.

(e) connect outlet of filter/water separator to inlet of the test tank and pressure fuel the test tank to the desired test volume.

(f) Establish a circulation of the fuel in the test tank. This may be accomplished either by using the aircraft engine fuel boost pump(s) or a separate circulating pump. The circulation shall be from the tank through a cooling heat exchanger and back into the tank terminating in a spray bar located below the fuel level. If the fuel boost pump(s) is used to circulate the fuel, provisions should be included for isolating the cooling heat exchanger and associated plumbing from the aircraft system during the test.

(g) Analyze samples from three points in the bulk of the fuel by the Karl-Fischer method. The average quantity of water from the three samples shall contain not less than the amount required to saturate the fuel at 80° F. and not more than this content plus 15 parts per million. The amount of water required to saturate fuel varies for different fuel blends. No fuel which is saturated with less than 90 parts per million shall be used.

(h) Cool the fuel to test temperature at a rate determined by the actual fuel cooling rate in the aircraft. Cooling by circulation through a heat exchanger shall be used.

(i) Repeat step (g) at test temperatures.

(j) Terminate circulation.

(k) Run the test.

(l) Repeat step (g) at test temperatures. Upon completion of the test the fuel should not contain less than 90 parts per million.

4.17.2 Aircraft shall also be capable of emergency operation with an excess of water in the fuel system. With 0.75 cc/gal. of free water in the fuel system, in addition to the saturated fuel, the aircraft and engine fuel system shall continue to operate in such manner that the safety of flight of the aircraft is not jeopardized. In order to assure that a safety of flight condition does not exist, the engine must maintain at least minimum flight power for 30 minutes. Fuel for this test should be preconditioned in accordance with the following:

(a) Repeat steps (a) through (g) of 4.17.1.

(b) Commence cooling to the desired test temperature.

(c) Still maintaining circulation of saturated fuel in the test tank, atomize 0.75 cc of water per gallon of fuel through two pneumatic atomizing nozzles located approximately 1 inch below the surface of the fuel in the test tank.

Note: This procedure for establishing a desired amount of water in suspension should be concluded by adding small amounts (approximately 100 cc) and then allowing a period (approximately 5 minutes) for proper distribution. In any event, however, all water shall have been atomized before fuel temperature in the test tank decreases below 45° F.

(d) Immediately upon reaching test temperature, begin the test run.

(e) Upon completion of the test, the fuel should not contain less than 0.60 cc/gal. of water over the quantity required to saturate the fuel at 80° F.

4.17.3 Fuel filter by-passes shall not stop fuel flow even under the most severe icing conditions. The following test shall be performed on the weapon system strainer or filter. For tests to determine if by-passes operate satisfactorily under these conditions, 2 cc/gal, of free water over saturation shall be added in accordance with the following:

(a) Repeat steps (a) through (g) of 4.17.1.

(b) After fuel is saturated and the excess water has been drained off but before cooling, atomize 2 cc/gal. of water over surface.

(c) Immediately begin rapid agitation and cooling simultaneously, thus keeping the free water suspended in the fuel.

(d) Immediately upon reaching test temperature, begin the test run.

(e) Upon completion of the test, the fuel should contain not less than 1.60 cc/gal. of water over the quantity required to saturate the fuel at 80° F.

4.17.4 The heater shall be tested as approved by the procuring activity.

5. PREPARATION FOR DELIVERY

Not applicable.

6. NOTES

6.1 Intended use. Material and design requirements covered in this specification are intended for use by aircraft manufacturers designing and producing aircraft for the procuring activity.

6.2 This specification may be used as a guide for the design of fuel/propellant systems using fluids other than conventional hydrocarbons.

Custodians:
Army—MO
Navy—WP

Reviewer activities:
Army—MO
Navy—WP

User activity:
Army—
Navy—

Preparing activity:
Navy—WP

Project No. 2915-0011

TABLE I. Fuel availability requirements for maneuvering

Type of aircraft	Attitude (measured from chord line)	Minimum time required	Fuel flow rate (for Standard Day, U. S. Standard Atmosphere, 1962)	Total feed tank fuel at end of maneuver
Fighter aircraft, attack aircraft designed for dive and loft bombing and other aerobatic maneuvers and training aircraft designed for fighter and attack training.	90° zoom	30 seconds	As required, assuming maneuver started from maximum speed level flight at sea level with intermediate power and augmentation.	20%
	Maximum rate of climb	Indefinite, within the climb or zoom limitations of airplane.	Same as above.	20%
	90° dive	Required for dive from service ceiling to minimum safe pullout altitude.	As required for full intermediate power with augmentation for 5 seconds, started from service ceiling, and thence at ground idle power if a jet engine or maximum cruise power if a reciprocating engine.	10%
	Extreme dive attitude reached during maximum rate of descent	Required for dive from service ceiling to sea level.	Same as above.	10%
	Negative "g" and zero "g".	10 seconds	To meet the time requirement, the fuel flow rate shall be as necessary to permit flight at 10,000 feet at intermediate power without augmentation or 20,000 feet at maximum thrust with augmentation whichever is greater. The contractor shall also show satisfactory operation of the aircraft fuel system at all altitudes within the operating envelope of the aircraft for negative "g" and zero "g" flight. The negative "g" and zero "g" provisins shall not be flow rate limited under the above conditions when augmentation is used.	20%
Other attack and training aircraft and patrol, early warning or barrier and reconnaissance aircraft.	Any attitude between and including maximum angle of sustained climb and maximum rate of descent plus wing low/high attitudes attained in radar and other search patterns.	Indefinite, within the climb or descent limitations of the airplane.	Maximum power and thurst.	20%
	Negative "g"	10 seconds	To meet the time requirement, the fuel flow rate shall be as necessary to permit flight at 10,000 feet at intermediate power without augmentation or 20,000 feet at maximum thrust with augmentation, whichever is greater. The contractor shall also show satisfactory operation of the aircraft fuel system at all altitudes within the operating envelope of the aircraft for negative "g" flight. The negative "g" provisions shall not be flow rate limited under the above conditions when augmentation is used.	20%
Other aircraft	All possible attitudes of normal sustained flight.	Indefinite	Maximum power or thrust.	20%

TABLE I. Fuel availability requirements for maneuvering (continued)

Type of aircraft	Attitude (measured from chord line)	Minimum time required	Fuel flow rate (for Standard Day, U. S. Standard Atmosphere, 1962)	Total feed tank fuel at end of maneuver
Other aircraft (continued)	Negative "g" flight for all turbine powered aircraft, except helicopters.	10 seconds	To meet the time requirement, the fuel flow rate shall be as necessary to permit flight at 10,000 feet at intermediate power without augmentation or 20,000 feet at maximum thrust with augmentation, whichever is greater. The contractor shall also show satisfactory operation of the aircraft fuel system at all altitudes within the operating envelope of the aircraft for negative "g" flight. The negative "g" provisions shall not be flow rate limited under the above conditions when augmentation is used.	20%
Guided missiles and target drones	All possible attitudes of normal sustained flight.	Indefinite	Maximum power or thrust.	5%
	Negative "g" and zero "g".	30 seconds	Maximum power or thrust.	5%

NOTE: 1. Fuel distribution at the start of the maneuver is that resulting from normal fuel feed and transfer system operation in level flight up to the time of starting the maneuver.
2. In all maneuvers where the time is "indefinite", availability requirements will be satisfied if the maneuver can be completed down to the quantity listed.

TABLE II. Fuel availability requirements for landing

Type aircraft	Attitude	Feed tank fuel remaining (down to)
All heavier-than-air piloted aircraft, except helicopters	(1) Attitude corresponding to jet penetration in landing configuration at idle power, plus 4° nose-down. (2) Airplane fuselage reference line horizontal at takeoff power. (3) Nose-up attitude corresponding to angle of attack for power landing approach, or wave-off, whichever is the greater angle, at takeoff power, plus 4° nose-up.	1%
Helicopters	15° from level flight attitude, all planes, at takeoff power. In addition, aircraft used for towing and mine sweeping shall be capable of operating in the attitudes associated with these missions down to 5% of the total feed tank fuel.	1%
Guided missiles and target drones	The attitudes and powers specified in the aircraft detail specification, wherever the general heavier-than-air condition above is not directly applicable.	1%

TABLE III. Fuel availability requirements for transfer systems

Type aircraft	Attitude	Fuel remaining in the transfer tank or tanks (down to)
All aircraft except lighter-than-air	Ground (3 point).	5%
	Required for level flight, at maximum range airspeed and altitude for a gross weight resulting when every transfer tank is exhausted.	1%
	Maximum angle of sustained climb.	20%
	Required for level flight at maximum range airspeed and altitude, for a gross weight resulting when each transfer tank is 90% depleted, plus 5° nose-down.	10%

NOTE: 1. For automatic transfer systems, the climb and glide requirements may be waived if it can be demonstrated by test rig that transfer fuel may be used down to 1% remaining during the normal flight profile for the airplane.

TABLE IV. Fuel feed to engine inlet

Operation condition	Engine inlet fuel condition to be satisfied	Fuel	Fuel temp. in tank	Ambient air temp.	Pressure alt. 3/	Airspeed, attitude	Power or Thrust
Normal	Normal fuel inlet pressure limits of engine model spec. and zero v/l.	Normal 2/	59° F	U. S. Standard Atmosphere 3/	All	Up to Vmax, level flight	Maximum
Extreme	Fuel system not to limit airplane performance within allowable engine operating limits.	Normal 2/	50° F	-22° F	Sea level to 10,000 ft.	Vmax, level flight	Maximum
For Avgas fueled aircraft, takeoff with single functional failure	Fuel v/l not to exceed that specified in the engine model spec. Fuel system shall not prevent immediate return to base. 1/	Normal 2/ saturated with air at 105° F at takeoff	80° F	59° F	Sea level to 12,000 ft. takeoff altitude.	Best rate of climb.	Takeoff (includes augmentation if normally required for optimum execution of mission).
For jet fueled aircraft, for max. power flight with single functional component failure	Fuel v/l not to exceed that specified in the engine model spec. Fuel system shall not prevent immediate return to base. 1/	Normal 2/ initally saturated with air at 110° F at takeoff	110° F	59° F	Sea level to 30,000 (or service ceiling), whichever is less at max. power 4/	(a) Best rate of climb during climb, and (b) Jet penetration at low fuel state	Takeoff (includes augmentation if normally required for optimum execution of mission).

1/ Vapor/liquid ratio is used as the parameter most critically affecting engine pump performance. The actual determination of vapor/liquid ratio is expected to be accomplished by conversion of data from applicable fuel system temperatures and pressures within the limits of the current state-of-the-art. Where the engine model specification does not specify an allowable fuel inlet vapor/liquid ratio, the inlet pressure, and temperature requirements specified shall be converted to a vapor/liquid ratio.

2/ Normal fuels refer to fuels as specified in 3.3.1. Conditions specified shall be met when using fuel with the maximum Reid vapor pressure allowable under the applicable fuel specification.

3/ Standard temperature and pressure are specified in U. S. Standard Atmosphere, 1962.

4/ In the event the applicable engine does not have a pump which can meet these conditions, the airplane fuel feed line shall be sized to limit the maximum vapor/liquid to that allowed by the engine detail specification for the minimum absolute inlet pressure required by the engine pump when operating without the airplane boost pump.

TABLE V. Fuel system test equipment summary

Test item		Applicable test paragraph	Applicable design paragraph	Minimum requirements for demonstrating satisfactory design 1/	Contract data or test spec.
Fuel system components	Standard	—	3.1.1.1	Gov't. qualification test under applicable AN or MIL specification.	MIL-D-8706
	Nonstandard	—	3.1.1.2	Prior satisfactory service.	MIL-D-8706
	New development	—	3.1.1.3	Vendor or aircraft manufacturer qual. test under vendor or aircraft manufacturer Spec. approved by procuring activity.	MIL-D-8706
	Reliability analysis	4.3	---	Engineering analysis.	MIL-D-8706
Fuel availability	Maneuvering	4.4	3.3.4.1	Production aircraft, test rig, and engineering analysis.	MIL-D-8706
	Landing	4.4	3.3.4.2		MIL-D-8706
	Transfer	4.4	3.3.4.3		MIL-D-8706
Engine inlet fuel feed	Normal	4.5	3.3.5.1	Production aircraft, test rig, and engineering analysis.	MIL-D-8706
	Extreme	4.5	3.3.5.2		MIL-D-8706
	TO w/functional fail	4.5	3.3.5.3		MIL-D-8706
	Maneuver w/functional failure	4.5	3.3.5.4	Engineering analysis.	MIL-D-8706
	Catapult w/part fuel load.	4.5	3.3.5.5	Engineering analysis.	MIL-D-8706
CG control		4.6	3.3.6	Production aircraft, test rig, and engineering analysis. 2/	MIL-D-8706
Fuel transfer rate		4.7	3.3.6.2	Test rig.	MIL-D-8706
Venting	Ground taxi	4.8.1	3.3.7	Test aircraft.	MIL-D-8708 3/
	Climb	4.8.2	3.3.7	Flight test	MIL-D-8708
	Level flight	4.8.2	3.3.7	Flight test.	MIL-D-8708
	Dive	4.8.2	3.3.7	Flight test.	MIL-D-8708
	Catapult w/arrested landing	4.8.3	3.3.7	Engine analysis	MIL-D-8706
	Extreme fuel temp.		3.3.7.1	Test rig and engineering analysis.	MIL-D-8706
	Fuel loss		3.3.8	Test rig and engineering analysis.	MIL-D-8706
	Tank pressure control		3.3.8	Test rig and engineering analysis.	MIL-D-8706
Fueling and defueling	Fueling rates	4.9	3.3.9.1	Test rig	MIL-D-8706
	Maximum rate fueling	4.9.2	3.3.9.3.2	Test rig	MIL-D-8706
	Defueling rate	4.9.3	3.3.9.6.1	Test rig	MIL-D-8706
	Emergency defueling	4.9.3	3.3.9.6.1.1	Test rig	MIL-D-8706
	Fuel level control	4.9.4	3.3.9.3.3	Test rig	MIL-D-8706
	Pressure fueling	4.9.1	3.3.9.4.1	Test rig and production aircraft	MIL-D-8706
	Gravity fueling	4.9.5	3.3.9.4	Test rig	MIL-D-8706
	Air refueling	[illegible].9.6	3.3.9.[illegible]	Production and test rig	MIL-D-8706
Fuel jettisoning		4.10	3.3.9.7	Flight test.	MIL-D-8708
Vent and drain line discharge		4.11	3.3.11.1	Flight test.	MIL-D-8708
Surge pressures		4.12	3.3.14	Test rig and engineering analysis.	MIL-D-8706
Drains		4.13	3.3.11	Actual aircraft and checkoff list.	MIL-D-8706
Vent icing		4.14	3.3.7	Checkoff list.	MIL-D-8706
Filler unit security		4.15	3.3.9.4	Checkoff list.	MIL-D-8706
Fuel system controls		4.16	3.3.12	Checkoff list.	MIL-D-8706
Fuel system icing		4.17	3.3.16	Analysis and test rig.	MIL-D-8706

1/ Minimum demonstration requirements follow in order of precedence from lowest to highest together with definition. Demonstration may be accomplished by the method listed or any method of higher precedence:

(a) Checkoff list - Tabulate item together with p/n, description of location, installation features, etc., as appropriate to establish compliance with design requirement.

(b) Engineering analysis - Applies primarily to fuel cg location and availability for feed or transfer under conditions which do not lend themselves to simple test rig, and to icing susceptibility.

(c) Test rig - Functionally duplicate mockup of complete or individual sections of the fuel system, as pertinent, tested under design conditions.

(d) Test aircraft - Use actual aircraft in lieu of test rig.

(e) Test rig and engineering analysis - Extrapolation of off design point test rig data to actual design conditions.

(f) Flight test - Conduct flight test on actual airplane under design conditions. Include engineering analysis of test results as appropriate.

2/ Test rig required only if cg is mechanically controlled.

3/ Submit MIL-D-8708 items by separate appending report.

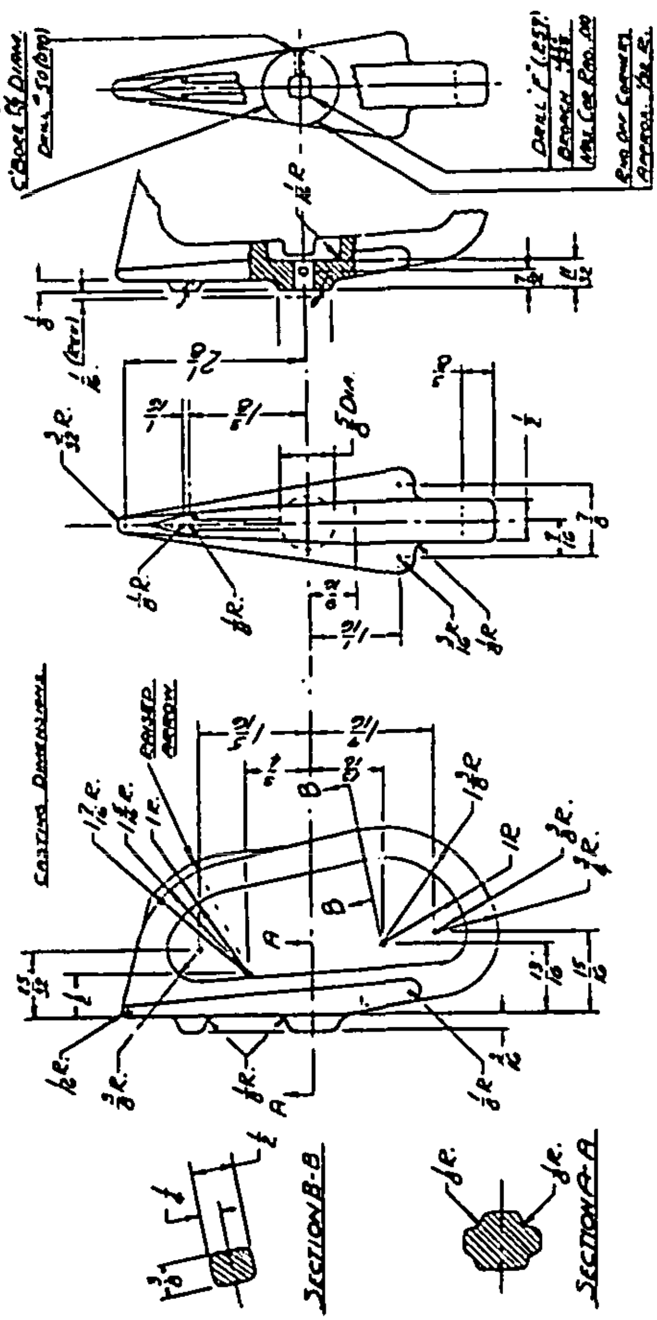


FIGURE 1. Handle - fuel selector valve

I TEST & REASON

Demonstrate flow rates to the engines with both boost pumps operating and the aircraft in an attitude corresponding to carrier approach in landing configurations plus 4°.

Required by engineering to determine characteristics of systems.

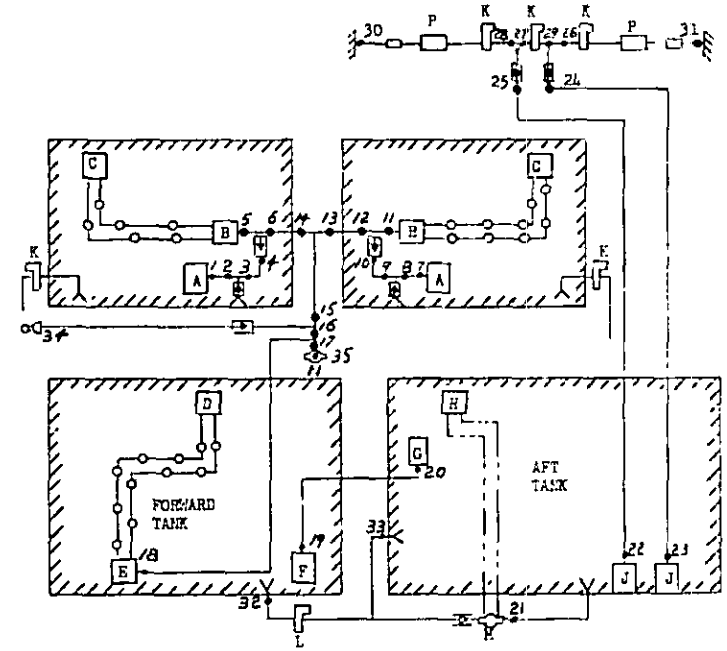
RESULTS

The system delivers fuel at a rate sufficient for any engine operating condition.

II TEST CONDITIONS	ACTUAL TEST CONDITIONS
Sump tank 50% full	Sump tank 50% full
Ambient temperature fuel	Temperature 74° F
R.V.P. 2.5-2.7 *	R.V.P. 2.0
Pumps "J" energized	Pumps energized
Cross feed valve closed	Valve closed
Record specific gravity and fuel temperature	S.G. 0.782
Place test vehicle 1.9° nose up	2° nose up
Place test vehicle 4.5° nose up	5° nose up
Altitude: Sea level	Sea level pressure

*Optional

III DATA REQUIRED	EXPECTED RESULTS
Pressure pickup at 22	0-20 PSI
Pressure pickup at 23	0-20 PSI
Pressure pickup at 24	0-20 PSI
Pressure pickup at 25	0-20 PSI
Pressure pickup at 26	0-20 PSI
Pressure pickup at 28	0-20 PSI
Pressure pickup at 30	0-20 PSI
Pressure pickup at 31	0-20 PSI
Flow pickups between 26 & 30, 28 & 31	20-40 GPM
Tank pressure	Ambient



CODE SYMBOLS

A-3015-36-10 Transfer Pump
B-32167-542 Shutoff Valve (N.C.)
C-64873-973 Pilot Valve (N.O.)
D-8-625-6 Pilot Valve
E-9-736-8 Shutoff Valve (N.C.)
F-3019-97-16 Transfer Pump
G-32168-937 Level Control Valve (N.C.)
H-37-694P-1 Float Switch
J-98764-M Boost Pump
K-Motor Operated Shutoff Valve
L-Manual Operated Shutoff Valve
M-32176-982 Pressure Fueling Adapter
N-36-8129-97 Pressure Fueling Adapter
P-Fuel Filter
R-Purge Bottle

SENSING LINE

WIRE

CHECK VALVE

•1; •2 ETC. DATA POINTS

FIGURE 2. Fuel system schematic (sample presentation)

FUEL SYSTEM TEST RESULTS

REPORT NO.	RECORDER CHANNEL NUMBER								
	21	22	3	7	8	23	24	4	25
TEST CONDITIONS	AIRPLANE PRESSURE PICKUP POSITION								
	22	23	24	25	26	28	30	31	
	PRESSURE - PSIG								FUEL FLOW [illegible]
PARAGRAPH 3.4.11 OF SR-73D-1 (REF) 2° NOSE UP	22.3	21.8	19.4	18.4	17.8	17.8	13.6	17.5	51.2
	21.9	21.7	19.9	18.3	17.4	17.9	13.0	11.7	29.5
	23.5	23.0	21.3	20.1	19.3	19.9	17.3	16.8	19.0
	23.1	23.0	21.5	19.9	19.7	20.4	17.8	16.4	17.7
	23.6	23.4	22.2	20.9	20.6	21.1	20.0	18.5	9.0
	23.6	23.4	22.2	21.0	20.7	21.1	19.6	18.5	9.5
	23.3	23.3	23.3	22.9	22.7	21.1	19.8	18.5	10.0
	23.5	23.5	22.4	21.7	21.0	21.2	20.3	21.2	4.0
5° NOSE UP	21.9	21.8	18.7	17.3	16.7	17.1	17.2	11.3	31.0
	22.7	22.2	22.2	19.2	16.7	19.4	16.9	14.8	20.1
	22.0	21.9	22.4	19.0	18.5	19.1	16.6	14.7	17.4
	21.9	21.8	22.4	19.0	18.6	18.9	15.9	15.5	19.7
	22.8	21.8	20.2	19.2	18.6	18.8	15.9	15.4	19.0
	22.4	22.4	21.2	19.9	19.3	20.0	18.6	17.0	17.1
	22.4	22.3	21.2	19.9	19.6	20.0	18.7	16.9	6.6
	22.5	22.4	21.3	20.1	19.7	20.4	19.3	16.7	4.0

SPECIFIC GRAVITY 0.782 @ 74°F

SUMP TANK PRESSURE 0 PSIG

FIGURE 3. Fuel system test results (sample data sheet)

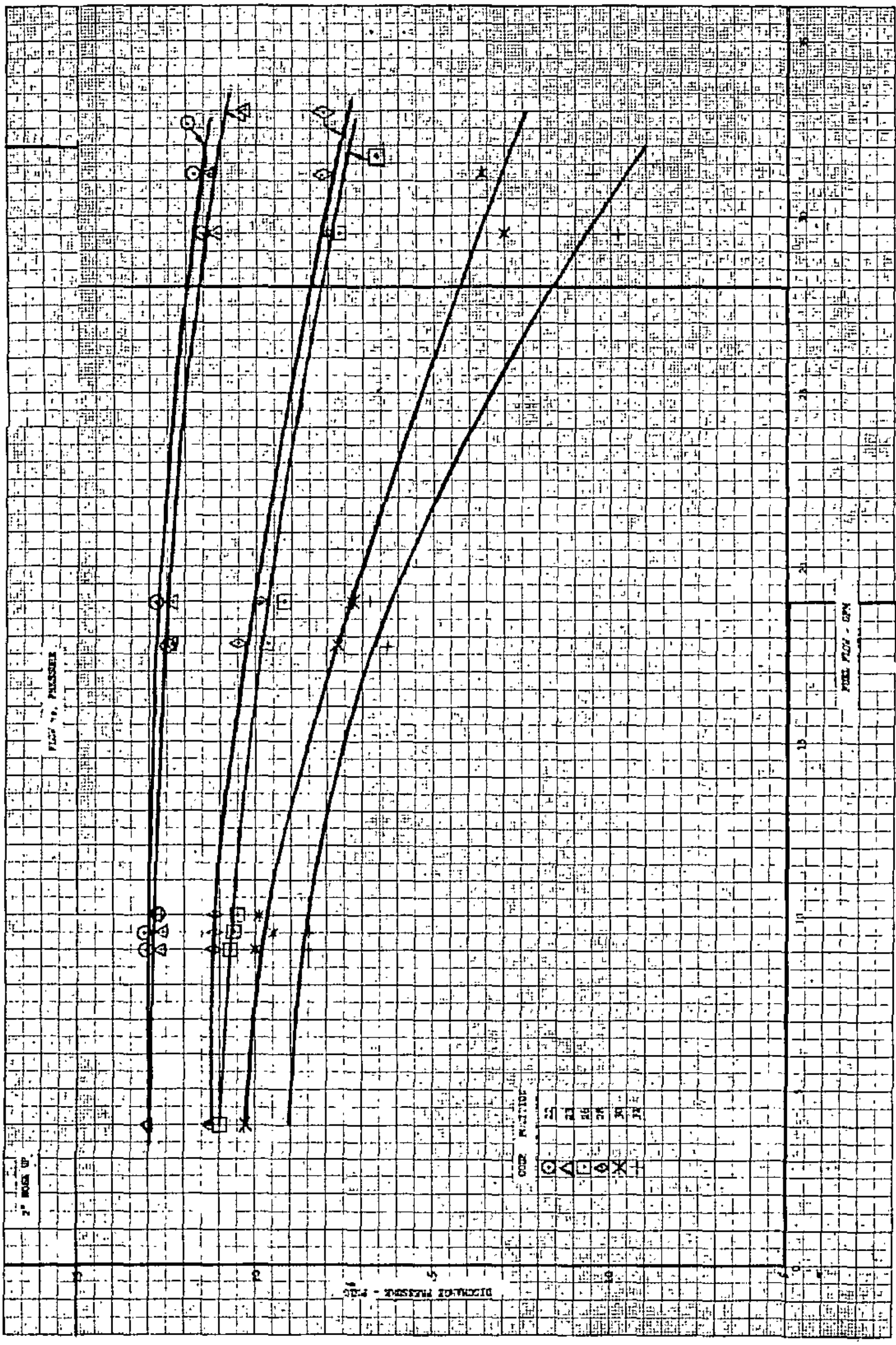


FIGURE 4. Fuel system test results (sample curve)

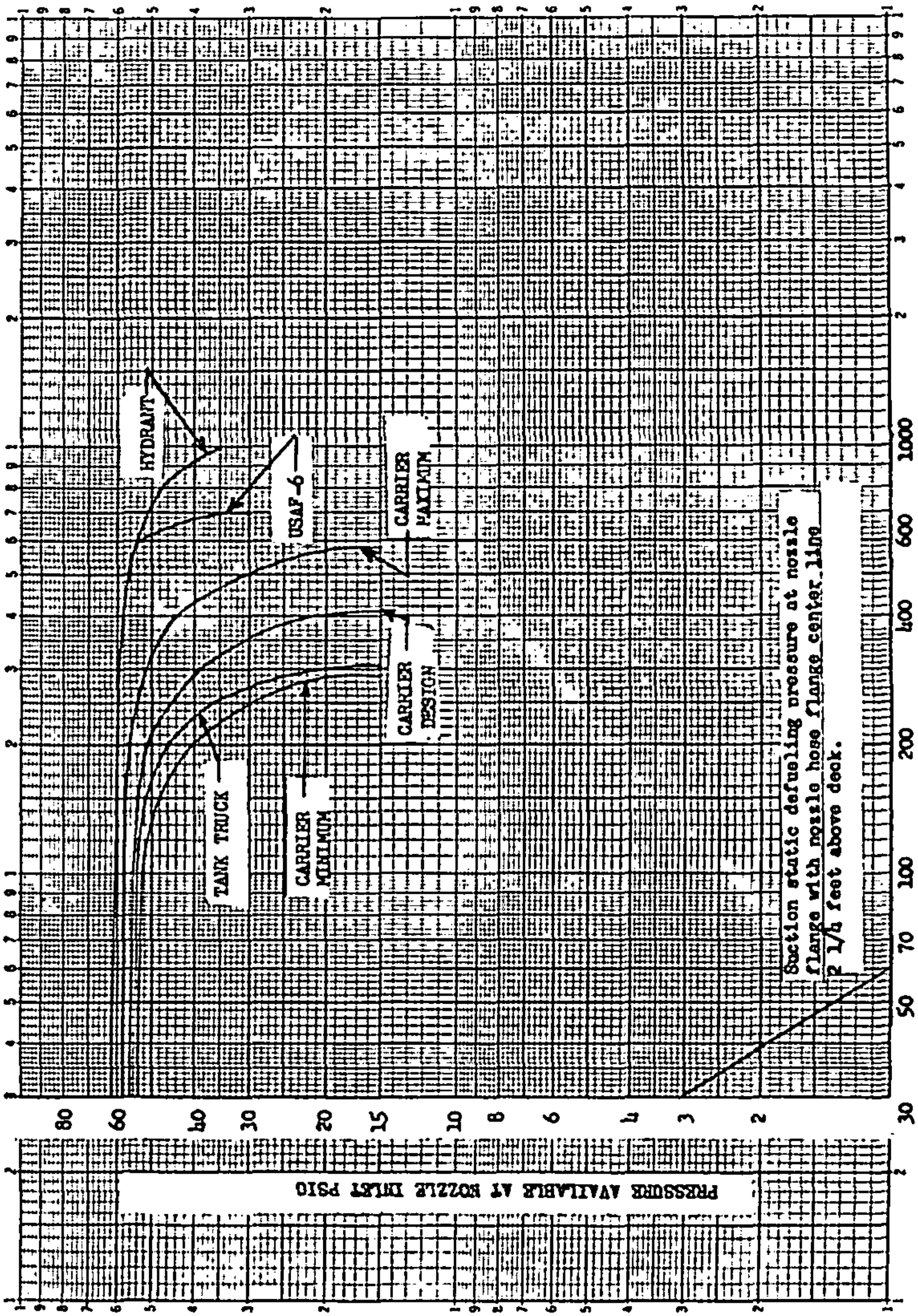


FIGURE 5. Flow per nozzle gpm.

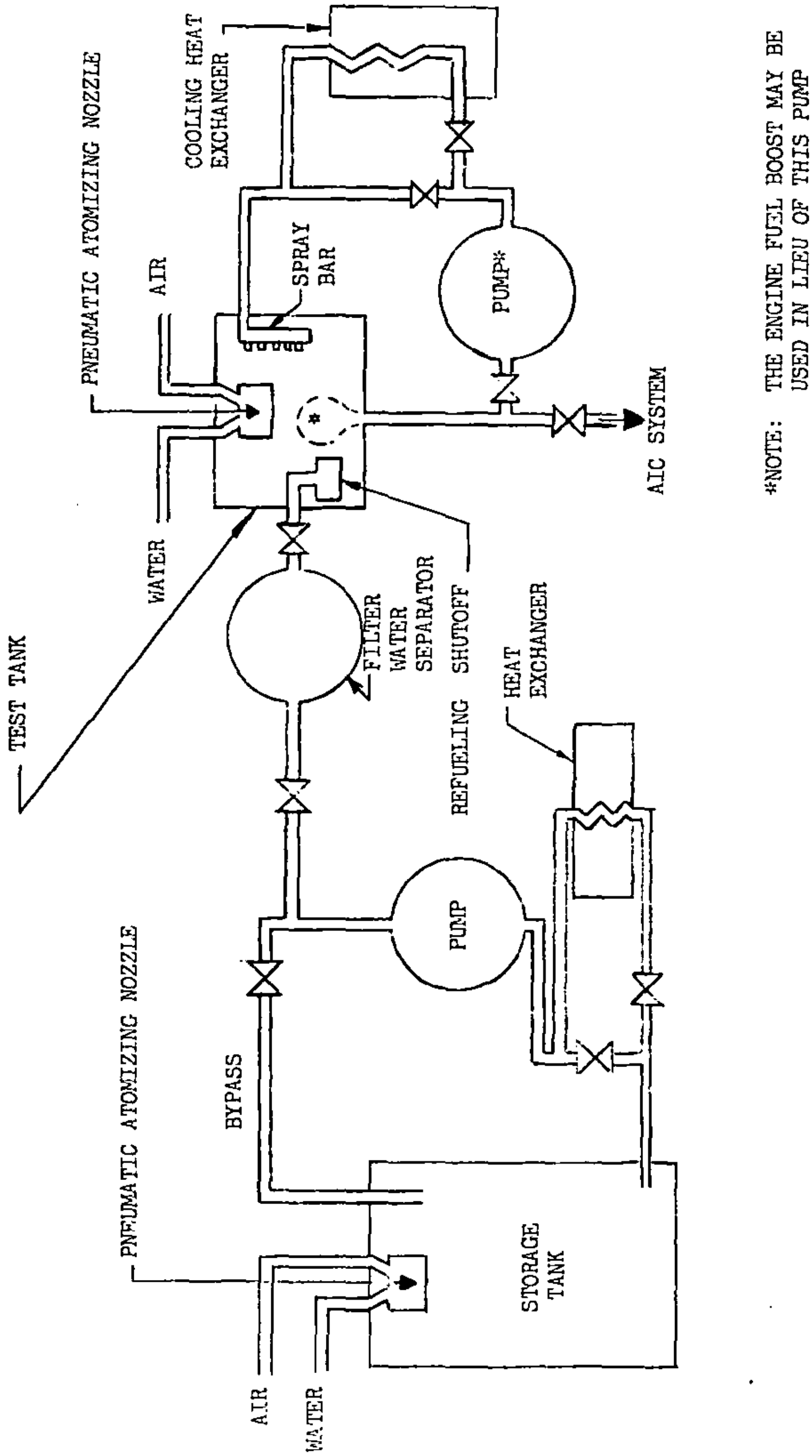
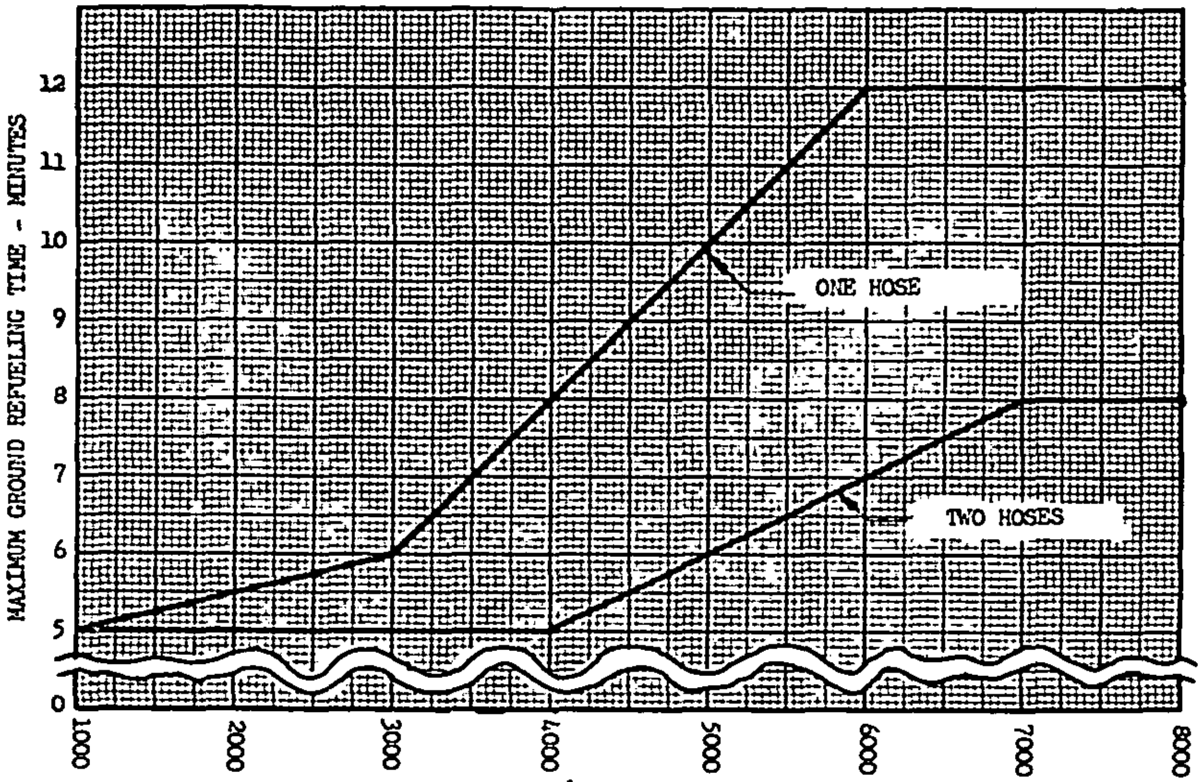


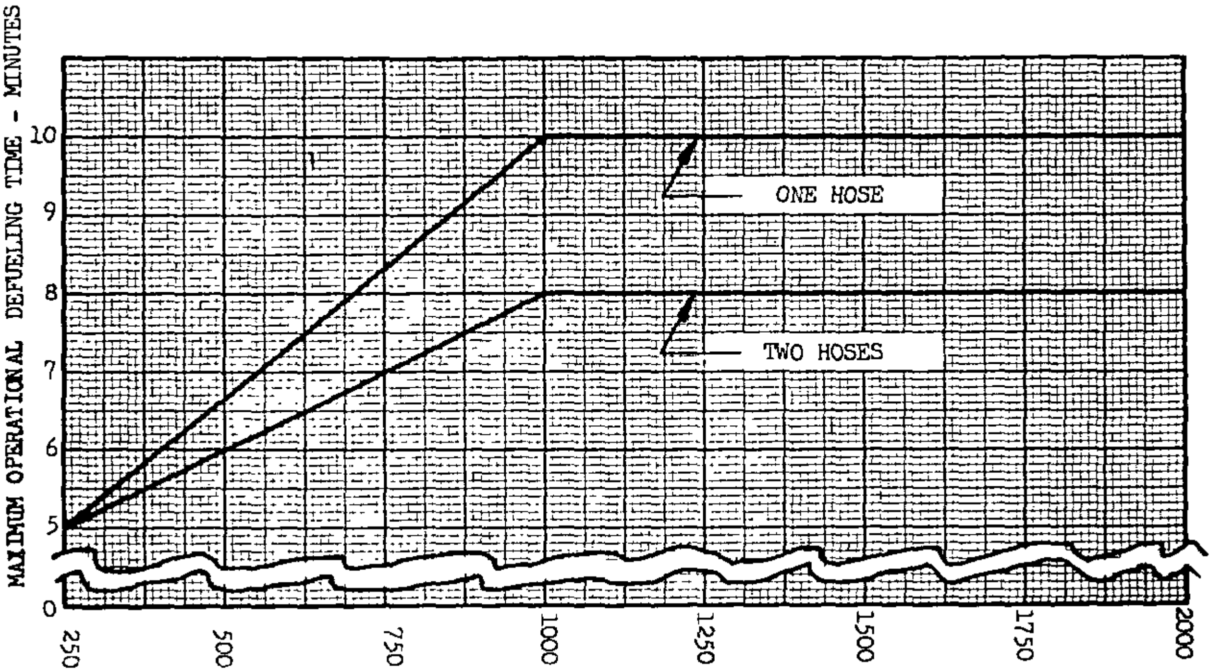
FIGURE 6. Icing rig test setup



1/ Fueling: (a) The fueling facilities for primary design of aircraft fuel systems shall be USAF-F6, AFS32R-2, and hydrant systems. The systems shall also function satisfactorily when refueled from Navy carriers, tank trucks, and seaplane tenders, as appropriate (see figure 5).

(b) Ferry fuel overload and similar nonstrategic and non-tactical overload conditions are excepted insofar as fueling time is concerned; however, the aircraft shall be capable of being fueled to maximum capacity.

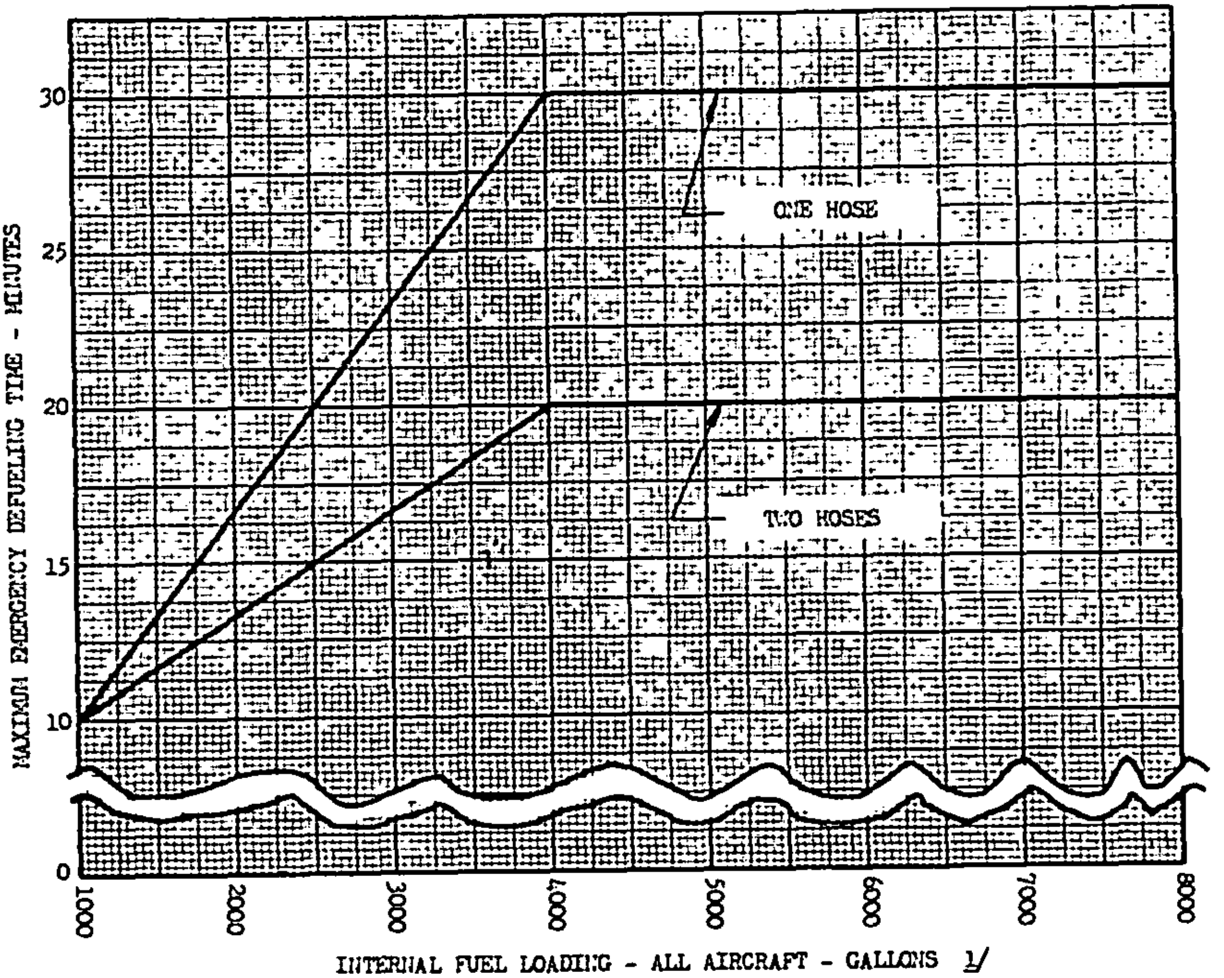
FIGURE 7. Fueling



INTERNAL FUEL LOADING - ALL AIRCRAFT - GALLONS 1/

1/ Operational defueling: Operational defueling applies to conditions of the aircraft on landing aboard a carrier with 25 percent of maximum fuel, or 40 percent of internal fuel, or 1,500 gallons, or the maximum permissible fuel load for landing aboard, whichever is less, except that if maximum permissible fuel for landing aboard is less than 25 percent of internal fuel, the defueling time shall be based on 25 percent of internal fuel remaining. External air and electrical power may be used to aid defueling, as approved by the procuring activity.

FIGURE 8. Operational defueling



1/ Emergency defueling: Emergency defueling applies to maximum (both internal and external) fuel capacity and may be accomplished with external air and electrical power, etc., as approved by the procuring activity.

FIGURE 9. Emergency defueling

SPECIFICATION ANALYSIS SHEET

Form Approved
Budget Bureau No. 119-R004

INSTRUCTIONS

This sheet is to be filled out by personnel either Government or contractor, involved in the use of the specification in procurement of products for ultimate use by the Department of Defense. This sheet is provided for obtaining information on the use of this specification which will insure that suitable products can be procured with a minimum amount of delay and at the least cost. Comments and the return of this form will be appreciated. Fold on lines on reverse side, staple in corner, and send to preparing activity *(as indicated on reverse hereof)*.

SPECIFICATION

MIL-F-17874B Fuel Systems: Aircraft, Installation and Test of

ORGANIZATION *(Of submitter)*

CITY AND STATE

CONTRACT NO.

QUANTITY OF ITEMS PROCURED

DOLLAR AMOUNT

$

MATERIAL PROCURED UNDER A

☐ DIRECT GOVERNMENT CONTRACT ☐ SUBCONTRACT

1. HAS ANY PART OF THE SPECIFICATION CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?

A. GIVE PARAGRAPH NUMBER AND WORDING.

B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES.

2. COMMENTS ON ANY SPECIFICATION REQUIREMENT CONSIDERED TOO RIGID

3. IS THE SPECIFICATION RESTRICTIVE?

☐ YES ☐ NO IF "YES", IN WHAT WAY?

4. REMARKS *(Attach any pertinent data which may be of use in improving this specification. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity)*

SUBMITTED BY *(Printed or typed name and activity)*

DATE

DD FORM 1 APR 63 1426

REPLACES NAVSHIPS FORM 4863, WHICH IS OBSOLETE

PLATE NO. 15419