MIL-T-5522D
30 Sep 1975
Superseding
MIL-T-5522C
25 March 1966

MILITARY SPECIFICATION

TEST REQUIREMENTS AND METHODS FOR AIRCRAFT HYDRAULIC AND EMERGENCY PNEUMATIC SYSTEMS

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

1. SCOPE

1.1 This specification establishes requirements for tests and methods for the testing of aircraft hydraulic systems designed in accordance with requirements of MIL-H-5440, MIL-H-8891, and of aircraft pneumatic systems designed in accordance with requirements of MIL-P-5518.

2. APPLICABLE DOCUMENTS

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

SPECIFICATIONS

Military

MIL-H-5440	Hydraulic Systems, Aircraft, Types I and II Design, Installation and Data Requirements For
MIL-P-5518	Pneumatic Systems, Aircraft Design, Installation and Data Requirements For
MIL-D-8706	Data, and Tests, Engineering: Contract Requirements for Aircraft Weapon Systems
MIL-F-8785	Flying Qualities of Piloted Airplanes

FSC 1650

SPECIFICATIONS

Military (Cont'd)

MIL-H-8891	Hydraulic Systems, Manned Flight Vehicles, Type III, Design, Installation, and Data Requirements For
MIL-B-8584	Brake Systems, Wheel, Aircraft, Design Of

STANDARDS

Military

MIL-STD-810	Environmental Test Methods

PUBLICATIONS

Navy Department Specification

SD-24	General Specification for Design and Construction of Aircraft Vol. I Fixed Wing Aircraft Vol. II Rotary Wing Aircraft

Air Force Systems Command Design Handbook

AFSC DH 2	Crew Stations and Passenger Accommodations

(When requesting applicable documents, refer to both title and number. Copies of unclassified documents may be obtained from the Commanding Officer, Naval Supply Depot (Code 1051), 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120. Requests for copies of classified documents should be addressed to the Naval Supply Depot, via the cognizant Government Inspector.)

3. TEST REQUIREMENTS - NEW AIRCRAFT - One or more of a new series of aircraft must complete the following tests before first flight. If an aircraft simulator is not available, the simulator tests must be performed on the aircraft. Test requirements vs. test methods are tabulated in Figure 1.

ITEM	REQUIREMENTS (3.0)					TEST METHODS (4.0)				
		GROUND AIRCRAFT			AIRBORNE		GROUND AIRCRAFT			AIRBORNE
	SIMULATOR (3.1)	GRD. CART (3.2)	VARIDRIVE (3.3)	ENG. OPER. (3.4)	FLT. TEST (3.5)	SIMULATOR (4.1)	GRD. CART (4.2)	VARIDRIVE (4.3)	ENG. OPER. (4.4)	FLT. TEST (4.5)
Proof Pressure	3.1.1	3.2.1	-	-	-	4.1.1	4.2.1	-	-	-
System Functional	3.1.2	3.2.2	3.3.1	3.4.1	3.5.1	4.1.2	4.2.2	4.3.1	4.4.1	4.5.3
Failure Mode	3.1.3	-	3.3.2	-	3.5.2	4.1.3	-	4.3.2	-	4.5.4
Mission Profile	3.1.4	-	3.3.2	-	*	4.1.4	-	4.3.2	-	*
Vibration Survey	3.1.5	-	3.3.3	3.4.2	3.5.4	4.1.5	-	4.3.3	4.4.2	4.5.6
Pressure Survey	3.1.6	3.2.3	3.3.4	-	3.5.6	4.1.6	4.2.3	4.3.4	-	4.5.3.1
Pump Ripple	3.1.7	3.2.4	3.3.5	3.4.4	-	4.1.7	4.2.4	4.3.5	4.4.3	-
System Temperature	3.1.8	-	3.3.6	3.4.3	3.5.5	4.1.8	-	4.3.6	4.4.4	4.5.3.2
Post Test Inspection	3.1.9	3.2.5	3.3.7	3.4.5	3.5.7	4.1.9	4.2.5	4.3.7	4.4.5	4.5.7
Engine Compatibility	3.1.10	-	-	-	-	4.1.10	-	-	-	-
Pre-Flight Check	-	-	-	-	3.5	-	-	-	-	4.5.1
Taxi Test	-	-	-	-	3.5	-	-	-	-	4.5.2
Flt. Capability	-	-	-	-	3.5.3	-	-	-	-	4.5.5

*For flight test, flight capability test replaces mission profile test.

FIGURE 1. Cross reference chart
(Requirements vs Test)

3.1 Simulator Tests - All simulator tubing and component installations shall be identical to those in the first flight vehicle as is practical. (All titanium tubing shall be prestressed as specified in MIL-H-5440.)

3.1.1 Proof pressure testing of simulator hydraulic systems shall be performed with components installed. System shall be tested to the requirements of MIL-H-5440 or MIL-H-8891 as applicable.

3.1.2 System functional test shall be performed on the simulator to insure that the systems and subsystems meet the design objectives. All normal operating requirements including emergency operations must be demonstrated in their most adverse condition.

3.1.3 A failure mode and effects test shall be conducted prior to first flight to evaluate the failure modes which are critical from a safety point of view or whose effects are unpredictable from the failure mode and effects analysis.

3.1.4 Mission profile test shall be performed to demonstrate that all normal missions can be satisfied. This test would include start-up, taxi, take-off, climb-out, cruise, mission maneuvering, return flight, landing, taxi, park, and shut-down.

3.1.5 Vibration survey shall be made on the simulator to insure that no detrimental resonant conditions exist induced by the hydraulic system.

3.1.6 Pressure survey shall be performed on the simulator to verify that system pressure peaks do not exceed design specification requirements.

3.1.7 Pump ripple test shall be performed to insure that no resonance ripple frequencies, created by any device, cause detrimental and destructive effects to the hydraulic system or aircraft. All normal speed ranges of the pump or other ripple generating device must be investigated.

3.1.8 System temperatures shall be monitored on the simulator to validate the analytical data. Deviation to predicted temperatures must be investigated and resolved. Extreme limits of the temperature envelope shall be tested by allowing the system temperature to rise to simulator limits and then extrapolating data to the extremes of the flight envelope.

3.1.9 Post test inspection shall be conducted to determine condition of system at the conclusion of each test. Data such as temperature, fluid level, accumulator pressure, quantity of dissolved air, air bottle pressure etc. shall be noted. Deviation to predicted values shall be investigated and resolved.

3.1.10 Engine Compatibility Tests - Engine mounted hydraulic components and systems shall demonstrate their compatibility with related engine operation on simulators such as engine test stand, air inlet control test stand, thrust reverser test stand, etc.

3.2 New Aircraft Ground Cart Test - All systems operable through ground test connections shall be demonstrated during this test.

3.2.1 Proof pressure of aircraft hydraulic system shall be performed with components installed. System shall be tested to the requirements of MIL-H-5440 or MIL-H-8891 as applicable.

3.2.2 Functional tests shall demonstrate satisfactory operation of all systems and their compatibility with designated ground carts.

3.2.3 Pressure survey shall be performed to determine that system pressure peaks from ground cart operation do not exceed design specification requirements.

3.2.4 Pump ripple tests shall be performed to insure that no resonant ripple frequencies created by ground cart operation cause detrimental and destructive effects to the hydraulic system or aircraft. All normal speed ranges of the generating device must be investigated.

3.2.5 A post test inspection shall be made to determine any leakage or damage to components, lines, structure, etc.

3.3 Aircraft Varidrive Operation - Varidrive driven pumps shall be installed in approximately the normal pump position in the aircraft. This test shall demonstrate normal operation of the aircraft system with engine driven pumps.

3.3.1 Functional test shall test the start, all engine RPM ranges, and shut down. All systems shall be operated thru all normal and emergency modes.

3.3.2 Mission profile and failure mode tests enumerated in paragraph 4.3.2 as a minimum shall be performed on the aircraft to demonstrate that safety of flight will not be endangered.

3.3.3 A vibration survey shall be conducted to determine if any unusual induced vibration modes exist from the hydraulic system and structural combination.

3.3.4 Pressure survey shall be performed to determine that system pressure peaks from varidrive driven pumps do not exceed design specification requirements.

3.3.5 A pump ripple test shall be performed to insure that no resonant ripple frequencies, created by any device, cause detrimental and destructive effects to the hydraulic system or aircraft. All normal speed ranges of the pump or other ripple generating device must be investigated.

3.3.6 Determine if system temperatures are within temperature limits specified by contractor.

3.3.7 A post test inspection shall be made to determine any leakage or damage to components, lines, structures, etc.

3.4 Aircraft Engine Operation - Aircraft engine power shall be used to demonstrate the operation of all hydraulic systems.

3.4.1 Functional tests shall demonstrate satisfactory operation of all systems except landing gear or other subsystems that cannot be safely demonstrated on the ground.

3.4.2 A vibration survey shall be conducted on critical areas that are instrumented for flight testing.

3.4.3 System temperatures shall be monitored to verify analytically predicted temperatures. High temperature areas require continuous monitoring during engine operation on the ground.

3.4.4 A pump ripple test shall be performed to insure that no resonant ripple frequencies, created by any device, cause detrimental and destructive effects to the hydraulic system or aircraft. All normal speed ranges of the pump or other ripple generating device must be investigated.

3.4.5 A post test inspection shall be made to determine any leakage or damage to components, lines, structures, etc.

3.5 Aircraft Flight Test - Flight test shall be in accordance with appropriate Military Specification (See Sec. 2.0) and performed as required by par. 4.5. Pre-flight and taxi tests shall be conducted in accordance with 4.5.1 and 4.5.2 to insure that the aircraft is suitable for flight.

3.5.1 Functional Tests - These tests shall demonstrate that all subsystems function within the extreme limits of the flight envelope for which the system was designed; i.e., landing gear retraction at maximum air speed for which system was designed. Back-up systems shall demonstrate their designed capability; i.e., emergency landing gear, flaps, flight controls, etc.

3.5.2 Flight test failure modes - Simulated failure mode tests shall be performed to demonstrate adequacy of the redundant and/or back-up systems.

3.5.3 Flight Capability - Critical flight envelope to which the system was designed should be flown to validate the system design. Normal flight envelope should be flown early in flight test program to verify basic design.

3.5.4 Vibration - Critical areas should be instrumented and monitored during all flight testing. Critical areas are determined from simulator and engine testing.

3.5.5 System temperatures shall be monitored to verify analytically predicted temperatures. High temperature areas require continuous monitoring during aircraft critical flight envelope.

3.5.6 Peak pressure shall be monitored during various flight tests. Areas of the system shown to be critical during simulator or other ground testing shall be instrumented for continuous surveillance.

3.5.7 Post test inspection of the aircraft after each flight for leaks, damage, or failures shall be conducted. All anomalies shall be cleared before next flight.

3.6 Data Submittal and Approval. Data submittal and approval requirements for a specific model aircraft will be covered by a contract with the appropriate procuring activity. Typical information and data re-

quired are listed in 5.2. The data shall be furnished in accordance with MIL-D-8706 or in accordance with appropriate line items of the Contractor Data Requirements List (DD Form 1423), as applicable.

4. TEST METHODS

4.1 Simulator Tests - These tests shall be conducted in accordance with the appropriate specification (see Sec. 2.0) and the requirements of paragraph 3.1.

The following ground support equipment shall be utilized:

a) Hydraulic test stand - Ground hydraulic carts or equivalent power sources shall be available to supply sufficient pressure to perform the proof pressure tests and also sufficient flow to move surfaces to alternate positions.

b) External electric power supply - Aircraft electrical power shall be supplied by a ground cart or equivalent power source.

c) Air Conditioning - Air conditioning shall be supplied to cool aircraft electronics during the tests. One NR-5B or equivalent ground air conditioning cart shall also be provided to be used as required to cool aircraft hydraulic systems.

d) Switch boxes or other special equipment - Special equipment shall be provided as necessary to perform all required operations.

The Simulator shall be placed in the following condition:

e) Simulator servicing - Reservoirs shall be serviced, accumulators charged, and all systems operable.

f) Simulator electrical power system - Verify all power is connected and all switches in their proper positions.

g) Hydraulic system subsystem configuration - Position all systems to their proper positions.

4.1.1 Proof Pressure Test - Proof pressure as specified in 3.1.1 shall be applied to the hydraulic system to prove the integrity of connections at each component. Pressure shall be sustained for at least five minutes.

After inspection for failures or leaks system pressure shall be restored to normal pressure. All systems shall be placed in their alternate position and proof pressure applied again. After system has been inspected return simulator to its original condition.

4.1.2 System Functional Tests - When conducting these functional tests the systems shall be configured in the following manner:

a) Simulator power supply - equipment for simulator - The test stand (containing the pumps) shall be identical, and connected, to the aircraft system in a like manner to the actual power system in the aircraft. All special test equipment shall be installed and system modifications, if any, completed. Hydraulic system shall be adequately bled of entrapped air, and reservoir(s) filled to their specified level with applicable hydraulic fluid. All accumulators shall be properly serviced and the entire system, components, and attached linkages and mechanisms properly adjusted. Pneumatic systems shall be properly lubricated, with all system components and attached linkages and mechanisms properly adjusted.

b) Test equipment for simulator - The following test equipment shall be installed on the simulator:

(a) Pump(s) equal in type and quantity to those normally used in the aircraft system.

(b) Variable speed drive(s) equipped with tachometer(s).

(c) Lines identical to the aircraft installation shall be used to connect pump to system.

(d) Calibrated pressure gages (mechanical or electronic), flowmeters, and other miscellaneous equipment as necessary.

(e) Suitable temperature-indicating equipment.

c) Separate systems - If the aircraft is designed to incorporate two or more separate systems provisions shall be made to operate the systems in their proper relationship with each other.

d) Artificial loading - If artificial loading of any service is necessary, such as wing flaps, air brakes, surface control boost or power systems, etc., adequate provision to accomplish such loading should be installed and calibrated. Simulation of preloads of doors and closures to structure in aircraft is required. Unsymmetrical loading is required during synchronized testing.

e) Reservoir pressure - Reservoir pressurization shall be identical to aircraft installation. Pressurized air can be substituted for engine bleed air.

4.1.2.1 Normal system test - Normal system pressure shall be applied to the entire hydraulic system, and each selector and control valve shall be operated for at least two complete cycles of its corresponding service. In addition, each control unit shall be operated through an incomplete half cycle, followed by a complete reversal of direction. Definition - A cycle is interpreted to mean the full travel of a service from down (closed) to up (open) and return to original down (closed). A half cycle illustration would be a landing gear from down to up.

The above operations shall be accomplished through both directions of operation. During the above operations, inspection shall be made to determine whether:

(a) The various functions are accomplished satisfactorily in accordance with specification requirements.

(b) The movement of all components is smooth and positive.

(c) Relief valves, devices for automatic termination of an operation, pressure controls, switches and signals, audible or other warning devices, and similar components function as intended. (Relief valves shall not by-pass fluid during normal operation of any component).

(d) All indicating devices function and synchronize with the movement of their respective component as specified.

(e) The specified functioning pressures are controlled and not exceeded. This may need to be determined at only one or at numerous locations in the system, but should not receive major consideration at any point where un-

realistic pressures are obtained on ground test as compared to entirely different pressures in flight conditions, unless the unrealistic pressures exceed design proof pressures or will adversely affect the system during operational use. Pressures may be obtained by normal system pressure gages, auxiliary mechanical gages, or electronic equipment as applicable. (Due consideration shall be given to this item and the type of equipment to be used, in preparing the test procedure. See 5.3.1.)

(f) All tubing and fitting joints and component external seals are free of leaks. Allowable leakages of component external seals shall be defined by contractor test plan. (See 5.3.1.)

(g) All fluid lines, fittings, and components are free from excessive movement and chafing.

(h) There is a full engagement of mechanical locks and latches, and that hydraulic back pressure does not cause inadvertent unlocking.

(i) The clearance for all moving parts, where applicable, throughout the entire range of movement is such that fouling of adjacent parts cannot occur. (Particular attention shall be given to flexible connections to insure that pinching or stretching does not occur.)

(j) Simulated normal flight operating conditions, or any possible inadvertent operation, will cause system malfunction.

(k) Values of operating temperatures and ambient temperature should be noted.

4.1.2.2 Fluid Level - The following reservoir conditions shall be demonstrated as part of the simulator tests:

(a) Low level - The fluid in the reservoir(s) shall be set to the lowest permissible indicated level, and all the gas charge removed from the largest accumulator in the system and a minimum gas charge in all others. Reservoir

pressurization, if applicable, should be set to the low limit of the normal pressurization range. The controls should then be operated at least once through the normal sequence of operations. The control valves should be set to simulate normal flight operation, whereby the minimum amount of fluid is returned to the reservoir. For "gas to fluid in contact" type reservoirs, the pump suction line opening shall be checked for any possibility that the opening has been uncovered and air introduced into the system. "Gas fluid separation" type reservoirs shall be checked to determine that the pump inlet pressure will not be less than the recommended minimum values. A simulation of an inverted flight condition or zero "g" shall also be included, if applicable.

(b) Overfill test - Reservoir shall be filled to overflow condition. A normal sequence of operation from taxi, take-off, landing, to park and shut down shall be simulated. Damage to reservoir or other components shall be noted. Fluid loss to the extent of the overfill is allowed.

4.1.2.3 Hand or auxiliary pump operations - Where hand pump, or auxiliary pump operation are applicable, the test stand should be disconnected and each service must be operated through at least one complete cycle. Any applicable items recorded or inspected under paragraph 4.1.2.1 should be duplicated herein. (In addition, any inadvertent fluid transfer between reservoirs, if applicable, should be noted for necessary correction). The number of cycles of hand pump operation required for functioning with each part of the system shall be recorded. The amount of this force shall be measured with a spring scale and recorded. (Care shall be taken in this test not to overheat electric motors driving pumps if such motors are not of the continuous duty type).

4.1.2.4 Emergency operations - All emergency operations (mechanical or otherwise) shall be tested upon those items normally to be operated by the hydraulic or pneumatic systems. Comments shall be made concerning the maintenance necessary to bleed or reset the system to normal operating conditions, including recharging of air bottles, etc. In the case of surface control boost or power systems which automatically revert from main system pressure to emergency system pressure, main system pressure shall be reduced in the most detrimental manner, allowing the emergency pressure to automatically take over. System shall be inspected for smooth, continuous operations during the changeover. If the emergency provision

consists of dual systems that simultaneously operate an aircraft service, each system shall be operated with the opposite system inoperable (simulated) and the applicable service actuated. The actuated service shall function within design requirements at its most severe operating condition (e.g., lowest air bottle pressure).

4.1.2.5 *Time of operation* - Requirements for measuring the elapsed time of operation for full or half cycles in the foregoing test procedure shall be made. Such a measurement during ground tests is desirable and necessary in some services. The time as measured on the ground is unrealistic due to lack of wind, inertia, and similar loads. However, this item is to be considered in the preparation of the test procedure for comparison with production aircraft.

4.1.2.6 Brake systems - Where Type IV brake systems (as defined by MIL-B-8584) are installed, the following tests shall be performed:

(a) Normal system - Tests shall include a minimum of 25 rapid pumping operations of each brake pedal, with and without hydraulic power, to assure satisfactory brake operation under these conditions.

(b) Emergency system - Demonstrate that the required emergency operations are available.

4.1.3 Failure Mode Tests - Failure mode tests for the simulator shall evaluate the hydraulic system's capability to cope with all the following specified failures. Other failure modes shall be evaluated as determined during development of the aircraft.

(a) Loss of fluid in any system

(b) Loss of fluid pressure in any system

(c) Fluctuation of fluid pressure in any system

(d) Effect of air in the hydraulic system

(e) Loss of accumulator pressure

(f) Simulated combat damage capability as defined in aircraft specification

(g) Engine shut down

(h) Operation of all emergency procedures

(i) Failed relief valve or failed pump compensator

4.1.4 Mission Profile Test - The hydraulic system simulator shall operate in a procedure that resembles all the anticipated mission profiles. Mandatory tests are as follows with additional tests being added to demonstrate capability in more difficult mission profiles.

(a) Take-off - maximum speed mission intercept - landing

(b) Maximum time at idle and taxi, return to flight line and shut down. (No flight mode)

(c) Normal mission. Take-off, flight, landing

(d) Turbulent weather conditions. (constant control actuation)

(e) Inverted flight (partial) if applicable (may be demonstrated by special test)

(f) High altitude flight

(g) Zero "g" if applicable (may be demonstrated by special test)

4.1.5 Vibration Survey - During the operation of systems, visual and instrument data shall be collected on lines and component installations to ascertain the levels of acceleration forces induced in the hydraulic system by the different modes of operation. Particular attention must be paid to those areas of rotation components and those systems having high inertia loads. In addition, high frequency cyclic inputs (as AFCS system and flight control system) must be reviewed carefully.

4.1.6 Pressure Survey - Tests shall be performed to measure peak hydraulic system pressures such as those induced by high inertia loads and rapid system reversals, as in landing gear systems, etc. The test shall be conducted under the most adverse realistic mode of operation.

4.1.7 Pump Ripple Tests - The maximum stresses induced into lines and components as a result of any pressure ripple producing component

in the system shall be measured. The procedure must cover all pump speed ranges and multiple pump operation including start and stop to insure that no detrimental pressure pulsations exist in the hydraulic system. Resonant conditions must be tested for sufficient periods at each resonant frequency to ensure that the system has adequate fatigue life.

4.1.8 System Temperature Tests - System temperature tests shall be performed to compare the actual operational temperatures with the analytically predicted temperatures. All mission profiles shall be performed and monitored. Comparisons shall be made for each mission simulation. These tests may be coordinated with the mission profile tests, para. 4.1.4.

4.1.9 Post Test Inspection Tests - An inspection is required after each formal test. Data shall be recorded noting the conditions of the hydraulic system. The following minimum data must be taken immediately after shut down and compared with initial or predicted values.

(a) System temperatures

(b) Reservoir level

(c) Filter button position

(d) Accumulator gas charge

(e) Brake system condition

(f) Position of all actuators

(g) Leakage noted

(h) Filter bowl contents

(i) Contamination level of fluid

(j) Pressure and temperature in air bottles

(k) List of anomalies that occurred and disposition

4.1.10 Engine Compatibility Tests - When conducting compatibility tests of hydraulic components and systems with related engine functions, simulators and test stands shall be configured as follows:

(a) Line runs on the engine shall be identical to the aircraft including clamp location and hardware. Line runs from the engine to aircraft structure shall be simulated insofar as is practical.

(b) Only aircraft hydraulic components shall be used. Engine mounting shall be identical to the aircraft.

(c) The method of providing reservoir pressurization shall be identical to the aircraft.

4.1.10.1 During the performance of tests the following shall be determined:

(a) Temperature data on the entire hydraulic system shall be collected with particular attention paid to engine mounted lines and components.

(b) Line and component vibrations shall be recorded to ascertain the levels of acceleration forces induced in the hydraulic system by the different modes of operation.

(c) Pump flows, temperatures, and pressures shall be monitored.

(d) All failures shall be reported and the cause of failure analyzed. Component and fitting leakage shall be determined. Temperatures shall not exceed allowable maximums.

4.2 Aircraft Ground Cart Test - These tests shall be conducted in accordance with appropriate Military Specification (See Sec. 2.0) and the requirements of paragraph 3.2.

The following ground test equipment configuration shall be utilized:

(a) Hydraulic test stand - Ground hydraulic carts shall be available to supply sufficient pressure to perform the proof pressure and also sufficient flow to move surfaces to alternate position.

(b) External electric power supply - Aircraft electrical power shall be supplied by a ground cart or equivalent power source.

(c) Air Conditioning - Air conditioning shall be supplied to cool aircraft electronics during the tests. One NR-5B or equivalent ground air conditioning cart shall also be provided to be used as required to cool aircraft hydraulic systems.

(d) Switch boxes or other special equipment - Special equipment shall be provided as necessary to perform all required operations.

(e) Jacks - Suitable jacks shall be available to raise the aircraft, as required by the test.

The aircraft shall be placed in the following conditions:

(f) Aircraft Servicing - Reservoirs shall be serviced, accumulators charged, and all systems operable.

(g) Electrical power system - Verify all power is connected and all switches in their proper positions.

(h) Hydraulic system subsystem configuration - Position all systems to their proper positions.

4.2.1 Proof Pressure Test - Proof pressure as specified in para. 3.2.1 shall be applied to the hydraulic system to prove the integrity of connections at each component. Pressure shall be sustained for at least five minutes. After inspection for failures or leaks, system pressure shall be restored to normal pressure. All systems shall be placed in their alternate position and proof pressure applied again. After system has been inspected return system to its original condition.

4.2.2 System functional tests - When conducting these functional tests the designated ground cart shall be attached to the aircraft with the shortest practical lines and the systems shall be configured as follows:

(a) Configuration - Hydraulic system shall be adequately bled of entrapped air, and the system and reservoir(s) filled

to their specified level with applicable hydraulic fluid. All accumulators shall be properly serviced and the entire system, components, and attached linkages and mechanisms properly adjusted. Pneumatic systems shall be properly lubricated, with all system components and attach linkages and mechanisms properly adjusted. The aircraft shall be suitably elevated and safely anchored in place to permit full operation of all hydraulically or pneumatically operated services or units.

(b) Test equipment - The following test equipment shall be installed on the aircraft.

Calibrated pressure gages (mechanical or electronic), flowmeters, and other miscellaneous equipment as necessary. Suitable temperature-indicating equipment if artificial loading of any service is necessary, such as wing flaps, air brakes, surface control boost, or power systems, etc., adequate provision to accomplish such loading should be installed and calibrated.

4.2.2.1 Normal system test - Nominal system pressure shall be applied to the whole installation, and each selector and control valve shall be operated for at least two complete cycles of its corresponding service. In addition, each control unit shall be operated through an incomplete half cycle, followed by a complete reversal of direction. Definition - A cycle is interpreted to mean the full travel of a service from down (closed) to up (open) and return to original down (closed). A half cycle illustration would be a landing gear from down to up.

The above operation shall be accomplished through both directions of operation. During the above operations, inspection shall be made to determine whether:

(a) The various functions are accomplished satisfactorily in accordance with specification requirements.

(b) The movement of all components is smooth and positive.

(c) Relief valves, devices for automatic termination of an operation, pressure controls, switches and signals, audible or other warning devices, and similar components function as intended. (Relief valves shall not by-pass fluid during normal operation of any component).

(d) All indicating devices function and synchronize with the movement of their respective component as specified.

(e) The specified functioning pressures are controlled and not exceeded. This may need to be determined at only one or at numerous locations in the system, but should not receive major consideration at any point where unrealistic pressures are obtained on ground test as compared to entirely different pressures in flight condition, unless the unrealistic pressures exceed design proof pressures or adversely affect the system during operational use. Pressures may be obtained by normal system pressure gages, auxiliary mechanical gages, or electronic equipment as applicable. (Due consideration shall be given to this item, and the type of equipment to be used, in preparing the test procedure. See 5.3.1.)

(f) All tubing and fitting joints and component external seals are free of leaks. Allowable leakages of component external seals shall be defined by contractor test plan. (See 5.3.1.)

(g) All fluid lines, fittings, and components are free from excessive movement and chafing.

(h) There is a full engagement of mechanical locks and latches, and that hydraulic back pressure does not cause inadvertent unlocking.

(i) The clearance for all moving parts throughout the entire range of movement is such that fouling of adjacent parts cannot occur. (Particular attention shall be given to flexible connections to insure that pinching or stretching does not occur).

(j) All hydraulically or pneumatically operated doors and closures are flush with surrounding surfaces within limits provided by approved contractor's drawings for closed position.

(k) The movement of flaps is synchronized under load and no-load condition and there is no excess play in the flaps. Unsymmetrical loading is required during synchronized testing.

(l) Simulated normal flight operating conditions, or any possible inadvertent operation, will cause system malfunction.

(m) Values of operating temperatures (if applicable) and ambient temperature should be noted.

4.2.2.2 Fluid level - The following reservoir conditions shall be demonstrated as part of the functional tests:

(a) Low Level - The fluid in the reservoir(s) shall be set to the lowest permissible indicated level, and all the gas charge removed from the largest accumulator in the system and a minimum gas charge in all others. Reservoir pressurization, if applicable, should be set to the low limit of the normal pressurization range. The controls should then be operated at least once through the normal sequence of operations. The control valves should be set to simulate normal flight operation, whereby the minimum amount of fluid is returned to the reservoir. For "gas to fluid in contact" type reservoirs, the pump suction line opening shall be checked for any possibility that the opening has been uncovered and air introduced into the system. "Gas fluid separation" type reservoirs shall be checked to determine that the pump inlet pressure will not be less than the recommended minimum values. There is no counterpart of this test for pneumatic systems.

(b) Overfill Test - Reservoir shall be filled to an overflow condition. A normal sequence of operation from taxi, take-off, landing, to part and shut down shall be simulated. No damage to reservoir or other components shall be noted. Fluid loss to the extent of the overfill is allowed.

4.2.2.3 Hand or auxiliary pump operations - Where hand pump, or auxiliary pump operations are applicable, each service must be operated through at least one complete cycle. Any applicable items recorded or inspected under para. 4.2.2.1 should be duplicated herein. The number of cycles of hand pump operation required for functioning with each part of the system shall be recorded. Where the force required to operate the hand pump appears to be excessive, the amount of this force shall be measured

with a spring scale and recorded. Care shall be taken in this test not to overheat electric motors driving pumps if such motors are not of the continuous duty type.

4.2.2.4 Emergency Operations - All emergency functions normally operated by hydraulic systems shall be tested. Maintenance necessary to bleed or reset the system to normal operating conditions, including recharging of air bottles, etc., shall be recorded. In the case of surface control boost or power systems which automatically revert from main system pressure to emergency system pressure, main system pressure shall be reduced in the most detrimental manner, allowing the emergency pressure to automatically take over. System shall be inspected for smooth, continuous operation during the change-over. If the emergency provision consists of dual systems that simultaneously operate an aircraft service, each system shall be operated with the opposite system inoperable (simulated) and the applicable service actuated. The actuated service shall function within design requirements at its most severe operating condition (i.e., lowest air bottle pressure).

4.2.2.5 Time of Operation - Requirements for measuring the elapsed time of operation for full or half cycles in the foregoing test procedure shall be made. Such a measurement during ground tests is desirable and necessary in some services. The time as measured on the ground is unrealistic due to lack of wind, inertia, and similar loads. However, this item is to be considered in the preparation of the test procedure for comparison with production aircraft.

4.2.2.6 Brake Systems - Where Type IV brake systems (as defined by MIL-B-8584) are installed, the following tests shall be performed:

(a) Normal system - Test shall include a minimum of 25 rapid pumping operations of each brake pedal, with and without hydraulic power, to assure satisfactory brake operation under these conditions.

(b) Emergency system - Demonstrate that the required emergency operations are available.

4.2.3 Peak Pressure Test - Tests shall be performed to measure peak hydraulic system pressures such as those induced by high inertia loads and rapid system reversals, as in landing gear systems, etc. The test shall be conducted under the most adverse realistic mode of operation.

4.2.4 Pump Ripple Tests - The maximum stresses induced into lines and components as a result of any pressure ripple-producing component in the system shall be measured. The procedure must cover all pump speed ranges including start and stop to insure that no detrimental pressure pulsations exist in the hydraulic system. Resonant conditions must be tested for extended periods at each resonant frequency to ensure that the system has adequate fatigue life.

4.2.5 Post Test Inspection - A post flight inspection is required after each formal test. Data shall be recorded noting the conditions of the hydraulic system. The following minimum data must be taken immediately after shut down and compared with initial or predicted values.

(a) System temperature

(b) Reservoir level

(c) Filter button position

(d) Accumulator gas charge

(e) Brake system condition

(f) Position of all actuators

(g) Leakage noted

(h) Filter bowl contents

(i) Contamination level of fluid

(j) Pressure and temperature in air bottles

(k) List of anomalies that occurred and disposition

4.3 New Aircraft Varidrive Operation Test Method

The tests shall be conducted in accordance with the appropriate Military Specification (see Sect. 2.0) and the requirements of paragraph 3.3 also with the following aircraft configuration and test equipment installed:

(a) Aircraft Configuration - Varidrive - varidrive driven aircraft pumps shall be installed in approximately the normal pump position in the aircraft. Hydraulic system shall be adequately bled of entrapped air, and the system and reservoir(s) filled to their specified level with applicable hydraulic fluid. All accumulators shall be properly serviced and the entire system, components, and attached linkages and mechanisms properly adjusted. Pneumatic systems shall be properly lubricated, with all system components and attached linkages and mechanisms properly adjusted. The aircraft shall be suitably elevated and safely anchored in place to permit full operation of all hydraulically or pneumatically operated services or units.

(b) Test Equipment - Calibrated pressure gages (mechanical or electronic), flowmeters, and other miscellaneous equipment as necessary. Suitable temperature-indicating equipment. If artificial loading of any service is necessary, such as wing flaps, air brakes, surface control boost, or power systems, etc., adequate provisions to accomplish such loading should be installed and calibrated.

4.3.1 Functional Testing - Functional testing shall consist of the following tests:

4.3.1.1 Normal system test - Nominal system pressure shall be applied to the whole installation, and each selector and control valve shall be operated for at least two complete cycles of its corresponding service. In addition, each control unit shall be operated through an incomplete half cycle, followed by a complete reversal of direction. Definition - A cycle is interpreted to mean the full travel of a service from down (closed) to up (open) and return to original down (closed). A half cycle illustration would be a landing gear from down to up.

The above operation shall be accomplished through both directions of operation. During the above operations, inspection shall be made to determine whether:

(a) The various functions are accomplished satisfactorily in accordance with specification requirements.

(b) The movement of all components is smooth and positive.

(c) Relief valves, devices for automatic termination of an operation, pressure controls, switches and signals, audible or other warning devices, and similar components function as intended. (Relief valves shall not by-pass fluid during normal operation of any component.)

(d) All indicating devices function and synchronize with the movement of their respective component as specified.

(e) The specified functioning pressures are controlled and not exceeded. This may need to be determined at only one or at numerous locations in the system but should not receive major consideration at any point where unrealistic pressures are obtained on ground test as compared to entirely different pressures in flight condition, unless the unrealistic pressures exceed design proof pressures or adversely affect the system during operational use. Pressures may be obtained by normal system pressure gages, auxiliary mechanical gages, or electronic equipment as applicable. (Due consideration shall be given to this item, and the type of equipment to be used, in preparing the test procedure. See 5.3.1.)

(f) All tubing and fitting joints and component external seals are free of leaks. Allowable leakages of component external seals shall be defined by contractor test plan. (See 5.3.1.)

(g) All fluid lines, fittings, and components are free from excessive movement and chafing.

(h) There is a full engagement of mechanical locks and latches, and that hydraulic back pressure does not cause inadvertent unlocking.

(i) The clearances for all moving parts throughout the entire range of movement is such that fouling of adjacent parts cannot occur. (Particular attention shall be given to flexible connections to insure that pinching or stretching does not occur).

(j) All hydraulically or pneumatically operated doors and closures are flush with surrounding surfaces within limits provided by approved contractor's drawings for closed position.

(k) The movement of flaps is synchronized under load and no-load condition and there is no excess play in the flaps. Unsymmetrical loading is required during synchronized testing.

(l) Simulated normal flight operating conditions, or any possible inadvertent operation, will cause system malfunction.

(m) Values of operating temperatures (if applicable) and ambient temperature should be noted.

4.3.1.2 Fluid Level - The following reservoir conditions shall be demonstrated as part of the functional tests:

(a) Low level - The fluid in the reservoir(s) shall be set to the lowest permissible indicated level, and all the gas charge removed from the largest accumulator in the system and a minimum gas charge in all others. Reservoir pressurization, if applicable, should be set to the low limit of the normal pressurization range. The controls should then be operated at least once through the normal sequence of operations. The control valves should be set to simulate normal flight operation, whereby the minimum amount of fluid is returned to the reservoir. For "gas to fluid in contact" type reservoirs, the pump suction line opening shall be checked for any possibility that the opening has been uncovered and air introduced into the system. "Gas-fluid separation" type reservoirs shall be checked to determine if pump inlet pressures approached below minimum values. There is no counterpart of this test for pneumatic systems.

(b) Overfill test - Reservoir shall be filled to overflow condition. A normal sequence of operation from taxi, take-off, landing, to park, and shut down shall be simulated. No damage to reservoir or other components shall be noted. Fluid loss to the extent of the overfill is allowed.

4.3.1.3 Hand or auxiliary pump operations - Where hand pump, or auxiliary pump operations are applicable, each service must be operated through at least one complete cycle. Any applicable items recorded or inspected under para. 4.3.1.1 should be duplicated herein. In addition, any inadvertent fluid transfer between reservoirs, if applicable, should be noted for necessary correction. The number of cycles of hand pump operation required for functioning with each part of the system shall be recorded. Where the force required to operate the hand pump appears to be excessive, the amount of this force shall be measured with a spring scale and recorded. Care shall be taken in this test not to overheat electric motors driving pumps if such motors are not of the continuous duty type.

4.3.1.4 Emergency Operations - All emergency functions normally operated by hydrualic systems shall be tested. Maintenance necessary to bleed or reset the system to normal operating conditions, including recharging of air bottles, etc., shall be recorded. In the case of surface control boost or power systems which automatically revert from main system pressure to emergency system pressure, special consideration shall be given to suddenly reducing main system pressure allowing the emergency pressure to automatically take over. The system shall be inspected for smooth, continuous operation during the change-over. If the emergency provision consists of dual systems that simultaneously operate an aircraft service, each system shall be operated with the opposite system inoperable (simulated) and the applicable service actuated. The actuated service shall function within design requirements at its most severe operating condition (i.e., lowest air bottle pressure).

4.3.1.5 Time of operation - Requirements for measuring the elapsed time of operation for full or half cycles in the foregoing test procedure shall be made. Such a measurement during ground tests is desirable and necessary in some services. The time as measured on the ground is unrealistic due to lack of wind, inertia, and similar loads. However, this item is to be considered in the preparation of the test procedure for comparison with production aircraft.

4.3.1.6 Brake systems - Where Type IV brake systems (as defined by MIL-B-8584) are installed, the following tests shall be performed.

(a) Normal system - Test shall include a minimum of 25 rapid pumping operations of each brake pedal, with and without hydraulic power, to assure satisfactory brake operation under these conditions.

(b) Emergency system - Demonstrate that the required emergency operations are available.

4.3.2 Mission profile and failure mode tests - These two tests shall be conducted in accordance with the appropriate Military Specification (See Sect. 2.0) and the requirements of paragraph 3.3.2.

4.3.2.1 Mission Profile Tests - The hydraulic system shall operate in a procedure that resembles all the anticipated mission profiles. Mandatory tests are as follows with additional tests being added to demonstrate capability in more difficult mission profiles.

(a) Take-off - maximum speed mission intercept-landing

(b) Maximum time at idle and taxi, return to flight line and shut down. (No flight mode.)

(c) Normal mission. Take-off, flight, landing

(d) Turbulent weather conditions. (Constant control actuation)

(e) Inverted flight (partial) if applicable. (May be demonstrated by special test)

(f) High altitude flight

(g) Zero "g" if applicable (May be demonstrated by special test)

(h) Loss of accumulator pressure

(i) Simulated combat damage capability as defined in aircraft specification.

(j) Engine shut down

(k) Operation of all emergency procedures

(l) Failed relief valve or failed pump compensator

4.3.2.2 Failure Mode Test - Failure mode tests for the aircraft shall evaluate the hydraulic system's capability to cope with all the following specified failures as a minimum. Other failure modes shall be evaluated as determined during development of the aircraft.

(a) Loss of fluid in any system

(b) Loss of fluid pressure in any system

(c) Fluctuation of fluid pressure in any system

(d) Effect of air in the hydraulic system

4.3.3 Vibration Survey - During the operation of systems, visual and instrument data shall be collected on lines and component installations to ascertain the levels of acceleration forces induced in the hydraulic system by the different modes of operation. Particular attention must be paid to those areas of rotation components and those systems having high inertia loads. In addition, high frequency cyclic inputs (as AFCS system and flight control system) must be reviewed carefully.

4.3.4 Peak Pressure Test - Tests shall be performed to measure peak hydraulic system pressures such as those induced by high inertia loads and rapid system reversals, as in landing gear system, etc. The test shall be conducted under the most adverse realistic mode of operation.

4.3.5 Pump Ripple Tests - The maximum stresses induced into lines and components as a result of any pressure ripple producing components in the system shall be measured. The procedure must cover all pump speed ranges and multiple pump operation including start and stop to insure that no detrimental pressure pulsations exist in the hydraulic system. Resonant conditions must be tested for sufficient periods at each resonant frequency to ensure that the system has adequate fatigue life. (Refer to MIL-STD-810 for vibration requirements.)

4.3.6 System Temperature - System temperature tests shall be performed to compare the actual operational temperatures with the analytically predicted temperatures. All mission profiles shall be performed and monitored. Comparisons shall be made for each mission simulation. These tests may be coordinated with the mission profile tests, para. 4.3.2.1.

4.3.7 Post Test Inspection - A post flight inspection is required after each formal test. Data shall be recorded noting the conditions of the hydraulic system. The following minimum data must be taken immediately after shut down and compared with initial or predicted values.

(a) System temperatures

(b) Reservoir level

(c) Filter button position

(d) Accumulator gas charge

(e) Brake system condition

(f) Position of all actuators

(g) Leakage noted

(h) Filter bowl contents

(i) Contamination level of fluid

(j) Pressure and temperature in air bottle

(k) List of anomalies that occurred and disposition

4.4 Aircraft Engine Operation Test - These tests shall be conducted in accordance with the appropriate Military Specification (see Sect. 2.0) and in accordance with Paragraph 3.4; also with the following aircraft configuration and test equipment installed:

(a) Aircraft Configuration - The hydraulic system shall be adequately bled of entrapped air and the system and reservoir(s) filled to their specified level with applicable hydraulic fluid. All accumulators shall be properly serviced and the entire system, components, and attached linkages and mechanisms properly adjusted. Pneumatic systems shall be properly lubricated with all system components and attached linkages and mechanisms properly adjusted. The aircraft shall be safely anchored in place to permit full operation of hydraulically or pneumatically operated services or units.

(b) Test Equipment - Calibrated pressure gages (mechanical or electronic), flowmeters, and other miscellaneous equipment as necessary. In addition, suitable temperature indicating equipment.

4.4.1 Functional Testing - Functional testing shall consist of the following tests:

4.4.1.1 Normal system test - Nominal system pressure shall be applies to the whole installation, and each selector and control valve shall be operated for at least two complete cycles of its corresponding service. In addition, each control unit shall be operated through an incomplete half cycle, followed by a complete reversal of direction. Definition - A cycle is interpreted to mean the full travel of a service from down (closed) to up (open) and return to original down (closed). Landing gear or any other system which jeopardizes the aircraft can be tested and accepted on prior tests.

The above operation shall be accomplished through both directions of operation. During the above operations, inspection shall be made to determine whether:

(a) The various functions are accomplished satisfactorily in accordance with specification requirements.

(b) The movement of all components is smooth and positive.

(c) Relief valves, devices for automatic termination of an operation, pressure controls, switches and signals, audible or other warning devices, and similar components function as intended. (Relief valves shall not by-pass fluid during normal operation of any component).

(d) All indicating devices function and synchronize with the movement of their respective components as specified.

(e) The specified functioning pressures are controlled and not exceeded. This may need to be determined at only one or at numerous locations in the system, but should not receive major consideration at any point where unrealistic pressures are obtained on ground test as compared to entirely different pressures in flight condition, unless the unrealistic pressures

exceed design proof pressures or will adversely affect the system during operational use. Pressures may be obtained by normal system pressure gages, auxiliary mechanical gages, or electronic equipment as applicable. (Due consideration shall be given to this item, and the type of equipment to be used, in preparing the test procedure. See 5.3.1.)

(f) All tubing and fitting joints and component external seals are free of leaks. Allowable leakages of component external seals shall be defined by contractor test plan. (See 5.3.1.)

(g) All fluid lines, fittings, and components are free from excessive movement and chafing.

(h) There is a full engagement of mechanical locks and latches, and that hydraulic back pressure does not cause inadvertent unlocking.

(i) The clearance for all moving parts throughout the entire range of movement is such that fouling of adjacent parts cannot occur. (Particular attention shall be given to flexible connections to insure that pinching or stretching does not occur.)

(j) All hydraulically or pneumatically operated doors and closures are flush with surrounding surfaces within limits provided by approved contractor's drawing for closed position.

(k) The movement of flaps is synchronized and thers is no excess play in the flaps.

(l) Simulated normal flight operating conditions, or any possible inadvertent operation, will cause system malfunction.

(m) Values of operating temperature (if applicable) and ambient temperature should be noted.

4.4.1.2 Fluid Level - The following reservoir conditions shall be demonstrated as part of the functional tests.

(a) Low level - The fluid in the reservoir(s) shall be set to the lowest permissible indicated level, and all the gas charge removed from the largest accumulator in the system and a minimum gas charge in all others. Reservoir pressurization, if applicable, should be set to the low limit of the normal pressurization range. The controls should then be operated at least once through the normal sequence of operations. The control valves should be set to simulate normal flight operation, whereby the minimum amount of fluid is returned to the reservoir. For "gas to fluid in contact" type reservoirs, the pump suction line opening shall be checked for any possibility that the opening has been uncovered and air introduced into the system. "Gas fluid separation" type reservoirs shall be checked to determine that the pump inlet pressure will not be less than the recommended minimum values. There is no counterpart of this test for pneumatic systems.

(b) Overfill test - Reservoir shall be filled to overflow condition. A normal sequence of operation from taxi, take-off, landing, to park and shut down shall be simulated. No damage to reservoir or other components shall be noted. Fluid loss to the extent of the overfill is allowed.

4.4.1.3 Hand or auxiliary pump operations - Where hand pump, or auxiliary pump operations are applicable, each service must be operated through at least one complete cycle. Any applicable items recorded or inspected under para. 4.4.1.1 should be duplicated herein. In addition, any inadvertent fluid transfer between reservoirs, if applicable, should be noted for necessary correction. The number of cycles of hand pump operation required for functioning with each part of the system shall be recorded. Where the force required to operate the hand pump appears to be excessive, the amount of this force shall be measured with a spring scale and recorded. Care shall be taken in this test not to overheat electric motors driving pumps if such motors are not of the continuous duty type.

4.4.1.4 Emergency Operations - All emergency functions normally operated by hydraulic systems shall be tested. Maintenance necessary to bleed or reset the system to normal operating conditions, including recharging of air bottles, etc. shall be recorded. In the case of surface control boost or power systems which automatically revert from main system pressure to emergency system pressure, main system pressure shall be reduced in the most detrimental manner, allowing the emergency pressure

to automatically take over. The system shall be inspected for smooth, continuous operation during the change-over. If the emergency provisions consist of dual systems that simultaneously operate an aircraft service, each system shall be operated with the opposite system inoperable (simulated) and the applicable service actuated. The actuated service shall function within design requirements at its most severe operating condition (i.e., lowest air bottle pressure).

4.4.1.5 Time of operation - Requirements for measuring the elasped time of operation for full or half cycles in the foregoing test procedure shall be made. Such a measurement during ground tests is desirable and necessary in some services. The time as measured on the ground is unrealistic due to lack of wind, inertia, and similar loads. However, this item is to be considered in the preparation of the test procedure for comparison with production aircraft.

4.4.1.6 Brake systems - Where Type IV brake systems (as defined by MIL-B-8584) are installed, the following tests shall be performed:

(a) Normal system - Test shall include a minimum of 25 rapid pumping operations of each brake pedal, with and without hydraulic power, to assure satisfactory brake operation under these conditions.

(b) Emergency system - Demonstrate that the required emergency operations are available.

4.4.2 Vibration Survey - During the operation of systems, visual and instrument data shall be collected on lines and component installations to ascertain the levels of acceleration forces induced in the hydraulic system by the different modes of operation. Particular attention must be paid to those areas of rotation components and those systems having high inertia loads. In addition, high frequency cyclic inputs (as AFCS system and flight control system) must be reviewed carefully.

4.4.3 Pump Ripple Tests - A pump ripple test plan shall be submitted that reviews the stresses induced into lines and components as a result of any pressure ripple producing component in the system. (See 5.3.1.) The procedure must cover all pump speed ranges and multiple pump operation including start and stop to insure that no detrimental pressure pulsations exist in the hydraulic system. Resonant conditions must be tested for sufficient periods at each resonant frequency to ensure that the system had adequate fatigue life. (Refer to MIL-STD-810 for vibration requirements.)

4.4.4 System Temperature Tests - A system temperature ground test shall be performed to compare the actual operational temperatures with the analytically predicted temperatures.

4.4.5 Post Test Inspection - A post flight inspection is required after each formal test. Data shall be recorded noting the conditions of the hydraulic system. The following minimum data must be taken after shut down and compared with initial or predicted values..

(a) System temperatures (continue monitoring after engine shut down and record maximum temperature)

(b) Reservoir level

(c) Filter button position

(d) Accumulator gas charge

(e) Brake system condition

(f) Position of actuators

(g) Leakage noted

(h) Filter bowl contents

(i) Contamination level of fluid

(j) Pressure and temperature in air bottles

(k) List of anomalies that occurred and disposition

4.5 Aircraft Flight Test - These tests shall be conducted in accordance with the appropriate Military Specification (see Sect. 2.0) and paragraph 3.5; also with the following aircraft configuration and test instrumentation.

(a) Aircraft Systems Configuration - The hydraulic system shall be adequately bled of entrapped air, and the system and reservoir(s) filled to their specified level with applicable hydraulic fluid. All accumulators shall be

properly serviced and the entire system, components, and attached linkages and mechanisms properly adjusted. Pneumatic systems shall be properly lubricated, with all system components and attached linkages and mechanisms properly adjusted.

(b) Aircraft Instrumentation - The aircraft shall be instrumented to measure and record (manually or automatically as applicable) all necessary pressures (operation peak or surge as applicable), ambient air and system temperatures, time of operation, and other data required on any individual system. The system(s) shall be properly serviced for adjustments, normal fluid level, bleeding of air, etc. All necessary special components, by-pass circuits, etc., as required, shall be installed and checked for proper and safe function. Those areas of the aircraft which are suspect as "high vibration" areas shall be monitored to automatically record "g" forces and vibration levels.

4.5.1 Pre-Flight Check - With engine power on and prior to taxi, all applicable services (except landing gear) shall be operated through a complete cycle to insure proper operation. As a result of this check, the suitability of the aircraft to continue the flight tests shall be determined.

4.5.2 Taxi Tests - The aircraft shall be taxied to a speed equal to the landing speed, if safe, and provided conditions allow. Both normal and emergency brake systems shall be applied. The brakes shall function satisfactorily under each system. The steering system, if provided, and any other service intended for use during taxiing or landing and take-off ground conditions shall also be operated in their normal and emergency manner. These services shall function satisfactorily under each applicable system.

4.5.3 Functional Flight Test - During flight, each of the services, as applicable and as defined below, shall be operated with the normal hydraulic system three times at each of the following altitudes. The aircraft shall fly at a conservative speed, not approaching maximum speed.

(a) Minimum safe altitude

(b) Operational ceiling as defined in aircraft detail specifications, or that intermediate altitude which would present more severe conditions.

NOTE: For the above test, operation of the services should be made at the end of a simulated operational mission wherever possible. In any event, the aircraft should be flown until system temperatures have stabilized prior to testing.

4.5.3.1 Pressures - Operating, peak, or surge pressures shall be measured. (Type of gage used must be noted.) Determine that all services and the power system(s) function within their design pressure limitations. Consideration shall be given, during the tests, to checking also hydraulic reservoir supercharging pressure, if applicable, variation of pressurization with flight and altitude conditions, hydraulic pump(s) inlet, outlet, and drain, or by-pass pressures. In emergency pneumatic systems the pressure of the stored gas shall be measured.

4.5.3.2 Temperature - Highest and lowest stabilized operating temperature at all critical points and anticipated hottest and coldest points in the systems shall be determined and identified with corresponding data, such as compartment air temperature, outside air temperature, and aircraft speed. In a hydraulic system, at least the reservoir inlet and outlet temperatures, pump outlet and bypass fluid temperatures, and heat exchanger inlet and outlet temperatures are considered important, plus any portion of the system which is considered critical due to high or restricted flow, low heat transfer conditions, proximity to sources of heat producing equipment, etc. In emergency pneumatic systems the pressure temperature of the stored gas shall be measured. It shall be demonstrated that the temperatures do not exceed those to which the components of the system are designed, with consideration given to the percentage of operating time expected to be encountered at the various temperatures and conditions. The temperatures recorded shall be converted to the standard 100° F hot day and listed in the chart noted as Figure 2.

4.5.3.3 Time of operation - The time of operation of all services shall be determined, in each case, under a flight condition which duplicates as near as practical the average expected design conditions. The following specific operations shall be checked for time of operation as follows:

LOCATION	GROUND OPERATION OAT °F				FLIGHT OPERATION								ENGINE SHUTDOWN OAT °F			
	TEMP °F				TEMP °F								SOAK TEMP °F			
	COMP STRUCT	COMP AIR	FLUID 1/ 2/	TOTAL TIME MIN 3/	COMP STRUCT	COMP AIR	FLUID 1/ 2/	PUMP RPM	MACH NO.	TOTAL TIME MIN 3/	ALT	OAT °F	COMP STRUCT	COMP AIR	FLUID 1/ 2/	TOTAL TIME MIN 3/
RESERVOIR																
PUMP PRESS LINE																
ACCUMULATOR																
_____																
_____																
_____																
_____																

1/ RECORDED.
2/ CONVERTED TO 100° F STANDARD HOT DAY.
3/ TOTAL TIME AT MAXIMUM TEMPERATURE.

METHOD USED BY CONTRACTOR TO DETERMINE THE VALUES OBTAINED UNDER THE 100° F STANDARD HOT-DAY TEMPERATURES:
(STATE METHOD USED)

FIGURE 2. Ground and flight test hydraulic system maximum temperatures

(a) Landing gear retraction under flow conditions representing take-off rpm of engine(s) and flight attitude, at design take-off indicated air speed (IAS), and near ground level. Temperature of the entire landing gear system must be warmer than -20° F at the time of this test. This can be accomplished if necessary by cycling the gear in flight to warm it up. Actual ambient air and applicable hydraulic system temperature shall be determined. The sequence of operation of the various landing gear elements (main gear, nose gear, tail wheel, etc.) shall be noted. Time should start when landing gear control lever is actuated, and stop when gear is up and locked and all fairing doors closed.

(b) Landing gear extension, with normal system, shall be under normal approach engine rpm, and at placard IAS. System temperature and sequence of operation of landing gear elements shall be recorded. Time should start when gear control is actuated and stop when all gears are down and locked.

4.5.3.4 Symmetrical lift and drag devices - All such hydraulically or pneumatically operated devices, which consist of two or more surfaces or panels designed to operate together, shall be tested for synchronous operation in flight. The device shall be operated while the aircraft is in a sideslip, or other manner, which will induce maximum safe unsymmetrical loading on the separate panels or surfaces. Any unsynchronized operation of any device shall be measured.

4.5.3.5 Surface control boost or power systems - All such systems shall be operated under all possible extremes of flight attitude, speed, and altitude to insure safe, smooth operation under normal power. Bypass valves, system shut-off valves and devices, or automatic devices to revert operation from normal system to emergency system must be operated in flight with simulated normal system failure, to check the suitable operation of such devices and to prove that the aircraft is controllable during and after the change in system power. Compliance with MIL-F-8785 shall be shown.

4.5.3.6 Fluid level - For "gas-fluid in contact" type reservoirs the pump suction line opening shall be checked for any possibility that the opening had been uncovered and air introduced into the system. For gas-fluid separation types, minimum pump inlet pressures shall be measured. This test must be conducted with the lowest permissible fluid level in the

reservoir. To simulate this condition; first, the fluid should be drained to lowest permissible level, then the air should be removed from accumulators as was done in 4.4.1.2 or from as many as safe flight conditions will permit up to half the applicable accumulators.

4.5.3.7 Possible malfunctions - The operation of all control valves shall be checked for possible malfunctions. Such as each control unit shall be operated through the incomplete half cycle, followed by a complete reversal of direction. This operation shall be accomplished through both directions of operation.

4.5.3.8 Hand or auxiliary pump operation - Hand or auxiliary pumps shall be used to operate all designated services at applicable conditions. If necessary, power pumps may be bypassed for this test. (A directional control valve may be employed to bypass the pump output to the reservoir.)

4.5.3.9 Emergency system operation - There shall be at least one operation of all applicable services by all emergency systems. All pneumatically operated services shall be checked as to the number of consecutive full cycles of operation possible before the air bottle(s) are discharged to a pressure below which operation is impossible. This should be accomplished at both altitudes referred to in 4.5.3 and any other applicable conditions. For services actuated by multiple systems in simultaneous operation, each system shall be tested with the other system(s) failed (simulated). Services operated by multiple systems shall be operated to the lowest level of design redundancy.

4.5.3.10 Self-contained hydraulic systems - Applicable features of the tests herein specified shall be employed for the testing of gun drive, radar drives powered by wire servo actuating packages, and any other such type external store system.

4.5.3.11 Zero or negative "g" performance - The satisfactory performance of all applicable systems shall be demonstrated at "g" levels within the design envelope of the aircraft unless analysis proves performance at these levels is not critical.

4.5.4 Failure modes - Failure modes shall be simulated in flight to evaluate the hydraulic system's capability to cope with specified failures.

4.5.5 Flight Capability - The hydraulic system's satisfactory operation shall be demonstrated for flight conditions critical to the hydraulic system. The conditions listed below shall be considered.

(a) Taxi

(b) Take off

(c) Climb

(d) Cruise

(e) Service ceiling

(f) Max. speed

(g) Inverted maneuvers, if applicable

(h) Idle descent

(i) Turbulent

(j) Landing

(k) Hover, if applicable

(l) Cargo handling, equipment operation

(m) Auto. rotation

4.5.6 Vibration Survey - During the operation of systems, instrument data shall be collected on selected lines and component installations to ascertain the levels of acceleration forces induced in the hydraulic system by the different modes of operation. Particular attention must be paid to high speed components and those systems having high inertia loads. In addition, high frequency cyclic inputs (as AFCS systems and flight control system) must be reviewed carefully.

4.5.7 Post Flight Inspection - A post flight inspection is required after each flight test. Data shall be recorded noting the conditions of the hydraulic system. The following minimum data must be taken after shut down and compared with initial or predicted values:

(a) System temperatures

(b) Reservoir level

(c) Filter button condition or position

(d) Accumulator gas charge

(e) Brake system condition

(f) Position of all actuators

(g) Leakage noted

(h) Filter bowl contents

(i) Contamination level of fluid

(j) Pressure and temperature in air bottles

(k) List of anomalies that occurred and disposition

5. NOTES

5.1 Intended use - This specification is for use in determining methods for testing aircraft hydraulic and emergency pneumatic systems.

5.1. Application - The hydraulic or emergency pneumatic system tests required by this specification are to be made on the installed system. When the hydraulic or pneumatic system, or subsystems thus tested, are changed before installation in service test or production aircraft in such manner as to require retest, in the opinion of the contractor or the procuring activity, such retests shall be performed.

5.2 Information for contracting officer - Contracts or orders should specify the following:

(a) Title, number, revision, and date of this specification.

(b) Items of data required (see 5.3)

5.3 Contract data requirements - Items of deliverable data required by this specification are cited in the following paragraphs:

Paragraph	Data Requirement	Applicable DID
5.3.1	Preparation & Submittal of Test Procedure	*
5.3.2	Preparation of Report	*

Such data will be delivered as described on approved (numbered) DID's (Data Item Description/DD Form 1664) when specified on DD Form 1423 (Contract Data Requirements List) and incorporated into the applicable contract.

5.3.1 Preparation and submittal of test procedure

5.3.1.1 Preparation - A detailed test procedure, applicable to the particular aircraft, shall be prepared by the contractor to cover all ground and flight tests required by this specification. Test procedures shall also cover type, use or function, and any applicable limitations of test equipment used, and all special procedures or modifications necessary in the system to perform the required tests. Systems in present aircraft are often too complicated and diversified in function to allow the use of a standard test procedure for every design. Each contractor can evolve a specific test procedure for his individual aircraft's hydraulic and/or pneumatic system.

Where methods or tests other than those described or suggested herein are used, they shall be briefly described and submitted for comparisons with the known standard procedures.

5.3.1.2 Approval - The Contractor's detailed test procedure shall be submitted to the applicable service for approval consistent with the data submittal requirements.

5.4 Preparation of report - Consistent with the data submittal requirements, a final report shall be submitted giving full details of the equipment tested and the results obtained. This report should be in paragraph form and should follow, as nearly as practicable, the logical sequence and the headings and sub-headings of the tests outlined herein, and in the Contractor's test procedure as approved by the procuring activity. Temperature data noted in figure 1 shall be included in the above report. Where required tests are not performed, substantiating data must be submitted as a part of this report.

5.5 Changes from previous issue - Asterisks are not used in this revision to identify changes with respect to the previous issue, due to the extensiveness of the changes.

Custodians:

Navy - AS
Air Force - 11
Army - AV

Review Activities:

Air Force - 71
Army - MI

Preparing Activity:

Navy - AS
(Project No. 1650-0325)

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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

OMB Approval
No. 22-R255

INSTRUCTIONS: The purpose of this form is to solicit beneficial comments which will help achieve procurement of suitable products at reasonable cost and minimum delay, or will otherwise enhance use of the document. DoD contractors, government activities, or manufacturers/ vendors who are prospective suppliers of the product are invited to submit comments to the government. Fold on lines on reverse side, staple in corner, and send to preparing activity. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements. Attach any pertinent data which may be of use in improving this document. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity.

DOCUMENT IDENTIFIER AND TITLE
MIL T 55220

NAME OF ORGANIZATION AND ADDRESS

CONTRACT NUMBER

MATERIAL PROCURED UNDER A
☐ DIRECT GOVERNMENT CONTRACT ☐ SUBCONTRACT

1. HAS ANY PART OF THE DOCUMENT CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?
   A. GIVE PARAGRAPH NUMBER AND WORDING.

   B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES

2. COMMENTS ON ANY DOCUMENT REQUIREMENT CONSIDERED TOO RIGID

3. IS THE DOCUMENT RESTRICTIVE?
   ☐ YES ☐ NO *(If "Yes", in what way?)*

4. REMARKS

SUBMITTED BY *(Printed or typed name and address - Optional)*

TELEPHONE NO.

DATE

DD FORM 1 JAN 72 1426 REPLACES EDITION OF 1 JAN 68 WHICH MAY BE USED

S/N 0102-014-1802

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