



AEROSPACE INFORMATION REPORT

AIR5696™**REV. A**

Issued 2006-09
Reaffirmed 2013-11
Stabilized 2019-09

Superseding AIR5696

Aerospace Fluid Power - FAA Regulatory History -
Transport Airplane Hydraulic Systems

RATIONALE

This document has been determined to contain interesting History and associated details still relevant as is for the industry. It is proposed by the committee to stabilize.

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1. SCOPE

This SAE Aerospace Information Report (AIR) contains regulatory and guidance information related to transport airplane hydraulic systems. It contains certain Civil Air Regulations (CAR) and Federal Aviation Regulations (formerly referred to as FARs) from Title 14 Code of Federal Regulations (CFR) in their current version as well as the historical versions. This gives the reader an ability to assemble certain CAR/CFR parts as they existed at any date in the past (referred to as a Regulatory Basis). A certain amount of preamble explanatory material is included, which led to the regulatory rule changes (Amendments to the CFR).

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 5096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AS1241	Fire-Resistant Phosphate Ester Hydraulic Fluid for Aircraft
AIR1899	Aircraft Hydraulic System Characteristics
ARP4752	Aerospace - Design and Installation of Commercial Transport Aircraft Hydraulic Systems

2.1.2 U.S. Government Publications

Available from the Superintendent of Documents, Government Printing Office, Washington, DC 20402-0001, <http://bookstore.gpo.gov>; Phone: toll-free (866) 512-1800.

Title 14, Code of Federal Regulations (14 CFR) part 25 - Airworthiness Standards: Transport Category Airplanes

2.2 Applicable References

Civil Air Regulations Part 04 Airplane Airworthiness Transport Categories: Effective November 9, 1945

Civil Air Regulations Part 04b Airplane Airworthiness Transport Categories: Effective Nov 22, 1946

Civil Air Regulations Part 4b Airplane Airworthiness Transport Categories: Effective May 1, 1949

Civil Air Regulations Part 514 Technical Standard Order, Effective October 12, 1951

Civil Aeronautics Manual (CAM) 4b Airplane Airworthiness Transport Categories: Effective January 1, 1958

Part 514, Technical Standard Order TSO-C75 - Hydraulic Hose Assemblies, Effective September 4, 1963

Title 14, Code of Federal Regulations (14 CFR) part 37 - TSO-C75 - Hydraulic Hose Assemblies, 11-17-64

Title 14, Code of Federal Regulations (14 CFR) part 25 Airworthiness Standards: Transport Category Airplanes, effective February 1, 1965

Amendment 25-13 - 14 CFR part 25, Effective July 27, 1967

Amendment 25-23 - 14 CFR part 25, Effective May 8, 1970

Amendment 25-41 - 14 CFR part 25, Effective September 1, 1977

Amendment 25-52 - 14 CFR part 25, Effective June 9, 1980

Amendment 25-72 - 14 CFR part 25, Effective August 20, 1990

Amendment 25-104 - 14 CFR part 25, Effective June 15, 2001

FAA Advisory Circular AC 25.1435-1, Effective June 15, 2001

TSO-C140 Aerospace Fuel, Engine Oil, and Hydraulic Fluid Hose Assemblies, Effective July 17, 2002

3. CHRONOLOGY

3.1 Air Commerce Act of 1926

- a. The roots of the FAA go back to 1926 when the U.S., as the only industrial nation that did not regulate aviation and air commerce enacted the Air Commerce Act of 1926. In addition, the Act was established to foster air commerce, license pilots, certificate aircraft for airworthiness, designate and establish airways, establish, operate and maintain aids to air navigation. Driven in part by the need to assure the success of the Air Mail Act of 1925, the Air Commerce Act established the Bureau of Air Commerce to promote aviation safety and the development of aeronautics using its regulatory authority.
 1. On December 31, 1926, the first Air Commerce Regulations of the Aeronautics Branch became effective. The regulations prescribed licensing, operational, and air traffic safety rules.
 2. On March 29, 1927, Type Certificate No. 1 was issued by the newly formed Bureau of Air Commerce to the manufacturer of the Buhl-Verville J4 Airster CA-3, a 3-place open cockpit land biplane. It had an empty weight of 1,415 pounds and a gross weight of 2,300 pounds.
 3. On March 1, 1933, the Aeronautics Bulletin No. 7F, became effective. This bulletin prescribed Airworthiness Requirements for Aircraft Components and Accessories.
- b. In 1934, after a reorganization, the Aeronautical Branch was renamed the Bureau of Air Commerce.
 1. Aeronautics Bulletin No. 7A, effective as amended October 1, 1934, prescribed Airworthiness Requirements for Aircraft.
 2. Aeronautics Bulletin No. 7-J, dated July 11, 1935, prescribed Special Requirements for Transport (or Airline) Aircraft.
 3. Aeronautics Bulletins 7-G and 7-H, respectively, prescribed requirements for engines and propellers, and alterations and repairs.

- c. The main part of the Civil Air Regulations (CARs), representing a thorough revision and codification of the Air Commerce Regulations, went into effect on November 1, 1937. The CARs Part 04 - Airplane Airworthiness, and Part 15 - Aircraft Equipment Airworthiness, contained relevant requirements for mechanical systems. Aeronautics Bulletins 7A, etc., were canceled.

3.2 Civil Aeronautics Act of 1938

- a. The Civil Aeronautics Act of 1938 abolished the Air Commerce Act of 1926. The Bureau of Air Commerce had come under criticism for not being effective, therefore, Congress created the Civil Aeronautics Authority (still under control of the Department of Commerce). It encompassed three unique features:
 - 1. An Administrator responsible for fostering air commerce, controlling air traffic, and establishing airways;
 - 2. An Authority (the only one in the Government), with a five-person board, responsible for promulgating safety (including design rules) and economic rules; and
 - 3. An independent three-person Air Safety Board responsible for determining the probable cause of accidents and recommending safety improvements.
- b. The Reorganization Act of 1939-40 abolished the Air Safety Board, making it part of the five-person board renamed as Civil Aeronautics Board (CAB). The Administrator's collective functions were designated as Civil Aeronautics Administration (CAA). The CAB and CAA reported to the Secretary of Commerce.
 - 1. For the next 18 years, the CAB made the rules while the CAA carried out operational functions. The CAR Parts 04 and 15 were reprinted and amended several times between 1940 and March 15, 1952, when Part 15 was rescinded in favor of a new Technical Standard Order (TSO) system of equipment qualification.
 - 2. Effective June 30, 1945, the CAA drafted comprehensive proposals for revision of the CARs and submitted them to the CAB. The Board was engaged in revising safety regulations to reflect wartime advances in aviation.

3.3 The Federal Aviation Act of 1958

- a. This Act was the culmination of long term effort to increase the effectiveness of the Government's effort to promote safety and develop aeronautics. In 1958, Congress created the Federal Aviation Agency by enacting the Federal Aviation Act.
- b. The Federal Aviation Act of 1958 repealed the Air Commerce Act of 1926, as amended; the Civil Aeronautics Act of 1938, as amended; and the 1939-40 reorganization plans. This Act created two independent agencies:
 - 1. the CAB (for economic regulation of air carriers and for accident investigations) and
 - 2. the Federal Aviation Agency, responsible for safety regulations.

3.4 Title 14, Code of Federal Regulations (14 CFR)

- a. Part 25, effective February 1, 1965, was added to replace part 4b of the Civil Air Regulations (CAR). The object of this recodification was to restate existing regulations.
- b. The pertinent provisions were freely reworded and re-arranged. In cases where well established administrative practice or construction had established authoritative interpretations, the revised rule language reflected the interpretations.
- c. The sections titled "CAA Policies which apply to Sec. 4b.xxx" were determined as "not rule" and deleted from the Code of Federal Regulations. As CAR Part 4a "Airplane Airworthiness" had not been used for certification of new airplanes since 1947, it was deleted.

3.5 Department of Transportation Act of 1966

- a. In 1966, the Department of Transportation (DOT) was created to consolidate the various governmental activities concerning transportation into one organization. The Federal Aviation Act of 1958 was amended to change the FAA, The Agency, to the FAA, the Administration. The FAA Administrator reports to the Secretary of Transportation as a result of this Act.
- b. The CAB's responsibilities for accident investigation were transferred to a new independent National Transportation Safety Board (NTSB). Although independent, the NTSB remained within the DOT for administrative purposes only until 1975, and then was separated entirely.

4. APPLICABILITY

- a. The information provided in this document is directed to airplane manufacturers, modifiers, foreign regulatory authorities, and Federal Aviation Administration (FAA) transport airplane type certification engineers, and their designees.
- b. This material does not change, create any additional, authorize changes in, or permit deviations from, regulatory requirements.

5. HISTORY OF REGULATIONS

5.1 Table 1 History of Regulations Index: 1945-2002

TABLE 1 - HISTORY OF REGULATIONS INDEX: 1945-2002

<u>Date</u>	<u>Action</u>	<u>General</u>	<u>Tests</u>	<u>Lines</u>	<u>Accum</u>
11-09-45	Adopted <u>new Part 04</u>	04.5610	04.5611	04.5612	04.5613
11-01-46	Amd't 04-1 Fire Prevention in Air Carrier Aircraft: 04.075				
11-22-46	Amd't 04-5 Differentiation of ##: <u>New Part 04 became Part 04b</u>				
01-01-48	Amd't 04b-8 Approval by the Administrator: Materials/Parts				
05-01-49	<u>Part 04b</u> designated as <u>Part 4b</u>				
10-01-49	Part 4b Reprinted	4b.826	4b.827	4b.828	4b.829
07-20-50	Part 4b Reprinted	4b.653(a)	4b.653(b)	4b.653(c)	653(d)
10-12-51	Part 514: The TSO System made available				
03-05-52	Amd't 4b-6 Substantive changes: added § 4b.18, Approval under TSO and re-titled par.	<u>Strength</u>	<u>Design</u>	<u>Fire Protection</u>	
		4b.653	4b.654	4b.655	
12-31-53	Part 4b Reprinted	4b.653	4b.654	4b.655	
01-01-58	CAM 4b Manual	4b.653	4b.654	4b.655	
10-01-59	Amd't 4b-11: Revised 4b.481/Flammfluids & 4b.483/Lines & fittings				
05-03-62	Amd't 4b-12: Due to service difficulties added rem'ts for tests....4b.656				
09-04-63	TSO-C75 - Hydraulic hose assemblies issued				
11-17-64	TSO-C75 issued as FAR § 37.181 [Amended 32FR 5769, 4-11-67]				
02-01-65	Re-codified 4b into FAR 25.1435 as follows:	<u>Design</u>	<u>Tests</u>	<u>Fire protection</u>	
		25.1435(a)	25.1435(b)	25.1435(c)	
07-27-67	Amd't 25-13	25.1435(a)	25.1435(b)	25.1435(c)	
05-08-70	Amd't 25-23	25.1435(a)			
09-01-77	Amd't 25-41	25.1435(a) greatly expanded; (a)(1) to (a)(8)			
06-09-80	Amd't 21-50/25-52/37-47: Part 37 revoked. TSOs became voluntary stds				
08-20-90	Amd't 25-72	25.1435(a)			
06-15-01	Amd't 25-104 FAR/JAR harmonized as follows;	<u>Element</u>	<u>System</u>	<u>Tests</u>	
		<u>Design</u>	<u>Design</u>		
		25.1435(a)	25.1435(b)	25.1435(c)	
		Also issued a new AC 25.1435-1			
07-17-02	TSO-C140 - Aerospace Fuel, Engine Oil, and Hydraulic Fluid Hose Assemblies issued				



5.2 Transport Category Airplane Hydraulic Systems: History of Regulations Text

5.2.1 Part 04: November 9, 1945: adopted New Part 04 {transports}

04.561 Hydraulic systems.

04.5610 General. Hydraulic systems and elements shall be so designed as to withstand, without exceeding the yield point, any structural loads which may be imposed in addition to the hydraulic loads.

04.5611 Tests. Hydraulic systems shall be substantiated by proof pressure tests. When proof tested, no part of the hydraulic system shall fail, malfunction, or experience a permanent set. The proof load of any system shall be 1.5 times the maximum operating pressure of that system.

04.5612 Lines. All hydraulic lines carrying inflammable fluids into a designated fire zone shall be constructed in accordance with § 04.490.

04.490 Fire resistant fluid lines. All lines not heretofore specified which carry inflammable fluids or gases into designated fire zones shall be constructed of corrosion resistance steel or material of equivalent fire resistance. Flexible connections in such lines shall employ fire resistant hose with factory fixed ends, detachable ends, or heat and corrosion resistant hose clamps. Fire resistant hose may be used in lieu of metal lines. Aluminum alloy fittings and accessories may be used if adequately fire resistant. All such lines shall be provided with suitable means to shut off or otherwise prevent the flow of hazardous quantities of inflammable fluids or gases into the designated fire zones. Unless equivalent safety is provided, such means shall not be located within the designated fire zone. Operation of the shut-off means shall not prevent the operation of emergency equipment such as propeller feathering systems and the like.

04.5613 Accumulators. Hydraulic accumulators or pressurized reservoirs shall not be installed on the engine side of the firewall except when they form an integral part of the power-plant.

5.2.2 Amendment 04-1, Effective November 1, 1946

04.075 Susceptibility of materials to fire

(a) *Fireproof.* "Fireproof" material means a material which will withstand heat equally well or better than steel, in dimensions appropriate for the purpose for which it is to be used. When applied to material and parts used to confine fires in designated firezones "fireproof" means that the material or part will perform this function under the most severe conditions of fire and duration likely to occur in such zones.

(b) *Fire-resistant.* When applied to sheet or structural members, "fire-resistant" material shall mean a material which will withstand heat equally well or better than aluminum alloy in dimensions appropriate for the purpose for which it is to be used. When applied to fluid-carrying lines, this term refers to a line and fitting assembly which will perform its intended protective functions under the heat and other conditions likely to occur at the particular location.

(c) *Flame-resistant.* "Flame-resistant" material means material which will not support combustion to the point of propagating, beyond safe limits, a flame after removal of the ignition source.

(d) *Flash-resistant.* "Flash-resistant" material means material which will not burn violently when ignited.

(e) *Inflammable.* "Inflammable" fluids or gases mean those which will ignite readily or explode.

04.49 Power-plant fire protection. Engine accessory sections; installations where no isolation is provided between the engine and accessory compartment, also regions wherein lie auxiliary power units, fuel burning heaters, and other combustion equipment shall be referred to as designated fire zones. Such zones shall be protected from fire by compliance with the following requirements.

04.490 *Inflammable fluids*. No tanks or reservoirs which are a part of a system containing inflammable fluids or gases shall be located in designated fire zones, except where the fluid contained, the design of the system, the materials used in the tank, the shut-off means, all connections, lines, and controls are such as to provide equivalent safety. Not less than 1/2 inch of clear air space shall be provided between any tank or reservoir and a fire wall or shroud isolating a designated fire zone.

04.4900 *Shut-off means*. Means for each individual engine shall be provided for shutting off or otherwise preventing hazardous quantities of fuel, oil, de-icer, and other inflammable fluids from flowing into, within, or through any designated fire zone, except that means need not be provided to shut-off flow in lines forming an integral part of an engine. In order to facilitate rapid and effective control of fires such shut-off means shall permit an emergency operating sequence which is compatible with the emergency operation of other equipment, such as feathering the propeller. Shut-off means shall be located outside of designated fire zones, unless equivalent safety is provided, (see 04.490) and it shall be shown that no hazardous quantity of such inflammable fluid will drain into any designated fire zone after shutting-off has been accomplished.

Adequate provisions shall be made to guard against inadvertent operation of the shut-off means and to make it possible for the crew to reopen the shut-off means after it has once been closed.

04.4901 *Lines and fittings*. All lines and fittings for same located in designated fire zones which carry inflammable fluids or gases and which are under pressure or which attach directly to the engine or are subject to relative motion between components, exclusive of those lines and fittings forming an integral part of the engine, shall be flexible, fire-resistant lines with fire-resistant end fittings of the permanently attached, detachable, or other approved types. Lines and fittings which are not subject to pressure or to relative motion between components shall be of fire-resistant materials.

04.5612 *Lines*. Hydraulic lines and fittings in all designated fire zones (see § 04.49) shall comply with the provisions of § 04.4901.

04.5613 *Reservoirs and accumulators*. Location of hydraulic reservoirs and accumulators shall comply with the provisions of § 04.490, except when they form an integral part of the engine or propeller.

5.2.3 Amendment 04-5, effective 11-22-46 changed new Part 04 to 04b

5.2.4 Amendment 04b-8 effective 01-01-48:

Added § 04b.05 and Established approval of parts and appliances by the Administrator via the TSO system. Specific text using the TSO system was not added to the regulation until 1952. The first TSO for Wheels and Brakes, TSO-C26 appeared in 1952.

Prior to this amendment approval of certain specified appliances was required by type certification. This entailed submission of detailed data for each appliance or variation thereof, which had to be examined and approved by the Administrator of Civil Aeronautics. The purpose of this amendment was to simplify and expedite approval by permitting, in lieu of type certification, the establishment and publication of specifications, in the form of "Technical Standard Orders (TSOs)" by the Administrator for such appliances. The TSOs were established after collaboration with the industry and upon consideration of pertinent aviation industry, federal, and military specifications. An appliance for which a TSO had been so established was deemed approved by the Administrator when the manufacturer certified that the appliance meets the specifications included therein, and the appliance does in fact meet the specification. Section 04.300 was repealed and a new § 04b.05 was added to read as follows:

§ 04b.05 *Approval of materials, parts, processes, and appliances*. Materials, parts, processes, and appliances shall be approved upon a basis and in a manner found necessary by the Administrator to implement the pertinent provisions of the Civil Air Regulations. The Administrator may adopt and publish such specifications as he finds necessary to administer this regulation, and shall incorporate therein such portions of the aviation industry, Federal, and military specifications respecting such materials, parts, processes, and appliances as he finds appropriate.

Any material, part, process, or appliance shall be deemed to have met the requirements for approval when it meets the pertinent specifications adopted by the Administrator, and the manufacturer so certifies in a manner prescribed by the Administrator.

5.2.5 Re-designation of Parts 04a and 04b as Parts 4a and 4b: effective May 1, 1949

5.2.6 Part 4b: October 1, 1949

Hydraulic systems

§ 4b.826 *General*. Hydraulic systems and elements shall be so designed as to withstand, without exceeding the yield point, any structural loads which may be imposed in addition to the hydraulic loads.

§ 4b.827 *Tests*. Hydraulic systems shall be substantiated by proof pressure tests. When proof tested, no part of the hydraulic system shall fail, malfunction, or experience a permanent set. The proof load of any system shall be 1.5 times the maximum operating pressure of that system.

§ 4b.828 *Lines*. Hydraulic lines and fittings in all designated fire zones (see § 4b.651) shall comply with the provisions of § 4b.654.

§ 4b.829 *Reservoirs and accumulators*. Location of hydraulic reservoirs and accumulators shall comply with the provisions of § 4b.652, except when they are an integral part of the engine or propeller.
[Amdt. 04-1, 11 F.R. 11351, effective November 1, 1946.]

§ 4b.651 *Zones*. [Similar to 04.49 *Power-plant fire protection*]

(a) Designated fire zones comprise the following regions:

- (1) Engine power section
- (2) Engine accessory section
- (3) Complete power-plant compartments in which no isolation is provided between the engine power section and the engine accessory section.
- (4) Auxiliary power unit compartments
- (5) Fuel -burning heater and other combustion equipment installations.

(b) Such zones shall be protected from fire by compliance with the requirements in §§ 4b.652-4b.655.

[Amdt. 04b-7, 12 F.R. 5960, effective September 29, 1947.]

§ 4b.652 *Location of tanks*. Same as 04.490 - *Inflammable fluids*.

[Amdt. 04-1, 11 F.R. 11351, effective November 1, 1946.]

§ 4b.653 *Shut-off means*. Same as 04.4900 - *Shut-off mean*.

[Amdt. 04-1, 11 F.R. 11351, effective November 1, 1946.]

§ 4b.654 *Lines and fittings*. Same as 04.4901 *Lines and fittings*.

[Amdt. 04-1, 11 F.R. 11351, as amended by Amdt. 04b-7, 12 F.R. 5960, effective September 29, 1947.]

§ 4b.655 *Vent and drain lines*. All vent and drain lines and fittings for same located in designated fire zones and which carry inflammable fluids or gases shall comply with the provisions of § 4b.654, if the Administrator finds that rupture or breakage of a particular drain or vent line may result in a fire hazard.

[Amdt. 04-1, 11 F.R. 11351, effective November 1, 1946.]

5.2.7 Part 4b Reprinted: July 20, 1950

§ 4b.653 *Hydraulic systems*.

(a) *Design*. Hydraulic systems and elements shall withstand, without exceeding the yield point, all structural loads which are expected to be imposed in addition to the hydraulic loads.

(b) *Tests*. Hydraulic systems shall be substantiated by proof pressure tests. When proof tested, no part of a hydraulic system shall fail, malfunction, or experience a permanent set. The proof load of any system shall be 1.5 times the maximum operating pressure of that system.

(c) *Lines and fittings.* Hydraulic lines and fittings in all designated fire zones (see § 4b.480) shall comply with the provisions of § 4b.483.

(d) *Reservoirs and accumulators.* Location of hydraulic reservoirs and accumulators shall comply with the provisions of § 4b.481, except when they are an integral part of the engine or propeller.

§ 4b.480 *Designated fire zones.* [Same as § 4b.651 (1949)]

(a)

(b) Such zones shall be protected from fire by compliance with the requirements in §§ 4b.481 through 4b.489.

§ 4b.481 *Flammable fluids.* Same as 4b.652 (1949) *Location of tanks.*

§ 4b.482 *Shut-off means.* Same as 4b.653 (1949)

§ 4b.483 *Lines and fittings.*

(a) All lines and fittings located in designated fire zones which carry inflammable fluids or gases and which are under pressure or which attach directly to the engine or are subject to relative motion between components, exclusive of those lines and fittings forming an integral part of the engine, shall be flexible, fire-resistant lines with fire-resistant end fittings of the permanently attached, detachable, or other approved types.

(b) Lines and fittings which are not subject to pressure or to relative motion between components shall be of fire-resistant materials.

[(a)+(b) above was § 4b.654 (1949)/04.4901(1946).]

(c) Vent and drain lines and fittings located in designated fire zones and which carry flammable fluids or gases shall be subject to the provisions of paragraph (a) of this section if it is found that rupture or breakage of a particular drain or vent line might result in a fire hazard. [was § 4b.655 (1949).]

§§ 4b.484 through 4b.489 are fire extinguisher/detector system, fire walls, cowling, engine accessory section, and protection of other airplane components against fire and not relevant to the hydraulic systems.

5.2.8 Part 514, Technical Standard Order, effective 10-12-51

Regulations of the Administrator, Part 514, was made available only through the Federal Register where it appeared on October 12, 1951, 16 FR 10403. Copies of Individual TSO's contained therein were available upon application to the Aviation Information Staff, Civil Aeronautics Administration, Department of Commerce, Washington 25, D.C.

5.2.9 Amendment 4b-6, effective 3-5-52

Added § 4b.18-Note in the regulatory text, allowing approval of equipment under the TSO system. The first TSO for Hydraulic Hoses TSO-C75 was effective 4-26-62. Section 4b.653 was rescinded and new sections 4b.653 through 4b.655 were added to read as follows:

§ 4b.653 *Hydraulic systems; strength:*

(a) *Structural loads.* All elements of the hydraulic system shall be designed to withstand, without detrimental permanent deformation, all structural loads which may be imposed simultaneously with the maximum hydraulic loads occurring in operation.

(b) *Proof pressure tests.* All elements of the hydraulic system shall be tested to a proof pressure of 1.5 times the maximum pressure to which the part will be subjected in normal operation. In such test no part of the hydraulic system shall fail, malfunction, or suffer detrimental deformation.

(c) *Burst pressure strength.* Individual hydraulic system elements shall be designed to withstand pressures which are sufficiently increased over the pressures prescribed in paragraph (b) of this section to safeguard against rupture under service conditions.

NOTE: The following pressures, in terms of percentage of maximum operating pressure for the particular element, in most instances are sufficient to insure against rupture in service: 250 percent in units under oil pressure, 400 percent in units containing air and oil under pressure and in lines, hoses, and fittings, 300 percent in units of system subjected to back pressure.

§ 4b.654 *Hydraulic systems; design:*

(a) *Pressure indication.* A means shall be provided to indicate the pressure in each main hydraulic power system.

(b) *Pressure limiting provisions.* Provisions shall be made to assure that pressures in any part of the system will not exceed a safe limit above the maximum operating pressure of the system and to insure against excessive pressures resulting from fluid volumetric changes in all lines which are likely to remain closed long enough for such changes to take place. In addition, consideration shall be given to the possible occurrence of detrimental transient (surge) pressures during operation.

(c) *Installation.* Hydraulic lines, fittings, and components shall be installed and supported to prevent excessive vibration and to withstand inertia loads. All elements of the installation shall be protected from abrasion, corrosion, and mechanical damage.

(d) *Connections.* Flexible hose, or other means of providing flexibility, shall be used to connect points in a hydraulic fluid line between which there is relative motion or differential vibration.

§ 4b.655 *Hydraulic system fire protection.* When flammable type hydraulic fluid is used, the hydraulic system shall comply with the provisions of §§ 4b.385, 4b.481, 4b.482, and 4b.483.

NOTE: Reservoirs and accumulators are implicitly covered under 4b.481.

§ 4b.385 *Flammable fluid fire protection.* In areas of the airplane where flammable fluids or vapors might be liberated by leakage or failure in fluid systems, design precautions shall be made to safeguard against the ignition of such fluids or vapors due to the operation of other equipment, or to control any fire resulting from such ignition.

§ 4b.481 *Flammable fluids.*

(a) No tanks or reservoirs which are a part of a system containing flammable fluids or gases shall be located in designated fire zones, except where the fluid contained, the design of the system, the materials used in the tank, the shut-off means, all connections, lines, and controls are such as to provide an equally high degree of safety.

(b) Not less than one-half inch of clear air space shall be provided between any tank or reservoir and a fire wall or shroud isolating a designated fire zone.

[(a)+(b) above was § 4b.481(1950)].

(c) No component of a flammable fluid-carrying system shall be located in close proximity to materials which can absorb such a fluid.