



# AEROSPACE STANDARD

AS5586™

REV. A

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Superseding AS5586

## General Requirements for Hydraulic System Reservoirs

### RATIONALE

AS5586 has been updated to Revision A for the following reasons:

- a. Minor technical changes
- b. The references have been updated

### FOREWORD

This document is based on two military specifications MIL-R-5520 and MIL-R-8931.

Hydraulic reservoirs are independent of the system working pressure as they are generally part of the low-pressure side of the hydraulic system. The exception to this is the hydraulically pressurized reservoir (known as the Bootstrap reservoir), which is also an integral part of the high-pressure system.

AIR1899 and AIR5005 provide the following information on hydraulic reservoirs used on various Military and Commercial aircraft:

- a. Reservoir type
- b. Reservoir volume
- c. Pressure applied to the fluid in the reservoir

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## 1. SCOPE

This SAE Aerospace Standard (AS) specifies the general requirements for hydraulic system reservoirs that are installed in commercial and military aircraft and helicopters and also in missile hydraulic systems.

This document includes design, test (production and qualification) criteria for various types of reservoirs. Appendix A provides information on hydraulic fluid volume requirements and reservoir sizing.

This document also provides a basis for the Procurement Specification to completely define individual reservoir requirements.

### 1.1 Reservoir Types

Type A - Separated, hydraulically pressurized (commonly referred to as a “bootstrap reservoir”)

Type B - Separated, gas pressurized (commonly through an engine bleed system or by a pressurized gas charge)

Type C - Separated, mechanically pressurized (usually by a spring and for emergency use)

Type D - Non-separated, gas pressurized (commonly through an engine bleed system)

Type E - Non-separated, non-pressurized (commonly referred to as an open reservoir)

## 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 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), [www.sae.org](http://www.sae.org).

|         |                                                                                            |
|---------|--------------------------------------------------------------------------------------------|
| AIR1899 | Aerospace Military Aircraft Hydraulic System Characteristics                               |
| AIR1922 | Aerospace - System Integration Factors that Affect Hydraulic Pump Life                     |
| AIR4543 | Aerospace Hydraulics and Actuation Lessons Learned                                         |
| AIR5005 | Aerospace - Commercial Aircraft Hydraulic Systems                                          |
| ARP1288 | Placarding of Aircraft Hydraulic Equipment to Identify Phosphate Ester Fluid Compatibility |
| ARP1383 | Aerospace - Impulse Testing of Hydraulic Components                                        |
| ARP4386 | Terminology and Definitions for Aerospace Fluid Power, Actuation and Control Technologies  |
| ARP4752 | Aerospace - Design and Installation of Commercial Transport Aircraft Hydraulic Systems     |
| ARP4925 | Aerospace Design and Installation of Commercial Transport Helicopter Hydraulic Systems     |
| AS1300  | Port - Ring Locked Fluid Connection Type Standard Dimensions For                           |

|        |                                                                                 |
|--------|---------------------------------------------------------------------------------|
| AS4059 | Aerospace Fluid Power - Cleanliness Classification for Hydraulic Fluids         |
| AS4088 | Aerospace Rod Scraper Gland Design Standard                                     |
| AS4941 | Aerospace - General Requirements for Commercial Aircraft Hydraulic Components   |
| AS5202 | Port or Fitting End, Internal Straight Thread, Design Standard                  |
| AS5440 | Hydraulic Systems, Military Aircraft, Design and Installation, Requirements For |
| AS8775 | Hydraulic System Components, Aircraft and Missiles, General Specification For   |

#### 2.1.2 ASME Publications

Available from ASME, P.O. Box 2900, 22 Law Drive, Fairfield, NJ 07007-2900, Tel: 800-843-2763 (U.S./Canada), 001-800-843-2763 (Mexico), 973-882-1170 (outside North America), [www.asme.org](http://www.asme.org).

ASME B46.1 Surface Texture (Surface Roughness, Waviness & Lay)

#### 2.1.3 RTCA Publications

Available from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, [www.rtca.org](http://www.rtca.org).

RTCA/DO-160 Environmental conditions and test procedures for airborne equipment

#### 2.1.4 U.S. Government Publications

Copies of these documents are available online at <http://quicksearch.dla.mil>.

MIL-STD-810 Environmental Test Methods and Engineering Guidelines

MIL-R-5520 Reservoirs, Aircraft, Hydraulic, Non-Separated Type (Cancelled)

MIL-R-8931 Reservoirs, Aircraft and Missile, Hydraulic, Separated Type (Inactive for new design)

#### 2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

##### 2.2.1 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, [www.faa.gov](http://www.faa.gov).

|                |                                                                                                                          |
|----------------|--------------------------------------------------------------------------------------------------------------------------|
| 14 CFR Part 23 | Code of Federal Regulations, Part 23 Airworthiness Standards, Normal, Utility, Acrobatic and Commuter Category Airplanes |
| 14 CFR Part 25 | Code of Federal Regulations, Part 25 Airworthiness Standards, Transport Category Airplanes                               |
| 14 CFR Part 27 | Code of Federal Regulations, Part 27 Airworthiness Standards, Normal Category Rotorcraft                                 |
| 14 CFR Part 29 | Code of Federal Regulations, Part 29 Airworthiness Standards, Transport Category Rotorcraft                              |

### 2.2.2 EASA Publications

Available from European Aviation Safety Agency, Ottoplatz, 1, D-50679 Cologne, Germany, Tel: +49 221 8999 000, [www.easa.europa.eu](http://www.easa.europa.eu).

|       |                                                                                     |
|-------|-------------------------------------------------------------------------------------|
| CS 23 | Certification Specifications for Normal, Utility, Aerobatic and Commuter Aeroplanes |
| CS 25 | Certification Specifications for Large Aeroplanes                                   |
| CS 27 | Certification Specifications for Small Rotorcraft                                   |
| CS 29 | Certification Specifications for Large Rotorcraft                                   |

### 2.3 Definitions

Refer to ARP4386 for general hydraulic system terms that are used in this Aerospace Standard.

**CONTRACTOR:** For military applications, the company or other organization on contract to the Government Procuring Activity, to design, develop, manufacture and qualify a reservoir.

**NOTE:** The Contractor typically writes a reservoir specification and sub-contracts the detail design of the reservoir to a Supplier.

**DESIGN OPERATING PRESSURE (DOP):** The DOP is defined as the normal maximum steady pressure that is applied to the high-pressure part of the Type A reservoir.

#### NOTES:

1. Excluded are:
  - a. Reasonable tolerances and transient pressure effects such as may arise from acceptable pump ripple, or
  - b. Reactions to system functioning or demands that may affect fatigue.
2. The term "Design Operating Pressure" is used in the design of commercial aircraft that are designed to comply with applicable airworthiness regulations. It was decided to only use this term in this document for ease of reading the document. For military applications, the term "Working or Rated Pressure" can be directly substituted for "Design Operating Pressure".

**EFFECTIVE BULK MODULUS ( $\beta_e$ ):** The combined compressibility of the fluid, fluid transport elements and any entrained air. Note: The total effective bulk modulus is obtained by summing the reciprocals.

**EMERGENCY RESERVOIR:** An emergency reservoir is one where hydraulic fluid is not returned to the reservoir for storage after having once been discharged. Note: This type is also known as an Auxiliary reservoir.

**ISA:** ISA is the abbreviated form of International Standard Atmosphere, which is 14.7 psia (101.3 kPa); 59 °F (15 °C).

**PROCUREMENT SPECIFICATION:** The Procurement Specification is the document that includes the following:

- a. Specific performance and technical criteria.
- b. Acceptance and qualification test requirements.
- c. Reliability requirements.

- d. Quality requirements.
- e. Packaging requirements.

**PURCHASER:** For commercial applications, the Purchaser is the organization that has the responsibility for the design and development of the hydraulic system that includes the reservoir. Note: Typically, the Purchaser is an aircraft manufacturer or a modification center. The Purchaser is responsible for compiling the Procurement Specification.

**REFILL LEVEL:** The refill level shall be the point below which it is considered that top-up fluid must be supplied to the reservoir in order to ensure that sufficient fluid is available to meet the hydraulic system's requirements.

**RESERVOIR DESIGN OPERATING PRESSURE (RDOP):** The RDOP is the normal operating pressure that is applied to the hydraulic fluid that is stored in the reservoir.

**SUPPLIER:** The Supplier is the manufacturer, and who will be responsible for the design, production and qualification of the reservoir.

**NOTES:**

1. The Purchaser or Contractor shall approve the Supplier for the design, development and manufacture of aerospace hydraulic components.
2. Hydraulic reservoirs can be designed and manufactured by the Purchaser or Contractor. In this case, the Procurement Specification is the Design Specification that is compiled by the Purchaser or Contractor as part of the design, development and qualification process for the reservoir.
3. In certain cases where performance criteria may be marginal and are a function of both system and detail reservoir design, the Reservoir Supplier may, through prior experience, contribute to the final Procurement Specification.

### 3. REQUIREMENTS

#### 3.1 Aircraft, Helicopter or Missile Requirements

**NOTE:** Aircraft, Helicopter or Missile are henceforth called a flight vehicle.

##### 3.1.1 Operating Characteristics

Refer to ARP4752, ARP4925, or AS5440 as applicable for the requirements for the integration of the reservoir into the flight vehicle system. AIR1922 should also be consulted for guidance into the factors concerning the hydraulic reservoir design that are required to ensure that the hydraulic pump performance and reliability conforms to the system requirements.

##### 3.1.2 Reservoir Installation

The design of the reservoir and its associated mounts shall be such that the reservoir shall be securely fastened in place with no weight and other structural loads carried by the fittings or fluid lines attached thereto. The mounting, when secured, shall impose no internal stress or abrasion of the reservoir or its fittings. The reservoir shall have features to permit it to be easily installed and removed whilst ensuring that the other requirements in this section can be complied with.

The instructions for installing the reservoir shall be noted on a label as worded in the Procurement Specification.

##### 3.1.2.1 Reservoir Ambient Vent Port (Type A and C Reservoirs only)

If the reservoir incorporates an ambient vent port, provisions should be made such that any moisture can freely drain out, for example by suitably orientating the vent port.

## 3.2 Servicing Requirements

### 3.2.1 Filling and Refill

The reservoir design shall be such that initial filling of the reservoir installed in the vehicle, and any subsequent refilling or replenishment of the fluid, shall be accomplished only through the use of a device such as a hand pump or power pump. No provision shall be incorporated which permits the transfer of hydraulic fluid into the reservoir by gravity flow from an external container.

#### 3.2.1.1 Reservoir Identification and Instruction Plate

##### 3.2.1.1.1 Reservoir Identification Plate

An identification plate shall be attached to the reservoir itself.

This plate shall include the following information:

- a. Name and part number of the reservoir.
- b. Serial Number (if specified by the procurement specification).
- c. Fluid specification number.
- d. If required by the Procurement Specification, color of fluid.

##### 3.2.1.1.2 Reservoir Instruction Plate

If required by the Procurement Specification an instruction plate (see Figure 1) shall be attached to either the reservoir itself or to the immediately adjacent vehicle structure near the fluid level indicating device, positioned so as to be easily readable

This plate should include the following information:

- a. Reservoir fluid capacity at full level.
- b. Full level indication references.
- c. Refill level indication references.
- d. Position of hydraulic devices and vehicle during filling procedure.
- e. Depressurizing procedure reference.
- f. Pressurizing warning notice.

Additional full and refill levels under various conditions of system pressure, temperature, vehicle, attitude, accumulator pre-charge should be added as required (see Figure 2). Any other information such as installation and/or removal instructions or dry weight may also be included.

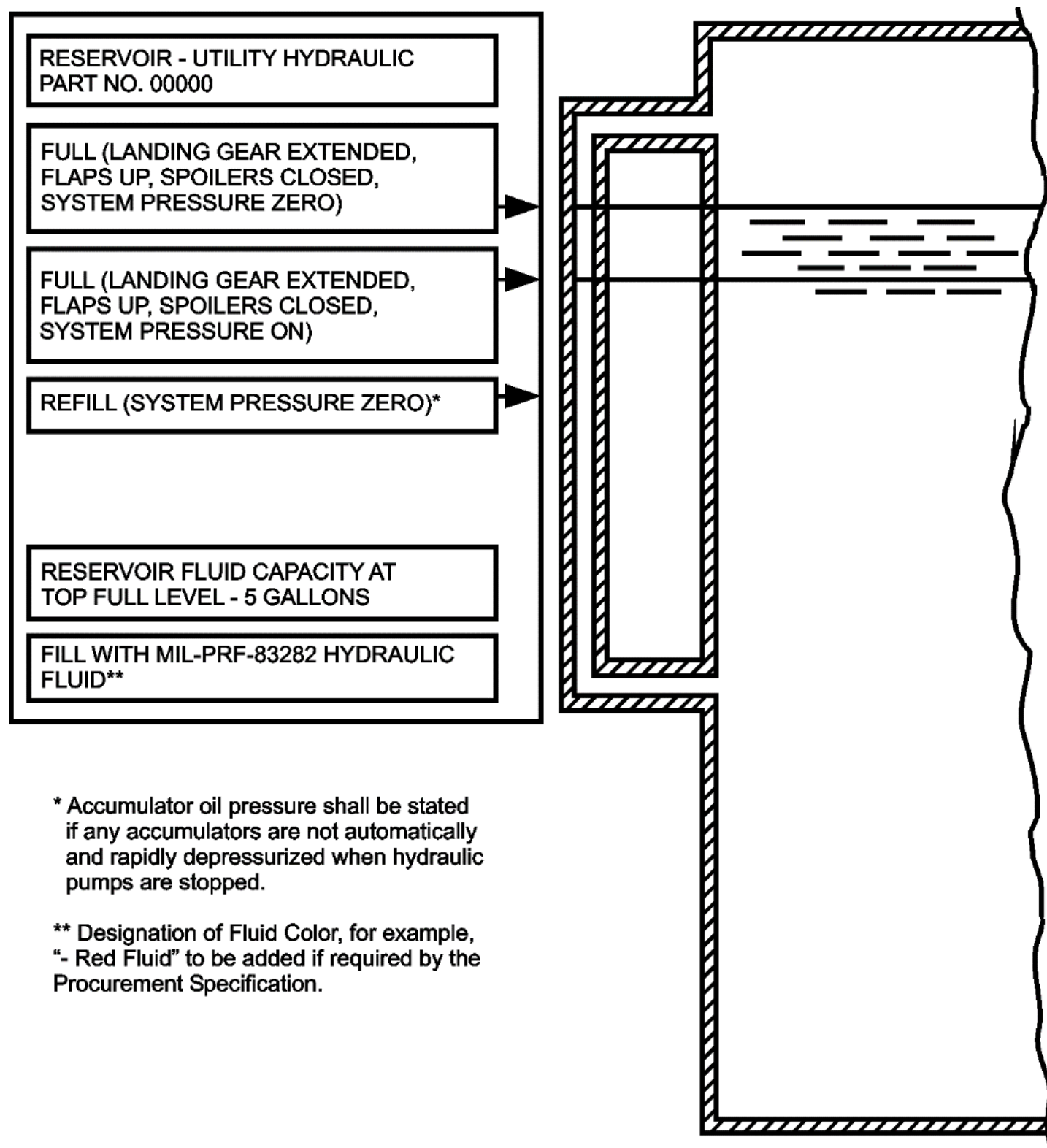
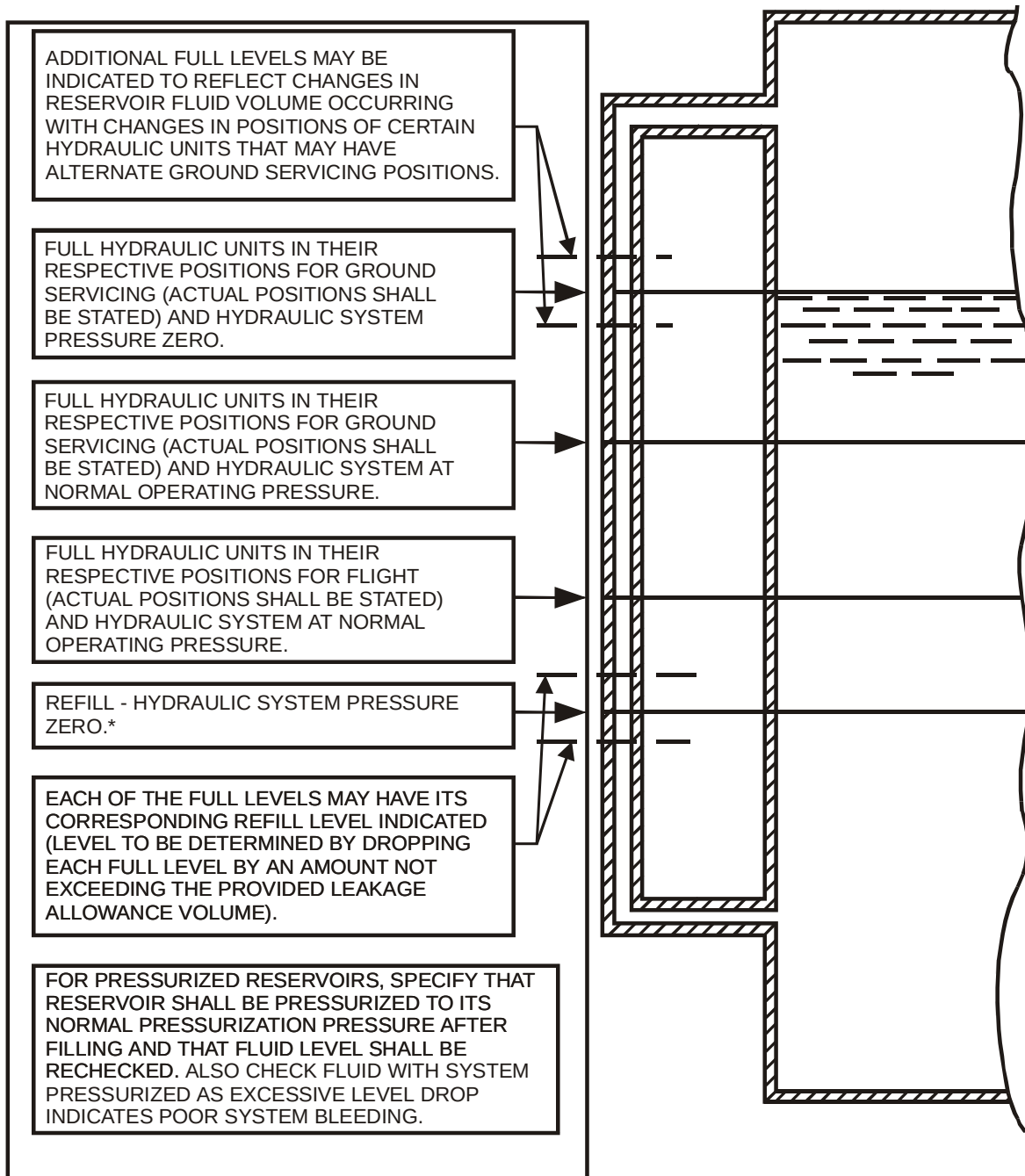


Figure 1 - Typical identification and instruction plate



\* If only one refill level is indicated, it should be that level which results from lowering the fluid level from the uppermost full level by an amount not exceeding the provided leakage allowance volume.

**Figure 2 - Considerations for fluid level designations on reservoir nameplates**

### 3.2.2 Bleeding

#### 3.2.2.1 Type A, B, and C Reservoirs

The reservoir design and installation shall be such that if entrained gas bubbles in the hydraulic fluid are allowed to accumulate in any space in the reservoir, means shall be provided for removing entrapped air in the bleeding operation (such as a manual or automatic bleed valve) without disconnecting any tubing. If possible, the angle at which the reservoir is installed in the flight vehicle should be such that any free air would migrate to the bleed point. Also, provisions shall be provided in the reservoir for either automatic or periodic manual removal of any hydraulic fluid from any cavities in the reservoir in which fluid is not present by design, such as the gas side of a Type B reservoir.

#### 3.2.2.2 Type D and E Reservoirs

The reservoir design and installation shall be such that any entrained gas bubbles in the hydraulic fluid shall be able to permeate to the reservoir gas space, and then, if necessary, be vented overboard.

### 3.2.3 Draining

Means shall be provided to ensure that the installed reservoir can be drained of fluid, when the flight vehicle is at rest. Cavities where fluid can be entrapped shall be minimized. The size of the drain means shall permit complete draining of the reservoir within the time and at the ambient temperature defined by the Procurement Specification.

## 3.3 System Requirements

### 3.3.1 Reservoir Capacity

Hydraulic reservoirs shall be designed to provide the minimum total capacity as determined by the following:

- a. Volumetric changes as hydraulic actuators are operated.
- b. Thermal effects.
- c. Allowance for operation of leak detection system and/or devices.
- d. Filling of accumulators.
- e. System pressurization.
- f. Emergency reservoir capacity (if applicable).
- g. Allowance for minimum volume, below which the reservoir cannot meet its functional requirements.
- h. Allowance for topping up the reservoir during routine maintenance.
- i. Allowance for gas space (non-separated reservoirs only).
- j. Allowance for an overfull volume (separated reservoirs only).

Appendix A provides a guide on how to estimate the hydraulic system fluid requirements and to determine the hydraulic reservoir size.

### 3.3.2 Reservoir Pressure

The following shall be considered when determining the reservoir pressure to be applied to the hydraulic fluid in the Type A, B, C, or D reservoirs:

- a. The hydraulic pump inlet pressure requirements are achieved. This should be determined using the guidelines contained in AIR1922. When analyzing the pump inlet pressure requirements, the following shall be considered:
  1. To verify that sufficient pressure is available so that the pump is able to deliver its maximum flow over the speed range, taking into consideration the pressure that is available to pressurize the reservoir as the aircraft descends and the engine is running at idle speed (this is applicable to those reservoirs pressurized by engine bleed air).
  2. To allow for the loss in reservoir pressure when more hydraulic fluid leaves the reservoir than returns to it.
  3. Atmospheric pressure, which varies with altitude, as it affects the reservoir absolute pressure.
- b. The pressure in the reservoir does not affect the operation of components/sub-systems, for example:
  1. Does not prevent the brakes from fully releasing.
  2. Does not cause problems with the hydraulic pump operation due to high pump case pressures.

NOTE: Type E reservoirs are not pressurized.

### 3.3.3 Operating Conditions

The flow of the hydraulic fluid supply from the reservoir outlet port to the pump inlet line shall avoid column separation for any condition of ground servicing, and any flight condition it is required to operate (including the effects of out of control flight).

NOTE: Non-separated reservoirs shall also cater for the most severe sloshing expected from either rolling or pitching action as well as acceleration effects of assisted takeoff conditions, as applicable.

When the volume of fluid in the reservoir is greater than the minimum volume, the hydraulic fluid emerging from the reservoir outlet port shall be free of froth or foam.

#### 3.3.3.1 Foaming

Foaming that may occur when the reservoir is tested in attitudes more severe than those for which it is required to operate, shall disappear and the flow of fluid supply to the hydraulic pump shall be without air bubbles after the reservoir is righted (ground level attitude). This shall occur within the time specified in the Procurement Specification.

#### 3.3.4 Negative Gravity

Provision shall be provided for a negative gravity protection chamber for non-separated reservoirs, particularly if compliance with applicable airworthiness regulations is required. The negative gravity protection facility shall ensure that, when returning from negative to positive gravity conditions, no air bubbles can be ingested into the pump inlet line.

#### 3.3.5 Interconnected Emergency Reservoirs

When an emergency interconnected reservoir is filled through a primary reservoir, sufficient space shall be provided in the primary reservoir for expansion into the emergency reservoir.

The interconnected supply line shall be of sufficient size to ensure that the emergency reservoir will completely fill in less time than it takes to fill the main supply reservoir under any operating temperature condition. If this interconnecting line is also designed to function in the capacity of a pump inlet line during conditions in which flow leaving the emergency reservoir is returned to the primary reservoir, it shall conform to the pump inlet line flow requirements of ARP4752, ARP4925, or AS5440. The guidelines for the pump inlet line contained in AIR1922 should also be considered. A check valve shall be provided in the line, when necessary, to prevent the depletion of the oil supply in the emergency reservoir in inverted flight.

The emergency reservoir vent line shall also be so routed that there are no fluid traps in the line. The vent line shall be connected into the top of the main reservoir separately from the main reservoir vent line in order to minimize loss of fluid overboard. The vent line shall be of sufficient diameter to prevent the plugging of the line by slugs of fluid due to surface tension or viscosity.

In cases where an emergency reservoir is interconnected to a primary reservoir, it shall not be possible to lose the emergency fluid supply by a failure in the primary system.

### 3.4 Component Requirements

#### 3.4.1 General

Reservoirs for military flight vehicles' hydraulic systems, which are designed to AS5440 requirements, shall conform to the general hydraulic components' requirements of AS8775.

Hydraulic reservoirs for commercial flight vehicles, which are designed to the applicable airworthiness regulations, shall conform to the general hydraulic components' requirements of AS4941.

#### 3.4.2 Negative Gravity Protection (Non-Separated Reservoirs)

The means for negative gravity protection generally comprises a chamber over the pump inlet and system return ports, together with a method of transferring fluid to and from outside the chamber to the inlet and return ports. In the event of negative gravity conditions, the fluid is retained in the chamber until positive gravity conditions re-occur.

#### 3.4.3 Return Line Inlet

The following requirements shall be taken into consideration for the design and location of the return line inlet connection:

- a. Means shall be provided to minimize surging or foaming of the fluid from the return line as it enters the reservoir. This shall be achieved by the design of the return line port connection and the internal configuration of the reservoir.
- b. It shall not be possible to directly transfer high velocity direct internal flow from the reservoir return line port to the pump inlet port.
- c. The return port shall be physically separated from the pump inlet port in order to ensure that the pump does not receive any highly aerated return fluid.

#### 3.4.4 Reservoir Design Operating Pressure (RDOP)

##### 3.4.4.1 Type A Reservoirs

The RDOP is the net effect of the input pressure that is generated by the DOP on the high-pressure piston to the output of the low-pressure piston. This includes the value determined by 3.3.2 plus a maximum of 5% (unless otherwise specified in the Procurement Specification) required to move the piston via the differential piston areas. The RDOP shall not include transient pressures or the effect of increased breakout friction at low temperatures.