SAE Aerospace
An SAE International Group

# AEROSPACE RECOMMENDED PRACTICE

ARP4835

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## Aerospace Fluid Power-Hydraulic Thermal Expansion Relief Valves

RATIONALE

This document was developed to assist the system designer in specifying the requirements for thermal relief valves that prevent the development of excessive pressure due to the thermal expansion of confined fluid.

## 1. SCOPE

This SAE Aerospace Recommended Practice (ARP) establishes the general requirements for hydraulic thermal expansion relief valves used in aircraft and missile hydraulic systems having operating pressures and temperatures as identified in 1.2.

### 1.1 Purpose

This document is intended for use in conjunction with a procurement specification to be prepared by the purchaser in which valve configuration, system fluid and other parameters for the particular application are defined as required herein.

### 1.2 Classification

The thermal relief valve shall be of classes and types based on the applicable system operating temperature and pressure. In addition, valves shall be classified by subtype based on fluid compatibility. The valves may be further classified by mounting style and size/flow rating. See Table 1 for the various classes, types, styles and sizes of thermal relief valves.





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TABLE 1 - CLASSIFICATION OF THERMAL RELIEF VALVES

| Class | System Operating Pressure psi (MPa) | |
|---|---|---|
| 1500<br>3000<br>4000<br>5000<br>8000 | 1500 (10.3)<br>3000 (20.7)<br>4000 (27.6)<br>5000 (34.5)<br>8000 (55.2) | |
| Type | Temperature Range °F | (°C) |
| I<br>II<br>III<br>IV | -65 to +160<br>-65 to +275<br>-65 to +450<br>-40 to +250 | (-54 to + 71)<br>(-54 to +135)<br>(-54 to +232)<br>(-40 to +121) |
| Sub Type | Fluid Compatibility | |
| A<br><br>B<br>AB | Petroleum and Synthetic Hydrocarbon Base (MIL-PRF-5606, MIL-PRF-83282, MIL-PRF-87257)<br>Phosphate Ester Base (AS1241)<br>Compatible with both Subtype A & B fluids | |
| NOTE: In the designation, Type and Subtype may be combined. Example:<br>Type IA: Compatible with Petroleum and Synthetic Hydrocarbon Base Fluids at temperatures from -65 to 160 °F (-54 to 71 °C). | | |
| **Mounting Style**<br>Style C: Cartridge: Cylindrical valves with O-ring glands for mounting.<br>Style L: Line Mount: Valve with standard fitting ends.<br>Style N: Insert: Cylindrical Valves with an expansion pin to seal and lock in a cylindrical cavity.<br><br>**Size/Flow Rate (see 3.3.1)**<br>Size 5 - 5 ml per minute minimum<br>Size 15 - 15 ml per minute minimum<br>Size X - As specified by purchaser | | |



## 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 724-776-4970 (outside USA), www.sae.org.

AS478 Identification Marking Methods

AS1241 Fire Resistant Phosphate Ester Hydraulic Fluid for Aircraft

AS1290 Graphic Symbols for Aircraft Hydraulic and Pneumatic Systems

ARP1383 Impulse Testing of Aerospace Hydraulic Actuators, Valves, Pressure Containers, and Similar Fluid System Components

AS4059 Aerospace Fluid Power Cleanliness Classification for Hydraulic Fluids

AS4941 Aerospace-General Requirements for Commercial Aircraft Hydraulic Components

AS5202 Bosses, Fluid Connection, Internal Straight Thread

AS5440 Hydraulic Systems, Aircraft, Design and Installation Requirements for

AS8775 Hydraulic System Components, Aircraft and Missiles, General Specification for

AS33514 Fitting End, Standard Dimensions for Flareless Tube Connection and Gasket Seal

2.1.2 Military Publications

Available from the Document Automation and Production Service, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, http://assist.daps.dla.mil/quicksearch/.

MIL-STD-130 Identification Marking of U.S. Military Property

MIL-PRF-5606 Hydraulic Fluid, Petroleum Base, Aircraft, Missile and Ordnance (Inactive for new design)

MIL-PRF-46170 Hydraulic Fluid, Rust Inhibited, Fire-Resistant, Synthetic Hydrocarbon Base

MIL-PRF-83282 Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base

MIL-PRF-87257 Hydraulic Fluid, Fire Resistant: Low Temperature Synthetic Hydrocarbon Base, Aircraft and Missile

2.2 Definitions

2.2.1 THERMAL EXPANSION RELIEF VALVE

A thermal relief valve is a pressure sensing valve, normally direct-operated, which ports small amounts of hydraulic fluid to return at a preset pressure to prevent overpressure caused by thermal expansion within a sub-circuit isolated from the main system relief valve. The actual relief setting is the preset pressure plus the return pressure that is subject to variation during system operation.

2.2.2 CRACKING PRESSURE

Cracking pressure is the pressure setting of the thermal relief valve and is defined as the rising pressure at which a sudden increase in flow occurs. Since cracking pressure is difficult to quantify for many valve types, it shall not be used as a specification requirement, but for reference only.

2.2.3 FLOW PRESSURE

Flow pressure is the differential pressure at which a specified flow occurs.

2.2.4 RESEAT PRESSURE

Reseat pressure is the pressure which corresponds to the leakage allowed on decreasing pressure after a thermal event.

2.2.5 FLOW GAIN

Flow gain is the change in flow divided by the change in pressure as pressure increases.

2.2.6 PRESSURE DECAY RATE

Pressure decay rate is the decrease in pressure with time after a thermal event. This term may apply to an aircraft system or a test volume used to monitor thermal relief valve reseat performance. The pressure decay rate decreases with increasing system or test volume.

3. REQUIREMENTS

The requirements of AS8775, for military applications, or AS4941, for commercial applications, shall apply as requirements of this specification, with the exceptions and additions specified herein. In event of conflict, this recommended practice shall govern.

3.1 Design and Construction

3.1.1 General Design

The configuration, dimensions, and other details of design shall conform to requirements specified by the purchaser. Valve configurations are as follows:

a. Cartridge: Cylindrical valves with O-ring grooves

b. Insert: Cylindrical valves with an expansion pin end to seal and lock

c. Line Mount: Valves with standard fitting ends (AS5202, AS33514, etc.)

3.1.2 Weight

The weight of the thermal relief valve shall be minimized consistent with the requirements of this specification.

3.1.3 Materials

Materials and processes used in the manufacture of these valves shall be of high quality, suitable for their purpose, and shall conform to accepted government or industry specifications. The material requirements of AS8775 apply for military applications and the material requirements of AS4941 including FAR/JAR/CS requirements therein apply for commercial applications.

3.1.3.1 Metals

All metals used shall be corrosion resistant, or utilize a corrosion resistant coating, and shall be compatible with the hydraulic fluid approved by the procuring activity.

3.1.3.2 Non-Metals

All non-metals including plastics, elastomeric materials, adhesives, and protective finishes shall not be capable of supporting fungus growth, and shall not be adversely affected by weathering. All non-metals shall be compatible with the hydraulic fluid and temperatures specified by the procuring activity. Materials requiring age control are not recommended. Non-metallic parts, other than plastic parts or standard seals, shall be subject to an immersion test in accordance with AS4941.

3.1.4 Standard Parts

Standard parts shall be used whenever they are suitable for the purpose. In the event there is no standard part in effect, non-standard parts may be used provided they conform to all requirements of this recommended practice.

3.2 Environmental Requirements

The thermal relief valve shall withstand operating temperatures as specified in Table 1 without detrimental effect, for the applicable type.

3.2.1 Fluid Compatibility

Thermal relief valves shall be compatible with the specified Type (fluid temperature) and Subtype (fluid type) as identified in 1.2.

3.3 Performance Requirements

3.3.1 Flow Requirements

Rated flow shall occur on increasing pressure at a maximum pressure not to exceed 135% of the Class System Operating Pressure. Maximum flow at 135% of the Class System Operating Pressure shall not exceed 50 times the minimum specified flow. The following flow rates are recommended but additional flow rates may be specified.

a. Size 5 - 5 ml per minute minimum

b. Size 15 - 15 ml per minute minimum

c. Size X - Flow rate as specified by purchaser

3.3.2 Minimum Reseat Pressure

On decreasing pressure the minimum reseat pressure shall not be less than 104% of the Class System Operating Pressure. At the minimum reseat pressure the leakage shall not exceed the maximum allowable leakage. It is recommended that one of the following maximum allowable leakage rates be specified:

a. Size 5 (low leakage) - 0.05 ml per minute (approximately 1 drop/min)

b. Size 5 (normal leakage) - 1 ml per minute (approximately 20 drops/min)

c. Size 15 (low leakage) - 0.1 ml per minute (approximately 2 drops/min)

d. Size 15 (normal leakage) - 1.5 ml per minute (approximately 30 drops/min)

3.4 Structural Requirements

3.4.1 Proof Pressure

A thermal relief valve shall withstand a proof pressure applicable to its Class as listed in Table 2 without any permanent deformation that would prevent it from acting as a thermal relief valve. External leakage shall be insufficient to form a drop, and there shall be no damage to any internal components.

3.4.2 Burst Pressure

The thermal relief valve shall withstand without rupture or loss of integrity a burst pressure applicable to its Class as listed in Table 2. The thermal relief valve is not required to function after burst testing.

TABLE 2 - PROOF AND BURST PRESSURES

| Class | Proof Pressure psi (MPa) | Burst Pressure psi (MPa) |
|---|---|---|
| 1500 | 2250 (15.5) | 3750 (25.9) |
| 3000 | 4500 (31.0) | 7500 (51.7) |
| 4000 | 6000 (41.3) | 10,000 (69.0) |
| 5000 | 7500 (51.7) | 12,500 (86.2) |
| 6000 | 12,000 (82.7) | 16,000 (110) |

3.4.3 Endurance

The thermal relief valve shall meet functional performance requirements (flow, re-seat pressure, internal leakage) after 20,000 endurance cycles as specified in 4.8.5.

3.4.4 Impulse

The thermal relief valve shall withstand impulse cycles as specified in 4.8.7.

3.5 Identification Marking

Each valve shall be clearly, permanently, and correctly marked as required below:

3.5.1 Identification Marking for Commercial Applications

Marking shall be in accordance with AS4941. If there is insufficient space for a nameplate on the component, permanent marking on the component in accordance with AS478 is acceptable. The following as a minimum shall be provided:

a. Supplier’s (Manufacturer's) part or drawing number

b. Supplier’s (Manufacturer's) name or trademark

c. Serial number

3.5.2 Identification Marking for Military Applications

Nameplates shall be in accordance with AS8775. Identification marking shall be in general accordance with MIL-STD-130 and specific requirements should be addressed in the procurement specification. If the procurement specification does not address the requirements, the following information shall be provided if sufficient space is available

a. Commercial and Government Entity (CAGE) Code (the CAGE Code can be found on the BINCS (Business Identification Number Cross-reference System) search engine)

b. Manufacturer’s part or drawing number

c. ARP4835 Type and Subtype

d. Procurement Specification number

e. Serial or lot number

f. Fluid (Identify fluid for intended use)

g. Date of manufacture

h. Weight and volume

If there is insufficient space for a nameplate on the component, permanent marking on the component in accordance with AS478 is acceptable and items a. and b. above shall be provided as a minimum.

NOTE: Information on BINCS is available at: https://www.bpn.gov/bincs/.

## 4. QUALITY ASSURANCE

### 4.1 Responsibility for Test and Inspection

Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all test and inspection requirements as specified herein including the selection of first article samples. The supplier/manufacturer shall be approved by the purchaser and the airworthiness authorities (where applicable) for the design, manufacture and testing of the valve.

### 4.2 Hydraulic Fluids and Fluid Cleanliness

The hydraulic fluid used for all tests shall be one listed as compatible with the specified subtype as identified in 1.2 unless the purchaser specifies a particular fluid. For all tests, except for endurance, the test fluid shall meet AS4059 Class 6B cleanliness requirements. For endurance testing, the procurement specification should specify a minimum acceptable contamination level that reflects the requirements of the system in which the valve is to be used. It is recommended the minimum acceptable contamination level be AS4059 Class 8B or dirtier.

### 4.3 Temperature

The tests shall be conducted at room temperature of 15 to 35 °C (59 to 95 °F) and a fluid temperature of 20 to 70 °C (68 to 158 °F) unless otherwise specified.

### 4.4 Hydraulic Pressure

Hydraulic pressure shall be applied using a hand pump, power driven pump, accumulator system, or combination of methods.

### 4.5 First Article Test Process

#### 4.5.1 First Article Test Samples

The first article test samples shall consist of two valves identified with the appropriate part number. Parts shall be fully representative of production hardware.

#### 4.5.2 First Article Tests

The test samples shall pass the first article tests specified herein. If the product is later modified in any way, the modified form shall be subjected to and shall pass the first article tests.

#### 4.5.3 Rejection Criteria

Any deviation from the performance specified herein shall be cause for rejection.

4.6 Quality Assurance Test and Inspection

Quality assurance consists of First Article (preproduction) Tests conducted to verify conformance with design characteristics and Production Acceptance Inspection and Tests to verify that the product is properly labeled and meets the required setting criteria.

4.6.1 Production Acceptance Inspection and Performance Tests

Each thermal relief valve supplied shall be subject to the following tests in the sequence listed, as described in 4.8.1, 4.8.2, and 4.8.3.

a. Examination of Product

b. Proof Pressure

c. Flow Pressure

d. Reseat Pressure

4.6.2 First Article (Preproduction) Tests

Prior to production, a first article or preproduction valves shall successfully pass the following inspections and tests:

a. Examination of Product

b. Proof Pressure

c. Performance Tests

d. Extreme Temperature Operation

e. Endurance

f. Vibration

g. Impulse

h. Burst

4.7 Sequence of First Article Tests

The first article units shall be tested in the sequence listed in Table 3 unless otherwise approved by the procuring activity.

TABLE 3 - SEQUENCE OF FIRST ARTICLE TESTS

| Order of Test Sample #1 | Test | Reference Paragraph |
|---|---|---|
| 1 | Examination of Product | 4.8.1.1 |
| 2 | Proof Pressure | 4.8.2.1 |
| 3 | Performance Tests (in sequence listed) | 4.8.3 |
| 4 | Low Temperature - High Viscosity | 4.8.4.1 |
| 5 | Intermediate Temperature Functioning | 4.8.4.2 |
| 6 | High Temperature - Low Viscosity | 4.8.4.3 |
| 7 | Performance Test | 4.8.3 |
| 8 | Endurance | 4.8.5 |
| 9 | Performance Test | 4.8.3 |
| 10 | Vibration | 4.8.6 |
| 11 | Performance Test | 4.8.3 |
| 12 | Burst | 4.8.8 |
| Sample #2 | | |
| 1 | Examination of Product | 4.8.1.1 |
| 2 | Impulse Test | 4.8.7 |

4.8 Test Methods

4.8.1 Examination of Product

Each valve shall be carefully examined to determine conformance with the requirements of this recommended practice, the applicable product drawing, and for any visible defects.

4.8.2 Structural Tests

4.8.2.1 Proof Pressure

Pressurize the assembly through the inlet port with the outlet port blocked or alternately or simultaneously pressurize each port. The pressure rise rate shall be 172 MPa/min (25,000 psi/min) maximum. Pressurize the units for 2 min to the proof pressure as specified in Table 1 (+5%/-0%). (Reduce pressure to the reseat pressure, relieve trapped pressure at the blocked outlet, then reduce pressure to zero.) See 3.4.1 for requirements.

4.8.3 Performance Tests

4.8.3.1 Flow Pressure

Pressure shall be applied to the inlet port with the outlet port open to atmosphere or plumbed to a suitable flow-measuring device. See 3.3.1 for requirements.

4.8.3.2 Reseat Pressure

The pressure shall be reduced to not less than the minimum reseat pressure and held for a period of not more than 3 min. Leakage shall then be measured for a period of 1 minute minimum and 3 minutes maximum (the longer period may be needed to accurately measure the leakage of low leakage valves). Leakage shall not exceed the maximum leakage specified for the minimum reseat pressure. See 3.3.2 for requirements.

4.8.3.3 Repeatability Test

The valve shall be cycled from 60 to 100% of the rated flow pressure 15 times with leakage at reseat pressure recorded every five cycles. Leakage shall not exceed the requirements of 4.8.3.2 during any of these cycles where leakage is measured.