SURFACE VEHICLE STANDARD

J747™ OCT2023

Issued 1956-04
Revised 2017-11
Reaffirmed 2023-10

Superseding J747 NOV2017

(R) Control Valve Test Procedure

RATIONALE

Major revision to update reference standards, change verbiage in regards to pressure and flow rating, valve test criteria, and figures containing worksheets and data plots.

SAE J747 has been reaffirmed to comply with the SAE Five-Year Review policy.

FOREWORD

In the selection and application of hydraulic directional control valves, it is necessary to know their operating characteristics. This SAE Recommended Practice provides the test and reporting procedure to obtain flow versus pressure drop, leakage rate, operating effort, metering pressure or flow versus spool travel and relief valve characteristics at fluid temperatures of 50 °C (122 °F) and 90 °C (194 °F).

1. SCOPE

This SAE Standard applies to hydraulic directional control valves as applied to self-propelled work machines referenced in SAE J1116. It describes a laboratory test procedure for evaluating:

a. Flow versus pressure drop

b. Leakage rate

c. Operating effort

d. Metering characteristics versus spool travel, pilot pressure, or electrical current

e. Relief valve characteristics

The document applies to single and multiple section hydraulic directional control valves.

This document illustrates axial, manually operated valves although the test procedure is applicable to other input forms such as rotary actuation, electric current, hydraulic or pneumatic pressure.

Performance characteristics such as metering hysteresis or dynamic response may have a significant effect on some of these tests.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

For more information on this standard, visit
https://www.sae.org/standards/content/J747_202310/

1.1 Purpose

To provide a uniform procedure for measuring and reporting the operating characteristics of a hydraulic directional control valve and associated relief valve when so equipped.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated the latest revision of SAE publications shall apply.

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.

SAE TSB 003 Rules for SAE Use of SI (Metric) Units

SAE J1116 Categories of Off-Road self-Propelled Work Machines

SAE J1117 Method of Measuring and Reporting the Pressure Differential-Flow Characteristics of a Hydraulic Fluid Power Valve

SAE J1235 Measuring and Reporting the Internal Leakage of a Hydraulic Fluid Power Valve

SAE J1276 Standardized Fluid for Hydraulic Component Tests

2.1.2 ISO Publications

Copies of these documents are available online at http://webstore.ansi.org/.

ISO 4406 Hydraulic Fluid Power – Fluids – Method for coding the level of contamination by solid particles

ISO 6743-4 Lubricants, Industrial oils and Related Products (class L) - Classification – Part 4: Family H (Hydraulic systems)

ISO 3448 Industrial Liquid Lubricants – ISO Viscosity Classification Second Edition

ISO 1219-1 Fluid power systems and components -- Graphic symbols and circuit diagrams -- Part 1: Graphic symbols for conventional use and data-processing applications

ISO 5598 Fluid power systems and components – Vocabulary

3. DEFINITIONS

3.1 RATED FLOW

Maximum design flow for valve inlet port, work ports, and return ports.

3.2 RATED PRESSURE

Maximum continuous design pressure for the valve inlet port, and peak design pressure for the workports.

3.3 PORT IDENTIFICATION

Work port "A" is the port farthest from the spool spring centering mechanism. Work port "B" is closest to the centering mechanism. The No. 1 circuit is the valve section located nearest the valve inlet port. “P” is the main flow inlet port. “T” is the main return flow outlet port. For special circumstances submit a sketch of all ports.

3.4 TEST PRESSURE

Valve test pressure agreed upon by user and supplier.

3.5 TEST FLOW

Valve test flow agreed upon by user and supplier.

3.6 DESIGNATED LOAD INTERFERENCE PRESSURE

Pressure difference between the “P” port and the “A” or “B” work port, which may be elevated when the same pump is providing flow to multiple functions, and one function is requiring a higher actuation pressure than another.

3.7 PRESSURE DROP

Pressure difference between any two measurement locations.

3.8 LEAKAGE RATE

Volume of oil per unit time that leaks past a blocked passage at a given pressure differential and oil viscosity.

3.9 OPERATING EFFORT

Maximum effort necessary to shift the spool from its hold or neutral position to its shifted position and the effort exerted by the spool or required to move the spool from each shifted position back to neutral.

3.10 METERING CHARACTERISTICS

Circuit output (pressure or flow) as it relates to a control input (spool stroke, pilot pressure, or electrical command current).

3.11 MAIN RELIEF

A relief valve which limits the inlet pressure of the valve (may or may not be integral to the valve).

4. GRAPHIC SYMBOLS

Graphic symbols used herein are in accordance with ISO R 1219- and ANSI Y14.17-. Where ISO R 1219- and ANSI Y14.17- are not in agreement, ISO R 1219- governs.

5. UNITS

5.1 The International System of Units (SI) is used herein in accordance with SAE TSB 003.

5.2 Approximate conversion to "U.S. customary" units appear in parenthesis after SI units.

6. SUMMARY OF DESIGNATED INFORMATION

6.1 Specify a full description of the valve, including all functions and features, on all requests for this test. For an example of descriptive data that may be documented (see Figure 1).

6.1.1 The number of total sections (if sectional valve), and/or total number of spools.

6.1.2 The rated flow and rated pressure

6.1.3 The port type (O-ring, flange, flare, etc.), size, and orientation or placement on the valve section.

6.1.4 The control input range (stroke, pilot pressure, current, etc.)

6.1.5 The location, type and setting of all relief valves (circuit, LS, etc.)

6.2 Specify a full description of the test fluid used (see Section 15):

6.2.1 The type of fluid.

6.2.2 The fluid test temperature.

6.2.3 The fluid cleanliness level.

7. GENERAL PROCEDURE

7.1 Conduct the test for entire control input range.

7.2 When referring to this specification for catalog information and sales literature, use only standardized values shown in Section 15.

7.3 Test and report of subplate mounted valves may run with the subplate included. Reports shall explicitly indicate how such valves were tested.

7.4 To minimize variables, the valve temperature shall be stabilized within 3 °C (5 °F) of the temperature of the fluid and actuate the valve spool or relief at least twice before taking respective data. For close coordination between testing laboratories, similar equipment, fluid and procedures are recommended.

8. THE CONDITION ACCURACY OF UNITS

Maintain the test condition accuracy within the limits shown in Table 1:

Table 1

Test Condition	Maintain Within ±	SI Unit	US Unit
Flow	2%	L/min	gpm
Pressure	2%	kPa	psi
Pressure Differential	2%	kPa	psi
Temperature	1 °C (3.5 °F)	°C	°F
Force	2%	N	1bf
Torque	2%	N.m	lbf.in
Spool Position (or Control Input) [1]	2%	mm	in
Time	0.5%	min or s	min or s

Percentages are of maximum reading.

8.1 Precautions shall be taken to obtain readings unaffected by turbulence and velocity.

8.2 Back pressure shall be 700 kPa (100 psi) maximum except by special agreement between user and manufacturer.

9. PRESSURE DROP

9.1 Open Center Pressure Drop (Inlet to Tank Port)

With control valve in the neutral position, vary the flow to the inlet port from zero to rated flow. See Figure 4.6. Test and record the pressure differential per SAE J1117.

9.2 Work Port Pressure Drop

9.2.1 Inlet to Work Port

Shift the control valve to direct flow from the inlet port to work port "A". Vary the input flow from zero to rated flow. Test and record the pressure differential per SAE J1117. Repeat for work port "B". (see Figure 4.1)

9.2.2 Work Port to Tank Port

Shift the control valve to direct flow from work port "B" to the tank port. Vary the input flow from zero to twice the rated flow. Test and record the pressure differential per SAE J1117. Repeat for work port "A". (see Figure 4.4)

9.3 Special Function Pressure Drop

Valves having a float, regenerative, etc. position shall not require test for pressure differential in this position, except by agreement between user and manufacturer.

[1] Other control inputs - use appropriate units

10. LEAKAGE RATE

The test should be conducted and data recorded in accordance to SAE J1235.

10.1 Work Port Leakage

The test shall be applicable to valves in which the work ports are blocked when the valve is in hold position. The leakage rate is to be measured individually with 75% rated pressure to the work port and all other ports open to low pressure while the valve is in the hold position. See Figure 4.4.

If a circuit overload relief is incorporated, test at this time in accordance with Section 13.

10.2 Inlet to Work Port Leakage

The test shall be applicable to closed center valves or valves in which the inlet is pressurized by a load such as another spool or power-beyond. The leakage rate is to be measured individually with rated pressure to the inlet port and all other ports open to low pressure except as required to provide applied pressure while the valve is in the neutral position. See Figure 4.1.

10.3 Inlet to Outlet Leakage

The test shall be applicable to closed center valves. It may also be applied to open center valves in the shifted and blocked condition, however, should be noted as such. The leakage rate is to be measured with rated pressure to the inlet port and all other ports open to low pressure except as required to provide the applied pressure. Valve is to be in the neutral position except as noted for open center valves. See Figure 4.6.

If a main relief is incorporated, test at this time in accordance with Section 13.

10.4 Work Port Load Holding Check Leakage

The test shall be applicable to valves incorporating this feature to prevent reverse flow when the valve is in the shifted position. The leakage rate is to be measured individually with 75% of rated pressure to the work port and all other ports open to low pressure while the valve is in the shifted position. See Figure 4.4.

If a circuit overload relief is incorporated, its effect shall be considered (see Section 13).

11. OPERATING EFFORT

11.1 Test Requirement

11.1.1 This test is for manually operated valves with direct connection of operating lever to the valve spool.

11.1.2 Valves requiring pilot pressure and/or electrical current for spool actuation are exempt from this test.

11.1.3 Refer to Figure 5. For load sense valves, use appropriate load sense pump. Valve to be installed on base at manufacturer's recommended mounting bolt torque.

11.1.4 Actuate the spool at a rate of 1.25 to 2.5 mm/s (0.05 to 0.10 in/s).

11.2 Recorded Data

11.2.1 For each valve section tested include all relevant data pertaining to the spool record:

a. Type of actuation (describe adequately, such as axial or rotary, etc.)

b. Lever type used for test (manufacturer's or special fabrication).

c. If lever operation, record lever lengths

d. Record force or torque measurements.

Data may be extracted from X-Y plots or X-Y plots substituted for the chart with appropriate information included. (Specify if positive force is required to return to neutral position.) See Figure 5.

11.3 No Load Condition (No Flow)

11.3.1 The valve shall be actuated (three times) in both directions with oil flowing through valve to wet all surfaces.

11.3.2 Turn off inlet flow to valve.

11.3.3 Actuate spool 3 times in both directions.

11.3.4 Measure and record:

a. Maximum axial force or torque necessary to shift from its neutral position to each shifted position.

b. Minimum axial force or torque required to move spool from each fully shifted position back to neutral.

11.4 Looped Work Port Condition

11.4.1 Work ports looped with an adjustable relief valve in loop. (see Figure 4.5)

11.4.2 Apply rated flow to inlet port. Shift valve spool to direct flow to either work port. Adjust relief valve in the work port loop to obtain rated pressure at inlet port.

11.4.3 Measure and Record

a. Maximum axial force or torque necessary to shift the spool from its neutral position to each shifted position.

b. Minimum axial force or torque necessary to shift the spool from each fully shifted position back to neutral.

c. Inlet port pressure, flow, and temperature.

d. Optional: Measure pressure, flow, and temperature at the work port and tank port.

11.5 Designated Load Interference Pressure

11.5.1 Work ports to tank. (see Figure 4.1)

11.5.2 Apply rated flow at rated pressure to inlet port. Block bypass flow with another spool or power beyond and set main relief valve at designated load interference pressure.

11.5.3 Measure and Record

a. Maximum axial force or torque necessary to shift spool from its neutral position to each shifted position.

b. Minimum axial force or torque necessary to move spool from each fully shifted position back to neutral.

11.6 Loaded Work Port Condition

11.6.1 Remove work port loop. Block inlet port.

11.6.2 Apply rated flow at rated pressure to each work port in turn. Plug opposite unused work port. (See Figure 4.4)

11.6.3 Measure and Record

a. Maximum axial force or torque necessary to shift spool from its neutral position to each shifted position.

b. Minimum axial force or torque necessary to move spool from each fully shifted position back to neutral.

11.6.4 Apply rated flow to inlet port. Repeat rated flow at rated pressure to each work port in turn. Leave opposite unused work port open to tank. (See combination of Figure 4.2 and 4.4)

11.6.5 Repeat 11.6.3.

12. METERING CHARACTERISTICS

Figure 4 shows recommended circuits for conducting metering test for driving and overhauling loads (see 12.1.1, 12.1.2, 12.1.3) and overhauling loads (see 12.2.1 and 12.2.2).

For each spool tested include all relavent data as described in 6.1

Figure 2 shows metering characteristics test results as a function of spool travel.

For load sense valves, use appropriate load sense pump.

12.1 Inlet to Work Port Metering

12.1.1 At No Load

Pump to be set for rated flow. Main relief shall be set for rated pressure of valve so that it does not pass any flow. Back pressure shall be minimized at work port and tank port at rated flow. Actuate the spool from neutral to fully shifted position first one way and then the other. Record flow to work port versus spool movement. Record inlet pressures versus spool movement. Also, record bypass flow versus spool movement for open center valves (see Figures 4.3 and 2.1) and inlet pressure.

12.1.2 At Rated Pressure

Pump to be set for flow of 10% greater than rated flow, or some flow agreed upon between customer and supplier. Set load relief valve at rated pressure. Record work port flow versus spool movement shifting both directions from neutral (see Figures 4.2 and 2.2). Also record by-pass flow and inlet pressure versus spool movement.

12.1.3 At Designated Load Interference Pressure

Pump to be set for flow of 10% greater than rated flow, or some flow agreed upon between customer and supplier. Block by-pass flow with another spool or power beyond plug and set main relief at designated load interference pressure. Record work port flow versus spool movement shifting both directions from neutral (see Figures 4.1 and 2.3).

12.2 Work Port to Tank Metering

Pump to be set for maximum circuit return flow and rated pressure. Consider cylinder area ratios resulting in flow magnification (see Figure 4.4 and 4.3).

12.2.1 Record tank flow versus spool movement first for work port "A" and then for work port "B".

12.2.2 Repeat 12.2.1 with test stand relief set at 25% of rated pressure, or other pressure setting agreed upon by customer and supplier.

13. RELIEF VALVE CHARACTERISTICS

Figure 4.6 depicts a recommended circuit to conduct main relief valve test. The main relief valve tests shall be conducted by applying rated flow to the valve inlet and shifting one valve spool to direct flow to a blocked work port with no port relief valve. If work ports have port relief valves, the work port relief valve setting shall be a minimum of 10% higher than the main relief setting; otherwise replace the work port relief valve with a plug for the duration of the main relief valve test.

Figure 4.4 depicts a recommended circuit to conduct work port relief test. Rated flow is applied to the work port with valve spool in neutral or holding position.

The following tests shall be conducted to obtain main or work port relief valve characteristics.

13.1 Override and Leakage Characteristics

With pump set for rated flow, gradually increase test stand relief valve pressure to gradually increase flow through relief valve under test. Record flow versus pressure. Gradually decrease the system pressure and record flow versus pressure. For leakage use Figure 3.1. For pressure rise use Figure 3.2.

Crack and reseat pressures may be determined from the leakage curve.

13.2 Overshoot and Response

Increase the pressure at a rate of at least 690000 kPa/s (100000 psi/s) and record pressure against time curve. Determine overshoot, undershoot and response time (see Figure 3.3) using appropriate instrumentation.

14. DATA PRESENTATION

14.1 Description of the Valve per Figure 1.

14.2 Pressure Drop (Chart per J1117).

14.3 Leakage Rate (Chart per J1235).

14.4 Operating Effort per Figure 5.

14.5 Metering Characteristics per Figure 2.

14.6 Relief Valve Override and Response per Figure 3.

15. STANDARDIZED VALUES

15.1 All tests should be run with a fluid per SAE J1276 unless otherwise specified. If an alternative fluid is used, each test document shall include the fluid type per ISO 6743-4, viscosity grade per ISO 3448, viscosity measurements at 40ºC (104 °F) and 100 °C (212 °F).

15.2 Fluid temperatures 50 °C (122 °F) and 90 °C (194 °F), measured at the valve inlet port.

15.3 Oil cleanliness shall have a minimum of 19/17/14 per ISO 4406.

16. IDENTIFICATION STATEMENT

Use the following statement in catalogues and sales literature when electing to comply with this voluntary standard. "Performance data obtained and presented in accordance with SAE J747."

Valve Manufacturer			
Valve Model		**Rated Flow**	
Valve Type		**Rated Pressure**	
Valve Serial Number			
Inlet Section Information		**Outlet Section Information**	
Port sizes	*Inlet, LS, aux, etc*	**Port sizes**	*oulet, aux, LS, etc*
System Relief Setting		**System Relief or LS Setting**	
Special Features		**Special Features**	*Power Beyond, regen, etc*
Work Sections			
Port sizes	*work port*	**Spool Type**	*single/double acting, motor, etc*
Circuit Relief Setting		**Spool Activation**	*manual, pilot, EH*
Special Features	*check valves, compensators, etc*	**Spool Travel**	*distance in mm or inch*

Figure 1 - Directional control valve descriptive data

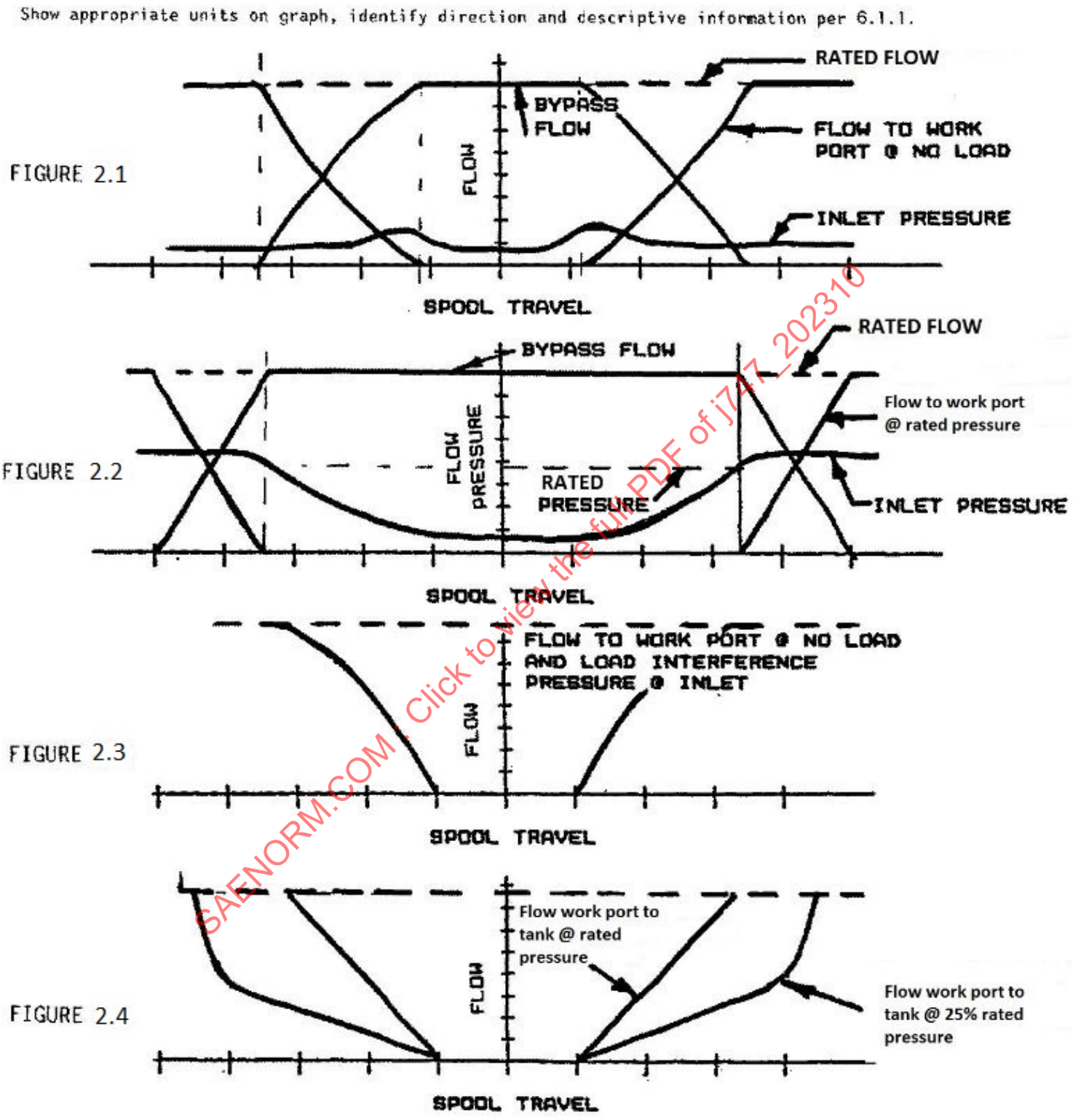

Figure 2 - Metering characteristics