

JIS

JAPANESE INDUSTRIAL STANDARD

**Test Methods for
Electro-hydraulic Proportional
Directional Bypass
Flow Control Valves**

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In the event of any doubt arising,
the original Standard in Japanese is to be final authority.

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Test Methods for Electro-hydraulic
Proportional Directional Bypass
Flow Control Valves

B 8657-1989

1. Scope

This Japanese Industrial Standard specifies test methods for verifying the rated capability or performance of electro-hydraulic proportional directional bypass flow control valves.

Remark: The units and numerical values in { } in this Standard are based on the traditional unit system and are appended for informative reference.

The conversion rate is as follows:

$$1 \text{ MPa } (=10.197 \text{ kgf/cm}^2) \approx 10 \text{ kgf/cm}^2$$

2. Definitions

For the main terms used in this Standard the definitions of JIS B 0142 apply, and the rest of the terms are as follows:

- (1) electro-hydraulic proportional directional bypass flow control valve A directional bypass flow control valve which can carry out flow control proportional to an analog electrical signal while leading excess liquid to the tank port.
- (2) dead zone The range where the output does not change when the input signal increases from zero. It is expressed by the value of input signal.
- (3) repeatability Dispersion of output when the input of the same setting is applied repeatedly to a valve under constant operating conditions such as fluid temperature. The maximum value of dispersion is expressed by the absolute value, or as the percentage of the maximum control flow or the maximum working pressure.
- (4) loading capacity The volume of pressurized working fluid contained in the machine and apparatus including the piping directly connected thereto.

Applicable Standards:

JIS B 0142-Glossary of Terms for Oil Hydraulics and Pneumatics

JIS B 8651-Test Methods for Electro-hydraulic Proportional Pressure Relief Valves

JIS D 0203-Method of Moisture, Rain and Spray Test for Automobile Parts

JIS D 1601-Vibration Testing Methods for Automobile Parts

JIS K 2213-Turbine Oils

- (5) solenoid An electro-mechanical transducer which produces a force proportional to the input current.
- (6) allowable back pressure The maximum pressure which does not cause breakage of machine and apparatus even if it acts on return side and back of pressure working plane of the machine and apparatus continuously or repeatedly.
- (7) input signal An effective signal into a valve or amplifier which results in a certain output.
- (8) absolute accuracy The accuracy of reading of the measured value, it is not the accuracy of measurement range.
- (9) resolution Increment of input signal required to produce a change in valve output at a prescribed signal level, which is expressed as a percentage of the input signal at the maximum control flow or of the input signal at the maximum working pressure. In general resolution is defined as the smallest signal necessary for increasing or decreasing valve output. If these signals are different it is recommended to use the larger value.
- (10) supply flow Amount of fluid which passes through supply port of a device or system.
- (11) internal leakage Flow through internal clearance of a device.
- (12) external leakage Leakage from the interior of a device to external atmosphere.
- (13) maximum control flow The maximum value of controllable flow which passes through a valve corresponding to the electrical analog input.

3. Classification of Test

All the tests given here are carried out as type tests.

Remark: Acceptance tests shall be determined by agreement between the parties concerned with acceptance based on this Standard.

4. Test Items

4.1 Solenoid Test The solenoid test shall be carried out on the following items:

- (1) Insulation resistance and dielectric withstand voltage
- (2) Coil resistance
- (3) Temperature rise

4.2 Static Characteristic Test The static characteristic test shall be carried out on the following items:

- (1) Input signal versus control flow characteristic
- (2) Resolution

- (3) Load pressure change versus control flow change characteristic (pressure compensation characteristic)
- (4) Repeatability
- (5) Unloading pressure characteristic
- (6) Fluid temperature change versus control flow change characteristic
- (7) Internal leakage
- (8) External leakage
- (9) Proof pressure
- (10) Load pressure change versus valve differential pressure change characteristic
- (11) External drain
- (12) Supply flow change versus control flow change characteristic
- (13) Pilot pressure change versus control flow change characteristic

4.3 Dynamic Characteristic Test The dynamic characteristic test shall be carried out on the following items:

- (1) Step response
- (2) Frequency response

4.4 Environmental Test The environmental test shall be carried out on the following items:

- (1) Resistance to vibration
- (2) Resistance to moisture and spray

5. Test Conditions and Tolerances in Measurement

5.1 Test Conditions The test conditions shall be as given below.

- (1) Kind of Working Fluid The oil shall be that of class 2 specified in JIS K 2213 which corresponds to VG 46 of ISO.
- (2) Oil Temperature $50 \pm 5^{\circ}\text{C}$
- (3) Contamination Level When the size and number of contaminant particles in 0.1 l of working fluid are classified into the grades as given in Table, the contamination level shall fall within a range of grade 9 to grade 11.

Table. Classification of Contamination

Contamination level		Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grade 9	Grade 10	Grade 11	Grade 12
Size (μm) and number of particles	5 to 15 μm	4 000	8 000	16 000	32 000	64 000	128 000	256 000	512 000	1 024 000
	15 to 25 μm	712	1 425	2 850	5 700	11 400	22 800	45 600	91 200	182 000
	25 to 50 μm	126	253	506	1 012	2 025	4 050	8 100	16 200	32 400
	50 to 100 μm	22	45	90	180	360	720	1 440	2 880	5 760
	100 μm and over	4	8	16	32	64	123	256	512	1 024

- (4) Attitude of Mounting Specimens shall be mounted as agreed between the parties concerned with acceptance if especially necessary.
- (5) Input Signal The input signal (current, voltage, dither, etc.) shall comply with the conditions determined for individual valve to be tested.
- (6) Tolerances on Test Pressure, Test Flow and Input Signal
- (a) Test Pressure $\pm 2.5 \%$ Provided, the minimum value is 0.1 MPa {1 kgf/cm²}.
- (b) Test Flow $\pm 5 \%$
- (c) Input Signal $\pm 1 \%$ Provided, the minimum value is 0.1 % of the input signal corresponding to the maximum control flow.

5.2 Tolerances on Measured Values The tolerances on measured values shall be as follows:

- (1) Pressure $\pm 2.5 \%$ Absolute accuracy, provided the minimum value is 0.1 MPa {1 kgf/cm²}.
- (2) Flow Rate $\pm 2.5 \%$ Static absolute accuracy, provided the minimum value is 1 % of the maximum control flow.
- (3) Temperature $\pm 2^\circ\text{C}$
- (4) Input Signal $\pm 2.5 \%$ Absolute accuracy
- (5) Electrical Resistance $\pm 2.5 \%$ Absolute accuracy

6. Test Equipment and Test Method

6.1 Solenoid Test

6.1.1 Insulation Resistance and Dielectric Withstand Voltage Tests It is not necessary to apply oil hydraulic pressure to the valve to be tested (specimen), in the insulation resistance and dielectric withstand voltage tests. However, the tests shall be carried out as given below, with the specimen filled up with the working fluid for the specimen of such construction that the internal electrical component (solenoid) comes in contact with the operating oil.

- (1) Apply a voltage of A.C. 1500 V (at power frequency) between one of the terminations and the body of the specimen for 60 s, by means of a withstand voltage tester, and verify that the leakage current is not exceeding 1 mA.
- (2) Measure the insulation resistance under the same connection as that in the above item by using a D.C. 500 V insulation resistance tester. It is recommended that the insulation resistance is not less than 100 MΩ.
- (3) For a solenoid of two-coil configuration, carry out this test also between the two coils.

6.1.2 Coil Resistance Test In the coil resistance test, measure the coil resistance between electric terminations of the specimen with a d.c. resistance tester. Measure the room temperature and record it on the test report, and indicate the resistance converted to 20°C.

6.1.3 Temperature Rise Test The temperature rise test shall be as follows:

- (1) Place the specimen on a base thermally insulated.
- (2) Apply the input signal corresponding to the maximum control flow to the specimen.
- (3) After elapse of sufficient time for increase and saturation of temperature, measure the surface temperature of solenoid with a surface thermometer and the temperature of solenoid by resistance method. Measure the room temperature and record it in the test report.

Obtain the value of temperature rise from the following formula:

$$\theta = \left(\frac{R_2}{R_1} - 1 \right) (234.5 + t_1) - (t_2 - t_1)$$

where, θ : temperature rise (°C)

R_1 : initial resistance value (Ω)

R_2 : resistance value at temperature saturation (Ω)

t_1 : initial ambient temperature (°C)

t_2 : ambient temperature at temperature saturation (°C)

6.2 Static Characteristic

6.2.1 Test for Input Signal versus Control Flow Characteristic The test for input signal versus control flow characteristic shall be as given below.

The test shall be carried out on each pair of two outlet ports confronting each other and the hydraulic graphical symbol of the spool shall be entered in the test results.

- (1) The test (oil hydraulic, this applies to the same situation) circuit shall be as given in Attached Fig. 1.
- (2) The measuring circuit shall be as given in Attached Fig. 2.
- (3) Set the pressure of oil supply in the test circuit to a sufficiently higher pressure than the maximum working pressure of the specimen.
- (4) Set the supply flow for the specimen to about 110 % of the maximum control flow of the specimen by means of variable displacement pump ④ or flow control valve ② in Attached Fig. 1. In the case of external pilot system, set the pilot side supply pressure to the pilot side maximum working pressure.
- (5) If only a safety valve is combined with the specimen, set the safety valve to the maximum working pressure.
- (6) If an electromagnetic proportional pilot relief valve is combined with the specimen, apply the input signal corresponding to the maximum working pressure to the relief valve, and completely close the safety valve, if also combined.
- (7) Set the load pressure by means of load pressure control restrictor ⑨ so that the supply side pressure of the specimen becomes 70 % of the maximum working pressure of the specimen at the maximum control flow.
- (8) Carry out change of specimen input current for one cycle from zero to the input current corresponding to the maximum control flow of the specimen and then to zero, at a cycle rate at which the specimen and measuring device are not dynamically affected, by means of a signal generator (triangular wave oscillator), record the input on X-axis of an X-Y recorder (or a substitutional instrument. This applies to the same situation) and the control flow of the specimen on Y-axis.
- (9) Read the characteristic values given below from the test results based on Attached Fig. 2.

(a) Hysteresis

$$\text{Hysteresis (\%)} = \frac{\Delta Q_{\max}}{\text{Maximum control flow}} \times 100$$

where, $\Delta Q_{\max}$: maximum value of difference between two values of specimen control flow corresponding to the same input signal over one cycle of specimen input signal sweep

- (b) The value of input signal at the maximum control flow
- (c) Dead zone

6.2.2 Resolution Test The resolution test shall be as given below.

The test shall be carried out on each pair of two outlet ports confronting each other, and the hydraulic graphical symbol of the spool shall be entered in the test results.

- (1) The test circuit shall be as given in Attached Fig. 1.
- (2) The measuring circuit shall be as given in Attached Fig. 2.
- (3) Set the pressure of oil supply in the test circuit to the maximum working pressure of the specimen.
- (4) Set the supply flow for the specimen to about 110 % of the maximum control flow of the specimen by means of variable displacement pump ④ or flow control valve ② in Attached Fig. 1. In the case of external pilot system, set the pilot side supply pressure to the pilot side maximum working pressure.
- (5) If only a safety valve is combined with the specimen, set the safety valve to the maximum working pressure.
- (6) If an electromagnetic proportional pilot relief valve is combined with the specimen, apply the input signal corresponding to the maximum working pressure to the relief valve, and completely close the safety valve, if also combined.
- (7) In the process of increasing the input signal from zero specified in 6.2.1 (8), stop the change at 15 % of the maximum control flow of the specimen, and note the value of this input signal (I_1). Maintain the standstill state for at least 10 s, gradually increase the input signal again, and note the value of input signal (I_2) at the instant when the control flow of the specimen increases again. The recording and reading may be done by using an X-Y recorder.
- (8) Apply the input signals so that the control flow is 50 % and 85 % of the maximum control flow of the specimen and repeat the procedure of (7) at each input signal. At each measurement point, set the load pressure to 70 % of the maximum working pressure of the specimen by means of load pressure control restrictor ⑨.
- (9) Express the resolution by the maximum value of -

$$\frac{I_2 - I_1}{\text{Input signal at maximum control flow of specimen}} \times 100 (\%)$$

obtained at each input signal level.

6.2.3 Test for Load Pressure Change versus Control Flow Change Characteristic The test for load pressure change versus control flow change characteristic shall be as given below.

The test shall be carried out on each pair of two outlet ports confronting each other, and the hydraulic graphical symbol of the spool shall be entered in the test results.

- (1) The test circuit shall be as given in Attached Fig. 1.
- (2) The measuring circuit shall be as given in Attached Fig. 8.
- (3) Set the pressure of oil supply in the test circuit to a sufficiently higher pressure than the maximum working pressure of the specimen.
- (4) Set the supply flow for the specimen to about 110 % of the maximum control flow of the specimen by means of variable displacement pump ④ or flow control valve ② in Attached Fig. 1. Set the pilot side supply pressure to the pilot side maximum working pressure.
- (5) If only a safety valve is combined with the specimen, set the safety valve to the maximum working pressure.
- (6) If an electromagnetic proportional pilot relief valve is combined with the specimen, apply the input signal corresponding to the maximum working pressure to the relief valve, and completely close the safety valve, if also combined.
- (7) Set the input signal so that the control flow of the specimen becomes the maximum control flow of the specimen.
- (8) Operate load pressure control restrictor ⑨ for one cycle of complete closed - open - closed positions, at a cycle rate at which the specimen and measuring device are not dynamically affected, record the load pressure on X-axis of an X-Y recorder and the control flow of the specimen on Y-axis.
- (9) Apply input signals so that the control flow of the specimen becomes 50 %, 10 %, 5 %, 3 % and 1 % of the maximum control flow of the specimen. Repeat the procedure of (8) at each input level.
- (10) Take the records of the X-Y recorder as the test results.

6.2.4 Repeatability Test The repeatability test shall be as given below.

The test shall be carried out on each pair of two outlet ports confronting each other and the hydraulic graphical symbol of the spool shall be entered in the test results.

- (1) The test circuit shall be as given in Attached Fig. 1.
- (2) The measuring circuit shall be as given in Attached Fig. 4.
- (3) Set the pressure of oil supply in the test circuit to a sufficiently higher pressure than the maximum working pressure of the specimen.
- (4) Set the supply flow for the specimen to about 110 % of the maximum control flow of the specimen by means of variable displacement pump ④ or flow control valve ② in Attached Fig. 1.
- (5) If only a safety valve is combined with the specimen, set the safety valve to the maximum working pressure.

- (6) If an electromagnetic proportional pilot relief valve is combined with the specimen, apply the input signal corresponding to the maximum working pressure to the relief valve, and completely close the safety valve, if also combined.
- (7) Set the load pressure with load pressure control restrictor ⑨ so that the supply pressure for the specimen at 50 % of the maximum control flow becomes 70 % of the maximum working pressure of the specimen.
- (8) Repeatedly apply two input signals, one corresponding to the maximum control flow of the specimen and the other corresponding to 50 % thereof, stepwise twenty times or more at a period during which the control flow of the specimen sufficiently stabilizes.
- (9) Apply the input signals so that 50 % of the maximum control flow of the specimen and zero control flow are achieved. Repeat the procedure of (8) at each flow level.
- (10) Drive the X-axis of an X-Y recorder with time, record the control flow of the specimen on Y-axis and read the dispersion of the control flow of the specimen at 50 % from the above records.
- (11) Take the values of dispersion width at increase of flow and at decrease of flow in the procedures of (8) and (9), and express the repeatability by the absolute value of the maximum value or by

$$\frac{\text{Maximum value of dispersion}}{\text{Maximum control flow}} \times 100 \%$$

6.2.5 Unloading Pressure Characteristic Test The unloading pressure characteristic test shall be as given below. The hydraulic graphical symbol of the spool shall be entered in the test results.

- (1) The test circuit shall be as given in Attached Fig. 5. The specimen shall be at null.
- (2) The measuring circuit shall be as given in Attached Fig. 6.
- (3) Set the pressure of oil supply in the test circuit to a sufficiently higher pressure than the maximum working pressure of the specimen.
- (4) Set the supply flow for the specimen to about 110 % of the maximum control flow of the specimen by means of variable displacement pump ④ or flow control valve ② in Attached Fig. 5. In the case of external pilot system, set the pilot side supply pressure to the pilot side maximum working pressure.
- (5) If only a safety valve is combined with the specimen, set the safety valve to the maximum working pressure.