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JAPANESE INDUSTRIAL STANDARD

Test Methods for Electro-hydraulic Proportional Bypass Flow Control Valves

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In the event of any doubt arising,
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Test Methods for Electro-hydraulic Proportional
Bypass Flow Control Valves

B 8656-1989

1. Scope

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

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

The conversion ratio 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 in JIS B 0142 apply, and the rest of the terms shall be as follows:

- (1) electro-hydraulic proportional bypass flow control valve A bypass control valve which is capable of controlling the flow proportional to the electric analog input signal.
- (2) minimum necessary valve differential pressure The minimum value of difference between inlet and outlet pressure of a valve which is necessary for the valve to maintain the pressure compensation function.
It is generally expressed in terms of the value when the maximum control flow is passed.
- (3) dead zone The range of input signal where the output does not change when the input signal increases from zero. It is expressed in terms of input signal.

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 Method for Automobile Parts

JIS K 2213-Turbine Oils

- (4) repeatability The dispersion of output signal which appears when the input signal of the same setting is repeatedly applied under the same working conditions such as fluid temperature. The maximum value of dispersion is expressed in terms of the absolute value or as the percentage of the maximum control flow or the maximum working pressure.
- (5) load capacity The volume of pressurized working fluid contained in the hydraulic system including the piping directly connected with the machine and apparatus.
- (6) solenoid An electro-mechanical transducer which generates a force proportional to the input signal.
- (7) permissible back pressure The maximum pressure which does not cause breakdown when applied continuously or repeatedly to return side of apparatus or back side of pressure working plane.
- (8) input signal The effective signal to a valve or an amplifier which results in a prescribed output.
- (9) absolute accuracy The accuracy on the measured value itself, not on the measuring range of instrument.
- (10) resolution The increment of input signal required to produce a change in valve output at a prescribed signal level. It is expressed as a percentage of input signal at the maximum control flow or that at the maximum working pressure.

In general the resolution is defined as the minimum signal necessary for increasing or decreasing of valve output. It is recommended to use the larger value if these signals differ.
- (11) supply flow The amount of fluid which passes through supply port of a device or system.
- (12) internal leakage The flow which passes through internal clearance of a device.
- (13) external leakage The leakage from interior of a device to external atmosphere.

3. Kind of Test

All tests are type tests.

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

4. Test Items

4.1 Solenoid Test Solenoid tests shall be carried out for the following items:

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

4.2 Static Characteristic Tests Static characteristic tests shall be carried out for the following items:

- (1) Input signal versus control flow characteristic
- (2) Resolution
- (3) Load pressure change versus control flow change characteristic
- (4) Supply flow change versus control flow change characteristic
- (5) Load pressure change versus valve differential pressure change characteristic
- (6) Repeatability
- (7) Fluid temperature change versus control flow change characteristic
- (8) External drain
- (9) Internal leakage into outlet port
- (10) Internal leakage into tank port
- (11) External leakage
- (12) Proof pressure
- (13) Free (reverse) flow pressure drop characteristic
- (14) Unloading pressure characteristic

4.3 Dynamic Characteristic Test Dynamic characteristic tests shall be carried out for the following items:

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

4.4 Function Test of Electro-hydraulic Proportional Pressure Relief Valve

4.5 Environmental Test Environmental tests shall be carried out for the following items:

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

5. Test Conditions and Tolerances in Measurement

5.1 Test Conditions The test conditions shall be as follows:

- (1) Kind of Working Fluid The fluid shall be the turbine oil of grade 2 specified in JIS K 2213 which corresponds to VG 46 of ISO.
- (2) Fluid Temperature $50 \pm 5^{\circ}\text{C}$

- (3) Contamination Level The contamination level shall fall within the range of grades 9 to 11 when the fluid is classified into grades as given in Table according to the size and number of contaminant particles in 0.1 l of working fluid.

Table. Classification of Contamination Level

Contamination level Size (μm) and number of contaminant particles	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grade 9	Grade 10	Grade 11	Grade 12
5 to 15 μm	4000	8000	16000	32000	64000	128000	256000	512000	1024000
15 to 25 μm	712	1425	2850	5700	11400	22800	45600	91200	182000
25 to 50 μm	126	253	506	1012	2025	4050	8100	16200	32400
50 to 100 μm	22	45	90	180	360	720	1440	2880	5760
100 μm min.	4	8	16	32	64	123	256	512	1024

- (4) Mounting Attitude If there is special requirement for use, the mounting attitude shall be as agreed between the parties concerned with acceptance.
- (5) Input Signal The input signal (current, voltage, dither, etc.) shall be as specified for individual valve to be tested (hereafter referred to as "specimen").
- (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 input signal corresponding to the maximum control flow.

5.2 Tolerances in Measurement The tolerances in the measurements shall be as follows:

- (1) Pressure $\pm 2.5 \%$ Absolute accuracy. Provided, the minimum value is 0.1 MPa {1 kgf/cm²}.
- (2) Flow $\pm 2.5 \%$ 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 Methods

6.1 Solenoid Test

6.1.1 Insulation Resistance and Dielectric Withstand Voltage Tests In the insulation resistance and dielectric withstand voltage tests, it is not necessary to apply hydraulic pressure to the specimen, but carry out the tests as specified below on the specimen filled with the working fluid, if the specimen is so structured that the internal electrical component (solenoid) comes in contact with the working fluid.

- (1) Apply a.c. 1500 V (power frequency) for 60 s by means of a withstand voltage tester between one of the electric input terminals of the specimen and the body of the specimen, and verify that the leakage current is not exceeding 1 mA.
- (2) Measure the insulation resistance using a d.c. 500 V insulation resistance tester in the same connection as stand in the above item. It is recommended that the insulation resistance is not less than 100 M Ω .
- (3) For a solenoid of two-coil system, carry out the above test between the two coils.

6.1.2 Coil Resistance Test In the coil resistance test, measure the resistance of coil between electric input terminals of the specimen by means of a d.c. resistance meter. Measure the room temperature at the measurement, record it in the test results and also indicate the value converted to 20°C.

6.1.3 Temperature Rise Test Carry out the temperature rise test as follows:

- (1) Place the specimen on a stand thermally insulated.
- (2) Apply an input signal corresponding to the maximum control flow to the specimen.
- (3) After lapse of enough time for the temperature to rise and saturate, measure the surface temperature of the solenoid with a surface thermometer and the temperature of the solenoid by resistance method. Measure the room temperature at the measurement and record it in the test results.

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 (Ω)

R_2 : resistance at temperature saturation (Ω)

t_1 : initial ambient temperature (°C)

t_2 : ambient temperature at saturation (°C)

6.2 Static Characteristic Tests

6.2.1 Input Signal versus Control Flow Characteristic Test Carry out the input signal versus control flow characteristic test as given below.

Carry out the test on each of two outlet ports confronting each other, and enter the hydraulic graphical symbol of the spool in the test results.

- (1) The test (oil hydraulic; this note applies hereafter to the same case) shall be as given in Attached Fig. 1.
- (2) The measurement circuit shall be as given in Attached Fig. 2.
- (3) The set pressure of oil supply in the test circuit shall be sufficiently higher than the maximum working pressure of the specimen.
- (4) Set the supply flow to the specimen to about 110 % of the maximum control flow of the specimen by means of the variable displacement pump or the flow control valve shown 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 valve to the maximum working pressure.
- (6) If an electro-hydraulic proportional pilot pressure relief valve is combined with the specimen, apply an input signal corresponding to the maximum working pressure to the valve. If a safety valve is further combined with the specimen, completely close the safety valve.
- (7) Set the load pressure by means of load pressure control restrictor ⑥, so that the supply-side pressure of the specimen at the maximum control flow becomes 70 % of the maximum working pressure of the specimen.
- (8) Change the input signal of the specimen by one cycle from zero to the input signal corresponding to the maximum control flow of the specimen and back to zero, at a cycle rate at which the specimen and the measuring devices are not dynamically affected, by means of a signal generator (triangular wave generator). Record the input signal on X axis and the control flow of the specimen on Y axis of an X-Y recorder (or a substitutional instrument; this note applies hereafter to the same case).
- (9) Read the following characteristic values from the test results based on Attached Fig. 4.

(a) Hysteresis

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

where, $\Delta Q_{\max}$: maximum value of difference between specimen control flows at the same input signal in one cycle of input signal to the specimen

(b) Input signal at the maximum control flow

(c) Dead zone

6.2.2 Resolution Test Carry out the resolution test as given below.

Carry out the test on each of two outlet ports confronting each other, and enter the hydraulic graphical symbol of the spool in the test results.

- (1) The test circuit shall be as given in Attached Fig. 1.
- (2) The measurement circuit shall be as given in Attached Fig. 2.
- (3) The set pressure of oil supply in the test circuit shall be sufficiently higher than the maximum working pressure of the specimen.
- (4) Set the supply flow to the specimen to about 110 % of the maximum control flow of the specimen by means of the variable displacement pump or the flow control valve shown 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 valve to the maximum working pressure.
- (6) If an electro-hydraulic proportional pilot pressure relief valve is combined with the specimen, apply an input signal corresponding to the maximum working pressure to the valve. If a safety valve is further combined with the specimen, completely close the safety valve.
- (7) Stop the change of input at 15 % of the maximum control flow of the specimen, in the process of increasing the input signal from zero stated in 6.2.1 (8), and record the input signal (I_1) at that time. Maintain this rest state for at least 10 s, gradually increase the input signal again, and record the input signal (I_2) at the instant when the control flow of the specimen starts again for increase. The record and the reading may be done by an X-Y recorder.
- (8) Apply input signals so that 50 % and 85 % of the maximum control flow of the specimen are achieved, and repeat the procedure of (7) at each level. Set the load pressure to 70 % of the maximum working pressure of the specimen, by means of load pressure control relief valve at each point.
- (9) Express the maximum value of

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

at each input signal level as the resolution.

6.2.3 Supply Pressure Change versus Control Flow Change Characteristic Test Carry out the supply pressure change versus control flow change characteristic test as given below.

- (1) The test circuit shall be as given in Attached Fig. 1.