

JIS

JAPANESE INDUSTRIAL STANDARD

Test Methods for Electro-hydraulic Servo Valves

JIS B 8659—1989

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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
Servo Valves

B 8659-1989

1. Scope

This Japanese Industrial Standard specifies test method for verifying the rated capability or performance of flow control electro-hydraulic servo 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 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 in JIS B 0142 apply, and the rest of the terms shall be as follows:

- (1) electro-hydraulic servo valve A valve which supplies an analog-controlled fluid power, as the output, corresponding to the analog electrical signal as the input command.
- (2) flow control electro-hydraulic servo valve A servo valve which controls the output flow in proportion to the electrical input signal.
- (3) torque motor An electro-mechanical transducer which produces a torque proportional to the input current. It is used in the first stage of a servo valve.
- (4) coil resistance D.C. coil resistance at a specified temperature. It is marked on each coil in Ω .
- (5) coil inductance The inductance of a coil at specific service conditions. It is expressed in H. If there are two or more coils, the total coil inductance includes the mutual inductance.

Applicable Standards:

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

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

Corresponding International Standard:

ISO 6404-Hydraulic fluid power-Servo valves-Test methods

- (6) rated current (rated signal) Specified input current of either polarity to produce rated flow under specified conditions. Rated current shall be specified for a particular coil connection (differential, series or parallel). It does not include null bias current.
- (7) valve polarity Relationship between the direction of control flow and the input current polarity.
- (8) control flow Flow of operating fluid through the valve control port.
- (9) rated flow Control flow which is obtained at a specified valve pressure drop under the rated current. All the flow which passes through a control port travels through another control port via the load device (four-way servo valve).

Rated load is normally specified as no-load flow.

- (10) no-load control flow Flow through the valve control ports when there is zero load pressure drop.
- (11) loaded control flow Flow through the valve control ports when there is load pressure drop.
- (12) flow curve Graphical representation of control flow versus input signal. This is normally a continuous plot of a complete cycle between plus and minus rated signal values at a cycle rate which is unaffected by the valve dynamic characteristics.
- (13) normal flow curve Locus of the mid-points of input signals (or flow) on increasing side and that on decreasing side. That is a flow curve without hysteresis.
- (14) flow gain Mean slope of the control flow versus input signal curve in any specific operating region. Following three operating regions are usually significant with flow control servo valves:
 - (a) The null region
 - (b) The normal region of flow control
 - (c) The region where flow saturation effects may occur

Where this term is used without qualification, it is assumed to mean the flow gain in normal region of flow control.

- (15) normal flow gain Slope of a straight line which is drawn from the zero flow point on normal flow curve so that the deviation from the normal flow curve is minimized over the region up to the rated current of each polarity.
- (16) linearity Deviation between the measured normal flow curve and ideal flow straight line having a slope equal to the normal flow gain. The linearity is defined as the maximum deviation of each polarity, and expressed by the greater as a percentage of rated signal (flow linearity).

- (17) symmetry Degree of equality between the servo-valve normal flow gain of one polarity and that of the reversed polarity. Symmetry is measured as the difference in normal flow gain of each polarity, and expressed as percentage of the greater.
- (18) hysteresis Difference in the valve input signals required to produce the same valve output during a single cycle of valve input signal when cycled at a rate below that at which dynamic effects are important.
- In general, the maximum hysteresis which is the maximum difference in input signal occurring in a cycle is indicated as a percentage of rated signal.
- (19) internal leakage Total internal valve flow from supply port to return port of a servo valve with zero control flow.
- (20) null leakage Total internal leakage from the valve in the null (quiescent) position.
- (21) load pressure drop Differential pressure between the control ports.
- (22) null This means a neutral point where the control flow is zero at zero load pressure drop.
- (23) null bias Input signal required to bring the valve to null. It is, excluding the effects of hysteresis, expressed as percent of rated signal.
- (24) null pressure Equalized pressure existing at both control ports at null with the both control ports closed.
- (25) null region Region about null where the flow gain is effected by parameters such as lap and internal leakage.
- (26) null shift Change in null bias due to changes in supply pressure, temperature and other operating conditions. It is expressed as a percentage of rated signal.
- (27) resolution Increment of input signal required to produce a change in valve control flow of a servo valve, specified as the minimum signal required to cause either an increase or decrease of valve output. It is expressed as a percentage of rated signal.
- (28) threshold Change of input signal required to produce a reversal in valve output at null. It is expressed as a percentage of rated signal.
- (29) valve pressure drop Sum of the differential pressures across two orifices of the output stage (four-way valve), which is equal to the supply pressure minus the return pressure minus the load pressure drop.
- (30) pressure gain Change in load pressure drop per unit input signal with zero control flow, control ports being blocked. Pressure gain is specified as the average slope of the curve of load pressure drop versus input signal in the defined region.

3. Classification of Tests

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 Torque Motor Tests The torque motor tests are classified as follows:

- (1) Insulation resistance and dielectric withstand tests
- (2) Coil resistance test
- (3) Coil inductance test

4.2 Static Characteristic Tests The static characteristic tests are classified as follows:

- (1) Preparation of test
- (2) No-load control flow (characteristic) test
- (3) Pressure gain (characteristic) test
- (4) Test for resolution and threshold at null region
- (5) Test for resolution and threshold outside null region
- (6) Null bias test
- (7) Test for null shift (characteristic) with supply pressure (change)
- (8) Test for null shift (characteristic) with return pressure (change)
- (9) Test for null shift (characteristic) with oil temperature (change)
- (10) Null pressure test
- (11) Internal leakage test
- (12) Loaded control flow (characteristic) test
- (13) Proof pressure test

4.3 Dynamic Characteristic Tests The dynamic characteristic tests are classified as follows:

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

4.4 Environmental Tests The environmental tests are classified as follows:

- (1) Vibration test

- (2) Moisture and spray test

5. Test Conditions and Tolerances on Measurement

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

- (1) Kind of Operating Oil 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) Degree of Contamination When the size and number of contaminant particles in 0.1 l of operating oil are classified into the grades as given in Table, the degree of contamination shall fall within a range of grade 5 to grade 8.

Table. Classification of Contamination

Degree of contamination		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	128	255	512	1 024

- (4) Attitude of Mounting Specimen 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 value to be tested.
- (6) Connection Method For two-coil four-terminal system, series, parallel, differential, etc.
- (7) Supply Pressure The supply pressure shall be the rated pressure plus the return pressure.
- (8) Return Pressure This pressure shall not exceed 5 % of rated pressure.
- (9) Tolerance on Test Pressure and Input Signal
 - (a) Test Pressure ± 2.5 % provided the minimum value is 0.1 MPa {1 kgf/cm²}.
 - (b) Input Signal ± 0.5 % provided the minimum value is 0.1 % of rated input signal.

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

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

6. Test Equipment and Test Methods

6.1 Torque Motor Test

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

- (1) Connect together the electric input terminations of specimen and apply, between them and the specimen body, a d.c. voltage of five times the maximum anticipated coil voltage or 500 V whichever is the greater, as the test voltage for 60 s. Measure the current flowing with the test voltage still applied.
- (2) Obtain the insulation resistance by dividing the test voltage by the measured current. It is recommended that the insulation resistance is not less than 100 M Ω . A commercially available insulation resistance tester (d.c. 500 V) may be used for the measurement of insulation resistance.
- (3) For a torque motor of two-coil four-termination configuration, this test shall also be carried out between the two coils.

6.1.2 Coil Resistance Test In the coil resistance test, measure the coil resistance between electric input terminations (terminations of each coil for two-coil four-termination configuration) with a d.c. resistance tester. Do not pass the operating oil through the specimen at the measurement, measure the room temperature and record it in the test report, and indicate the resistance converted to 20°C.

6.1.3 Coil Inductance Test In the coil inductance test, carry out the measurement on the specimen operated under the conditions of 5.1. Carry out the measurement as given below on each coil in each of series connection and parallel connection for the specimen of two-coil four-termination configuration.

- (1) The measuring circuit shall be as shown in Attached Fig. 1.

Connect a precision non-inductive resistor with the coil termination in series, and connect an oscillator to drive the specimen coils.

- (2) Set the oscillator frequency at either 50 or 60 Hz, so that it is different from the frequency of the electrical power supply to the test equipment. Adjust the specimen input current to a peak amplitude equal to the specimen rated current.
- (3) Measure the a.c. voltages (e_r , e_k , e_v)
- (4) Construct the diagram as shown in Attached Fig. 2, to show the vector relationship of the voltages.
- (5) Obtain the apparent coil inductance from the following formula:

$$L = \frac{R}{2\pi f} \times \frac{e_k}{e_r}$$

where, L : apparent coil inductance (H)

R : resistance of precision non-inductive resistor (Ω)

f : test frequency (Hz)

e_r : as shown in Attached Fig. 2.

e_k : as shown in Attached Fig. 2.

e_v : as shown in Attached Fig. 2.

6.2 Static Characteristic Tests

6.2.1 Preparation for Tests The preparation for tests shall be as follows:

- (1) Prior to all the tests, attach the specimen to the test equipment and then adjust the null of specimen to its correct position.
- (2) Connect both control ports directly, apply the supply pressure to the supply port, and change the input signal cyclically between the rated values several times.

6.2.2 No-load Control-flow Test The no-load control-flow test shall be as follows:

- (1) The test (oil pressure) circuit and measuring circuit shall be as given in Attached Fig. 3.
- (2) Open return port valve ⑩ and control port valves ⑭, ⑮ in the test (oil pressure) circuit.
- (3) Set the supply pressure of the specimen to 7 MPa {70 kgf/cm²}.

- (4) Apply the specimen input signal of continuous several cycles with an amplitude equal to the band between positive and negative rated values plus the anticipated null bias, at a cycle rate at which the specimen and measuring equipment are not dynamically affected, by means of a signal generator (triangular wave generator). Then carry out one cycle of such sweep, record the input signal on X-axis of an X-Y recorder (or a substitutional instrument) and the control flow of specimen on Y-axis.
- (5) Confirm that the supply pressure is constant at 7 MPa {70 kgf/cm²} during one cycle of input signal.
- (6) Draw the normal flow curve from the test results (no-load control-flow characteristics) in accordance with Attached Fig. 4, and obtain the normal flow gain.
- (7) Read the following characteristic values from the test results (no-load control-flow characteristics), normal flow curve and normal flow gain based on Attached Fig. 4.
 - (a) Valve polarity
 - (b) Rated flow
 - (c) Hysteresis

$$\text{Hysteresis (\%)} = \frac{\Delta I_{r \max}}{\text{Rated input signal}} \times 100$$

where, $\Delta I_{r \max}$: maximum value of ΔI_r in Attached Fig. 4.

Evaluate hysteresis in each polarity, and express the larger value.

- (d) Linearity

$$\text{Linearity (\%)} = \frac{\Delta I_{l \max}}{\text{Rated input signal}} \times 100$$

where, $\Delta I_{l \max}$: maximum value of ΔI_l in Attached Fig. 4.

Evaluate linearity in each polarity, and express the larger value.

- (e) Symmetry

$$\text{Symmetry (\%)} = \frac{S_1 - S_2}{S_1} \times 100 \quad (\text{Provided } S_1 > S_2)$$

where, S_1 : as given in Attached Fig. 4.

S_2 : as given in Attached Fig. 4.