

JAPANESE INDUSTRIAL STANDARD

JIS K 6400:1997

Test methods for flexible polyurethane foam

July, 1997

ERRATA

Page 5

Subclause 6.3.1

Delete the phrase “, and take the read load as hardness(H).” from the 8th line, and should read as follows:

“ nearest 1 N {0.1kgf}. Measure one time, and” .

Remarks : This errata is for correcting the first edition of this Standard.

Japanese Standards Association

JIS

JAPANESE
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JIS K 6400 : 1997

**Test methods for flexible
polyurethane foam**

ICS 83. 100

Descriptors : urethane, polyurethane, foams

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Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of International Trade and Industry through deliberations at Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law:

Date of Establishment: 1997-02-20

Date of Public Notice in Official Gazette: 1997-02-20

Investigated by: Japanese Industrial Standards Committee
Divisional Council on Consumer Life

This establishment is made for conformity with corresponding International Standards ISO 845, *Cellular plastics and rubbers – Determination of apparent (bulk) density*, ISO 1798, *Polymeric materials, cellular flexible – Determination of tensile strength and elongation at break*, ISO 1856, *Polymeric materials, cellular flexible – Determination of compression set*, ISO 2439, *Polymeric materials, cellular flexible – Determination of hardness (indentation technique)*, ISO 3385, *Flexible cellular polymeric materials – Determination of fatigue by constant-load pounding*, ISO 3795, *Road vehicles, and tractors and machinery for agriculture and forestry – Determination of burning behaviour of interior materials*, ISO 7231, *Polymeric materials, cellular flexible – Method of assessment of air flow value at constant pressure-drop*, ISO 8067, *Flexible cellular polymeric materials – Determination of tear strength*, and ISO 8307, *Flexible cellular polymeric materials – Determination of resilience*, and for reorganization of standardizing system.

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the original JIS is to be the final authority.

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Test methods for flexible polyurethane foam

Introduction This Standard is the Japanese Industrial Standard prescribed based on ISO 845, *Cellular plastics and rubbers—Determination of apparent (bulk) density*, ISO 1798, *Polymeric materials, cellular flexible—Determination of tensile strength and elongation at break*, ISO 1856, *Polymeric materials, cellular flexible—Determination of compression set*, ISO 2439, *Polymeric materials, cellular flexible—Determination of hardness (indentation technique)*, ISO 3385, *Flexible cellular polymeric materials—Determination of fatigue by constant-load pounding*, ISO 3795, *Road vehicles, and tractors and machinery for agriculture and forestry—Determination of burning behaviour of interior materials*, ISO 7231, *Polymeric materials, cellular flexible—Method of assessment of air flow value at constant pressure-drop*, ISO 8067, *Flexible cellular polymeric materials—Determination of tear strength* and ISO 8307, *Flexible cellular polymeric materials—Determination of resilience*, and there is no technical modification in it except the contents specified below.

[Outline of differences in specified contents]

① Test conditions for delivery tests are added. ② The dimensions of test pieces determined in Japan are added. ③ Japanese testing devices are added. ④ Japanese measuring methods are added. ⑤ Japanese calculation methods are added. ⑥ Reports based on Japanese calculation method are added.

1 Scope This Japanese Industrial Standard specifies general test methods for flexible polyurethane foams (hereafter referred to as “foams”).

Remarks 1 The units and numerical values given in [] in this Standard are based on the traditional units and are those for informative reference.

2 The International Standards corresponding to this Standard are given below.

ISO 845 *Cellular plastics and rubbers—Determination of apparent (bulk) density*

ISO 1798 *Polymeric materials, cellular flexible—Determination of tensile strength and elongation at break*

ISO 1856 *Polymeric materials, cellular flexible—Determination of compression set*

ISO 2439 *Polymeric materials, cellular flexible—Determination of hardness (indentation technique)*

ISO 3385 *Flexible cellular polymeric materials—Determination of fatigue by constant-load pounding*

ISO 3795 *Road vehicles, and tractors and machinery for agriculture and forestry—Determination of burning behaviour of interior materials*

ISO 7231 *Polymeric materials, cellular flexible—Method of assessment of air flow value at constant pressure-drop*

ISO 8067 *Flexible cellular polymeric materials—Determination of tear strength*

ISO 8307 *Flexible cellular polymeric materials—Determination of resilience*

2 Normative references The following standards are cited in this Standard:

JIS B 1501 *Steel balls for ball bearings*

JIS B 7721 *Tensile testing machines*

JIS Z 8401 *Rules for rounding off of numerical values*

3 Test items Test items shall be as follows:

- a) apparent density
- b) hardness
- c) compression set
- d) fatigue by constant-load pounding
- e) rebound resilience
- f) tensile strength and elongation
- g) tear strength
- h) burning behavior
- i) air flow value

4 General conditions for test

4.1 Sampling method of test piece Unless otherwise specified, test pieces shall be sampled after elapse of 72 h or longer from the manufacture. However, for a delivery test, the test piece may be sampled after elapse of 12 h from manufacture.

The test pieces shall be, as a rule, sampled from the central part of the product. If test pieces of a prescribed size can not be sampled, they may be sampled from the foam manufactured under the same conditions as that for the product. Further, the thickness direction shall be the foaming direction. When the test pieces can not be sampled with the thickness direction being the foaming direction, such a fact shall be recorded.

4.2 Conditioning of test piece Test pieces, when not especially specified, shall be conditioned for 16 h or longer under the following conditions prior to subjected to the test.

- a) $(23 \pm 2)^\circ\text{C}$ temperature, $(50 \pm 5)\%$ relative humidity

However, in the delivery test, the conditioning for 6 h or longer under the following condition is permitted.

- b) $(23 \pm 5)^\circ\text{C}$ temperature, $(50^{+20}_{-10})\%$ relative humidity

4.3 Standard condition of testing place The standard conditions of the testing place shall be, as a rule, the same temperature and humidity as those for conditioning of the test piece.

5 Apparent density The measurement of apparent density of a foam shall be as follows.

5.1 Test piece At least three test pieces each of which having a volume of 100 cm³ or more shall be sampled. When the test pieces having such a size can not be sampled, the test pieces shall be sampled as agreed upon between the purchaser and the supplier.

5.2 Measuring instrument The measuring instruments shall be as follows:

- a) **Dial gauge** Unless otherwise specified, the dial gauge shall have a measuring area of about 10 cm² to 20 cm², and a precision of 0.05 mm or better.
- b) **Vernier caliper** The vernier caliper shall have a precision of 0.1 mm or better.
- c) **Metal rule or steel tape measure** The metal rule or the steel tape measure shall have a precision of 0.5 mm or better.
- d) **Balance** The balance shall have a precision of 0.5 % or better.

Recommendable measuring instruments shall be selected from Table 1 according to the measuring size.

Table 1 Recommendable measuring instrument

Size of measuring object mm	Recommendable measuring instrument
10 max.	Dial gauge of 0.05 mm precision
Over 10 up to and incl. 100	Vernier caliper of 0.1 mm precision
Over 100	Metal rule or steel tape measure of 0.5 mm precision

5.3 Measuring method Carry out the measurement for each of thickness, width and length, on a test piece at three different positions or more under such a state that the foam is not deformed, take each average, and calculate the volume of each test piece. Then, measure the mass of each test piece to an accuracy of 0.5 % and express it in gram.

5.4 Calculation Calculate each apparent density (ρ) according to the following formula (1), and round off the average on all the test pieces to one place of decimal in accordance with JIS Z 8401.

$$\rho = \frac{W}{V} \times 10^6 \dots\dots\dots (1)$$

where, ρ : apparent density (kg/m³)
 W : mass of test piece (g)
 V : volume of test piece (mm³)

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5.5 Report The following items shall be entered in the report.

- a) Apparent density
- b) Other necessary items
 - 1) The temperature and humidity at which the test pieces were conditioned
 - 2) The presence or absence of surface skin
 - 3) The presence or absence of seam or other defects on test piece
 - 4) The shape and size of each test piece, and place where the test pieces were sampled

6 Hardness Hardness of foams shall be measured in accordance with the following A, B, C or D method.

6.1 Test piece Test pieces of a square of 380^{+20}_0 mm one side and (50 ± 2) mm thickness shall be taken from the product. When the test piece of 50 mm thickness can not be taken, that of a size as near to the standard thickness as possible is taken, and the thickness shall be reported. Further, in such cases that the test piece which is a final product or does not conform to the said size, the test piece shall be sampled as agreed upon between the purchaser and the supplier.

Remarks : When the same test piece is repetitively tested, the test piece is left as it is for 16 h or longer for recovering, and then subjected to the test.

6.2 Testing machine The testing machine shall be as follows:

- a) **Testing machine** The testing machine shall be able to indent the test piece between an indenter which shall have a uniform relative motion, in the vertical direction, of (100 ± 20) mm/min and a supporting surface. The testing machine shall be able to measure the load with a precision of $\pm 1\%$ or ± 1 N or better, and to measure the thickness of the test piece under load with a precision of ± 0.25 mm.

Informative reference : The testing machine in 6.6 method D is a material tester with a load pointer, or an automatic recorder capable of recording a load deflection curve, which is capable of keeping compression speed constant.

- b) **Supporting surface** The supporting surface, unless otherwise specified, shall have a horizontal smooth and solid surface which is larger than the test piece. Further, in order to allow the escape of air from below the test piece, the supporting surface shall have vent holes of about 6 mm diameter at about 20 mm pitch.
- c) **Indenter** The indenter shall be mounted with a ball joint so as to move freely by vertical movement. It shall be a flat disk of 200^{+3}_0 mm in diameter and its lower edge shall have a radius of $1.0^{+0.5}_0$ mm. The lower surface of the indenter shall be smooth but not polished.

6.3 Method A

6.3.1 Measuring method Place the test piece flatly at the center on the base of the testing machine, put the indenter on the upper surface of the test piece, read the thickness when the load is 5_{-2}^{0} N ($0.5_{-0.2}^{0}$ kgf) to the nearest 0.1 mm, and take that as an initial thickness. Then, after pushing the indenter by (75 ± 2.5) % of the initial thickness at a speed of (100 ± 20) mm per min, immediately remove the load, push again immediately the indenter by (25 ± 1) % of the initial thickness at a speed of (100 ± 20) mm per min, read the load when 20 s has elapsed after standing still to the nearest 1 N (0.1 kgf), and take the read load as hardness (H). Measure one time, and round off the numerical value in accordance with JIS Z 8401 for the hardness.

6.4 Method B

6.4.1 Preliminary compression The preliminary compression shall be as follows.

- a) Place the test piece on the supporting surface so that the center of the test piece or the test part agreed upon between the purchaser and the supplier is positioned below the center of the indenter. For the test piece having a skin on one side, let the skin side face to face the supporting surface.
- b) Apply a load of 5_{-2}^{0} N ($0.5_{-0.2}^{0}$ kgf) to the specified place, and measure the thickness.

Push the indenter into by (70 ± 2.5) % of the thickness at a speed of (100 ± 20) mm per min.

- c) After pushing the indenter into by 70 %, return the load at the same speed. Repeat two times the operation wherein the load is applied and removed.

6.4.2 Measuring method After removing the load of 6.4.1 c), quickly push the indenter into by (40 ± 1) % of the thickness of the test piece. After keeping compression for (30 ± 1) s, read the load at that time, take the read load as the hardness, measure a value up to 100 N (10.2 kgf) to the nearest 1 N (0.1 kgf), and measure a value of 100 N (10.2 kgf) or over to the nearest 5 N (0.5 kgf).

6.5 Method C

6.5.1 Preliminary compression Carry out the preliminary compression of 6.4.1.

6.5.2 Measuring method After removing the load of 6.4.1 c), carry out quickly the following operation.

- a) Indent the test piece to (25 ± 1) % of the thickness.
- b) Keep the compression for (30 ± 1) s.
- c) Measure the load.
- d) Indent the test piece to (40 ± 1) % of the thickness
- e) Keep the compression for (30 ± 1) s.

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- f) Measure the load.
- g) Indent the test piece to $(65 \pm 1) \%$ of the thickness.
- h) Keep the compression for (30 ± 1) s.
- i) Measure the load.
- j) Take the read load as the hardness. Measure a value up to 100 N {10.2 kgf} to the nearest 1 N {0.1 kgf}, and measure a value of 100 N {10.2 kgf} or over to the nearest 5 N {0.5 kgf}.

6.6 Method D

6.6.1 Preliminary compression Carry out the preliminary compression of 6.4.1.

6.6.2 Measuring method After removing the load of 6.4.1 c), carry out quickly the following operation.

- a) Operate the recorder of the material testing machine. Otherwise, return the pointer of the load indicator, and quickly indent the test piece to $(40 \pm 1) \%$ of the thickness.
- b) Record the load of the pointer. Otherwise, record the instantaneous maximum load of the material testing machine.
- c) Take the read load as the hardness, measure a value up to 100 N {10.2 kgf} to the nearest 1 N {0.1 kgf}, and measure a value of 100 N {10.2 kgf} or over to the nearest 5 N {0.5 kgf}.

6.7 Report The following items shall be entered on the report.

- a) Testing method
- b) Dimensions of test piece, especially its thickness
- c) Hardness
- d) Other necessary items
 - 1) Conditioning, test temperature, and relative humidity
 - 2) Kind of test piece (material or product)
 - 3) The number of test pieces when they are piled up
 - 4) Presence or absence of skin, if presents, its number

7 Compression set The compression set of a foam shall be measured as follows.

7.1 Test piece Sample five test pieces of (25 ± 1) mm thickness, (50 ± 1) mm length, and (50 ± 1) mm width. If the thickness of test piece is less than 25 mm, use the test pieces by piling them up. In the test piece, upper surface shall be parallel to the lower surface, and the side surface shall be normal to the bottom surface.



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7.2 Testing machine The testing machine shall be composed of two smooth plates which are larger than the test piece, and a spacer and a clamp for keeping the plates parallel to each other shall be used.

7.3 Measuring method Measure the thickness (t_0) of the central part of the test piece to the nearest 0.1 mm with the measuring instrument of 5.2 under such a state that no deformation is given to the foam. Compress the test piece by 50 % or 75 % of its thickness (t_0), if necessary, by 90 % using two compression plates and fix it. Put the test piece as it is compressed into a thermostat at a temperature $(70 \pm 1)^\circ\text{C}$ within 15 min, and heat it for 22 h. Take the testing apparatus out from the thermostat, take the test piece out from the compression plates within 1 min, and place it on material of low thermal conductivity such as wood. After recovering the test piece by leaving as it is for 30 min under conditioning environment specified in 4.2, remeasure the thickness (t_1) at the same position to the nearest 0.1 mm.

7.4 Calculation Calculate compression set (C_s) according to the following formula (2), and round off to one place of decimal in accordance with JIS Z 8401. Further, obtain the median of the test results on five pieces.

$$C_s = \frac{t_0 - t_1}{t_0} \times 100 \quad (2)$$

where, C_s : compression set percentage (%)
 t_0 : initial thickness of test piece (mm)
 t_1 : thickness after test of test piece (mm)

7.5 Report The following items shall be entered in the report:

- a) Individual compression set percentage and the median on all pieces
- b) Thickness of test piece (for those excepting specified thickness)
- c) Other necessary items
 - 1) Temperature and humidity at which conditioning is carried out

8 Fatigue by constant-load pounding The relative fatigue by constant-load pounding of a foam shall be measured according to the following A or B method.

8.1 Method A

8.1.1 Test piece Sample test pieces of rectangular parallelepiped of 20 mm or over in thickness and 50 mm or over in width and length from the product.

8.1.2 Testing machine The testing machine having a mechanism as given in Fig. 1 shall be used.

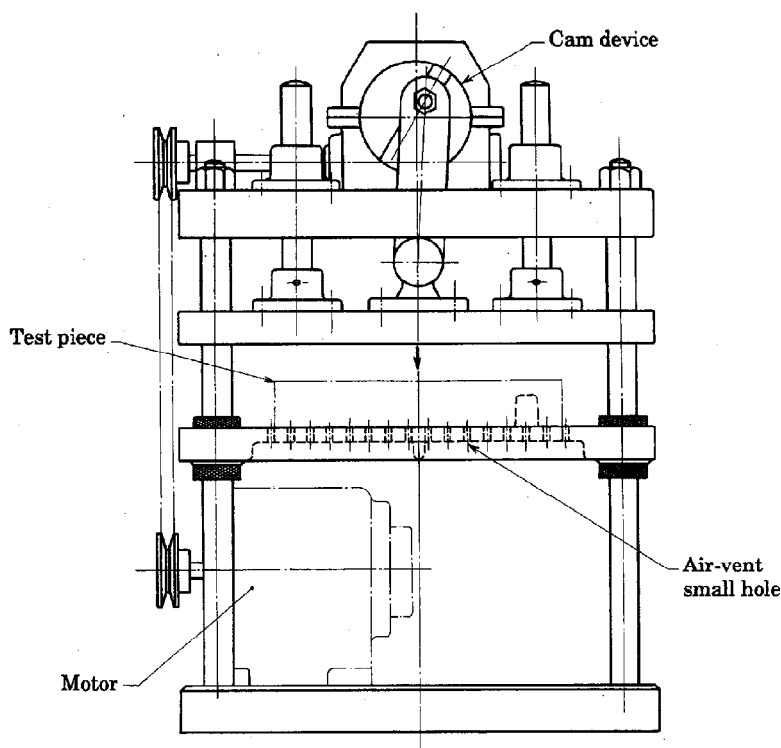


Fig. 1 Constant load pounding testing machine
for urethan foam (example)

8.1.3 Measuring method Measure the thickness (t_0) at the central part of the test piece to the nearest 0.1 mm with no deformation given to the foam, place the test piece on the platen perforated with small holes, and carry out pounding for continuous 80 000 cycles to 50 % of the thickness (t_0) of the test piece at a speed of 60 cycles per min. Thereafter, take out the test piece, let it stand for 30 min under the state specified in 4.2, and remeasure the thickness (t_1) at the same position to the nearest 0.1 mm.

8.1.4 Calculation Calculate relative fatigue by constant-load pounding (Cf_a) on each of three test pieces according to the following formula (3), and round it off to one place of decimal in accordance with JIS Z 8401. Express the median of numerical values so obtained as the result.

$$Cf_a = \frac{t_0 - t_1}{t_0} \times 100 \quad (3)$$

where, Cf_a : relative fatigue by constant-load pounding (%)

t_0 : initial thickness of test piece (mm)

t_1 : thickness after test of test piece (mm)

8.1.5 Report The following items shall be stated on the report.

- Testing method
- Relative fatigue by constant-load pounding
- Thickness of test piece
- Other necessary items

8.2 Method B

8.2.1 Test piece Sample three test pieces, having (50 ± 2) mm thickness and (380 ± 20) mm width and length. In general, test the test piece in the direction of service of the final product.

8.2.2 Testing machine The testing machine shall be as follows.

- a) **Platen** The platen shall be perforated with many small holes as specified in 6.2 b).
- b) **Indenter** The indenter shall be of a circle of (250 ± 1) mm diameter with a (25 ± 1) mm radius at its lower edge on a flat bottom to which the maximum load in loading cycle can be applied. The lower surface of the indenter shall be smooth but not polished.

By means of a crank or other suitable mechanism, the indenter shall be capable of pressurizing the horizontal test piece.

- c) **Indenter support mounting** When the indenter is solidly fixed and the support mounting approaches as near as possible to the test piece platen, the mounting shall be capable of supporting the indenter so that only the maximum force of the indenter is loaded vertically on the test piece, and over load is not applied. Further, means shall be provided whereby at any stroke the time can be controlled during which the full force is exerted by the indenter.

When a load is adjusted manually as given in Fig. 2, the indenter shall be accurately set to the support mounting. An apparatus which adjusts automatically a load as given in Fig. 3 may suffice the purpose. When a hydraulic adjusting valve adjusts the stroke, a little transfer of the indenter may not be clarified.

- d) **Force measuring device** The force measuring device shall be capable of measuring pressure applied by the indenter.

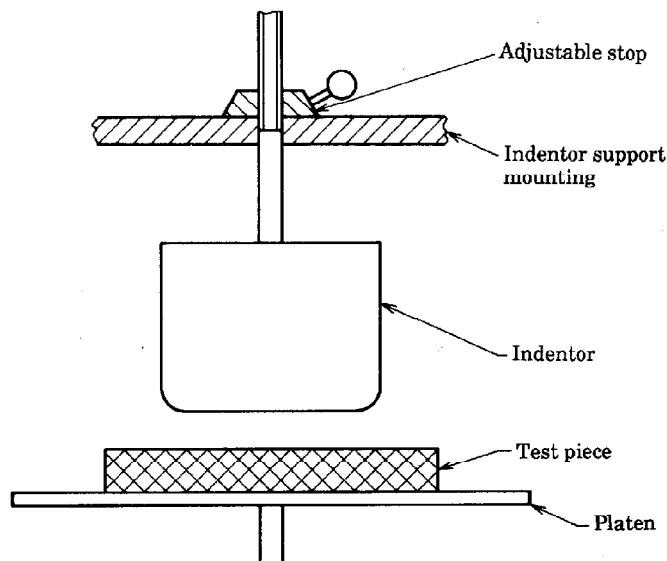


Fig. 2 Manually adjusted machine of indenter (example)

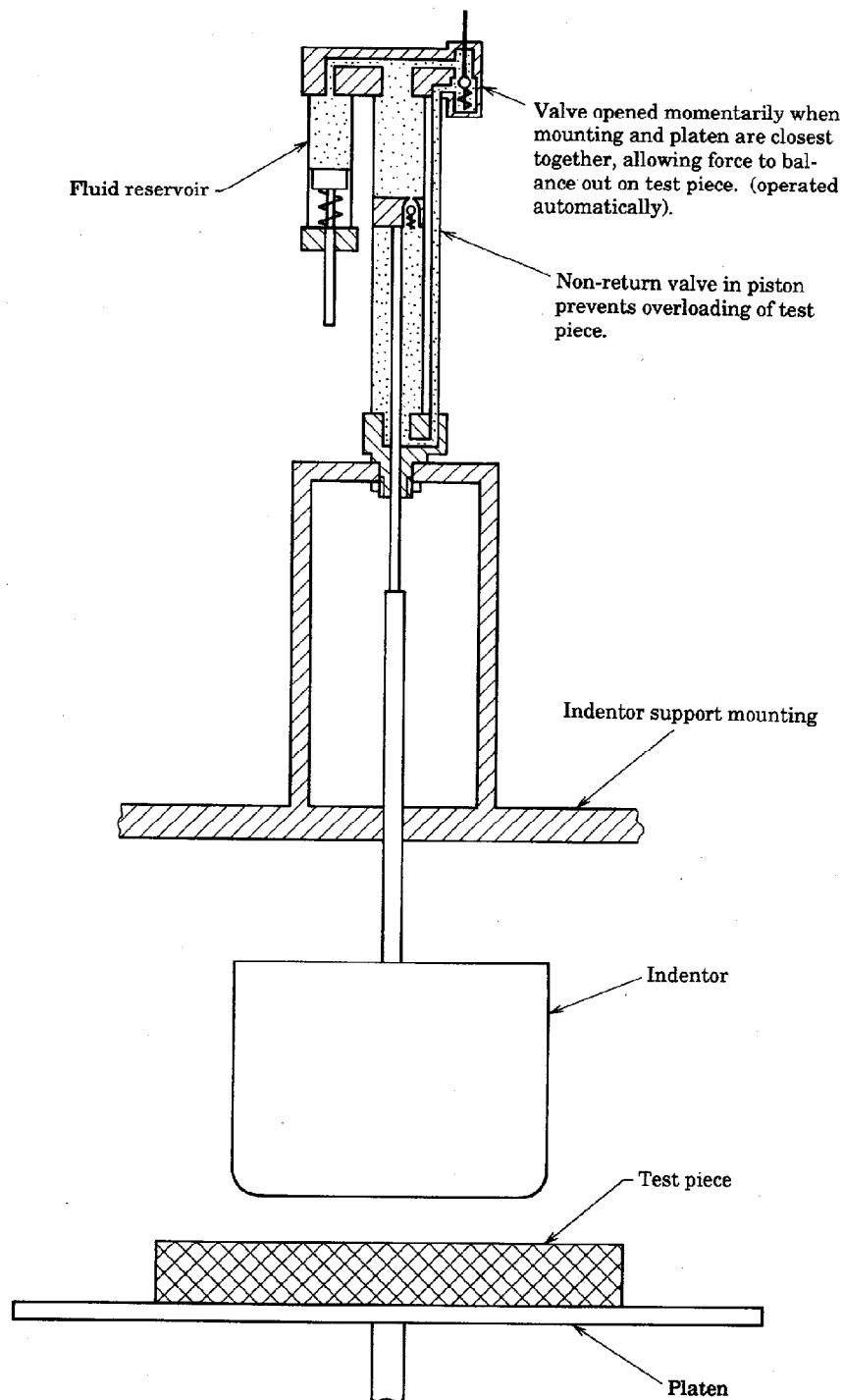


Fig. 3 Automatically adjusted machine of indenter (example)

8.2.3 Measuring method Measure the initial thickness (t_0) at the central part of the test piece and the initial hardness (H_0) by the method as given in 6.4. Place the test piece concentrically below the indenter, and adjust the device so that the test piece is pressed horizontally by the indenter. Adjust the indenter so that a load of (750 ± 20) N is applied on the test piece at a rate of (70 ± 5) cycles per min, and carry out for 80 000 continuous load cycles. Indent with the maximum load (750 ± 20) N $\{(76.5 \pm 2) \text{ kgf}\}$ for 25% or under the time required for continuous load. If necessary, a load larger than (750 ± 20) N $\{(76.5 \pm 2) \text{ kgf}\}$ may be applied. After end of the test, leave the test piece as it is under no-load state for (10 ± 0.5) min, and remeasure the thickness (t_1) at the same position and the hardness (H_1) at $(40 \pm 1)\%$ compression by the method as given in 6.4. Calculate the $(40 \pm 1)\%$ indentation from the initial thickness (t_0).

8.2.4 Calculation Calculate relative fatigue by constant-load pounding (Cf_b), hardness loss (ΔH), and hardness loss percentage (H_w) on three test pieces according to the formulae (4), (5), (6) respectively, and round off Cf_b , H_w to one place of decimal and ΔH to an integer in accordance with JIS Z 8401. Express the median of numerical value so obtained as the result.

$$Cf_b = \frac{t_0 - t_1}{t_0} \times 100 \quad (4)$$

where, Cf_b : relative fatigue by constant-load pounding (%)

t_0 : initial thickness of test piece (mm)

t_1 : thickness after test of test piece (mm)

$$\Delta H = H_0 - H_1 \quad (5)$$

where, ΔH : hardness loss (N {kgf})

H_0 : initial hardness (N {kgf})

H_1 : hardness after test (N {kgf})

$$H_w = \frac{H_0 - H_1}{H_0} \times 100 \quad (6)$$

where, H_w : hardness loss percentage (%)

H_0 : initial hardness (N {kgf})

H_1 : hardness after test (N {kgf})

8.2.5 Report The following items shall be stated on the report.

- a) Testing method
- b) Relative fatigue by constant-load pounding
- c) Hardness loss
- d) Hardness loss percentage
- e) Other necessary items
 - 1) When a test piece is different from the standard test piece, dimensions and shape used for the test
 - 2) Directional property of test piece