

Precision levels

1. Scope This Japanese Industrial Standard specifies the precision levels ⁽¹⁾ of which length of measuring face of one side is from 150 mm to 300 mm (hereafter referred to as "levels").

Note ⁽¹⁾ An indicating instrument to measure the minute inclination from horizontal or vertical, using a precision bubble tube, by directly reading the displacement of its bubble on the graduation of the bubble tube.

Remarks: The standards cited in this Standard are given in the following:

JIS B 0601 Surface roughness — Definitions and designation

JIS B 7513 Precision surface plates

JIS B 7538 Autocollimators

JIS Z 8103 Glossary of terms used in instrumentation

2. Definitions For the purposes of this Standard, main definitions given in JIS Z 8103 apply, and the rest of the terms shall be as given in the following:

- (1) flat level The level of which bubble tube is being built in a square bar shaped structural body, and its bottom is used as the measuring face.
- (2) square level The level of which bubble tube is being built in a side of an equal quadrilateral frame shaped structural body, and the four faces of periphery are used as the measuring faces respectively.
- (3) sensitivity The sensitivity of a level is the inclination required to allow the bubble of the main bubble tube to displace by one graduation, and it is expressed by a height (μm in unit) or angle (second in unit) in respect to 1 m of bottom side.

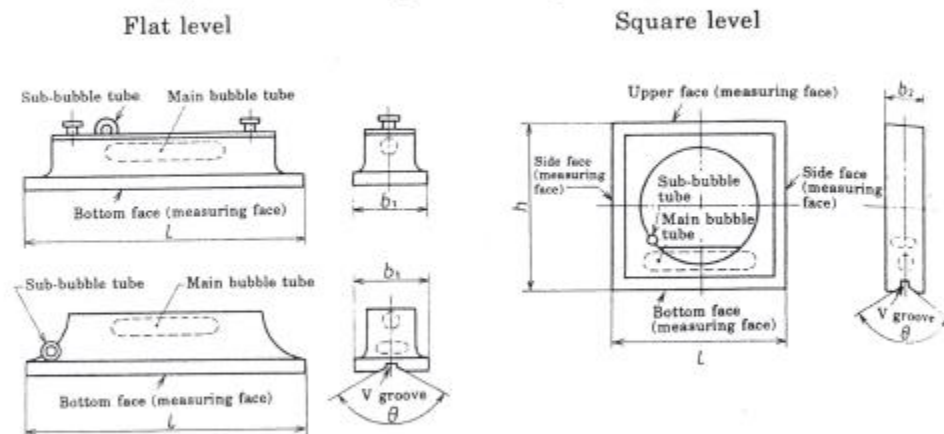
Informative reference: The relation between the angle and the height in respect to the bottom side shall be as follows:

Angle 1 second = $4.85 \mu\text{m}$ per 1 m

$\approx 5 \mu\text{m}$ per 1 m

3. Names and symbols of respective parts The names and symbols of main parts of the levels shall be in accordance with Fig. 1.

Fig. 1. Names and symbols of respective parts



Remarks: These figures shall be for indicating the names and symbols of respective parts only, and shall not be for indicating the standard of structure and shapes.

4. Classification and grades

4.1 Classification The levels shall be classified into three classes according to sensitivities as given in Table 1.

Table 1. Sensitivities of levels

Class	Sensitivity (mm/m)
Class 1	0.02 ($\approx 4''$)
Class 2	0.05 ($\approx 10''$)
Class 3	0.1 ($\approx 20''$)

Remarks: Numerals given in parentheses are informative reference values.

4.2 Grades The grades of the levels shall be two grades of grade A and grade B according to performances thereof.

5. Performances

5.1 Indication accuracies As to the indication accuracies of the main bubble tube, the indicating accuracies of the full scale ranges (hereafter referred to as "full range accuracies") and the differences of the indication error in the adjacent graduations (hereafter referred to as "adjacent accuracies") are specified, and respective permissible value is as shown in Table 2.

Table 2. Permissible values of indication accuracies

Item	Class of sensitivity	Grade A	Grade B
Full range accuracies	Class 1	± 0.5 graduations	± 0.7 graduations
	Class 2 and Class 3	± 0.3 graduations	± 0.5 graduations
Adjacent accuracy	Class 1, Class 2 and Class 3	0.2 graduations	0.5 graduations

5.2 Flatnesses of bottom face, side faces and upper face The tolerance values of the flatnesses of the bottom face, each side face and upper face shall be 0.003 mm for those of class 1 of sensitivity, and 0.005 mm for those of class 2 and class 3.

5.3 Angle formed between a plane having V-groove and V-groove The angle formed between the plane having a V-groove and the V-groove shall be the angle formed between the plane having the V-groove and the vertical axis of the cylinder on the V-groove, and its permissible value shall be 0.5 graduations.

5.4 Perpendicularity of bottom face in respect to side face The permissible value of the perpendicularity of the bottom face in respect to each side face of the square level shall be in accordance with Table 3.

Table 3. Permissible values of perpendicularities of bottom face in respect to side face of square level

Class of sensitivity	Unit: mm/m	
	Grade A	Grade B
Class 1	0.015	0.02
Class 2 and Class 3	0.025	0.035

5.5 Angle formed between bottom face and upper face The permissible value of the angle formed between the bottom face and the upper face of the square level shall be 0.5 graduations.

Remarks: The tolerance values and permissible values specified in 5. shall be those of at 20°C.

6. Shapes and dimensions The lengths of measuring faces (l , h), widths of measuring faces (b_1 , b_2) and angle (θ) of V-groove of the levels shall be in accordance with Table 4 (see Fig. 1).

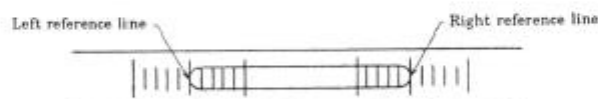
Table 4. Dimensions of respective parts

Designation	l (mm)	h (mm)	b_1 (mm)	b_2 (mm)	θ (degree)
150	150	150	35 to 45	35 to 45	120 to 150
200	200	200	40 to 50	35 to 45	
250	250	250	45 to 55	40 to 50	
300	300	300	50 to 60	50 to 60	

7. Structure and appearance The structure and appearance of the levels shall be as given in the following:

- (1) The painting and plating of each part shall be steady, and shall not be liable to cause discoloration, exfoliation, rust, etc.
- (2) The bottom face, side faces and upper face shall be finished by scraping or by the finishing equal to or superior to this, and the surface roughness shall be of 0.8a of JIS B 0601.
- (3) The movement of the bubble in the bubble tube shall be smooth.
- (4) A sub-bubble tube shall be provided in right angles to the main bubble tube.
- (5) On the main bubble tube, it should be preferable to install a bubble chamber capable of adjusting the length of the bubble.
- (6) The main bubble tube shall be provided with a zero point adjusting device, which is capable of adjusting the position of the bubble within $\frac{1}{10}$ graduation, when it has been placed horizontally.
- (7) The operation of the zero point adjusting device shall be excellent, and no strain shall cause on the main bubble tube.
- (8) Undercut or V-groove may be provided on the bottom face, side faces and upper face.
- (9) The graduations of the main bubble tube shall be clear, and be graduated in equal interval of approximately 2 mm, and should preferably be so made that the both ends of the bubble may meet with the reference lines of the left and right as shown in Fig. 2.

Fig. 2. Relation between the bubble and graduations



8. Measuring methods of performances The measuring methods of the performances of the levels shall be in accordance with Table 5.

Table 5. Measuring methods of performances

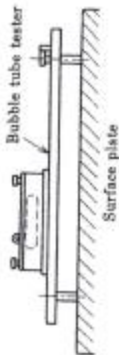
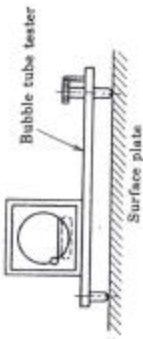
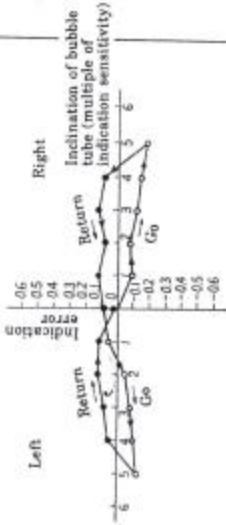
No.	Item	Measuring method	Explanatory Figures	Measuring instruments
1	Full range accuracy	<p>Place the level on the inclination stand of the bubble tube tester, and adjust the both ends of the bubble to the left and right reference lines. Allow the inclination stand to incline for each indication sensitivity of the level, obtain the mean value of the indication errors of the both ends of the bubble on each graduation, and consider this to be the go indication error.</p> <p>Next, while returning the inclination, obtain the return indication error in the same manner as above.</p> <p>Successively obtain the go-and-return indication errors of the bubble on the opposite side of the bubble tube in the same manner, prepare the error curves as given in the Figure in the right (an example), and obtain the maximum value and the minimum value of the indication errors.</p>	 <p>Bubble tube tester</p> <p>Surface plate</p>  <p>Bubble tube tester</p> <p>Surface plate</p> <p>Error curve (an example)</p> 	<p>Surface plate</p> <p>Bubble tube tester (that is capable of measuring the inclination of $\frac{1}{10}$ the sensitivity of the level to be measured)</p>
	Adjacent accuracy	<p>From the error curve, obtain the maximum value of the differences of the indication error between the adjacent graduations.</p>	<p>Remarks</p> <ol style="list-style-type: none"> 1. That side where the sub-bubble tube is located shall be the left side. 2. As to the sign of error, it shall be considered to be +, when the bubble is located at the right side of the graduation line. 	

Table 5. (continued)

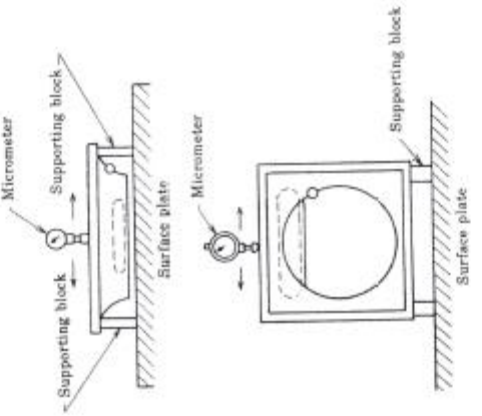
No.	Item	Measuring method	Explanatory Figures	Measuring instruments
2	Flatness of bottom face, side faces and upper face	<p>Place the level on the surface plate, with the face to be measured upwards by means of the supporting blocks or adjustable supporting stand, and adjust the heights of the both end parts in its longitudinal direction to the same height as far as possible.</p> <p>Taking the surface plate as the reference, scan all over the face applying the measuring probe of the micrometer (²) to this face, and obtain the maximum difference of indicated values thereof.</p> <p>In addition, when the face to be measured is of the scraping finish, apply the measuring probe through a small plane-parallel plate.</p>	 <p>The left diagram shows a micrometer positioned vertically to measure a surface plate. Two supporting blocks are placed on either side of the surface plate to support it. The right diagram shows a micrometer positioned vertically to measure a surface plate. A supporting block is placed on one side of the surface plate, and a small plane-parallel plate is placed on the other side to support the micrometer's probe.</p>	<p>Precision surface plate (grade 0 specified in JIS B 7513)</p> <p>Micrometer (²) (1 μm or under in scale interval or minimum indication quantity, and 0.5 μm or under in instrumental error)</p> <p>Supporting block or adjustable supporting stand</p>

Table 5 continued

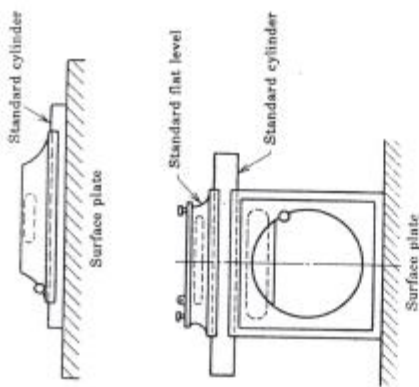
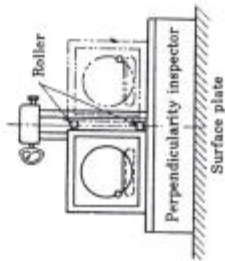
No.	Item	Measuring method	Explanatory Figures	Measuring instruments
3	Angle between the plane having V-groove and the V-groove	<p>As to the flat level, place the V-groove of the level on the standard cylinder on the surface plate, and as to the square level, place the standard cylinder on the V-groove of this level, and place the standard flat level on it.</p> <p>Obtain the differences between respective readings of the level at this time and when the level has been placed directly on the surface plate or on the square level excluding the standard cylinder.</p>		<p>Precision surface plate (grade 0 specified in JIS B 7513)</p> <p>Standard cylinder (both end diametral difference 0.005 mm or under/1 m)</p> <p>Standard flat level (that of the same sensitivity as of the level to be measured)</p>
4	Perpendicularity of side face in respect to bottom face	<p>Calculate the perpendicularity per 1 m from the difference between the readings of the perpendicularity inspector, when the side face of the level has been contacted with the one side of the two rollers of the perpendicularity inspector, and when the same side face has been contacted with another side of the rollers. As to the other side face, obtain in the same manner as mentioned above. However, the contacting positions with the rollers shall be 10 mm apart from the both ends of the side face respectively.</p>		<p>Perpendicularity inspector or Precision surface plate (grade 0 specified in JIS B 7513)</p> <p>Rollers of equal diameter</p> <p>Autocollimator (scale interval not more than 1 μm or 1 second in angle specified in JIS B 7538)</p>

Table 5. (continued)

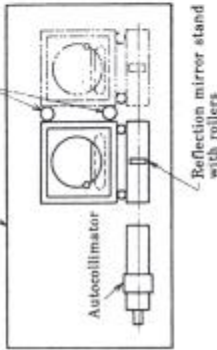
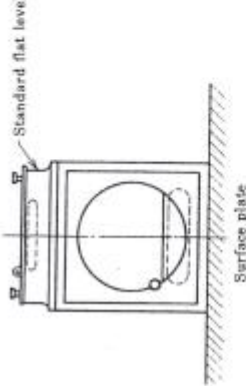
No.	Item	Measuring method	Explanatory Figures	Measuring instruments (as stated above)
4	Perpendicularity of side face in respect to bottom face (continued)	<p>Or place the level flatly on the surface plate, apply the one side of the side surface to two rollers of equal diameter fixed on the surface plate, and take the reading of autocollimator when applied two rollers of reflecting mirror stand with rollers to the bottom surface as θ_1 s.</p> <p>Next, transfer the level to the opposite side of the rollers of the surface plate by reversing, carry out the same measurement mentioned above, obtain the reading θ_2 s, and calculate the perpendicularity from the following formula:</p> $\frac{5}{1000} \times \left(\frac{ \theta_2 - \theta_1 }{2} \right) \text{ mm}$ <p>However, the contacting positions of the rollers shall be 10 mm respectively from the both ends of the side face.</p>		(as stated above)

Table 5. (continued)

No.	Item	Measuring method	Explanatory Figures	Measuring instruments
5	Angle between upper face and bottom face	Obtain the difference of readings of the standard flat level, when the standard flat level has been placed on the upper face of the square level being placed on the surface plate, and when the standard flat level has been placed directly on the surface plate, without the square level.	 <p>The diagram illustrates the measurement setup. A square level is placed on a surface plate. A standard flat level is placed on the upper face of the square level. Another standard flat level is placed directly on the surface plate. The difference in readings between these two standard flat levels is used to determine the angle between the upper face and bottom face of the square level.</p>	<p>Precision surface plate (grade 0 specified in JIS B 7513)</p> <p>Standard flat level (that of the same sensitivity as of the level to be measured)</p>

Note (2) The precision measuring instrument of the length which indicates an extremely small displacement of the measuring probe with scale by the pointer or digitally.

9. Inspection The inspection of the levels shall be carried out on the performances, shape and dimensions, structure, and appearance, and the results shall conform to the requirements of 5., 6. and 7.

10. Designation The designation of the levels shall be in accordance with the title of standard or standard number, distinction of flat type and square type, class (sensitivity), designation, and grade.

Example 1.	Precision level	Flat type	Class 1	200	Grade A
Example 2.	JIS B 7510	Square type	Class 2	300	Grade B

11. Marking The body of level shall be marked with the following information:

- (1) Class (sensitivity)
- (2) Grade
- (3) Manufacturer's name or abbreviation

12. Precautions for handling In handling the level, attention shall be paid on the following matters:

- (1) The measuring face of the level shall be protected carefully, and prior to use, confirmation shall be made that it is free from burr and rust.
- (2) Care shall be taken on the position of the centre of the bubble of the level.

Prior to use, it shall be confirmed that no difference exists between the reading, when the level has been placed on a surface plate, and the reading, when it has been reversed by 180°. When any difference between these readings exists, it shall be adjusted rightly by the adjusting screw of the zero point adjusting device.

- (3) The length of the bubble is sensitive to the temperature change. Particularly the change in length of bubble due to the temperature change during measuring results in the measurement error directly, so that in carrying the level care shall be taken on its thermal insulation.
- (4) For the purpose of carrying out the correct reading by the level, the mean value of the indication values at the both ends of the bubble shall be obtained without fail.