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**Measurement methods of
pump discharge**

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Foreword

This Japanese Industrial Standard has been revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by The Japan Society of Industrial Machinery Manufacturers (JSIM)/Japanese Standards Association (JSA) with a draft being attached, based on the provision of Article 12, paragraph (1) of the Industrial Standardization Act applied mutatis mutandis pursuant to the provision of Article 16 of the said Act. This edition replaces the previous edition (**JIS B 8302 : 2002**), which has been technically revised.

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Measurement methods of pump discharge

1 Scope

This Japanese Industrial Standard specifies the methods for measuring the pump discharge¹⁾.

Note ¹⁾ Volume of liquid discharged per unit time from the pump.

2 Normative references

Part or all of the provisions of the following standards, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS B 7551 *Variable area flowmeters*

JIS B 7554 *Electromagnetic flowmeters*

JIS B 8301 *Rotodynamic pumps — Hydraulic performance acceptance tests — Grades 1, 2 and 3*

JIS Z 8762-1 *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 1 : General principles and requirements*

JIS Z 8762-2 *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 2 : Orifice plates*

JIS Z 8762-3 *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 3 : Nozzles and Venturi nozzles*

JIS Z 8762-4 *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 4 : Venturi tubes*

JIS Z 8765 *Method of flow measurement by turbine meters*

3 Terms and definitions

For the purpose of this Standard, the terms and definitions given in **JIS B 8301** apply.

4 Types of measurement method

The pump discharge is measured by one of the following methods.

The methods by means of weirs, restriction devices and measuring instruments shall be applied to the measurement of constant flow rate of clean, cold water specified in

5.7.1A.1 of JIS B 8301 (hereafter referred to as water).

The method by container may be applied to the flow rate measurement of other water.

- a) Measurement by weirs See Annex C for the flow rate measurement range by this method. See Annex D for dimensions of newly installed weirs.
 - 1) Right-angle triangular weir For the measurement of small quantities of flow by means of a weir, an acute-angled triangular weir should preferably be used. For flow rate measurement using a 60° triangular weir, see Annex A.
 - 2) Rectangular weir
 - 3) Full-width weir See Annex B for details of submerged weir.
- b) Measurement by restriction devices
 - 1) Orifice
 - 2) **ISA 1932** nozzle
 - 3) Elliptical nozzle
 - 4) Venturi tube
 - 5) Venturi nozzle
- c) Measurement by measuring instruments
 - 1) Float-type area flowmeter
 - 2) Electromagnetic flowmeter
 - 3) Turbine flowmeter
- d) Measurement by container

5 Measurement by weirs

5.1 Construction of weirs

5.1.1 General

A weir shall consist of a weir plate, a support plate and a channel.

5.1.2 Weir plate and support plate

The weir plate and the support plate shall conform to the following.

- a) The weir plate shall have a cross-section in which the inside plane surface and the upper end surface form a right angle as shown in Figure 1. The right-angled corner shall be sharp without any roundness. The upper end surface shall be about 2 mm in width, and then incline about 45° in the outward direction.

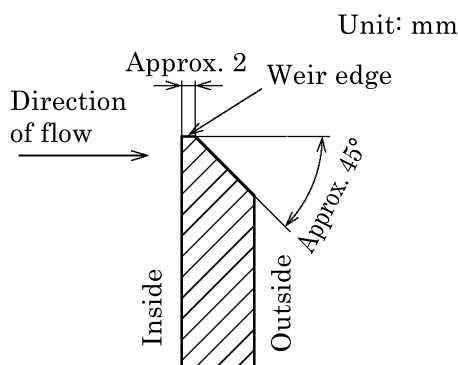


Figure 1 Cross-section of weir plate

- b) The inside surface of the weir plate shall be flat, and made smooth in the area within 100 mm from the upper end of the plate (see Figure 2). The surface beyond this area need not be smooth so far as it does not cause turbulence of flow. Thus, this part shall be mounted on the support plate according to either of the illustrations given in Figure 2.

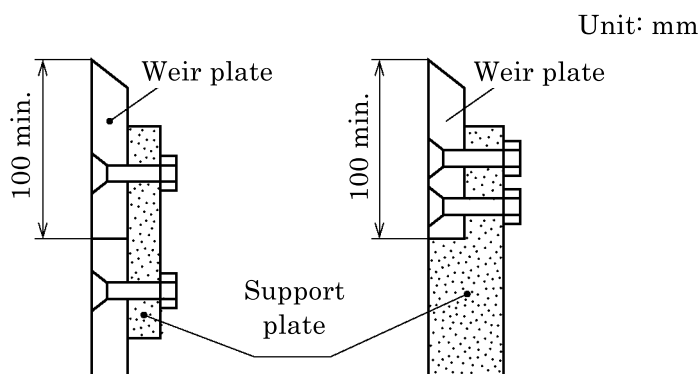


Figure 2 Inside surface of weir

- c) The material of the weir plate shall be resistant to rusting and corrosion.
- d) The support plate shall be made of mild steel plate or concrete to prevent the deformation of the weir plate due to inside hydraulic pressure, and have such a construction and dimensions that the splash of the falling water will not disturb the shape of the overflow when the water level rises 30 mm or more above the bottom edge of the notch for the rectangular weir, and above the weir edge for the full-width weir (70 mm or more above the bottom point of the notch for the triangular weir).
- e) The weir plate and the support plate shall be installed vertically and with their inside surface normal to the longitudinal axis of the channel.
- f) The notch of the right-angle triangular weir shall conform to the following.
- 1) The notch angle of the right-angle triangular weir shall be 90° as shown in Figure

3, and the bisector of the notch angle shall be vertical and positioned in the middle of the channel width B .

- 2) The tolerance on the notch angle shall be $\pm 5'$.

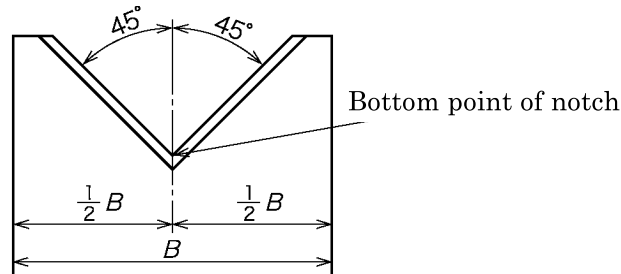


Figure 3 Notch of right-angle triangular weir

- g) The notch of the rectangular weir shall conform to the following.

- 1) The notch of the rectangular weir shall be such that both sides are normal to the bottom edge, as shown in Figure 4.
- 2) The tolerance on the notch angle shall be $\pm 5'$.
- 3) The notch shall be positioned in the middle of the channel width B , and its bottom edge shall be horizontal.
- 4) The width of the weir b shall be expressed by the length of bottom edge of the notch.
- 5) The tolerance on the width of the weir b shall be $\pm 0.001 b$.

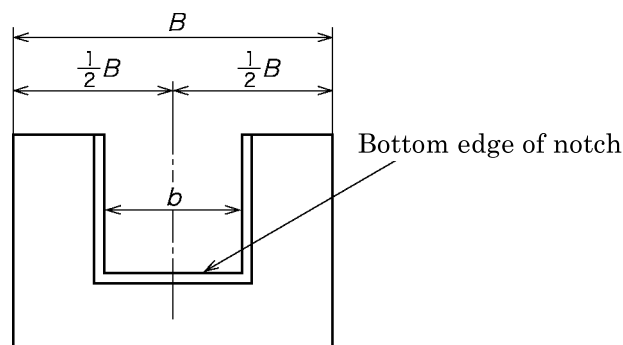


Figure 4 Notch of rectangular weir

- h) The width of the full-width weir b shall conform to the following.

- 1) The weir edge of the full-width weir shall be horizontal throughout the width of the channel, as shown in Figure 5.
- 2) The width of the weir b shall be expressed by the length of the weir edge held be-

tween the channel wall surfaces at both ends of the weir plate.

- 3) The tolerance on the weir width b shall be $\pm 0.001 B$.

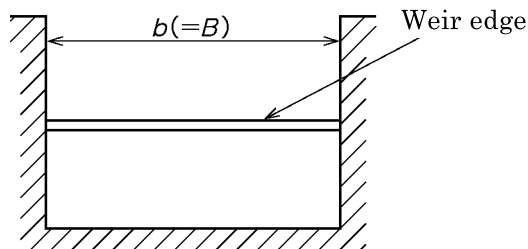


Figure 5 Weir edge of full-width weir

5.1.3 Channel

The channel shall consist of a driving section, a flow straightening section and a straightened flow section as shown in Figure 6. In Figure 6, L_1 is the length of the straightened flow section, L_s is the length of the flow straightening section, and L_2 is the length of the driving section, and $h_{\max}$ is the maximum measuring value of the weir head ²⁾ h .

When no flow straightening section exists, the length of the straightened flow section L_1 shall be at least ten times the width of the channel B .

Note ²⁾ The vertical distance between the water flow level of the upper stream of the weir plate and the bottom point of notch (for right-angle triangular weir), the centre of the bottom edge of notch (for rectangular weir) or the centre of weir ridge (for full-width weir).

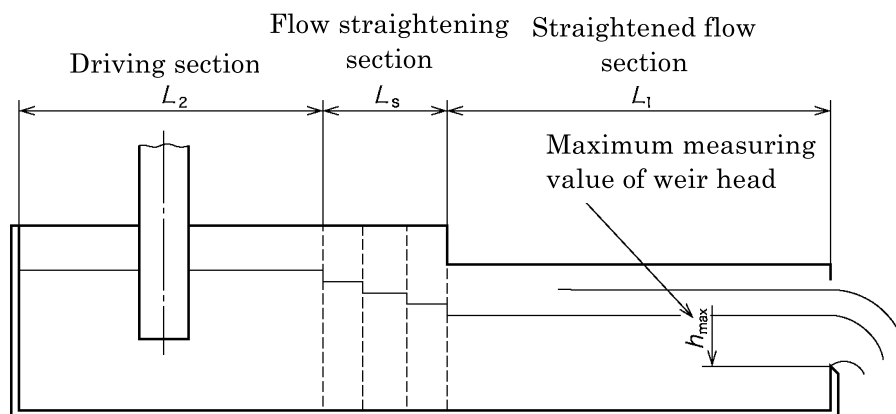


Figure 6 Channel

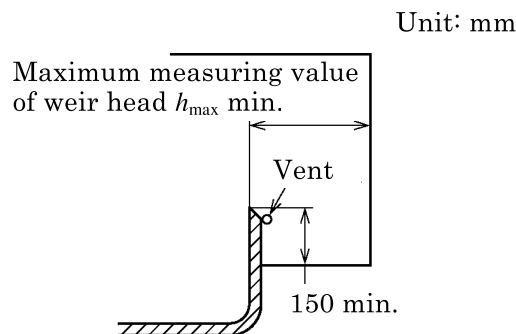
- a) The length of each part of the channel shall conform to Table 1.

Table 1 Length of each part of channel

	L_1	L_s	L_2
Right-angle triangular weir	$>B + 2h_{\max}$	Approx. $2h_{\max}$	$>B + h_{\max}$
Rectangular weir	$>B + 3h_{\max}$	Approx. $2h_{\max}$	$>B + 2h_{\max}$
Full-width weir	$>B + 5h_{\max}$	Approx. $2h_{\max}$	$>B + 3h_{\max}$

- b) The channel in the straightened flow section shall have a horizontal bottom and vertical sides, and shall be rigidly structured to resist deformation when filled up with water. Further, the axial line of the channel in this section shall be straight, and the width of the channel shall be substantially uniform.
- c) In a channel with a full-width weir, both side walls of the channel shall be extended by at least a length equal to the maximum head $h_{\max}$ toward the downstream side of the weir plate and support plate as shown in Figure 7 in order to prevent the water flowing down the weir from overflowing sideways. The lower end of this extended wall shall be 150 mm or more below the edge of the weir plate.

The channel wall shall be provided with a vent having a passage area sufficiently large to allow a free passage of atmospheric air inside the water flowing down over the weir plate.

**Figure 7 Channel with full-width weir (extension of channel walls)**

- d) The width of the channel in the flow straightening section shall be the same as that in the straightened flow section and the height of its side wall the same as that in the driving section. The flow straightener used shall be capable of preventing wave propagation as well as straightening the water flow almost perfectly.
- e) The water storage capacity of the driving section should be as large as possible. Both the width and depth of this section shall be larger than those of the straightened flow section.

The side wall height in the driving section should be made larger than that in the straightened flow section in order to prevent overflowing of water.

The end of the water introducing pipe should preferably be submerged in the water.

5.2 Apparatus for measuring weir head

The apparatus used for measuring the weir head shall be as follows.

- a) The measurement of weir head shall be carried out by determining the water level in a small tank connected to the channel through a small hole provided on the side wall of the straightened flow section of the channel, as shown in Figure 8.

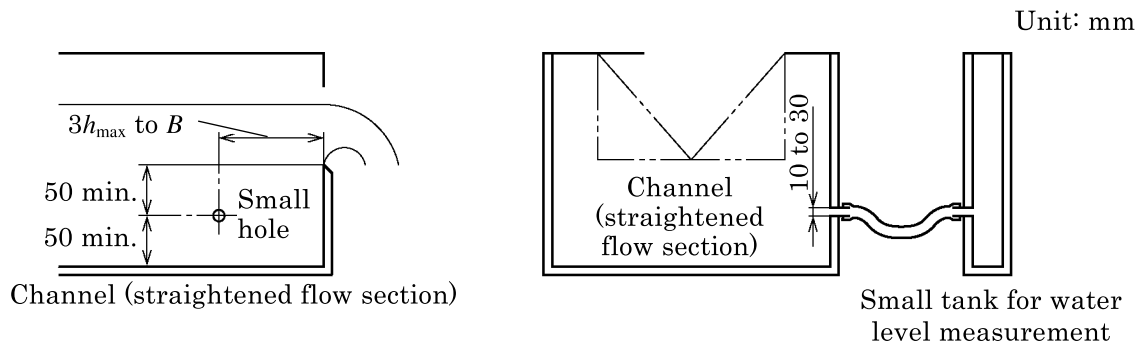


Figure 8 Apparatus for measuring weir head

- b) The position of the small hole shall be $3h_{\max}$ to B upstream of the inside surface of the weir plate, 50 mm or more below the bottom point of the notch, the bottom edge of the notch, or the edge of the weir, and 50 mm or more above the bottom of the channel.
- c) The small hole shall be 10 mm to 30 mm in inside diameter, and shall be bored perpendicular to the inside wall surface of the channel, with the wall surface around the hole flat and the edge around the hole free of burrs.

5.3 Measurement of weir head

The measurement of weir head shall be carried out according to the following.

- a) The measurement shall be carried out under such a condition that the water flowing down over the weir plate does not touch the edge surface of the weir plate or the support plate.
- b) The measurement of the zero point of the weir head shall be carried out according to the following method. The tolerance on the measured value shall be ± 0.2 mm.
 - 1) In the case of a rectangular weir or a full-width weir, install an auxiliary hook on the centre of the inner side of the weir, adjust it to the level of the weir edge by use of a level, carefully introduce water up to this level, and then read the indication of the hook gauge in the small measuring tank, taking the reading as the zero point. When alternatively using a glass pipe, adjust the zero point of the scale to the water level.
 - 2) In the case of a triangular weir, install an auxiliary hook on the inner side of the weir, place a truly circular round rod (d in diameter) on the notch edge horizontally and in parallel with the longitudinal axis of the channel, and then obtain the

height of the bottom side of the round rod by the method described in 1), taking the reading as the zero point by calculation (see Figure 9).

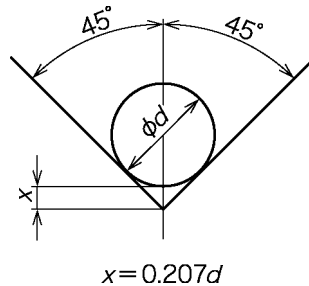


Figure 9 . Calculation of zero point of head of triangular weir

- c) The uncertainty of head measurement shall be 1/250 of the weir head in the case of a right-angle triangular weir, and 1/150 of the weir head in the case of a rectangular weir and a full-width weir.
- d) For the measurement of head, a hook gauge or a float gauge capable of indicating within the uncertainty specified in c), or a water level gauge of an equivalent precision shall be used.
- e) The measurement of weir head shall be performed after the water level in the small tank has stabilized.

5.4 Calculation of flow rate

Calculation of flow rate shall be as follows.

- a) **Right-angle triangular weir** (see Figure 10)

$$Q = Kh^{\frac{5}{2}}$$

$$K = 81.2 + \frac{0.24}{h} + \left(8.4 + \frac{12}{\sqrt{p}} \right) \left(\frac{h}{B} - 0.09 \right)^2$$

where,

Q : flow rate (m³/min)

h : head of weir (m)

K : flow coefficient

B : width of channel (m)

p : height of bottom point of notch relative to the bottom of channel (m)

The above equations shall apply within the following ranges :

$$B \text{ (m)} : 0.5 \leq B \leq 1.2$$

$$p \text{ (m)} : 0.1 \leq p \leq 0.75$$

$$h \text{ (m)} : 0.07 \leq h \leq 0.26 \text{ (where, } h = B/3 \text{ or less)}$$

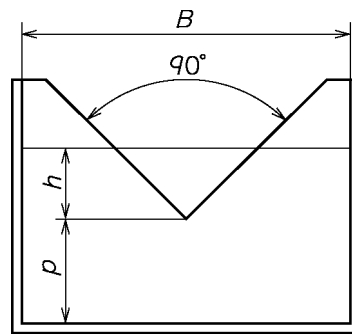


Figure 10 Right-angle triangular weir

b) **Rectangular weir** (see Figure 11)

$$Q = Kbh^{\frac{3}{2}}$$

$$K = 107.1 + \frac{0.177}{h} + 14.2 \frac{h}{p} - 25.7 \sqrt{\frac{(p-b)h}{pB}} + 2.04 \sqrt{\frac{B}{p}}$$

where, Q : flow rate (m³/min)
 b : width of weir (m)
 h : head of weir (m)
 K : flow coefficient
 B : width of channel (m)
 p : height of bottom edge of notch relative to the bottom of channel (m)

The above equations shall apply within the following ranges :

$$B(\text{m}) : 0.5 \leq B \leq 6.3$$

$$b(\text{m}) : 0.15 \leq b \leq 5.00$$

$$p(\text{m}) : 0.15 \leq p \leq 3.50 \text{ (where, } \frac{bp}{B^2} \geq 0.06 \text{)}$$

$$h(\text{m}) : 0.03 \leq h \leq 0.45 \sqrt{b}$$

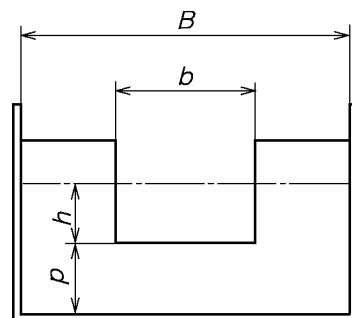


Figure 11 Rectangular weir