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JAPANESE INDUSTRIAL STANDARD

**Measuring Methods for
Coefficient of Discharge of
Safety Valves**

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Measuring Methods for Coefficient
of Discharge of Safety Valves

B 8225-1986

1. Scope

This Japanese Industrial Standard specifies measuring methods for coefficient of discharge of safety valves for steam and gas, hereinafter referred to as the "safety valves".

Remark: In this Standard the units and numerical values shown in { } and calculation formulae are in accordance with the International System of Units (SI) and, appended for informative reference.

2. Definitions

For the purposes of this Standard following definitions apply:

- (1) safety valve The valve which actuates automatically when the pressure at the inlet side has become the preliminarily definite pressure, returns again to the normal condition when the pressure lowers, and has the capability to exhaust the nominal discharge amount.
- (2) discharge amount The discharge amount of fluid (steam, air or gas) measured experimentally to be expressed by kgf/h {kg/h}.
- (3) theoretical discharge amount The calculated discharge amount, which is the amount specified in 4.2.2 relating to each fluid.
- (4) nominal discharge amount The discharge amount guaranteed for each safety valve which is specified in 5.

Applicable Standards:

JIS B 7503-Dial Gauges Reading in 0.01 mm

JIS B 8210-Spring Loaded Safety Valves for Steam Boilers and Pressure Vessels

JIS C 1602-Thermocouples

JIS C 1604-Resistance Thermometer Sensors

JIS Z 8704-Electrical Methods of Temperature Measurements

JIS Z 8705-Method of Temperature Measurement by Liquid-in-Glass Thermometers

JIS Z 8762-Measurement of Fluid Flow by Means of Orifice Plates, Nozzles and Venturi Tubes

- (5) coefficient of discharge The ratio of discharge amount to theoretical discharge amount.
- (6) nominal coefficient of discharge The coefficient to be applied to nominal discharge amount which is in accordance with the specification of 4.2.3.
- (7) diameter of valve seat opening The inner diameter of fitting surface of valving element with the valve seat (Refer to Appendix Attached Figure of JIS B 8210).
- (8) lift The travelling amount of valve element or valve stem in axial direction from the closed position of valve to the opened position of valve during discharge of safety valve.
- (9) valve seat angle The angle included by valve axis and valve seat face. In the flat seat valve, the valve seat angle becomes 90° (Refer to Appendix Attached Figure of JIS B 8210).
- (10) valve seat area The area formed according to diameter of valve seat opening.
- (11) discharge area The area to determine the flow rate passing through the safety valve which is used for calculation of nominal discharge amount (Refer to Appendix Attached Figure of JIS B 8210).
- (12) area of gorge The area of narrowest part of nozzle from fluid inlet until valve seat face. Relating to lower-guide valve, the area subtracted by the areas of vane and shaft. In a whole amount type safety valve, the gorge area becomes the discharge area (Refer to Appendix Attached Figure of JIS B 8210).
- (13) determination pressure for nominal discharge amount The pressure to determine the nominal discharge amount which is the pressure specified in Appendix of JIS B 8210.
- (14) back pressure The pressure at outlet side of safety valve. There are following two pressures:
 - (a) The pressure generated at outlet side of safety valve by resistance of discharge side when the safety valve has started discharge.
 - (b) The pressure existing at discharge side already before discharge of safety valve.
- (15) nominal diameter The nominal diameter expressing the size of safety valve is expressed by diameter of fluid inlet and is in accordance with the specification of 3. (3) of JIS B 8210.

3. Tests

3.1 Test Methods

3.1.1 Fluid for Test The fluid to be used for test shall be steam, air or gas clear in physical value and respective back pressure side, the atmospheric pressure.

3.1.2 Type of Test The type of test and its application shall be as follows:

- (1) Test A Relating to those of the same design series ⁽¹⁾, select three kinds of representative nominal diameters, measure actual discharge amounts of nine pieces in total respectively at three different pressures, and determine the nominal coefficient of discharge, hereinafter referred to as the " K_d ".

Its K_d may be used for every pressure and nominal diameter relating to every one of this design series. However, in the case where the range of nominal diameters is not more than six kinds, it may be performed on nominal diameters of two kinds.

- (2) Test B Relating to four pieces of the same diameter of the same design series, measure the actual discharge amounts at different pressures respectively to determine K_d .

Its K_d may be used for all pressures of nominal diameters of this design.

- (3) Test C Select three kinds of nominal diameters representative to the same design series and measure the actual discharge amounts at the same pressure to determine K_d .

Its K_d may be used to the tested pressure relating to all nominal diameters of this design.

Note ⁽¹⁾ It means safety valves of the same design conception for example a group of safety valves to be expressed by style number or the like constituting of a series nominal diameters relating to each nominal pressure.

3.2 Instruments and Measuring Methods

3.2.1 Measurement of Atmospheric Pressure Measure by means of a suitable instrument of not more than 0.25 mmHg {33.3 Pa} in instrumental error. However, the measured value reported from the meteorological observatory of each district performed with the height correction may be used as the atmospheric pressure.

3.2.2 Measurement of Temperature The measurement of temperature shall be as follows:

- (1) The temperature should preferably be in accordance with the instrument and measuring method specified in JIS Z 8705, JIS C 1602, JIS C 1604 and JIS Z 8704.
- (2) For measurement of temperature, use the thermometer certified by official organization or a thermocouple or resistance bulb calibrated by the thermometer certified by official organization relating to the temperature scale in its using range and insert into the piping or thermometer cylinder to measure. However, in the case of measuring a temperature of not more than 150°C, it is preferable to attach the temperature detector in the piping directly without using thermometer cylinder.

- (3) The thermometer cylinder shall be clean and free from rust, and, inserted with a suitable liquid having a boiling point not lower than the highest value of temperature to be measured into its inner part.

Further, the thickness shall be made as thinner as possible in the safe stress range and also its inner, as smaller as possible.

- (4) The temperature at safety valve inlet shall be measured at the positions shown in Fig. 1 and Fig. 2. In cases where the piping length from the temperature measuring point to the specimen valve is not more than five times the piping diameter and is free from harmful variation in piping diameter, this temperature may be treated as the temperature of fluid passing the throttling mechanism.
- (5) The measuring of temperature of fluid passing the throttling mechanism shall be in accordance with the specifications of JIS Z 8762.

(6) Cautions to Temperature Measurement

(6.1) General Cautions General cautions shall be as follows:

- (a) Restrict the heat amount given by conduction or radiation to the temperature measuring device from substances other than those to be measured in temperature to the minimum limit.
- (b) The part near the inserting point of thermometer and the exposure part of thermometer cylinder shall be heat-insulated.
- (c) In the case of measuring the temperature of fluid in a small bore tube, the detecting part of thermometer shall be inserted more deeply than the centre of piping.
Further, in the case of a large bore tube exceeding 300 mm, the detecting part of thermometer shall be inserted by 150 mm at least.
- (d) In the case of measuring the fluid temperature, the detecting part of temperature measuring device shall not be placed at a portion where the flow is congested.

(6.2) Cautions in Cases of Using Mercury-in Glass Thermometer Cautions in cases of using mercury-in glass thermometer shall be as follows:

- (a) The thermometer kept in a metal case shall not be used.
- (b) Correction to exposed part shall be in accordance with 9. of JIS Z 8705.

Further, the mercury reservoir of thermometer for correction of exposed part shall be so heat-insulated that the influence from those other than mercury column of main thermometer is not received as far as possible.

(6.3) Cautions in Cases of Using Thermocouple Cautions in cases of using thermocouple shall be as follows:

- (a) The temperature-measuring contact point shall be complete and relating to temperature graduation in using range together with compensation conductor, be authorized.
- (b) The material of thermocouple shall be suitable to fluid and temperature to be measured.
- (c) The thermocouple specified in JIS C 1602 shall be used.

3.2.3 Measurement of Pressure The measurement of pressure shall be as follows:

- (1) As to measurement of pressures, for measuring of static pressure not more than 1 kgf/cm² {0.1 MPa} use a liquid column meter, and for pressure or differential pressure exceeding 1 kgf/cm² {0.1 MPa} use a Bourdon tube pressure gauge completed with calibration.
- (2) The pressure gauge shall be divided into graduations within 1 % of the maximum graduation, in scale.
- (3) The Bourdon tube pressure gauge shall be used in the range within $\frac{2}{3}$ of the maximum graduation.
- (4) Pressure measuring positions shall be arranged in the portion where the flow is practically parallel to walls of piping and container.
- (5) The safety-valve inlet pressure shall be the static pressure measured at positions of pressure gauge shown in Fig. 1 and Fig. 2.
- (6) In the case where water or other liquid column exists between the pressure-measuring point and the pressure gauge, the correction to reading of pressure shall be conducted.

3.2.4 Measurement of Flow Rate For measurement of flow rate, the orifice specified in JIS Z 8762 shall, as a rule, be used and, as follows.

Further, in cases where it is impossible to use orifice, the nozzle specified in JIS Z 8762 may be used.

- (1) In the case where a flow-rate measuring method other than that specified in JIS Z 8762 is applied, the attachment, procedures and calculation of instantaneous flow rate shall be agreed upon between the parties concerned with delivery.
- (2) Selection of method, selection of flowmeter, details of its use, etc. shall be agreed upon between the parties concerned with delivery prior to test.
- (3) The orifice shall comply with the following specifications:
 - (a) The orifice shall be set at upstream side of specimen valve inlet. The setting conditions and positions are shown in Fig. 1 and Fig. 2.

- (b) The throttling aperture diameter of orifice shall be of such that the differential pressure before and after the orifice is not less than 100 mm in water column.
 - (c) The maximum differential pressure before and after the orifice should, preferably, be not more than 2500 mm in water column.
 - (d) Throttling diameter ratio of orifice to piping diameter shall not exceed 0.7.
 - (e) The orifice shall be confirmed that it is clean through during the test period according to a suitable method.
- (4) The differential pressure before and after the orifice and the temperature of fluid shall be measured with arranging the instruments at the positions shown in Fig. 1 and Fig. 2. Cautions of 3.2.3 applies to pressure measurement, and cautions of 3.2.2, to temperature measurement respectively.
 - (5) The length of straight tube at the upstream side of orifice shall be taken so sufficiently that the approaching flow to the orifice becomes regular and uniform flow velocity distribution (Refer to JIS Z 8762).

Further, depending upon the agreement, a rectifier may be used at upstream side of straight pipe part.

In order to secure a reliable pressure measuring, a sufficiently long straight tube part of the same diameter shall be provided at the downstream of the orifice (Refer to JIS Z 8762).

- (6) In the case of measuring of flow rate, the flow shall be stabilized as far as possible and the measuring differential pressure of liquid column meter, free from pulsation (total amplitude) exceeding 2 %.

Further, in case where pulsation exceeding 2 % exists, the source shall be confirmed to be corrected. However, the pulsation shall not be decreased only by liquid column meter.

3.2.5 Measurement of Lift The measurement of lift shall be as follows:

- (1) The lift shall, as a rule, be measured by dial gauge. However, other calibrated measuring device may be used.
- (2) In the case of using dial gauge, it shall be the dial gauge reading in 0.01 mm specified in JIS B 7503.
- (3) The valve stem shall be attached with a limiting device for lift so as the lift not to rise to the design value or over.
- (4) The basic point (zero point) of dial gauge shall be regulated directly before the safety valve starts discharge.
- (5) In the case where the valve body, and valve stem vibrate during actuation of safety valve, the centre of amplitude of lift shall be read out.

3.2.6 Measurement of Steam Property The measurement of steam property shall be as follows:

- (1) Relating to the steam properties, measure the temperature, pressure, and humidity of steam at safety valve inlet. At the same time, for determination of humidity, measure also the atmospheric pressure.
- (2) Measure the temperature of steam according to the specification of 3.2.2.
- (3) Measure the pressure of steam according to specification of 3.2.3.
- (4) Measure the atmospheric pressure according to specification of 3.2.1.
- (5) Determine the humidity of steam by measuring the steam temperature after reducing of pressure by means of a throttling calorimeter of generally allowable structure. However, this does not apply to the steam not less than 10 % in humidity.
- (6) Let the thermometer to be used for throttling calorimeter be glass thermometer (Refer to JIS Z 8705) and, be in accordance with 3.2.2.
- (7) Let the humidity of steam be the isoenthalpy change between the condition determined by steam temperature measured by throttling calorimeter and atmospheric pressure and the condition of steam pressure at throttling calorimeter inlet, and obtain by drawing from h - s diagram (issue of Japanese Machinery Society) or obtain the enthalpy at each condition from the steam table (issue of Japanese Machinery Society) according to the following formula:

$$\text{Humidity (\%)} = 100 - x$$

$$\text{where } x : \text{dry degree (\%)} \quad x = \frac{h_x - h_{1'}}{h_{1r}} \times 100$$

h_x : overheat steam enthalpy at steam temperature measured by throttling calorimeter and at the atmospheric pressure (kcal/kg) {J/kg}

$h_{1'}$: saturated-water enthalpy at steam pressure at inlet of throttling calorimeter (kcal/kg) {J/kg}

h_{1r} : heat of evaporation at steam pressure at inlet of throttling calorimeter (kcal/kg) {J/kg}

- (8) The overheat degree of overheat steam at outlet of throttling calorimeter should preferably be not less than 4.5°C.
- (9) The orifice opening diameter of throttling calorimeter should preferably be as larger as possible.
- (10) The throttling calorimeter shall be sufficiently insulated in order to prevent radiation heat loss.