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JAPANESE INDUSTRIAL STANDARD

Testing Methods for Turbo-
Blowers and Compressors

JIS B 8340—1976

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JAPANESE INDUSTRIAL STANDARD

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Testing Methods for Turbo-Blowers
and CompressorsB 8340-1976
(Reaffirmed: 1979)1. Scope

This Japanese Industrial Standard specifies the testing and inspecting methods on the turbo-blowers⁽¹⁾ and compressors, hereinafter referred to as the "compressors", of pressure ratio of approximately 1.1 or over, to be carried out at factories using air of ordinary temperature and ordinary pressure.

In the case of tests and inspections on the compressors to be used under special conditions or using special gas, this standard is applicable, as agreed between the parties concerned, properly selecting and complementing this standard.

Note (¹) Including those of centrifugal, mixed and axial flow.

Remark: The units and numerical values given in { } in this standard are in accordance with the International System of Units (SI), and are appended for reference.

Applicable Standards:

JIS B 0601-Surface Roughness

JIS B 8330-Testing Methods for Turbo-Fans and Blowers

JIS C 1502-Sound Level Meters

JIS Z 8731-Methods for Measurement of Sound Level

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

JIS Z 8763-Measurement of Fluid Flow by Means of Venturi Tubes

Reference Standard:

JIS B 8341-Testing Methods for Displacement Compressors



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2. Definitions

For the purposes of this standard, the following definitions apply:

- (1) conditional formula of air The conditional formula which is given in the following formula:

$$Pv = RT \dots\dots\dots(1)$$

Reference: In the case of an adiabatic change, the following relation is given furthermore.

$$P_k = \text{constant} \dots\dots\dots(2)$$

where P : absolute pressure of air (kgf/m² abs) = $P_a + p$ {Pa}

P_a : atmospheric pressure (kgf/m² abs) {Pa}

p : gauge pressure of air (kgf/m²) {Pa}

T : absolute temperature of air (K) = 273 + t

t : air temperature (°C)

v : specific volume of air at P and T (m³/kgf) {m³/kg}

$$R : \text{gas constant of air} = \frac{29.27}{1 - 0.378\phi} \frac{P_i}{P}$$

k : adiabatic exponent of air

where P_i : saturated vapour pressure {Pa}
(kgf/m²)

ϕ : relational temperature (decimal)

The value of gas constant R of air under standard suction conditions is considered to be 29.44, and the value of adiabatic exponent k is considered to be 1.4. These values may be applied to the atmosphere of temperature -15 to 40°C.

- (2) standard suction condition The suction condition in the case where the compressor draws in humid air of 20°C in temperature, 760 mmHg in absolute pressure and 65 % in relative humidity.

Remark: The weight per unit volume of air under the standard suction conditions is considered to be 1.20 kgf{density 1.20 kg/m³}.

- (3) pressure of air Unless particularly stated, a static pressure of air (gauge pressure).

Remark: The static pressure is a pressure which is imparted on the surface of a wall in parallel with the flow, and is measured through a hole bored vertically to its surface.

- (4) capacity of compressor An air volume calculated from the test which has been converted into the standard suction conditions.

Remark: In the case where particularly stated, it is expressed by converting into the volume at the specified conditions.

Furthermore, in this standard, in the case where any gas other than air is treated, it is also called as the air capacity.

- (5) specified number of revolutions of compressor Number of revolutions per unit time of a compressor shaft when it has been driven under the specified power source condition in the case of electric motor driving, and under the specified driving condition in the case of the other prime mover.

Remark: Because this number of revolutions differs to some extent according to air volume of compressor, if it is required to indicate its numerical value, a number of revolutions of a compressor at the specified capacity is employed representatively.

- (6) shaft power of compressor An input to the shaft end of the compressor.

Remark: In the case where the compressor is driven using transmission gear, if it is difficult to measure the loss of power in the transmission gear, an input to the transmission gear is considered to be the shaft power of the compressor.

- (7) noise of compressor A noise level in surroundings of the compressor body during running.

3. Tests and Inspection Items

3.1 Test Items The test items shall be as follows:

Temperature, pressure, suction air volume, number of revolutions, shaft power, noise, running condition

3.2 Inspection Items The inspection items shall be as follows:

Discharge pressure and air volume, shaft power, overall adiabatic efficiency and overall isothermal efficiency, noise, running condition

4. Test Conditions

4.1 Test Number of Revolutions of Air Compressor The test of compressors shall be carried out at the specified number of revolutions, and its method shall be in accordance with 4.3 (1) to (5). However, in the case where it is difficult to run the compressor at the specified number of revolutions, due to reasons of power source, facilities and the like, it shall be run at $\pm 20\%$ of the specified number of revolutions for a single-stage. However, it may be reduced to -35% according to agreement in the case of the single-stage. For a multi-stage, it may be tested at a number of revolutions in a range of $\pm 5\%$.

Irrespective of the single-stage or multi-stage, if it is impossible to carry out testing due to large scale or large power, model test shall be carried out. However, acceptability of the test results shall be as agreed between the parties concerned.

4.2 Test Number of Revolutions of Gas Compressor In the case where it is impossible to carry out testing under specified suction conditions of the gas compressor, it may be carried out at an equivalent test number of revolutions using air. The method shall be in accordance with 4.3 (1) to (5).

The equivalent test number of revolutions shall be expressed by the following formulae:

$$N_{eq} = N \sqrt{\frac{\frac{n_{eq}}{n_{eq}-1} Z_{eq} R_{eq} T_{1eq} [r^{n_{eq}-1} - 1]}{\frac{n}{n-1} Z R T_1 [r^{n-1} - 1]}} \quad (3)$$

$$= N \sqrt{\frac{H_{peq}}{H_p}} \quad (4)$$

where N_{eq} : equivalent test number of revolutions (rpm)

N : specified number of revolutions (rpm)

n_{eq} : polytropic exponent of air under equivalent test condition

Z_{eq} : compressibility factor under equivalent test condition

R_{eq} : gas constant under equivalent test condition

T_{1eq} : suction absolute temperature under equivalent test condition (K)

r : ratio of suction volume to discharge volume = v_1/v_2
in the case where the test has been carried out at n_{eq} or n

n : polytropic exponent of the specified gas

Z : compressibility factor of the specified gas

R : gas constant of the specified gas (m/K)

T_1 : absolute suction temperature of the specified gas (K)

H_{peq} : polytropic head of air under equivalent test condition [kgf·m/kgf]

H_p : polytropic head of the specified gas [kgf·m/kgf]

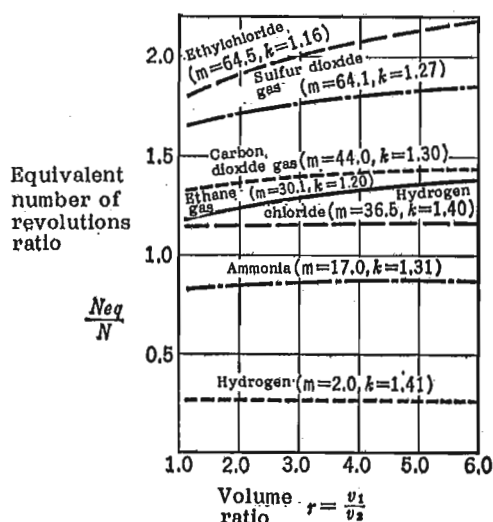
$$= \frac{n}{n-1} Z R T_1 \left[\left(\frac{P_2}{P_1} \right)^{\frac{n-1}{n}} - 1 \right]$$

Reference: An example of relations of $r=v_1/v_2$ with N_{eq}/N for various gases⁽²⁾ is given in Reference Fig. 1.

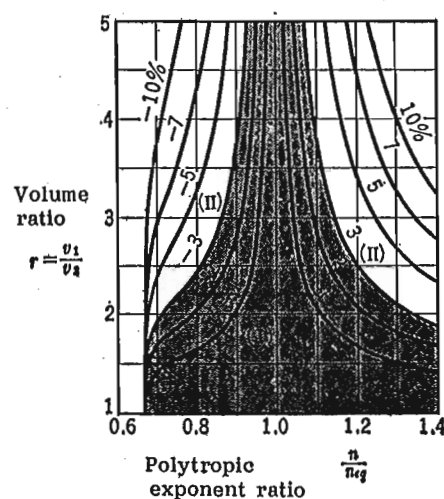
Furthermore, the relation of n/n_{eq} with $r=v_1/v_2$ is given in Reference Fig. 2.

Note (2) The gases mentioned herein are those other than air.

Reference Fig. 1



Reference Fig. 2



In the case where it is in the region (II) of Reference Fig. 2, the test shall be in accordance with JIS B 8345. Therefore, this standard is limited to the range of the region (I).

4.3 Measuring Points The measuring points shall be as follows:

- (1) The centrifugal compressor shall be tested up to a larger air capacity as far as possible for five or more different air volumes from the surging point, and it shall be carried out at least at one point of the lower pressure than the specified pressure.
- (2) The mixed flow compressor shall be tested relating from a smaller air volume and up to a larger air volume as far as possible, for five or more different air volumes including the specified air volume.
- (3) The axial flow compressor shall be tested up to the surging point for five or more different air volumes from the opened condition, and it shall be carried out at least at one point of the smaller air volume than the specified air volume.
- (4) In the tests of the compressors, measurements of performance values shall be carried out after confirming that temperatures at respective parts have reached approximately constant under required conditions.
- (5) In a compressor having an intercooler, the air temperature at outlet of the intercooler shall be adjusted to near the design temperature with regulating the cooling water volume.

4.4 Revolution Test of High Speed Rotor Because to the revolution test on a rotor exceeding 25 m/s in peripheral speed of impeller, Industrial Safety and Health Regulation Chapter 8 Article 149 (Ordinance No. 32, notified on 1972-09-30) is applied, the test shall be carried out after confirming the safety.

5. Test Equipment

5.1 Test Equipment The test equipment shall be those capable of measuring correctly the values required for expressing performances and running condition of the compressor. The arrangements of the test equipment and measuring devices for the compressor shall generally be in accordance with Figs. 1 to 6. Measuring position of discharge pressure P_2 shall be at a distance of xD from the outlet of the compressor, and the value of x shall be in accordance with the following according to the pressure ratio.

Pressure ratio P_2/P_1	x
Under 1.1	6
1.1 to 1.2 excl.	5
1.2 to 1.3 excl.	4
1.3 to 1.5 excl.	3
1.5 and over	2

Remark: In the case where the Pitot static pressure tube of Fig. 2 is not used, the air volume may be measured using a suction nozzle.

Fig. 1

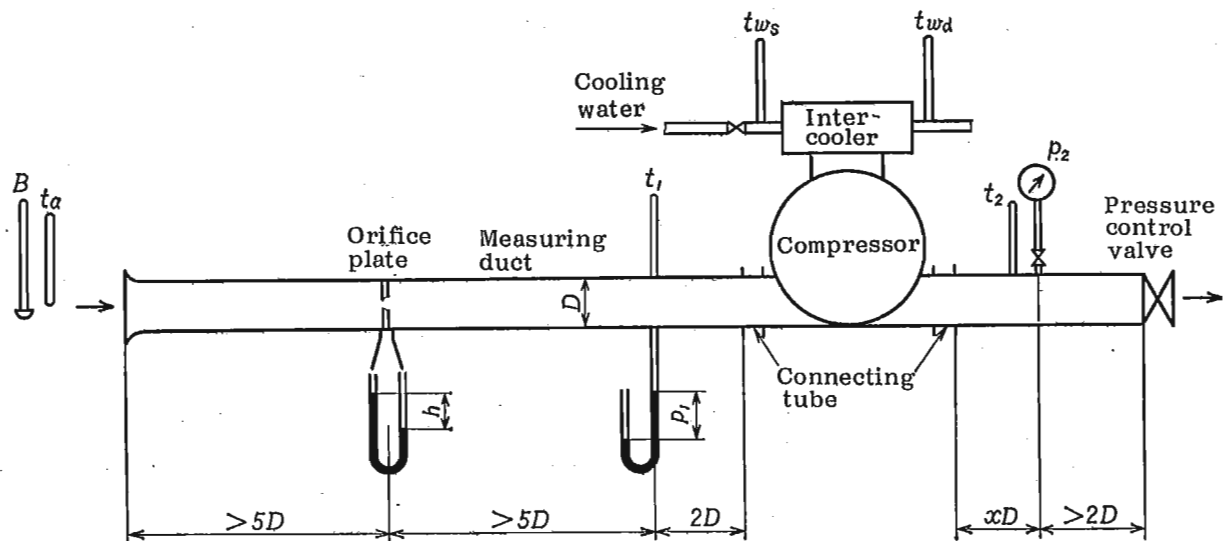


Fig. 2

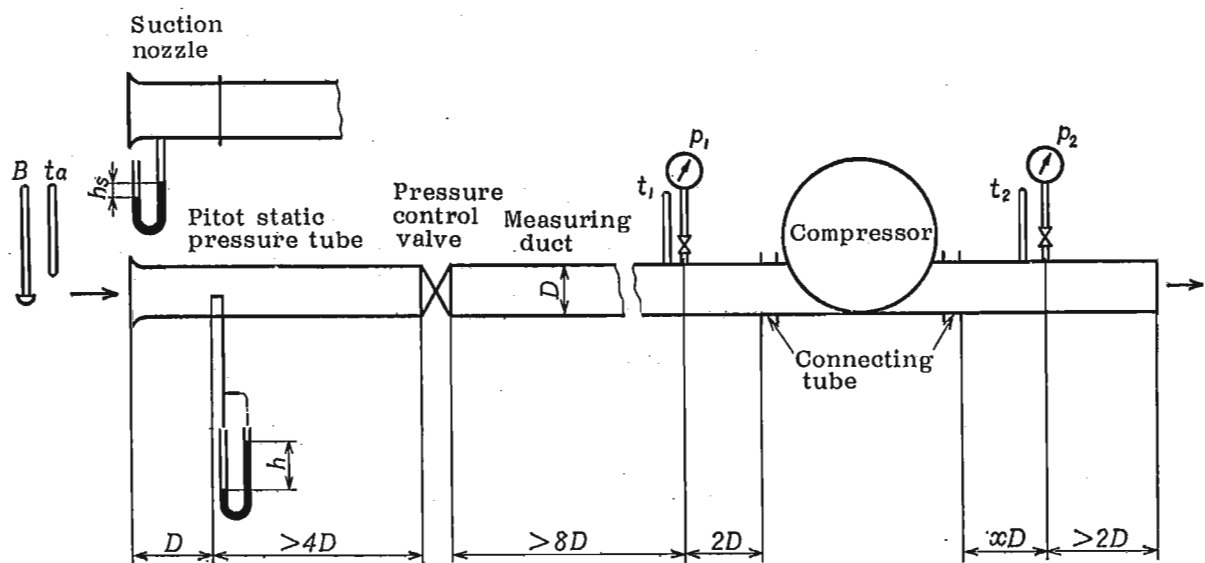


Fig. 3

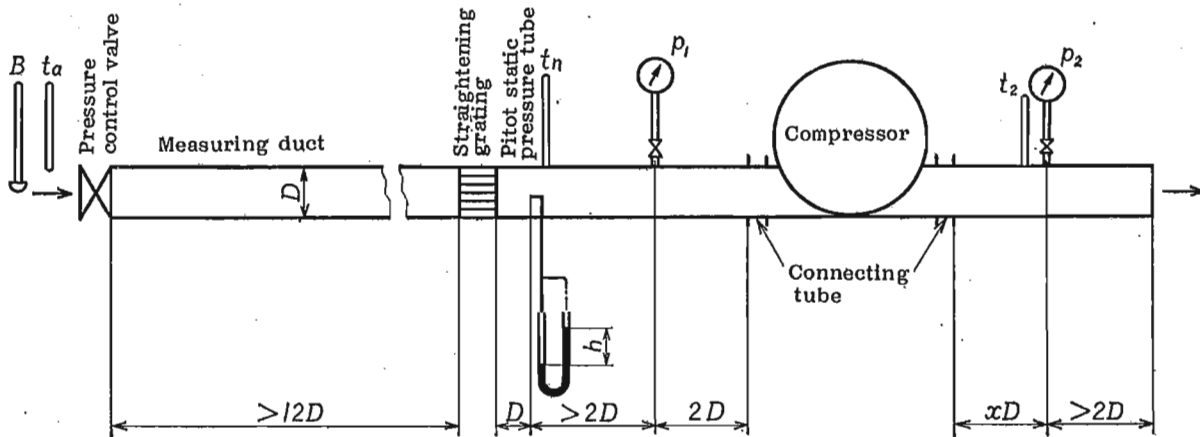


Fig. 4

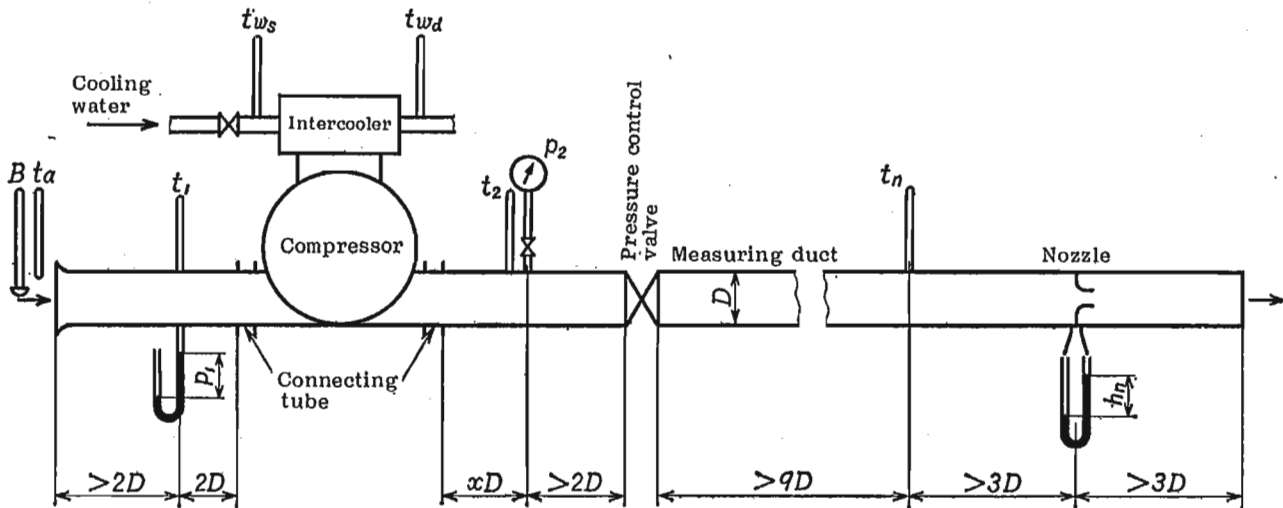


Fig. 5

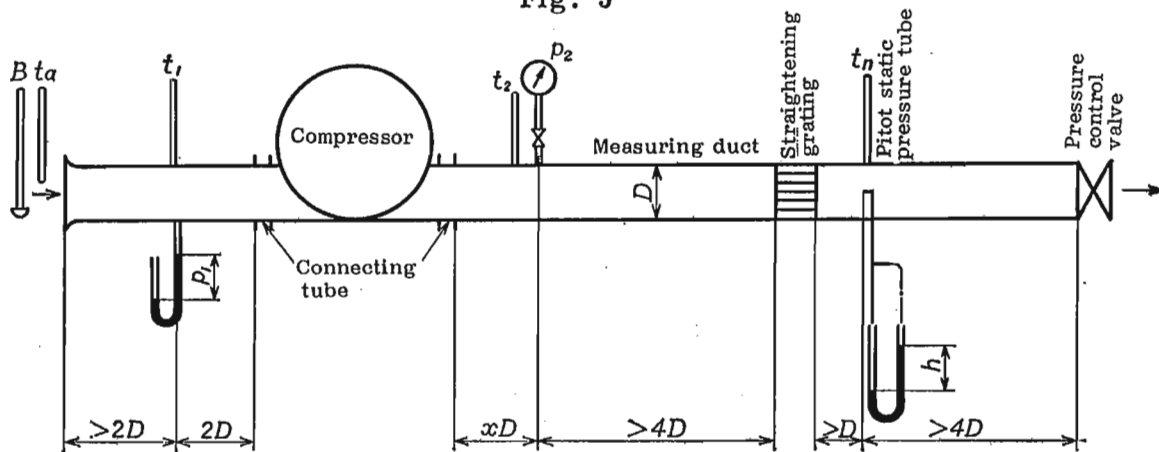
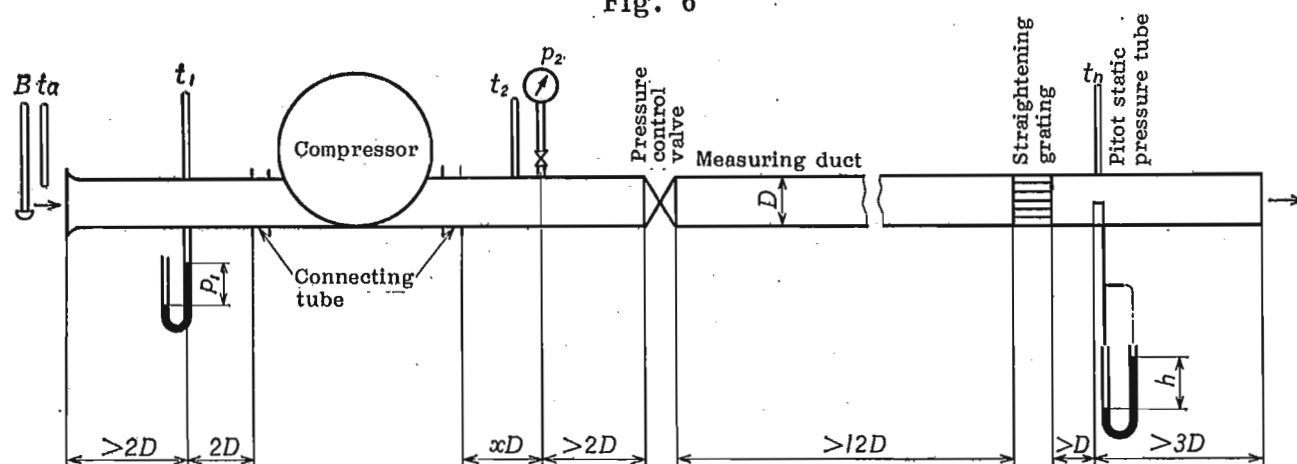


Fig. 6



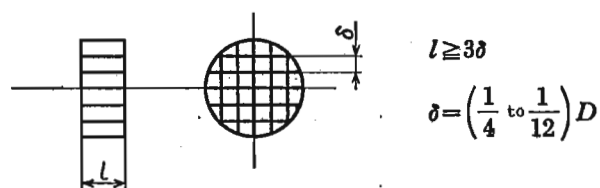
5.2 Connecting Tube The tube which connects the compressor with the measuring duct shall be avoided of bend, restriction and the like which cause pressure loss as far as possible. Sectional area of the measuring duct shall be 0.7 to 1.3 times the sectional area of suction opening or discharge opening of the compressor.

5.3 Measuring Duct The measuring duct shall be a straight pipe of circular section of smooth inside surface, and shall have length as given in Figs. 1 to 6, according to the measuring instruments and positions thereof.

Furthermore, the suction opening should preferably be provided with a bell mouth tube.

5.4 Straightening Grating The axial directional length l of the straightening grating shall be three times or over the one side length δ of aperture (square) of the straightening grating as given in Fig. 7. δ shall be $1/4$ to $1/12$ of the inside diameter D of the measuring duct.

Fig. 7. Straightening Grating



5.5 Measuring Instruments of Atmospheric Pressure and Humidity A Fortin barometer shall be used for measuring atmospheric pressure, and a psychrometer shall be used for measuring humidity.