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**Vacuum technology—
Turbomolecular pumps—
Measurement of performance
characteristics**

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Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee according to the proposal for establishment of Japanese Industrial Standard submitted by The Vacuum Society of Japan (VSJ) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law.

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Vacuum technology—Turbomolecular pumps—Measurement of performance characteristics

Introduction

This Japanese Industrial Standard has been prepared based on the first edition of **ISO 5302** published in 2003 with some modifications of the technical contents to conform to the actual situation in Japan.

The portions given sidelines or dotted underlines are the matters in which the contents of the original International Standard have been modified. A list of modifications with the explanations is given in Annex JA.

1 Scope

This Standard specifies the measurement methods for performance characteristics of turbomolecular pumps.

It is applicable to all types of turbomolecular pumps irrespective of sizes or types. For example, all turbomolecular pumps are covered regardless of the divisions shown below.

- a) mechanical bearing (plain bearing/rolling bearing) and magnetic bearing
- b) with or without drag pump stage

NOTE : The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 5302:2003 *Vacuum technology—Turbomolecular pumps—Measurement of performance characteristics* (MOD)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21**.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitutes provisions of this Standard. The most recent edition of the standard (including amendments) indicated below shall be applied.

JIS Z 8126-2 *Vacuum technology—Vocabulary—Part 2: Vacuum pumps and related terms*

NOTE : Corresponding International Standard: ISO 3529-2 *Vacuum technology—Vocabulary—Part 2: Vacuum pumps and related terms* (MOD)

3 Terms and definitions

For the purpose of this Standard, the terms and definitions given in **JIS Z 8126-2** and the following definitions apply.

3.1 inlet pressure

pressure at the inlet of turbomolecular pump, and also called the vacuum pressure on inlet

3.2 backing pressure

pressure at the outlet of turbomolecular pump, and also called the pressure on outlet

3.3 maximum throughput

highest gas load that can be pumped continuously without damage or destruction of the pump for which the unit of $\text{Pa} \cdot \text{m}^3/\text{s}$ or $\text{Pa} \cdot \text{L}/\text{s}$ are used

NOTE : The limiting parameter depends on the design of the pump. In most cases, it will be given as a maximum temperature at a defined location of the pump. The value of maximum throughput Q_{max} depends on the type of gas pumped, the backing pressure and the cooling conditions.

3.4 volume flow rate (pumping speed)

volume of gas which, under ideal conditions, flows through the pump inlet per unit time, and the unit of m^3/s or L/s are used

For practical reasons; however, the volume flow rate (pumping speed) S of a pump for a given gas is obtained according to the following equation (1) by using the equilibrium pressure p at a given point of the test dome for which the gas throughput Q and the prescribed operating conditions are specified.

$$S = \frac{Q}{p} \dots\dots\dots (1)$$

3.5 ultimate pressure

pressure ultimately approached in the test dome asymptotically under the conditions where the gas admission valve is closed and the pump is in normal operation

3.6 minimum operational pressure

practically measurable ultimate pressure obtained in the test dome 48 h after the bake-out degassing

3.7 compression ratio

ratio of the backing pressure p_2 to the inlet pressure p_1 of the turbomolecular pump for a given gas, and obtained according to the following equation (2).

$$K_{\text{eff}} = \frac{p_2}{p_1} \dots\dots\dots (2)$$

NOTE : To obtain the maximum compression rate at zero throughput K_0 for a given gas, the partial pressure of this gas in the outlet duct shall be at least 90 % of p_2 .

3.8 maximum working pressure

highest inlet pressure at which the turbomolecular pump and the power supply device for driving are capable of operating without failure

4 Symbols

The designations and units of symbols used in this Standard shall be in accordance with table 1.

Table 1 Designation and unit of symbol

Symbol	Designation	Unit
C	conductance	m^3/s ($= 10^3 \text{ L/s}$)
d	orifice diameter	m
D	internal diameter of test dome	m
K_{eff}	compression ratio	—
K_0	maximum compression ratio	—
L	thickness of orifice wall	m
M	molecular mass of gas	kg/mol
p	equilibrium pressure at defined location of test dome	Pa
p_1	inlet pressure	Pa
p_{01}	minimum inlet pressure	Pa
$p_{1\text{max}}$	maximum working pressure	Pa
p_2	backing pressure	Pa
p_{02}	minimum backing pressure	Pa
p_a, p_b	pressure at defined location of test dome	Pa
p_{0a}, p_{0b}	pressure at defined location of test dome before gas input	Pa
Q	gas throughput	$\text{Pa} \cdot \text{m}^3/\text{s}$ ($= 10^3 \text{ Pa} \cdot \text{L/s}$)
Q_{max}	maximum throughput	$\text{Pa} \cdot \text{m}^3/\text{s}$ ($= 10^3 \text{ Pa} \cdot \text{L/s}$)
R	gas constant	$\text{N} \cdot \text{m}/\text{mol} \cdot \text{K}$
S	volume flow rate (pumping speed)	m^3/s ($= 10^3 \text{ L/s}$)
S_X	expected maximum volume flow rate (pumping speed) of turbomolecular pump	m^3/s ($= 10^3 \text{ L/s}$)
S_B	volume flow rate (pumping speed) of backing pump	m^3/s ($= 10^3 \text{ L/s}$)
S_{Beff}	effective volume flow rate (pumping speed) of backing pump	m^3/s ($= 10^3 \text{ L/s}$)
T	temperature of gas in test dome	K

5 Measurement apparatus for volume flow rate (pumping speed)

5.1 Measurement apparatus using throughput meter: inlet pressure $\geq 10^{-4} \text{ Pa}$

For measurements, a test dome 1 as shown in figure 1 with the same internal diameter D as that of the pump inlet shall be used. The face of the dome opposite the inlet flange shall be flat, conical or slightly curved with the same average height above the flange as the flat face. The test dome shall be capable of fitting a device for bake-out ensuring uniform heating of the dome to achieve the minimum operational pressure.

For pumps with an inlet of under 100 mm in internal diameter, the internal diameter of the dome shall be 100 mm. The connection between the test dome and the pump inlet shall be made through a 45° taper fitting as shown in figure 1. For pumps with an inlet of 100 mm or over in internal diameter, the internal diameter D of the dome shall be equal to that of the actual inlet of the pump.

5.2 Measurement apparatus by orifice method: inlet pressure $< 10^{-4}$ Pa

For measurements, a test dome 2 as shown in figure 2 shall be used. The test dome shall be capable of fitting a device for bake-out ensuring uniform heating of the dome to achieve the minimum operational pressure.

The diameter of the thin wall orifice plate shall be chosen according to the expected throughput (volume flow rate) and shall be such that the ratio of the pressures measured at p_a and p_b (see figure 2) lies between 3 and 50. Care shall be taken to ensure that at the inlet pressure $p_1 (= p_b)$, the mean free path of the gas particles is not smaller than the orifice diameter d .

For pumps with an inlet of under 100 mm in internal diameter, the internal diameter of the dome shall be 100 mm. The connection between the test dome and the pump inlet shall be made through a 45° taper fitting as shown in figure 2. For pumps with an inlet of 100 mm or over in internal diameter, the internal diameter D of the dome shall be equal to that of the actual inlet of the pump.

5.3 Pressure gauge

The measurement of total pressure shall be made using pressure gauges calibrated to within ± 5 % accuracy for pressures at least 10^{-4} Pa or within ± 10 % for pressures less than this value.

It is recommended that the calibration of the vacuum gauge(s) is checked after the completion of measurements, for example, by comparison with a reference gauge in situ.