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Vacuum technology — Standard methods for measuring vacuum-pump performance —

Part 4:
Turbomolecular vacuum pumps

Technique du vide — Méthodes normalisées pour mesurer les performances des pompes à vide —

Partie 4: Pompes à vide turbomoléculaires

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Foreword

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This document was prepared by Technical Committee ISO/TC 112, *Vacuum technology*.

A list of all parts in the ISO 21360 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document specifies methods for measuring the performance data of turbomolecular vacuum pumps. This document complements ISO 21360-1, which provides a general description of the measurement of performance data of vacuum pumps.

The methods described here are well known from existing national and international standards. The aim in drafting this document was to collect together suitable methods for the measurement of performance data of turbomolecular vacuum pumps. This document takes precedence in the event of a conflict with ISO 21360-1.

Vacuum technology — Standard methods for measuring vacuum-pump performance —

Part 4: Turbomolecular vacuum pumps

1 Scope

This document, in conjunction with ISO 21360-1, specifies methods for the measurement of performance characteristics of turbomolecular vacuum pumps. It is applicable to all sizes and all types of turbomolecular vacuum pumps, including those

— with mechanical or magnetic bearings;

— with or without an additional drag stage(s) or other pumping stages on the shaft;

— with one or more inlet ports.

Since turbomolecular vacuum pumps are backed by primary pumps, their performance cannot be completely defined by the volume flow rate curve. Also, the driving device and the backing pressure of the turbomolecular vacuum pump is important to the performance.

The following completes the performance characteristics:

— information about throughputs and backing pressure of the turbomolecular vacuum pump;

— the compression ratio curve (compression ratio vs backing pressure of turbomolecular vacuum pump).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 21360-1:2012, *Vacuum technology — Standard methods for measuring vacuum-pump performance — Part 1: General description*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 21360-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
critical backing pressure
p_c
maximum backing pressure p_3 on the outlet that the vacuum pump and the driving device can withstand for continuous operation without being damaged or overloaded while the pump still has a compression ratio $p_3/p_1 > 10$ and the purge gas flow is off

Note 1 to entry: p_1 is the (high) vacuum pressure on inlet. The rotational speed of the turbomolecular vacuum pump can be reduced at this working point. The value of p_c depends on the rotational speed and the type of gas, therefore both shall be named together with the value of p_c.

Note 2 to entry: Measurement with purge gas leads to different results (during pumping light gases at the inlet the use of heavy purge gas will influence the performance regarding critical backing pressure p_c). Therefore, the purge gas flow has to be zero.

3.2
maximum throughput
Q_{max}
highest gas load that can be pumped continuously without damage or destruction of the pump

Note 1 to entry: Given in pascal litres per second (Pa l/s), millibar litres per second (mbar l/s) or standard cubic centimetres per minute (sccm).

Note 2 to entry: The limiting parameter depends on the design of the pump. In most cases it will be given as a maximum temperature at defined locations. The value of Q_{max} depends on, for example, the gas pumped, the backing pump used, the rotational speed and the conditions of cooling. If the Q_{max} is stated in the units Pa l/s or mbar l/s, then the test dome temperature shall also be documented, because this value depends on the gas temperature. This is not the case if the Q_{max} value is stated in the unit sccm.

3.3
volume flow rate
q_V

$$q_V = \frac{dV}{dt} \tag{1}$$

where

V is the volume;

t is time.

EXAMPLE In the context of the ISO 21360 series, the volume flow rate is the volume of gas per unit time which, under ideal conditions, flows from the test dome through the pump inlet.

Note 1 to entry: For practical reasons, the volume flow rate of a given pump and for a given gas is conventionally considered to be equal to the quotient of the throughput of this gas and of the equilibrium pressure at a given location. The volume flow rate is expressed in cubic metres per hour or litres per second.

Note 2 to entry: The term "pumping speed" and symbol "S" are often used instead of "volume flow rate".

[SOURCE: ISO 21360-1:2012, 3.1]

3.4
ultimate pressure
value towards which the pressure in the test dome approaches asymptotically

Note 1 to entry: This ultimate pressure is always lower than the base pressure p_{b1}.

Note 2 to entry: It is the lowest pressure obtainable with the pump.

Note 3 to entry: It is recommended that ultimate pressure values are not given in the manufacturer's specification. Therefore, no procedure to measure the ultimate pressure is given in this document. However, if the manufacturer lists the ultimate pressure, the operating conditions and measurement time durations under which the measurement is made should be stated.

3.5
base pressure turbomolecular pump
p_{b1}
pressure obtained in the dome 48 h after the bake-out procedure

Note 1 to entry: That is the conditioning of the vacuum pump and the test system without any test gas (see 5.6).

3.6
effective compression ratio
K_{eff}
ratio of the backing pressure p_3 to the inlet pressure p_1 of the turbomolecular vacuum pump

$$K_{eff} = \frac{p_3}{p_1} \quad (2)$$

3.7
compression ratio
K_0
maximum compression ratio without gas load through the turbomolecular vacuum pump, wherein p_{b3} is the base pressure of the backing pump and p_{b1} is the base pressure of the turbomolecular vacuum pump

$$K_0 = \frac{p_3 - p_{b3}}{p_1 - p_{b1}} \quad (3)$$

4 Symbols and abbreviated terms

Symbol	Designation	Unit
K_{eff}	compression ratio of vacuum pump	—
K_0	maximum compression ratio of vacuum pump at zero throughput	—
p_{b1}	base pressure turbomolecular pump	Pa (or mbar)
p_{b3}	base pressure of backing pump	Pa (or mbar)
p_1	(high) vacuum pressure on inlet	Pa (or mbar)
p_3	vacuum pressure in backing line	Pa (or mbar)
p_c	critical backing pressure	Pa (or mbar)
Q	throughput of vacuum pump	Pa l/s (or mbar l/s) or sccm
Q_{max}	maximum throughput	Pa l/s (or mbar l/s) or sccm
q_V	volume flow rate	l/s
q_{V0}	volume flow rate at $K_{eff} = 1$	l/s

