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Vacuum technology — Standard methods for measuring vacuum-pump performance — Part 5: Non-evaporable getter (NEG) vacuum pumps

~~*Élément introductif — Élément central — Partie 5: Élément complémentaire*~~

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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~~www.iso.org/members.html.

Introduction

This document specifies methods for measuring the performance data of non-evaporable getters (NEGs) with the shape of pill, disk, ring, strip, module, cartridge, pump structures and coatings. 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. This document aims to show a collection of suitable methods for the measurement of performance data of NEGs. ~~Apply the~~The method specified in this document ~~instead of~~takes precedence over the volume flow rate (pumping speed) measurement ~~shown~~given in ~~the section of~~ISO 21360-1:2020, 5.1, 5.2 and 5.3 ~~of ISO 21360-1~~.

Vacuum technology — Standard methods for measuring vacuum-pump performance — Part 5: Non-evaporable getter (NEG) vacuum pumps

1 Scope

This document specifies methods for the measurement of pumping characteristics of non-evaporable getters (NEGs). It is applicable to all sizes and all types of NEGs, including those:

— with the shape of pill, disk, ring, strip, module, cartridge;

— with pump structures;

— and NEG coatings on inner surface of pipes and vacuum chamber.

A significant difference of pumping characteristics of NEG with other vacuum pumps is that the pumping speed of NEG depends on the sorption quantity. ~~Besides~~Furthermore, especially in the case of NEG coating, the sticking probability rather than the pumping speed is often ~~is~~ the index of the pumping performance. Therefore, this document specifies the methods for measuring the pumping speed, the sorption quantity, and the sticking probability of NEGs.

WARNING It is assumed that the user is familiar with ~~ultra-high vacuum technology and~~the handling of combustible gases and ~~poison~~poisonous ones and with ultra-high vacuum technology.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

— IEC Electropedia: available at ~~https://www.electropedia.org/~~https://www.electropedia.org/

3.1
non-evaporable getter
NEG
getter material to sorb gases in vacuum chambers without evaporation

Note 1 to entry: Sorbing gases mean the process of removing gases from vacuum chambers by adsorption or absorption phenomena. The adsorption is a kind of sorption in which the gas is retained at the surface of the getter material. Most of gas molecules are chemisorbed at the surface of the getter material. The absorption is also a kind of sorption in which the gas molecules diffuse into the bulk of the getter material. The term of “sorption”, “adsorption”, “chemisorption” and “absorption” are defined at ISO 3529 1:2019, 3.4.1, 3.4.2, 3.4.4 and 3.4.6, respectively.

Note 2 to entry: ~~NEG has in~~NEGs have a variety of forms, such as pellets (pills), bars, chips, powders, sheets, strips, washers, wires, module and cartridge.

3.2
non-evaporable getter vacuum pump
NEG- vacuum pump
entrapment vacuum pump with a reactive porous alloy or powder mixtures getter material

[Source: ISO 3529-2:2020, 3.1.36]

Note 1 to entry: non-evaporable getter vacuum pumps are mounted on a vacuum flange in typical. The internal heaters and the controller for the activation may be included.

3.3
non-evaporable getter coating
NEG coating
thin films made from non-evaporable getter, which is coated on inner surface of pipes and vacuum chamber

3.4
surface getter
getter where only the surface shows pumping action

Note 1 to entry: The pumping speed and sorption capacity are essentially proportional to the surface area.

Note 2 to entry: For example, Zr-Fe-V alloy acts as a surface getter for CO at room temperature.

3.5
volume getter
getter where the pumping speed and/or sorption capacity depends on the volume

Note 1 to entry: The dependence of the pumping speed and sorption capacity of the volume getters on the temperature and operation pressure is more significant compared with the *surface getter* (3.4).

Note 2 to entry: For example, Zr-Fe-V alloy acts as a volume getter for H_2 at room temperature. Zr-Fe-V alloy also acts as a volume getter for CO at high temperature.

3.6
activation
conditioning by thermal treatment of a getter to develop its gettering characteristics

Note 1 to entry: Hydrogen reversibly acts with non-evaporable getters (NEGs) and therefore allows to be released by activation.

Note 2 to entry: Other active gases such as CO, CO_2, N_2, and O_2 are chemisorbed irreversibly with NEGs. The activation promotes the diffusion of these gas atoms into the bulk.

3.7
getter pumping speed
S
volume of gas sorbed per unit time

Note 1 to entry: The pumping speed is the same meaning of the volume flow rate.

Note 2 to entry: Getter pumping speed depends on gas species and the amount of gas being sorbed.

3.8
initial pumping speed of getter (or NEG)
instantaneous pumping speed 3 min after the start of the test at the chosen pressure and temperature

Note 1 to entry: This time delay is necessary to allow initial transient effects, until the pressure equilibrium has become negligible.

3.9
intrinsic sticking probability
sticking coefficient
ratio of the number of sorbed gas molecules to that of impinging ones at a unit area per unit time, where the surface is assumed to be flat.

3.10
sticking probability
α
ratio of the number of sorbed gas molecules to that of impinging ones at a unit apparent area per unit time

Note 1 to entry: Sticking probability depends on gas species, surface chemical composition, surface roughness and coverage.

Note 2 to entry: Sticking probability is typically measured as pumping characteristics of NEGs.~~3.11~~

3.11
sorption quantity
C_q
quantity of gas sorbed by the getter

3.~~15~~12
sorption capacity
C_C
quantity of gas sorbed by the getter until the getter pumping speed decrease to 10 % of the initial pumping speed

4 Symbols and abbreviated terms

Symbol	Designation	Unit
A	apparent surface area of getter material	m^2
C_0	conductance of orifice	m^3/s
C_q	sorption quantity	Pa m^3
C_C	sorption capacity	Pa m^3
F_1	correction factor of vacuum gauge 1, where $F_1 = 1/K_1$	
F_2	correction factor of vacuum gauge 2, where $F_2 = 1/K_2$	

K_1	sensitivity of vacuum gauge 1	
K_2	sensitivity of vacuum gauge 2	
p_{R1}	pressure reading of vacuum gauge 1, which is located at the upstream side of orifice	Pa
p_{R2}	pressure reading of vacuum gauge 2, which is located at the downstream side of orifice	Pa
p_{B1}	base pressure of vacuum gauge 1	Pa
p_{B2}	base pressure of vacuum gauge 2	Pa
Q_{pv}	gas flow rate	Pa m³/s
Q_{mol}	molar flow rate	mol/s
R	ideal gas constant	8,134 J/(mol K)
S	getter pumping speed	m³/s
T	temperature	K
α	sticking probability	-
α_0	initial sticking probability	

5 Test methods

5.1 General

5.1.1 Test gases

H_2 and CO shall be used to test for NEG. CO can be replaced ~~to~~by N_2 or CO_2 from ~~the~~a safety ~~issue~~perspective when an agreement is made between customer and testing laboratory. In addition, other gases such as O_2 can be required depending on the application. The purity of the test gas in the gas cylinder shall be higher than 99,99 % for H_2 and 99,95 % for CO, respectively. It is also recommended to measure the purity of the test gas by using quadrupole mass spectrometer (QMS) in the vacuum chamber because the test gas can be polluted during the transportation from the gas cylinder to the vacuum chamber.

5.1.2 Vacuum chamber

The vacuum chamber shall consist of all-metal vacuum components with a baking system. When the valves of elastomer sealing parts are used, they shall be bakeable and fabricated for the usage of UHV condition. The cleanliness shall be appropriate to obtain sufficiently low base pressure in the range of ultrahigh vacuum or extreme-high vacuum (XHV). The apparatus shall be capable of reaching a base pressure of less than 1×10^{-6} Pa without NEG sample installation or with uncoated tube. In addition, it is recommended to measure the residual gas by QMS to make sure that both the air leak and the outgassing of H_2O, CO, CO_2, and hydrocarbons are sufficiently small.

~~NOTE~~ Note that H_2 should be the dominating gas species at the base pressure.