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Vacuum technology — Vacuum gauges — Specifications for hot cathode ionization gauges

Technique du vide — Manomètres à vide — Spécifications pour les manomètres à ionisation à cathode chaude

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 27894 was prepared by Technical Committee ISO/TC 112, *Vacuum technology*.

Introduction

Ionization gauges are commonly used in the measurement of high and ultra-high vacua. The collected ion current in this gauge is proportional to gas density, respectively pressure, at a known temperature in high and ultra-high vacua. The ionization of neutral gas particles is accomplished by fast electrons. These electrons are either produced by a self-sustaining discharge or by an emissive cathode. In commercial ionization gauges, this emissive cathode is provided by a heated wire (“hot cathode”) emitting electrons by thermionic emission.

Since ionization gauges with a self-sustaining discharge by crossed electrical and magnetic fields show non-linearity in discharge current versus gas density, they are tedious to calibrate. For this reason, ionization gauges with “hot cathodes” exhibiting a more linear reading are the ones mainly used for the dissemination of the pressure scale in high and ultra-high vacua.

For the dissemination of the pressure scale and a reliable measurement of high and ultra-high vacuum pressures by an ionization gauge, the relevant parameters and uncertainties must be given, and are described in this International Standard. It therefore complements ISO/TS 3567 when using ionization gauges as reference standards.

Vacuum technology — Vacuum gauges — Specifications for hot cathode ionization gauges

1 Scope

This International Standard defines terms relating to hot cathode ionization vacuum gauges, and specifies which parameters are given by manufacturers of hot cathode ionization gauges and which measurement uncertainties have to be considered when operating these gauges. The reasons for this are as follows.

a) This International Standard updates some terms and definitions given in ISO 3529-3:1981.

b) This International Standard specifies information for suitable laboratories to correctly calibrate vacuum gauges under high and ultra-high vacua, since ionization gauges with hot cathodes are often used as reference standards. This information consists of the relevant parameters and characteristics suitable for quotation in manufacturers' instructions to users employing ionization gauges for traceable measurement of pressure under high or ultra-high vacua.

c) This International Standard also lists those uncertainties associated with the measurement of pressure by the ionization gauge, which are known to be significant, and gives guidelines on how to evaluate them. It is possible that the list is not comprehensive for some current or future vacuum gauges.

d) This International Standard complements ISO/TS 3567 and ISO/TS 27893 when using ionization gauges as reference standards.

2 Normative references

The following referenced documents are indispensable for the application 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/TS 3567, *Vacuum gauges — Calibration by direct comparison with a reference gauge*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

3 Terms and definitions

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

3.1 Definitions of components

3.1.1
gauge head
gauge tube
part of the gauge that is exposed to the vacuum

NOTE 1 Adapted from ISO 3529-3:1981.

NOTE 2 The gauge head of the hot cathode ionization gauge contains at least a cathode or filament, anode, ion collector and the corresponding electrical vacuum feedthroughs. See Figure A.1 in Annex A.

3.1.2
control unit
controller
part of the ionization gauge which comprises the electrical circuits necessary to energize the tube, to control and measure currents or voltages, and, in some cases, to supply power for degassing of tube elements

NOTE 1 See Figure B.1 in Annex B.

NOTE 2 This cancels and replaces the definition for “gauge control unit” in ISO 3529-3:1981.

3.1.3
integrated type
active gauge type
transmitter type
gauge in which the tube and controller form one piece of equipment which may be separated for baking

NOTE See Figure 1 a).

3.1.4
separated type
passive gauge type
gauge in which the tube and gauge controller are separate pieces of equipment connected by a cable

NOTE See Figure 1 b).

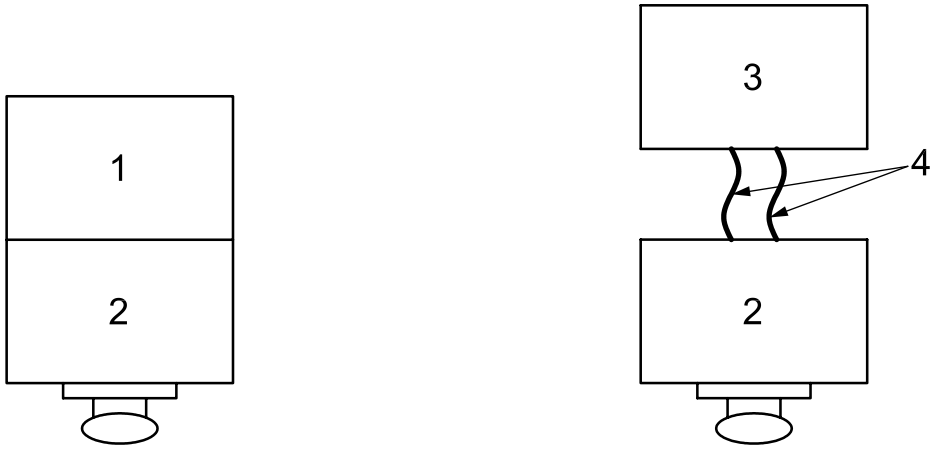
3.1.5
single gauge
one gauge in one piece of equipment

NOTE See Figure 2 a).

3.1.6
combined gauge
more than one gauge in one piece of equipment

NOTE See Figure 2 b).

3.1.7
envelope
wall of metal or glass that encloses the operating elements of a vacuum gauge



a) Integrated type

b) Separated type

Key

1 controller
2 gauge tube
3 control unit
4 cable

Figure 1 — Vacuum gauges; integrated and separated type

a) One gauge in a body (single gauge)

b) Two gauges in a body (combined gauge)

Key

1 gauge tube
2 gauge tube (gauge 1)
3 gauge tube (gauge 2)

Figure 2 — Vacuum gauges; single and combined gauge

3.2 Definitions of physical parameters

3.2.1
sensitivity
sensitivity coefficient
S
quantity given by

$$S = \frac{I_c - I_{c0}}{I_e (p - p_0)} \tag{1}$$

where

I_e is the emission current;

I_c is the ion current, measured at pressure p;

I_{c0} is the ion current, measured at pressure p_0;

p is the pressure;

p_0 is the residual pressure.

NOTE This definition cancels and replaces the definition of “ionization gauge coefficient” given in ISO 3529-3:1981. This quantity was formerly also referred to as “gauge constant”.

3.2.2
ionization sensitivity
S_+
quantity given by

$$S_+ = SI_e = \frac{I_c - I_{c0}}{p - p_0} \tag{2}$$

where

I_e is the emission current;

I_c is the ion current, measured at pressure p;

I_{c0} is the ion current, measured at pressure p_0;

p is the pressure;

p_0 is the residual pressure;

S is the **sensitivity** (3.2.1).

NOTE This definition cancels and replaces the definition of “sensitivity coefficient”, synonym “sensitivity”, given in ISO 3529-3:1981.

3.2.3
relative sensitivity factor
r_x
quantity given by

$$r_x = \frac{S_x}{S_{N_2}} \tag{3}$$

where

S_x is the sensitivity for a specified gas species "x";

S_{N_2} is the sensitivity for nitrogen for the same gauge at the same pressure and the same operating conditions.

NOTE 1 Adapted from ISO 3529-3:1981.

NOTE 2 The pressure reading p_{ind} of a gauge which is correct for nitrogen has to be divided by the relative sensitivity factor r_x of a gas species to obtain the correct pressure p_x of the gas, when it is measuring that gas.

$$p_x = \frac{p_{ind}}{r_x} \tag{4}$$

3.2.4
correction factor
f_c
factor by which a pressure reading of a gauge has to be multiplied to obtain the correct pressure according to a calibration

$$p = f_c \cdot p_{ind} \tag{5}$$

NOTE In a calibration, f_c is determined by the quotient of the pressure standard p_{std} and the indicated reading p_{UUC} of the unit under calibration; f_c may depend on pressure.

$$f_c = \frac{p_{std}}{p_{UUC}} \tag{6}$$

3.2.5
relative correction factor
$f_{c\,x/N_2}$
quantity given by

$$f_{c\,x/N_2} = \frac{f_{c\,x}}{f_{c\,N_2}} \tag{7}$$

where

$f_{c\,x}$ is the correction factor for a specified gas species "x";

$f_{c\,N_2}$ is the correction factor for nitrogen for the same gauge at the same pressure and the same operating conditions.

NOTE 1 The pressure reading p_{ind} of a gauge which is correct for nitrogen has to be multiplied by the relative correction factor of a gas species to obtain the correct pressure of the gas, when it is measuring that gas.

$$p = f_{c\,x/N_2} \cdot p_{ind} \tag{8}$$

NOTE 2 $f_{c\,x/N_2}$ may depend on the pressure.

3.2.6
warm-up time
time after which the ion gauge reading is stable within a specified value (e.g. 2 %) at a constant pressure after switching on the gauge

NOTE There should be no trend in the gauge reading at constant pressure after warm-up time.

3.2.7
residual current
smallest ion collector current that can be obtained when the gauge is operated at its normal operating conditions and at a pressure that is zero or negligible compared with the lower measurement pressure limit of the gauge

NOTE The residual current can be measured in a baked-out ultra-high vacuum system with the ionization gauge in the baked-out and degassed condition. The residual pressure is defined as the ion current obtained when the vacuum system has returned to normal room temperature < 30 °C, 48 h after stopping bake-out. The residual current is mainly composed of the X-ray effect, the inverse X-ray effect, the electron-stimulated desorption effect, outgassing and leakage currents from other potentials.

3.2.8
residual current-equivalent pressure
equivalent pressure of nitrogen to the **residual current** (3.2.7)

NOTE The residual current-equivalent pressure is given in pascals (Pa).

3.2.9
internal volume
〈vacuum gauges〉 volume inside the envelope up to the sealing plane minus the volume of the electrodes reaching out of the sealing plane

NOTE The internal volume is the volume of the gauge tube exposed to a vacuum system. For a nude gauge, in extreme cases, the internal volume may be negative, when the electrode volumes exceed the volume below the sealing plane.

4 Symbols and abbreviated terms

Symbol	Designation	Unit
f_c	correction factor	1
p	pressure	Pa
p_0	residual pressure	Pa
p_{ind}	indicated pressure of a gauge	Pa
p_{std}	pressure of a primary or reference standard	Pa
p_{UUC}	indicated pressure of a unit (gauge) under calibration	Pa
r_x	relative sensitivity factor	1
I_e	emission current	A
I_c	ion current at pressure p	A
I_{c0}	ion current at pressure p_0	A
S	sensitivity (coefficient)	Pa^{-1}
S_+	ionization sensitivity	$A \cdot Pa^{-1}$

5 Principle of hot cathode ionization gauge

Electrons emitted from the cathode are accelerated by the anode (grid) potential to ionize gas molecules that are within their way, which then produce an ion current collected by the ion collector. The ion current I_c is proportional to the gas density, or pressure p at constant temperature T; I_c is given by

$$I_c = I_e \sigma \Delta l \frac{p}{kT} \tag{9}$$

where

I_e is the emission current;

σ is the ionization cross-section area;

Δl is the mean path length of the electron;

k is the Boltzmann constant.

There may be additional electrodes for different purposes. The number of electrodes, their configuration and their shape depend on the specific type of hot cathode ionization gauge.

6 Specifications for hot cathode ionization gauge to be provided by manufacturers

The features and specifications given in 6.1 to 6.20 shall be provided by the manufacturer, in order to enable users of their gauges to estimate the measurement uncertainty and/or to disseminate the pressure scale.

6.1 Type of gauge

The manufacturer shall specify the gauge type, such as triode gauge, Bayard-Alpert gauge, extractor gauge, to mention just a few common types.

For combined gauges, all types of gauges including the non-ionization gauge type shall be specified.

6.2 Display and measurement signal output

The display of the gauge shall show the SI unit of pascal (Pa). Other units of pressure are also allowed.

If the gauge or control unit has a different measurement signal output than pressure, e.g. voltage, a clear assignment of this value to pressure shall be made by an equation, table or graph.

6.3 Measurement range

The measurement range depends generally on the accepted measurement uncertainty. For this reason, the manufacturer shall define measurement uncertainty limits. The measurement range is the range between minimum and maximum pressure where the reading of the gauge is within the defined measurement uncertainty limits. The pressure range and the pressure reading shall be given in pascals. Equivalent pressures in other units may also be given.

6.4 Measurement uncertainty or accuracy

The total relative measurement uncertainty (accuracy) u of the gauge shall be specified in percent of the reading and/or full scale for the measurement range described in 6.3. The relative standard uncertainty in accordance with ISO/IEC Guide 98-3 shall be given. The relative measurement uncertainty can also be given by a formula with a constant and pressure-dependent term, e.g.

$$\frac{u(p)}{p} = \frac{2\times10^{-8}}{p} + 0{,}15 \qquad (10)$$

It is understood that this uncertainty is valid for a batch of gauges. If an individual gauge is calibrated, the uncertainty of the calibration supersedes the uncertainty of the batch.

6.5 Residual current-equivalent pressure

The residual current-equivalent pressure as defined in 3.2.8 shall be given in pascals (Pa). Additionally, other units may be used.

6.6 Fitting to chamber

The fitting type and size of gauge tube should be specified; e.g. Conflat flange, KF/NW, O-ring, etc.

6.7 Type of envelope

The envelope types shall be specified, such as glass, metal and nude tube, etc.

6.8 Maximum bake-out temperature

The maximum temperatures shall be specified respectively for the gauge tube and cables. If the control unit of an integrated gauge can be removed, this shall be stated and the maximum bake-out temperature for either the gauge head or control unit shall be given.

6.9 Filament material and emission current

The number and material of filament(s) should be specified. Also, if designed to be constant in some pressure range, the emission current, including its possible fluctuation and drift, shall be given. When the emission current is changed with pressure (or ion current reading) by the control unit, the pressure switch point shall be given. There may be different switch points for increasing and decreasing pressures. Either shall be given. If the emission current is changed continuously with the ion current, respectively pressure, this shall be stated and the range of the emission current shall be given.

NOTE Typically, emission current is measured from anode to ground or from anode to filament cathode. The emission current is adjusted by the gauge controller unit. The emission current is typically between 0,1 mA and 10 mA. The number of electrons emitted is normally proportional to the emission current. The stability and disturbance of electrons emitted and hence emission current are very significant for accurate pressure measurement using hot cathode ionization gauges.

6.10 Electrical operating condition

All potentials referred to ground potential inside the gauge tube shall be specified. Knowing the electron energy is useful for a user to estimate the relative sensitivity and relative correction factors for different gas species, since the ionization probability significantly depends on the electron energy.

NOTE 1 The anode potential from ground is generally between +150 V d.c. and +200 V d.c. Electrons emitted from the hot filament (cathode) are attracted to the positive anode. However, many electrons miss the relatively open anode (grid) and swing past it several times before finally striking it.

NOTE 2 The filament potential from ground is generally between +10 V d.c. and +50 V d.c. Some gauges apply a.c. voltage to the filament.

NOTE 3 The potential of the ion collector is ground level and it attracts positive ions. The collector is typically made from hairpin-type tungsten material. The positive ions that impact the collector account for the ion current.

6.11 Interface

The method of communication with a computer shall be specified; e.g. RS-232, RS-485, GPIB, Ethernet, USB, Fieldbus (e.g. Profibus, DeviceNet).

6.12 Compatibility between gauge tube and control unit

The types and models of the gauge tube that are compatible with a control unit shall be specified.

6.13 Dimensions of gauge tube and controller

The dimensions of the gauge tube and controller should be specified in outline drawings in SI units. It may be expressed as width, depth and height ($w \times d \times h$). Other units (e.g. inch) can also be used.

6.14 Nominal operating conditions

The temperature and humidity range at which the gauge can be operated for reliable measurement of pressure shall be specified.

6.15 Input power of controller

The voltage (a.c. or d.c.), current and frequency shall be specified.

6.16 Cable length

The maximum cable length between the gauge tube and controller shall be specified. A longer cable is sensitive to electromagnetic interference.

6.17 Replaceability of filament

Whether the filament is replaceable (e.g. nude gauge), or not, shall be stated.

6.18 Set point of pressure

Whether the setting pressure to control another unit is available or not should be specified.

NOTE There is a significant stabilization time to obtain steady-state conditions, if the set-point range is switched frequently.

6.19 Shut-down pressure

The shut-down point of overpressure shall be specified.

6.20 Switch pressure

In the case of combined gauges, the switch pressures between the different gauges shall be defined (both for rising pressure and decreasing pressure).

7 Additional (optional) specifications for hot cathode ionization gauge to be provided by manufacturers

7.1 Repeatability and reproducibility (long-term stability)

Repeatability or reproducibility (long-term stability) shall be expressed in percent of reading and/or percent of full-scale for a specified period (e.g. 1 h, 2 weeks, 1 month, 1 year). For such measurements, pure gases at stable or repeatable pressures shall be used and the gauge be operated under its normal conditions. Typical values may be given by the manufacturer. Manufacturers decide to what extent this measurement is economically feasible, considering the type of gauge and its intended field of application. If feasible, manufacturers should also try to obtain such information from their key customers for the sake of new customers.

NOTE Especially repeatability and reproducibility (long-term stability) are greatly influenced by the user and the field of application.

7.2 Display range

The complete pressure range where the gauge gives an indication may be given.

NOTE The measurement range, in accordance with 6.3, is equal to or smaller than the display range.

7.3 Material of gauge tube

The material of the envelope, grid (anode) and collector may be specified.

7.4 Degassing method

For accurate pressure measurement, most gauges are often degassed to remove contaminant from electrodes and the envelope of the gauge tube. The degassing method should be specified, such as electron bombardment or ohmic heating. The degassing time is often adjustable in gauge controllers. Some special controllers automatically return to measurement mode after degassing. It is recommended that the manufacturer should specify the time interval and the automatic returning function if it is available. A maximum pressure for degassing must be specified to avoid filament damage.

7.5 Degas power

The degas power is not usually adjustable in the control unit. The degas power (e.g. voltage and current) may be specified, whether or not the power is adjustable.

7.6 Relative sensitivity factor for gas species other than nitrogen

The relative sensitivity factors, as defined in 3.2.3, or relative correction factors, as defined in 3.2.5, may be given in a table or graph (if dependent on pressure) for various gas species.

7.7 Typical sensitivity coefficient for nitrogen

If feasible, the typical value of sensitivity coefficient for nitrogen shall be given since the coefficient may scatter in a produced batch. Sensitivity depends, among other influences, on the geometry of the electrodes of the gauge tube. It shall be expressed in reciprocal pascals as shown in Equation (1).

NOTE For an integrated type of gauge, the pressure indication is provided by the electronics and usually no sensitivity can be given.

7.8 Internal volume

The internal volume, as defined in 3.2.9, shall be specified. The internal volume is needed for calibration with static expansion systems and to estimate the total additional volume for a calibration chamber as defined in ISO/TS 3567.

7.9 Storage and transportation condition

The manufacturer is encouraged to specify conditions of storage and transportation to avoid damage and harm to the gauge, e.g. gas environment, cleanliness, temperature, relative humidity, vibration, shock, etc.

7.10 Photographs

For a clear outlook and details, a photograph or drawing of the upright gauge tube and the front and back panels (connector side) of the gauge controller is recommended.

7.11 Inspection record and calibration certificate

An inspection record may be supplied with the gauge. This will increase the confidence of the user in the reading of the gauge. If a calibration certificate is available, it shall contain information on how it is traceable to a national standard concerning vacuum.

8 Influences contributing to the measurement uncertainty with hot cathode ionization gauges

8.1 Emission current

The total ion current is influenced by the emission current as indicated in Equations (1) and (2). The instability of the emission current (Reference [4]) and its density distribution (Reference [5]) should be taken into account for uncertainty evaluation. The sensitivity coefficient depends on the emission current. The gauge with automatic control of the emission current has different sensitivity coefficients at lower and higher pressures.

NOTE Modern gauges or controllers automatically use the proper emission current when calculating the pressure. In these cases, it is not possible to estimate the influence of emission current separately.

8.2 Residual current

The X-ray effect, the inverse X-ray effect and the electron-stimulated desorption effect are the main causes of residual current and are strongly influenced by the surface conditions of electrodes. Leakage current among potentials of electrodes is produced by the contamination of surfaces inside the gauge. Outgassing also causes a serious pressure increase in the gauge tube. In order to avoid these influences the gauge should be kept clean. A proper degassing process is necessary for ultra-high vacuum (UHV) and extremely high vacuum (XHV) measurement ($< 10^{-8}$·Pa). The residual current should be measured before practical measurement of XHV or UHV, even though this measurement is difficult. The typical value, including its variation, should be mentioned by the manufacturer for estimation of uncertainty.

8.3 Resolution of signal output

The smallest difference between indications of the signal readout can be meaningfully distinguished for a small pressure change.

NOTE For analogue display units, particularly with logarithmic scale, this is often difficult to estimate.

8.4 Scatter of signal output and repeatability

The scatter of signal output of ion current and its repeatability should be taken into account for uncertainty evaluation. It can be measured by repeated observations at constant pressure.

8.5 Non-linearity of sensitivity coefficient

The linearity of the sensitivity coefficient in Equation (2) is often not only lost at high pressure, but also sometimes at lower pressures. Linearity (pressure dependence) is also influenced by operating conditions, such as anode potential, emission current and gas species.

8.6 Environmental conditions

An accurate measurement of the ionization current of the gauge can be influenced by environmental conditions, e.g. temperature (References [6], [7]), wind effects, magnetic fields, electric fields, and ionizing radiation.

Strictly, ion current is proportional to gas density, not to pressure. A change in temperature during the calibration should be corrected for in the pressure evaluation (References [6], [7]). Influence of temperature on outgassing from the gauge shall also be taken into account.

A temperature change in the gauge tube caused by wind should be considered.

Magnetic and electric fields which influence the trajectory of the electrons and ions produced should be eliminated.

Radiation which produces unexpected ionization should be eliminated.

8.7 Prior usage, cleanliness

In process gases, the electrodes, especially the hot cathode, may be contaminated by deposits. Deposits on the hot cathode change the emission characteristics greatly and may damage the cathode irreversibly. As an example, it has been observed that thin collector wires can be dissolved in pressure cycling with oxygen-containing gas mixtures. Such processes usually allow a correct measurement of pressure with hot cathode ionization gauges only for a limited amount of time. The gauges shall be protected from these process gases as far as possible and/or cleaned or exchanged frequently, if a correct pressure reading is necessary.

Dust or contamination on the connecting flange shall be removed (cleaned), since the pressure in the gauge tube is strongly influenced by their outgassing.

A visual inspection is very important before a calibration.

8.8 Reproducibility (long-term stability) including transport stability

Electrodes in ionization gauges are not stiff. The surfaces of the electrodes change with environmental conditions. Reproducibility (long-term stability) and transport stability shall be taken into account for quantitative measurement. Only under special circumstances, such as gauges with specially prepared surfaces, operating only under clean conditions and always kept under vacuum and transported carefully, the reproducibility (long-term stability) may be as low as 1 % (relative standard uncertainty of reading or sensitivity). For commercially available gauges of highest quality, operated under clean conditions and carefully transported, a value between 2 % and 5 % can be assumed. For regular gauges of normal quality, reproducibility (long-term stability) lies typically between 10 % and 15%; for simple gauges used under rougher conditions, 30 % to 50 % is quite realistic (References [8] to [14]).

8.9 Gas composition

The sensitivity coefficient of a hot cathode ionization gauge depends on the gas species. Different types of gauges show different relative sensitivities, as do individual gauges of the same type, the scatter being smaller than for different types of gauges. Therefore, the gauge shall be calibrated against the gas species to be measured. Correction (or compensation) using the same relative sensitivity factor or relative correction factor as given in manuals or publications (References [15] to [17]) have to be considered with standard uncertainties of at least 10 %.

In the case of measurement for an unknown gas component (or mixtures), the nitrogen-equivalent pressure shall be indicated.

8.10 Pumping effect

In the pressure measurement of a vacuum system with a very small pumping speed, the pumping effect of a hot cathode ionization gauge shall be taken into account. Typically, the pumping speed of hot cathode ionization gauges varies between 0,01 L/s to 0,1 L/s (References [18] to [20]).

8.11 Thermal transpiration effect

There is a pressure difference between the vacuum system (chamber) and gauge tube due to the thermal transpiration effect. This effect is usually included in the sensitivity coefficient during calibration. If the temperature is different from that during the calibration or the heat conduction from the gauge to the vacuum system is different, the change in this effect shall be compensated (Reference [7]).

8.12 Orientation of the gauge

For precise measurement, it should be noted that some gauges have different sensitivity coefficients with their orientation.

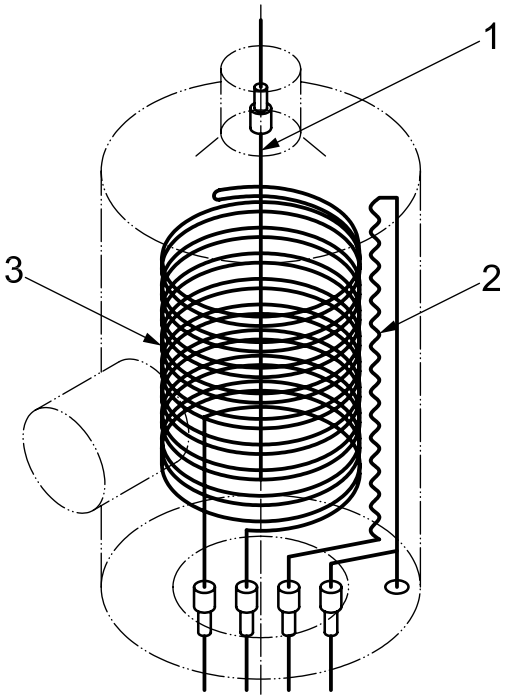
8.13 Enclosure

The sensitivity coefficient of a gauge is influenced by the potential distribution around electrodes. It should be noted that the sensitivity coefficient of a nude gauge is influenced by the diameter of its enclosure (Reference [21]).

In the case of a glass tube gauge, potential distribution around the electrode is influenced by charging-up inside the envelope, resulting in hysteresis of the pressure reading.

Annex A
(informative)

Typical Bayard-Alpert gauge with a glass envelope



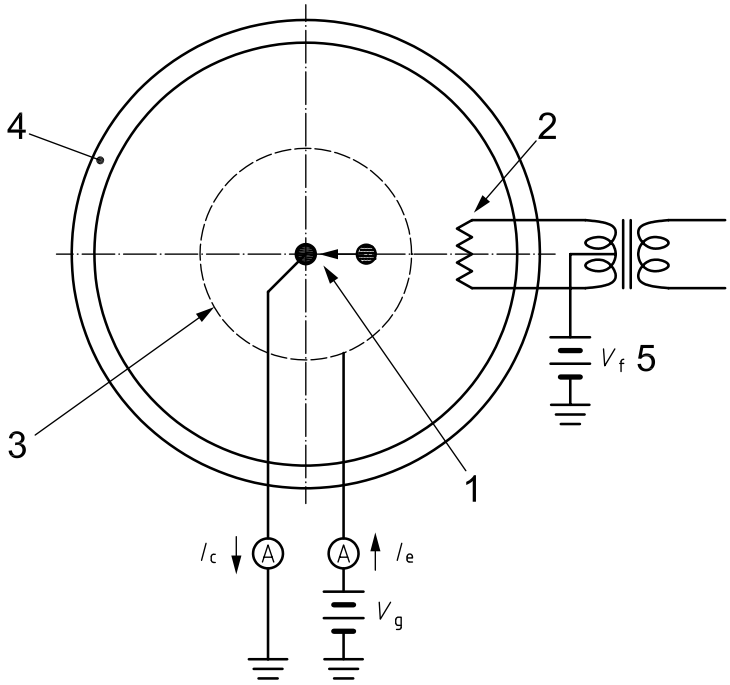
Key

1 ion collector
2 filament
3 anode (grid)

Figure A.1

Annex B
(informative)

Typical electrical connection of a Bayard-Alpert gauge



Key

1 ion collector
2 filament
3 anode (grid)
4 envelope
5 power supply

Figure B.1

Annex C
(informative)

Problems with ionization gauges

C.1 Vibration and shock

The collector is commonly of a hairpin type made from tungsten. It can be easily damaged due to vibration or external impacts. This is also true for other parts, such as a filament or other electrodes.

C.2 Magnetic field

The gauge head must be protected from the electromagnetic field, even for metal-enveloped gauges. The electromagnetic field will affect accurate measurement of the ionization current.

C.3 Cross-talk

Gauge tubes must be placed in the vacuum chamber in order to prevent ionic interference from each other. If several gauges confront each other inside the vacuum chamber, this will cause interference between them; a so-called cross-talk effect. If multiple-gauge tubes are installed in a vacuum system, this will increase the temperature inside the chamber.

C.4 Baking

The gauge head and envelope should be baked out during the vacuum chamber bake-out, in order to remove moisture and contaminant from the gauge tube.

NOTE Baking can cause temperature overshooting which easily generates permanent damage in the gauge tube or cables.

C.5 Degassing

The degassing time is fixed in common gauges. However, some gauges are adjustable using control units. In order to permit accurate pressure measurement, most gauges should be degassed to remove contaminant from the gauge tube. A minimum waiting time after degassing on and off is recommended to be at least 15 min for accurate measurement.

C.6 Sensitivity (sensitivity coefficient)

The sensitivity to gas depends on operating parameters, gas species, geometry of electrodes, and environmental conditions, electron emission current, etc.

C.7 Envelope

The damage to the grid, filament, and collector of a glass-type envelope can be visually inspected. However, it is easily broken and causes damage to the vacuum system and is a hazard to personnel. It should be

carefully handled. A metal-type envelope prevents grid and filament damage during mounting and eliminates the risk of glass breakage. The damage can be checked by testing the resistance. For a nude-type envelope, the outgassing is relatively small.

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