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Vacuum technology — Vocabulary

Part 3: Total and partial pressure vacuum gauges

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National foreword

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Vacuum technology — Vocabulary —

Part 3:
Total and partial pressure vacuum gauges

Technique du vide — Vocabulaire —

Partie 3: Manomètres de pression totale et analyseurs de pressions partielles

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Foreword

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The committee responsible for this document is ISO/TC 112, *Vacuum technology*.

This second edition cancels and replaces the first edition (ISO 3529-3:1981), which has been technically revised in order to include terms of now common vacuum gauges and to adapt terms to new developments and general use of terms in publications.

ISO 3529 consists of the following parts, under the general title *Vacuum technology — Vocabulary*:

— *Part 1: General terms*

— *Part 2: Vacuum pumps and related terms*

— *Part 3: Total and partial pressure vacuum gauges*

Vacuum technology — Vocabulary —

Part 3: Total and partial pressure vacuum gauges

1 Scope

This part of ISO 3529 gives definitions of total and partial pressure vacuum gauges. lt is a continuation of ISO 3529-1, which defines general terms used in vacuum technology, and of ISO 3529-2, which gives definitions of vacuum pumps and related terms.

The terms for those gauges are defined, which had been either very important in the past or are important today and normally commercially available or which physical principle is important still today.

2 Terms and definitions

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

NOTE A tree diagram of total pressure vacuum gauges is illustrated in Figure A.1.

2.1 General terms

2.1.1
pressure gauge
instrument for measuring gas or vapour pressures, greater, equal to or less than the prevailing atmospheric pressure

2.1.2
vacuum gauge
instrument for measuring gas or vapour pressures less than the prevailing atmospheric pressure

Note 1 to entry: A vacuum gauge is a subset of a pressure gauge.

Note 2 to entry: Some types of vacuum gauges commonly in use do not actually measure a pressure (as expressed in terms of a force acting on a surface), but some other physical quantity related to pressure, under specific conditions.

2.1.2.1
gauge head
<of certain types of gauge> part of the gauge which contains the pressure-sensitive element and which is directly connected to the vacuum system

2.1.2.1.1
nude gauge
gauge head without an envelope

Note 1 to entry: In this case, the sensitive element is inserted directly into the vacuum system.

2.1.2.2
control unit
controller
<of certain types of gauge> part of the gauge containing the power supply and all electrical circuitry necessary for the operation of the gauge

2.1.2.2.1
indicator
indicating unit
<of certain types of gauge> part of the gauge which indicates the output signal, usually scaled in units of pressure

2.2 General categories of vacuum gauges

2.2.1
differential vacuum gauge
vacuum gauge which measures the difference of pressures existing simultaneously on either side of a sensitive partition element, for example a flexible diaphragm or a movable separating liquid

2.2.2
absolute vacuum gauge
vacuum gauge by means of which pressure may be determined in terms of measured physical quantities alone

2.2.3
total pressure vacuum gauge
vacuum gauge for measuring the total pressure of a gas or a gaseous mixture

2.2.4
partial pressure vacuum gauge
partial pressure analyser
vacuum gauge for measuring currents derived from the ionized constituents of a gaseous mixture

Note 1 to entry: These currents represent partial pressures with different proportionality constants for different components.

Note 2 to entry: Sometimes this gauge is denoted as a “residual gas analyser”. Since this term characterizes only one of several possible applications of partial pressure analysers, it should be avoided.

2.3 Characteristics of vacuum gauges

2.3.1
measurement range
<of a vacuum gauge> range between minimum and maximum pressure where the reading of the gauge is within the specified measurement uncertainty limits

Note 1 to entry: For certain types of gauge, this range depends on the nature of the gas. In such a case, the pressure range for nitrogen shall always be specified.

2.3.2
sensitivity
sensitivity coefficient
<for a given pressure> change in the signal indicated by the vacuum gauge, divided by the corresponding change in pressure and, where appropriate, divided by parameters not depending on pressure

Note 1 to entry: For certain types of gauge, the sensitivity depends on the nature of the gas. In such a case, the sensitivity for nitrogen shall always be specified.

2.3.3
relative sensitivity factor
<of a vacuum gauge for a specified gas> sensitivity of the gauge for that gas divided by the sensitivity of the gauge for nitrogen, at the same pressure and under the same operating conditions

2.3.4
ionization sensitivity
<for a given gas> change of ion current divided by the corresponding change in pressure

2.3.5
equivalent nitrogen pressure
<of a gas acting on a vacuum gauge> that pressure of nitrogen which would produce the same gauge reading

2.3.6
X-ray limit
<of an ionization gauge> that pressure of pure nitrogen which would give the same gauge reading, without a X-ray effect, as is produced by the residual current caused by photo-electrons mainly emitted at the ion collector

Note 1 to entry: For ionization gauges with a discharge by crossed electromagnetic fields, the X-ray limit is normally not significant.

2.4 Total pressure vacuum gauges

2.4.1 Vacuum gauges based on mechanical phenomena

2.4.1.1
liquid level manometer
absolute differential manometer, commonly a U-tube, in which the sensitive element is a movable separating liquid (for example mercury)

Note 1 to entry: The pressure difference is obtained by measuring the difference in the liquid levels.

2.4.1.2
elastic element gauge
differential vacuum gauge in which the flexible partition is an elastic element

EXAMPLE Bourdon gauge, diaphragm gauge, capacitance diaphragm gauge, etc.

Note 1 to entry: The pressure difference can be determined by measuring either the displacement of the elastic element (direct method) or the force required to compensate its displacement (zero method).

2.4.1.2.1
Bourdon gauge
elastic element gauge where the elastic element is a tube formed into a spiral or a helix.

2.4.1.2.2
diaphragm gauge
membrane gauge
elastic element gauge where the elastic element is a membrane that changes the shape under a pressure difference across it

EXAMPLE An example is a piezoresistive gauge where the force onto the membrane is measured by a piezo element. Another example is the *capacitance diaphragm gauge* (2.4.1.2.3) and the resonant silicon gauge.

2.4.1.2.3
capacitance diaphragm gauge
diaphragm gauge where the membrane is part of a capacitor

Note 1 to entry: A capacitance diaphragm gauge is sometimes also termed a “capacitance manometer”.

2.4.1.3
compression gauge
McLeod gauge
vacuum gauge in which a known volume of the gas at the pressure to be measured is compressed (for example by the movement of a column of liquid – e.g. mercury) in a known ratio and the resulting higher pressure then measured

Note 1 to entry: If the higher pressure is measured by a liquid level manometer, such a gauge is absolute for a gas which satisfies the ideal gas law.

2.4.1.4
pressure balance
piston gauge
absolute vacuum gauge in which the pressure to be measured is suitably applied to an accurately matched piston-cylinder assembly of known cross-sectional area, the resulting force being compared with the gravitational force acting on a group of known masses or being measured by a force meter

Note 1 to entry: A piston gauge where the piston and surrounding cylinder rotate against each other is called a "rotating piston gauge" or "rotating pressure balance".

2.4.2 Vacuum gauges based on transport phenomena in gases

2.4.2.1
viscosity gauge
vacuum gauge in which the pressure is determined in relation to the viscous forces acting on a surface

EXAMPLE Quartz friction gauges, tuning fork gauges, decrement gauge, molecular drag gauge.

Note 1 to entry: This gauge is based on the viscosity of a gas being pressure dependent.

2.4.2.1.1
spinning rotor gauge
viscosity gauge in which the surface is a spinning rotor magnetically suspended in a vacuum thimble and the relative deceleration rate of the rotor is measured

Note 1 to entry: The deceleration of the rotor is caused by momentum transfer from the rotor to the gas molecules in high vacuum and additionally by gas friction (viscous forces) at higher pressures.

2.4.2.1.2
quartz friction vacuum gauge
viscosity gauge in which resonant frequency of the quartz tuning fork depends on the pressure

2.4.2.2
thermal conductivity gauge
vacuum gauge in which the pressure is determined in relation to the transfer of thermal energy between the surfaces of two fixed elements maintained at different temperatures

EXAMPLE Pirani gauge, thermocouple gauge, thermistor gauge, bimetal gauge.

Note 1 to entry: This gauge is based on the thermal conductivity of a gas being pressure dependent.

2.4.2.2.1
thermocouple gauge
thermal conductivity gauge in which the temperature of the heated element is measured by a thermocouple attached to it

2.4.2.2.2
Pirani gauge
thermal conductivity gauge in which the heated element is part of a Wheatstone bridge that supplies the energy to the element and by which the electrical resistance or the dissipated power of the element is being measured

Note 1 to entry: The heated element, often a wire, may be maintained at a constant temperature and the required heating power in dependence of pressure is measured. This is the most accurate measuring principle of a Pirani gauge. Alternatively, the heating power (as in the original design of Pirani) or the current is kept constant and the compensation current in the bridge is used as a measure of pressure.

2.4.2.2.3
thermistor gauge
thermal conductivity gauge in which the heated element is a semiconductor with a high specific resistance coefficient

2.4.2.2.4
thermo-molecular gauge
vacuum gauge in which the pressure is determined by measuring the net rate of transfer of momentum by gas molecules striking fixed surfaces maintained at different temperatures

EXAMPLE Knudsen gauge, diamagnetic levitation.

Note 1 to entry: The dimensions shall be very small compared to the mean free path of the gas molecules.

2.4.3 Vacuum gauges on ionization phenomena in gases

2.4.3.1
ionization vacuum gauge
vacuum gauge in which the molecular density is determined by measuring the ion current produced in the gas by ionization under controlled conditions

Note 1 to entry: The pressure is directly related to gas density.

2.4.3.2
crossed field ionization gauge
ionization vacuum gauge in which the ions are produced by a cold cathode discharge in crossed electrical and magnetic fields

Note 1 to entry: This kind of gauge was formerly defined as a “cold cathode gauge”. Due to the availability of cold cathodes like field emission cathodes or carbon nano tubes as emitting cathodes, the new term was introduced.

2.4.3.2.1
Penning gauge
crossed field ionization gauge with a magnet and which has a particular electrode geometry

Note 1 to entry: One of the electrodes consists of two linked parallel discs. The other electrode (normally the anode) is usually annular and placed between the discs, parallel to them. The magnetic field is perpendicular to the discs.

2.4.3.2.2
magnetron gauge
crossed field ionization gauge having electrodes arranged as coaxial cylinders, the cathode being the inner one, and an axial magnetic field perpendicular to the electric field

2.4.3.2.3
inverted magnetron gauge
crossed field ionization gauge having electrodes arranged as coaxial cylinders, the anode being the inner one, and an axial magnetic field perpendicular to the electric field

2.4.3.3
emitting cathode ionization gauge
ionization vacuum gauge in which the gas is ionized by electrons emitted from a cathode

Note 1 to entry: The cathode is commonly a hot wire, but may also be an electron field emitter or carbon nanotubes, etc.

2.4.3.3.1
hot cathode ionization gauge
ionization vacuum gauge in which the gas is ionized by electrons emitted from a heated cathode

2.4.3.3.2
triode gauge
emitting cathode ionization gauge with a conventional triode structure, the filament being axially located with the grid as anode, and the plate as ion collector concentric to it

2.4.3.3.3
high pressure ionization gauge
emitting cathode ionization gauge designed in such a way that its pressure range is shifted towards the medium vacuum range, compared with the pressure range of a conventional triode gauge

Note 1 to entry: This is mainly achieved by reducing the distances between the electrodes.

2.4.3.3.4
Bayard-Alpert gauge
emitting cathode ionization gauge in which the X-ray limit is reduced by the use of a thin ion-collector wire arranged axially in a cylindrical grid with the cathode mounted outside the grid

2.4.3.3.5
modulator gauge
emitting cathode ionization gauge of the Bayard-Alpert type fitted with a modulator electrode in which the effect of residual currents (including any X-ray currents) may be estimated by measuring the effect on ion collector current when the potential applied to the modulator is varied

2.4.3.3.6
suppressor gauge
emitting cathode ionization gauge in which the X-ray limit is reduced by mounting a suppressor electrode in the vicinity of the ion collector so that any secondary electrons emitted at the ion collector are returned to it

2.4.3.3.7
extractor gauge
emitting cathode ionization gauge in which the X-ray limit and the influence of ions formed by electron stimulated desorption is reduced by using a short thin wire as ion collector, axially located outside the cylindrical grid within a shield, thus extracting ions from the ionization region

2.4.3.3.8
ion energy analysing gauge
emitting cathode ionization gauge in which ions are analysed according to their energy in order to separate ions formed in free space and formed on surfaces within the gauge

EXAMPLE Helmer gauge, ion spectroscopy gauge, axial symmetric transmission gauge, bent beam gauge.

Note 1 to entry: This kind of emitting cathode ionization gauge is mainly designed for low UHV measurement.

2.4.3.3.9
orbitron gauge
emitting cathode ionization gauge in which electrons are injected so that they are made to orbit in long paths, so increasing the number of ions produced per electron

Note 1 to entry: Injection takes place in a electrostatic field between a cylindrical ion collector and a coaxial thin wire. Low electron currents reduce the effects of X-rays and desorbed ions

2.4.3.3.10
hot cathode magnetron gauge
Lafferty gauge
emitting cathode ionization gauge with a heated cathode, resembling a simple cylindrical magnetron operating under cut-off conditions, in which a magnetic field is used to lengthen the electron path and so increase the number of ions produced

2.5 Partial pressure vacuum gauges

2.5.1
mass spectrometer
instrument which separates ionized particles of different mass/charge ratios and measures the respective ion currents

Note 1 to entry: The mass spectrometer may be used as a vacuum gauge to measure the partial pressure of a specific gas, as a leak detector sensitive to a particular search gas, or as an analytical instrument to determine the percentage composition of a gas mixture. Types are distinguished by the methods of separating the ions.

2.5.2 With shaped electric fields

2.5.2.1
radio frequency mass spectrometer
mass spectrometer in which ions travel in a linear path and are accelerated through a series of openings of grids alternately attached to a radio frequency oscillator, emerging into an electrostatic field which permits only the ions accelerated in the radio frequency field to reach the collector

2.5.2.2
quadrupole mass spectrometer
mass spectrometer in which ions are injected axially into a quadrupole lens consisting of a system of four electrodes, usually rods, to which radio frequency and d.c. electric fields in a critical ratio are applied, so that only ions with a certain mass-to-charge ratio emerge

2.5.2.3
monopole mass spectrometer
mass spectrometer in which an V-shaped electrode and a single rod symmetrically disposed to it provide a field configuration similar to that in one quadrant of the quadrupole, ions being injected near to the corner of the V-shaped electrode and only ions with a certain mass to charge ratio (depending on the electric fields) emerging

2.5.2.4
ion trap mass spectrometer
mass spectrometer in which the ions are oscillating in a suitably shaped electrostatic, electromagnetic, high-frequency electrical or high-frequency electromagnetic field and are then separated and directed to a detector by exhibiting the ions to a field that introduces path instability according to their respective mass/charge ratios

2.5.3 With crossed electric-magnetic fields

2.5.3.1
magnetic deflection mass spectrometer
mass spectrometer in which accelerated ions are separated into different circular arcs under the action of a magnetic field

2.5.3.2
double focusing mass spectrometer
mass spectrometer in which ions are separated by the successive actions of a radial electrostatic field and a magnetic sector field so that the velocity dispersion is opposite and approximately equal in the two analysers

2.5.3.3
trochoidal focusing mass spectrometer
mass spectrometer in which ions are separated by crossed electric and magnetic fields in which they follow different cycloidal paths, coming to different foci depending on their mass-to-charge ratios

2.5.3.4
omegatron mass spectrometer
mass spectrometer in which ions are separated by following spiral paths of increasing radius due to a cyclotron resonance effect provided by radio frequency electric and steady magnetic fields which are perpendicular to one another

2.5.4 Time of flight

2.5.4.1
time of flight mass spectrometer
mass spectrometer in which ions or neutrals with same energy are dispersed in time according to their velocity in a drift space of known length

2.5.4.1.1
reflectron mass spectrometer
time-of-flight mass spectrometer which contains a section with a retarding electrical field that cause the ions to revers direction

2.5.4.1.2
Wiley-McLaren mass spectrometer
time-of-flight mass spectrometer which contains a pulsed two-grid ion source to compensate for temporal and initial kinetic energy distribution

Annex A
(informative)

Tree diagram of total pressure vacuum gauges

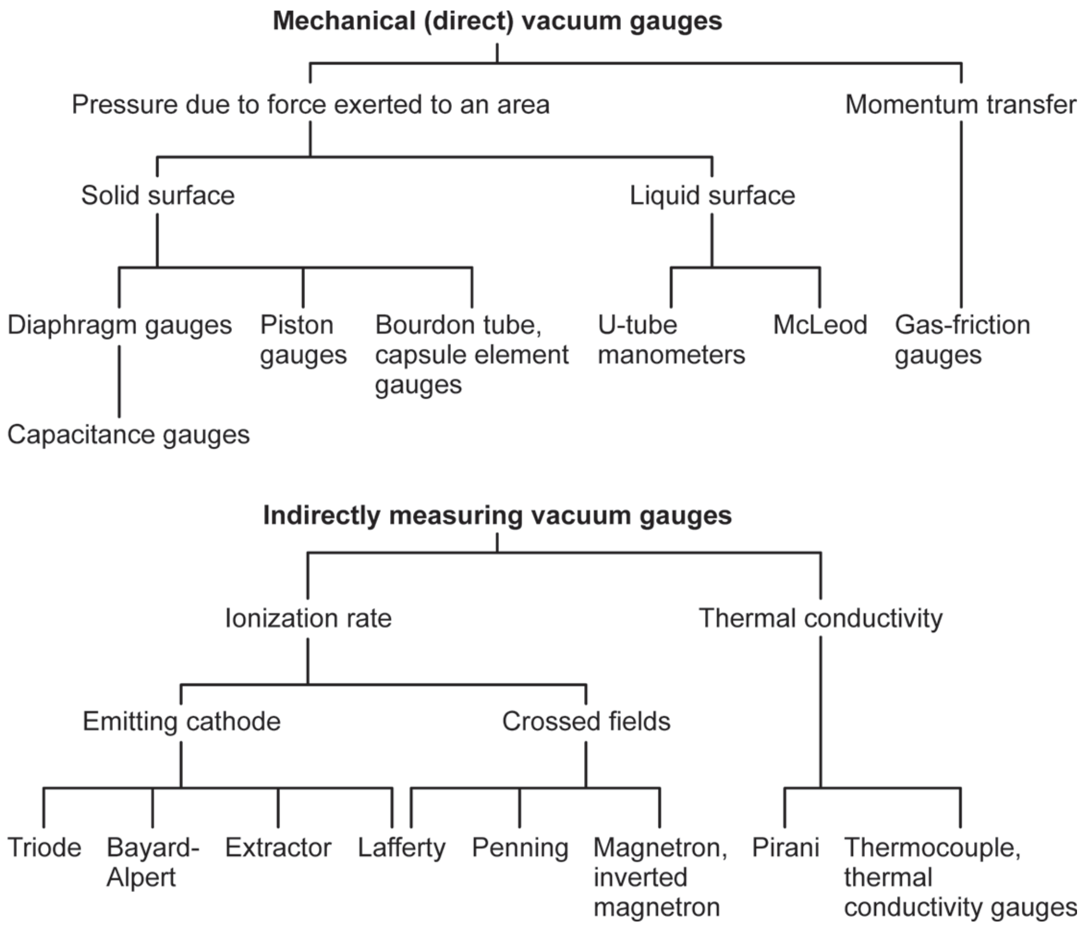

Figure A.1 — Tree diagram of total pressure vacuum gauges[1]

Bibliography

[1] Jousten K. ed. *Handbook of Vacuum Technology*. 1012 pgs., 2008, Copyright Wiley-VCH Verlag GmbH & Co KGaA. Reproduced with permission

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