
**Vacuum gauges — Definitions and
specifications for quadrupole mass
spectrometers**

*Manomètres à vide — Définitions et spécifications des spectromètres
de masse quadripolaires*

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Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 14291 was prepared by Technical Committee ISO/TC 112, *Vacuum technology*.

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Introduction

Quadrupole mass spectrometers (QMSs) are nowadays used not only for leak detection and residual gas analysis in vacuum but also as instruments to provide quantitative analysis in processes and control processes such as physical and chemical vapor deposition, and etch processes.

Total pressure, composition of the gas mixture, QMS settings, environment conditions, etc., have a significant influence on the measured signal, its uncertainty and interpretation. For this reason, it is not possible to calibrate QMS for all its possible applications. Instead, it has either to be calibrated for the particular conditions of use or for a standardized condition.

There is also some need for standardization in order to enable QMS users to compare devices of different manufacturers and to use the QMS properly.

In continuation of efforts of TC 112 during the 1990s, this International Standard takes a first step towards establishment of a standardized calibration procedure for QMS by defining the terms and parameters.

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Vacuum gauges — Definitions and specifications for quadrupole mass spectrometers

1 Scope

This International Standard defines terms relevant to quadrupole mass spectrometers (QMSs) and specifies the parameters required for specification by QMS manufacturers necessary for proper calibration and for maintaining the quality of partial pressure measurement.

This International Standard applies to QMSs with an ion source of the electron impact ionization type. Such QMSs are designed for the measurement of atomic mass-to-charge ratios m/z typically <300 . QMSs with other ion sources, such as those of the chemical ionization, photoionization, and field ionization types, as well as the measurements of m/z above 300, which are mainly used to specify organic materials, lie outside the scope of this International Standard.

2 Terms and definitions

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

2.1 Definitions of components

2.1.1 quadrupole mass spectrometer QMS

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/charge ratio emerge

[SOURCE: ISO 3529-3:1981,^[2] 3.5.2.2]

Note 1 to entry Such a QMS consists of a sensor head and electronic unit.

2.1.2 sensor head analyser tube sensor sensor unit sensing head gauge head

equipment consisting of an ion source, quadrupole mass filter, and ion detector in one enclosure

2.1.3 ion source

part of the QMS in which ions of gas molecules and atoms are produced

Note 1 to entry For the production of positive ions, the ion source generally uses an electron impact ionization process.

2.1.3.1 open ion source

ion source with a high conductance to the surrounding vacuum environment, often designed as an open grid structure

Note 1 to entry All of the operational components of this ionization hardware are exposed to the same vacuum region.

2.1.3.2

closed ion source

enclosed ion source

differential pressure ion source

ion source that uses a nearly sealed container to ionize the gas to be analysed with openings only for passing; sample gas; energetic electrons (for impact ionization); and exciting ions

Note 1 to entry This type of ion source permits ionization at pressures that are higher than the mass filter and detector. It should be used in a sample pressure reduction system with a high vacuum pump on the mass filter.

2.1.3.3

molecular beam ion source

crossed beam ion source

ion source that accepts a focused beam of neutral gas molecules directed at the ion formation region without interference from any ion source components

Note 1 to entry The molecular beam traverses the ion formation region and is usually at right angles to the electron beam and mass filter axes.

Note 2 to entry For molecular beam epitaxy, the crossed beam ion source is also designed to accept molecular beams at various acceptance angles. Some molecular beam ion source designs include a protective shroud around the ion source with an aperture to the ion formation region. As the molecular beam exits the ion source, it may be trapped or pumped to minimize contribution to background from scattered molecules.

2.1.4

quadrupole mass filter

device consisting of four parallel conductive rods arranged in a square array with opposite rods connected electrically in parallel

Note 1 to entry A quadrupole mass filter separates the ions coming from the ion source on the basis of their mass-to-charge ratios by a critical ratio of radio frequency (r.f.) and direct current (d.c.) electrical fields applied to the rods. The rod pairs are driven with opposite r.f. phase and d.c. polarity. [ISO 14291:2012](https://standards.iteh.ai/catalog/standards/sist/36c467a5-c3ce-4e54-aaae-860622539575/iso-14291-2012)

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2.1.5

ion detector

ion collector

device collecting the positive ions that have passed through the mass filter to measure the ion current

Note 1 to entry Two types of ion detectors are common: Faraday cup and secondary electron multiplier (SEM).

2.1.5.1

Faraday cup

metal plate or open cylinder or similar on which the ions from the mass filter are collected

Note 1 to entry An actual Faraday cup ion detector is illustrated in Figure 1 a). However, a metal plate, Figure 1 b), open cylinder, Figure 1 c), or similar on which the ions from the mass filter are collected is usually called a Faraday cup-type ion detector. A Faraday cup generally has a gain of unity, i.e. for each ion collected, one electron flows from the detecting electrometer.

2.1.5.2

secondary electron multiplier

SEM

detector in which the ions from the mass filter strike the entrance surface and release electrons

Note 1 to entry The released electrons are accelerated and strike another surface of the SEM resulting in multistage amplification of the electron current. SEMs can use discrete dynodes or a continuous dynode surface with a potential gradient to increase the electron current and microchannel plate electron multiplier.

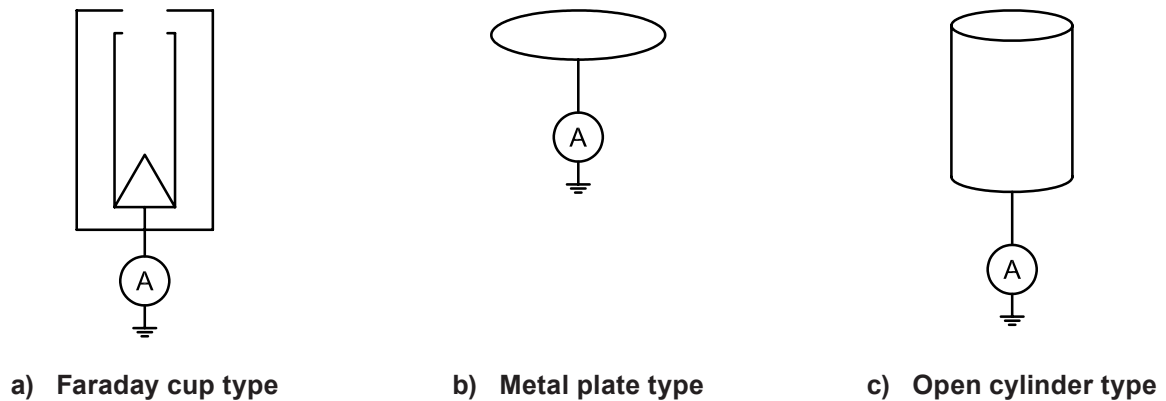


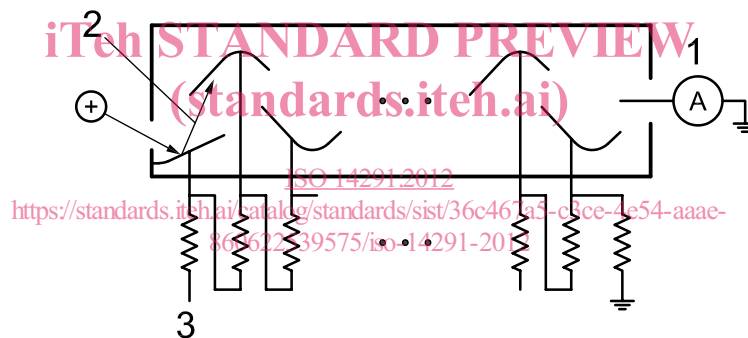
Figure 1 — Faraday cup type ion detector

2.1.5.2.1

discrete dynode electron multiplier

secondary electron multiplier that uses discrete dynodes between which secondary electrons are accelerated

Note 1 to entry The voltages applied to each dynode establish the potential gradients that accelerate the secondary electrons and lead to increased numbers of electrons at each stage. Figure 2 is a schematic diagram of a discrete dynode electron multiplier.



Key

- 1 ammeter
- 2 electron
- 3 negative high voltage

Figure 2 — Discrete dynode electron multiplier

2.1.5.2.2

continuous dynode electron multiplier¹⁾

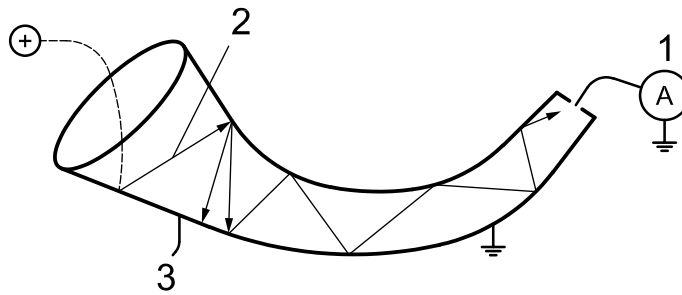
CEM

type of secondary electron multiplier with a continuous dynode, often with a horn-like channel

Note 1 to entry See Figure 3.

Note 2 to entry The applied voltage from entrance to exit of the channel establishes the potential gradient along the channel which accelerates secondary electrons and leads to increased numbers of electrons from entrance to exit.

1) One of the original CEMs is known as Channeltron®. Channeltron® is the trademark of a product supplied by Burle. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named.



- Key**
- 1 ammeter
 - 2 electron
 - 3 negative high voltage

Figure 3 — Continuous dynode electron multiplier (CEM)

2.1.5.2.3
microchannel plate electron multiplier
MCP electron multiplier

type of secondary electron multiplier which consists of a large number of small, parallel continuous-dynode channels (typically 5 µm to 25 µm in diameter), in a planar array, or “plate”

2.1.6
electronic unit

unit consisting of a radio frequency source and several regulated power supplies and amplifiers which operate the ion source and mass filter as well as measure detected ion current

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Note 1 to entry The electronic unit usually incorporates a microprocessor and firmware to control the electronics and usually pass data to an external computer. Electronic units may be integrated or separate.

2.1.6.1
integrated type

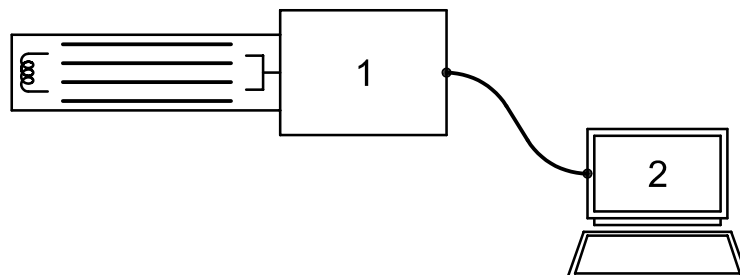
electronic unit mounted directly on sensor head

Note 1 to entry See Figure 4.

2.1.6.2
separated type

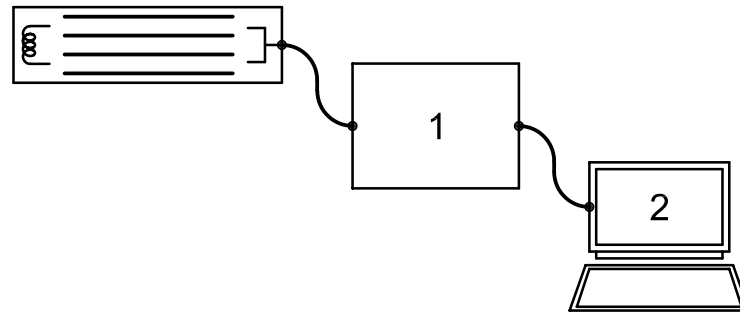
electronic unit separated from the sensor head but connected to it via one or more cables

Note 1 to entry See Figure 5.



- Key**
- 1 electronic unit
 - 2 computer

Figure 4 — Integrated electronic unit

**Key**

- 1 electronic unit
2 computer

Figure 5 — Separated electronic unit

2.2 Definitions of physical parameters

2.2.1

sensitivity

S

ratio of the change in spectrum peak height (ion current), $I - I_0$, to the corresponding change in partial pressure, $p - p_0$

$$S(p) = \frac{I - I_0}{(p - p_0)}$$

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(1)

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where

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I is the ion current measured at partial pressure p ;

I_0 is the ion current measured at residual pressure p_0

Note 1 to entry Sensitivity is expressed in amperes per pascal.

Note 2 to entry Sensitivity is defined differently in ISO 27894:2009^[4] for an ionization gauge with an emissive cathode. The sensitivity of a hot-cathode ionization gauge is defined as

$$S = \frac{I_c - I_0}{I_e (p - p_0)}$$

(2)

where

I_c is the ion current measured at pressure p ;

I_0 is the ion current measured at residual pressure p_0 ;

I_e is the emission current.

2.2.2

relative sensitivity factor

r_x

sensitivity S_x for a specified gas species, x, divided by sensitivity S_{N_2} for nitrogen for the same device at the same pressure and the same operation conditions:

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

(3)