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Vacuum technology — Vacuum gauges — Specifications, calibration and measurement uncertainties for Pirani gauges

Technique du vide — Manomètres à vide — Spécifications, étalonnage et incertitudes de mesure pour les jauges Pirani

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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

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Introduction

ISO 3567 and ISO 27893 are basic standards with no specific guidelines of a special type of vacuum gauge and are generally applicable. Detailed guidance for a specific gauge is intended to be given in separate technical specifications for the calibration of special types of gauges.

This document complements ISO 3567 and ISO 27893 when characterizing or calibrating Pirani gauges or using them as reference gauges.

Pirani gauges are widely used to measure pressures in the medium vacuum up to atmospheric pressure. The relevant parameters, calibration guidelines and uncertainties for the dissemination of the pressure scale and measurement of low and medium vacuum pressures by a Pirani gauge are described in this document.

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Vacuum technology — Vacuum gauges — Specifications, calibration and measurement uncertainties for Pirani gauges

1 Scope

This document identifies parameters of Pirani gauges, their calibration procedure, and describes measurement uncertainties to be considered when operating these gauges.

This document applies to Pirani vacuum gauges operating over a pressure range of 0,01 Pa to 150 kPa.

This document complements ISO 3567 and ISO 27893 when calibrating Pirani gauges and using them as reference standards.

In addition, this document defines procedures to characterize Pirani gauges for response time and hysteresis.

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 3567:2011, *Vacuum gauges — Calibration by direct comparison with a reference gauge*

ISO 27893, *Vacuum technology — Vacuum gauges — Evaluation of the uncertainties of results of calibrations by direct comparison with a reference gauge*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

3 Terms and definitions

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

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

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

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

3.1 Definitions of components

3.1.1
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

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

[SOURCE: ISO 3529-3:2014, 2.4.2.2, modified — Example has been deleted.]

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3.1.2
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: Some types of Pirani gauges have an extended upper limit of measurement range by using the heat convection inside the tube. This type is often called convection-enhanced Pirani gauge.

Note 2 to entry: See Annex A.

[SOURCE: ISO 3529-3:2014, 2.4.2.2.2, modified — Note 1 to entry has been replaced.]

3.2 Definitions of physical parameters

3.2.1
internal volume
volume of the gauge that is exposed to the vacuum system where it is attached to, counted from the connecting flange plane

3.2.2
thermal accommodation coefficient
ratio of the absolute temperature of the molecule after a hit with the heated element in a Pirani gauge and the absolute temperature of the heated element

3.2.3
long-term instability

quantity characterizing the typical change of relative measurement error $e = \frac{\Delta p}{p} = \frac{p_{\mathrm{UUC}} - p}{p}$ over time

where the period needs to be specified

Note 1 to entry: Measurement errors to determine long-term instability of this gauge type are taken for nitrogen at a pressure of $p = (10 \pm 1)$ Pa (nitrogen) after a specified period. This quantity δ_t shall be a relative quantity and may be determined in two ways:

a) as the relative standard deviation of measurement error e_i obtained from at least three calibrations each being separated by the specified period

$$\delta_t = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(e_i - \bar{e}\right)^2}$$

with n being the number of calibrations i, and

$$\bar{e} = \frac{1}{n}\sum_{i=1}^{n} e_i$$

b) as the mean of absolute (non-negative) changes of measurement error Δp_i between recalibrations separated by the specified period

$$\delta_t = \frac{\sum_{i=1}^{n-1}\left|e_{i+1} - e_i\right|}{n-1}$$

and n as described above

Note 2 to entry: The formula in a) is recommended when the measurement error does not show a significant drift but random variations, and the formula in b) when the measurement error shows a systematic and monotonic drift.

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Note 3 to entry: If the output signal of the gauge is not pressure (e.g. voltage or current), this signal shall be converted to pressure based on the manufacturer's specification, before the measurement error is calculated.

Note 4 to entry: Long term instability can be determined by recalibrations with a more accurate gauge or a primary standard. This often requires a transport which itself can lead to an instability of the calibrated value. For this reason, it is not reasonable to assume a linear relationship of instability with time (e.g. δ_t for a period of 2 years is not 2 times δ_t for a period of 1 year).

Note 5 to entry: If not specified otherwise, it is recommended to determine δ_t over a period of 1 year. This is usually a reasonable compromise between costs and influence of transport on the one hand and a possible drift and lowest possible measurement uncertainty on the other hand.

EXAMPLE If δ_t was determined to 6,5 % according to the formula in b), where the period of recalibration was 1 year, the report will be "δ_t = 6,5 % for a period of one year".

3.2.4
response time
τ
time that elapses when the Pirani gauge is exposed to a sudden pressure change of nitrogen between 1 kPa to 100 Pa (up or down to be specified), until the Pirani shows 90 % of the pressure change difference

Note 1 to entry: See Figure 1.

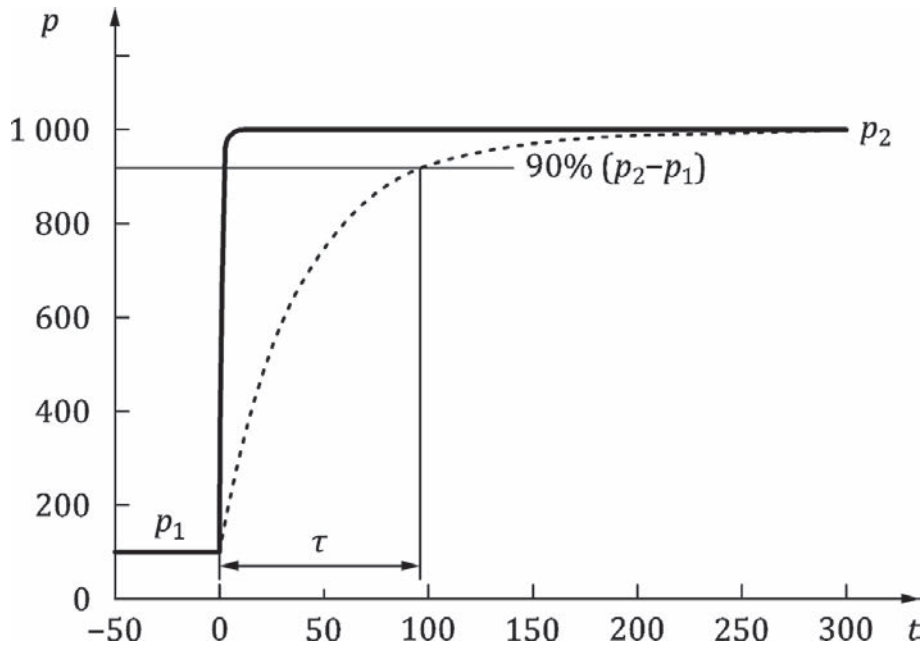


Figure 1 — Illustration to explain definition of response time τ

3.2.5
hysteresis
relative difference of indication of a Pirani gauge when exposed to the same pressure in a rising and decreasing sequence

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