Physikalisch-Technische Bundesanstalt
Nationales Metrologieinstitut

Kalibrierschein

Calibration Certificate

Gegenstand: *Object:*	Spinning Rotor Gauge (SRG)
Hersteller: *Manufacturer:*	The Manufacturer
Typ: *Type:*	A998
Kennnummer: *Serial No.:*	99999-998
Auftraggeber: *Applicant:*	Physikalisch-Technische Bundesanstalt Abbestraße 2–12 10597 Berlin
Anzahl der Seiten: *Number of pages:*	4
Geschäftszeichen: *Reference No.:*	7.5-9.9-99-99-98
Kalibrierzeichen: *Calibration mark:*	75998PTB20
Ort der Kalibrierung: *Location of calibration:*	PTB Berlin
Datum der Kalibrierung: *Date of calibration:*	2020-06-17

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Im Auftrag
On behalf of PTB

Berlin, 2020-07-31

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Im Auftrag
On behalf of PTB

Givenname1 Name1

Givenname2 Name2

1. Description relating to calibration device

The device was shipped under atmospheric pressure. During the shipping the rotor was fixed by means of a magnet.

The rotor was not baked before calibration.

The previous calibration performed by PTB is described in the calibration certificate 75998 PTB 18.

2. Calibration procedure

The effective accommodation coefficient $\sigma(p)$ was determined between 0.1 Pa and 1 Pa by using the pressures generated in the PTB primary standard SE3 metrologically linked to the primary standard SE2, which is based on the static expansion method. The extrapolated effective accommodation coefficient σ_0 ($p < 1 \times 10^{-2}$ Pa) was determined by extrapolation for $p \to 0$ of the linear regression analysis of the data. A run-in-time of at least 12 h was provided before calibration.

The measurements were performed with 6 readings for each of the 5 target points.

The gas temperature T during calibration using the static expansion method with nitrogen was (295.849 ± 0.033) K at a room temperature of (296.16 ± 0.04) K.

The device was operated with the following setup:

Diameter of the rotor (d): 4.5 mm
Density of the rotor (ρ): 7.7 g cm^{-3}
Sigma: 1.0
Viscosity: 0
Unit: 1/s (DCR)

For the measurement with nitrogen, a molar mass (M) of 28.013 g mol^{-1} was used.

A sample of the residual drag (RD) including its scatter was measured before the calibration at a base pressure below 1×10^{-6} Pa. Before the measurement with the calibration gas nitrogen, a RD of 1.5429×10^{-6} s^{-1} with a standard deviation of 8.0×10^{-10} s^{-1} was determined. Before each calibration point, RD (6 readings) was checked at the base pressure and subtracted from the subsequent measurement of the relative deceleration rate.

3. Accommodation coefficient

The effective accommodation coefficient was obtained by:

$$\sigma(p_{\mathrm{cal}}) = \frac{1}{p_{\mathrm{cal}}} \frac{\pi \rho d}{20} \sqrt{\frac{8RT}{\pi M}} \left(-\frac{\dot{\omega}}{\omega} - \mathrm{RD}(\omega) \right)$$

with R the gas constant, $-\dot{\omega}/\omega$ the relative deceleration rate and p_{cal} the calibration pressure generated by the primary standard. For the calibration with the measurement gas nitrogen the extrapolated effective accommodation coefficient σ_0 for $p < 1 \times 10^{-2}$ Pa was:

$$\sigma_0 = \lim_{p_{\mathrm{cal}} \to 0} \sigma(p_{\mathrm{cal}}) = 0.9555 \quad \text{(nitrogen)}$$

With this σ_0 together with d and ρ from the parameter set under section 2, the SRG controller will give the correct reading of pressure within the measurement uncertainties according to this calibration for

pressures $p < 1 \times 10^{-2}$ Pa. Alternatively, the pressure can be calculated from the relative deceleration rate according to

$$p_{\mathrm{ind}} = \frac{\pi \rho d}{20\sigma_0}\sqrt{\frac{8RT}{\pi M}}\left(-\frac{\dot{\omega}}{\omega} - \mathrm{RD}(\omega)\right).$$

In both cases offset and temperature have to be determined for each measurement.

In the pressure range $p > 1 \times 10^{-2}$ Pa up to $p = 2$ Pa, the real pressure p will be received by multiplication of the indicated pressure p_{ind} with a correction factor $f(p_{\mathrm{ind}})$:

$$p = p_{\mathrm{ind}} f(p_{\mathrm{ind}})$$

and viscosity = 0 entered in the controller. From our calibration, $f(p_{\mathrm{ind}})$ was obtained for this rotor by the following equation:

$$f(p_{\mathrm{ind}}) = (1 + ((0.017\,96 \pm 0.000\,60)\,\mathrm{Pa}^{-1}) \cdot p_{\mathrm{ind}}) \quad \text{(nitrogen)}$$

4. Uncertainty

The uncertainty of σ_0 at the time of calibration is estimated to 0.26 % (this includes the relative deviation of σ_0 with different orientations after a new suspension). The uncertainty stated is the expanded measurement uncertainty obtained by multiplying the standard measurement uncertainty by the coverage factor $k = 2$. It has been determined in accordance with the “Guide to the Expression of Uncertainty in Measurement (GUM)”. The value of the measurand then normally lies, with a probability of approximately 95 %, within the attributed coverage interval.

Die Physikalisch-Technische Bundesanstalt (PTB) in Braunschweig und Berlin ist das nationale Metrologieinstitut und die technische Oberbehörde der Bundesrepublik Deutschland für das Messwesen. Die PTB gehört zum Geschäftsbereich des Bundesministeriums für Wirtschaft und Energie. Sie erfüllt die Anforderungen an Kalibrier- und Prüflaboratorien auf der Grundlage der DIN EN ISO/IEC 17025.

Zentrale Aufgabe der PTB ist es, die gesetzlichen Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI) darzustellen, zu bewahren und weiterzugeben. Die PTB steht damit an oberster Stelle der metrologischen Hierarchie in Deutschland. Die Kalibrierscheine der PTB dokumentieren eine auf nationale Normale rückgeführte Kalibrierung.

Dieser Ergebnisbericht ist in Übereinstimmung mit den Kalibrier- und Messmöglichkeiten (CMCs), wie sie im Anhang C des gegenseitigen Abkommens (MRA) des Internationalen Komitees für Maße und Gewichte enthalten sind. Im Rahmen des MRA wird die Gültigkeit der Ergebnisberichte von allen teilnehmenden Instituten für die im Anhang C spezifizierten Messgrößen, Messbereiche und Messunsicherheiten gegenseitig anerkannt (nähere Informationen unter http://www.bipm.org).

Diese Aussage und das CIPM-MRA-Logo beziehen sich nur auf die Messergebnisse in diesem Kalibrierschein.

The Physikalisch-Technische Bundesanstalt *(PTB) in Braunschweig and Berlin is the National Metrology Institute and the supreme technical authority of the Federal Republic of Germany for metrology. The PTB comes under the auspices of the Federal Ministry of Economics and Energy. It meets the requirements for calibration and testing laboratories as defined in DIN EN ISO/IEC 17025.*

The central task of PTB is to realize, to maintain and to disseminate the legal units in compliance with the International System of Units (SI). PTB thus is at the top of the metrological hierarchy in Germany. The calibration certificates issued by PTB document a calibration traceable to national measurement standards.

This certificate is consistent with the Calibration and Measurement Capabilities (CMCs) that are included in Appendix C of the Mutual Recognition Arrangement (MRA) drawn up by the International Committee for Weights and Measures (CIPM). Under the MRA, all participating institutes recognize the validity of each other's calibration and measurement certificates for the quantities, ranges and measurement uncertainties specified in Appendix C (for details, see http://www.bipm.org).

The CIPM MRA Logo and this statement attest only to the measurement component of the certificate.

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