

Digital pressure balance Model CPD8000



WIKA data sheet CT 32.04

Applications

- High-level digital primary standard
- Reference instrument for calibration laboratories and high-end sensor production for the testing, adjustment and calibration of pressure measuring instruments
- Complete, stand-alone system, also suitable for on-site use

Special features

- Absolute and gauge pressure
- Unique working principle
- 15 measuring ranges up to 50 MPa
- Total measurement uncertainty down to 20 ppm of reading
- Ideal for automatic calibration systems



Model CPD8000-AL digital pressure balance, fitted with low-pressure measuring head

Description

Reference primary standards

Pressure balances are high-precision fundamental pressure standards that define the derived unit of pressure directly from the fundamental units of mass, length and time following the formula $p = F/A$.

The model CPD8000 digital pressure balance is a worldwide exclusivity combining two high-level technologies:

- High-end piston-cylinder units, whose effective area (A) converts the pressure into the respective force.
 - High-accuracy force cell which measures the force F.
- CPD8000 is defined as a digital pressure balance and is thus a high-precision pressure measurement standard.

Functionality

The CPD8000 measuring concept is a primary principle. It combines the measurement uncertainty and reliability of fundamental pressure standards with the ease of use of automatic digital pressure measuring instruments.

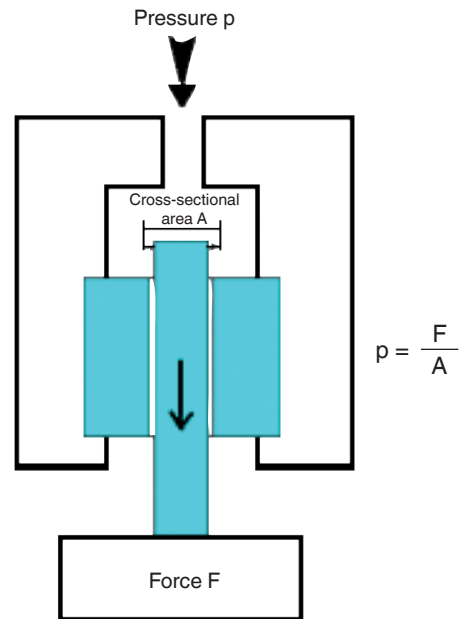
Easy to use

The model CPD8000 offers the same high measurement uncertainty as a high-end pressure primary standard with the benefits of:

- Mass load not necessary
- Built-in reference mass for auto calibration
- Displaying and digital transmission of fully corrected reference pressure

The working principle

- The pressure is applied on the cross-sectional area of the piston and turned into a proportional force. The force is transferred to the measuring-force cell.
- The measuring-force cell continuously measures and calculates the pressure-generated force.
- A microprocessor converts the measured force to the measurement parameter pressure and corrects the environmental influences.



Model CPD8000 basic principle

Gauge and absolute pressure

The model CPD8000 is available in two versions:

CPD8000-GH (gauge pressure)

Available measuring ranges up to 5MPa with atmospheric pressure reference.

CPD8000-AL and CPD8000-AH (gauge and absolute pressure)

Available measuring ranges up to 50 MPa in gauge mode and up to 500 psi / 3.447 MPa in absolute pressure.

The installation of a measuring-force cell in a vacuum-sealed reference pressure chamber enables operation in gauge and absolute pressure mode. Continuous measuring process in absolute pressure is possible without interruption contrary to classic absolute pressure balances, where the reference vacuum has to be interrupted with each pressure change.

The measurement is placed under a reference vacuum chamber. Absolute pressure measurement is a simple and fast solution. It is capable to operate in an absolute pressure mode without interrupting the vacuum between each pressure point, as it is with the classical pressure balances.



Model CPD8000-GH



Model CPD8000-AL/CPD8000-AH

General assembly

CPD8000's measurement quality and long-term performance are based on five key concepts.

■ Piston-cylinder measuring system

Key element

The role of the piston-cylinder unit is to precisely convert the pressure into force. The quality of this transformation is due to its excellent geometry and very low sensitivity to external disturbances.

The Desgranges & Huot's piston-cylinder units (PCUs) are manufactured in a special grade of tungsten carbide, which has been perfected for more than 50 years.

The manufacturing tolerances are typically below 0.1 µm, promoting best possible sensitivity, linearity and repeatability.

Tungsten carbide has the advantage of minimal distortion under pressure and temperature. Therefore, the piston maintains the metrological qualities regardless of the operating conditions.

A large choice of pressure ranges

Desgranges & Huot manufactures 21 different piston-cylinder units (6 for the CPD8000-AL/-AH, 15 for the CPD8000-GH). For easier handling and assignment, the cross-sections of the piston-cylinder units are dimensioned with a nominal conversion factor (Kn).

■ The measuring head

A comfortable unit

The measuring head contains the piston-cylinder units. Trouble-free force transmission from the rotating piston to the measuring-force cell is ensured by the coupled drive system.

It is equipped with a 4-wire platinum resistance thermometer allowing for the necessary temperature measurement.

The coupling of the measuring head with the force cell allows for simple and fast exchange of the measuring heads.

■ The measuring cell

A force-transferring function

The electronic measuring-force cell has been developed for the highly accurate production of mass comparators.

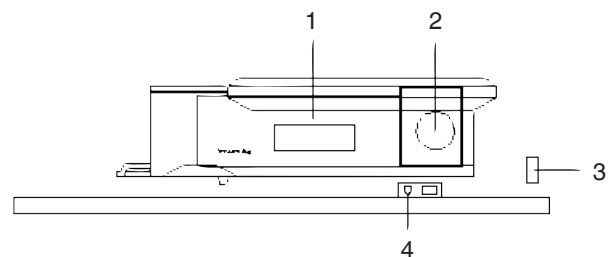
It uses the MONOBLOC technology manufactured by electro erosion. This technology reflects the latest innovations realised in mechanics, electronics, computer science and opto-electronics, hence eliminating operations that require comprehensive maintenance.

■ The auto-calibrating function (ACF)

The CPD8000 force cell response may drift with time. This drift is a result of the change in the environmental parameters ambient temperature, relative humidity and atmospheric pressure.

The measuring-force cell is associated with an auto-calibrating function which, whenever necessary, enables easy application of a reference mass ($F = M \times g$) for recalibration purposes while the measuring head is connected.

Optionally a set of external standard masses can be used for linearisation of the measuring-force cell.



- 1 Measuring-force cell
- 2 Internal standard mass
- 3 Computer connection
- 4 EMM sensors

Basic principle of the auto-calibrating function (ACF)

■ The environment monitoring module (EMM)

In order to determine whether it is necessary to use the ACF, the CPD8000 is equipped with an environment monitoring module which consists of three sensors for ambient temperature, relative humidity and barometric pressure.

After the calibration, the EMM keeps on monitoring the evolution of the ambient conditions in real time.

If these conditions vary in proportions that might noticeably affect the measuring accuracy, the CPD8000 displays a warning flag. The user's attention is drawn to the fact that the ACF has to be activated in order to readjust the measuring instrument to the new operating conditions. The warning is also sent to the command software if the CPD8000 is operated from a remote computer.

Displayed pressure calculation

The pressure displayed by the CPD8000 is calculated according to the following formula:

$$P = Kn \times \frac{N}{N_k} \times \frac{g_l}{g_n} \times (1 - (\lambda_{PC} \times P)) \times (1 - a_{PC} \times (t - 20)) \times \left(\frac{\rho_{ac} - \rho_m}{\rho_{an} - \rho_m} \right) + P_{Vac}$$

Legend:

- Kn** Specific coefficient of the piston-cylinder unit
- N** Indication of the measuring-force cell in count
- N_k** Sensitivity of the measuring-force cell
- g_l** Local gravitational acceleration in m/s²
- g_n** Normal gravitational acceleration in m/s²
- λ_{PC}** Pressure-distortion coefficient of the piston-cylinder unit
- a_{PC}** Thermal-dilation coefficient of the piston-cylinder unit
- t** Temperature of the piston-cylinder unit in °C
- ρ_{ac}** Air density during the adjustment of the measuring-force cell in kg m⁻³. This parameter is null when the CPD8000-A operates in absolute mode.
- ρ_m** Density of the adjustment mass in kg m⁻³
- ρ_{an}** Normal air density in kg m⁻³
- P_{Vac}** Residual gas pressure in the vacuum chamber

Variable parameters

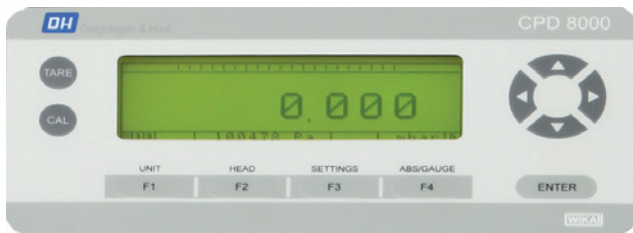
The variable parameters affecting the calculation of the pressure are automatically measured and integrated in the expression of the pressure:

- Temperature of the piston-cylinder unit (t)
- Ambient temperature ¹⁾
- Humidity ¹⁾
- Atmospheric pressure ¹⁾
- Residual vacuum (P_{Vide})

¹⁾ Defining the air density during the calibration (ρ_{ac})

The pressure is automatically converted into any of the common pressure units and the user has the possibility to configure the system to special units.

This rigorous metrology enables an ease of use as well as speed of measurement operation.



Display of the model CPD8000

Constant parameters

The constant parameters entering in the computing of pressure are stored in the memory of the CPD8000:

- Kn of the piston-cylinder unit
- Sensitivity of the measuring-force cell (**N_k**)
- Normal gravitational acceleration (**g_n**)
- Local gravitational acceleration (**g_l**)
- Pressure-distortion coefficient of the piston-cylinder unit (**λ_{PC}**)
- Thermal dilation coefficient of the piston-cylinder unit (**a_{PC}**)
- Density of the calibration mass (**ρ_m**)
- Normal air density (**ρ_{an}**)

Some of these parameters are specific to each piston-cylinder unit and are determined during the calibration. You can easily modify them if necessary. The parameters of six different piston-cylinder units can be stored.

Measuring ranges

The pressure measuring ranges of the CPD8000 depend on the specific coefficient (Kn) of the piston-cylinder units with which the measuring head is equipped.

The CPD8000 can be used with various measuring heads.

Measuring head	Pressure ranges	Resolution	Measurement uncertainty ¹⁾		Piston-cylinder unit Kn	Usable medium
			Standard	Premium		
Absolute and gauge pressure with model CPD8000-AL and CPD8000-AH						
A01	0.001 mbar ... 1 bar	0.001 mbar	0.005 %	0.0025 %	0.1 bar/kg	Pure gas
A02	0.002 mbar ... 2 bar	0.002 mbar	0.005 %	0.0025 %	0.2 bar/kg	Pure gas
A03	0.005 mbar ... 5 bar	0.005 mbar	0.005 %	0.0025 %	0.5 bar/kg	Pure gas
A04	0.01 mbar ... 10 bar	0.01 mbar	0.005 %	0.0025 %	1 bar/kg	Pure gas
A05	0.02 mbar ... 20 bar	0.02 mbar	0.005 %	0.0025 %	2 bar/kg	Pure gas
A06	0.05 mbar ... 50 bar	0.05 mbar	0.005 %	0.0025 %	5 bar/kg	Pure gas
A07	0.0005 ... 500 psi	0.0005 psi	0.005 %	0.0025 %	50 psi/kg	Pure gas
Gauge pressure with model CPD8000-GH						
G01	0.001 mbar ... 1 bar	0.001 mbar	0.005 %	0.0025 %	0.1 bar/kg	Pure gas
G02	0.002 mbar ... 2 bar	0.002 mbar	0.005 %	0.0025 %	0.2 bar/kg	Pure gas
G03	0.005 mbar ... 5 bar	0.005 mbar	0.005 %	0.0025 %	0.5 bar/kg	Pure gas
G04	0.01 mbar ... 10 bar	0.01 mbar	0.005 %	0.0025 %	1 bar/kg	Lubricated gas
G05	0.02 mbar ... 20 bar	0.02 mbar	0.005 %	0.0025 %	2 bar/kg	Lubricated gas
G06	0.05 mbar ... 50 bar	0.05 mbar	0.005 %	0.0025 %	5 bar/kg	Lubricated gas
G07	0.1 mbar ... 100 bar	0.1 mbar	0.005 %	0.0025 %	10 bar/kg	Lubricated gas
G08	0.2 mbar ... 200 bar	0.2 mbar	0.005 %	0.003 %	20 bar/kg	Lubricated gas
G09	0.5 mbar ... 500 bar	0.5 mbar	0.005 %	0.0035 %	50 bar/kg	Lubricated gas
G20	0.0002 ... 200 psi	0.0002 psi	0.005 %	0.0025 %	20 psi/kg	Lubricated gas
G21	0.0005 ... 500 psi	0.0005 psi	0.005 %	0.0025 %	50 psi/kg	Lubricated gas
G22	0.001 ... 1,000 psi	0.001 psi	0.005 %	0.0025 %	100 psi/kg	Lubricated gas
G23	0.0025 ... 2,500 psi	0.0025 psi	0.005 %	0.003 %	250 psi/kg	Lubricated gas
G24	0.003 ... 3,000 psi	0.003 psi	0.005 %	0.003 %	300 psi/kg	Lubricated gas
G25	0.005 ... 5,000 psi	0.005 psi	0.005 %	0.003 %	500 psi/kg	Lubricated gas

1) The total measurement uncertainty is defined as the uncertainty in measurement attributed via the reference standard uncertainty, influence of environmental conditions, resolution of the instrument, repeatability and hysteresis characteristics during the measurement with the coverage factor $k = 2$.

Other pressure ranges on request.

Specifications Model CPD8000

Piston-cylinder system

Material	Tungsten carbide
Poisson's ratio	0.218
Young's modulus	$6 \cdot 10^{11}$ N/m

Typical geometry researched

Straightness	0.1 μm (typical manufacturing tolerance)
Roundness	0.1 μm (typical manufacturing tolerance)
Parallelism	0.1 μm (typical manufacturing tolerance)
Clearance between the piston and the cylinder	0.2 ... 0.4 μm according to the model
Stability of the effective area	≤ 1 ppm/year

Standard masses

Internal masses

Material	304L non-magnetic stainless steel
Mass density	$7,900 \text{ kg/m}^3 \pm 10 \%$

External optional calibration masses

Material	304L non-magnetic stainless steel
Mass density	$7,920 \text{ kg/m}^3 \pm 10 \%$
Composition of the set	5 x 2 kg

Base instrument

Case

Dimension (L x W x H)	530 x 400 x 320 mm
Weight	20 kg

Display

Screen	LCD back-lighting graphic screen with contrast setting
Indication	Pressure display in 12 pressure units and a user unit EMM parameter display Permanent display of the residual gas pressure

Front foil	TARE button CAL button, automatic calibration function (ACF)
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Sensor specifications

Maximum overpressure	110 % FS
Pressure transmission medium	Clean, dry, non-corrosive gases

Voltage supply

Power supply	AC 110 ... 240 V, 50/60 Hz
Power consumption	60 ... 80 VA

Base instrument

Environmental measuring module (EMM)	Sensor type	Accuracy	Alarm setting
Ambient temperature	4-wire Pt100	±0.2 °C	±2 °C
Relative humidity	Capacitive sensor	±5 % r. h.	±20 % r. h.
Atmospheric pressure	Strain sensor	±2 mbar	±10 mbar
PCA temperature	DIN 43760 4-wire Pt100	±0.1 °C	N/A
Residual vacuum	Pirani gauge ≥ 1 Pa ±1 E ⁻⁴		
Researched metrological specifications			
Linearity	2 E ⁻⁶ FS		
Hysteresis	2 E ⁻⁶ FS		
Repeatability	≤ 5 E ⁻⁶ FS		
Temperature effect	Full compensation		
Measurement uncertainty	down to 25 ppm of reading, depending on the measuring range		
Permissible ambient conditions			
Operating temperature	18 ... 28 °C		
Relative humidity	15 ... 85 % r. h. (non-condensing)		
Communication			
Interface	RS-232-C		
Sampling rate	100 ms		

Approvals and certificates

CE conformity

Pressure equipment directive 97/23/EC (Module A)

Certificate

Calibration Standard: COFRAC certificate
Option: LNE/PTB certificate

Scope of delivery

- Digital pressure balance, model CPD8000 incl. transport case
- Measuring head
- Pt100 probe
- Cover for measuring head and measuring cell
- Power cord
- RS-232 interface cable
- Set of accessories for standard operation of the CPD8000
- Operating instructions
- COFRAC calibration certificate

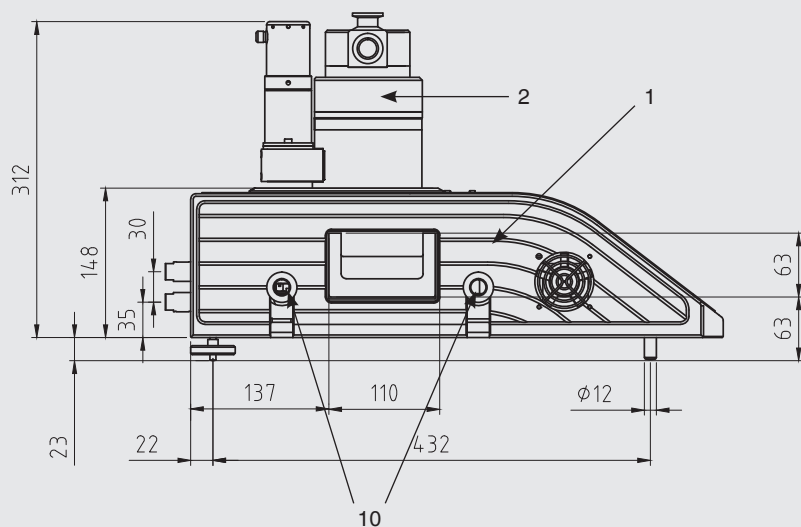
Options

- Premium uncertainty incl. LNE/PTB calibration certificate

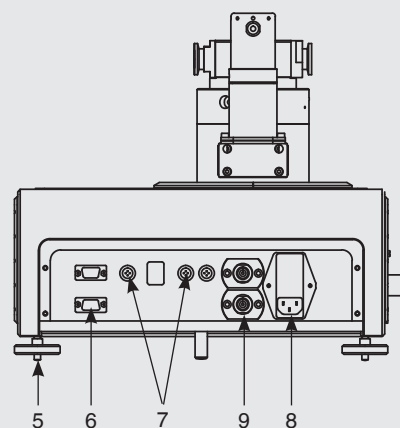
Dimensions in mm

Model CPD8000-AL and CPD8000-AH

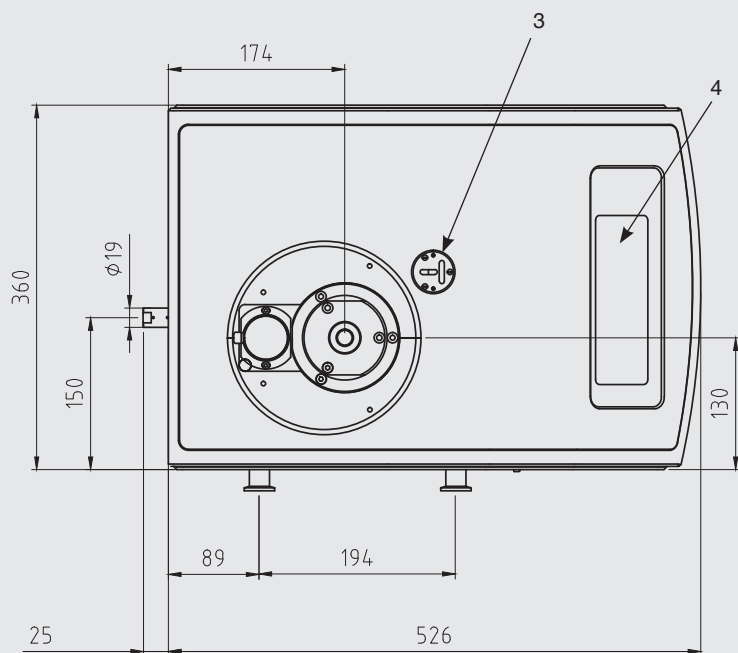
Side view



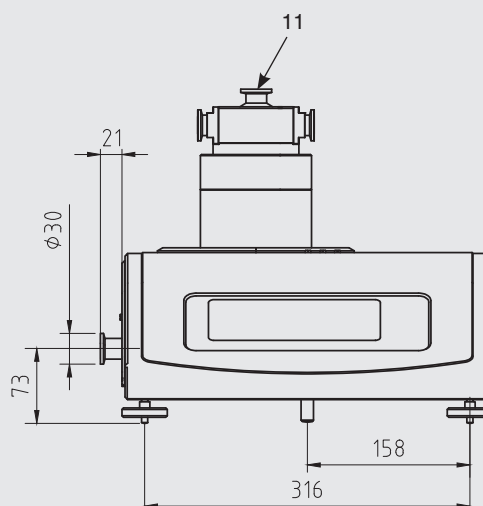
Rear view



Top view

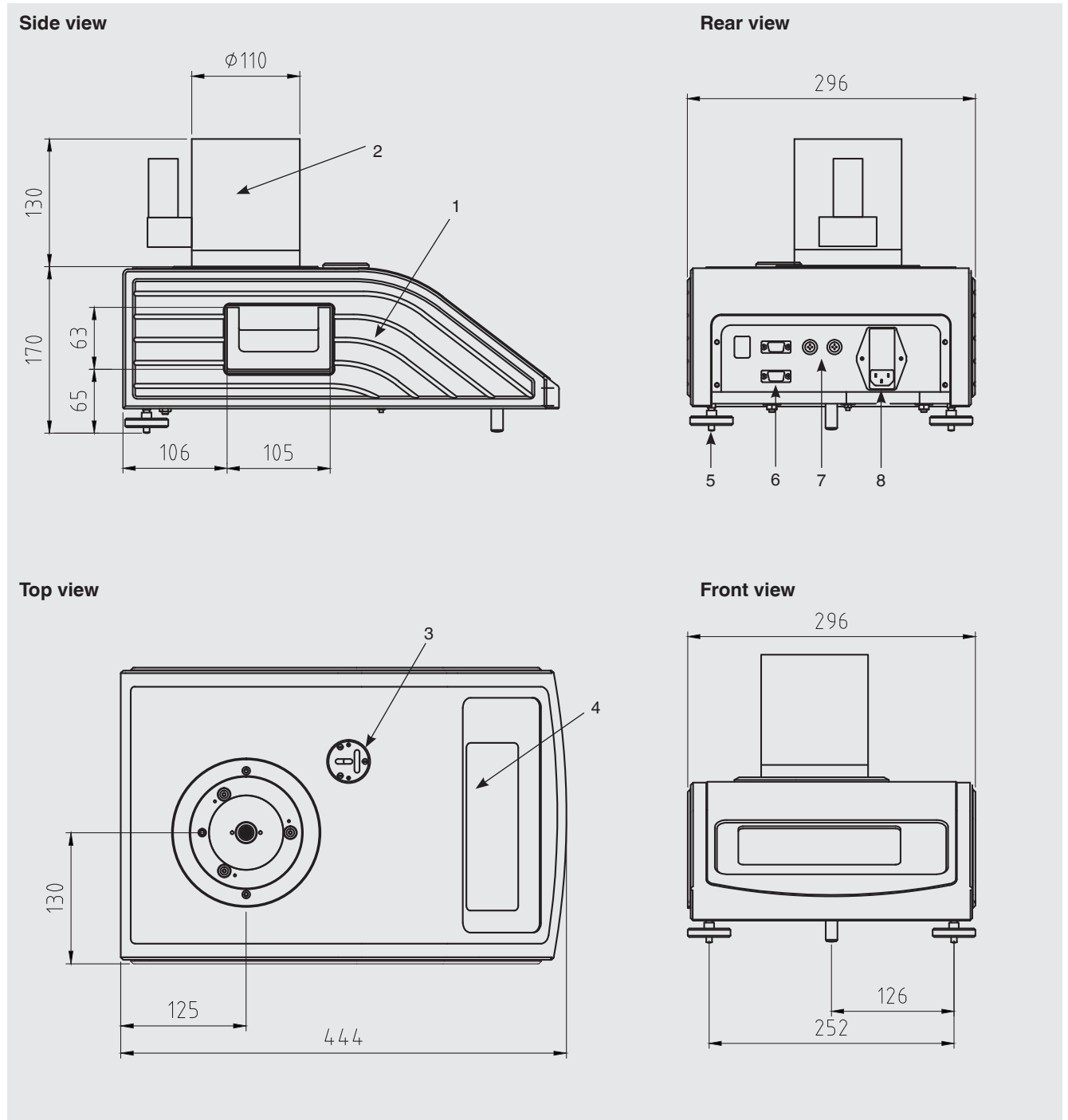


Front view



- | | | | |
|---|-----------------|----|---|
| 1 | Measuring cell | 7 | Connection port for motor and platinum resistance thermometer (PRT) |
| 2 | Measuring head | 8 | Mains supply |
| 3 | Levels | 9 | Connection for gas lubrication (for AH version) |
| 4 | Digital display | 10 | Reference vacuum connections |
| 5 | Levelling feet | 11 | Connection flange to the test item |
| 6 | COM port to PC | | |

Model CPD8000-GH



- | | | | |
|---|-----------------|---|---|
| 1 | Measuring cell | 7 | Connection port for motor and platinum resistance thermometer (PRT) |
| 2 | Measuring head | 8 | Mains supply |
| 3 | Levels | | |
| 4 | Digital display | | |
| 5 | Levelling feet | | |
| 6 | COM port to PC | | |

Remote control

All of the CPD8000 functions, even the **ACF** running command, can be executed from an external computer through serial interface (RS-232-C), which enables it to be integrated in an automatic calibrating system.

Maintenance

The CPD8000 is delivered with the operating instructions, accessories and tools allowing its general maintenance. No other maintenance is necessary if the standard is used in accordance with the routine instructions described in the operating instructions. Recalibration is recommended every five years depending on the operating conditions.

Calibration

All CPD8000 are delivered with a gauge COFRAC calibration certificate by Degranges & Huot (accreditations 2-1033 and 2-1129). The COFRAC calibration guarantees the traceability of the measurements done by the CPD8000 to the national and international standards, and it takes into account:

- The **Kn** specific coefficient determination
- The automatic calibration function (**ACF**)

The uncertainty calculation presented in the certificate respects the ISO TAG4 and EAL recommendations and shows the enlarged measurement uncertainty of the CPD8000 with a coverage factor $k = 2$.

It takes into account the CPD8000's intrinsic measuring deviations, the uncertainty of the reference standards as well as the influence of the ambient conditions.

CE compatibility

The CPD8000 complies with the following European directives and standards:

- N° 89/336/CEE **Electromagnetic Compatibility Directive** dated May 3th, 1989 modified by the N° 92/31/CEE directive dated May 12th, 1992 and the N° 93/68/CEE directive dated July 22th, 1993
- N° 73/23/CEE Low Tension Directive dated February 19th, 1973 modified by the N° 93/68/CEE directive dated July 22th, 1993
- EN 50082-1 Ed.92 standard (Emission with the 89/336/CEE directive)
- EN 55022 B Class Ed. 87 standard (Immunity with the 89/336/CEE directive), EN 61010 standard (Safety rules for the use of measuring, regulating and laboratory electric instruments with the 73/23/CEE directive)

Option

By using a special adaptation kit, it is possible to use the measuring head of model CPD8000-GH with the CPD8000-AL/-AH. These heads can be used to work only in gauge mode but allow extending the range capability of the CPD8000-A up to 50 MPa.

Conclusion

Due to the design and performance, the model CPD8000 digital pressure balance is unique in the world. The operations with the balance do not necessitate a bell to create the vacuum and masses load.

Connected to an automatic controller (CPC6000 or CPC8000), the CPD8000 enables performing fast calibrations, without having to break the vacuum between each pressure point, with a high metrological reliability. These instruments are used by national laboratories, calibration labs, meteorology, the R&D laboratories, sensor manufacturers and aerospace or avionic companies.

Summary of the functions

The CPD8000 has a great variety of functions aimed at facilitating its use and assuring the quality of its long-term operation:

- Menus in English, French, German and Spanish
- Saving of the metrological characteristics for 6 pressure ranges
- Overpressure visual and sound warning
- Mechanical protection against overpressure up to 110 %
- User-adjustable pressure stability criterion
- Choice between internal/external calibration
- Visual warning when the calibration of the force cell is necessary
- Temperature measurement at the piston-cylinder unit with a platinum resistance thermometer (**PRT**)
- Auto-calibrating function (**ACF**) including the acquisition and correction calculation of the environment parameters (**EEM**)

Further pressure balances within our calibration technology programme

Primary-standard pressure balance, model CPB6000

Measuring ranges:

- Pneumatic up to 1,000 bar
- Hydraulic up to 5,000 bar

Measurement uncertainty: down to 0.002 % of reading, depending on model

For specifications see data sheet CT 32.01



Primary-standard pressure balance, series CPB6000

Primary-standard differential pressure balance, model CPB6000DP

Measuring range = (static pressure + differential pressure):

- Pneumatic up to 800 bar

Measurement uncertainty: 0.005 % of reading
up to 0.002 % of reading (optional)

For specifications see data sheet CT 32.02



Primary-standard differential pressure balance, model CPB6000DP

Automatic pressure balance, model CPB8000

Measuring ranges:

- Pneumatic up to 1,000 bar
- Hydraulic up to 5,000 bar

Measurement uncertainty: 0.005 % of reading
up to 0.003 % of reading (optional)

For specifications see data sheet CT 32.03



Automatic pressure balance, model CPB8000

Ordering information

Model / Instrument version / Accuracy / Measuring head / Calibration for pressure balance / Additional order information

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We reserve the right to make modifications to the specifications and materials.

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