

Metrological pressure balance Model CPB6000



Desgranges & Huot WIKA Data Sheet CPB6000 04/2012

Applications

- High level Primary standard.
- Reference instrument for testing, adjusting and calibrating pressure measuring instruments in factories and calibration laboratories.
- Cross-floating for piston cylinder effective area determination.
- Self-contained, complete system also suitable for on-site measurements/calibrations

Special Features

- Total accuracy of measurement down to 5 ppm of reading depending on model (see table page 9).
- Calibration certificate as a standard from our Cofrac accredited laboratory.
- Available up to 1000 bar pneumatic and 5000 bar hydraulic.
- 15 different piston-cylinder sizes available.



Model CPB6000 pressure balance

Description

Reference primary standards

Pressure balances are **high accuracy** 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 direct measurement of the pressure with a balance; combined to the know-how of Desgranges & Huot guarantee **the best metrological specifications on the market**: high quality piston/cylinder units (high floating time, long term stability), cast aluminium housing and robust sub-assemblies (minimum maintenance and overhaul services).

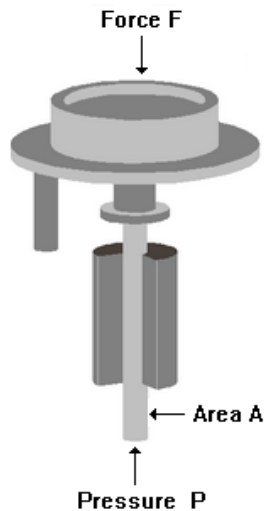
This type of pressure balance has been successfully tested by national institutes, calibration laboratories and all type of industries.

Our Models

There are **six series**, in the CPB6000 family which reflect a concerted **long term effort** to offer the user a broad range of **choice** in selecting a standard as well suited as possible to current and future requirements.

CPB6000 pressure balances are applicable in a very **wide variety** of pressure calibration and measurement problems. There are **appropriate** configurations for use in primary standards laboratories at the **highest level** offering state of the art specifications as well as for use as **production tools** on the shop floor.

This catalogue is intended to present in detail the full potential of the Model CPB6000 pressure balances and to allow the configuration of a CPB6000 system that **best meets your particular requirements**.



CPB6000-PL (Pneumatic – Low Pressure)

This is a **pure gas** pressure standard for high level metrology application. This balance uses **very large area piston cylinder** to measure low gas pressure up to 20 bar with very high resolution down to **0.01 Pa**.

CPB6000-PX (Pneumatic – High Pressure)

This is a **gas* operated** pressure balance with **liquid lubricated** piston-cylinders covering the range of 0.2 to 800 bar in standard (1000 bar in option). Model CPB6000-PX is intended for use with any non-corrosive gas as the test medium. Their use is **simpler and faster** than either gas lubricated pressure balances or the combination of oil operated standard and separators or interfaces. Liquid lubrication **eliminates** the operational problems associated with gas operated pistons without compromising metrological performance.

**CPB6000-PX is also available for oxygen compatibility use.*

CPB6000DP

This is a **dual gas operated** pressure balance with **liquid lubricated** piston-cylinders; offering “two pressure balances Model CPB6000-PX in the same housing”. Model CPB6000DP is **specifically intended for differential pressure calibrations at elevated static pressures**. Differential pressures start at 10 Pa and static pressures range from 0.5 to 80 MPa. Model CPB6000DP can also be used as a dual range system with two different piston-cylinders mounted simultaneously.

CPB6000-HL (Hydraulic – Range up to 1500 bar)

This is **oil operated** pressure balance covering the range of 0.2 to 1500 bar. Model CPB6000-HL is intended for use with oil as the pressurized medium. Oil operation is the **fastest and easiest** way to use pressure balances. The ability to interface oil/air or oil/water using a direct visible level interface makes it possible to calibrate using another medium when necessary. Model CPB6000-HL can drive **DH Dividers and Multipliers** making them an excellent starting point in the configuration of an overall pressure calibration system from vacuum to 1000 MPa.

CPB6000-HX (Hydraulic – Range up to 5000 bar)

This is **oil operated** pressure balance uses the same working principle than CPB6000-HL at the exception that Model CPB6000-HX has a 5:1 pressure intensifier enabling to cover the range from 0,5 to 500 MPa.

CPB6000-HS (Hydraulic with built-in interface)

This is **oil operated** pressure balance (same working principle as CPB6000-HL) covering ranges up to 1500 bar. Those machines are fitted with **internal pressure interface** oil/water or oil/gas allowing to works with gas or water with an oil pressure balance. Model CPB6000-HS has been especially designed for gas companies performing pipeline testing. Another alternative of CPB6000-HS, with built-in variable volume, is available for sale: this type of pressure balance can perform hydraulic and pneumatic calibration with a single balance.

General assembly

A balance designed for high accuracy, long life and optimal safety

Every detail of CPB6000 pressure balances has been thoroughly studied to assure that their use is **practical, safe and reliable** over years of operation. Operating components are built-in to a compact, specially designed light alloy housing that **protects the operator from pressurized components** and provides a rigid and stable base for piston-cylinder mounting and mass loading.

Each model is presented as a complete and self-contained instrument that requires minimal bench space and is easily moved.

Components such as valves, variable volumes, pumps and reservoirs are designed, manufactured and tested to **the stringent requirements of use in a high accuracy pressure standard**.

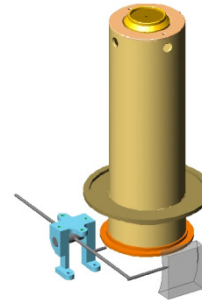
Working volumes are kept to an absolute minimum. Internal tubing are ¼ inch O.D. seamless stainless steel and threaded fittings are used throughout. All tubing connects to a sump in which liquid and solid impurities coming from the system under test drop out and can be purged periodically.



Make and break operations between the standard and the system under test are made by leak free hand tightened quick connectors that use a pressure activated seal. All controls are easily accessible and clearly labelled. The standard's reference level is identified by a label on the front face of the housing. A platinum resistance thermometer is built-in to each mounting post to monitor piston temperature.

Piston displacement and position monitoring

When the standard is used with the mass carrying bell installed, piston position is monitored and displayed by a pointer fitted onto the end of a lever on a fulcrum. The lever's movement multiplies the indication of the piston's movement by a factor of four. The operator is aware of the precise piston position and movement at all times without having to directly observe mass position relative to a scribed reference point. As an option, electronic monitoring of piston position and displacement is available. Piston position is displayed on an analogue meter (with 5 or 25 times multiplication) on the front panel of a separate electronic module which can be placed at a location remote from the standard. A ± 10 volt proportional signal of piston position is also available on rear panel terminals. This signal can be read by a computer to monitor piston movement automatically and to automate pressure control.



Piston orientation

In order of the force acting on the piston to be properly calculated the piston must be vertical. For this reason, each instrument is provided with a precision bubble level and levelling feet.

Piston rotation

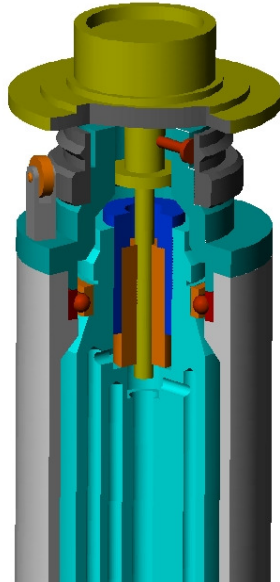
For a piston-cylinder to perform its role effectively, the piston must rotate in the cylinder. Piston rotation is maintained by means of a motor, an oval drive and pulley fitted with a drive pin. Due to the oval drive, the pulley is alternately accelerating and decelerating. The piston only receives an impulse when it has slowed down enough of the drive pin to catch it. The piston is almost always rotating completely freely at the optimum mean speed (around 30 rpm).

The drive motor is a squirrel cage motor that can be left on all times. The automatic rotation system is set to rotate the piston in a counter clockwise direction. Piston-cylinder manufacturing techniques result in piston-cylinders upon which the direction of rotation has no significant effect. If rotation by hand is desired the drive pin can easily be removed.

Piston cylinder mounting post

Protecting the piston

In order to avoid risk of interference with the piston's vertical mobility, the masses must be loaded directly onto the piston.



This is accomplished by loading the masses onto a mass loading bell that rests directly on a plate into which the piston is fitted. When the piston is floating the piston and the mass load are completely free and there is **no possibility of unintended friction or interference with their free movement**.

When the piston is at the bottom of its stroke the piston plate rests on the drive pulley and rotates with it. When the piston is at the top of its stroke, the piston plate's movement is arrested by three travel limit pins that are set into the pulley. In either position, even if the motor is on and the piston is rotating, there is no friction point.

Maximum mass can be loaded with no pressure applied or maximum pressure can be applied with no mass loaded without risk of damage to the instrument or injury to the operator.

Lubrication mode

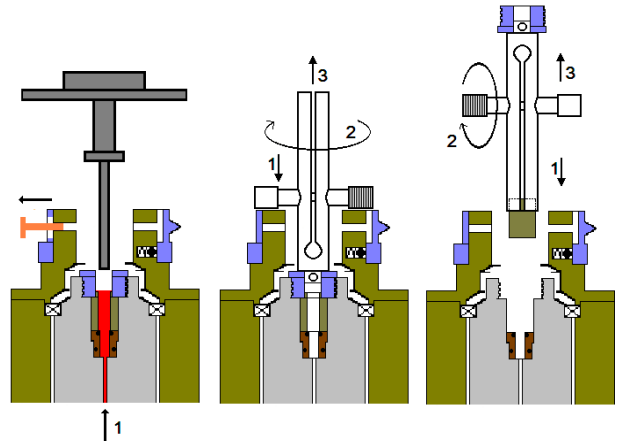
There are two main types of measuring posts:

- **Free deformation mode (FD)**
- **Re-entrant mode (RE).**

The re-entrant measuring post accepts piston cylinder with nominal diameter from 1.6 mm to 11.2 mm. The maximum working pressure of this measuring post is 1500 bar. The free deformation measuring post accepts pistons from 1.6 mm to 5 mm maximum but can work up to 5000 bar with the one working with the CPB6000-HX pressure balance.

Piston-cylinder inter-changeability:

Numerous inter-changeable piston-cylinders are available for each type of CPB6000; making possible multiple ranges with a single instrument. In all cases, changing the piston-cylinder requires no major disassembly and the only tool used is a special tool supplied with the standard. The maximum time required to change a piston-cylinder is less than 1 minute.



KN CONVERSION FACTOR

What is the Kn factor?

All piston-cylinder units and masses mountable on CPB6000 pressure balances are built around a nominal **mass to pressure conversion coefficient, Kn**. The nominal effective area of each piston-cylinder size is such that, under standard conditions, the piston loaded with 1 kg of mass will generate a pressure equivalent to the Kn value.

All mass values, including the mass of the piston and of the mass loading bell are adjusted to be a whole number or fraction of the kilogram.

The nominal pressure defined by any Model CPB6000 is calculated as Kn multiplied by the mass loaded in kg.

Corrections are applied to Kn to calculate the pressure defined within the accuracy tolerance of the Model CPB6000 used.

The use of Kn and whole number masses in no way affects the traditional pressure equation or the factors that affect a pressure measurement made with a pressure balance. Kn is the basis of a coherent relationship between mass, effective area and pressure throughout the CPB6000 series. It is intended as a tool that reduces operator confusion and errors by simplifying the calculation of mass loads and measured pressures.

The Piston / Cylinder, heart of the system

The piston-cylinder is the heart of the pressure balances and the key to its performance. DH's expertise in manufacturing piston-cylinders is the result of over fifty years devoted to perfecting every step of the process. That expertise is widely recognized throughout the world of high accuracy pressure measurement and is the company's single most valuable asset.



Multiple sizes

There are 15 different types of CPB6000 piston-cylinder sizes ranging from a 35.3 mm diameter to a 1.6 mm diameter. This range of sizes includes the largest and the smallest diameters available in a high accuracy pressure balances today. The advantage to the user is in being able to choose, from a very wide selection, the size that best fits his pressure range and other requirements. Small diameters are difficult to manufacture but provide a high pressure to mass ratio which saves the user from having to manipulate excessive amounts of mass and helps miniaturize the overall system.

Materials and machining

In most cases, both piston and cylinder are made of tungsten carbide which is both extremely hard and wear resistant. Tungsten carbide has a Young's modulus of about $6 \times 10^{11} \text{ N/m}^2$ and a linear thermal expansion coefficient of $4.5 \times 10^{-6}/^\circ\text{C}$. Deformation due to pressure is very low and the effect of temperature is small.

The homogeneity of tungsten carbide permits ultra-precise finishing of the piston-cylinder. Deviation from ideal geometry is generally less than 0.1 micron (4 micro-inches). The radial clearance between piston and cylinder can be controlled very closely and varied from about 0.2 to 1 micron (8 to 40 .micro-inch) depending upon the clearance required to achieve optimum performance. The smaller diameter pistons are also available in special tool steel with minimal effect on performance since the most active element is the cylinder, which is always in tungsten carbide.

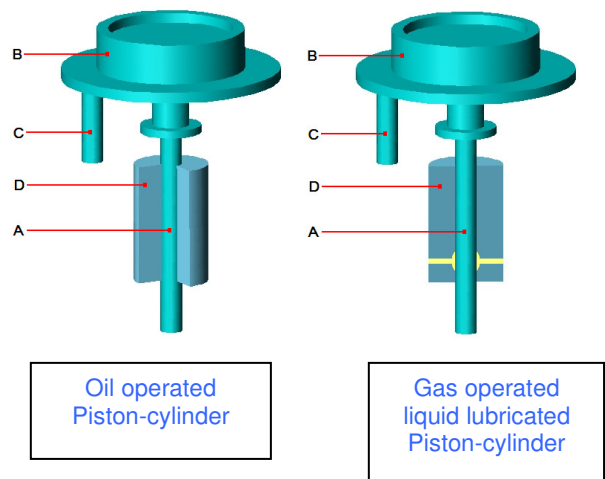
Operating types

There are three types of CPB6000 piston-cylinders. The largest diameter (lowest range) piston-cylinders are intended for pneumatic operation and use as gas lubrication in the space between the piston-cylinder in the Model CPB6000-PL. Piston-cylinders of $\text{Kn}=0,1 \text{ MPa/kg}$ and above exist in two forms:

- One is intended for **pneumatic operation** with liquid lubrication in CPB6000-PX and CPB6000DP pressure balances.
- The other is for **hydraulic operation** in the CPB6000-HL/HX pressure balances.

The piston-cylinders for pneumatic operation with liquid lubrication have a groove set into the inner bore to which liquid is supplied through two radial holes.

All type of CPB6000 piston and plate assemblies are adjusted to a mass of 200 g



A: Piston B: Piston head C: Rotation pin D: Cylinder

The Mass Set

Nine different of mass sets for CPB6000 are available ranging from 20 kg to 100 kg. Masses are machined out of 304 L **non-magnetic stainless steel**. All individual masses are whole numbers or fractions of the kilogram and are adjusted to their nominal values within the tolerance of their accuracy class. The different accuracy classes are defined as needed to achieve certain nominal accuracies on pressure. Each mass set is delivered in sturdy and attractive cabinets that are easily transportable.

The kilogram

The unit of mass used is always the kilogram because the kilogram is the SI unit and the national and international standard for mass from which all other mass units are derived. The kilogram also offers the convenience of being based on the decimal system which facilitates mass totalling and data reduction.

Mass set configuration

All mass sets include a number of **main masses of 2 or 5 kg** as well as 1 kg and fractions of the kilogram **down to 0.01 g**. All pistons have a mass of 200 g and all loading bells a mass of 800 g. The minimum load then is 200 g and the piston loaded with the bell has a mass of 1 kg. A 5, 2, 2, 1 progression of mass values is used making it possible to load any value desired with a resolution of 0.01 g at any point in the range. Each mass is identified with the mass set serial number as well as with an individual number within the set.

Mass loading: the 5, 2 and 1 kg masses are discs with a central hole which are loaded onto the mass carrying bell. The smaller masses are loaded onto the piston plate. The majority of the load is therefore below the centre of gravity of the piston and the entire load is well centred on the vertical axis of the piston-cylinder.

Standard composition and custom sets

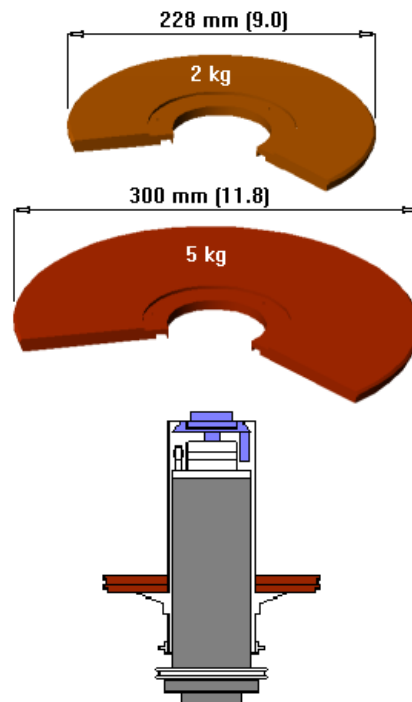
The composition of the standard CPB6000 mass sets does not include the piston assembly (200 g) and the bell (800 g). Individual masses can be added to a mass set at any time. If so desired, a unique custom mass set may be composed from standard masses.

Mass set combinations

Mass set	Weight in kg						
	5	4	2	1	0.5	0.2	0.1
40 kg	-	-	19	1	1	2	1
50 kg	8	1	2	1	1	2	1
60 kg	10	1	2	1	1	2	1
80 kg	14	1	2	1	1	2	1
100 kg	18	1	2	1	1	2	1

Adjustment and interchangeability

Adjusting each mass to its nominal value within the tolerance of its accuracy class allows **complete mass interchangeability** within one set as well as among different sets. Piston-cylinders are not married to specific mass sets and the user need not be concerned with loading masses in prescribed sequences or with complex mass load calculations using different mass values for each mass. Whole number masses are also much easier than odd values to verify and recalibrate. The advantages of adjusted masses are great and their use never significantly compromises the accuracy ultimately achieved on pressure



Reference mass sets

Reference mass sets made up of solid polished masses of the same shape and materials as CPB6000 masses can be supplied. These are convenient as in house standards for local verification or recalibration of CPB6000 mass sets.

Pressure progression

The configuration of the mass sets allows a binary progression

- First point: Piston
- Second point: Piston + Bell
- Then any point up to full scale with a resolution of 100mg

Specifications

Model CPB6000

Model CPB6000-PL - Pneumatic pure gas pressure balance

Pressure range: up to 20 bar

Mass set up to 100kg

Available pressure ranges in bar:

PCU KN	First point (bar)	Complete mass set in kg				
		40	50	60	80	100
		Maximum pressure in bar				
0.1 bar/kg	0.05	4	5	6	8	10
0.2 bar/kg	0.1	8	10	12	16	20

Correspondence Mass (kg) / Pressure (bar):

Unitary weight in kg							Piston	Bell	Unit
5	4	2	1	0.5	0.2	0.1			
0.5	0.4	0.2	0.1	0.05	0.02	0.01			
1	0.8	0.4	0.2	0.1	0.04	0.02	0.1	0.4	Bar

Model CPB6000-PX - Pneumatic with oil lubrication pressure balance

Pressure range: up to 1000 bar

Mass set up to 80kg

Available pressure ranges in bar

PCU KN	First point (bar)	MASS SET in kg			
		40	50	60	80
		Maximum pressure in bar			
1 bar/kg	0.2	40	50	60	80
2 bar/kg	0.4	80	100	120	160
5 bar/kg	1	200	250	300	400
10 bar/kg	2	400	500	600	800
20 bar /kg	10	800	1000	-	-

Correspondence Mass (kg) / Pressure (bar)

Unitary weight in kg							Piston	Bell	Unit
5	4	2	1	0.5	0.2	0.1			
5	4	2	1	0.5	0.2	0.1			
10	8	4	2	1	0.4	0.2	0.4	1.6	Bar
25	20	10	5	2.5	1	0.5	1	4	Bar
50	40	20	10	5	2	1	2	8	Bar
50	25	25	50	25	10	5	10	40	Bar

Available pressure ranges in psi

PCU KN	First point (psi)	MASS SET in kg			
		40	50	60	80
		Maximum pressure in psi			
50 psi/kg	10	2000	2500	3000	4000
100 psi/kg	20	4000	5000	6000	8000
200 psi/kg	40	8000	10000	12000	-

Correspondence Mass (kg) / Pressure (psi)

Unitary weight in kg							Piston	Bell	Unit
5	4	2	1	0.5	0.2	0.1			
250	200	100	50	25	10	5			
500	400	200	100	50	20	10	20	8	psi
1000	800	400	200	100	40	20	40	160	psi

Models CPB6000-HL and CPB6000-HX - Hydraulic pressure balance

Model CPB6000-HL Up to 1500 bar and up to 100 kg mass set

Model CPB6000-HX Up to 5000 bar and up to 100 kg mass set

Available pressure ranges in bar

PCU KN	First point (bar)	MASS SET in kg				
		40	50	60	80	100
		Maximum pressure in bar				
5 bar /kg	1	200	250	300	400	500
10 bar /kg	2	400	500	600	800	1000
20 bar /kg	4	800	1000	1200	1600	2000
50 bar /kg	10	2000	2500	3000	4000	5000

Correspondence Mass (kg) / Pressure (bar)

Unitary weight in kg							Piston	Bell	Unit
5	4	2	1	0.5	0.2	0.1			
5	2.5	2.5	5	2.5	1	0.5	1	4	bar
10	5	5	10	5	2	1	2	8	bar
20	10	10	20	10	4	2	4	16	bar
50	25	25	50	25	10	5	10	40	bar

Available pressure ranges in psi

PCU KN	First point (psi)	MASS SET in kg				
		40	50	60	80	100
		Maximum pressure in psi				
100 psi/kg	20	4000	5000	6000	8000	10000
200 psi/kg	40	8000	10000	12000	16000	20000
250 psi/kg	50	10000	12500	15000	20000	25000
300 psi/kg	60	12000	15000	18000	21000	30000
500 psi/kg	100	20000	25000	30000	40000	50000

Correspondence Mass (kg) / Pressure (psi)

Unitary weight in kg							Piston	Bell	Unit
5	4	2	1	0.5	0.2	0.1			
100	50	50	100	50	20	10	20	8	Psi
200	100	100	200	100	40	20	40	160	Psi
250	125	125	250	125	50	25	50	200	Psi
300	150	150	300	150	60	30	60	240	psi
500	250	250	500	250	100	50	100	400	psi

Model CPB6000-HS - Hydraulic pressure balance with integrated oil / water interface

Especially designed for pipeline testing with integrated oil / water interface

Pressure range Up to 1000 bar and up to 80 kg mass set

PCU KN	First point (bar)	MASS SET in kg			
		40	50	60	80
		Maximum pressure in bar			
5 bar /kg	1	200	250	300	400
10 bar /kg	2	400	500	600	800
20 bar /kg	4	800	1000	-	-

Unitary weight in kg							Piston	Bell	Unit
5	4	2	1	0.5	0.2	0.1			
5	2.5	2.5	5	2.5	1	0.5	1	4	bar
10	5	5	10	5	2	1	2	8	bar
20	10	10	20	10	4	2	4	16	bar

Available on demand

CPB6000 With integrated oil / gas interface (for hydraulic and pneumatic calibrations with a single balance)

Other Piston cylinder assemblies for hydraulic CPB6000: 1 bar/kg and 2 bar/kg (Re-entrant measuring post)

Specifications (Continuation)

Model CPB6000

Pressure transmission medium		Lubrication medium
CPB6000-PL	Clean and dry air or nitrogen	Clean and dry air or nitrogen
CPB6000-PX/DP	Clean and dry air or nitrogen	Drosera™ oil or Krytox™ when oxygen compatibility required
CPB6000-HL/HX/HS	Hydraulic fluid : Sebacate as standard except CPB6000-HS using Univis J13	Hydraulic fluid : Sebacate as standard except CPB6000-HS using Univis J13

Material

Piston	Tungsten carbide as standard, except for 50 bar/kg and 500 psi/kg in special stainless steel
Cylinder	Always in Tungsten carbide
Mass	304 L non-magnetic stainless steel
Bell	304 L non-magnetic stainless steel

Weight and dimension of the balance

	Weight (base only)	Dimension (mm)
CPB6000-PX	27 kg	410 x 500 x 510
CPB6000-HL	26 kg	410 x 500 x 510
CPB6000-HX	33 kg	410 x 500 x 510
CPB6000-HS	27 kg	410 x 500 x 510
CPB6000DP	45 kg	620 x 500 x 510
CPB6000-PL	18 kg	410 x 420 x 460

Accuracy

All Desgranges & Huot equipments are delivered with calibration certificate issued by our Cofrac accredited Laboratory.

Accuracy is the result of $\sqrt{(\text{Repeatability}^2 + \text{Resolution}^2 + \text{Linearity}^2 + \text{Hysteresis}^2)}$ and are expressed in % of reading

Typical accuracy of reading (in 1.0E-6 x P (ppm))	PCU KN	Usable Medium
5	0.01 MPa/kg – 0.1 bar/kg	Pure gas
5	0.02 MPa/kg – 0.2 bar/kg	Pure gas
10	0.1 MPa/kg – 1 bar/kg	Gas lubricated / Oil
10	20 psi/kg	Gas lubricated / Oil
10 / 5	0.2 MPa/kg – 2 bar/kg	Gas lubricated / Oil
10 / 5	50 psi/kg	Gas lubricated / Oil
5	0.5 MPa/kg – 5 bar/kg	Gas lubricated / Oil
5	100 psi/kg	Gas lubricated / Oil
10 / 5	1 MPa/kg – 10 bar/kg	Gas lubricated / Oil
10 / 5	200 psi/kg	Gas lubricated / Oil
10	250 psi/kg	Oil only
10	2 MPa/kg – 20 bar/kg	Oil only
10	300 psi/kg	Oil only
15	500 psi/kg	Oil only
15	5 MPa/kg – 50 bar/kg	Oil only

Accessories and special service

DH offers a complete line of accessories and related equipment for use with CPB6000 pressure balances. These include hardware such as pressure interfaces, gas boosters, tubing, fittings, quick-connectors, valves and manifolds. Complete multi-function calibration systems can be configured.

All accessories have been designed and manufactured by DH or carefully selected from qualified suppliers specifically for use in high quality pressure calibration systems. DH welcomes the opportunity to address your special requirements and to help ensure that your CPB6000 pressure balance is used to greatest advantage



SELECTION CRITERIA

Because of the wide range of users and applications that exist, the CPB6000 family of pressure balances intentionally leaves to the user a great degree of latitude in selecting a pressure standard. Extra time taken now to thoroughly consider all of the possibilities will be rewarded over years to come by the satisfaction of working with a tool perfectly adapted to the job at hand.

A complete pressure balance is configured by selecting a **base instrument**, a **mass set** and at least **one piston-cylinder**. Masses and piston-cylinders determine accuracy and can be up-graded, added or changed at any time. The most important decision is the selection of the base instrument(s) keeping in mind that mass sets and in many cases piston-cylinders can be used in more than one base instrument. The general information in the previous pages can direct one towards a particular series and the detail that follows should allow the selection of the most appropriate model or combination of models.

Careful consideration of the following factors will help the decision process:

- What are the most important selection criteria: accuracy, range, pressurized media, convenience of operation, ruggedness, expandability, cost, other?
- What pressurized medium is preferred in most cases and what other media may be required?
- What are the ranges of the instruments to be calibrated and what range(s) is (are) needed to cover them adequately? What ranges may be required in the future?
- In what environment will the system be operated?
- What are the qualifications of the system operator(s)?
- What accuracy is desired? What accuracy is needed now and may be required in the future?
- Would a CPB8000 automated pressure balance or a CPD8000 (digital pressure balance) be more suitable in this application?

The DH/WIKA customer service department is at your complete disposal and will do everything possible to assist you. Please do not hesitate to ask for a visit to your facility, a demonstration or a complete working evaluation.