Operating Manual
for

Deadweight Tester
(Pressure Balance)

Type CPB5000

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1. General Notes

In this operating manual you get all necessary information for the operation of the Deadweight Tester CPB5000.
For further information, or in case of problems, please contact your dealer.

The deadweight tester CPB5000 is - if not stated contrary - calibrated according international norms and rules and traceable to a national pressure standard.

The warranty period of the deadweight tester CPB5000 is 24 months after date of shipment, acc. to our payment and shipment terms. There is no warranty in case of ignoring this operation manual and in case of wrong handling of the unit.

2. Product Description

2.1 General information about Deadweight Tester (pressure balances)

Deadweight Testers are the primary standard for pressure measurement. Utilising the well-proven piston system, consisting of a vertically mounted precision plapped piston and cylinder assembly, accurately calibrated weight masses (force) are loaded on the piston (area) which rises freely within its cylinder. These weights balance the upward force created by the pressure within the system.

$$\mathrm{Pr}\,essure = \frac{Force}{Area}$$

2.2 Influencing factors

The deadweight tester is calibrated according to nominal standards (or customers specification). If there are differences between the calibrated conditions and the real conditions “on site”, correction calculations have to be made. Following influencing factors have to be considered:

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2.2.1 Local gravity

Gravity varies greatly with geographic location, and so will the Deadweight Tester reading. Due to the significant change in gravity throughout the world (up to 0.5%), ensure that the Deadweight Tester has either been manufactured to your local gravity, or that you have applied the correction from the calibrated gravity.

$$True\,\mathrm{Pr}essure = Nominal\ pressure \bullet \frac{LocalGravity}{CalibratedGravity}$$

Example: Calibrated gravity of the supplied Deadweight Tester: 9.806650 m/s² (*g Norm*)
Your local gravity: 9.811053 m/s² (*g Local*)

Nominal pressure: 100 bar

True Pressure: $p = p_{Nominal} \frac{g_{lokal}}{g_{Norm}} = 100bar \frac{9{,}81105}{9{,}80665} = 100{,}0449bar$

Without correction you would heave a reading error of 0.05%.
*NOTE: With the **Intelligent Kalibration-Module Type IKM** the calculation for correction can be automatized.*

2.2.2 Temperature at the piston-/cylinder-system

The effective area of the piston depends on the temperature. This influence depends on the used material of the piston and is expressed as the Temperature Coefficient (TK). The deadweight tester is typically calibrated for a piston-/cylinder-temperature of +20˚C. If you measure another temperature, a correction has to be calculated as follows:

$$True\,\mathrm{Pr}essure = Nominal\ Pressure \bullet \frac{1}{(1 + (t_{measured} - t_{calibrated}) \bullet TK)}$$

Example: Calibrated temperature: 20˚C
Measured temperature: 23˚C
TK: 0,0022%

$$True\,\mathrm{Pr}essure = 100bar \bullet \frac{1}{(1 + (23 - 20) \bullet 2{,}2^{-5})} = 99{,}99340bar$$

Without correction you would have a reading error of 0.007%.
*NOTE: With the **Intelligent Kalibration-Module Type IKM** the calculation for correction can be automatized.*

2.2.3 Environmental conditions

Temperature and Air Density variations are less siginificant, variations should be corrected for when maximum accuracy is required.

$$Mass = NominalMass \bullet (1 - \frac{AirDensity}{MassDensity})$$

The Air Density is typically 1.2 kg/m³ (at nominal conditions 20˚C / 40% r.h. / 1030 hPa)
The density of the masses (non-magnetic steel) is 7960 kg/m³, of the aluminium masses 2700 kg/m³.

If the Air Density differs about 5%, an additional reading error of about 0.001% happens.
*NOTE: With the **Intelligent Kalibration-Module Type IKM** the calculation for correction can be automatized.*

2.2.4 Dependency of pressure and the effective area of the piston

At higher pressures (appr. >1000 bar) the effective area of the piston is changing due to the pressure force. This dependency is expressed as “pressure distortion coefficient” (λ).
The pressure distortion coefficient (λ) of your Deadweight Tester is stated on the calibration certificate.

$$True\ Pressure = Nominal\ Pressure : (1 + \lambda \bullet Nominal\ Pressure)$$

Example: Check point: 1000 bar

Pressure distortion coefficient: 10^{-7} 1/bar

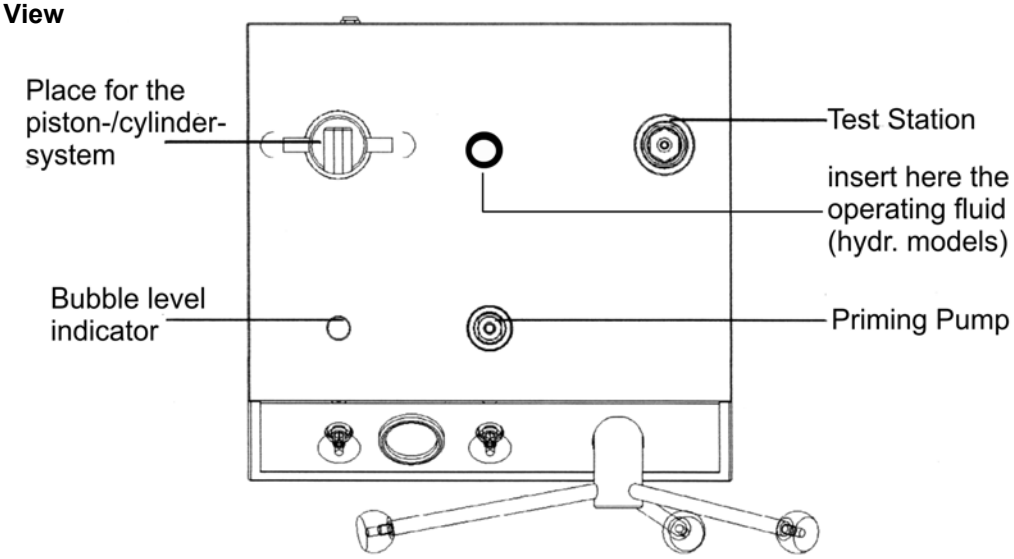
$$True\ Pressure = 1000 : (1 + 1 \bullet 10^{-7} \bullet 1000)\ bar = 999.90\ bar$$

Without correction you would have a reading error of 0.01%.
*NOTE: With the **Intelligent Kalibration-Module Type IKM** the calculation for correction can be automatized.*

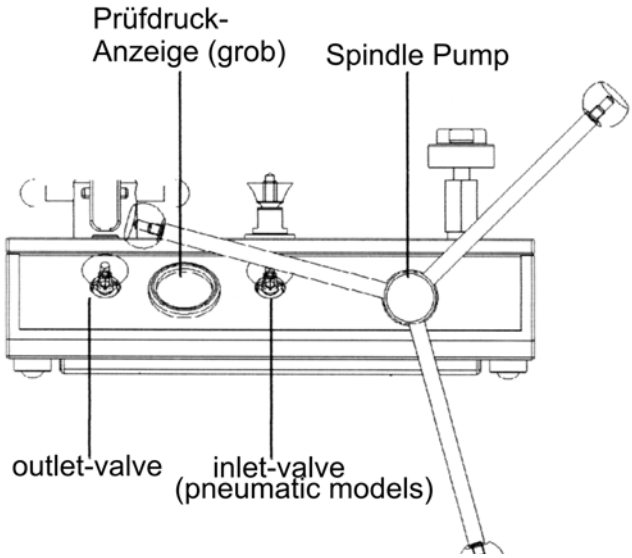
HINT:
The ***Intelligent Kalibration-Module Type IKM*** is available as an accessorie - see page 12.

2.3 Position of the operating elements

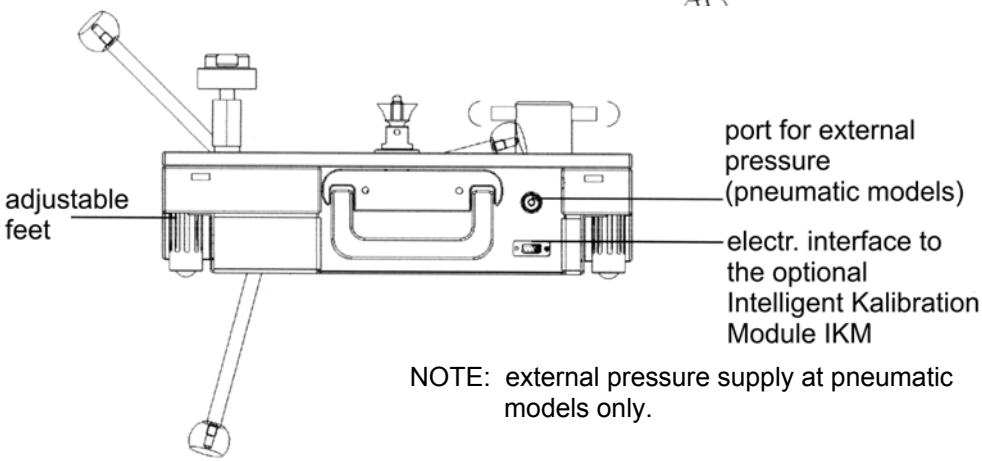
2.3.1 Top View



2.3.2 Front View



2.3.3 Rear View



NOTE: external pressure supply at pneumatic models only.

3. Preparation and Operation

3.1 Preparation

3.1.1 Installation of the Deadweight Tester

- Place the Deadweight Tester on a rigid surface. Avoid an unsafe stand and vibrations. This could cause misreading of the measured values.
- If there is no air-conditioned room available, please place the Deadweight Tester not close to the heating system and not close to windows to avoid or minimize incident solar radiation and air flow.
- The bubble level indicator shows the right positioning of the Deadweight Tester. Please use the adjustable feet of the Deadweight Tester, the air bubble must be centered.
- At pneumatic operated models, an external pressure source must be connected, at least for pressures higher than 10-20 bar.
  IMPORTANT: The external pressure source may not exceed 110% of the Deadweight Tester Piston Range. Please use dry and clean gases (free of particles), e.g. Nitrogen 4.0 or synthetic air.
- At hydraulic operated models, please check wether the oil reservoir is filled with appr. 200-250 ml special oil (ST 55) which is supplied with the Deadweight Tester (1 Litre bottle). Do never use other fluids for operation.
- Attach the handle (placed in the cover) to the spindle pump.
- We recommend to turn the spindle pump fully anti-clockwise, before you start the operation of the Deadweight Tester. This enables enough volume also for higher pressure values. For this operation please open the outlet-valve.

3.1.2 Mounting the Piston-/Cylinder-System

- If you have several piston-/cylinder-units, select the suitable one (depends on the requested pressure range).
- ATTENTION: Make sure that the complete system is NOT pressurised before you dismount the blanking plug (open the outlet valve).
- Open the protection-box of the piston-/cylinder-unit, handle it with care!
- **Check wether the O-ring (4 x 2.2) is in well condition and placed well at the right place.**
- Place the piston-/cylinder-unit vertically in the bayonet type quick-release device.
  NOTE: Never interchange pneumatic and hydraulic piston-/cylinder-units.
- Turn the wing bolt clockwise (appr. 1/2 turn). Do not use any tools. The system is pressure-tight.

3.1.3 Mounting an Unit under Test

- Make sure, that at the test station the right thread adapter is placed (standard: 1/2" BSP). Screw the unit under test in the test station with the knurled nut, without using any tools (self-tightened).
- Check wether the O-ring (8 x 2) is in well condition and placed well at the right place.
- Further thread adapters for the test station are available on request (single or as complete set).

Now, the Deadweight Tester is ready for use.

3.2 Operation

3.2.1 Placing of weights (masses)

The Deadweight Tester is supplied with a complete set of calibrated weights, including a bell-shaped weight for use at higher pressures.

- Place the weights (masses) which corresponds to the requested pressure (see certificate) on the piston resp. the weight-bell. Start with the largest ones and place the smaller ones on top to get a low balance point.
  HINT: The weights should be fingered with cotton gloves.
- All pieces of weights are marked with a number, corresponding to the supplied calibration certificate and the serial number of instrument.
- The reached pressure is equal to the sum of the pieces of weights (and piston).
- For an easy calculation of needed weights we suggest to use our optional “Intelligent Kalibration Module IKM”.

3.2.2a Reaching a requested check point (hydraulic operated models)

- See 3.1.1 for filling the system with the special oil ST55 (supplied).
- For priming, use the manual priming pump several times until max. 50 bar are reached (see built-in pressure gauge).
- Now turn the spindle pump clock-wise until the check point is reached, the piston starts floating up. With a little flair you can adjust the check point very sensitive.

3.2.2b Reaching a requested check point (pneumatic operated models)

- With the built-in prime pump you can reach up to appr. 20 bar.
- For higher pressures you need an external pressure source (max. 110% of full scale pressure of the mounted piston-/cylinder-unit. Use the inlet-valve and the outlet-valve for the adjustment.
- Use the spindle pump to make the fine adjustment of the check point.

3.2.3 Pressure check point stable

- Turn the spindle pump sensitive clockwise to increase the pressure until there is a balance between pressure and the placed weights. The stack of weights is floating, the right level you can check looking into the mirror located in the ground plate of the deadweight tester.
  ATTENTION: Short before reaching the balance point there might be a faster movement. Turn the spindle slow and sensitive.
- When the check point (balance point) is reached and the stack of weights is floating at the right level, initiate the weights with your hand to let them rotate (not too fast) clockwise.
- The piston (and this means, the pressure) remains stable for several minutes. Use this time to read the value from your unit under test, make adjustments at your unit under test etc.

3.2.4 Next check point (pressure step)

- To adjust the next higher pressure check point follow the above mentioned precedure (3.2.1 to 3.2.3), after you placed the additional needed pieces of weights on the stack.

3.2.5a Relief pressure (lower check point, hydraulic operated models)

- Take pieces of weights from the stack, that the remaining weights correspond to the requested (lower) pressure.
- Turn the spindle pump anti-clockwise (sensitive!) to adjust the requested check point.
- For a faster decrase, open very sensitive the outlet-valve. In this way you can also vent the complete system.

3.2.5b Relief pressure (lower check point, pneumatic operated models)

- Take pieces of weights from the stack, that the remaining weights correspond to the requested (lower) pressure.
- Open very sensitive the outlet-valve to vent the system smoothly.
- Make the fine adjustment turning the spindle pump anti-clockwise.
  ATTENTION: short before reaching the balanced position, the piston goes down a bit faster.

3.3 Finishing

- After you have finished your calibration with the Deadweight Tester close the inlet-valve (pneumatic models only) and open the outlet-valve.
- Dismount your unit under test opening the knurlet nut from the test station.
- If you have to make further calibrations with the mounted piston-/cylinder-unit you can let it be mounted. Otherwise we recommend to dismount the piston-/cylinder-unit. Turn the wing bolt appr. 1/2 turn anti-clockwise, retain the piston-/cylinder-unit and place it in the supplied protection box.

4. Trouble Shooting

Fault description	Possible cause and how to solve it
No pressure build-up possible, leakage in the system	• Outlet-vent not fully closed. ATTENTION: This valve may be tightened by hand only. • Check whether the gaskets (O-rings) at the test station (8 x 2) and at the quick-fit connection of the piston-/cylinder-unit (4 x 2.2) are in well condition. Replace if necessary.
Piston is not rotating after smoothly initiating by hand, or is insensitive	• ATTENTION: If the piston is not smooth rotating, or is “squeaking”, do not turn it with force. Otherwise you may damage it. • The piston must be cleaned. (see chapter 5.1.1)

5. Maintenance and Service

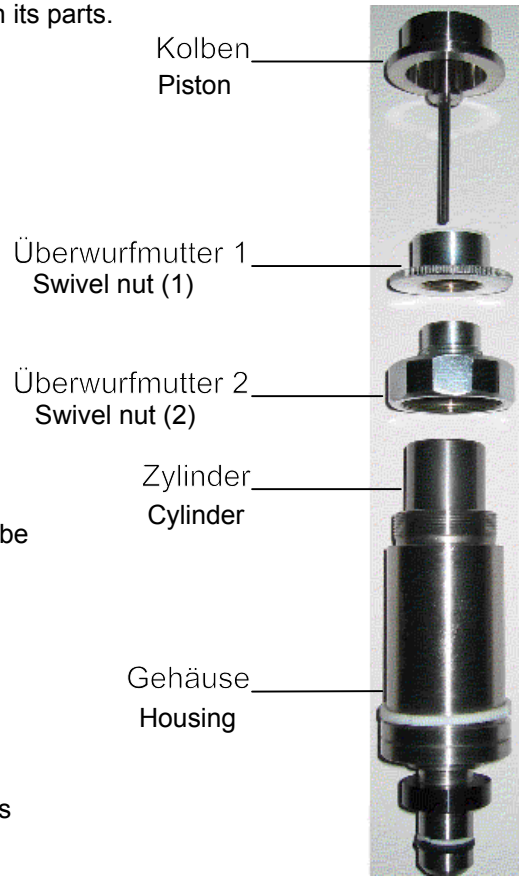
5.1 Cleaning

5.1.1 Piston-/cylinder-system

Depending on the usage, it is recommended to clean the piston-/cylinder-system from time to time. The need is indicated by no smooth rotation and insensitivity.

For cleaning the piston-/cylinder-system must be demounted in its parts.

- Release the lateral screws at the swivel nut (1)
- Detach the swivel nut (1) completely
- Now the piston must be moved vertical upward out of the cylinder, very careful and slow.
- For this, we suggest to place the piston-/cylinder-system on a plain table and keep it calm.
- At hydraulic systems, also the swivel nut (2) must be detached.
- Now the cylinder can be extracted.



Assembly of the piston-/cylinder-system

For the cleaning of the parts we suggest:
Do not touch the piston surface with your fingers!

- Put the piston with your thumb and your forefinger at the most upper part of the piston. The outside surface may not be touched with your fingers.
- Wash the piston with fluent lukewarm water.
  Dry the piston with a clean, dust-free and lint-free cloth.
- If you want you may dry the piston with absolute clean and dry compressed air (free of oil!)

Afterwards, assemble the piston into the cylinder:

- Place the cylinder into the housing (the beveled edge shows to the bottom)
- Mount the swivel nut
  (at hydraulic systems mount both swivel nuts, take care for the right order)
- Place the system vertical on a plain table and insert the piston from top carefully into the cylinder. Because of its dead load this should happen very easy.
- Tighten the lateral screws at the swivel nut (1).

5.1.2 Weights (set of masses)

- Handle the weights with clean gloves only.
- If necessary, clean the weights with pure alcohol (spirit).

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5.2 Recalibration

The recommended cycle for re-calibration is 5 years. This is a recommendation of the DKD (Deutscher Kalibrier-Dienst / German Calibration Service), assumed that you take care in operating and handling of the Deadweight Tester and the weights.
Rude conditions (dirty or dammaged weights) should result in shorter re-calibration cycles, e.g. 3 years or 12 months.

As a result of a recalibration you can get a traceable factory calibration certificate or a DKD certificate. Please contact

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6. Types (overview) and Accessories

6.1 Types (overview) / available pressure ranges

Range in bar	Execution	needed masses in kg	Accuracy 1) in % of reading	Smallest pressure step
0,03...2	**Pneumatic** (suitable for clean dry air or nitrogen - other on request)	10	**0,015** 1) The accuracy is characterised by the deviation span, which is the sum of the systematic error and the uncertainties of measurement. Long-term stability is not taken into account. Please note that corrections might be required, if the instrument is used without the Intelligent Kalibration Module IKM. As an option, an accuracy ±0.010% is available.	0.01 bar
0,2...10		10		0.05 bar
0,4...50		10		0.25 bar
0,4...100		20		0.25 bar
0,2...60	**Hydraulic** (suitable for special oil , included in standard supply - other media on request)	30		0.1 bar
0,2...100		50		0.1 bar
5...250		25		0.4 bar
5...400		40		1 bar
5...600		30		1 bar
5...1000		50		1 bar
25...2500		50	**0.025** (optional: 0.025	
25...4000		80		

*) without optional trim masses

6.2 Optional Accessories

6.2.1 Intelligent Kalibration Module Type IKM:

Especially when highly accurate measuring values with uncertainties of measurement of less than 0.025 % are required, complicated mathematic calculations and corrections used to be necessary. With this optional addition to the system all critical ambient parameters are registered and automatically corrected. Furthermore a calibrator function for pressure transmitters is integrated, so that a voltage can be supplied to the sensors and sensor output signals can be measured without any problem. No additional devices are required for that purpose.

6.2.2 Other optional accessories:

- Set of trim masses (weights 1 mg to 50 g)
- Oxytester: The purifier has been specially conceived for measuring instruments where the filling medium should not come into contact with the pressure balance. It is typically used with pneumatic pressure balances for the calibration of instruments with the test media water and oil.
- Dirt trap: For test objects that are very dirty the use of a dirt trap is recommended in order to avoid the penetration of dirt particles into the deadweight tester.
- Set of adapters in a tool case: As a standard the pressure balance is equipped with a clamp for the adaptation of the test object. For this purpose various threaded adapters, which can be easily exchanged, are available. The set of adapters includes the five most commonly used threaded adapters as well as a spanner, flats 32 and flats 14, for exchanging the adapters.