WIKA Instruments India Pvt. Ltd.

Calibration Laboratory for pressure measurement

C - 0133

Calibration Certificate

Calibration mark: WD14-010 / 2014-03

Object	**Dead weight tester**
Manufacturer	**Pressurements**
Type	**M2800/I**
Serial number	**11283-98**
Customer	**Internal Calibration** **WIKA INDIA** **CALIBRATION LABORATORY**
Order No.	**Internal**
Number of pages of the certificate	**8 pages + enclosure**
Date of calibration	**11-Mar-14**

This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).

The user is obliged to have the object recalibrated at appropriate intervals.

This calibration Certificate may be reproduced other than in full except the permission of the NABL ant the issusing laboratory.

Calibration Certificate without signatures and seal are not valid.

The results in this certificate only relate to the object stated.

Recommanded Cal.Frequency for object-5 Years

Seal	Date	Calibrated by	For Head of Cal. Laboratory
WIKA INSTRUMENTS INDIA PVT. LTD. NABL C-0133	11/ March 2014	V.Patil	Kshirsagar

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Object (DUT)

Deadweight-tester

Serial- No.	**11283-98**	
Pressure range	**0.20bar...1100bar**	
Accuracy according to the manufacturer	**0.015**	%

Number of piston- cylinder systems **2**

Pressure range from [bar]	10	0.2	
Pressure range until [bar]	1000	55	
Piston - cylindersystem	L519	L360	
Material piston	Steel	Steel	
Material cylinder	Steel	Steel	

Weight - set

-Serial - No.:	**11283-98**
-Number of weights:	**20**
-Material of the weights:	**SS**

Stroke of the piston **15**

Pressure reference level

Horizontal level which pass through the level of the lower edge of the piston in measuring position.

Float position of piston

The measuring position of the piston is at the half stroke.

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Reference

Name	**Model-CPB5000,Range- 0.2/1000 bar, Validity- 13/09/16**
CalibrationNo.	**A4553, Accuracy-0.008% rdg,serial number-2116 & 3136**

Calibration conditions

Pressure media for calibration	**ST25**	*with* $\rho_{20°C}$ =	870.00
Temperature of the piston- cylindersystem in °C	**22.66**		**+/- 0.05**

Ambient conditions

Place	**Laboratory**	
local gravity in m/s²	**9.783667**	

Mass determination

Room temperature in °C	**22.70**	**+/- 1**
Ambient pressure in mbar	**944.30**	**+/- 1**

Area determination

Room temperature in °C	**22.30**	**+/- 1**
Ambient pressure in mbar	**944.40**	**+/- 1**

Calibration process

For the calibration are used the following norms:

-Guideline EA-4/17 "Calibration of pressure balance", July 1997
-Guideline EAL-R2 "Expression of the uncertainty of measurement in calibration", December 1999

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Results

For the effective area A_0 at overpressure p_e=0 and at the temperature 20°C following values for the temperature coefficients ($\alpha+\beta$) and for the distortion coefficient λ of the piston-cylinder-systems are detected:

Pressure range from [bar]	10	0.2	
Pressure range until [bar]	1000	55	
Piston - cylindersystem	L519	L360	
Effective area A_0 in m²	4.033237E-06 +/- 1.553737E-10	8.069638E-05 +/- 2.565848E-09	
TC ($\alpha+\beta$) in K^{-1}	2.2E-05 +/- 1E-06	2.2E-05 +/- 1E-06	
Distortion coefficient λ in Pa^{-1}	3.974361E-12 +/- 5.961542E-13	0,000E+00 +/- 0,000E+00	

Following values are measured about the measuring system:

Measuring system	Pressure [bar]	Sinkrate [mm/min]	Pressure [bar]	Free rotation time [min]
L519	1000	1	200	5
L360	55	1	11	5

All values are valid, if the piston is floating and rotating in measurement position.

The reported uncertainty values for the effective area and for the mass values accord to the expanded uncertainty,which is the standard uncertainty multiplied with the coverage factor k=2.
The uncertainty is determined according to EA 10/03.
The values are in this range with a coverage propability of 95%.
These values do not cover the long-term stability.

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Further results

True mass of the weights:

	Mass name	Mass No.	True Mass in kg	Density in kg/m³	Expanded uncertainty in mg
	Bell	Bell	0.389293	7960	2.50
*1)	Piston	L519	0.023310	7960	0.30
*1)	Piston	L360	0.169740	7960	1.00
	Mass	11283-98 No.1	4.124054	7960	25.00
	Mass	11283-98 No.2	4.124054	7960	25.00
	Mass	11283-98 No.3	4.124054	7960	25.00
	Mass	11283-98 No.4	4.124054	7960	25.00
	Mass	11283-98 No.5	4.124054	7960	25.00
	Mass	11283-98 No.6	4.124054	7960	25.00
	Mass	11283-98 No.7	4.124054	7960	25.00
	Mass	11283-98 No.8	4.124054	7960	25.00
	Mass	11283-98 No.9	4.124054	7960	25.00
	Mass	11283-98 No.10	4.124054	7960	25.00
	Mass	11283-98 No.11	2.061977	7960	25.00
	Mass	11283-98 No.12	0.412386	7960	2.50
	Mass	11283-98 No.13	0.412393	7960	2.50
	Mass	11283-98 No.14	0.412398	7960	2.50
	Mass	11283-98 No.15	0.412389	7960	2.50
	Mass	11283-98 No.16	0.206195	7960	2.50
	Mass	11283-98 No.17	0.041240	7960	0.30
	Mass	11283-98 No.18	0.041242	7960	0.30
	Mass	11283-98 No.19	0.041239	7960	0.30
	Mass	11283-98 No.20	0.041237	7960	0.30

*1) Consideration of hollow volume, boost volume and surface tension

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Calculation of the values for a deadweight-tester

The measured overpressures with the deadweight-tester at the reference level can be calculated in the unit bar with the following numerical equation. The overpressure is with the using of the already defined symbols and the values in the denoted unit:

$$p_e = g_n \cdot \frac{\sum m_i \cdot (1 - \frac{\rho_L}{\rho})}{A(p_e, t)} \cdot 10^{-5}$$

Thereby is g_n the local gravity in m/s².

$\Sigma mi(1-\rho_L/\rho)$ is the total mass of piston, bell and all masses corrected by air-bouancy.

$A(p_e,t)$ is the effective area at the overpressure p_e in bar and at a divergent measuring temperature to 20°C:

$$A(p_e,t) = A_0[1 + (\alpha + \beta) \cdot (t - 20°C) + \lambda p_e]$$

Middle values of overpressure can be displayed by adding trim masses with known density.

The overpressure p_e can also be calculated by the sum of the overpressure (see table) for the used piston,bell and all masses multiplied with the factor

$$\frac{g}{g_n} \cdot \frac{1}{1 + (\alpha + \beta) \cdot (t - 20) + \lambda \cdot p_e}$$

Thereby is t the measuring-temperature in °C at the piston-cylindersystem.

For the reference level of the DUT the pressure difference to the piston-lower-edge must be considered, if needed.

For detailled information: enclosure 2

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Expanded uncertainty

Denoted is the expanded uncertainty, which is calculated out of the standard uncertainty by multiplying with the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of 95%.The values are calculated according to ***DKD- 3***.

Piston L519

Uncertainty	**0.01**	**% of reading**
At least:	**4**	**mbar**

Piston L360

Uncertainty	**0.01**	**% of reading**
At least:	**0.40000001**	**mbar**

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Label

The basement of the deadweight-tester is labeled with a calibration mark, which shows the NABL-sign.
All masses are additionally labeled with their own, consecutively numbers.

More helpinformation for the effective application of a deadweight-tester

In the enclosure 1 choosen pressure values are calculated .
(valid for t=20°C and for the local gravity)

Enclosure 2 shows the corrections
for using the dead-weight tester not under reference- conditions.

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Pressure values of the masses under reference conditions:

Mass Name	Mass No.	Pressure value for system 1000 bar	Pressure value for system 55 bar	
		in bar	*in bar*	
Piston	L519	0.565528		
Piston	L360		0.206256	
Piston	Bell	9.463972		
Mass	1	100.262028	5.011257	
Mass	2	100.262028	5.011257	
Mass	3	100.262028	5.011257	
Mass	4	100.262028	5.011257	
Mass	5	100.262028	5.011257	
Mass	6	100.262028	5.011257	
Mass	7	100.262028	5.011257	
Mass	8	100.262028	5.011257	
Mass	9	100.262028	5.011257	
Mass	10	100.262028	5.011257	
Mass	11	50.129794	2.505568	
Mass	12	10.025740	0.501103	
Mass	13	10.025909	0.501111	
Mass	14	10.026031	0.501117	
Mass	15	10.025813	0.501106	
Mass	16	5.012906	0.250553	
Mass	17	1.002596	0.050111	
Mass	18	1.002644	0.050114	
Mass	19	1.002571	0.050110	
Mass	20	1.002523	0.050108	
	Calculation with g= 9.80665 m/s²			

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Notes for the application of a deadweight-tester

If the conditions like in the calibration certificate cannot be kept, then the pressure values must be corrected.

Deviation from the reference level

Is there a significant height difference between the reference level of the reference and the device under test, a pressure correction must be calculated due to the additional static pressure.

$$p_h = -g \cdot (\rho_m - \rho_l) \cdot (h'-h)$$

Thereby are:

p_h	Correction due to height differences
g	Gravity
ρ_m	Density of the media, for gases apply

$$\rho(p, t) = \rho(p_0, t_0) \cdot \frac{p_{abs} \cdot 297{,}15\,K}{1\,bar \cdot (273{,}15 + t)}$$

Thereby are:

$\rho(p_0,t_0)$ the density of the gas under standard conditions (p_0=1013 mbar, t_0=0°C)

	for nitrogen:	1,255 kg / m³
	for air:	1,293 kg / m³
t	the temperature of the gas	
p_{abs}	the absolute pressure of the gas	
ρ_l	air density	
(h'-h)	Height difference between the reference level of the reference and the device under test	

Attention:

The hydrostatic pressure will be added to the reference pressure,if the reference level of the reference is higher than the device under test.The pressure will be subtract, if the reference level is lower than the reference´s.

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then the pressure values must be corrected.

Deviation from the reference temperature 20°C

If the pressure should be calculated for a temperature different 20°C,
a correction factor must be added to the overpressure of the loaded masses.

$$p_\delta = -(\alpha + \beta) \cdot (t - t_{20}) \cdot p_{20}$$

Thereby are:

$p\delta$	Correction due to temperature differences
$\alpha+\beta$	Temperature coefficient of the piston-cylinder system
t	Temperature of the measuring system
t_{20}	Reference temperature 20°C
p_{20}	Pressure value according to the certificate

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