Operating manual for oil deadweight tester 0.015% accuracy

ODWT15

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1 introduction

1.1 general product description

The model ODWT15 Pressure Standard is an oil operated deadweight tester used for calibrating test gauges, transducers and transmitters. The system consists of the following main components :

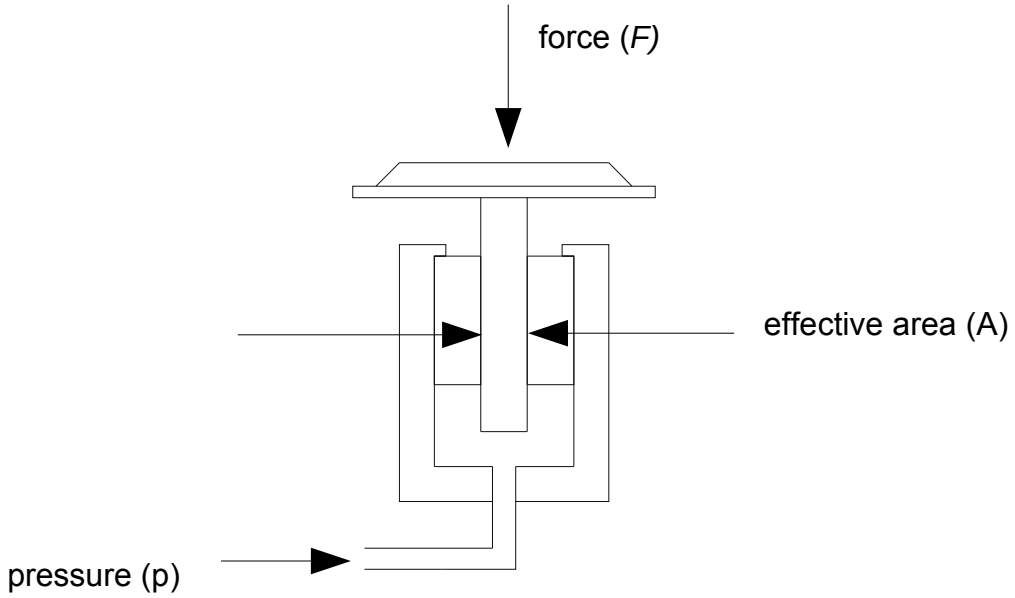
deadweight tester platform	1
piston cylinder assembly	Tungsten carbide, built in
mass set	1 set
pressure control	manually oil operated variable volume

The oil lubricated / oil operated pistons of the ODWT15 series are specially designed to have superior performance and a high range ability.

1.2 operating principle

The primary function of the deadweight tester is to combine two primary metro logical quantities:

1. the piston-cylinder which defines an effective area, *A*.
2. the masses, value *m*, which press on the piston with a force F.

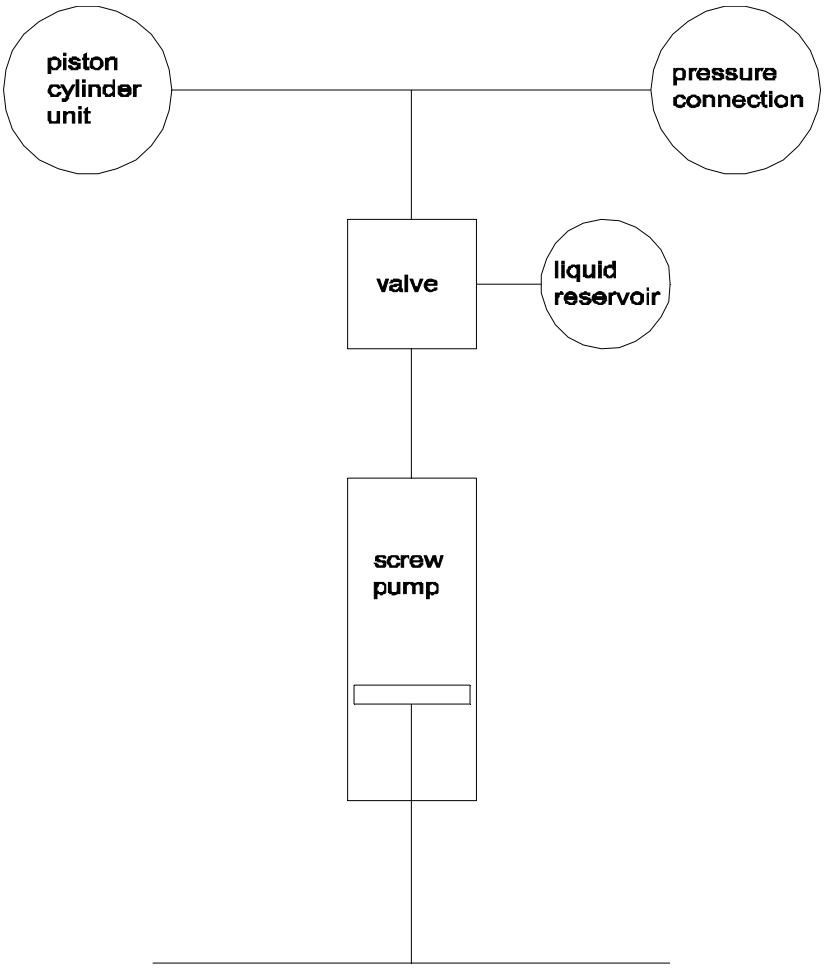


2 general specifications

measurement uncertainty p*	$1.5 \cdot 10^{-4} \cdot p_e$ (of reading)	
certification	standard delivered with company certificate (***EA***[1] traceable)	
pressure connection	3/8" BSP LH	with BSP adapters
footprint base plate	340 (w) x 225 (d)	mm
maximum size	340 (w) x 430 (d)	mm
overall height (excl. weights)	220	mm
overall height (incl. weights)	Max. 450 (depending on range)	mm
pressure media oil	DWT oil Miglyol 812N	Sasol

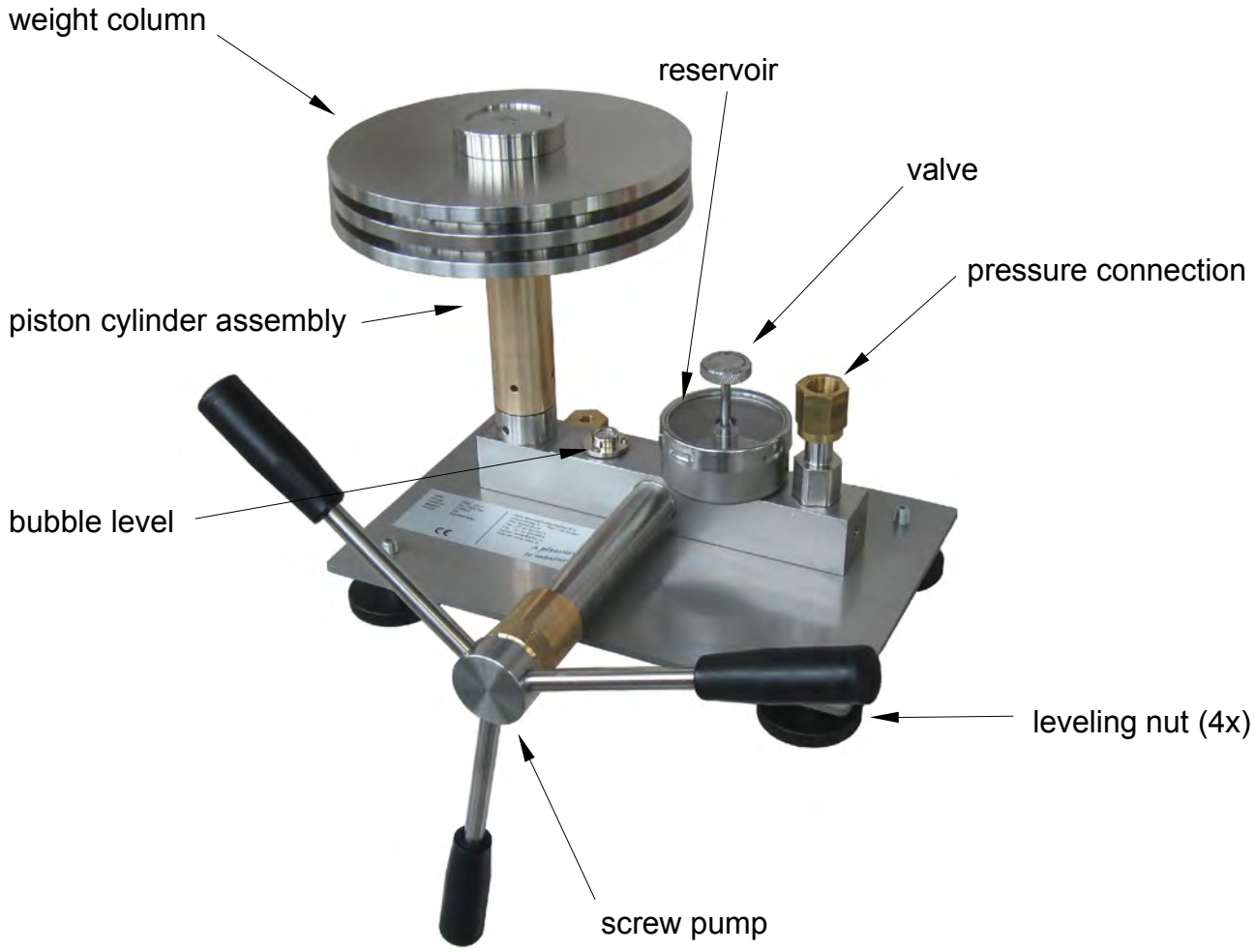
* when using the formula of chapter 4.2.

2.1 hydraulic scheme

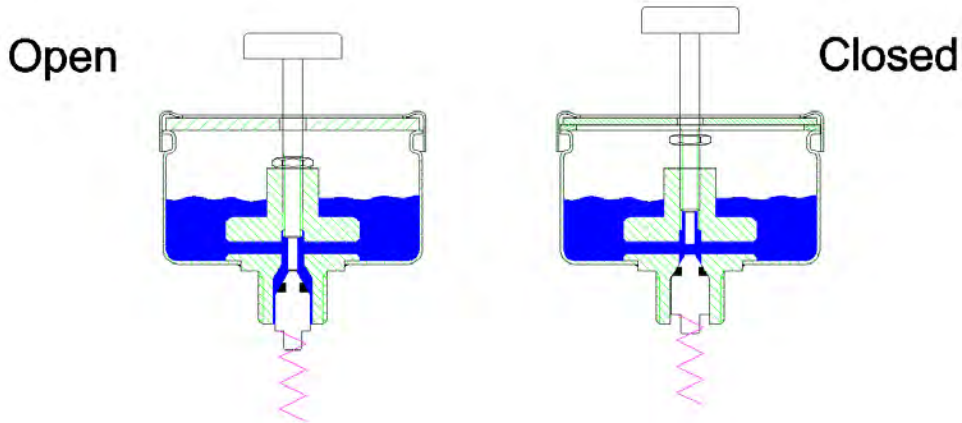


1 European Accreditation, see http://www.european-accreditation.org

2.2 instrument outline



2.3 vent valve



Only open the valve when the pressure is below 5 bar.

3 installation

3.1 site requirements

The ODWT15 is delivered with a mounting plate which is designed to contain the platform and variable volume pump. BSP adapters are also included in the scope of delivery.

- The room in which the instrument is placed should have proper founding, no vibrations are allowed during operation of the ODWT15 as this results in unpredictable errors.
- The ODWT15 should be placed on a rugged table which is rated for at least 140 kg without deforming. The table should be horizontally leveled. The ODWT15 can be places on the table without fixation. Or can be fit the a table using the extra set of leveling nuts. Use the stencil to mark the screw holes.
- Air movement around the ODWT15 should be avoided.
- Room temperature needs to be stable between 18 … 22°C during the time the ODWT15 is used to avoid uncertainties due to the thermal expansion coefficients of the piston cylinder and adiabatic effects in the measuring system.

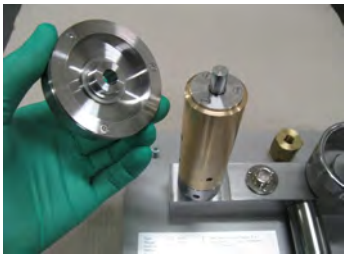
3.2 filling up

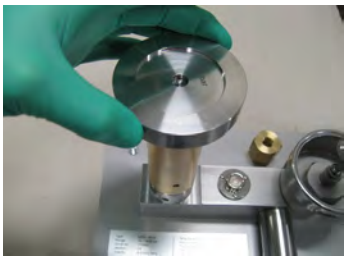
Before connecting any external device it is good practice to fill up the ODWT15 first.

make sure there is sufficient liquid (Miglyol 812N oil) in the reservoir

1. open the valve (clockwise, till its mechanical stop)
2. rotate the screw pump clockwise until it hits its end stop
3. block the pressure connection with a plug or a finger
4. rotate the screw pump anti clockwise until it hits its end stop (the pump is filled with liquid)
5. close the valve (anti clockwise, max 2 turns)
6. unplug the pressure connection
7. carefully operate the screw pump until the liquid level is at the sealing of the pressure connection
8. mount the pressure instrument (instrument under test)
9. carefully operate the screw pump (clockwise) up to maximum 5 bar
10. carefully open the valve, the pressure will be reduced and air will be pressed out
11. repeat step 10 and 11 until no air bubbles escape when the valve is opened
12. the deadweight tester is ready for use

Mount the table as shown below. It is not necessary to fasten it, it will tighten itself by the weights put on later.



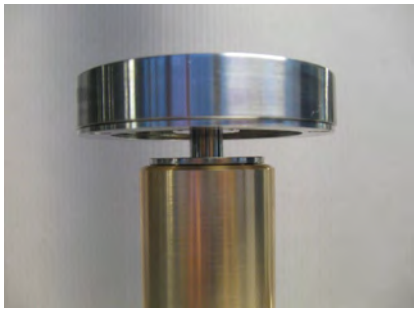


4 operating instruction

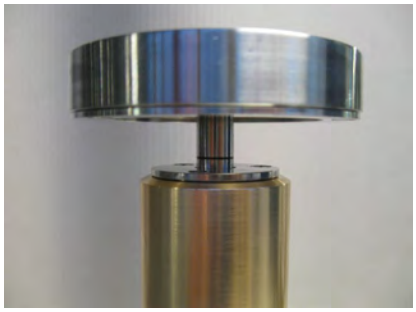
4.1 working instruction

1. before using the deadweight tester, check oil reservoir and if necessary fill up with Miglyol 812Noil (see chapter 3.2 for filling up)
2. place the instrument on a firm level base
3. check if the bubble level is in the center, if not: level the instrument with the leveling nuts
4. the instrument under test may be connected to the tester, using one of the adapters supplied
5. the correct number of weights to give the pressure desired may be placed on the piston cylinder
6. open isolation valve (clockwise, till its mechanical stop)
7. turn screw pump clockwise till end of its stroke
8. turn screw pump contra-clockwise till end of its stroke
9. close isolation valve (anti-clockwise, max. 2 turns)
10. turn screw pump slowly clockwise until the carrying table floats about 3mm higher than the pillar
11. rotate the weights and piston cylinder assembly clockwise
12. collect the readout of the instrument under test together with the mass load of the deadweight tester and file them
13. carefully change the mass load to realize the next pressure step
14. continue with 10
15. after the test, turn the screw pump contra clockwise until the piston has reached its end stroke and open the isolation valve
16. remove the weights and remove the pressure gauge

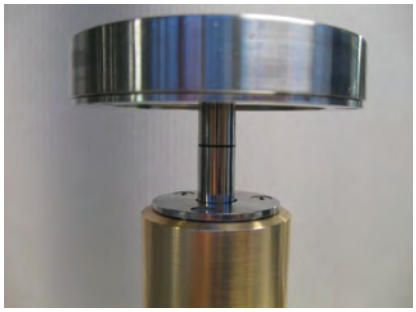
Piston in lower position



Piston starting to float



Piston in highest position



4.2 determine of the pressure

The reference level of the deadweight tester is at the top of the sealing of the pressure connection.

If the weight set is marked with a pressure unit (bar; psi or kg/cm²) the pressure can be determined by the formula:

$$p_e = (p_0 + \Sigma p_c) \cdot \frac{g_l}{g_n}$$

where	p_e *	:	Gauge pressure at reference level	[bar; psi; kg/cm²]
	p_0	:	Starting pressure piston + plate	[bar; psi; kg/cm²]
	Σp_c	:	Summarized pressure equivalent of the weights	[bar; psi; kg/cm²]
	g_l	:	Local gravity	[N/kg]
	g_n	:	Normal gravity (9.80665)	[N/kg]

* The value of the pressure p_e which puts the piston into equilibrium.

When using this formula the maximum error will not exceed 0.03% of reading. To reach the maximum accuracy of 0.015% of reading the following formula has to be used:

$$p_e = \left(\frac{m_c \cdot (1 - \rho_a / \rho_m) \cdot g_l + \pi \cdot T \cdot d}{A_0 \cdot (1 + \lambda \cdot p) \cdot (1 + (\alpha_p + \alpha_c) \cdot (t - 20))} - \rho_{oil} \cdot g_l \cdot h \right) \cdot 10^{-6} \quad [MPa]$$

p_e *	:	gauge pressure at reference level		[MPa]
m_c	:	conventional mass		[kg]
$1 - \rho_a / \rho_m$	:	air buoyancy correction	(= 0,99985)	[-]
g_l	:	local gravity		[N/kg]
A_0	:	effective area at zero pressure		[m²]
T	:	surfase tension of Miglyol 812N oil	0.031	[N/m]
d	:	diameter piston low: ≤140 bar (2000 psi) :	0.0071	
		medium: ≥150 bar (3000 psi) ; ≤700 bar (10000 psi) :	0.0032	[m]
		high: ≥700 bar (10000psi) :	0.00225	
λ	:	pressure distortion coefficient piston + cylinder		[MPa^{-1}]
p	:	nominal line pressure		[MPa
$\alpha_p + \alpha_c$	:	thermal expansion coefficient piston + cylinder	(= 9.0 .10^{-6})	[1/°C]
t	:	piston temperature		[°C]
ρ_{oil}	:	specific weight Miglyol 812N	950	[kg/m²]
h	:	height difference between the seal of the pressure connection (reference level) and the position of the bottom of the piston in mid floating situation		[m]

* The value of the pressure p_e which puts the piston into equilibrium.

The conventional masses m_c, the coefficient λ, the effective area A_0 and the height difference between the seal of the pressure connection (reference level) and the position of the bottom of the piston in mid floating situation are listed in the calibration certificate.

5 maintenance

The entire tester should be kept clean as dirt and grit will cause rapid wear.

As instruments to be tested come from an unknown process it is likely that the inside of the instrument is contaminated, this will in time contaminate the inside of the deadweight tester.

To guarantee the performance of the deadweight tester it is good practice to change the Miglyol 812N oil once a year (dependent on the use and local conditions).

In case of poor running performance it is possible to clean the piston and guidance piston. Disassemble the bronze cylindrical part. When taking off the bronze part take hold off the guidance piston else it could fall. Clean the measuring piston/cylinder, bearings, guidance piston and bushing with Loc-tite 7063. Grease the piston and guidance piston with a little Miglyol 812N oil.

Mount the cylinder and close the oil reservoir valve and turn the hand pump clockwise until oil comes out of the cylinder. Put the measuring piston in the cylinder and move the piston up an down several times to spread the oil. Assemble the bronze part with the guidance piston and move the piston up an down several times to spread the oil. Mount the table as shown in chapter 3.2

5.1 changing the liquid

1. open the valve
2. rotate the screw pump clockwise until it hits its end stop
3. take out the liquid
4. blow through the pressure connection with low pressure air
5. clean the reservoir
6. see chapter 3.2 purging

5.2 recalibration

Although the ODWT15 is designed to have a very good long term stability, a first recalibration at 2 years after purchase is recommended both for piston cylinder and mass set. The results of the recalibration can be used as a guideline for future recalibration. Depending on the environment and frequency of use a recalibration interval of 2 to 5 years is normal.

6 parts list

Part	Code	Qty.	Remark
Base plate	340 x 225 mm	1	
Piston cylinder assembly		1	Including start weight
Oil hand pump		1	16 mm piston
U-cup	Merkel T20 8-16-5.7 1	1	In piston of oil pump
Back-up ring	041-959-01 PTFE	1	In piston of oil pump for U-cup
Multi seal under cylinder	Ø10,35x16 x2	1	Mounting of cylinder
Bearings (degreased)*	Ø21xØ12 x 5	2	For guidance piston
Bearing	Ø9.5 x Ø5.2 x 1.2	1	Under measuring piston
Oil reservoir and valve		1	
O-ring in valve	Ø5.23x2.62 mm 90° shore	1	
Leveling nut	M10 x 55 mm	4	For base plate
Fixed level nut	M10 x 55 mm	4	For base plate
O-ring	Ø23 x 2,4 mm 90° shore NBR	1	For mounting oil reservoir
O-ring	Ø15,88 x 2,62 mm 90° shore NBR	1	For mounting hand pump
O-ring	Ø18,6 x 2,4 mm 90° shore NBR	3	For mounting pressure connections
Adapter 1/2” bsp	027-411-26	1	
Adapter 3/8” bsp	027-411-14	1	
Adapter 1/4” bsp	027-411-25	1	
Adapter 1/8” bsp	027-411-15	1	
Multi seal	065-260-09	2	Ø13,2 x 6,9 x 1,3 mm, for adapters
Certificate		1	Traceble to European standard
Weight box		1...3	for weight set
Deadweight tester oil	Miglyol 812N	0.5 ltr.	Sasol

* only for mid and high piston-cilinder.

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