

# [Calibrating a pressure gauge using an air-operated dead-weight pressure gauge tes...](https://assignbuster.com/calibrating-a-pressure-gauge-using-an-air-operated-dead-weight-pressure-gauge-tester-for-air-gauges/)

[Environment](https://assignbuster.com/essay-subjects/environment/), [Air](https://assignbuster.com/essay-subjects/environment/air/)

### INTRODUCTION:

Calibrationis the set of operations that establish the relationship between the values of quantities indicated by a measuring instrument and the corresponding values realized by standards. The result of a calibration allows for the determination of corrections to be made with regards to the indicated values. It may also help in determining other metrological properties such as the effect of influence quantities.

The results of a calibration are usually documented and referred to as calibration certificate or a calibration report. Necessary adjustments are made to the instrument after calibration so that it always indicates readings corresponding to given values of the quantity measured.

When the instrument is made to give a null indication corresponding to a null value of the quantity to be measured, the set of operation is called zero adjustment .

### The Calibration Process

The first thing to consider in calibrating an instrument is its design. In order to be able to calibrate an instrument, the design of the instrument has to be capable of measurements that are " withinengineering tolerance" when used within certain conditions and over a reasonable period of time.

The criteria used for assigning tolerance values vary according to regions and according to type of industry. Manufacturers of instruments assign a general measurement tolerance and suggest the calibration interval as well as the optimum environment for use and storage of the instrument. The user of the instrument on the other hand assigns the actual calibration interval, on the instrument's likely usage level. For example, if a manufacturer states that an instrument needs to be calibrated after usage for 8-12 hours of use 5 days per week is six months, that same instrument in 24/7 usage would generally get a shorter interval. The assignment of calibration intervals can be a formal process based on the results of previous calibrations.

### Calibration process versus cost

Generally, the process of calibrating an instrument is a difficult and expensive one. As a rule of thumb, the cost for ordinary equipment support is generally about 10% of the purchasing cost of the instrument on a yearly basis. Exotic devices such asscanning electron microscopes, gas chromatographsystems andlaserinterferometerdevices can be even more expensive to calibrate.

When the instruments being calibrated are integrated with computers, the integrated computer programs and any calibration corrections are also under control.

### The calibration paradox

Successful calibration has to be consistent and systematic. At the same time, the complexity of some instruments requires that only key functions be identified and calibrated. Under those conditions, a degree of randomness is needed to find unexpected deficiencies. Even the most routine calibration requires a willingness to investigate any unexpected observation.

Theoretically, anyone who can read and follow the directions of a calibration procedure can perform the work. It is recognizing and dealing with the exceptions that is the most challenging aspect of the work. This is where experience and judgement are called for and where most of the resources are consumed.

### THEORY

Principles of Operation Of Dead Weight Testers

Pressure is defined as force per unit area i. e.

P= F/A

F= M x g (product of mass and the acceleration acting on that mass)

This simple principle is used by Dead weight pressure testers to generate a very stable and accurate pressure. A series of weights are loaded on to a piston unit which is housed inside a cylinder. In principle, the components of the above equations are as follows:

A is the effective cross-sectional area of the piston unit

M is the mass of the weights loaded on top of the piston unit in addition to the mass of the piston unit itself.

g is the gravitational acceleration acting on the piston and mass set.

For example, if a piston of area A = in2 (0. 18cm2) weighing M = 12. 5lb (5. 67kg) is supported by a fluid in a cylinder, the pressure in the fluid is 12. 5lb= 100lb/in2 (7kg/cm2). The piston- cylinder and the weights are called a dead-weight balance.

The effective area of the piston and cylinder unit is an approximation of the average of the areas of the piston and of the cylinder. The performance of a tester depends largely on the accuracy with which the piston and cylinder are manufactured. These should be straight and round and have a good finish. They are usually made from hardened and stabilised tool steels, however, on the air operated type, high chromium steel is used to prevent corrosion. They are protected from high pressure such that the piston would not leave its cylinder and if the weights are supplied without air- pressure, the piston will not be in compression. The accuracy can be illustrated by stating that a variation of 0. 1Î¼m on the effective diameter of a piston/cylinder unit would result in an area charge of 63ppm.

The area of the piston-cylinder units are compared with NPL Standards. Two units can be compared by connecting them hydraulically (or on gas) under pressure; when they were in balance, the area say AD to be determined was found from the known area of an NPL unit say Ak, showing the weights applied to each say WD and Wk from the equation.

When instrument accuracies are calculated, allowance is made for the fact that effective area of the piston/cylinder unit increases with pressure. These is negligible on low pressure testers but becomes significant on testers such as type 380D (600 bar) and 380H (1200 bar). For the 4000 bar type the weights for equal increments of pressure are greater as the pressure increases up to 4000 bar and weight must be applied in the correct sequence. The accuracy certificate of a tester takes into account the buoyancy of the piston immersed in liquid.

When testing gauges on liquid it may also be necessary to allow for liquid head (1 cm corresponds to 1 mb). The datum levels of the hydraulic piston/cylinder units are marked with a groove on the outer diameter of the unit. The effect of heads could normally be ignored on air testers. The certificate also gives details of the corrections to be made for change in temperature of the unit from 20oC due to expansion of the piston/cylinder unit and also of corrections due to 'g' varying from standard gravity. The hydraulic testers can have accuracies of 0. 01% on 1/16 in2 piston/cylinder unit, 0. 015% on 1/80 in2 and 0. 02% on 1/160 in2 units.

### Apparatus:

1. A pressure gauge that could measure up to 100 lb/in2bar

2. A Budenberg an air-operated pressure gauge calibrator: Made with levelling screws at its base which is used to mount it on a bench, a 0. 5 square inch piston-cylinder unit, two control valves, one 0. 5 inch B. S. P gauge connection, some weights (each marked with corresponding pressures they exert).

### The apparatus can basically be divided into three elements:

- The piston and cylinder units

- The weights

- The testers.

### The Piston-Cylinder unit

The effective area of the piston and cylinder unit is an approximation of the average of the areas of the piston and of the cylinder and is 0. 5 in2. The weight exerted by the unit is 0. 1 kg/cm2 or 0. 1bar. The Piston-Cylinder unit is made from high chromium steel is used to prevent corrosion. It is also fitted with mechanical stops to prevent the piston leaving the cylinder housing if the applied pressure is excessive, and if the weights are supplied without air- pressure, the piston will not be in compression.

There is a small gap between the piston and the cylinder so that when the piston rotates in the cylinder the pressure medium forms a bearing eliminating friction and metallic contact; any viscous forces are circumferential and so do not act in a vertical direction and so do not affect the accuracy of the balance.

If the gap between the piston and the cylinder is too small, the piston will not rotate freely at low pressure long enough for a true balanced pressure to be attained. If the gap is too large, there will be a leakage between the two and the piston will fall in the cylinder. The piston will spin for a reasonable length of time at low pressure and will remain in its floating position for several minutes at high pressures.

### The Weights

The weights used are DH-Budenberg, manufactured from series 300 austenitic stainless steel, which makes them highly resistant to corrosion and magnetic permeability. They are marked with the nominal pressure value that they will generate (in bar) when used with the piston-cylinder unit they are designed for. These weights have been manufactured to specific set of tolerances and according to National (NPL) standards to give an accuracy of 0. 015% under all nominal conditions. They give the appropriate force when subjected to a gravitational acceleration of 9. 80665m/s2(International Standard, g) and in an air of density 1. 2 kg/m3.

### The Tester

This is the last element of the dead-weight tester. This unit is generally called the pneumatic dead weight tester base. It is the unit that generates the pressure which is then applied to the piston-cylinder unit and the instrument under calibration. It is supplied with an incoming port where a clean dry non-corrosive source of gas is connected. The type 240 air-operated tester has two valves: one valve to admit air from a H. P. supply to raise the pressure and one to release air to the atmosphere.

### PROCEDURE

1. The gauge to be calibrated was properly cleaned to remove any dirt or chemical contamination that could contaminate the tester. Using a bonded seal at the joint the Gauge was screwed on to the calibration equipment.

2. Using the conversion table given, (see table 2) the weight required in bar to test a pressure indicated by the gauge (the one being calibrated) was checked and the dead-weight piston was loaded with weight equivalent to the desired pressure less the pressure of the Piston-Cylinder unit. For example, when it was required to test the 10 lb/in2 reading on the gauge scale, the amount of weight required was 0. 69 bar (from the table). But the piston already weighed 0. 1 bar so this was subtracted from 0. 69 bar to get 0. 59 bar. So only 0. 59 bar of weight equivalent was loaded onto the piston.

3. Next, the left-hand valve which releases pressure from the tester was closed.

4. Then, to test for rising pressure, the right-hand valve which admits pressure to the tester was opened carefully. This admitted pressure into the tester and the rate of pressure rise was watched on the gauge under test. As the pressure approached the desired value to be tested, the weights were spun carefully, and as soon as the piston began to float half way between the two stops, the reading of the pressure gauge was taken. The release valve was opened and the admitting valve was closed.

5. Next, to test for falling pressure, the release valve was closed and the admitting valve was opened. As the pressure rose beyond the desired pressure, the admitting valve closed and the release valve was opened slowly to enable the pressure drop in the tester. As the pressure approached the required pressure, the weight was spun carefully and ss soon the piton began to float half way between the two stops, the reading on the gauge was taken. All the pressure was then released.

6. A new set of weights were loaded on the piston to test the next pressure reading. These steps were carried out for pressure readings of from 10 lb/in2 to 100 lb/in2 at intervals of 10 lb/in2. The readings obtained were tabulated in table 2.

### RESULTS

The results obtained were tabulated as in below

|  |  |  |
| --- | --- | --- |
| Pressure being tested (lbf/in2)  | Applied Load Minus 0. 1 (bar)  | Actual reading  |
| Up pressure (lbf/in2)  | Down Pressure (lbf/in2)  |
| 10  | 0. 69  | 10. 5  | 9. 50  |
| 20  | 1. 38  | 19. 50  | 19. 00  |
| 30  | 2. 07  | 29. 50  | 29. 00  |
| 40  | 2. 76  | 39. 00  | 39. 00  |
| 50  | 3. 45  | 49. 50  | 49. 00  |
| 60  | 4. 14  | 59. 50  | 59. 00  |
| 70  | 4. 83  | 69. 00  | 69. 00  |
| 80  | 5. 52  | 79. 00  | 78. 50  |
| 90  | 6. 21  | 89. 00  | 88. 50  |
| 100  | 6. 9  | 99. 00  | 99. 50  |

### Table 1 showing readings from calibration exercise.

### CONCLUSION

The calibration of the pressure gauge using a dead weight tester was carried out;

Based on the experimental results obtained a deviation in the calibrated reading was compared to the theoretical values. Therefore the pressure gauge on the downwards pressure was observed to be not appropriate for very low pressure levels; Especially when the supplied air pressure is low & incapable of lifting the applied load this can be express mathematically as:

Psa = W/Pd were W = Psa x Pd

W = weight/load

Pd = downwards pressure

Psa = supplied air pressure

Therefore applied load/weight is directly proportional to the obtainable pressure gauge calibration meter readings.

### Sources of Errors:

· Possible air leakage from the valves.

· Error due to parallax when reading the half way level mark.

· Possible pushing down on the piston while spinning the weight.

· Possible loss of pressure in the piston hydraulics.

### REFERENCE

1. N. E. Connor, Gas Quality Measuring Devices on Gas Measurement University of Salford, 1969

2. DH- Budenberg, An-Introduction-to-Dead-Weight-Testers @ http://www. scribd. com/doc/18933664 (25th Nov, 2009)

3. Wikipedia Encyclopaedia (www. wikipedia. com)

4. Practical Manual on pressure gauge calibration, 2009.