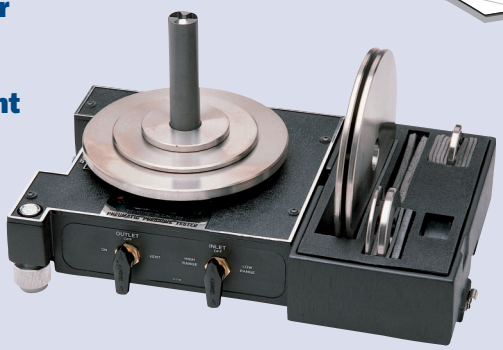
Engineer's Notebook

Improving Deadweight Tester Accuracy

The deadweight tester is a primary standard for pressure calibration. It produces pressure by exerting a force (the weights) over a known area (the piston). The accuracy of a deadweight tester is determined in large part by the precision of the weight set and the piston, but there are several sources of potential error. Understanding these errors and how to correct for them can greatly improve the accuracy of pressure calibrations.



Lets look at a sample calibration

We want to produce a pressure of 100 PSI using a tester with an accuracy specification of 0.05% of produced pressure. Any appropriate weight combination we use for this tester should produce a pressure of 100 PSI ± 0.05 PSI. Stated another way, the pressure produced will be between 99.95 and 100.05 PSI. We assume it to be 100.00.

Error source one: Weight combination

If we look at actual calibration data for this tester, we will see that depending on the weight combination used, we produce actual pressures of 99.96, 99.98, 100.01, and 100.02 PSI. This is normal and expected. To improve accuracy, use the actual weight values from the calibration certificate, rather than the nominal values stamped on the weights. By the way, if you compare accuracy specifications for testers, you will see they range from 0.1% to 0.015%, much based on the quality of the weights. Generally speaking, stainless steel weights can be machined with greater precision than cast weights. Your best testers will have stainless steel weights.

Error source two: Gravity variations

If you took a 100 PSI Deadweight tester to the moon, it would produce only about one sixth the pressure, thanks to lower gravity. By the same token, the pull of gravity varies around the world, and even based on elevation (what floor of a building is it used on). To improve accuracy, you must correct for local gravity.

Unless specified otherwise, a deadweight tester is calibrated to a standard gravity value, 980.665 gals. When used at some other gravity, the error may be significant. For example, a "standard" tester used at a location in Houston, TX will produce only 99.85 PSI instead of the 100PSI indicated-and this 0.15% error will be produced by even the best deadweight tester.

To eliminate this error you have a few choices:

1. When buying a new tester, order it calibrated to local gravity. This eliminates the error.
2. If you have a tester already, find your local gravity, and calculate corrected pressure values for each weight combination you use. To do this take the actual pressure values from your most recent DWT calibration, and multiply them by a correction factor (local gravity/standard gravity) If your local gravity is 979.276, the correction is (979.276/980.665) or 0.9985.

How do you find your local gravity?

Contact the US Geodetic Information Center in Rockville, MD at 301-713-3242. Provide the latitude and longitude in degrees, minutes, and seconds where the tester will be used. This can be found on a survey or topographic map. Also provide elevation if you are not at ground level. They will provide a gravity prediction at a nominal cost.

Other error sources

Dirty, corroded, or chipped weights will not provide accurate measurements. In addition, deadweight testers are position sensitive, they should always be leveled.

Properly used, a DW tester provides a primary reference for pressure calibration. But, if you use an uncorrected tester to calibrate other portable measuring devices (test gauges or digital calibrators for example), the error will be passed on to everything in the chain.

Deadweight Testers