P3000 Deadweight Tester Setup, Part 2: Full and Partial Correction Methods

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This tutorial is for configuring a P3000 series (Pressurements) deadweight tester to be used with COMPASS for Pressure software in the *Full* or *Partial Correction* methods. A similar tutorial addresses configuring the software for the *Limited Partial Correction* method of operation.

In short, the *Full Correction* method uses COMPASS for Pressure to calculate the fundamental pressure equation for a deadweight tester, thus treating it as a piston-gauge – solving for the effective area of the piston-cylinder and the sum of the force acting on it. In the *Partial Correction* method, a correction is applied for the temperature of the piston-cylinder and a local gravity correction.

The user should be familiar with the P3000 Series Uncertainty Analysis technical note 2170TN13 -- "Guide for the Uncertainty Analysis in Pressure when using P3000 Series Deadweight Testers".

http://us.flukecal.com/literature/articles-and-education/pressure-calibration/application-notes/guide-uncertainty-analysis-

The technical note defines several methods of operating a deadweight tester as a means to attain various levels of performance. The following three methods are described in 2170TN13: *Full Correction*, *Partial Correction*, and *No Correction*. Due to the structure of the COMPASS for Pressure Piston Gauge Calculator tool, a fourth term is introduced in Part 1 of this tutorial series -- "*Limited Partial Correction*".

Full Correction:

- The pressure is calculated for the influences of ambient conditions, piston-cylinder temperature, fluid head, and changes to the effective area of the piston due to deformation. This method is nearly identical to calculations required for a piston gauge.
- The P3000 device definitions are configured as a "Piston Gauge"
- This method is addressed in technical note 2170TN13.

Partial Correction:

- Corrections to the nominal pressure are limited to the temperature of the piston-cylinder, acceleration of local gravity, and DUT fluid head.
- The P3000 device definitions are configured as a "Piston Gauge"
- From an operations perspective with COMPASS for Pressure, there is not much difference between this and the *Full Correction* method other than not needing to update the ambient conditions.
- This method is addressed in technical note 2170TN13.

NOTE: Per technical note 2170TN13, the term *Partial Correction* is defined as correcting for local gravity and piston-cylinder temperature. In COMPASS, when the Platform Type selection is "Deadweight Tester", a correction for piston-cylinder temperature is not included. COMPASS limits the correction to local gravity (and fluid head) only. This is why the term *Limited Partial Correction* is used.

Limited Partial Correction:

- Only local gravity and a fluid head correction are applied.
- The P3000 device definitions are configured as a "Deadweight Tester".
- This term is not used in technical note 2170TN13.

No Correction:

- This method is referred to as "stack-and-spin" and does not require software. The nominal pressure values of the weights are summed together and represent the reference pressure.
- This method is addressed in technical note 2170TN13.

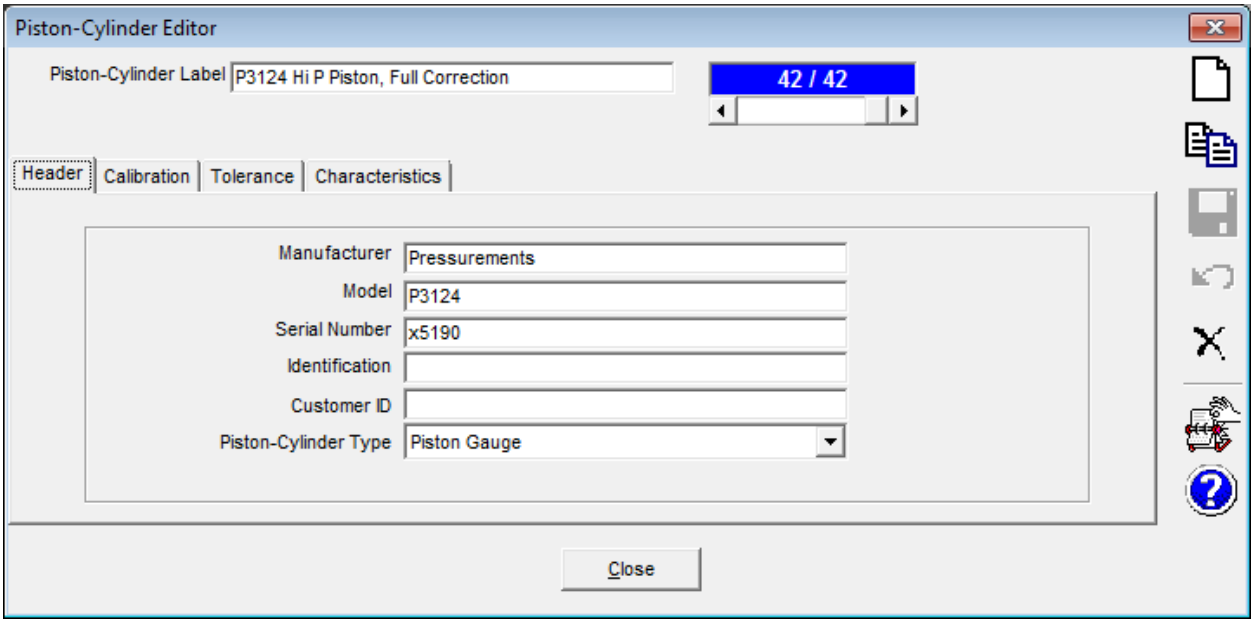
The required tasks for this setup include:

- ✓ Create the Piston-Cylinder definition
- ✓ Create the Mass Set definition
- ✓ Create the Mass Bell ("Weight Carrier") definition
- ✓ Create the Piston Gauge Platform definition
- ✓ Configuring local gravity

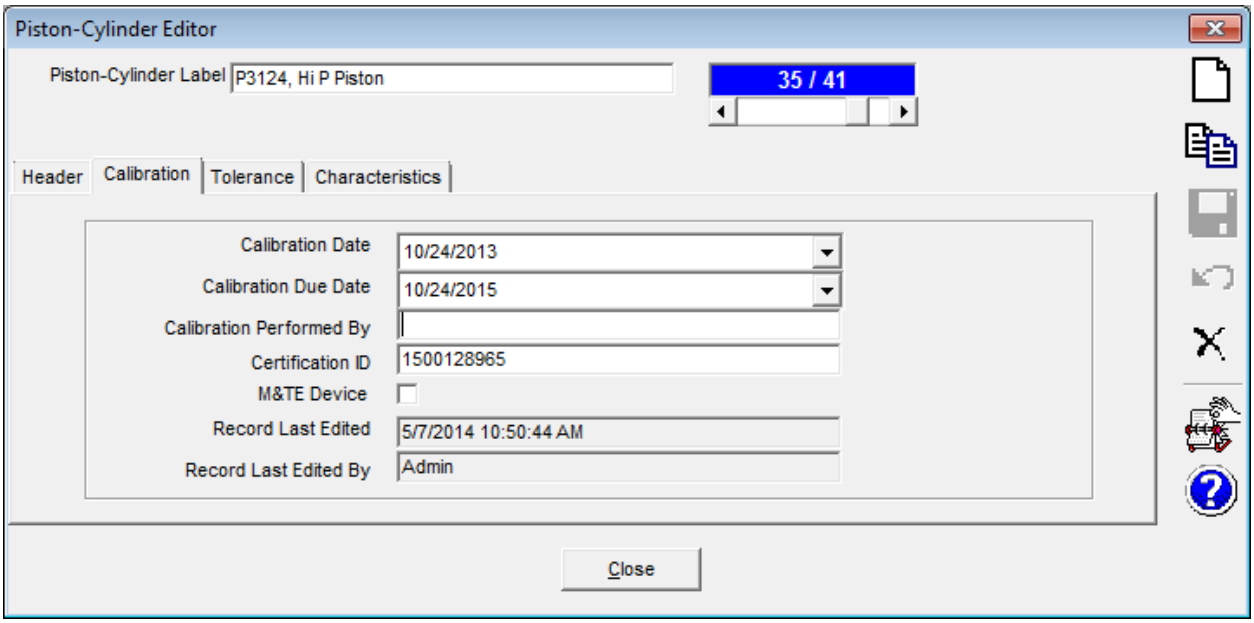
The screen shots are specific to a P3124, but are applicable to the P3000 Series models and the principles can be extended to other 3rd Party DWTs. With COMPASS for Pressure version 4.2 or older, the inverted piston negative gauge (vacuum) method of the P3011 and P302x models is not supported.

Creating the Piston-Cylinder definition(s): [Setup],<Piston Gauge> → "Piston-Cylinder"
The critical selection is the "Piston-Cylinder Type". The choice of Piston Gauge fundamentally changes how COMPASS handles the metrology. The *Full* and *Partial Correction* methods require the Piston-Cylinder type to be "Piston Gauge". The metrological characteristics of the piston-cylinder assembly are required to calculate the pressure.

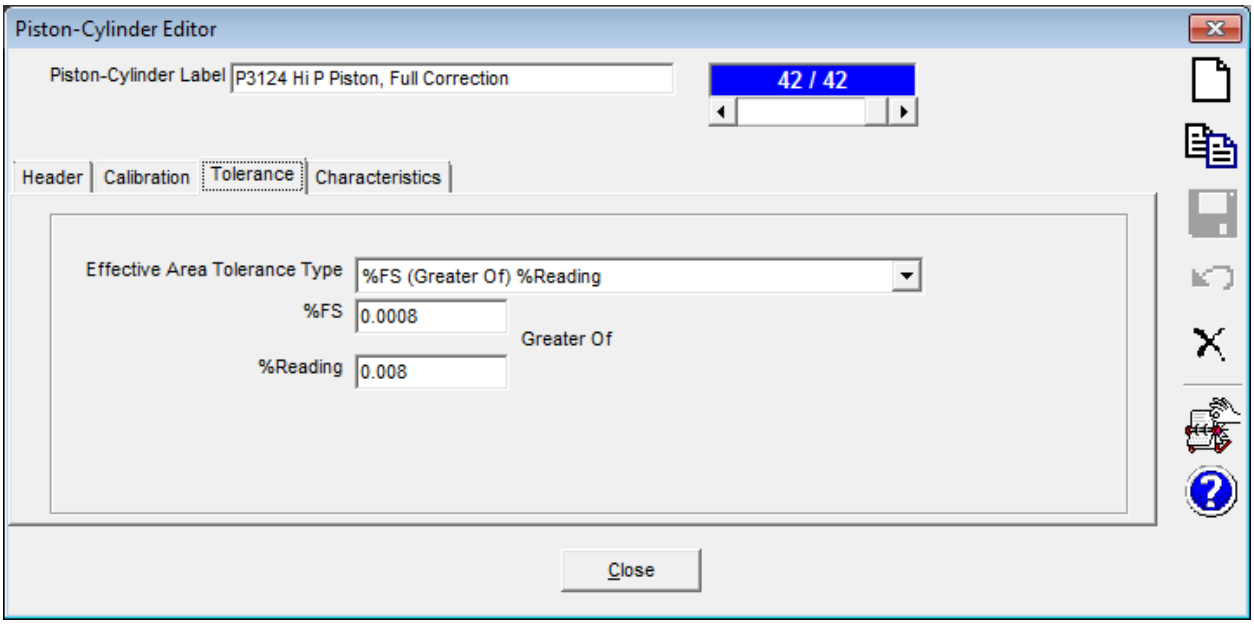
At a minimum only a serial number, Identification, or Customer ID is required for a valid setup. In this scenario the serial number of the piston is being used to uniquely identify the piston-cylinder instead of the top-level serial number of the P3124. The device label has been modified to make it clear that this piston-cylinder definition is different from the version that was made for use as a simple Deadweight Tester piston.



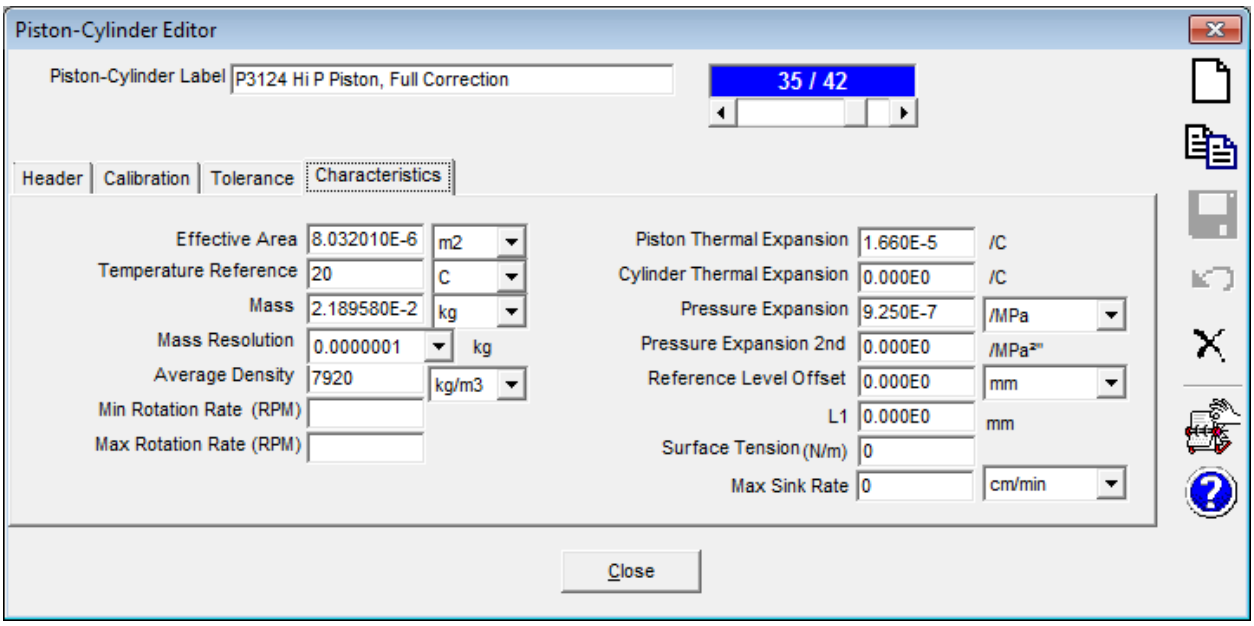
The fields in the Calibration tab are optional, and are not required for a valid setup.



The tolerance specification reflects the uncertainty that can be attained when software is used to calculate the pressure using the *Full Correction* method.



The Characteristics tab is populated from the calibration report. It describes the effective area and how it changes with changes in temperature and deformation. For P3000 piston-cylinders manufactured before July 2012 the Temperature Reference value is 20°C. These models are identified with the "P3000-n" nomenclature where "n" is an integer representing a unit of measure option such as 3 = psi, or 1 = Bar, etc. For P3000 piston-cylinders manufactured from July 2012 and thereafter the Temperature Reference value is 23°C. The model nomenclature was changed to "P3000-PSI" and similar for other units of measure.



Effective Area = Reported in units of square meters. Be mindful of the exponent.

Temperature Reference = Either 20°C or 23°C, depends on date of manufacture

***Mass** = The mass of the piston corrected for the influences of fluid buoyancy, surface tension, and head correction.

On some calibration reports, a small factor for "Residual Oil" is identified for informational purposes only. This influence has already been factored into the piston mass value.

Average Density = Use apparent mass density value

Min / Max Rotation = Typically not used with DWTs

Piston Thermal Expansion = A combination of the piston + cylinder

Cylinder Thermal Expansion = Typically set to 0.00 due to it being combined with the piston

Pressure Expansion = Elastic Deformation due to the applied pressure

Pressure Expansion 2nd = Typically not used with DWTs

Reference Level Offset = Typically not used with DWTs

L1 = Typically not used with DWTs

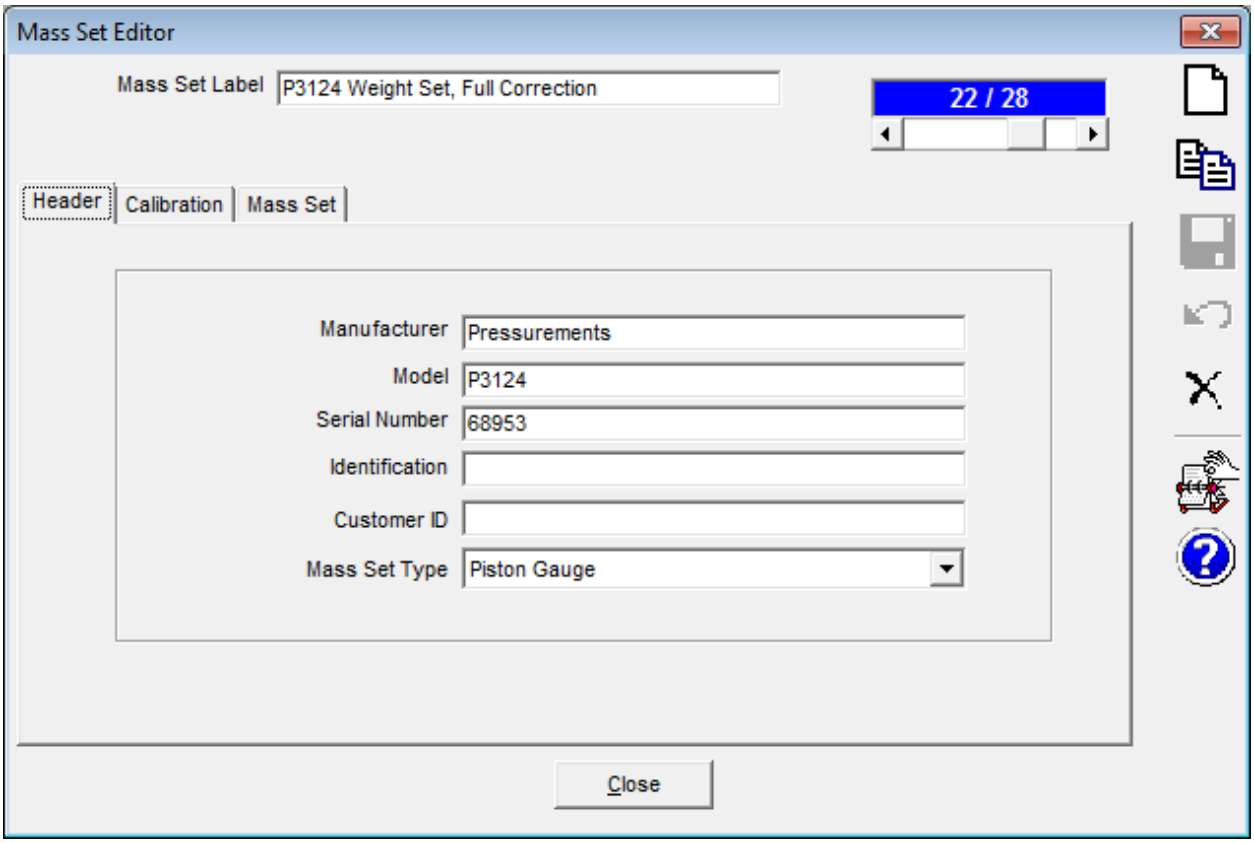
***Surface Tension** = Combined with the piston mass

Max Sink Rate = Only applicable if an automated float position sensor is used

* Piston Mass: the calibration reports from Fluke Calibration provide a value for the piston mass. This represents the apparent mass of the piston. The report also provides corrections for the influences of surface tension, fluid buoyancy, and a small fluid head (the distance from the reference level of the piston to the o-ring seal on the test port). When used with COMPASS for Pressure, the piston mass must be modified by summing the four values together. Be careful to notice the Head Correction value is a negative value. (See section 5.11.4 of technical note 2170TN13).

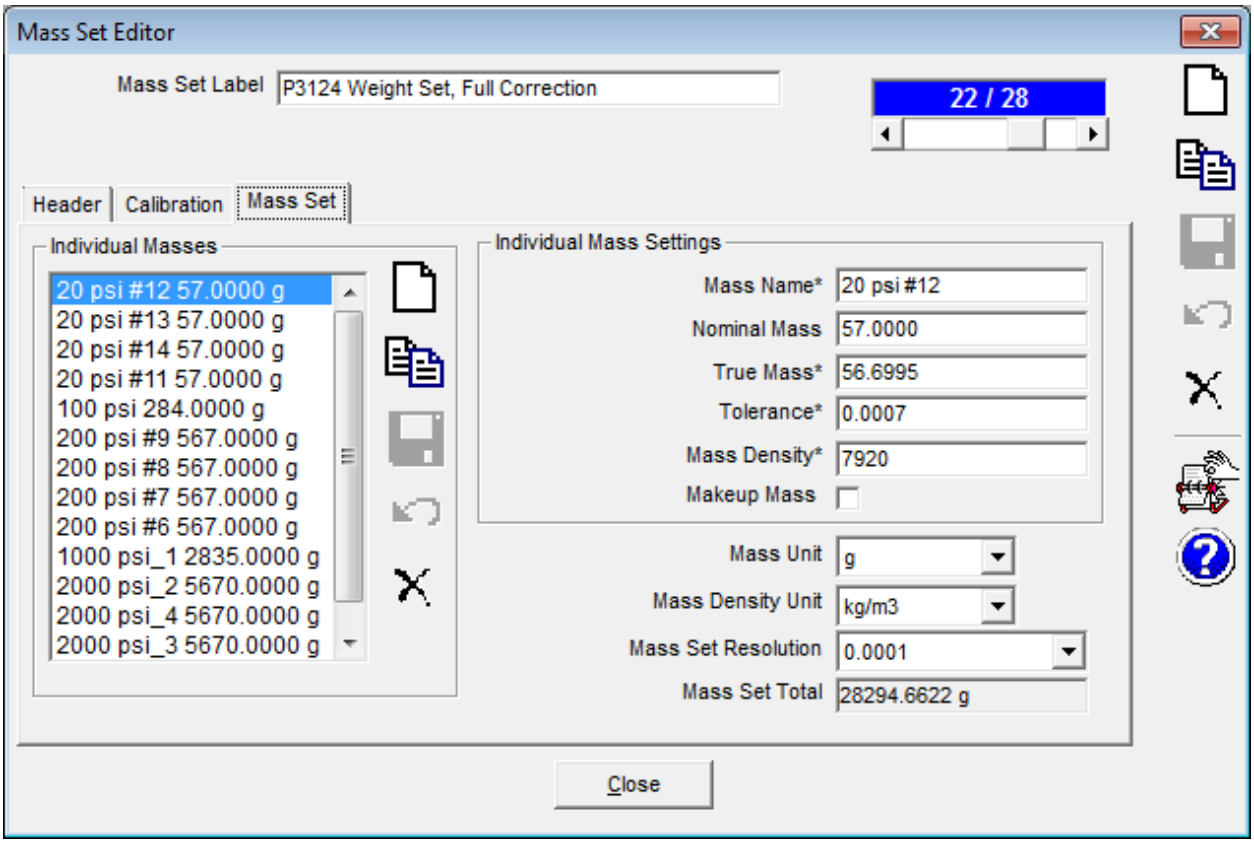
Creating the Mass Set definition: [Setup],<Piston Gauge> → "Mass Set"
The critical selection is the "Mass Set Type". The choice of Piston Gauge fundamentally changes how COMPASS handles the metrology. The *Full* and *Partial Correction* methods require Mass Set Type to be "Piston Gauge".

At a minimum only a serial number, Identification, or Customer ID is required for a valid setup. The device label has been modified to make it clear that this mass set is different from the version that was made for use as a simple Deadweight Tester weight set.



The fields in the calibration tab are optional, and are not required for a valid setup.

The Mass Set tab is a summary of the individual weights and the associated pressure. The screen shot shows a completed mass set.



Mass Name = A text field entry to describe the mass

Nominal Mass = Optional field for summarizing the mass value (numeric entry only)

True Mass = The mass value from the calibration report. The report provides an Apparent Mass value for how much the mass would "weigh" if it had a density of 7920 kg/m^3

Tolerance = The uncertainty of the mass

Mass Density = The apparent mass density

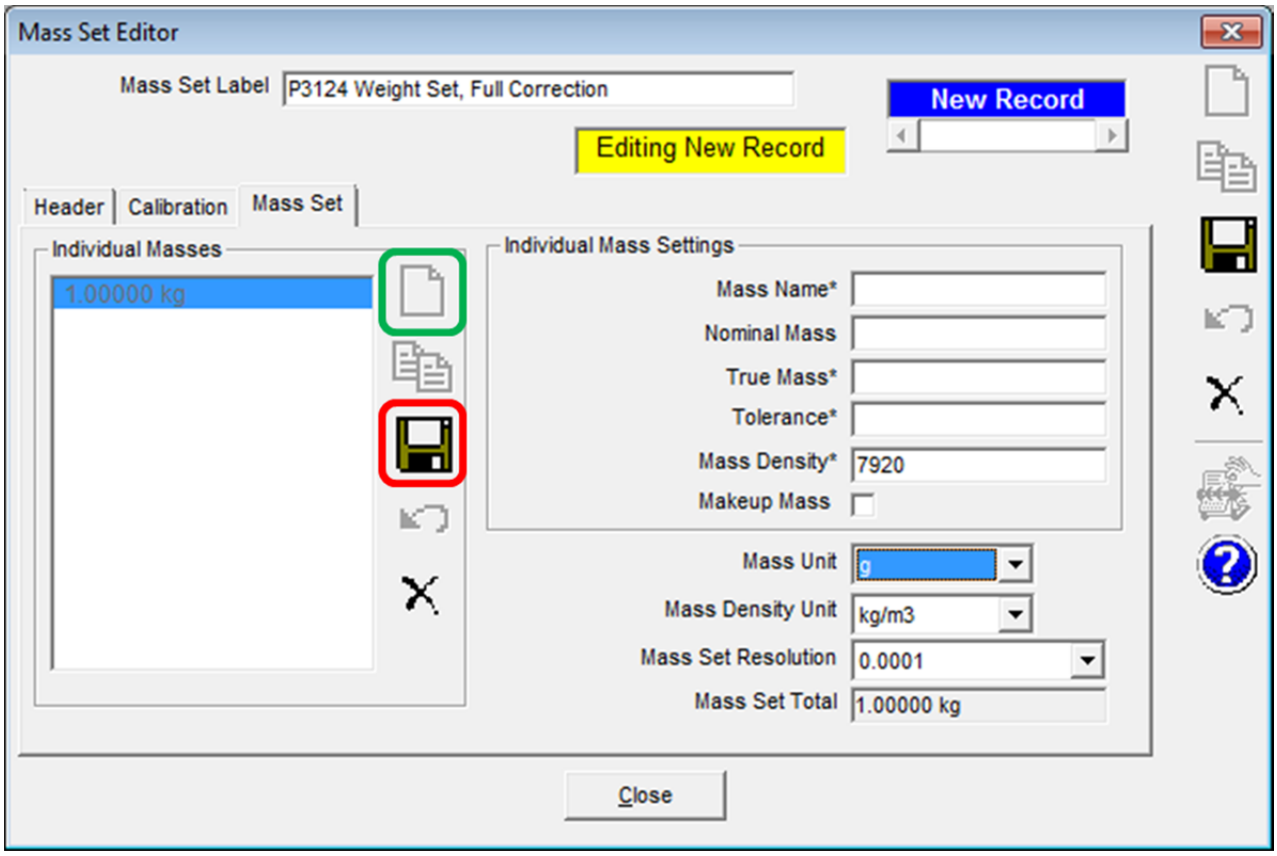
Makeup Mass = Not typically used with a DWT

Mass Unit = Choose from the drop down menu. Be consistent. Use the same selection for all masses

Mass Density Unit = Choose from the drop down menu. Be consistent. Use the same selection for all masses

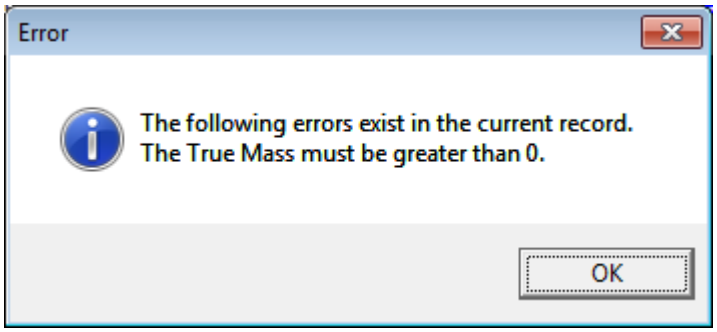
Mass Set Resolution = The resolution of the reported mass values

When the Mass Set Editor is new all fields are blank. Each mass is treated as a separate entity which requires separate actions of clicking on the “New” and “Save” buttons. The goal is to create individual masses which are grouped together as the “P3124 Weight Set, Full Correction”.



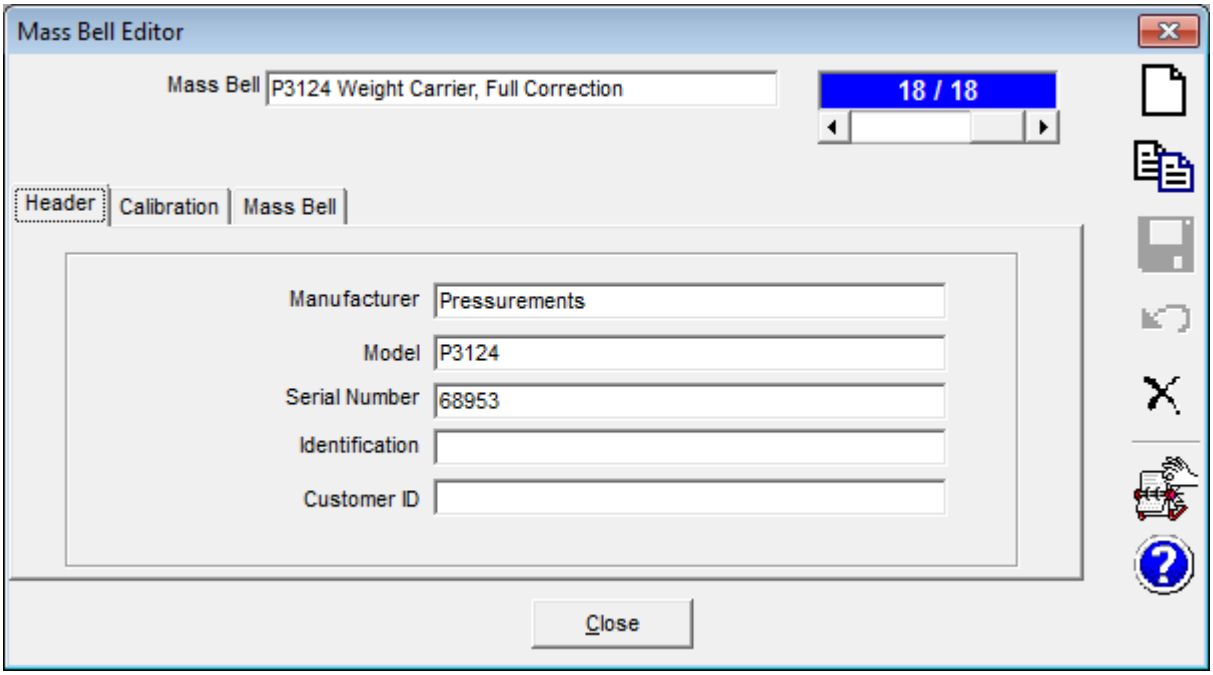
To create a new mass entry, click on the “New” button  in the middle of the window. Fill in the data for the mass, then save using the “Save” button  in the middle of the window. To create the next mass entry, click the “New” button (in the middle of the window) again. Repeat this process until all masses have been defined.

The following error message may appear when saving the individual masses. Click “OK” and resave the mass entry to clear the message.

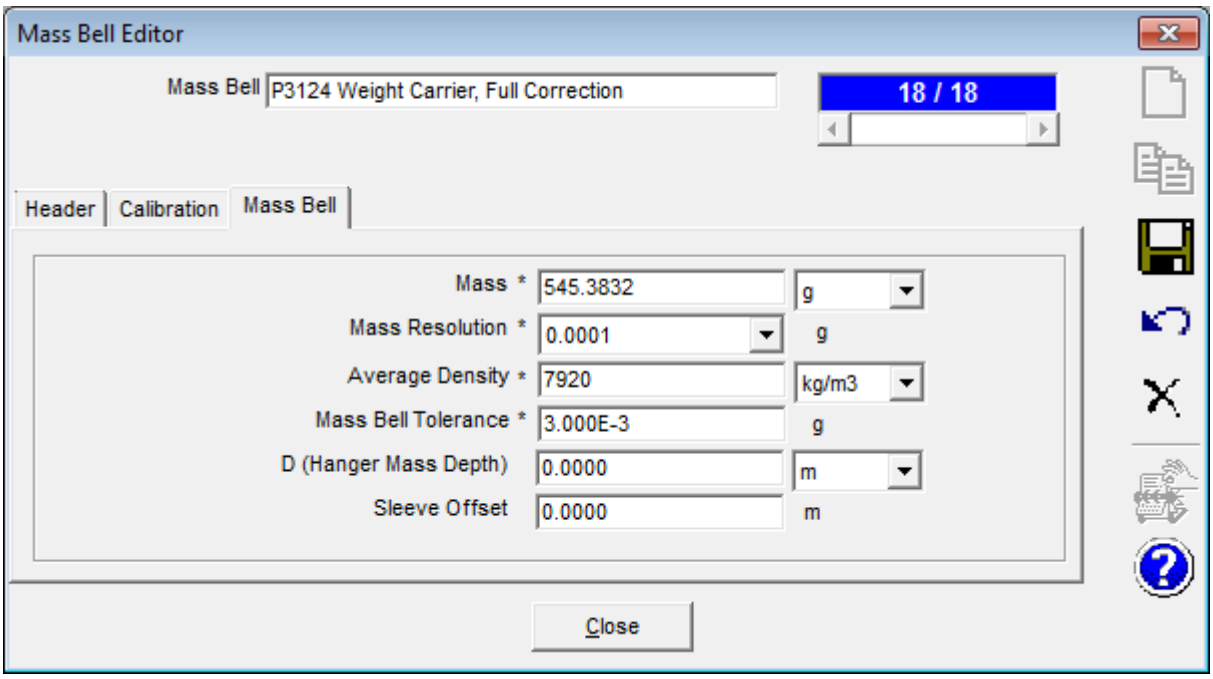


Creating the Mass Bell definition: [Setup],<Piston Gauge> → ”Mass Bell”
The Weight Carrier assembly consists of the weight carrier tube that fits over the piston and the small ring weight that slips over the tube and sits at the bottom. This assembly is considered to be the “Mass Bell”. For low pressure units, there is not a weight carrier tube but a weight carrier table. This should be treated as the same.

The calibration report identifies the weight carrier assembly as mass ID “A” or “B”. The reported mass value does not include the mass of the piston.



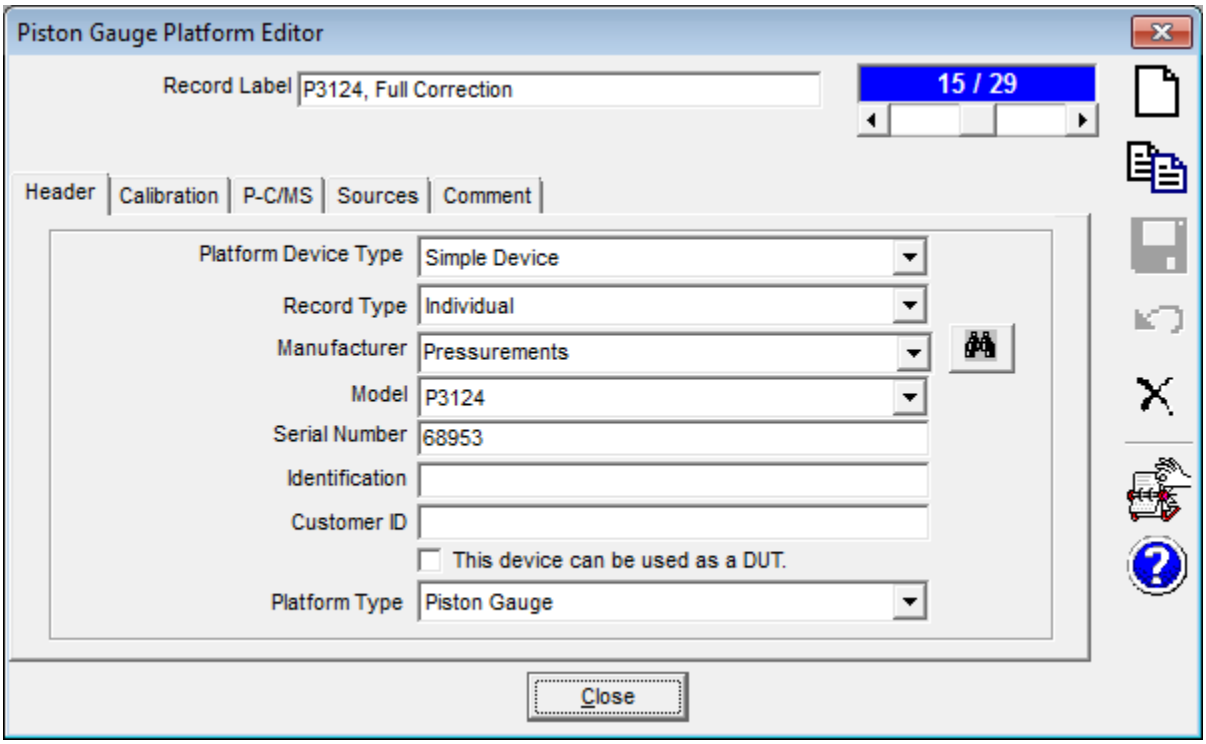
The fields in the calibration tab are optional, and are not required for a valid setup.



The Hanger Mass Depth and Sleeve Offset fields are for Ruska 2400 piston gauges and are not applicable to the P3000 Series.

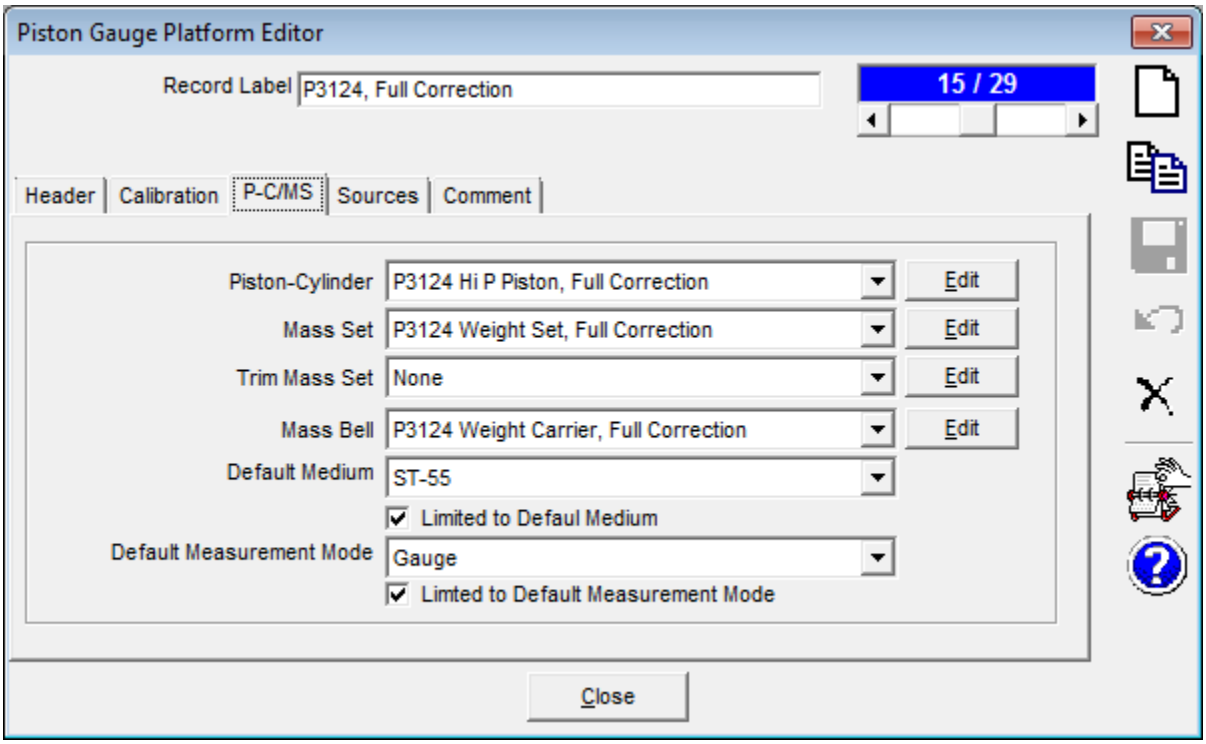
Creating the Piston Gauge Platform definition: [Setup],<Piston Gauge> → "Piston Gauge"

The critical selection is the "Platform Type". At a minimum only a serial number, Identification, or Customer ID is required for a valid setup.

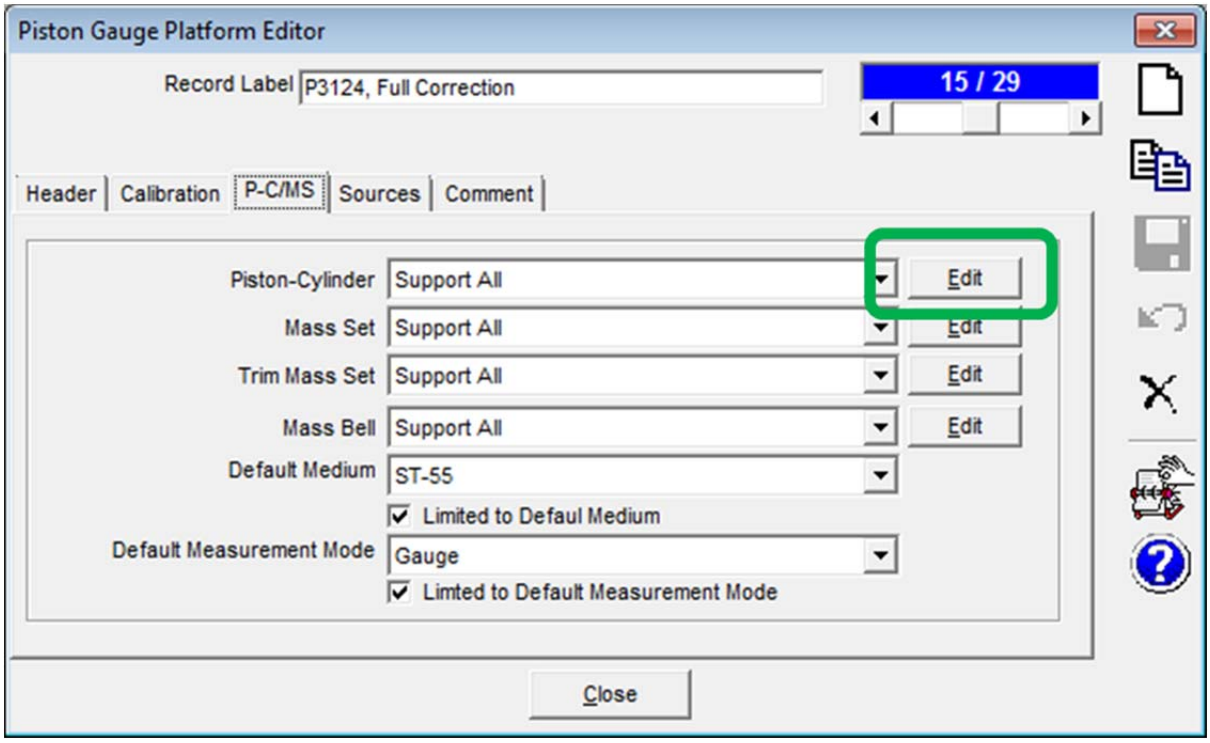


The fields in the calibration tab are optional, and are not required for a valid setup.

The P-C/MS tab is where the piston-cylinder and the mass set are assigned for use with the P3124 platform.



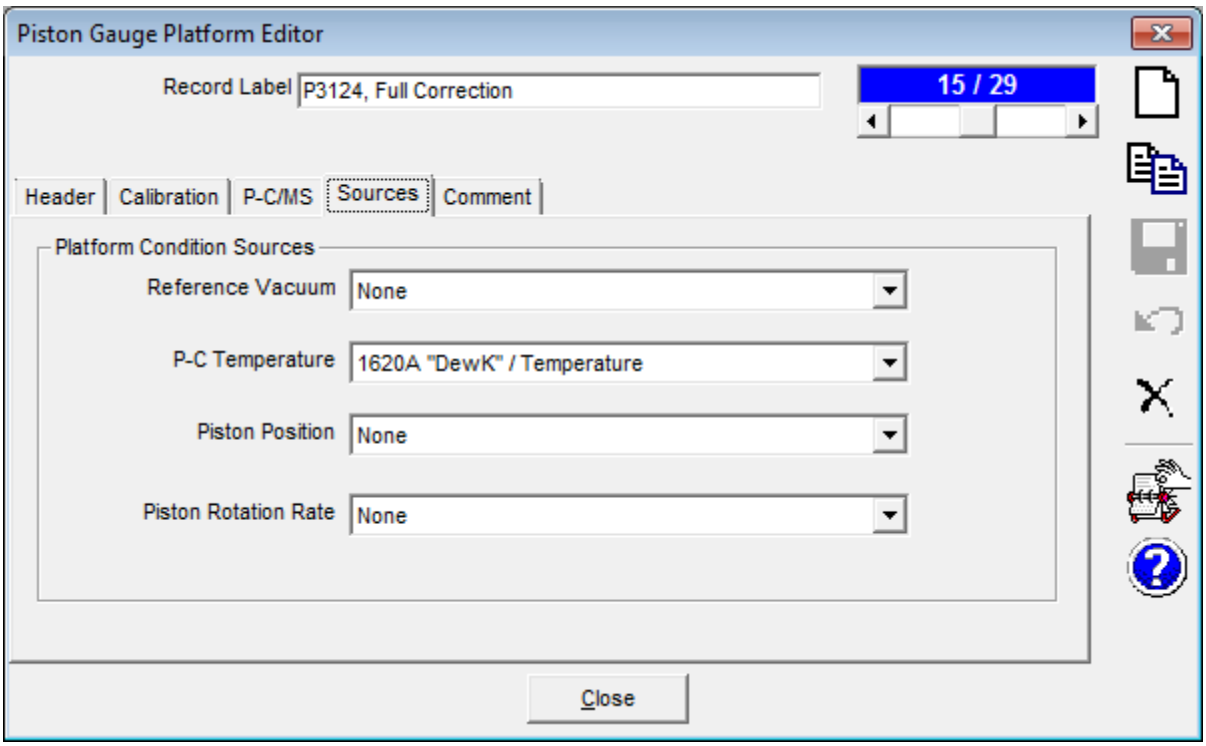
A new Platform Editor screen will have unpopulated drop down menus with “Support All” shown in them. The concept of “Support All” is to make every piston-cylinder and mass set in the database available for use with the P3124. In many situations this is not ideal. For example you would not want to use a hydraulic piston-cylinder with a gas operated DWT. Therefore, the idea is to assign which piston-cylinder(s) and mass set definitions can be used with the platform.



Click on the “Edit” button to the right of the Piston-Cylinder field to select the “P3124 Hi P Piston, Full Correction”. If there is a definition for the low range piston (the P3124 model has both a Low and High pressure piston-cylinder) then select it at this time as well. Repeat the process for the Mass Set and Mass Bell.

Trim Mass Sets are not typically used with a Deadweight Tester, but could be used when the *Full Correction* method is used. Choose the appropriate fluid medium and measurement mode.

The Sources tab is used to associate external devices for use with the P3124. In this example, a model 1620A has been defined and assigned for use as the ambient temperature source. The selections can be later changed when a test is initialized, but by associating them with the P3000 Platform they become the default selection. This provides an extra measure to ensure that the correct support devices are used with the P3124. The P3000’s uncertainty analysis assumes that the piston-cylinder temperature will be similar to ambient temperature.



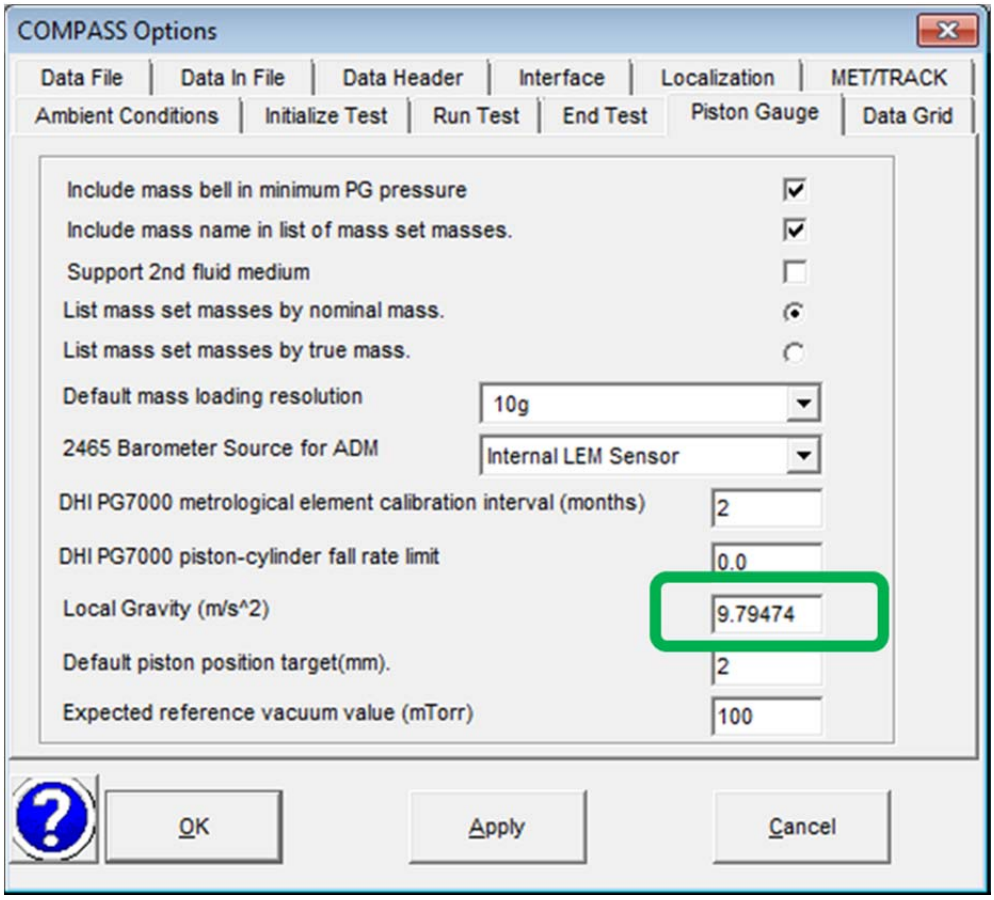
Configuring local gravity:

The biggest source of potential error when using a pressure balance, be it a piston-gauge or a DWT, is having the wrong value for the local acceleration of gravity. When operating the P3000 in *Full* or *Partial Correction* method the local gravity is handled differently than it is with a regular DWT (e.g: *Partial Limited Correction* method). It's a variable in the force component and it must be known for the location where the P3000 is being operated.

The input for local gravity is located under the [Tools],<Options…> menu → "Piston Gauge" tab.

An application note is available at www.Flukecal.com to help determine local acceleration of gravity:

http://download.flukecal.com/secure/4218960B_EN_Accounting_For_Gravity_w.pdf?nvb=20140507200439&nva=20140507201939&token=0d431b7f84ff2c15956e9


COMPASS Options
Data File
Data In File
Data Header
Interface
Localization
MET/TRACK
Ambient Conditions
Initialize Test
Run Test
End Test
Piston Gauge
Data Grid
Include mass bell in minimum PG pressure
Include mass name in list of mass set masses.
Support 2nd fluid medium
List mass set masses by nominal mass.
List mass set masses by true mass.
Default mass loading resolution
10g
2465 Barometer Source for ADM
Internal LEM Sensor
DHI PG7000 metrological element calibration interval (months)
2
DHI PG7000 piston-cylinder fall rate limit
0.0
Local Gravity (m/s^2)
9.79474
Default piston position target(mm).
2
Expected reference vacuum value (mTorr)
100
OK
Apply
Cancel

When running a test the Piston Gauge Calculator tool is used to indicate the mass load and the corresponding pressure with corrections for environmental and system influences. The corrected Reference Pressure is given as 1193.2359 psi. The Mass List window shows the masses that should be used to attain this pressure. The window can be expanded to see a sequential list [>>] of the mass load.