

COMPASS for Pressure

Introduction, Overview, and Structure

What is pressure calibration?

A series of comparisons under specified conditions of applying known pressure to a pressure measuring Device Under Test (“D.U.T.”) over its measurement range in order to determine or verify the relationship between pressure input and the DUT’s output.

Required components:

- **DUT(s)**
- **Reference pressure device**
- **Generation and control hardware**
- **Measurement and/or control hardware for other parameter(s) (e.g. temperature, humidity, etc.)**
- **Data acquisition and interconnection hardware**

What is pressure calibration?

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Calibration

The process includes the following steps:

- **Connecting the DUT together with the reference**
- **Generating and controlling the applied pressure**
- **Reading the DUT**
- **Reading the reference device**
- **Comparing values**
- **Determining in / out of tolerance**
- **Adjustment of DUT (if necessary)**
- **Verification of adjustment (if necessary)**
- **Reporting results**

Why should you automate pressure calibration?

Benefits realized through automation:

- **Reduction of operator error**
- **Electronic records of results**
- **Long and complicated tests can be accomplished unattended or overnight**
- **Improved lab efficiency**
- **Standardization of operational procedures; leak test, exercise, dwell time, ready/not ready, data collection**
- **Software configurations can be readily duplicated by multiple operators, in multiple locations.**

Levels of calibration automation

The level of test automation possible depends on the type of **DUT** being tested.

Visual interface
analog gauges



Manual, User-Assisted Data Acquisition

Analog output devices
transmitters
transducers



Full Data Acquisition through Support Devices

Digital output devices
monitors,
controllers,
digital gauges
digital meters



Full Data Acquisition

Levels of calibration automation

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Calibration

Also depends on the **reference...**

Visual interface

gauges or display only devices



Manual, User-Assisted Data Acquisition

Manual interface devices

deadweight testers



Semi-automated through Support Devices

Digital interface devices

controller/calibrators, monitors (molbox)



Full Automation

Automated Primary Standards

piston gauges with AMH and digital interface



Full Automation

Levels of calibration automation

Pressure generation and **controller** options

Automatic Pressure Controllers

pressure regulators



Full Automation

Manual Pressure Controllers

valves (shutoff or needle)
pressure regulators



Operator sets pressure

Software manages test
- data collection may be automatic

Control devices may also contain the reference measurement

COMPASS for Pressure calibration software is PC software designed to assist in the pressure calibration process

- **Various levels of automation are supported for DUTs, references, controllers**
- **Multiple DUTs – Typically limited only by data acquisition hardware**
- **Support of 3rd party (non-Fluke Calibration) references**
- **User-scripted test point definitions**
- **Data saved in unique data files, and in a database**
- **Calibration report generation tool included that is configurable**

COMPASS for Pressure

- **Two different levels available:**
 - **Basic:**
 - **Most features available**
 - **Enhanced: All of Basic plus...**
 - **Use of multiple references within a test**
 - **DUTs with multiple outputs or DUTs that also control pressure**
 - **Complex tolerance specifications**
 - **Test event macros**
 - **Line pressure or multiple temperature points**

- **Setup DUTs**
 - **Enter for all devices: manufacturer, model, serial number, ID, unit, min/max range, tolerance, raw output(s), final output, remote command(s), etc.**
 - **Entered info can be used during test and/or shown on calibration reports**

The screenshot shows the 'DUT Editor' window with the following fields and values:

Field	Value
Record Label	Pressure Gauge 1000 kPa Absolute
DUT Type	Simple Pressure DUT
Record Type	Individual
Manufacturer	Ashcroft
Model	1082
Serial Number	1234
Identification	Pressure Gauge 1000 kPa ABS
Customer ID	140099999

The interface includes a 'Record Label' field, a '1 / 6' indicator, a tabbed menu (Header, Calibration, Communications, Output, Comment), a 'Close' button, and a vertical toolbar with icons for file operations and help.

Setup DUT, cont.

DUT Editor

Record Label: Pressure Gauge 1000 kPa Absolute 1 / 6

Header: Calibration | Communications | Output | Comment

Calibration Date: 10/27/2014 Calibration Due Date: 10/27/2014

Calibration Performed By: Certification ID:

Calibration Setting1: Calibration Setting3:

Calibration Setting2: Calibration Setting4:

Default Test: Pressure Gauge Test

Record Last Edited: 10/27/2014 8:11:55 PM

Record Last Edited By: Admin

Close

Specify Test

Specify COM method

DUT Editor

Record Label: Pressure Gauge 1000 kPa absolute 8 / 49

Header: Calibration | Communications | Output | Comment

Interface

Data Acquisition Type: Manual

Interface Settings: HART via RS232, IEEE-488, Macro, Manual, Other Device, RS232, TCP/IP

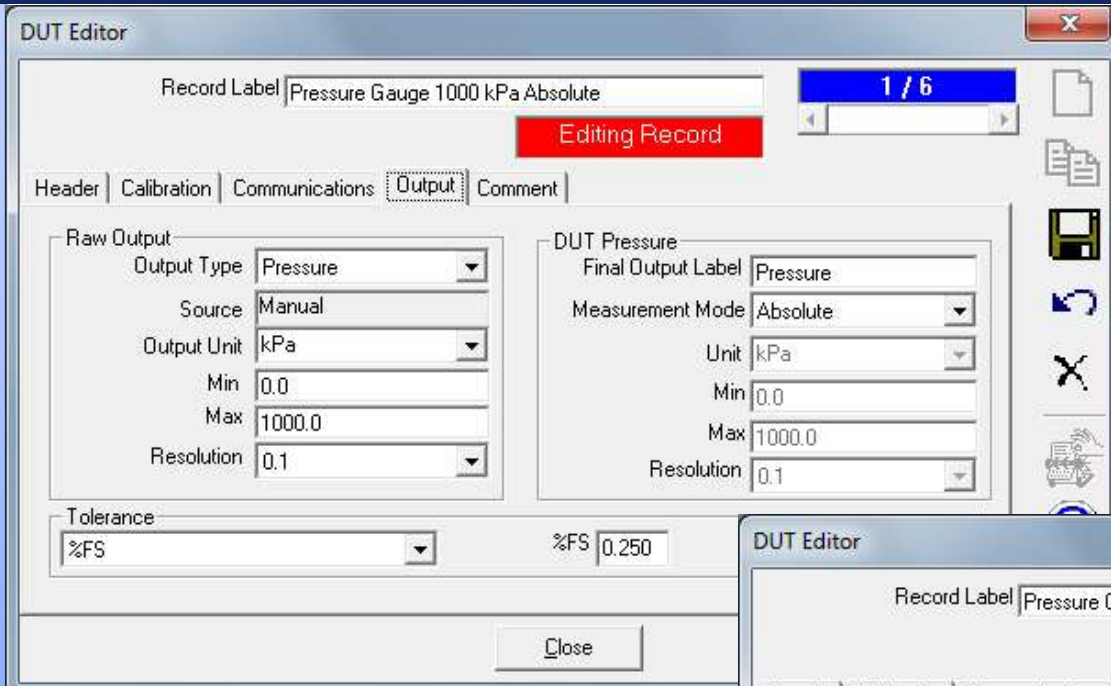
Command Timeout(s): 8

Command Terminator: <CR><LF>

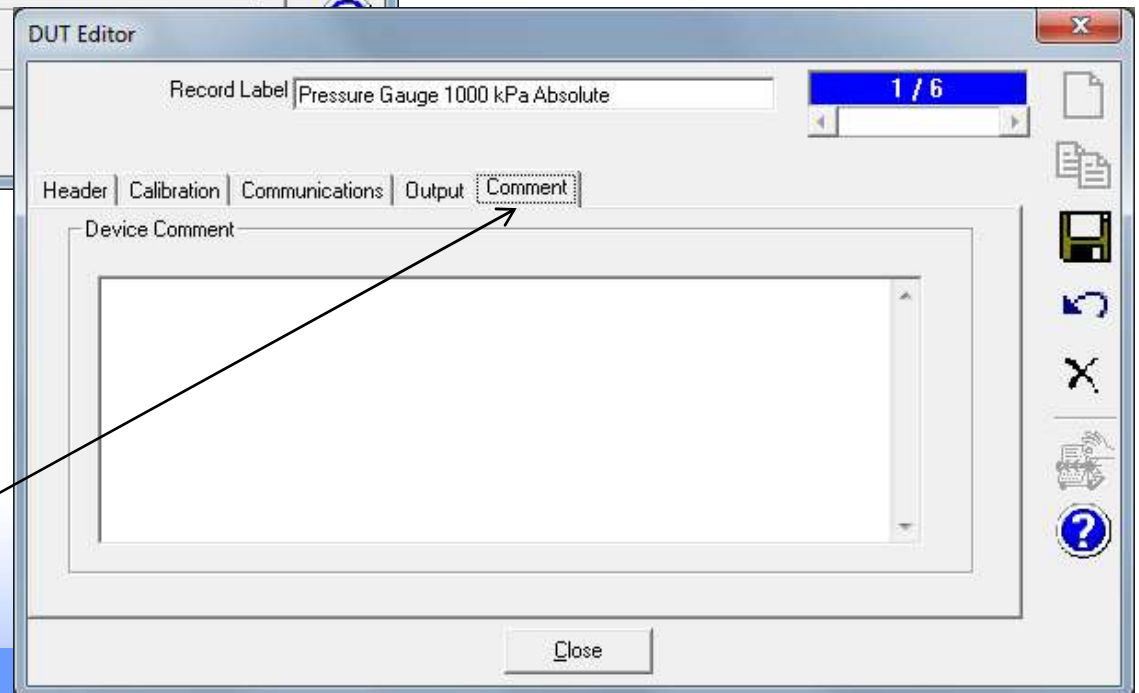
Response Terminator: <CR><LF>

Close

Setup DUT, cont.



- Raw output could be volts with final output being pressure. Advanced DUT could have multiple raw outputs (e.g. pressure & temperature)



Comments are shown during test initialization and can be saved in data file if desired

Setup devices

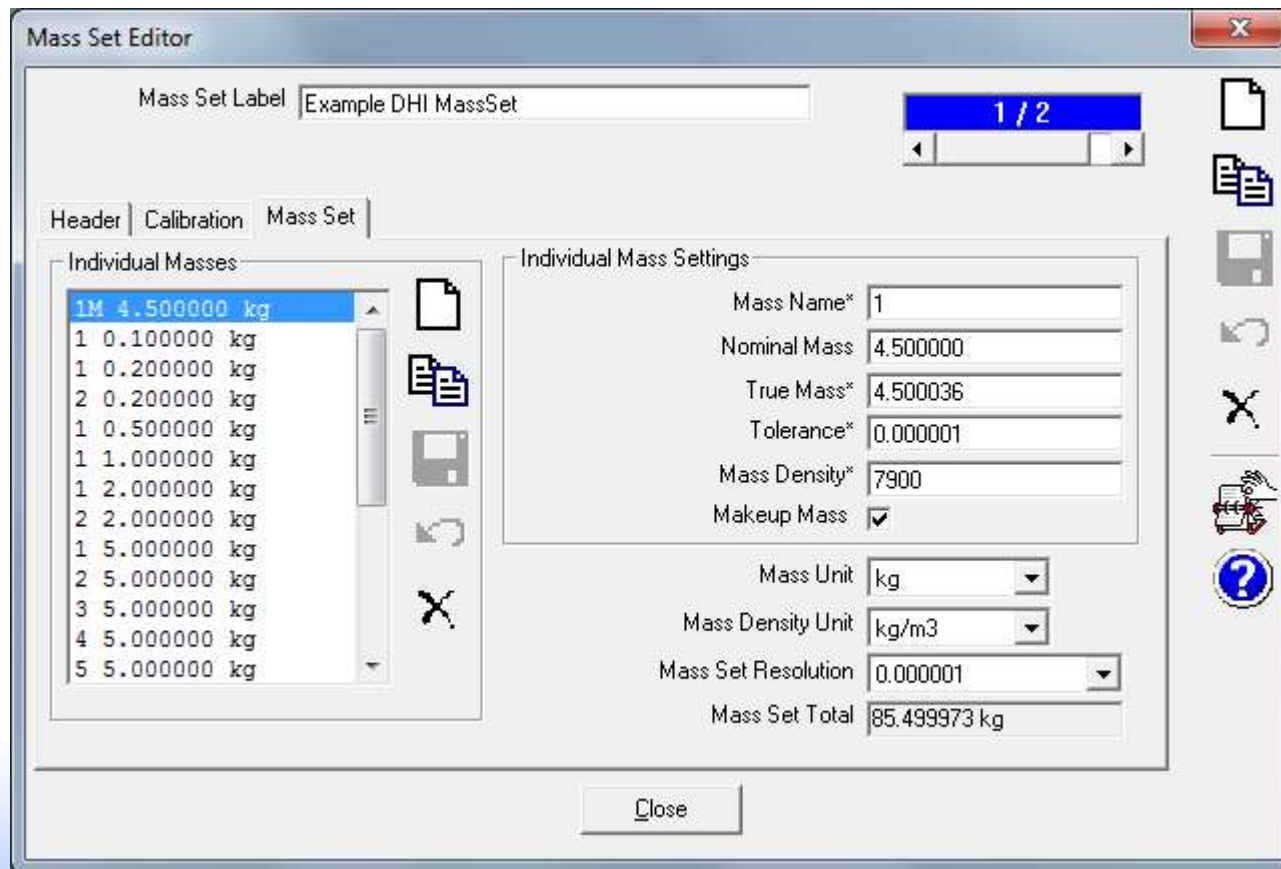
- Setup **piston gauges and deadweight testers:** effective area, true mass, etc.
 - Setup piston cylinder

The screenshot shows the 'Piston-Cylinder Editor' window. At the top, there is a text field for 'Piston-Cylinder Label' containing 'Exmple Piston Cylinder' and a page indicator '2 / 2'. Below this are four tabs: 'Header', 'Calibration', 'Tolerance', and 'Characteristics'. The 'Calibration' tab is active, displaying two columns of parameters. The left column includes Effective Area (9.80537E2 mm2), Temperature Reference (20 C), Mass (1.99946E-1 kg), Mass Resolution (0.000001 kg), Average Density (4260 kg/m3), Min Rotation Rate (RPM) (20), and Max Rotation Rate (RPM) (60). The right column includes Piston Thermal Expansion (4.500E-6 /C), Cylinder Thermal Expansion (4.500E-6 /C), Pressure Expansion (1.790E-6 /MPa), Pressure Expansion 2nd (0.000E0 /MPa²), Reference Level Offset (3.250E1 mm), L1 (0.000E0 mm), Surface Tension (N/m) (0), and Max Sink Rate (0 cm/min). A 'Close' button is located at the bottom center. On the right side of the window, there is a vertical toolbar with icons for file operations, help, and other functions.

Parameter	Value	Unit
Piston-Cylinder Label	Exmple Piston Cylinder	
Effective Area	9.80537E2	mm ²
Temperature Reference	20	C
Mass	1.99946E-1	kg
Mass Resolution	0.000001	kg
Average Density	4260	kg/m ³
Min Rotation Rate (RPM)	20	
Max Rotation Rate (RPM)	60	
Piston Thermal Expansion	4.500E-6	/C
Cylinder Thermal Expansion	4.500E-6	/C
Pressure Expansion	1.790E-6	/MPa
Pressure Expansion 2nd	0.000E0	/MPa ²
Reference Level Offset	3.250E1	mm
L1	0.000E0	mm
Surface Tension (N/m)	0	
Max Sink Rate	0	cm/min

Setup piston gauge, cont.

- **Setup mass set with true mass values**
 - **Can import WinPrompt mass set (.ms) and piston cylinder (.pc) files**



Setup piston gauge, cont.

- **Setup mass bell (sleeve weight) with true mass value**

The screenshot shows the 'Mass Bell Editor' window. At the top, there is a text field for 'Mass Bell' containing 'Example Mass Bell' and a page indicator '1 / 1'. Below this are three tabs: 'Header', 'Calibration', and 'Mass Bell', with 'Mass Bell' being the active tab. The main area contains several configuration fields, each with a text input and a unit dropdown menu:

Mass *	2.78698E-1	kg
Mass Resolution *	0.000001	kg
Average Density *	5.058E3	kg/m3
Mass Bell Tolerance *	0.000E0	kg
D (Hanger Mass Depth)	0.0000	m
Sleeve Offset	0.0000	m

At the bottom of the window is a 'Close' button. On the right side of the window, there is a vertical toolbar with icons for file operations (new, open, save, print), a search icon, a help icon (question mark), and a close icon (X).

Setup piston gauges and DWTs

- **COMPASS Piston Gauge Calculator determines resulting pressure**

$$pressure = \frac{F}{A} = \frac{M \cdot g}{A_{(t,p)}}$$

$$P = \frac{M g l \left(1 - \frac{\rho^{(air)}}{\rho^{(mass)}} \right) + \pi D T}{A_{(20,0)} [1 + (\alpha_p + \alpha_c)(\theta - 20)] (1 + \lambda P)} - (\rho_{Fl} - \rho_{air}) g l h$$

Setup piston gauges and DWTs

Sum of masses x local gravity

Buoyancy correction (density of air and mass)

Surface tension

Head correction (height difference)

$$P = \frac{\sum_i M_i g_l \left(1 - \frac{\rho_a}{\rho_m}\right) + \pi D \tau}{A(T_r, P_r) \left[1 + (\alpha_p + \alpha_c)(T - T_r)\right] (1 + \lambda P)} - \rho_r g_l h$$

Thermal expansion coefficient, piston & cylinder

Pressure deformation of piston-cylinder

Area (temperature and pressure corrected)

Temperature difference from design temperature

COMPASS Piston Gauge Calculator

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Calibration

Piston Gauge Calculator

Piston Gauge Platform: Ruska 2465-754
Piston-Cylinder: 2465 Lo Range PC
Mass Set: Ruska 2465-799 MS
Trim Mass Set: None
Mass Bell: Ruska 2465-799 Sleeve Weight
Medium: N2 Nitrogen
Measurement Mode: Gauge

Ambient Temperature (C): 20.00
Ambient Humidity(%RH): 50
Ambient Pressure (kPa): 100.00
Ambient Pressure Height (cm): 0.00
Vent Height (cm): 0.0
Head Height (cm): 0.0

P-C Temperature (C): 23.00
Piston Position (mm): 0.0
Local Gravity (m/s²): 9.79474
Mass Loading Resolution: 1g
Pressure Display Resolution: 0.0001

Pressure (psi): 3 2.9939
True Mass (kg): 0.707621
Nominal Mass (kg): 0.710000

Mass List

- Piston 0.04700 kg
- 1 Bell 0.500000 kg
- 14 0.010000 kg
- 13 0.020000 kg
- 12 0.030000 kg
- 11 0.050000 kg
- 10 0.100000 kg
- 9 0.200000 kg
- 8 0.300000 kg
- 7 0.500000 kg
- 2 1.000000 kg
- 3 1.000000 kg
- 4 1.000000 kg
- 5 1.000000 kg

Masses To Load

- Piston 0.04700 kg
- 1 Bell 0.500000 kg
- 14 0.010000 kg
- 11 0.050000 kg
- 10 0.100000 kg

Calculations

Air Density (P,T): 1.1834
Mass Density: 7.7932E+03
Area (P,T) (m2): 3.3572E-04

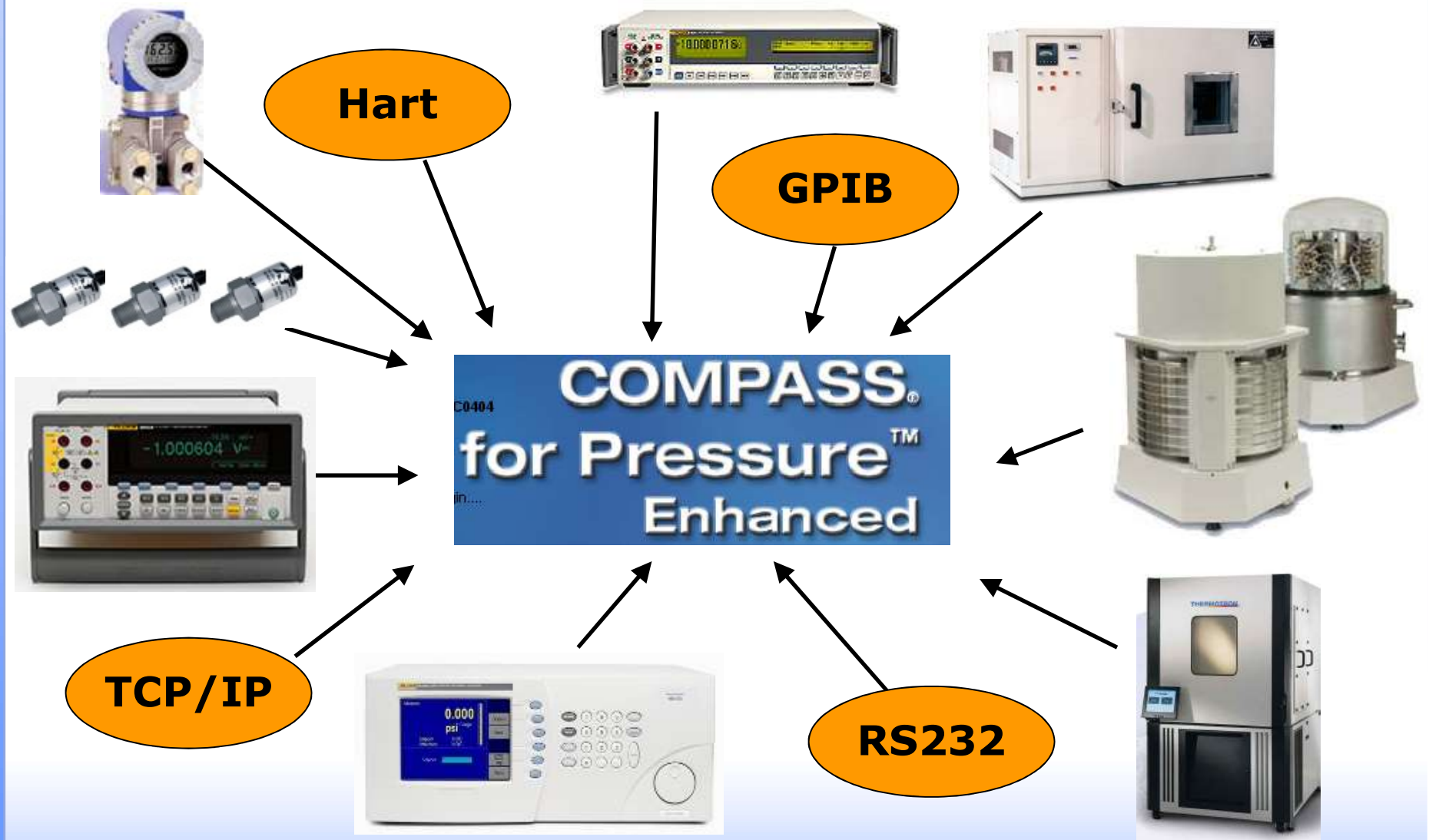
Head Total (Pa): 0.0452
Density 1: 1.3729
Head 1 (Pa): 0.0000
Density 2: 0.0000
Head 2 (Pa): 0.0000
Piston Height (m): 0.0244
Piston Head (Pa): 0.0452
ATM Head (Pa): 0.0000

(* Density in kg/m3)

Close

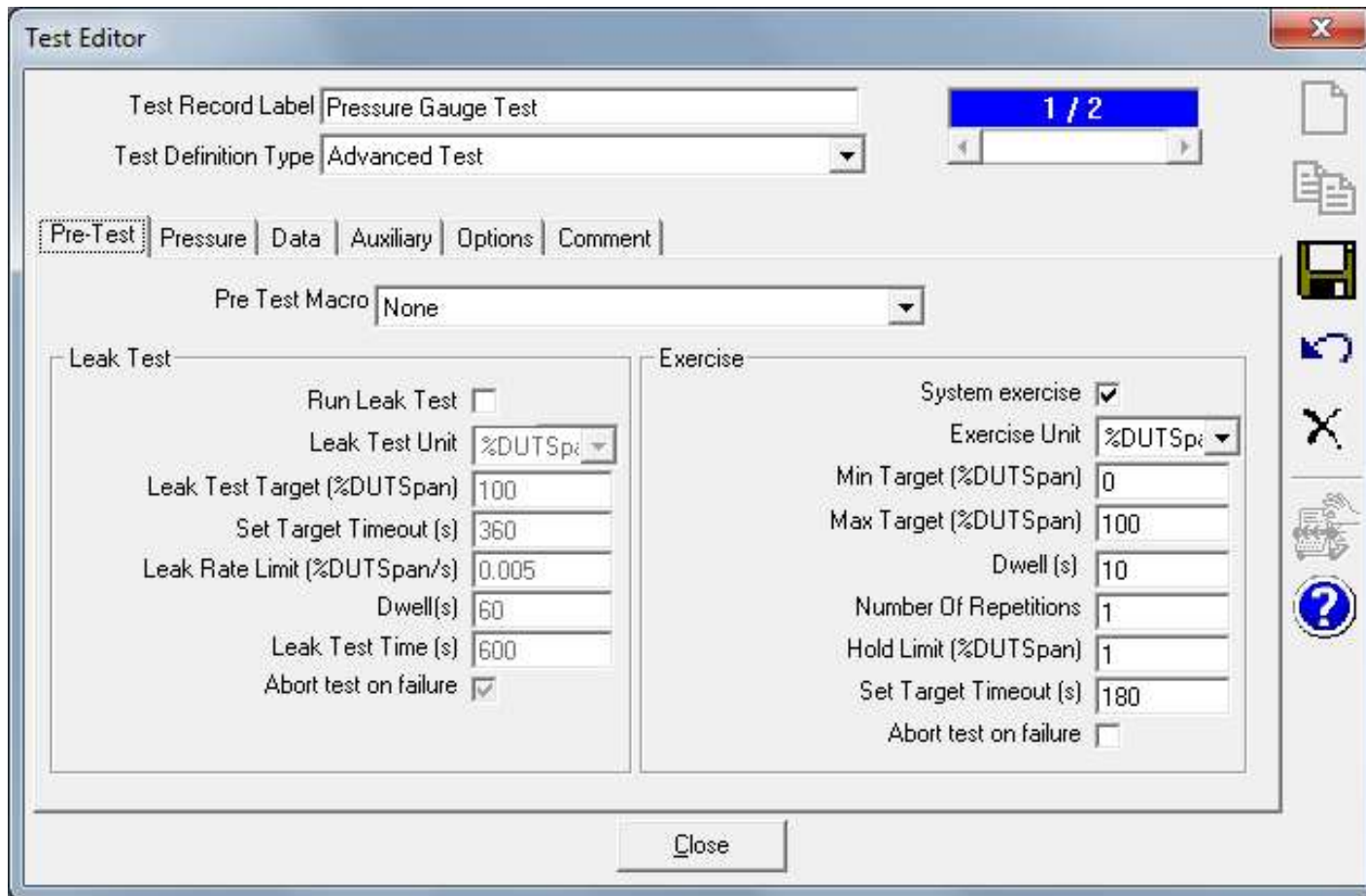
- **Setup **Support Devices**** (anything that is not a DUT, PG or DWT)
 - **Reference - Autodetect for Fluke Cal devices**
 - **Controller - Might be same device as reference**
 - **Monitors – Ambient conditions, Aux. pressure, etc.**
 - **Similar to DUT setup tabs but also have a Set (control) tab that is optional**
 - **Enter for all devices: manufacturer, model, serial number, asset IDs, unit, min/max range, tolerance, raw output(s), final output, remote command(s), etc.**
- **When finished with setups, the device definitions are saved and you do not need to do this work again**

Data Acquisition Capabilities



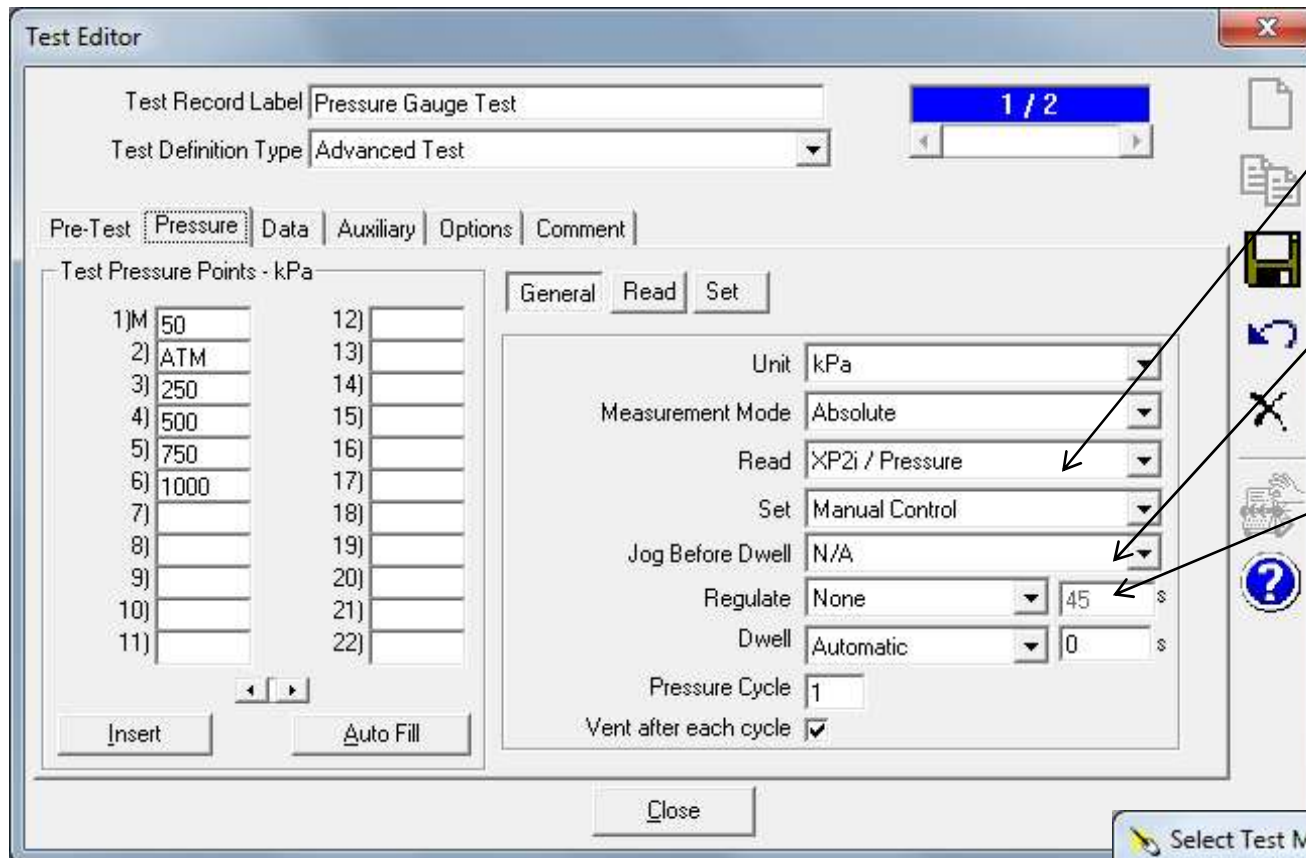
- **Setup Test Definitions** - specifies how the test will be performed.
 - Leak check and/or exercise the DUT (optional)
 - Define setpoints
 - Specify **Reference(s)**, any other **Support Devices**
 - Need Enhanced version for multiple references
 - Ready/not ready criteria (stability, how close to setpoint, for how long)
 - Dwell time (wait time before taking data)
 - Data collection method, (manual or averaging)
 - Calibration report template to use (Advanced test with COMPASS for Pressure enhanced)
- When finished, the Test Definitions are saved and you do not need to do this work again

Setup test definitions, Pre-Test tab



- **Some prefer to do any Leak Checks and Exercise cycles manually before the test**

Setup test definitions, Pressure tab

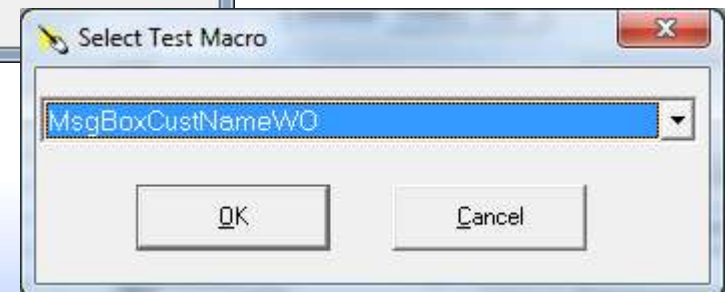


Specify Reference

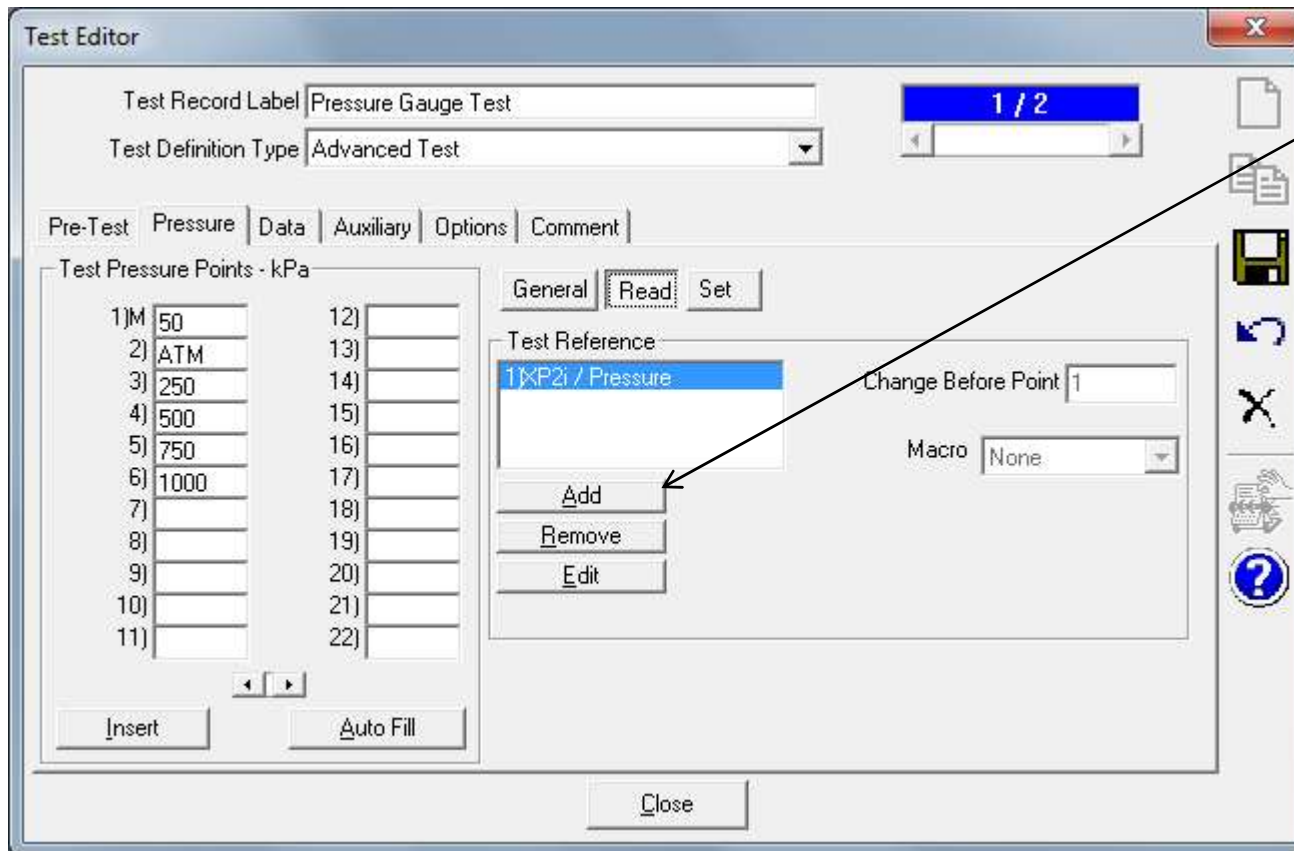
Jog is usually used with analog gauges and automated pressure controllers

Regulate is usually used with digital gauges/meters and you use automated controller to control to a cardinal point on the DUT

- **Pre-point macro message box in point 1 to prompt user to enter customer name and work order**

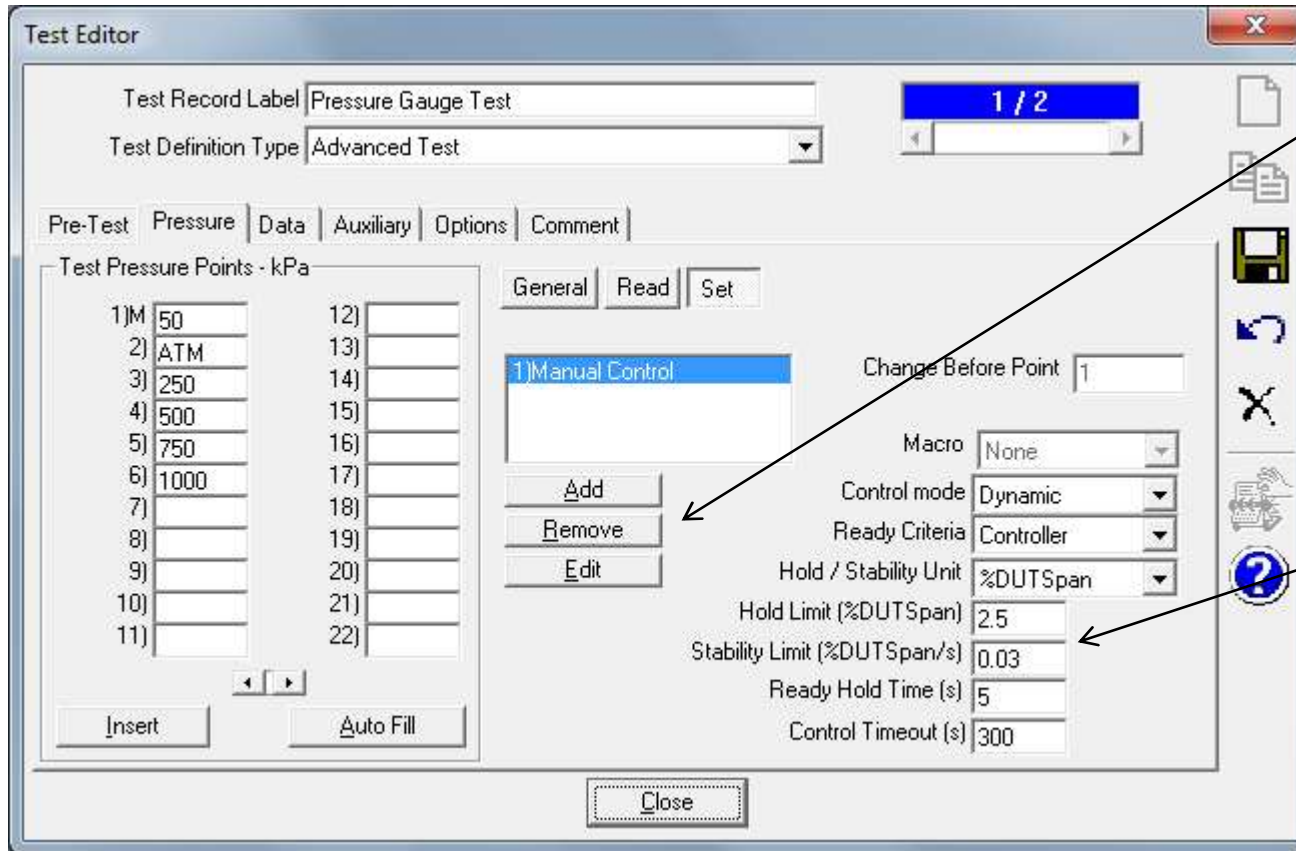


Setup test definitions, Read child tab



Add or Edit References, specify what points they are used at

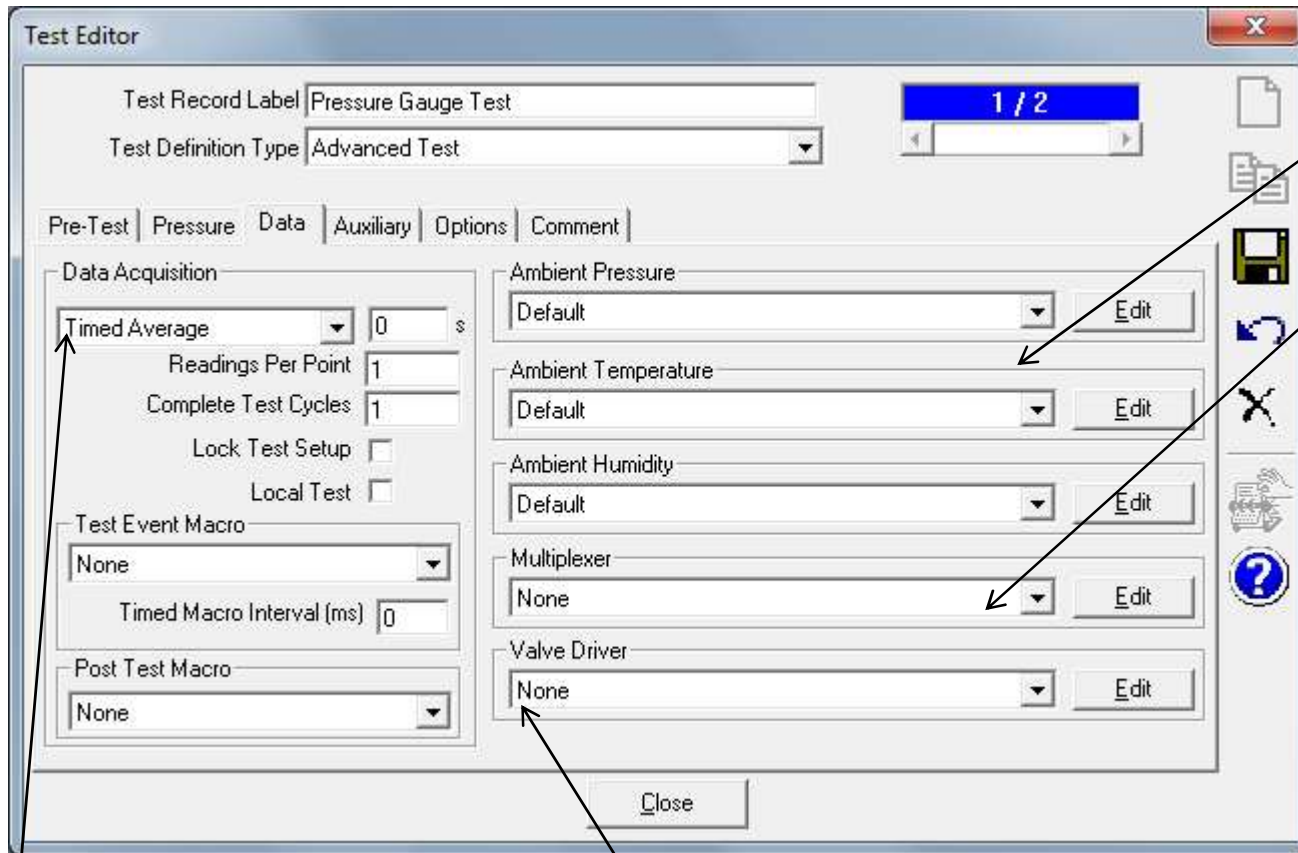
Setup test definitions, Set child tab



Add or Edit Set devices (controllers), specify what points they are used at

Specify ready/not ready criteria. Typically make stability 10 times better than DUT tolerance to ignore these effects (control noise, environmental effects)

Setup test definitions, Data tab



Specify ambient devices (optional)

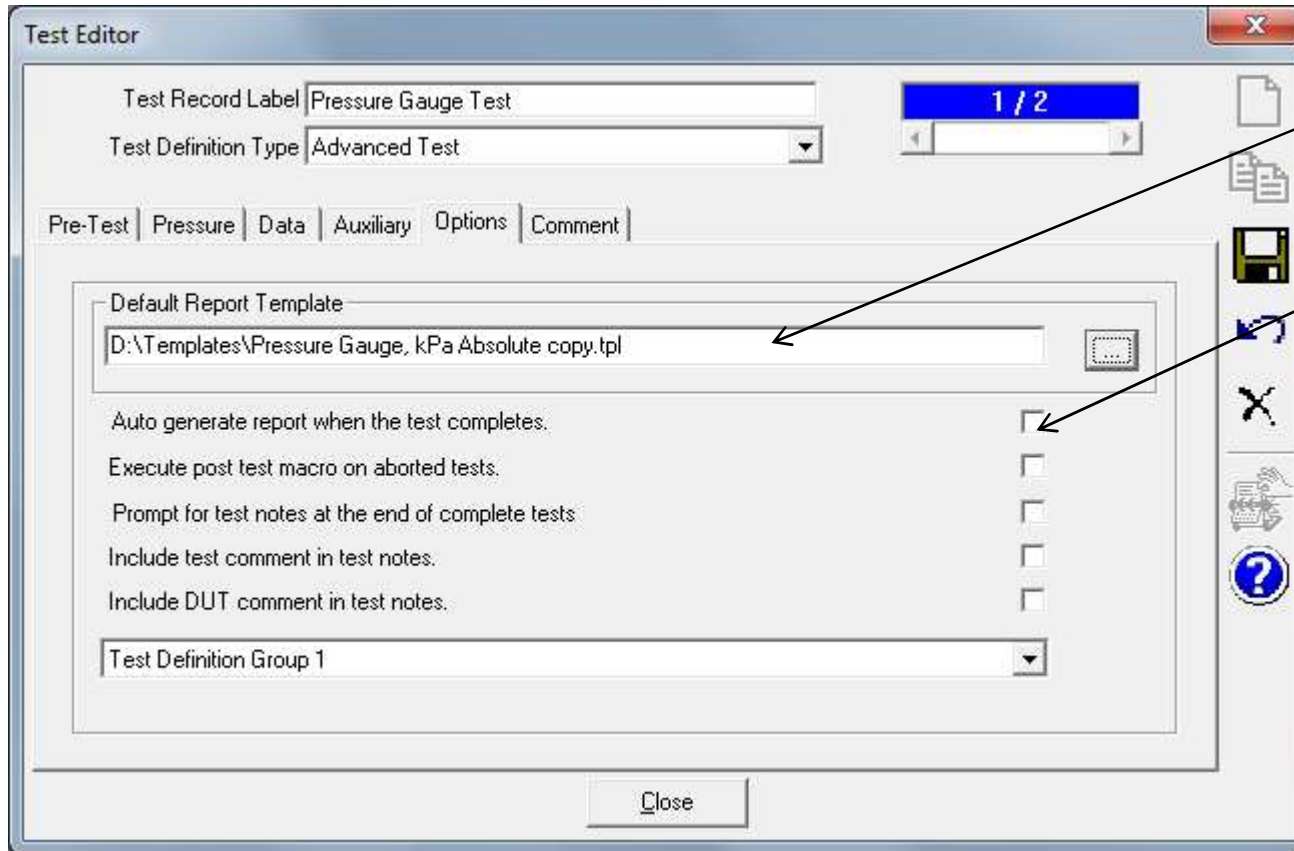
Specify MUX if always used in test

Specify valve driver if always used in test (e.g. turn on vac pump through a relay, open a valve)

Zero second timed average is a single point

Valve driver(s) might be used to open/close valves, turn on vacuum pump, etc.

Setup test definitions, Options tab



Specify calibration report template

Automatically open calibration report when test is done

Run Test:

- **Run Test Definition**
 - Follow the on-screen prompts for selection of DUT(s), Support Devices, and Test Definition
 - Proceed through the leak test/exercise, test points, collecting data – fully automated, or guiding the user through the test
 - Upon completion, user has the option of compiling the data into a formatted calibration report using the **COMPASS Report Editor** (can be setup to automatically open cal report)
- **Run Manual Test**
 - Same but don't choose a test. User selects points and saves data

Test data:

- **As COMPASS runs, data is written to a storage location, saved as an ASCII delimited text file**
 - **Storage location is local drive or network location**
 - **Optional, can also save in *.mdb database file**
- **Export to Excel[®], open data file(s) in pre-selected Excel workbook (Enhanced)**
- **Export to MET/TRACK database**
 - **Must have licensed MET/CAL version 7.3.39 or version 8**
 - **Automatic at end of test, or anytime through menu paths with a COMPASS data file**

COMPASS Report Editor

- Produces professional quality calibration reports

Calibration Report		Apr 7 2010					
Model: XP2i		Serial Number: 324					
Report Information							
Report Compiled: Apr 7 2010							
Date of test: 20090810							
Time of test: 9:13:44 AM							
Data file: C:\dhi\COMPASS for Pressure\Data\Crystal Engineering\324\20090810_000.dat							
Test file: Sample Test							
User: Admin							
DUT Information		Reference Information					
Manufacturer	Crystal Engineering	Manufacturer	DH Instruments				
Model	XP2i	Model	PPC4				
Serial Number	324	Serial Number	123				
Identification		Identification					
Pressure Range	0.000 to 300.000 psi	Pressure Range	0.000 to 300.000 psi				
Data Acquisition Method	RS232	Data Acquisition Method	RS232				
Nominal Uncertainty	0.1 %Span	Nominal Uncertainty	0.024 %FS OR 0.01 %Rdg				
Test Information							
Pressure Units: psi							
Dwell Time: 10 s							
Leak Rate:							
Pressure Stability setting: 0.01 %DU TSpan							
Test Data							
Set Pt	Reference Pressure	DUT Pressure	DUT Output	Abs. Error	"% Span" Error	DUT Tolerance	Status
psi	psi	psi	psi	psi	%	psi	
0.000	0.000	0.00	0.00	0.00	-0.0007	0.30	
60.000	60.000	59.98	59.98	-0.02	-0.0071	0.30	
120.000	120.000	119.96	119.96	-0.04	-0.0138	0.30	
180.000	180.000	179.93	179.93	-0.07	-0.0221	0.30	
240.000	240.000	239.90	239.90	-0.10	-0.0337	0.30	

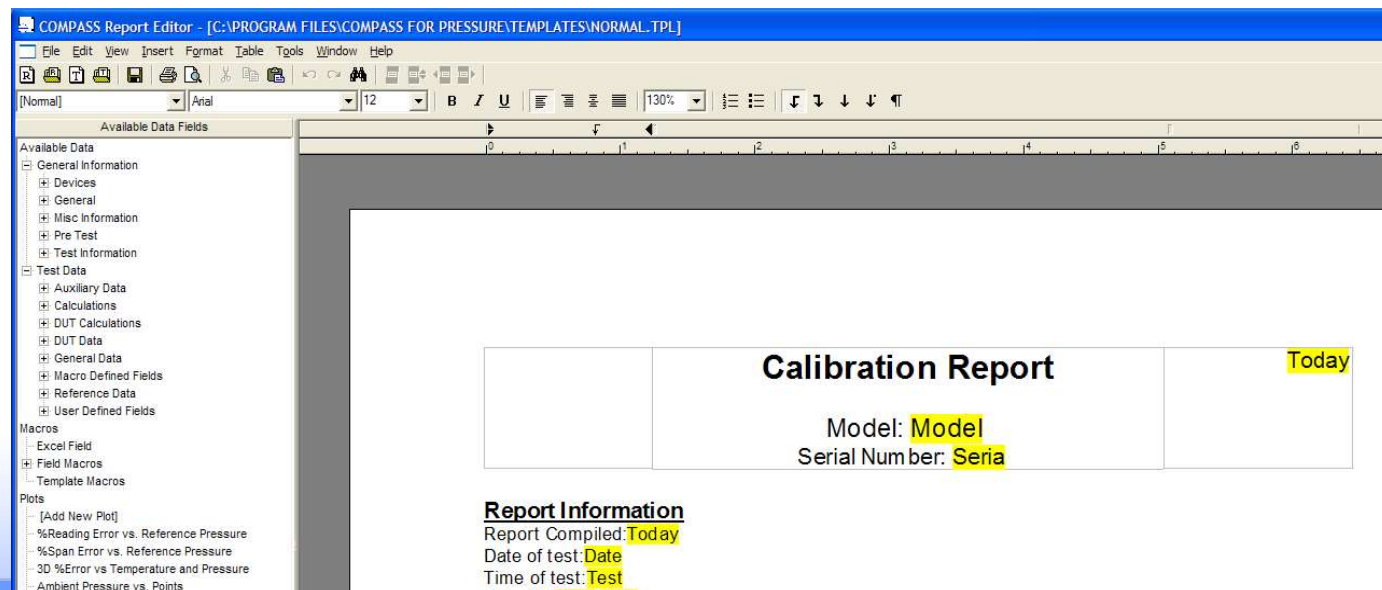
Calibration report customization

FLUKE®

Calibration

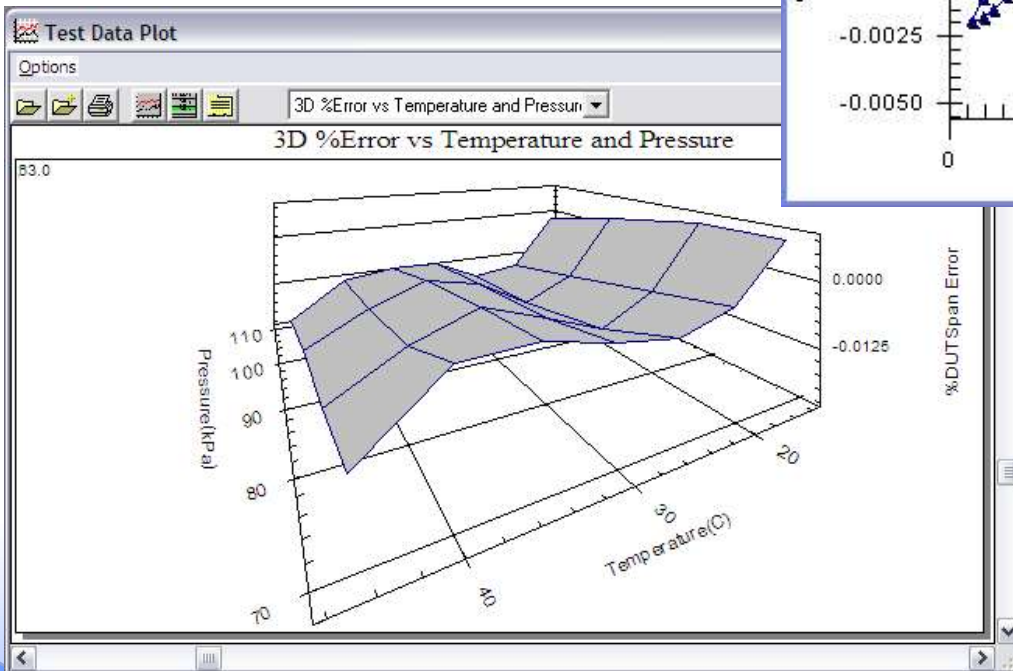
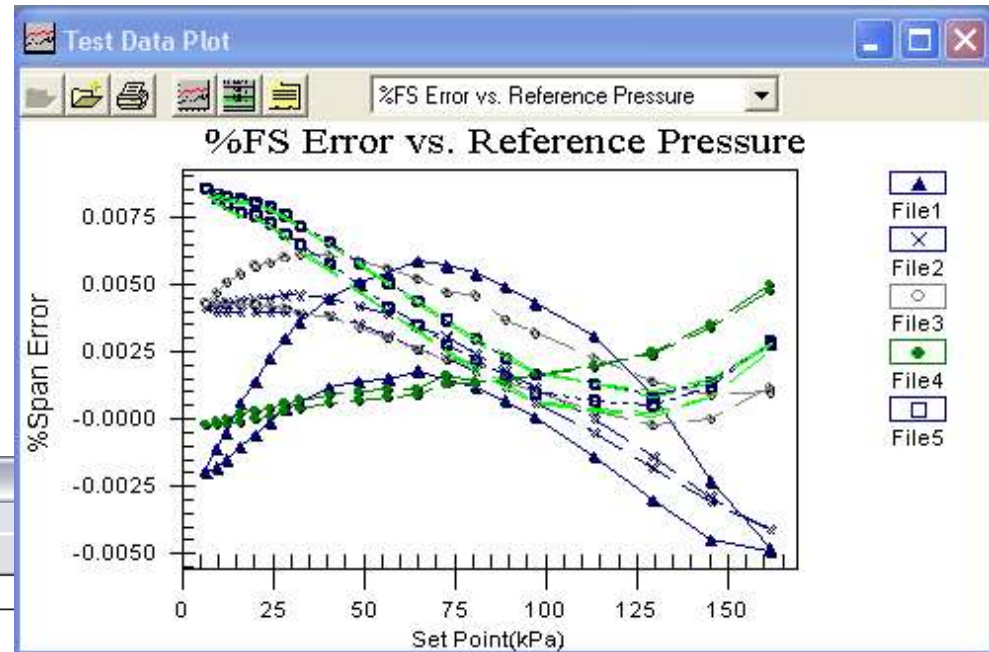
Calibration reports

- Generated from data file(s) and template
 - Predefined and customizable templates
 - Black and white is fully editable text
 - Yellow is data fields from data file or built in calculations, or user calculations via a macro



COMPASS Advanced Plot Support

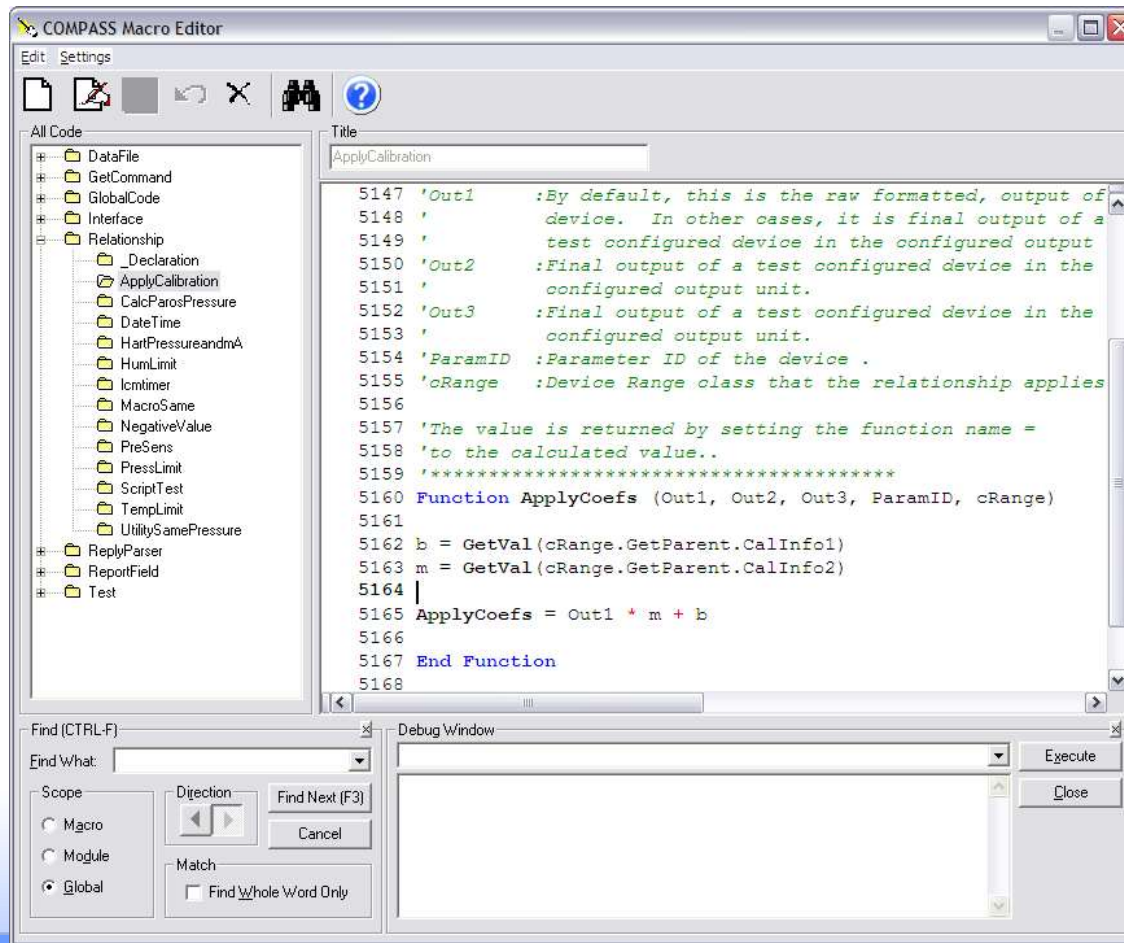
Multiple sensors can be plotted together



Fully customizable 2D and 3D plots

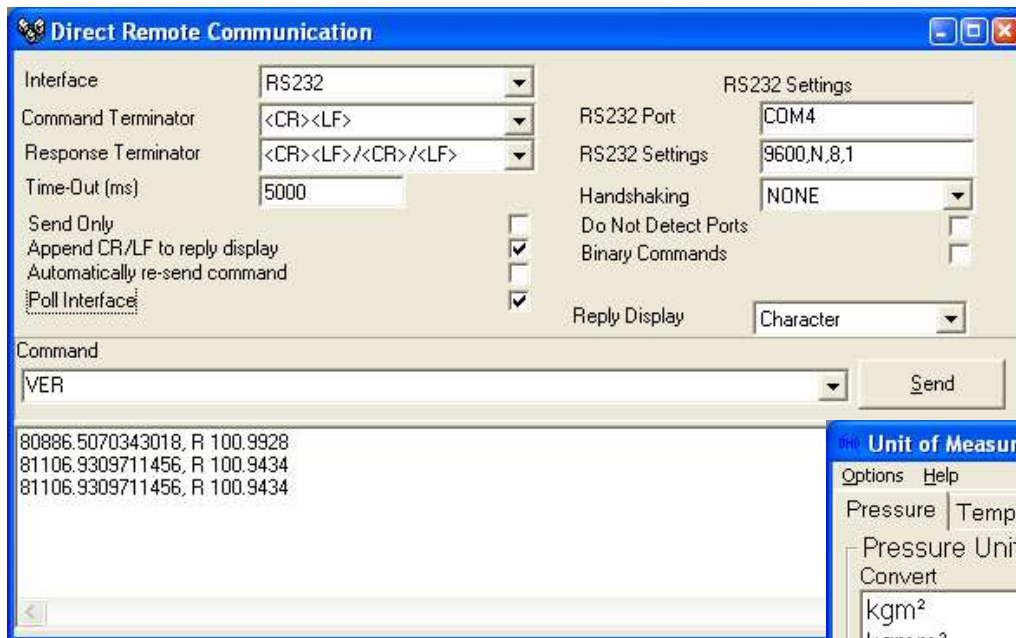
Other COMPASS features

COMPASS Macro Editor – VB Script editor for specialized interface, calculations, programming needs



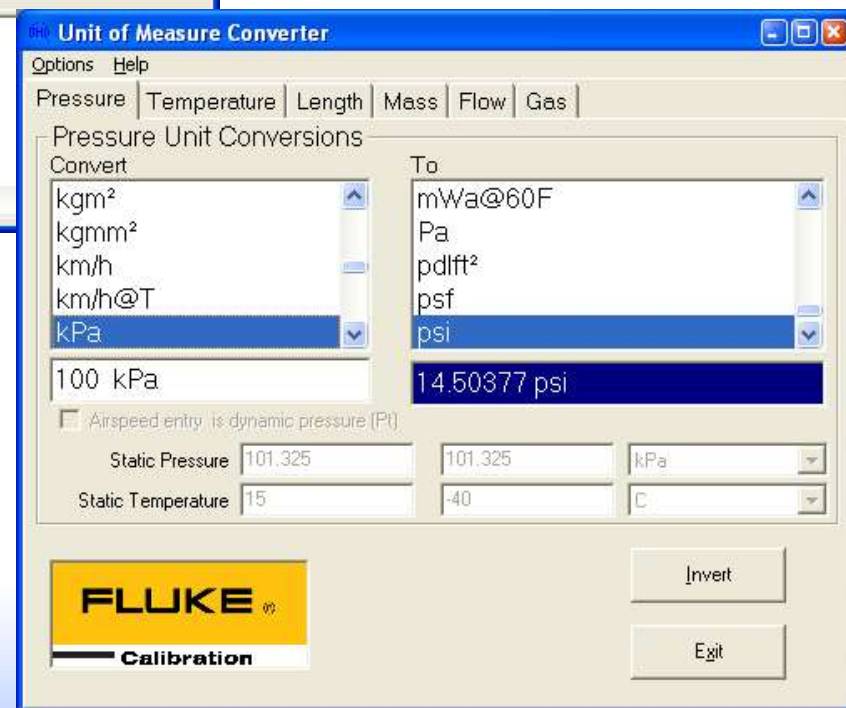
- **Run Manual Test**
 - **Manual Data Acquisition mode**
 - **Collect or log data from devices without the need for following a pre-defined test definition**
 - **Great for logging data and troubleshooting devices (communications, intermittent bad readings)**

Remote Comm. / Unit of Measure



Remote Communications Tool - Convenient tool for testing of command syntax and response without running a test. RS232, IEEE, TCP/IP, Hart, etc.

Unit of Measure Converter - Pressure, Temperature, Length, Distance Flow, Gas (with density, viscosity, compressibility)



Other COMPASS features

- **Temperature test (Need Enhanced, has to be with pressure test)**
- **Differential Pressure Test (Need Enhanced)**
 - **Pressure test with Line Pressure (e.g. natural gas or steam DP sensors)**
- **User and feature display options**
 - **Hide test initialization windows and options that are not necessary for simple tests. Simplifies the user interface when advanced functions are not required**
 - **Specify default hardware (power supply, DMM, ambient conditions monitors, etc.)**
 - **User levels with passwords**
 - **Network options**
 - **Seat-based licensing**

COMPASS test demonstration

Each device in the demonstration has an RS232 interface.

- Test at 25% increments.
- PPC4 will apply the pressure,
- Wait for a “Ready” condition
- Dwell for 5 seconds
- Average data for 5 seconds
- Log the ‘as received data’
- Run a function to calculate new coefficients
- Apply the new coefficients
- Run a second, ‘as left’ test
- Generate test report when finished



Thank you.

Questions?

Visit the Fluke Calibration website for COMPASS demos, upgrades, and updated example set up database

www.flukecal.com