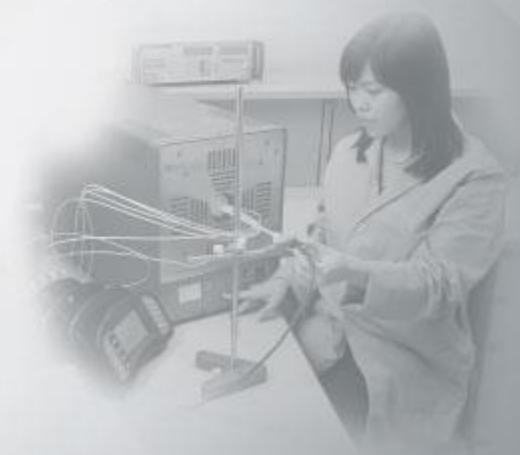**FLUKE** ®

Calibration

End-to-End Calibration of PMM200 and PMM600 Pressure Measurement Modules

Kyle Clark
5-October-2017

FLUKE ® Calibration

Example

- Calibrate a PM200 module from a 6270A pressure calibrator in the PMM Calibration Kit with a PPC4 pressure controller (any reference can be used)

- Macros are used to:
  - Read cal coefficients
  - Calculate new coefficients
  - Run Verification (optional)

6270A

PMM Cal Kit

PPC4

Example (apply to other applications)

Although this example is to calibrate a PM200 module from a 6270A pressure calibrator in the PMM Calibration Kit with a PPC4 pressure controller, the logic and macros can be used for many types of DUTs

Changes for other DUTs

- Change the commands in the macros
- Comment out or delete unnecessary lines of code in the macros.

Configuring COMPASS to run a test

- Setup → DUT

- Setup → Piston Gauge (only if you use piston gauges or deadweight testers)

- Setup → Support Device (any device that is not a DUT, deadweight tester or piston gauge)
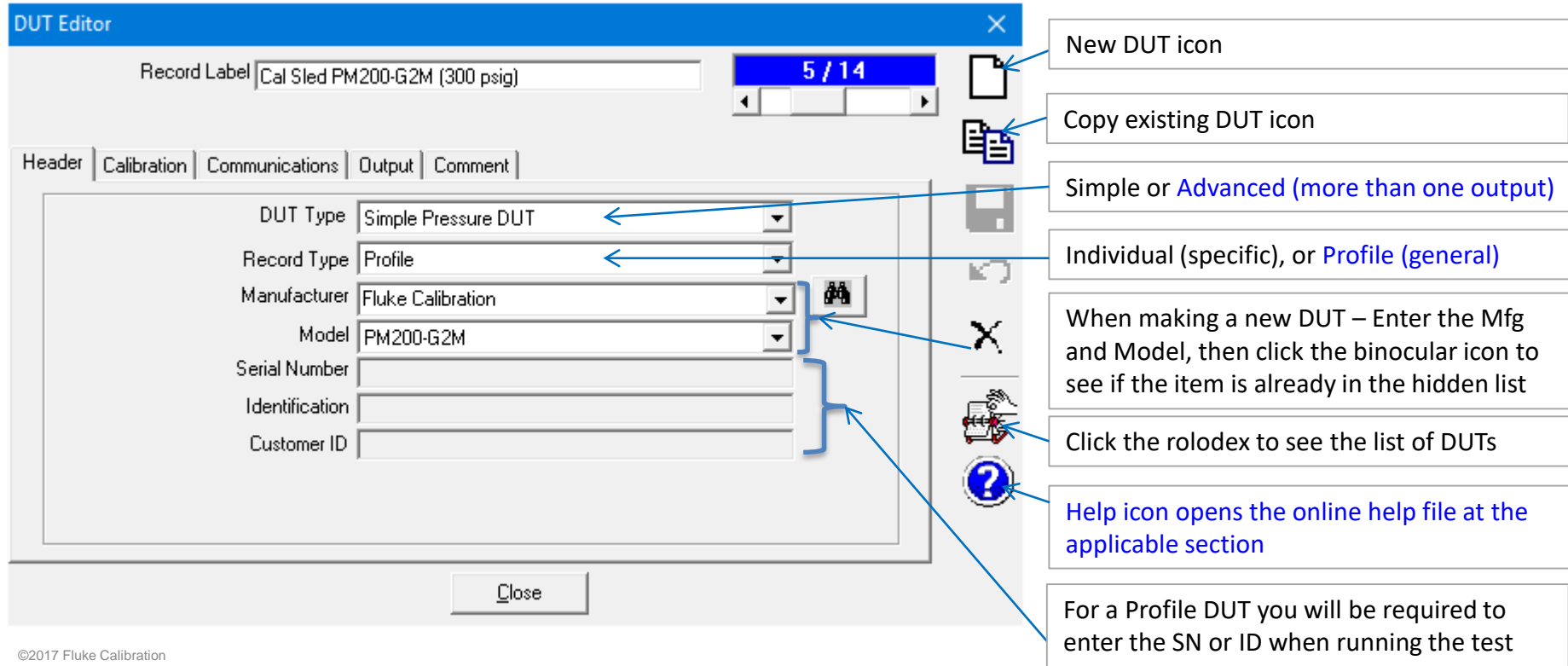
- Setup → Test

    Note that there are many comments in the following pages explaining what additional choices can be made. Default settings are shown, and should remain unless necessary.

Setup DUT (Screen-shots on following pages)

- Enter for all devices
  - Manufacturer, model, serial number and/or ID (SN or ID not needed for profile/generic DUTs)
  - Test to use with the DUT
  - Communication method (manual, RS232, IEEE, other device, etc.)
  - Min/max range, unit, tolerance
  - Remote command(s)
- The entered info can be used during the test, is saved to the data file, and can be shown on calibration reports

Setup DUT (Device Under Test)
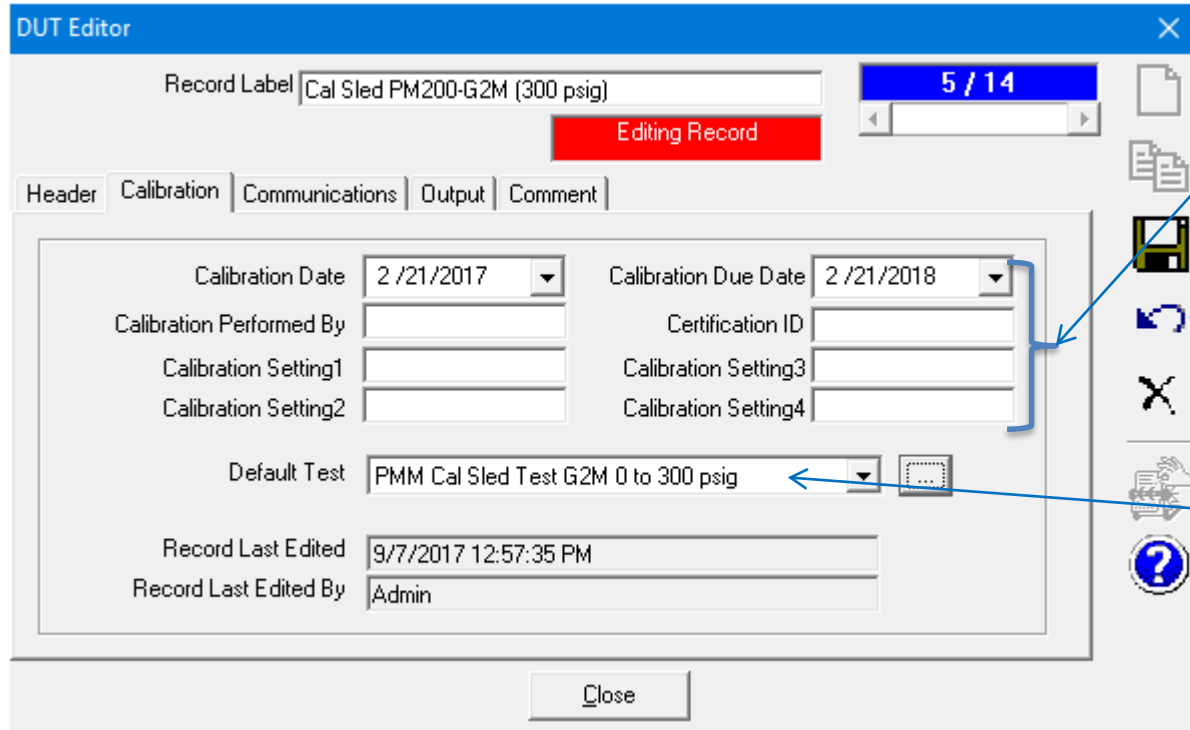
Header Tab – PM module is setup as a Simple DUT

DUT Editor

Record Label: Cal Sled PM200-G2M (300 psig)   5 / 14

Tabs: Header | Calibration | Communications | Output | Comment

- DUT Type: Simple Pressure DUT
- Record Type: Profile
- Manufacturer: Fluke Calibration
- Model: PM200-G2M
- Serial Number:
- Identification:
- Customer ID:

Close

New DUT icon

Copy existing DUT icon

Simple or Advanced (more than one output)

Individual (specific), or Profile (general)

When making a new DUT – Enter the Mfg and Model, then click the binocular icon to see if the item is already in the hidden list

Click the rolodex to see the list of DUTs

Help icon opens the online help file at the applicable section

For a Profile DUT you will be required to enter the SN or ID when running the test

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Setup DUT (Device Under Test)

Calibration Tab - All cells are optional

Calibration info or settings can be included on the cal report and/or used in a macro. Example: Cal Setting 1 (CalInfo1) could be offset & Cal Setting 2 (CalInfo2) could be slope. You could also prompt for these at the start of a test.
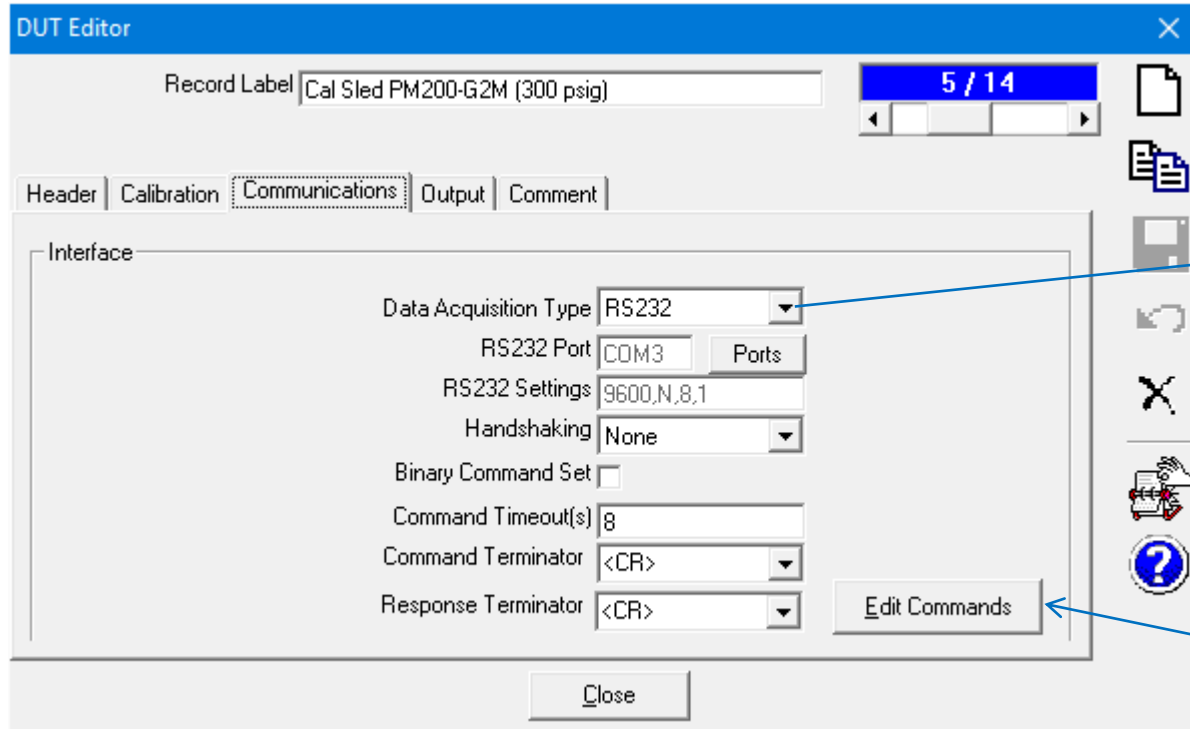
Click the Restore button at any time to undo any changes and restore to the last saved version

Specify the Default Test so the technician doesn't have to pick it when initializing the test

Setup DUT (Device Under Test)

Communications Tab – for the PMM Cal Kit

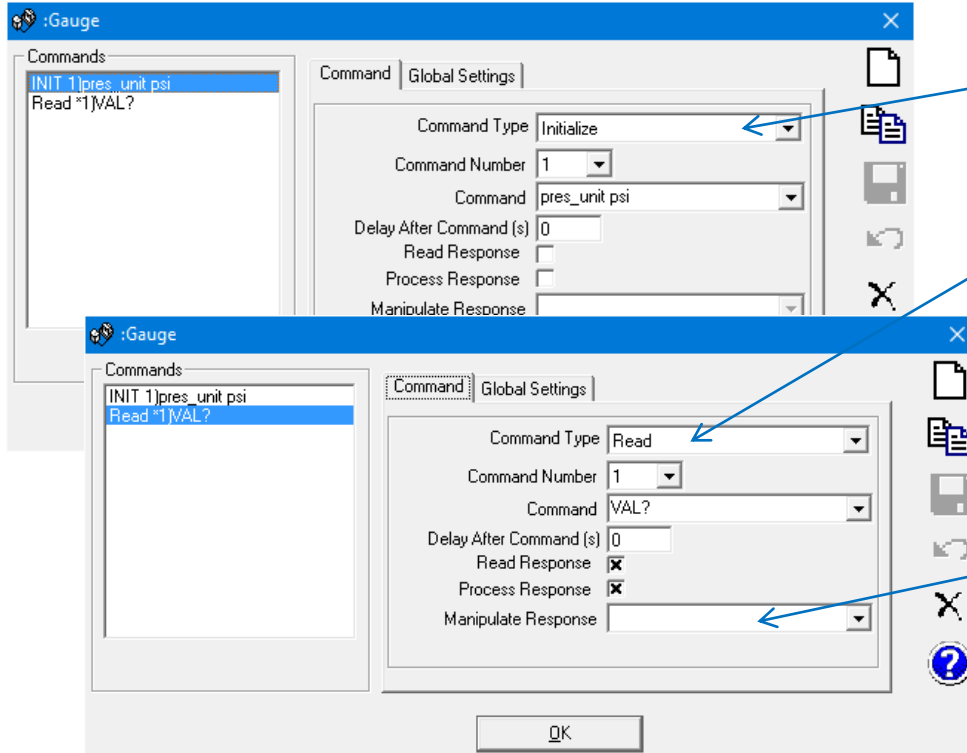Many communications methods possible

For a Simple DUT, commands are edited from the Communications tab view

Setup DUT (Device Under Test)

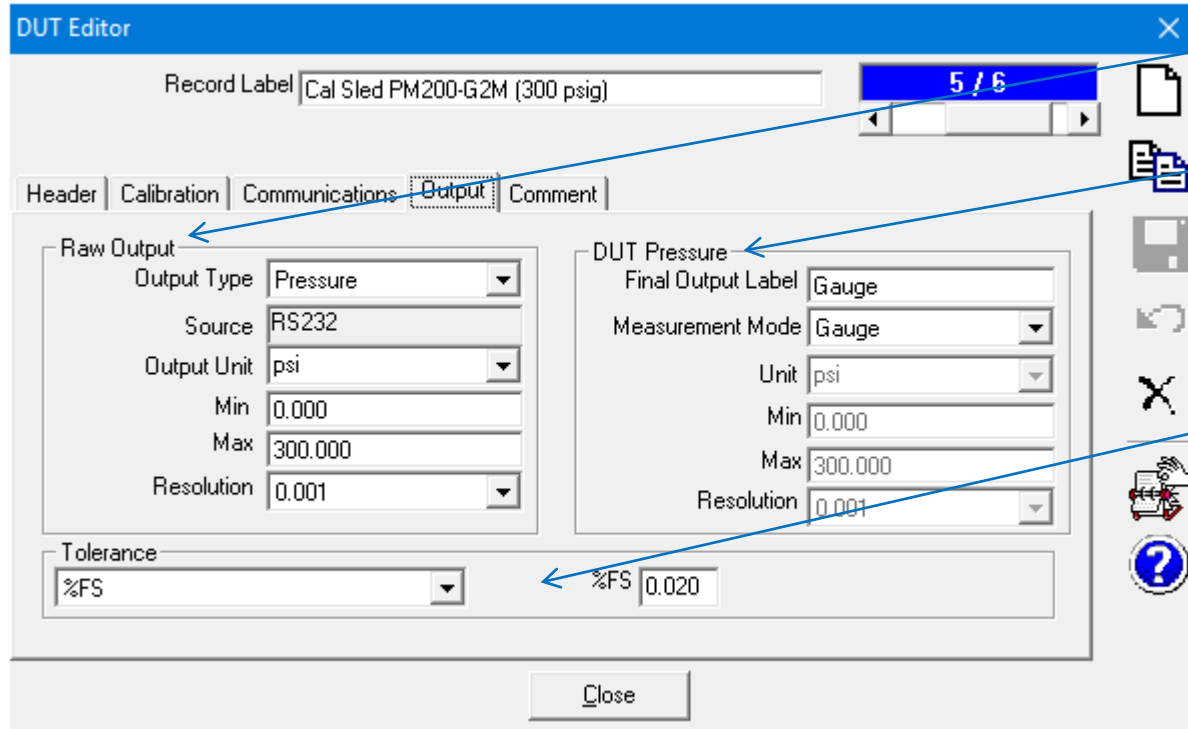## Communications Tab – [Edit Commands] button, for the PMM Cal Kit

Initialize command sets units to psi.
Test macros can be called here also
(instruct technician to do something, etc.)

Read command is processed by COMPASS

Manipulate Response box can be used to parse the reply; enter two commas to skip everything before the second comma, enter the number 4 to skip the first 4 characters of a reply, or use a ReplyParser macro

Setup DUT (Device Under Test)

Output Tab – Simple DUT

Raw Output is typically pressure, volts or milliamps

Final output is always pressure (for a DUT)

If different, the final output is linear proportional to the raw output.
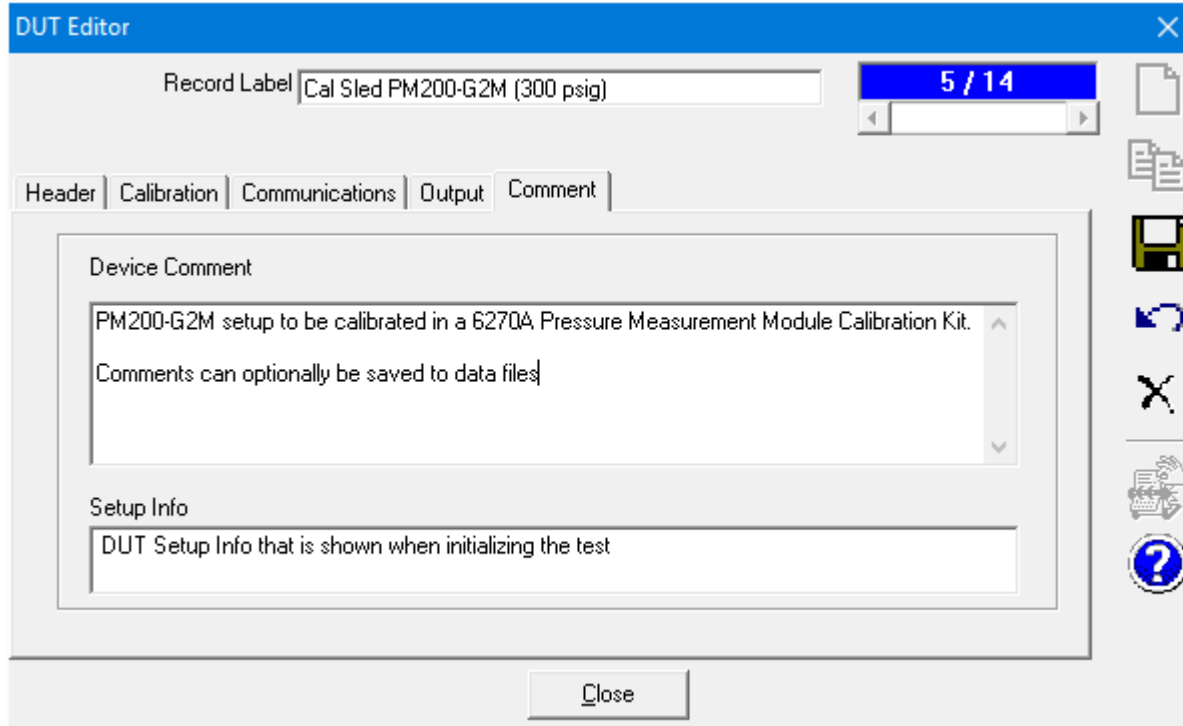For example 0-5V to 0-100 psi

Many options for Tolerance (even more for Advanced DUTs)

Setup DUT (Device Under Test)

Comment Tab – All cells are optional

DUT setup takes some time but is done only once for each DUT, and doesn't have to be done each time you run a test.

Most often, existing DUTs are copied to make new DUTs (edit range, commands, etc.)

Setup Support Devices

Support Devices are all devices that are not DUTs, piston gauges or deadweight testers

- Setup is the same as DUT (advanced/simple device, read and set outputs, communications)
- Example today uses a PPC4 controller

Setup Test (Screen-shots on following pages)

Test Definitions specify how the test will be performed

- Leak check and/or exercise the DUT (optional)

- Define set points

- Specify Reference(s), any other Support Devices

- Ready/not ready criteria

- Dwell time (wait time before taking data)

- Data collection method (manual or averaging)

- Specify calibration report template to use (with Advanced test with COMPASS for Pressure Enhanced)

Pre-Test Tab – all settings are optional

Pre Test Macro to provide instructions, query technician for needed info (message entry box), turn on a driver (to a vac pump), etc.

Leak Test – Typically set "Leak Rate Limit" to 10% of the DUT's tolerance

Setup Test

Pressure Tab – Set Points

Unit - Set to %DUT FS for a more universal test

Read - Specify the Reference Device (more options on the [Read] child tab

Set - Specify the Controller (more options on the [Set] child tab)

Jog Before Dwell - Typically only for cardinal point calibrations on analog gauges (needle exactly on the mark)
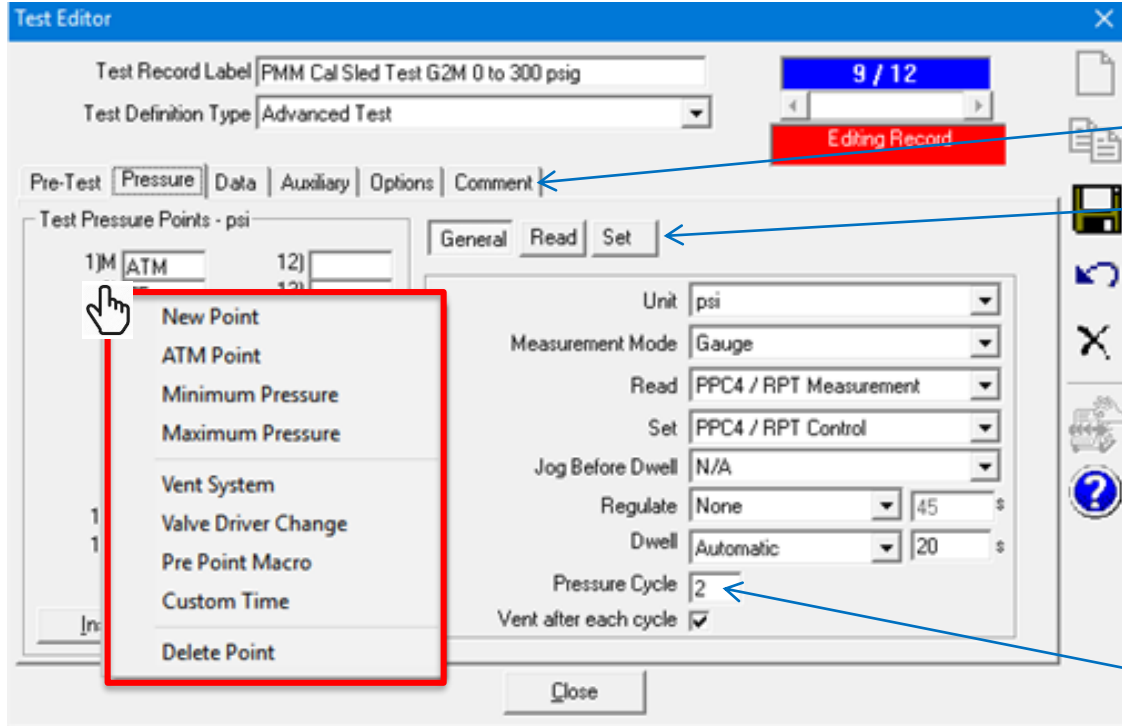
Regulate – With an automated controller, adjust the pressure every xx seconds so the Reference or DUT pressure matches the set point exactly

Dwell – Enter zero (0) for no dwell (soak) time

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Setup Test

Pressure Tab

Called "Parent Tabs" in help file

Called "Child Tabs" in help file

Click the point number next to each point to get a list of point options
- "Valve Driver Change" will activate the specified driver (typically a relay). Must have a Valve Driver Controller setup as a Support Device. (open/close a valve, turn on/off a vacuum pump, etc.)
- "Pre Point Macro" is added the same way as a Pre Test Macro

How many times to run this pressure cycle. In our example we run two, As Found & As Left

Setup Test

Pressure Tab – "Read" Child Tab

Add or Edit References, specify what points they are used at. Can also specify exactly which Q-RPT or piston or module to use so the technician doesn't have to (if applicable) in the [Edit] window

Pressure Tab – "Set" Child Tab

Add or Edit Controllers (not common), specify what points they are used at

Dynamic or **Static** control mode (if applicable)

COMPASS or **Controller** determines ready condition (if Controller has a Ready/Not Ready reply)

How close to set point to get a Ready condition (in Dynamic mode). Typically 10% of the DUT tolerance (if possible)
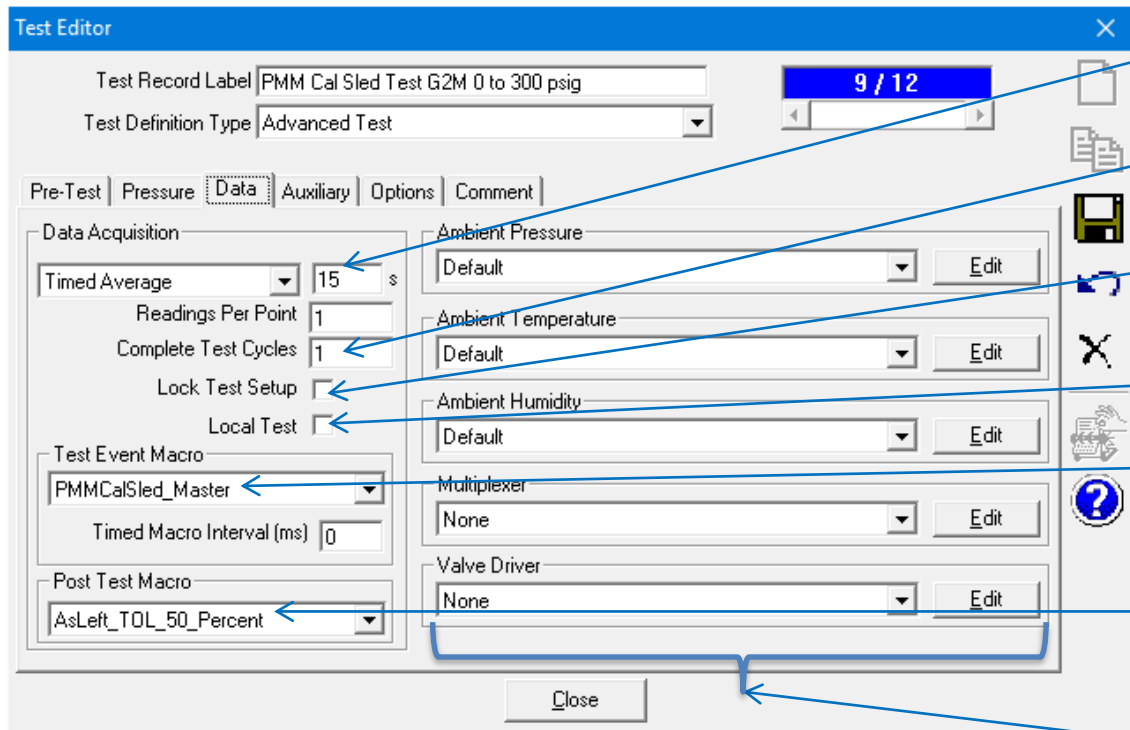
How stable to get a Ready condition (in Dynamic mode). Typically 10% of the DUT tolerance (if possible)

How long to be Ready to continue to Dwell

Timeout to get Ready (continue or abort test)

Data Tab

Enter zero for no averaging

How many Complete Test Cycles to run (with pre test macro, leak test, exercise (optional temperature and/or line pressure cycles)

Prevent users from editing tests

If checked test can only run on this PC (must have networked install)

Add a Test Event TestMacro (many capabilities with this)

Add a Post Test TestMacro (many capabilities with this). This one checks if any as-left errors are more than 50% of the tolerance. Change to"None" if you don't want this checked.

Specify other Support Devices to use

Setup Test

Auxiliary Tab – Optional, specify any Aux devices to use

Setup Test

Options Tab (only with Advanced Test)

Specify calibration report template. Useful if you have multiple templates. Our example uses a custom As Found – As Left template

Automatically open cal report when test is done

Setup Test

Comments Tab – All cells are optional
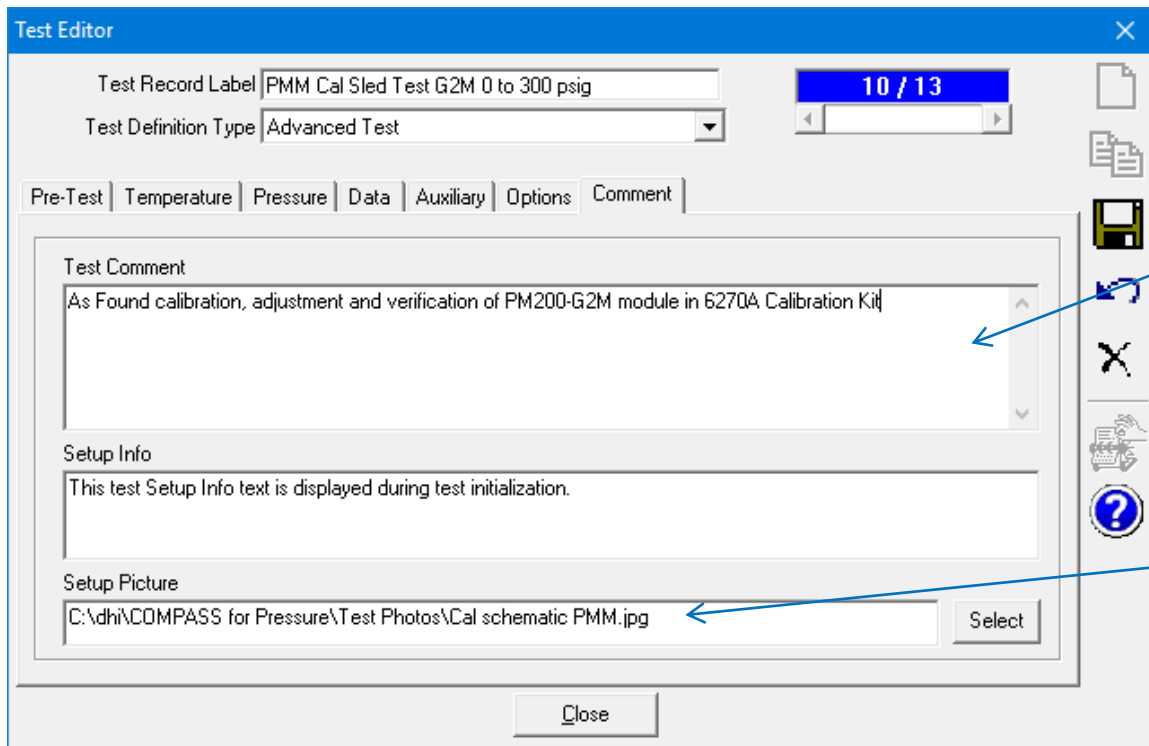
Can be saved to data file if desired

Technician can view this picture when initializing the test

Run Test

Run → Run Test Definition (screen-shots follow)

- Initialize Test - Follow the on-screen prompts for selection of DUT(s), the Test and any Support Devices

- Run Test - Proceed through the leak test/exercise, test points, collecting data (might be fully automated)

- End Test - Upon completion, click to create the calibration report in the COMPASS Report Editor (or it might open automatically if configured to do so)

Initialize Test

Select Units / User
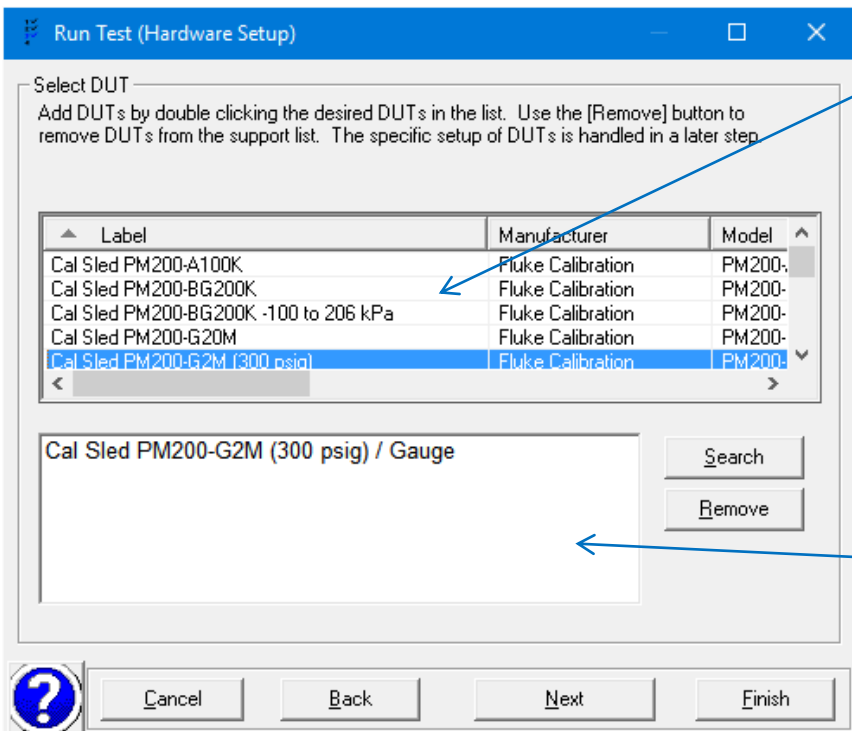
Can run test in different units than device and/or test setups

Clear history of the previous run. If you want to run the same exact DUT, test, etc. (you made a mistake the last time) just press the [Finish] button and the same previous test will run

Initialize Test

Select DUT(s)
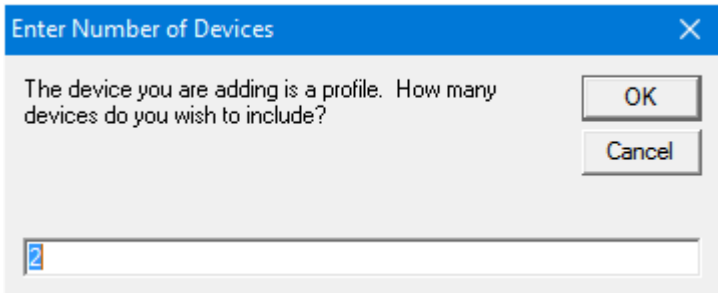
List of available DUTs. Double-click to select (then shows in bottom window). Double-click a profile DUT more than once and COMPASS will prompt you for how many

Selected DUT, PM200-G2M

Configure DUT(s)

Have to enter Serial Number, Identification or Customer ID of any Profile DUTs now

No temperature output is needed for a PMM

Click "Customize Output" link to change the range of a Profile DUT if desired

Select Test
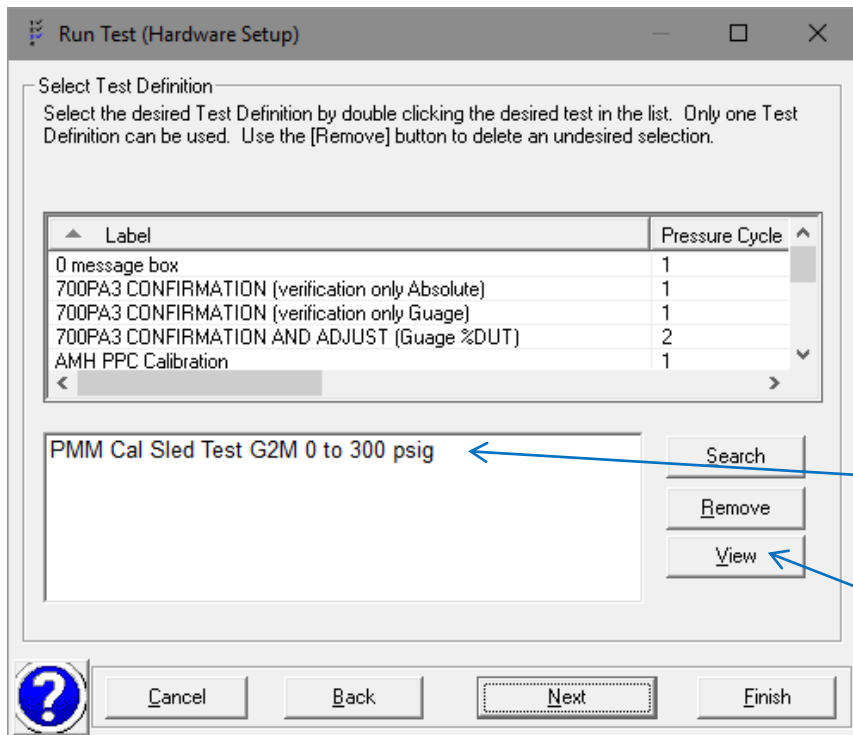
The Test we specified on the "Calibration" tab in the DUT Setup is here. Can change if desired unless the Test is locked

Can view all tabs of the Test here

Test Hardware Configuration

Devices that we specified in the Test setup populate here. Can change if desired unless the Test is locked

The image specified in the Comments tab in the Test setup shows if you click the [Setup Picture] button
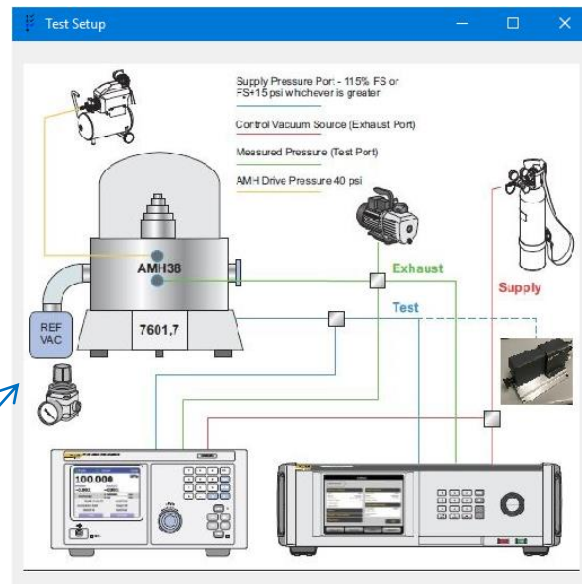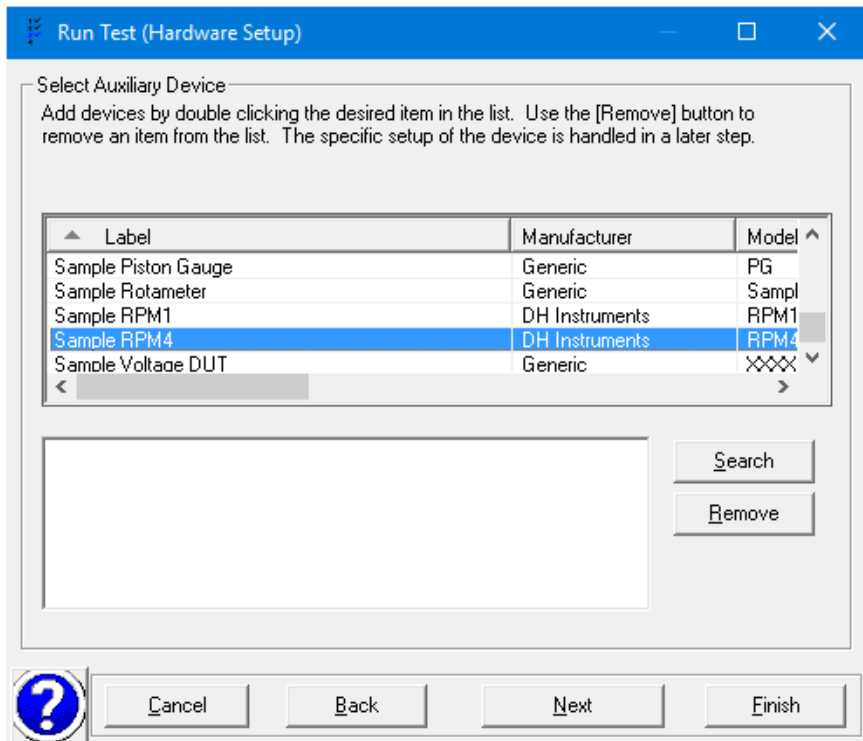
Text from the "Comments" tab in the Test setup (bold and blue to stand out)

Initialize Test

Select Auxiliary Devices (optional)

Same selection method as DUTs

You can prevent this screen from showing by this path: [Tools], <Options>, "Initialize" tab

Initialize Test

Configure/Verify Reference, Controller, Auxiliary Device(s)

Initialize Test

Final Verification / Summary

COMPASS Macro Editor (view of)

Test Macro "PMMCalSledMaster" (Specified on the Data tab in the Test)

COMPASS Macro Editor

Edit   Settings

All Code
- DataFile
- GetCommand
- GlobalCode
- Interface
- Relationship
- ReplyParser
- ReportField
- Test
  - _Declaration
  - AsLeft_TOL_30_Percent
  - AsLeft_TOL_50_Percent
  - CalActivate
  - CalActivate_PreTest
  - Fluke700_Zero
  - Fluke700CalibrationAdjust
  - Fluke700P_Zero
  - Fluke700PCalibrationAdjust
  - Fluke700PShutDown
  - FPG_CloseBypass
  - FPG_OpenBypass
  - FPG_ZeroandVent
  - LogReadyAndPrs
  - MsgBoxPreTestDummy
  - PM200_BG200k_pretest
  - PMMCalSled_Master

Title

PMMCalSled_Master

```
5273  Function PMMCalSled_Master(iT, iL, iC, iP, cTest, cConfig)
5274
5275  ' Determine which macro to run.   There are five Meas Mode codes:
5276  '0 = Absolute
5277  '1 = Gauge
5278  '2 = Abs by Atms
5279  '3 = Differential (Bi-Directional)
5280  '4 = ???
5281  '5 = Negative Gauge
5282
5283      Select Case cTest.TestPrsMeasMode
5284          Case 0:
5285              Call FlukeCalSledAbsolute(iT, iL, iC, iP, cTest, cConfig)
5286          Case 1:
5287              Call FlukeCalSledGauge(iT, iL, iC, iP, cTest, cConfig)
5288          Case 3:
5289              Call FlukeCalSledDifferential(iT, iL, iC, iP, cTest, c
5290
5291      End Select
5292
5293  End Function
```
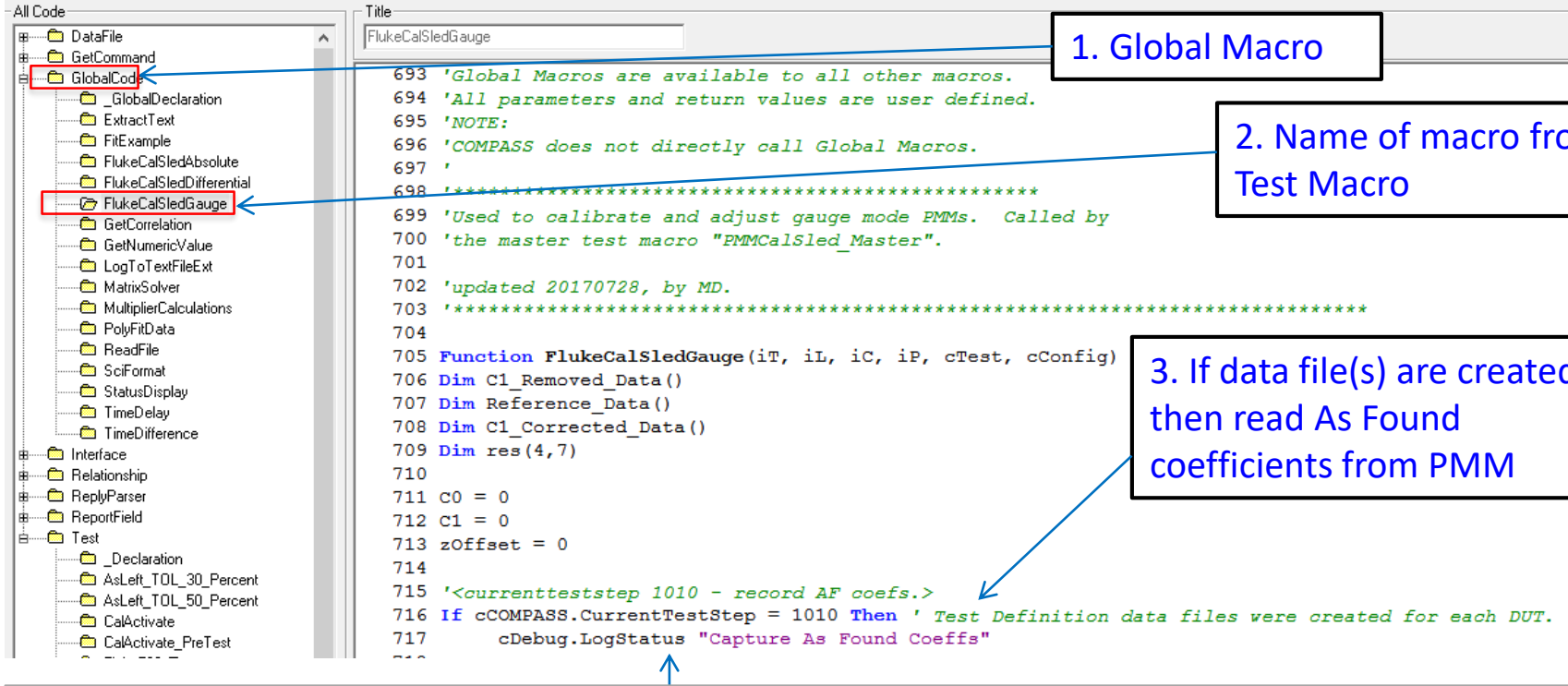
1. Test Macro

2. Macro

3. This Test Macro calls the appropriate GlobalCode macro based on the mode of the Test; Absolute, Gauge, Differential

4. Green text are comments

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Calibration

Global Macro "FlukeCalSledGauge"

1. Global Macro

2. Name of macro from Test Macro

3. If data file(s) are created then read As Found coefficients from PMM

4. Debug statements show in the macro spy window (during the test) and are logged to the macstat.log file. Very useful for troubleshooting macros and saving extra info that is not saved to the data file

Global Macro "FlukeCalSledGauge"

```
cDebug.LogStatus "Capture As Found Coeffs"

For i = 1 To cConfig.DUTPrs.Count
        cDebug.LogStatus "DUT: " & i

        ' Read A/F C0 from PMM; write to calcoef1:
        C0 = cConfig.DUTPrs(CInt(i)).IoSendCommand("OFFSET_SET?", False)
        cCOMPASS.DataCollection(i).DUT.CalibrationCoefficient1 = c0
                cDebug.LogStatus "Command OFFSET_SET?: " & C0
                cDebug.LogStatus "CalibrationCoefficient1: " & cCOMPASS.DataCollection(i).DUT.CalibrationCoefficient1

        ' Read A/F C1 from DUT; write to calcoef2
        C1 = cConfig.DUTPrs(CInt(i)).IoSendCommand("GAIN_SET?", False)
        cCOMPASS.DataCollection(i).DUT.CalibrationCoefficient2 = c1
                cDebug.LogStatus "Command GAIN_SET?: " & C1
                cDebug.LogStatus "CalibrationCoefficient2: " & cCOMPASS.DataCollection(i).DUT.CalibrationCoefficient2

        ' Read A/F zOffset from PMM, write to calcoef3:
        zOffset = cConfig.DUTPrs(CInt(i)).IoSendCommand("UCOEF_SET[0]?", False)
        cCOMPASS.DataCollection(i).DUT.CalibrationCoefficient3 = zOffset
                cDebug.LogStatus "Command UCOEF_SET[0]?: " & zOffset
                cDebug.LogStatus "CalibrationCoefficient3: " & cCOMPASS.DataCollection(i).DUT.CalibrationCoefficient3
```

For each DUT, send command to PMM to read Offset (C0) and save to DUT Cal Coef 1

Same for Slope (C1) and zOffset/AutoZero/Tare)

Macro continues…

1. Reads PMM calibration date
2. Zeroes the PMM reading at the start of the first pressure cycle
   a. Calls macro FlukeCalSled_WaitForReady that is in the PMMCalSled_Master Test Macro
   b. Calls macro FlukeCalSled_Dwell in the same test macro with a dwell time of 10 seconds
   c. Sets zOffset (AutoZero) value to zero (As Found value is already stored)
   d. Reads current offset to newOffset and converts to psi as newOffsetPsi
   e. Writes newOffsetPsi to the module to zero it, verifies it and saves to DUTRaw3
3. Test continues through the pressure points in pressure cycle 1

Global Macro "FlukeCalSledGauge"

Macro continues…

4. Calls Global Macro PolyFitData with test data
   a. Sends Reference data
   b. Sends Raw DUT data – As Found data adjusted for As Found C0 and C1 coefficients removed
   c. PolyFitData calculates new C0 and C1 values
5. Send new C0, C1 and cal date to PMM and save to DUTCalCoef4 and DUTCalCoef5
6. Test continues through pressure cycle 2 (verification run)

Macro continues…

7.   Message box is displayed
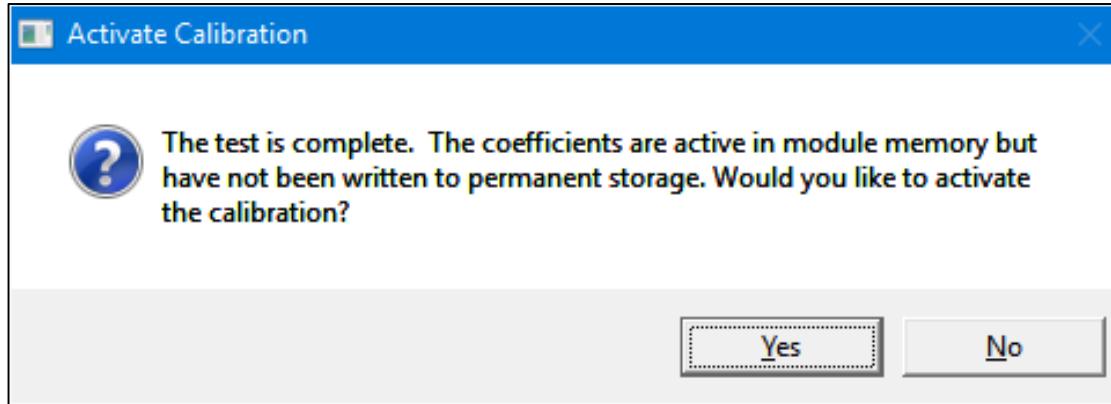
    a. [Yes], command sent to PMM to save new coefficients and cal date

    b. [No], another message box instructing to cycle power of the PMM Cal Kit to remove the coefficients from the PMM

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Calibration

Macro Spy (show macro calls and macro debug statements)

- If the test does not have a macro in it, the option to view the macro spy window does not appear
- Click the Device Run Screen Display icon and select <Show Macro Spy> to bring up the Macro Spy Window
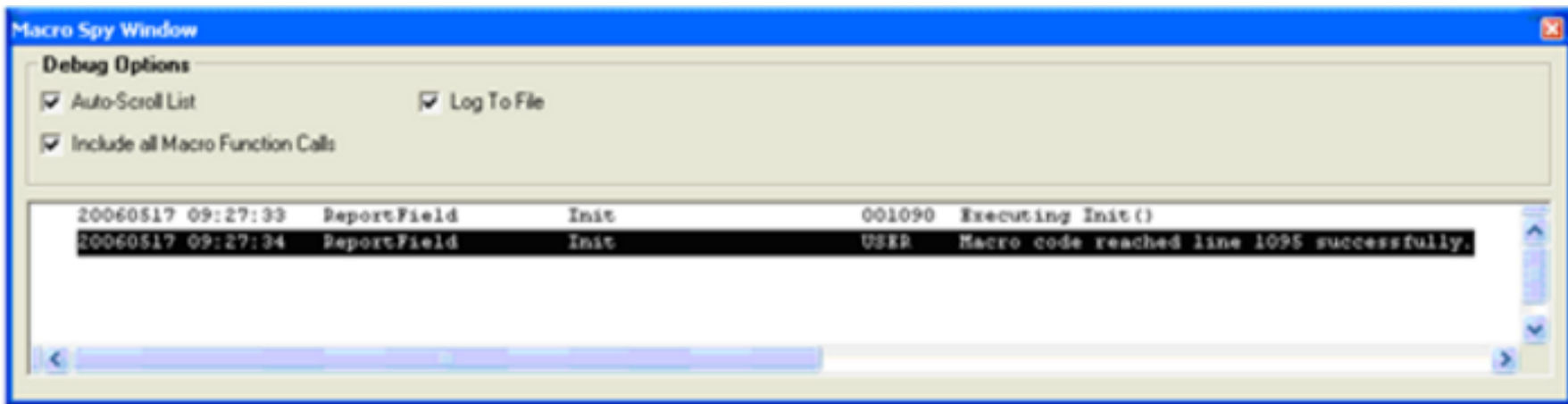
Macro Spy and macstat.log

- Ensure that the "Log To File" and "Include all Macro Function Calls" checkboxes are checked to log any debug statements and macro calls to the file c:\dhi\common\MacStat.log

- MacStat.log

20170906 14:30:20||Test||FlukeCalSledCalibrat||USER|	FlukeCalSledCalibrationAdjust new_C0: -6.68389887431305E-02
20170906 14:30:20||Test||FlukeCalSledCalibrat||USER|	CalibrationCoefficient4: -6.68389887431305E-02
20170906 14:30:20||Test||FlukeCalSledCalibrat||USER|	Sent command: OFFSET_SET -6.68389887431305E-02
20170906 14:30:20||Test||FlukeCalSledCalibrat||USER|	CalibrationCoefficient5: 0.997338053453363
20170906 14:30:20||Test||FlukeCalSledCalibrat||USER|	Sent command: GAIN_SET 0.997338053453363
20170906 14:30:20||Test||FlukeCalSledCalibrat||USER|	CalDueDate: 9/6/2017
20170906 14:30:20||Test||FlukeCalSledCalibrat||USER|	Sent command: CAL_DATE 09/06/17
20170906 14:30:20||Test||FlukeCalSledCalibrat||USER|	Sent command: UCOEF_SET[0] 0
20170906 14:30:20||Test||FlukeCalSledCalibrat||USER|	Finished with CurrentTestStep 1150
20170906 14:30:49||Test||FlukeCalSledCalibrat||003668||Executing FlukeCalSledCalibrationAdjust(1, 1, 2, 1, <object>, <object>)	

End of Test

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

- Import COMPASS data file into MET/TEAM (Optional – do from MET/TEAM)

Calibration Report

COMPASS Report Editor Produces professional quality calibration reports
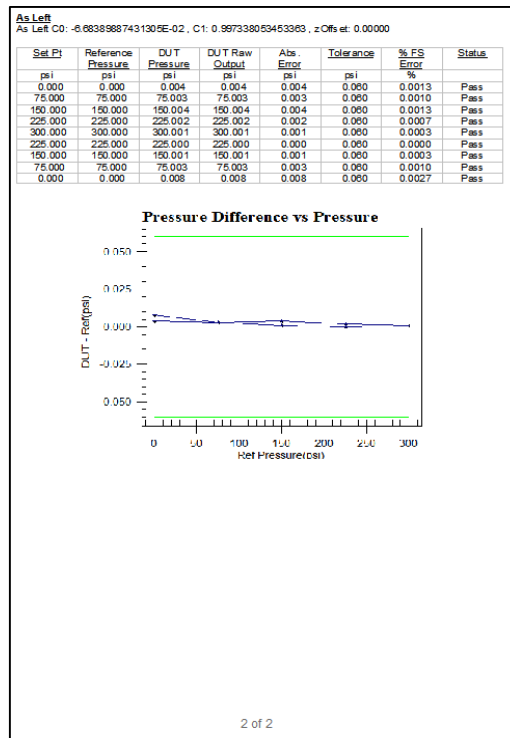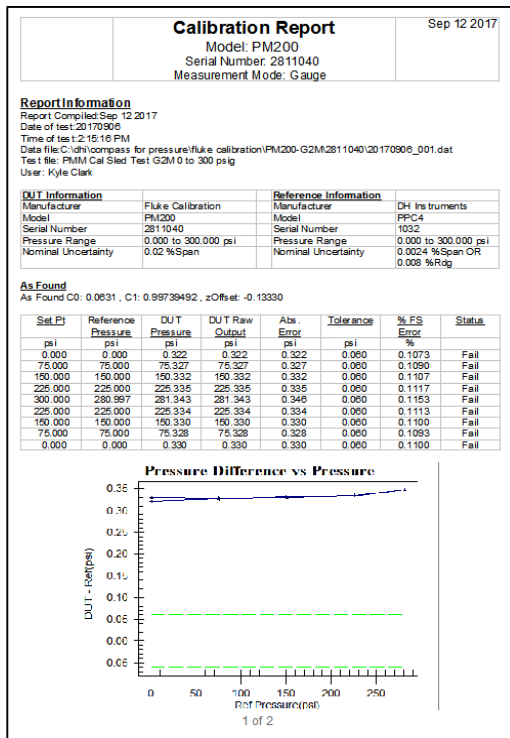
Calibration Report

COMPASS Report Editor Produces professional quality calibration reports

Title / Header section

	Calibration Report Model: PM200 Serial Number: 2811040 Measurement Mode: Gauge	Sep 12 2017

Report Information
Report Compiled:Sep 12 2017
Date of test:20170906
Time of test:2:15:16 PM
Data file:C:\dhi\compass for pressure\fluke calibration\PM200-G2M\2811040\20170906_001.dat
Test file: PMM Cal Sled Test G2M 0 to 300 psig
User: Kyle Clark

DUT Information		**Reference Information**	
Manufacturer	Fluke Calibration	Manufacturer	DH Instruments
Model	PM200	Model	PPC4
Serial Number	2811040	Serial Number	1032
Pressure Range	0.000 to 300.000 psi	Pressure Range	0.000 to 300.000 psi
Nominal Uncertainty	0.02 %Span	Nominal Uncertainty	0.0024 %Span OR 0.008 %Rdg

Calibration Report

As Found Data

As Found

As Found C0: 0.0631 , C1: 0.99739492 , zOffset: -0.13330

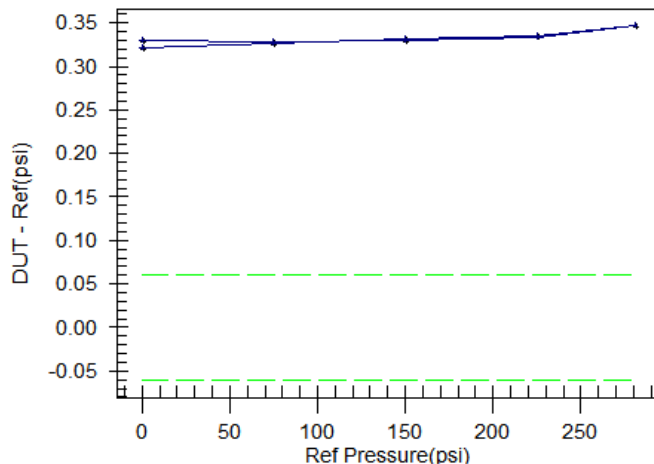| Set Pt	Reference Pressure	DUT Pressure	DUT Raw Output	Abs. Error	Tolerance	% FS Error	Status
psi	psi	psi	psi	psi	psi	%	
0.000	0.000	0.322	0.322	0.322	0.060	0.1073	Fail
75.000	75.000	75.327	75.327	0.327	0.060	0.1090	Fail
150.000	150.000	150.332	150.332	0.332	0.060	0.1107	Fail
225.000	225.000	225.335	225.335	0.335	0.060	0.1117	Fail
300.000	280.997	281.343	281.343	0.346	0.060	0.1153	Fail
225.000	225.000	225.334	225.334	0.334	0.060	0.1113	Fail
150.000	150.000	150.330	150.330	0.330	0.060	0.1100	Fail
75.000	75.000	75.328	75.328	0.328	0.060	0.1093	Fail
0.000	0.000	0.330	0.330	0.330	0.060	0.1100	Fail

Significant offset shift, unusual for a gauge mode module (but remember this is a demo)

Pressure Difference vs Pressure

Calibration Report

As Left Data

Good As Left results

As Left
As Left C0: -6.68389887431305E-02 , C1: 0.997338053453363 , zOffset: 0.00000

Set Pt	Reference Pressure	DUT Pressure	DUT Raw Output	Abs. Error	Tolerance	% FS Error	Status
psi	psi	psi	psi	psi	psi	%	
0.000	0.000	0.004	0.004	0.004	0.060	0.0013	Pass
75.000	75.000	75.003	75.003	0.003	0.060	0.0010	Pass
150.000	150.000	150.004	150.004	0.004	0.060	0.0013	Pass
225.000	225.000	225.002	225.002	0.002	0.060	0.0007	Pass
300.000	300.000	300.001	300.001	0.001	0.060	0.0003	Pass
225.000	225.000	225.000	225.000	0.000	0.060	0.0000	Pass
150.000	150.000	150.001	150.001	0.001	0.060	0.0003	Pass
75.000	75.000	75.003	75.003	0.003	0.060	0.0010	Pass
0.000	0.000	0.008	0.008	0.008	0.060	0.0027	Pass

Pressure Difference vs Pressure
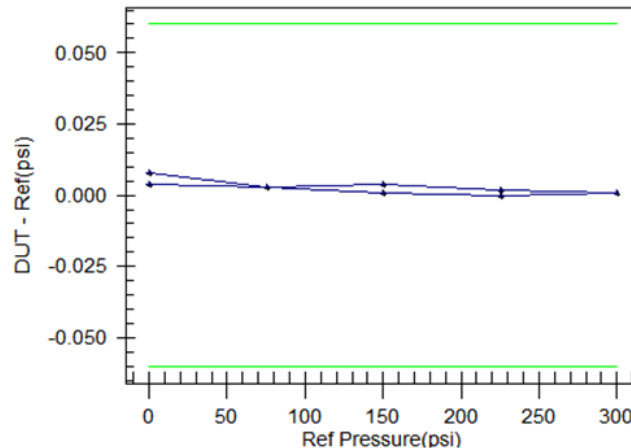
COMPASS Report Editor

Customize template (.tpl) files

- Edit any black/white text (even change language)
- Yellow fields can be selected from the available fields to the left
  - Data from data file
  - Plots (edit or make new)
  - Calculations
  - Apply macros to the data in the data file

COMPASS Macro Editor

- VB Script editor for specialized interfaces, parsing (stripping out bad replies), calculations, etc.
  - For terms unique to COMPASS see online Knowledge Base article "Macros in COMPASS for Pressure - Find names of variables, fields, parameters
        https://support.flukecal.com/hc/en-us/articles/204376304
  - For VB Script help, search internet for "vbscript" and the search term
  - Run multiple Test macros in a test by making a "master" Test macro that calls the other macros, Macros: Call multiple macros with a single macro
  - Measurement Uncertainty Macro included with COMPASS version 5

Other COMPASS resources

- Application Notes
  - Knowledge and Information tab of the COMPASS for Pressure web page at flukecal.com

- Overview and video tutorial files
  - Online Knowledge Base at support.flukecal.com

- Miscellaneous
  - Search Fluke Calibration website flukecal.com for "COMPASS for Pressure"

Other COMPASS resources

- Example macros
  - Look through the COMPASS Macro Editor
    - [Ctrl] + [F] for the Find/Search window
    - Copy the text from a macro to a new macro and edit it
      - The macros in this example are a great template for many devices
  - Search the COMPASS Macro Editor help file
  - Search the COMPASS help file (yes, two different help files)
- Contact Pressure Technical Support
  - pressuresupport@flukecal.com

COMPASS Training Classes

1. **Formal courses in Phoenix, Arizona, USA**

   ## [Register today at](#)

   http://us.flukecal.com/training/pressure-calibration-training/setting-and-using-compass%C2%AE-pressure-software

2. **Onsite at your facility**

Register now: Setting Up and Using COMPASS® for Pressure Software

October 3-6, 2017
4 days
Phoenix, AZ, USA

Learn to set up and use COMPASS for Pressure calibration software. Bring your laptop and a device under test and practice configuring a setup that is specific to your needs. We'll use piston gauges, automated pressure controller/calibrators, reference pressure monitors and a variety of gauges, calibrators, transducers and transmitters to give you plenty of hands-on experience.

Course topics

- Overview of COMPASS objectives
- General principles and structure
- Advanced devices under test
- Advanced tests and software macros

Register today

Questions?

Contact Pressure Technical Support
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Thank you

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