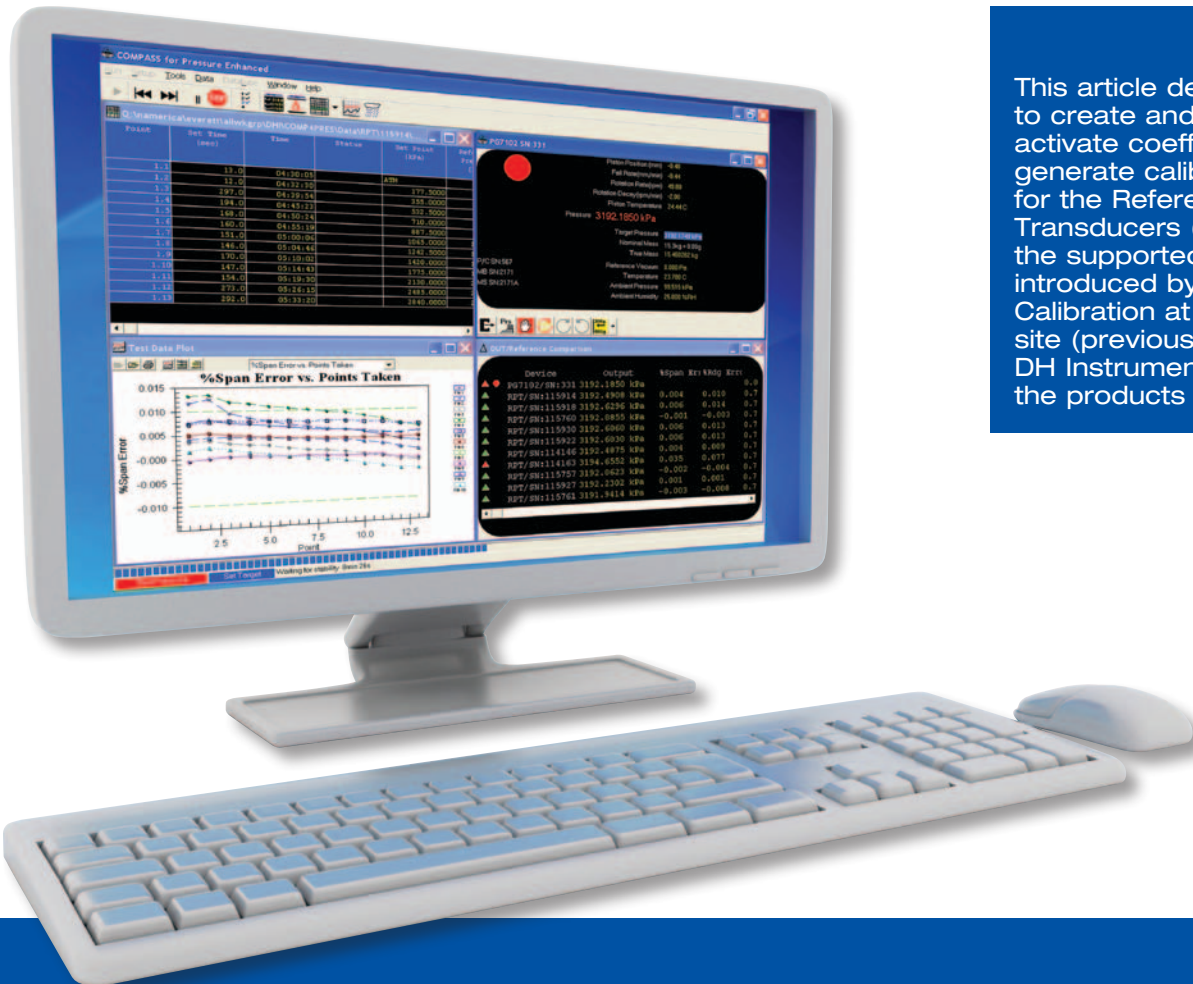


How to calibrate reference pressure transducers with COMPASS® for Pressure Software

Application Note



This article describes how to create and run tests, activate coefficients and generate calibration reports for the Reference Pressure Transducers (RPTs) in the supported products introduced by Fluke Calibration at the Phoenix site (previously known as DH Instruments) including the products listed below.



- PPC series pressure controller/calibrators



- RPM series pressure monitors



- molbox® flow terminals

Requirements

The following items are required to implement this setup.

- **COMPASS for Pressure Enhanced** version 4.2 or later. The calibration test needs to use macros, so the enhanced version of COMPASS software is required.
- The .NET DLL **CaltoolExt.dll** and the associated files. The DLL is installed and registered with the installation of COMPASS for Pressure version 4.2 or later. The associated files will be copied to the same directory of CaltoolExt.dll during the installation.
- Macros used for the **Test Definition** and for reporting. The default.mdb shipped with COMPASS for Pressure version 4.2 or later contains these macros.
- The **report templates** "RPTCalibration.tpl" and "RPTCalibration_As Left.tpl".

Supported products

Except for a few legacy products (PPC1, PPC2 and PPCK), all former DHI products that use RPTs are supported, including:

- PPCs: PPC2+, PPC2AF, PPCK+, PPCH, PPCH-G, PPC3, PPC4, PPC4E
- RPMs: RPM3, RPM4, E-DWT
- molbox: molbox1, molbox1+, molbox RFM

When running tests and calibrating these devices, the device needs to be set up as a device under test (DUT) with "Autodetect setup" on the [Header] tab of the DUT Editor.

Note: Caltool for RPTs will still be available as free software. But it is frozen without further code modification to support new products or new Microsoft Windows® platforms, or fix any bugs. The calibration of legacy products such as PPC1, PPC2 and PPCK has not been incorporated into COMPASS for Pressure. Caltool for RPTs is still a good choice to calibrate these products.

License

There is no special license needed to enable COMPASS for Pressure to do user calibration on the supported products mentioned above. To adjust the factory coefficients for factory calibration, a license file, Caltool.lic, is required in the directory of "C:\DHI\COMPASS for Pressure."

The capability to calibrate DHI RPT products (referred as "Caltool Mode") is always available to the user even after the Demo license expires, or the available license seats exceed the allowed limits. In such cases, COMPASS for Pressure will turn into "Caltool Mode" and only the "Autodetect" products will show on the DUT list.

Collecting calibration coefficients

The difference between the normal tests run under COMPASS for Pressure and the test run under Caltool Mode of COMPASS for Pressure is that the latter collects the calibration information of the DUT and saves the information in the data file. The calibration information will be used later to calculate the new coefficients and predict the As Left DUT data during report generating process.

To enable Caltool Mode of COMPASS for Pressure, the following option under [Tools][Options][Initialize Test] must be enabled:

Load calibration info for auto-detect devices.

In addition, the fields "User Defined1," "User Defined2" and "User Defined3" shall be selected to log in the data file from [Tools][Options][Data In File]. These fields are used to store the predicted DUT pressure, predicted "%FS error" and predicted "%Reading error", which will be saved in the data file as "res file" after successfully activating the new coefficients to the product.

The CalInfo1 to CalInfo5 of DUT header in the data file are used to store the calibration information. See the details as the following:

As received

Calinfo1: "RPT range unit mode SN" like "IH 10342.0 kPa A SN97174"

Calinfo2: "{(As Received) User PA:0 PM:1 Date:20060106 ZOff:1}"

Calinfo3: "{(As Received) Factory PA:0 PM:1 Date:20060106}"

Calinfo4: IO settings, "IEEE 10" or "COM1 9600 E 7 1"

As left

Calinfo5: "{(As Left) User PA:0 PM:1 Date:20060106 ZOff:1 ZNatErr:2}"
or

Calinfo5: "{(As Left) Factory PA:0 PM:1 Date:20060106 ZOff:1 ZNatErr:2}"

Activating when generating a report

Using the special report templates, a calibration report can be generated from the data file collected under Caltool Mode with calibration coefficients. After the report is generated, the user has the option to activate the new coefficients into the device connected. The template can also be selected as the “Default Report Template” in the test definition, so that the report will be generated automatically at the end of test.

Note: Up to 10 data files can be loaded to generate reports at the same time under the condition that all the data files were generated during the tests that have the same measurement mode.

Several items are needed in the report template:

- The Template Macro “CalToolExt”. This macro is used to create the object for CaltoolExt.dll and pass the data files (up to 10) to the DLL.
- Field Macro “CalInfo”. This macro is used to get the calibration info from DUT Calinfo fields and extract the fields to display on the report.
- User defined plot “%Span Error vs. Reference Pressure – As Left”. This plot is used to display the predicted %FS error.

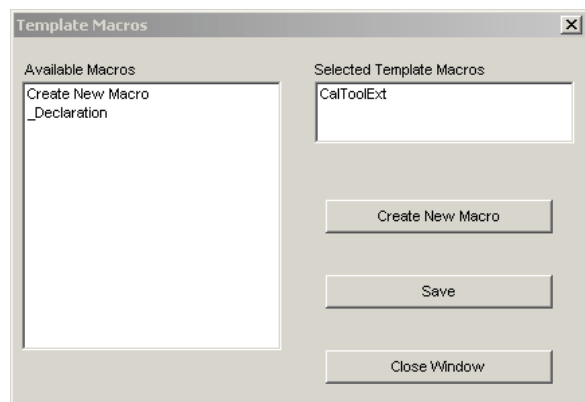
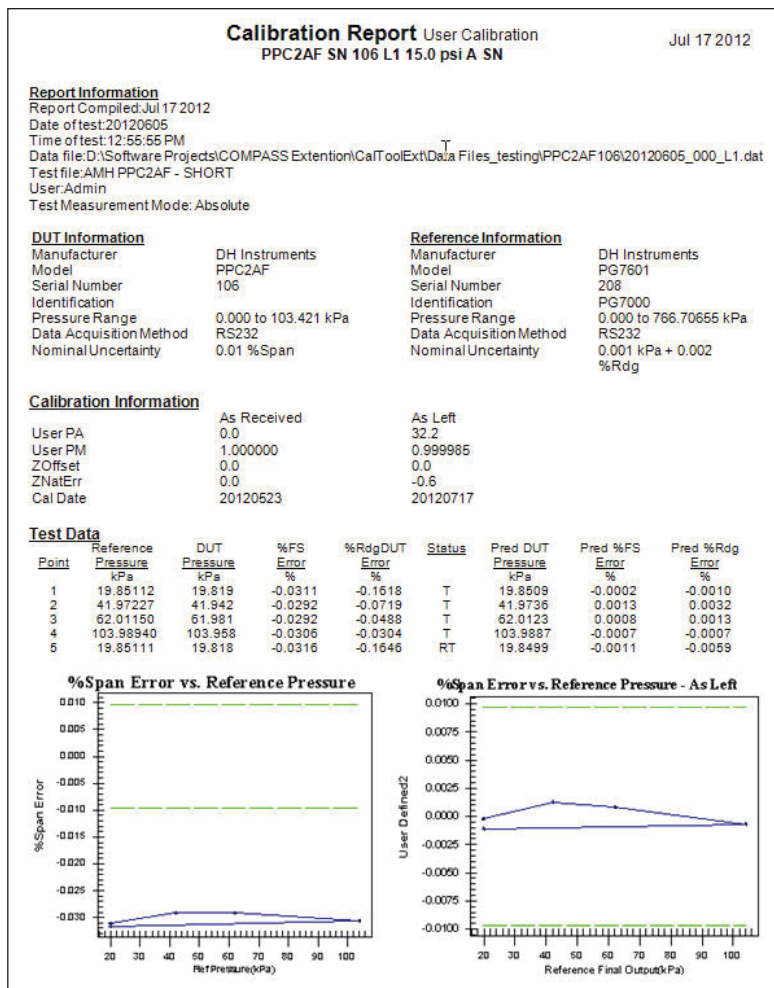


Figure: Select Template Macro “CalToolExt” in the report template

The “Force Standard Regression” option is shown only when the test is conducted in Gauge mode. If it is checked, the standard regression is used. Otherwise, the new pressure adder is determined by taking the average difference from the reference pressure from the first and last point, and then this adder is applied to the DUT pressure prior to regression.

After the report is generated, the following “Calibration Activation” form is displayed. The user can inspect the calibration reports and choose the DUTs to be activated. If the report is generated at the end of test, the IO settings for each DUT should be still valid. If the report is generated from data files, the IO settings maybe be different, and should be modified and tested on this form before activating the new coefficients.

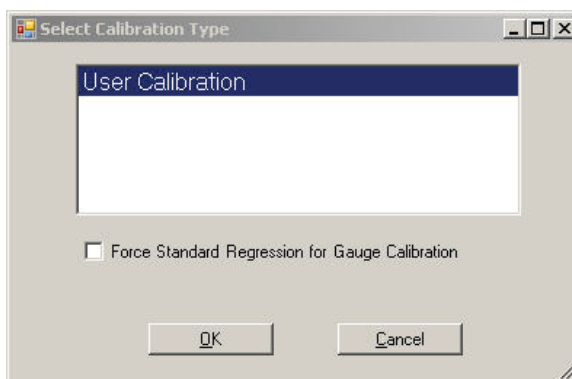


Figure: Calibration Type selection

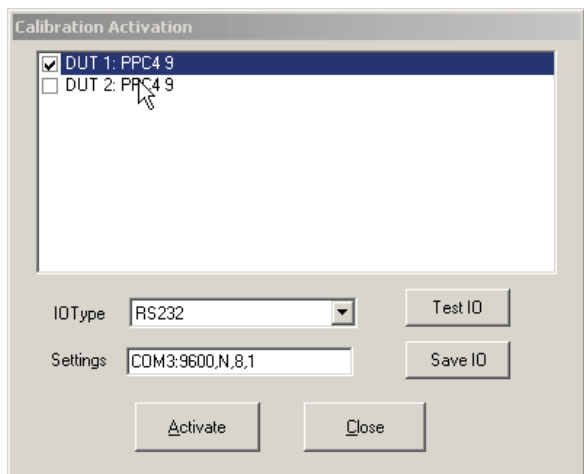
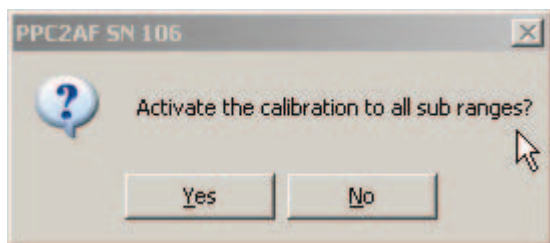


Figure: Calibration Activation

For PPC2+, PPC2AF, PPCK+ and RPM3, the user can have the option to activate the sub-ranges if applicable. Example: for the calibrated range “L2,” the new calibration coefficients can be activated to both L1 and L2 if the user chooses “Yes” in the following prompt during activation of the new coefficients:



Activating at the end of pressure cycle 1

The new coefficients can also be written to the calibrated product at the end of the first pressure cycle of the test, and then continue to run the pressure cycle 2 to collect the “As Left” data. There is no user prompt in the middle of test, and all the DUTs in the test will be activated. Two macros are required to set up the test:

1. Pre-Test macro “CalActivate_PreTest.”

This macro is used to select options related to the calculation and activation of the new coefficients at the start of the test.

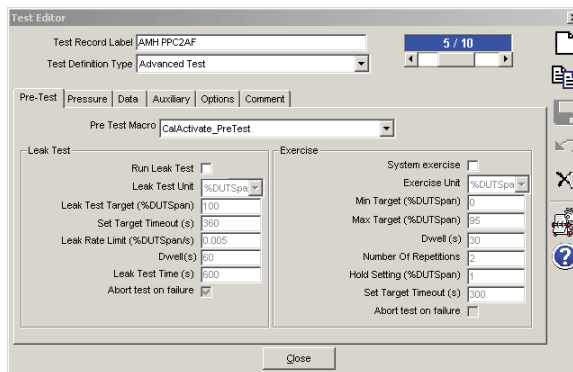


Figure: Pre-Test Macro “CalActivate_PreTest”

- **Option 1: Force Standard Regression for Gauge Calibration**

The default is false. If this option is selected, the standard regression will be used for Gauge test. If this option is not selected, the new pressure adder (Pa) is determined by taking the average difference from the reference pressure at the first and last point, and then this adder is applied to the DUT pressure prior to regression.

- **Option 2: Activate Sub-range When Applicable**

The default is false. If this option is selected, the sub-ranges will be activated with the same coefficients when applicable for PPC2+, PPC2AF, PPCK+ and RPM3. For example, if the calibrated range is “L2”, the new calibration coefficients can be activated to both L1 and L2 if the user checks this option.

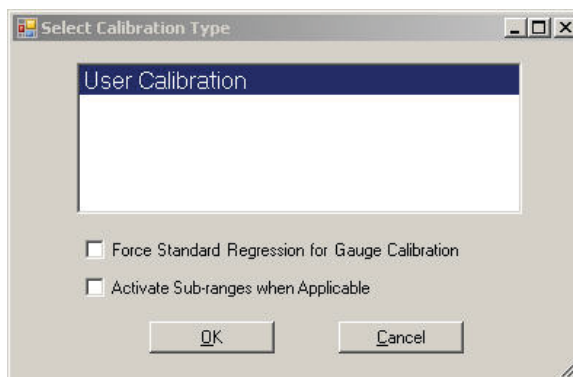


Figure: Prompt to select Calibration Type and Activation Options

2. Test Event macro "CalActivate."

This macro is used to pass data between COMPASS software and CaltoolExt.DLL to calculate the new coefficients and to write the new coefficients to the DUT.

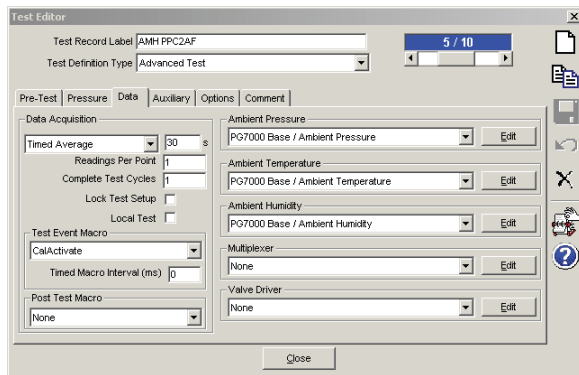
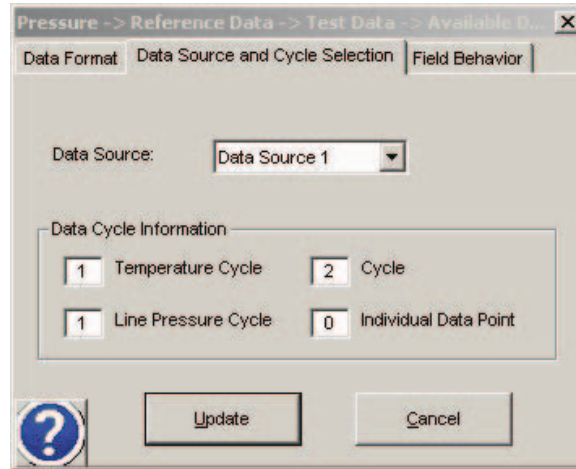


Figure: Test Event Macro "CalActivate"

In the template, "As Left" data use "Cycle" 2, while "As Received" data use "Cycle 1".



The report template for this type of test is different from the one described in previous section that activate the DUT at the end of test. Since this test activates the DUT during the middle of test, there is no need to select "CaltoolExt" macro as Template macro in the report template.

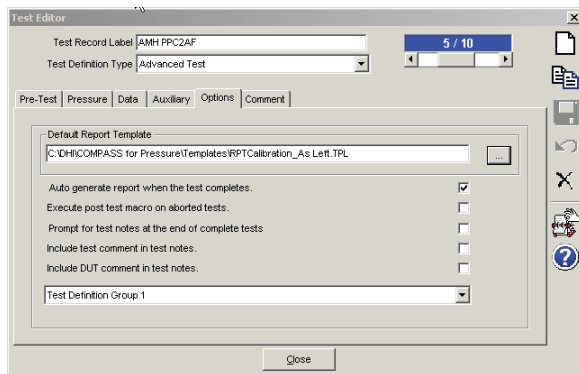
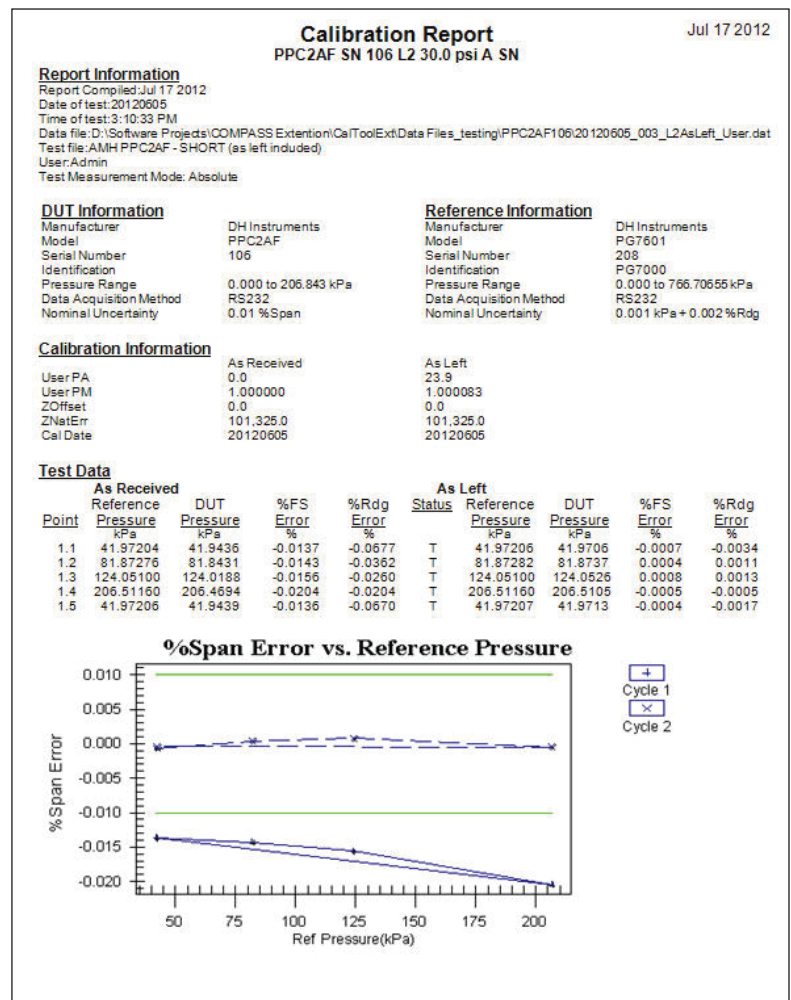


Figure: Template "RPTCalibration_As left.tpl"



View calibration coefficients

The calibration coefficients can be viewed through menu [Data][View Calibration Coefficients]. User selects the product, set up the IO and click <Continue> button to load the calibration coefficients from the support products.

Figure: View Calibration Coefficients setup form

The report shows the device information and the calibration information.

RPM4 Calibration Information	
SN 378	
Generated: 2012 June 12 15:09	
Header	
Manufacturer	:Fluke
Model	:RPM4
Serial Number	:378
Hi RPT SN	:97174
Lo RPT SN	:95365
Calibration	
Range	:IH 10342.0 kPa Abs
User PA	:0.0 Pa
User PM	:1.000000
User Calibration Date	:20120525
Zoffset	:1.0 Pa
Factory PA	:-887.2 Pa
Factory PM	:1.000014
Factory Calibration Date	:20060106
Range	:IL 3447.0 kPa Abs
User PA	:0.0 Pa
User PM	:1.000000
User Calibration Date	:20120525
Zoffset	:2.0 Pa
Factory PA	:0.0 Pa
Factory PM	:1.000049
Factory Calibration Date	:20060105

Macro code

DataFile Macro CalToolExt

```

Dim firstCall 'Caltool:flag to indicate the first function call

Function CalToolExt(colData, curFile)

Dim Obj

flag = colData(CInt(curFile)).DataInfoCollection("ID410002").flags
colData(CInt(curFile)).DataInfoCollection("ID410002").flags = flag Or 2^3

'only initialize once
If firstCall <> 1 Then
Set Obj = GetObject("", "Fluke.CalToolExt.clCalToolExt")

'already did
firstCall = 1

If colData.Count > 10 Then
msgbox "Only 10 DUTs can be supported in one calibration. Select 10 or less data files to
generate calibration report."
Exit Function
End If

'poorman parameter passing. Hard to pass collection to .NET DLL or create a collection in macro
Select Case colData.Count
Case 1:
obj.Calibrate colData.Count, colData(1), colData(1), colData(1), colData(1), colData(1), colData(1), colData(1),
colData(1), colData(1), colData(1)

```

DataFile Macro CalToolExt (continued)

```

    Case 2:
    obj.Calibrate colData.Count, colData(1), colData(2), colData(1), colData(1), colData(1), colData(1), colData(1), colData(1),
colData(1), colData(1), colData(1)
    Case 3:
    obj.Calibrate colData.Count, colData(1), colData(2), colData(3), colData(1), colData(1), colData(1), colData(1), colData(1),
colData(1), colData(1), colData(1)
    Case 4:
    obj.Calibrate colData.Count, colData(1), colData(2), colData(3), colData(4), colData(1), colData(1), colData(1), colData(1),
colData(1), colData(1), colData(1)
    Case 5:
    obj.Calibrate colData.Count, colData(1), colData(2), colData(3), colData(4), colData(5), colData(1), colData(1), colData(1),
colData(1), colData(1), colData(1)
    Case 6:
    obj.Calibrate colData.Count, colData(1), colData(2), colData(3), colData(4), colData(5), colData(6), colData(1), colData(1),
colData(1), colData(1), colData(1)
    Case 7:
    obj.Calibrate colData.Count, colData(1), colData(2), colData(3), colData(4), colData(5), colData(6), colData(7), colData(1),
colData(1), colData(1)
    Case 8:
    obj.Calibrate colData.Count, colData(1), colData(2), colData(3), colData(4), colData(5), colData(6), colData(7), colData(8),
colData(1), colData(1)
    Case 9:
    obj.Calibrate colData.Count, colData(1), colData(2), colData(3), colData(4), colData(5), colData(6), colData(7), colData(8),
colData(9), colData(1)
    Case 10:
    obj.Calibrate colData.Count, colData(1), colData(2), colData(3), colData(4), colData(5), colData(6), colData(7), colData(8),
colData(9), colData(10)
    End Select

    obj.Activate

End If

If curFile = colData.Count Then
    Set obj = Nothing
End If

End Function

```

ReportField Macro CalInfo

```

Function CalInfo(colData, curFile, userParam)

'Calinfo1: "RPT range unit mode SN" Like "IH 10342.0 kPa A SN97174"
'Calinfo2: "(As Received) User PA:0 PM:1 Date:20060106 ZOff:1 ZNatErr:2"
'Calinfo3: "(As Received) Factory PA:0 PM:1 Date:20060106"
'Calinfo4: IO settings, "IEEE 10" Or "COM1 E 7 1"

'As Left
'Calinfo5: "(As Left) User PA:0 PM:1 Date:20060106 ZOff:1 ZNatErr:2"
'Calinfo5: "(As Left) Factory PA:0 PM:1 Date:20060106 ZOff:1 ZNatErr:2"

id = GetVal(UserParam)

Select Case id
Case 1, 2, 3, 4, 5
    'Calinfo2: "(As Received) User PA:0 PM:1 Date:20060106 ZOff:1 ZNatErr:2"
    temp = colData(curFile).DUT.CalibrationCoefficient2
    temp2 = trim(qextract(temp,id,id+1,":"))

Case 6, 7, 8
    'Calinfo3: "(As Received) Factory PA:0 PM:1 Date:20060106"
    temp = colData(curFile).DUT.CalibrationCoefficient3
    temp2 = trim(qextract(temp,id-5,id-4,":"))

Case 11, 12, 13, 14, 15
    'Calinfo5: "(As Left) User PA:0 PM:1 Date:20060106 ZOff:1 ZNatErr:2"
    temp = colData(curFile).DUT.CalibrationCoefficient5
    temp2 = trim(qextract(temp,id-10,id-9,":"))

Case 16, 17, 18
    'Calinfo5: "(As Left) Factory PA:0 PM:1 Date:20060106"
    temp = colData(curFile).DUT.CalibrationCoefficient5

    If instr(temp,"Fact") <> 0 Then 'only if it is user cal
        temp2 = trim(qextract(temp,id-15,id-14,":"))
    End If

```

ReportField Macro CalInfo (continued)

```

Case 21
    'Calinfo5: "(As Left) Factory PA:0 PM:1 Date:20060106"
temp = colData(curFile).DUT.CalibrationCoefficient5

    If instr(temp,"Fact") = 0 Then
        rtv = "User Calibration"
    Else
        rtv = "Factory Calibration"
    End If

    CalInfo = rtv
    Exit Function
End Select

If temp2 = "" Or left(temp2,5) = "-9999" Then
    CalInfo = "N/A"
Else
    rtv = qextract(temp2,0,1," ")

    If id = 4 Or id = 5 Or id = 14 Or id = 15 Then 'Zoffset, ZNatErr
        CalInfo = formatnumber(CDbl(rtv),1)
    ElseIf id = 1 Or id = 5 Or id = 11 Or id = 15 Then 'PA
        CalInfo = formatnumber(CDbl(rtv),1)
    ElseIf id = 2 Or id = 6 Or id = 12 Or id = 16 Then 'PM
        CalInfo = formatnumber(CDbl(rtv),6)
    Else
        CalInfo = rtv
    End If

End If

End Function

```

Test Macro CalActivate_PreTest

```

Function CalActivate_PreTest(iT, iL, iC, iP, cTest, cConfig)
Dim Obj

Set Obj = GetObject("", "Fluke.CalToolExt.clCalToolExt")
rtv = Obj.getPretestOption
If rtv = -1 Then
    cDebug.LogStatus "User Cancelled on Activation Selection form"
    Set Obj = Nothing
    cCOMPASS.AbortTest True
    Exit Function
End If
cDebug.LogStatus "Option: " & rtv

If (rtv And 2^0) <> 0 Then
    factCal = 1
Else
    factCal = 0
End If
cConfig.DUTPrs(1).SetParamData 1,CDbl(factCal)
cDebug.LogStatus "factCal: " & cConfig.DUTPrs(1).GetParamData(1)

If (rtv And 2^1) <> 0 Then
    forceStdReg = 1
Else
    forceStdReg = 0
End If
cConfig.DUTPrs(1).SetParamData 2,CDbl(forceStdReg)
cDebug.LogStatus "forceStdReg: " & cConfig.DUTPrs(1).GetParamData(2)

If (rtv And 2^2) <> 0 Then
    subRange = 1
Else
    subRange = 0
End If
cConfig.DUTPrs(1).SetParamData 3,CDbl(subRange)
cDebug.LogStatus "subRange: " & cConfig.DUTPrs(1).GetParamData(3)

Set Obj = Nothing

End Function

```


Test Macro CalActivate

```

Function CalActivate(iT, iL, iC, iP, cTest, cConfig)
Dim Obj

' Test pressure cycle complete. All pressure points defined in a pressure cycle have been logged.
If cCOMPASS.CurrentTestStep= 1150 And iC = 1 Then 'only activate at the end of first pressure cycle.
cDebug.LogStatus "At the end of first pressure cycle."
    cDebug.LogStatus "#Data files:" & cCOMPASS.DataCollection.Count

Set Obj = GetObject("", "Fluke.CalToolExt.clCalToolExt")
factCal = cConfig.DUTPrs(1).GetParamData(1) 'set in CalActivate_PreTest macro
forceGauge = cConfig.DUTPrs(1).GetParamData(2)
activateSubRanges = cConfig.DUTPrs(1).GetParamData(3)
cDebug.LogStatus "Factory call: " & factCal
cDebug.LogStatus "forceGauge: " & forceGauge
cDebug.LogStatus "activateSubRanges: " & activateSubRanges

For i = 1 To cConfig.DUTPrs.Count
If cConfig.DUTPrs(CInt(i)).DHIDevice Then
    cDebug.LogStatus "DUT " & i & ":" & cConfig.DUTPrs(CInt(i)).RangeMain.GetParent.Label

    Obj.Activate2 cCOMPASS.DataCollection(i), factCal, forceGauge, activateSubRanges

model = cConfig.DUTPrs(CInt(i)).RangeMain.GetParent.Model
cDebug.LogStatus "model=" & model
If model = "RPM3" Then 'need to get the current unit
cmd = Obj.nextWriteCoefsCmd(reply) 'first cmd
RPTUnit = cConfig.DUTPrs(CInt(i)).RangeMain.ToSendCommand(CStr(cmd), False)
cDebug.LogStatus cmd & "->" & RPTUnit
End If

'loop through all the cmds
reply = ""
Do While 1
cmd = Obj.nextWriteCoefsCmd(reply)
cDebug.LogStatus "Cmd: " & cmd
If cmd = "" Then
Exit Do
Else
lastCmd = cmd
reply = cConfig.DUTPrs(CInt(i)).RangeMain.IoSendCommand(CStr(cmd), False)
cDebug.LogStatus cmd & "->" & Reply

End If
loop
If model = "RPM3" Then 'restore the test unit
cmd = replace(lastCmd, "xxx", RPTUnit)
reply = cConfig.DUTPrs(CInt(i)).RangeMain.IoSendCommand(CStr(cmd), False)
cDebug.LogStatus cmd & "->" & reply
End If

'gauge mode to vent and unvent to autoZ
If cTest.TestPrsMeasMode <> 0 Then
cDebug.LogStatus "Gauge mode. vent for autoZ"
cConfig.DUTPrs(CInt(i)).IoSetOutput 1,0,1 'vent and wait for ready
cCOMPASS.TimeDelay 5 'delay for a while
cConfig.DUTPrs(CInt(i)).IoSetOutput 1,-1,1 'close the vent valve
End If
End If

Next

Set obj = Nothing
End If
End Function

```

Appendix

Calculations

Overview

This section describes the mathematical manipulations used by COMPASS for Pressure to determine new calibration coefficients and predicted “as left” data. The predicted “as left” data is the result of applying the new calibration coefficients to the DUT readings taken during the test, so the predicted “as left” data shows what the DUT would have read if it had already had the new calibration coefficients. The coefficients used include: PA (Pressure Adder), PM (Pressure Multiplier), ZOFFSET, ZNATERR and ATMOFFSET. All coefficients that are pressure values are expressed in the pressure unit Pascal (Pa) but are applied mathematically in the current measurement unit when calculating predicted “as left” data. For more information on the calibration coefficients used by DHI products, see the Calibration of Reference Pressure Transducers and AutoZ Sections of the DUT’s Operation and Maintenance Manual.

Note: Not all supported DUTs utilize the AutoZ capability of multi-ranging products such as the RPM3 and PPC2+. For these devices, ZNATERR, ZOFFSET and ATMOFFSET are not used or manipulated. In these cases, assume zero in any mathematical description. molbox1 and molbox RFM do not use AutoZ.

Note: In the case of the calibration of an absolute RPT (AXXXX) in gauge measurement mode on a DUT that supports AutoZ, ZOFFSET is no longer a calibration value, it is the current atmospheric tare value to simulate gauge operation. For this reason <N/M> (Not Meaningful) displays in all ZOFFSET fields on the <Data Manipulator> display for absolute RPTs calibrated in gauge measurement mode.

Data used for calculations is read directly from the selected Data File. All data acquired during tests is simply written to this file without manipulation regardless of the type of test run. During any calibration of an absolute RPT in gauge measurement mode, if AutoZ is ON, the values of ZOFFSET and ATMOFFSET are also recorded for every “as received” pressure point. Refer to the DUT Operation and Maintenance Manual for additional information on products that support AutoZ.

The steps in manipulating any test data and set of calibration coefficients is as follows:

- Determine factory pressure** (see Section 1.2) for each calibration point: The factory pressure is the pressure read by the DUT with “as received” calibration coefficients and AutoZ backed out (PA = 0, PM = 1, ZOFFSET = 0).
- Find the new PA and PM** (see Section 1.3) by performing a linear regression of the factory pressures against the reference pressures. The offset is PA, the slope is PM.
- Modify AutoZ values** (see Section 1.4) depending on the RPT type and measurement mode.
- Determine predicted “as left” pressures** (see Section 1.5) by applying the new PA and PM values to the factory pressures.

Determining factory pressure

The first step in determining new calibration coefficients for a DUT is to determine DUT factory pressures. DUT factory pressures are the DUT test readings in the Data File with the DUT “as received” calibration coefficients (PA, PM) and ZOFFSET backed out. The exact manipulation required depends on the RPT measurement mode, the measurement mode of the calibration and the state of AutoZ during the calibration.

Table 1 describes the relationship of these variables and the resultant calculations of factory pressure. Table 2 defines the terms used in the factory pressure equations.

Note: Not all DUTs support AutoZ. For these DUTs, assume ZOFFSET to be 0 and refer to the case with AutoZ turned OFF. molbox1 and molbox RFM do not support AutoZ.

Note: Gauge mode calibrations may have an independent ZOFFSET value for each point.

Factory Pressure Equation	RPT Measurement Mode	Calibration Measurement Mode	AutoZ State
$P_{FACT} = \frac{P_{DUT} - PA}{PM}$	Absolute	Absolute	OFF
$P_{FACT} = \frac{P_{DUT} - PA + P_{ZOFFSET}}{PM}$	Absolute	Absolute	ON
$P_{FACT} = \frac{P_{DUT} + P_{ZOFFSET} - PA}{PM} - P_{ZOFFSET}$	Absolute	Gauge	OFF
$P_{FACT} = \frac{P_{DUT} + P_{TARE} - PA}{PM} - P_{TARE}$ $P_{TARE} = P_{ZOFFSET} + P_{ATMOFFSET}$	Absolute	Gauge	ON
$P_{FACT} = \frac{P_{DUT} - PA}{PM}$	Gauge	Gauge	OFF
$P_{FACT} = \frac{P_{DUT} - PA + P_{ZOFFSET}}{PM}$	Gauge	Gauge	ON

Table 1. Factory pressure equations.

Variable	Definition
P_{DUT}	DUT pressure reading in the unit of pressure in which the test was run. This value is read directly from the Data File without manipulation.
P_{FACT}	Calculated raw DUT pressure. This is the value the DUT would output without the current calibration applied.
PA	“As received” DUT pressure adder converted from Pascal to the pressure unit in which the test was run.
PM	“As received” DUT pressure multiplier.
P_{TARE}	Temporary storage variable that holds the effective atmospheric pressure value for absolute RPTs calibrated in gauge mode.
$P_{ZOFFSET}$	ZOFFSET value logged for the pressure point for gauge mode calibrations of gauge RPTs when AutoZ is ON and for gauge mode calibrations of absolute RPTs.
$P_{ATMOFFSET}$	ATMOFFSET value logged for the pressure point for gauge mode calibrations of absolute RPTs. This value is not used in any other calibration cases and is never used on DUTs that do not support AutoZ.

Table 2. Definition of Factory Pressure Equation Terms.

Determining PA and PM

To determine the new pressure adder (PA) and pressure multiplier (PM), a linear regression is performed on the factory and reference pressures. The regression results in the lowest value of residual of error of the DUT factory pressures relative to the reference pressures. The least squares best fit method is used for the regression. See the section on PA and PM coefficients in the DUT Operation and Maintenance Manual for additional information on PA and PM and their determination.

Table 3 documents the equations used to calculate PA and PM depending on the measurement mode in which the calibration was run. Table 4 defines the terms used in the PA and PM equations.

Note: When an RPT is zeroed, in gauge measurement mode, the pressure adder is canceled out. Therefore, the slope must be determined in such a way as to minimize the impact of the adder while still correcting the DUT. This is done by forcing the adder to the average error at zero, then determining the slope based on the adder. This method of determining the slope and offset is always used for gauge mode calibrations. For this reason, gauge measurement mode calibrations must always begin and end with 0.

ZNATERR, ZOFFSET Modifications

Note: Not all DUTs support AutoZ. For example, molbox1 and molbox RFM do not support AutoZ. This section does not apply for these DUTs. For DUTs that do not support AutoZ, always assume ZOFFSET to be 0 and refer to the case with AutoZ turned OFF in calibration calculations. In many cases DUTs that support AutoZ require modification of ZOFFSET and ZNATERR as part of the calibration. These changes are detailed in Table 5 based on the RPT measurement mode type (AXXXX or GXXXX) and calibration measurement mode as well as the state of AutoZ during the test. Under no circumstances is the value of ATMOFFSET modified.

The new value of ZNATERR is predicted by performing a second order fit of the predicted “as left” DUT readings and the reference pressures and determining the resultant residual (error) at 101.325 kPa.

Note: If the DUT is a PPC2 AF, the value of ZNATERR (called PA(z) Tare) is not determined by COMPASS for Pressure. With PPC2 AF, the instruments on-board PA(z)Tare routine must be executed using the front panel of the pressure controller as part of the activation of new calibration results.

Predicting “As Left” DUT Results

To predict the “as left” DUT results based on the new calibration coefficients, the newly calculated PA and PM values (see Section 1.3) are applied to the factory pressures (see Section 1.2). This requires multiplying the factory pressure by PM and adding PA for each test point. The predicted errors are determined by comparing the predicted “as left” pressures to the reference pressures taken during the test. Table 6 describes the equations used for this process.

Note: When determining predicted “as left” data for an absolute RPT calibrated in gauge measurement mode, first the value of ZOFFSET must be removed, then PA and PM applied, finally the value of ZOFFSET added back.

PA AND PM Equations	Calibration Measurement Mode
$PM = \frac{n \sum P_{FACT} P_{STD} - (\sum P_{FACT})(\sum P_{STD})}{n \sum P_{FACT}^2 - (\sum P_{FACT})^2}$ $PA = \frac{\sum P_{FACT}}{n} - PM \frac{\sum P_{STD}}{n}$	Absolute (Gauge mode when [Force Standard Regression] option is checked.)
$PM = \frac{\sum (P_{FACT} P_{STD}) - PA \sum P_{STD}}{\sum P_{STD}^2}$ $PA = \frac{(P_{FACT(n)} - P_{STD(n)}) + (P_{FACT(1)} - P_{STD(1)})}{2}$	Gauge

Table 3. PA and PM Equations.

Variable	Definition
P_{STD}	Reference pressure reading in the unit of pressure in which the test was run. This value is read directly from the Data File and is not manipulated. The subscripts 1 and n represent the first and last pressure points in the data file.
P_{FACT}	Factory pressure which is the DUT reading in the unit of pressure in which the test was run with the “as received” calibration coefficients backed out (see Section 1.2). The subscripts 1 and n represent the first and last points in the data file.
PA	New DUT pressure adder in the pressure unit of test. The value is then converted to and expressed in Pascal.
PM	New DUT pressure multiplier.

Table 4. Definition of PA and PM Equation Terms.

RPT Measurement Mode	Calibration Measurement Mode	AutoZ State	ZOFFSET Changed To	ZNATERR Changed To
Absolute (AXXXX)	Absolute	OFF	0	Predicted value at 101.325 kPa
Absolute (AXXXX)	Absolute	ON	0	Predicted value at 101.325 kPa
Absolute (AXXXX)	Gauge	OFF	N/A	0
p Absolute (AXXXX)	Gauge	ON	N/A	0
Gauge (GXXXX)	Gauge	OFF	N/A	0

Table 5. Changes to ZOFFSET and ZNATERR.

Equation To Predict “As Left” DUT Pressure	RPT Measurement Mode	Calibration Measurement Mode	AutoZ State
$P_{DUT} = P_{FACT}PM + PA$	Absolute (AXXXX)	Absolute	OFF or ON
$P_{DUT} = (P_{FACT} + P_{ZOFFSET})PM + PA - P_{ZOFFSET}$	Absolute (AXXXX)	Gauge	OFF
$P_{DUT} = (P_{FACT} + P_{TARE})PM + PA - P_{TARE}$ $P_{TARE} = P_{ZOFFSET} + P_{ATMOFFSET}$	Absolute (AXXXX)	Gauge	ON
$P_{DUT} = P_{FACT}PM + PA$	Gauge (GXXXX)	Gauge	OFF or ON

Table 6. Predicted “As Left” DUT Results Equations.

Miscellaneous

A number of other calculations are used in addition to what are described in the above sections. These calculations are defined in Table 7 and their variables identified in Table 8.

Calculation Of	Equation
DUTSpan	$P_{DUTSpan} = P_{Max} - P_{Min}$
DUT Tolerance	$P_{Tol} = P_{DUTSpan} T_{Tol}$
%DUTSpan Error	$E_{Span} = \frac{(P_{DUT} - P_{Ref})}{P_{DUTSpan}} 100$
%Rdg Error	$E_{Rdg} = \frac{(P_{DUT} - P_{Ref})}{P_{Ref}} 100$
Leak Rate	$E_{Leak} = \frac{(P_{Start} - P_{End})}{T}$

Table 7. Miscellaneous CalTool Equations.

Variable	Definition
$P_{DUTSpan}$	The difference between the maximum and minimum DUT pressures. This value differs from the DUT full scale pressure only when the minimum defined pressure is a value other than 0.
P_{Max}	Maximum DUT pressure.
P_{Min}	Minimum defined DUT pressure.
T_{Tol}	DUT tolerance specified in the test definition.
P_{DUT}	DUT pressure.
P_{Ref}	Reference pressure.
P_{Start}	DUT pressure at the beginning of the leak test.
P_{End}	DUT pressure at the end of the leak test.
T	Time duration of the leak test in seconds.

Table 8. Miscellaneous Equation Terms.

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Electrical	RF	Temperature	Pressure	Flow	Software
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