**Introduction**

In today’s process plants, most new field instruments are smart digital instruments. *Smart* implies a microprocessor-based instrument with extra functionality and digital compensation, supporting multiple sensor types or multiple variables. These instruments generally offer better accuracy, long-term stability, and reliability than conventional analog instruments.

The most common class of smart instruments incorporates the HART protocol, with more than five million HART instruments in use in 100,000 plants worldwide. HART, an acronym for Highway Addressable Remote Transducer, is an industry standard that defines the communications protocol between smart field devices and a control system that employs traditional 4–20 mA wiring.

Two capabilities are required to properly service HART instruments: precision analog source and measure capability and digital communication capability. Until recently, this required two separate tools, a calibrator and a communicator. Today, the capabilities of those two tools are available in a single HART Documenting Process Calibrator that can help you quickly and effectively service HART instruments.
HART calibration is required!

A common misconception is that the accuracy and stability of HART instruments eliminate the need for calibration. Another misconception is that calibration can be accomplished by re-ranging field instruments using only a HART communicator. Still another misconception is that the control system can remotely calibrate smart instruments. These are not true. All instruments drift. Re-ranging with just a communicator is not calibration. A precision calibrator or standard is required. Regular performance verification with a calibrator traceable to national standards is necessary due to:

1. Shifts in performance of electronic instruments over time, due to exposure of the electronics and the primary sensing element to temperature, humidity, pollutants, vibration, and other field environmental factors.

2. Regulations governing occupational safety, consumer safety, and environmental protection.

3. Quality programs such as ISO 9000 standards for all instruments that impact product quality.

4. Commercial requirements such as weights, measures, and custody transfer.

Regular calibration is also prudent since performance checks will often uncover problems not directly caused by the instrumentation, such as solidified or congealed pressure lines, installation of an incorrect thermocouple type, or other errors and faults.

A calibration procedure consists of a verification (As Found) test, adjustment to within acceptable tolerance if necessary, and a final verification (As Left) test if an adjustment has been made. Data from the calibration are collected and used to complete a report of calibration, documenting instrument performance over time.

All instruments, even HART instruments, must be calibrated on a regular, preventive maintenance schedule. The calibration interval should be set short enough to insure that an instrument never drifts out of tolerance, yet long enough to avoid unnecessary calibrations. Alternatively, the interval may be determined by critical process requirements, e.g., calibration before each batch.

How are HART instruments properly calibrated?

To calibrate a HART instrument consistent with its application, it is very helpful to understand the functional structure of a typical HART transmitter.

HART instruments consist of three distinct sections (see Figure 1). Proper HART calibration may involve either or both sensor trim and output trim. Adjusting range values (LRV and URV) without a calibrator is not calibration. Performing an output trim while ignoring the input section is not proper calibration. Adjusting range values with a calibrator may be a practical calibration alternative for instruments operated in 4–20 mA analog mode, provided that the PV and PVAO are not used for process control.

Figure 1.
New tool speeds calibration

Today, instrument maintenance is moving out of the shop and into the field. This reduces process interruptions and avoids the time and expense of returning instruments to the shop. Portable communicators and calibrators are often used together to complete field calibrations. However, the desire to carry less equipment and to perform maintenance in the field has created a need for a new class of calibration tool.

The new 754 Documenting Process Calibrator from Fluke is a powerful yet easy-to-use tool for field calibration of HART instrumentation. Pressing a single key enters the HART mode and displays the essential HART information in the Active Device Screen, shown in Figure 2. Additional HART functionality is accessed with only a few more keystrokes, per the menu tree in Figure 3.
**No communicator is required!**

The 754 requires no external box or communicator for everyday HART calibration and maintenance. It supports many popular models of HART transmitters, with more device-specific command support than any other HART field calibrator.

- Interrogate HART devices to determine type, manufacturer, model, tag-ID, PV, and PVAO
- Perform automated HART sensor trim and output trim for selected devices
- Adjust ranging, damping, and other basic process-configuration settings
- Read and write HART tag and message fields to re-label smart transmitters
- Clone additional transmitters with basic HART configuration data

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**Figure 3.**

<table>
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<th>Process</th>
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<td>- Re-map process variables (Dual sensor temperature devices)</td>
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<table>
<thead>
<tr>
<th>Basic</th>
<th>Detailed (coriolis)</th>
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<td>- Config Sensor</td>
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<td>- PV units</td>
<td>- Config Output</td>
<td>- Sensor lower and upper limits</td>
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</tr>
<tr>
<td>- LRV, URV</td>
<td>- Software Version</td>
<td>- Temperature devices only:</td>
<td>- Change Sensor Type</td>
</tr>
<tr>
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<td>- Final assembly number</td>
<td>- Change Sensor Connections</td>
<td>- Change Sensor Connections</td>
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<td>- Transfer function</td>
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<th>HART Output</th>
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<td>- Model</td>
<td>- Change Sensor Type</td>
<td>- Change Sensor Type</td>
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<td>- Device HART ID</td>
<td>- Software revision</td>
<td>- Change Sensor Connections</td>
<td>- Change Sensor Connections</td>
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<td>- Software revision</td>
<td>- Hardware revision</td>
<td>- Dual Sensor Config (Dual sensor temperature devices)</td>
<td></td>
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<tr>
<td>- Number of preambles</td>
<td></td>
<td>- Write protect</td>
<td>- Write protect</td>
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<thead>
<tr>
<th>Sensor 1</th>
<th>Sensor 2</th>
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<tr>
<td>- Dual Sensor Config (Dual sensor temperature devices)</td>
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</tr>
<tr>
<td>- Loop test</td>
<td>- Loop test</td>
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<tr>
<td>- Pressure zero trim</td>
<td>- Pressure zero trim</td>
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<tr>
<td>- Output trim</td>
<td>- Output trim</td>
</tr>
<tr>
<td>- Sensor trim</td>
<td>- Sensor trim</td>
</tr>
</tbody>
</table>

- Keypad input
- Adjust URV, LRV to applied values
- Temperature devices only:
- Change Sensor Type
- Change Sensor Connections
- Dual Sensor Config (Dual sensor temperature devices)
- Write protect
- Alarm state
- HART poll address
- HART burst mode
- HART burst command

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4 Fluke Corporation  Abridged HART Transmitter Calibration
Calibration of a Rosemount 3051 HART Pressure Transmitter

Basic connections

This example assumes that the transmitter is isolated from the process and is not electrically connected to a loop power supply. Make basic connections to the 3051 per the diagram in Figure 4. A separate 250 ohm resistor is not necessary because the 754 incorporates a resistor in series with the loop supply through its mA jacks. The 3051 in this example is configured for mbar units.

Procedure

1. Power on the Fluke 754 Calibrator. Press the red key followed by the Loop Power softkey and the 754 will display the basic HART information for the 3051 (Figure 5).

2. Press the key again and you are prompted to select the 754 configuration (Figure 6). Selecting MEAS mA, SOURCE mbar will configure the calibrator to measure the analog mA output and the pressure being applied simultaneously to the transmitter input and the pressure module. (Selecting MEAS PV, SOURCE mbar will configure the 754 to evaluate the digital PV output from the transmitter.) Press to select.

3. Vent the pressure line and press CLEAR (ZERO) to zero the pressure module. Press the As Found softkey, and then press ENTER to select Instrument for a linear transmitter calibration. (If the 3051 is configured for square root output, select Instrument.) Notice that the calibration template is automatically completed with the exception of Tolerance. Fill in the appropriate test tolerance and press Done.

4. Press the Manual Test softkey to begin calibration. Apply the input pressures as instructed in the SOURCE screen. Press the Accept Point softkey when the correct pressure is applied for each point. When the test is complete, the error summary table is displayed (Figure 7). Test errors exceeding the tolerance are highlighted. When done viewing the table, press the Done softkey. Press Done again to accept, or ENTER to change the tag, serial number or ID fields.

Example 1

Figure 4.

Figure 5.

Figure 6.

Figure 7.
5. If the As Found test failed (i.e., there were highlighted errors in the error summary table), adjustment is necessary. Press the Adjust softkey. Select Sensor Trim and press ENTER. (Do not select Pressure Zero Trim. It is the same as trimming the lower sensor point at zero, which is useful for pressure transmitters that do not offer Sensor Trim.) The 754 screen should look like Figure 8.

6. Select Perform user trim – both and press ENTER. Zero the pressure module (vented to atmosphere) by pressing CLEAR (ZERO). Press the Continue softkey and you are prompted for the Lower Trim value. For best results, apply the LRV pressure and press Fetch to load the value being measured by the pressure module. Press Trim. Then press Continue to move to the Upper Trim. As before, apply the URV pressure, press Fetch, and press Trim. If the 3051 is used with the digital PV output, skip to step 8 and perform the As Left test. If the 4–20 mA analog output is used in the process, continue on to step 7.

7. Select Output Trim and press ENTER. The value of the primary variable (PVAO) is in the upper right corner of the display. This is normally a 4 mA signal. The mA value, as constantly measured by the Fluke 754, is in the center of the display. Press the Fetch softkey to load the measured mA value. Press Send to send the value to the 3051 to trim the output section for the 4 mA value. Press Continue for the 20 mA trim and repeat this step.

8. After completing Output Trim, press the Done softkey and proceed with the As Left verification test. Press the As Left softkey. Press Done and then press Manual Test. Apply the requested pressures and press Accept Point when the readings are stable. On completion an error summary table is displayed. If none of the errors are highlighted (Figure 9), the 3051 passes the calibration test. If errors are highlighted, the test has failed and further adjustment is required. Return to step 5 for adjustment of the 3051.

**Example 2**

**Calibration of a Rosemount 3144 HART Temperature Transmitter**

**Basic connections**

This example assumes that the transmitter is isolated from the process and is not electrically connected to a loop power supply. Make basic connections to the 3144 per the diagram in Figure 10. A separate 250 ohm resistor is not necessary because the 754 incorporates a resistor in series with the loop supply through its mA jacks. The 3144 in this example is configured for a type K thermocouple sensor with a span of 0 °C to 300 °C.
Procedure

1. Power on the Fluke 754 Calibrator. Press the red key followed by the Loop Power softkey. Press [Enter] to bypass the warning screens and the 754 will display the basic HART information for the 3144 (Figure 11).

2. Press the key again and you are prompted to select the 754 configuration (Figure 12). Selecting MEAS mA, SOURCE T/C typ K configures the calibrator to measure the analog mA output of the transmitter and source the correct temperature stimulus at the 3144 input. (Selecting MEAS PV, SOURCE T/C typ K will configure the 754 to evaluate the digital PV output from the transmitter.) Press [Enter] to select.

3. Press the As Found softkey, and then press [Enter] to select Instrument for a linear transmitter calibration. Notice that the calibration template is automatically completed with the exception of the Tolerance. Fill in the appropriate test tolerance and press the Done softkey.

4. Press the Auto Test softkey to begin calibration. Once the test is complete, an error summary table is displayed (Figure 13). Test errors exceeding the tolerance are highlighted. When done viewing the table, press the Done softkey. Press Done again to accept, or [Enter] to change the tag, serial number or ID fields.

5. If the As Found test failed (i.e., there were highlighted errors in the error summary table), adjustment is necessary. Press the Adjust softkey. Select Sensor Trim and press [Enter]. Select Perform user trim – both and press [Enter]. The 754 screen should look like Figure 14.

6. For best results, press LRV to apply the LRV for the Lower Trim value. Press Trim and then Continue to move to the Upper Trim. Press URV, press Trim, and then press Done. If the 3144 is used with the digital PV output, skip to step 8 and perform the As Left test. If the analog 4-20 mA output is used in the process, continue on to step 7.

7. Select Output Trim and press [Enter]. The value of the primary variable (PVAO) is in the upper right corner of the display. (Figure 5). This is normally a 4 mA signal. The mA value, as constantly measured by the Fluke 754, is in the center of the display. Press the Fetch softkey to load the measured mA value. Press Send to send the value to the 3144 to trim the output section for the 4 mA value. Press Continue for the 20 mA trim and repeat this step.

8. After completing Output Trim, press the Done softkey and proceed with the As Left verification test. Press the As Left softkey. Press Done and then press Auto Test. On completion, an error summary table is displayed. If errors are highlighted, the test has failed and further adjustment is required. Return to step 5 for adjustment of the 3144.
Note on Uploading Results to Your PC
If you are using a 743/744 or 753/754, you may choose an instrumentation management software package from this list:

**Fluke DPC/TRACK2™**


PRM (Plant Resource Manager) from Yokogawa Electric Corporation.

Prime Technologies

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**Ordering information**

**FLUKE-753 Documenting Process Calibrator**

**FLUKE-754 Documenting Process Calibrator-HART**

Standard accessories include: Three sets of stackable test leads, three sets of TP220 Test Probes with three sets of “extended tooth” alligator clips, two sets AC280 Hook Clips, BP7240 Li-ion Battery Pack, BC7240 Battery Charger, C799 Field Soft Case, USB communication cable, getting started guide, instruction manual on CD-ROM, NIST traceable certificate of calibration, DPC/TRACK2 sample software that enables upload and printing of calibration records, three-year warranty. Model Fluke-754 includes HART communication cable.

**FLUKE-750SW DPC/TRACK2 Software**

Included with DPC/TRACK software: Software media, instruction manual, USB cable.

**FLUKE-750-Pxx Pressure Modules**

Included with each Fluke Pressure Module: Adapters, instruction sheet, NIST traceable calibration report and data, three-year warranty.

**Accessories**

- **Fluke-700PMP** Pressure Pump; 100 psi/7 bar
- **Fluke-700LTP-1** Low Pressure Test Pump
- **Fluke-700PTP-1** Pneumatic Test Pump; 600 psi/40 bar
- **Fluke-700HTP-2** Hydraulic Test Pump; 10,000 psi/700 bar
- **Fluke-700HTH-1** Hydraulic Test Hose
- **Fluke-700PRV-1** Pressure Relief Valve Kit for HTP
- **Fluke-700-IV** Current Shunt (for mA/mA applications)
- **Fluke-700PCK** Pressure Calibration Kit
- **Fluke-700TC1** TC Mini-Plug Kit, 9 types
- **Fluke-700TC2** TC Mini-Plug Kit, J/K/T/E/RS
- **Fluke-700TLK** Process Test lead kit
- **754HCC** Smart Instrument Communication Cable
- **BC7240** Battery Charger
- **BP7240** Li-ion Battery Pack
- **C700** Hard Carrying Case
- **C781** Soft Carrying Case
- **C799** Field Soft Case