A Practical Guide to Hand Held Calibrators
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As Keith Mobley said in his November article: "Effective preventive maintenance requires reliable, accurate instrumentation and gauges." Preventive maintenance is the regular testing and calibration of instrumentation. In order to perform this activity, the right test and calibration equipment is required. How do you select the right equipment – that's what we're here to discuss.

Categories and Use.

Test and Calibration equipment generally fall into three grades: Industrial, Instrument and Laboratory. Laboratory grade equipment is generally just that – used in a laboratory under stable laboratory conditions or a controlled environment. Industrial grade devices are used in a broad range of conditions for testing or reading, usually with whole number resolution. Instrument grade equipment is used for tolerance validation, test and calibration. This equipment has at least four times the accuracy of the instrument to be calibrated or tested, and preferably with full scale temperature compensation for use over a broad range of environmental conditions (temperature and humidity).

Table 1 Test and Calibration Equipment Grades

Grade	Category	Meriam Process Technology Products	Use	Precision (vs field device)
Laboratory	Dedicated function, dedicated personnel, controlled conditions	None	Primary, Secondary, Tertiary Calibration Standards	Accuracy ≥ 10 X Resolution to at least five decimal places
Instrument	Multi-function Single Function	MFT4000 series Meri-Cal Smart Manometer	Calibration Tolerance Verification	Accuracy ≥ 4 X Resolution to at least three decimal places
Industrial	Multi-function Single Function	Digital Manometer Meri-Gauge	General Purpose Test Gauge, Thermometer, DVM	Accuracy ≥ 1 X Resolution to one decimal place

Precision – Accuracy and Resolution

Accuracy is one of the most challenging parameters to compare for calibration or process equipment. The accuracy spec is considered the amount of uncertainty associated with the measurement. Each manufacturer expresses accuracy in a format that is favorable to their equipment, but makes it a challenge to compare between manufacturers.

Accuracy specifications are stated as Full scale (FS), range, % of scale, % of reading, of indicated value, , may include temperature compensation, etc. For digital instrumentation, counts or digits are often part of the specification.

In order to interpret these varied descriptions for accuracy we have use arithmetic to determine the magnitude of the uncertainty of the measurement. Let's look at an example:

A pressure transmitter has a range of 0 to 30 PSI and an overall accuracy spec of ±1% full scale. The uncertainty in the measurement is 0.3 PSI, throughout the full scale range (1% X 30 PSI). Therefore, at a given reading, for example, 15 PSI, the uncertainty in the measurement ranges between 14.7 PSI and 15.3 PSI.

If you want a comparison between devices, similar math may be applied at the same measurement value. This provides a practical measure of comparison for evaluating instruments.

Selection Criteria for Accuracy Standards.

In table 1 we noted the ratio of accuracy between a measurement standard and a device or unit under test (UUT) or calibration. In practice, for calibration purposes of field devices, many companies have adopted a 4 to 1 accuracy ratio between the measurement standard and the UUT. Stated differently, the measurement standard must be 4 times as accurate as the UUT, for the given range.

In selecting the measurement standard, the range must be as close as possible to the UUT. Once selected, the accuracy comparison is applied to key calibration points throughout the measurement range.

For example, let's use the transmitter listed above, 0 to 30 PSI, ±1% full scale accuracy, and the 4 to 1 accuracy ratio. We'll compare an industrial grade test gauge with a 0 to 100 PSI range, and ±.25% full scale accuracy. On the surface, if we just compared full scale accuracy, one might guess the test gauge may be used as a calibration standard. And just for fun, lets also compare an instrument grade dedicated hand held pressure calibrator, also with a 0 to 100 PSI range, but with ±0.025% full scale accuracy.

Remember that the uncertainty of the measurement must be applied to the full scale – 0 to 100 PSI in both cases. The table below illustrates the results. The UUT has an uncertainty of 0.30 PSI, and test gauge has an uncertainty of 0.25PSI. The test gauge, with a 1.2 to 1 accuracy ratio, is inappropriate for a calibration standard, but is appropriate for a test or indicator gauge. The dedicated hand held pressure calibrator has an uncertainty of 0.03 PSI, and a 12 to 1 accuracy ratio, therefore the dedicated hand held calibrator is appropriate for a calibration standard.

Scale	Lower	Upper	Full Scale	Accuracy	Uncertainty	Ratio	Instrument
PSI	0 PSI	30 PSI	30 PSI	1.00%	0.30 PSI		Transmitter
PSI	0 PSI	100 PSI	100 PSI	0.25%	0.25 PSI	1.2	Test Gauge
PSI	0 PSI	100 PSI	100 PSI	0.025%	0.03 PSI	12	Calibrator

Table 2 Test and Calibrator Accuracy Ratio

Now let's select a more accurate transmitter, 0.1% full scale accuracy, instead of 1% with the same range. Will the calibrator above still be appropriate? From the table below, we can see that dedicated hand held calibrator is not an appropriate calibration standard, if a 4 to 1 accuracy ratio is required. In fact, if the accuracy for that calibrator were 0.01%, it would still only provide a 3 to 1 accuracy ratio. But a hand held calibrator with the same scale as the UUT, is an appropriate standard.

Scale	Lower	Upper	Full Scale	Accuracy	Uncertainty	Ratio	Instrument
PSI	0 PSI	30 PSI	30 PSI	0.10%	0.03 PSI		Transmitter
PSI	0 PSI	100 PSI	100 PSI	0.025%	0.03 PSI	1.2	Calibrator
PSI	0 PSI	30 PSI	30 PSI	0.025%	0.01 PSI	4	Calibrator
PSI	0 PSI	100 PSI	100 PSI	0.010%	0.01 PSI	3	Calibrator

Table 3 Accuracy Ratio for Calibration

The calibration procedure should clearly reflect the appropriate standard, so these calculations may be performed only once. The validity of any calibration program is dictated by sound management, calibration procedures and documentation.

Calibration Frequency

Why do we need calibration? Drift and Tolerance. All field devices drift, whether via mechanical or electrical means. However, it's the drift beyond a specified tolerance range the dictates the need for calibration. Calibration frequency is subject a number of variables, including, but not limited to manufacturer recommendation, environment and critical nature of the measurement. A manufacturer may recommend annual testing and/or calibration for a given device. However, the environment a device is subjected may accelerate the drift component. Devices that are critical to a process will typically have tight tolerances, and may be exposed to environmental extremes, leading to an increased calibration frequency. Non-critical devices should have broader tolerance ranges, and in some cases, milder environmental conditions, resulting in annual calibration cycles, or with experience, beyond a year.

If an organization has Safety Instrumented Systems are part of a quality program, critical devices may be further categorized by Safety Integrity Level. Devices for use in Life Safety Systems or exposed to harsh chemical environments will require frequent testing.

All calibrators also require a calibration frequency, as they will drift with time. Aside from the drift caused by exposure to physical elements, calibrators must be traceable to national standards for any or all of the following reasons:

- Regulations related to occupational safety, environmental protections and consumer safety;
- Instrument quality programs such as ISO9000, Six Sigma, etc that impact product quality;
- Commercial requirements for weights, measures and custody transfer.

Most manufacturers require annual recertification for their hand-held calibrators. Some have facilitated field recertification by a qualified operation or organization's metrology department, others require returning the product to the manufacturer for recertification. The drawback of the latter is that the calibrator is out of use for an extended period of time – anywhere from two weeks to several months.

Once again, a quality device management program will help maintain a devices at peak performance, resulting in consistent quality and uptime.

Smart Field Device Impact:

Smart field devices are a significant portion of the installed base, and an even higher percentage of new instrument sales. These micro-processor based units have been around for over a decade, yet the DPC is a relatively new product. Calibration of HART devices typically requires a DVM to monitor the 4-20 mA output, a HART Host communicator, and a calibrator. With a DPC, one unit can perform the entire calibration procedure. HART devices make up the majority of smart devices in terms of installed base and annual sales. In the last year, every major plant automation system (DCS/PLC) provider has introduced HART I/O.

Multi-function Tester / Documenting Process Calibrators:
The newest class of test and calibration equipment is the Documenting Process Calibrator or DPC. These portable intelligent field calibrators are designed for in situ (field) calibration, reducing the time required to execute a calibration procedure.

The typical DPC will have the following features:

- multiple bays for different calibration standards;
- some DVM capability;
- dedicated memory for storing calibration results;
- communication with smart transmitters;
- dedicated memory for storing device configurations;
- communication with a device management software tool.

Dedicated purpose calibrators have one or two of these capabilities, but the DPC has it all. The table below is a partial listing of DPCs and compatibility with the most popular device management software tools. They produce significant savings and reduce down time – as we'll see later.

Modular vs All In One:

This is the age old argument: do you buy a modular system or one with all the functions built into it? Some things to consider – if you have only one calibrator to serve a variety of devices, and you don't mind sending it back to the factory, then the all-in-one unit may be for you. However, if you don't have a wide variety of devices to calibrate, or you have a number of technicians that share equipment, then the modular or dedicated approach may better suit your needs. With a modular approach, the calibration standards may be shared between base units, so you only buy the sensor types that you require.

Perhaps the strongest argument for a modular calibrator is that it facilitates a broader array of sensor ranges better matched to your devices, so you can maintain the 4 : 1 accuracy ratio.

Introducing Device Management Solutions:

A typical field device calibration cycle consists of pre-calibration planning, performing the actual calibration, and post calibration documentation. The actual calibration operation consists of tolerance verification (As-Found across the entire range); if necessary, adjustment to within acceptable tolerance, and a final verification (As-Left). Pre-calibration planning includes gathering the calibration procedure and related documentation, locating the correct calibration standard, a DVM, a Hart Host communicator, printing the calibration sheets, finding a pen and scheduling someone to perform the calibration, either as part of a preventive maintenance program, or as part of opportunistic downtime. Post calibration documentation includes reviewing and recording the calibration results, achieving all necessary signoffs; updating an audit trail and/or filing the results. In many cases the data is transferred manually to a computer program like Excel or Access, then printed in a standard format. This entire operation is time consuming. Some organizations even remove field devices from service, and calibrate on a bench top, significantly extending the time it takes to calibrate a field device.

A documenting process calibrator can reduce the time devoted to the field device calibration cycle – minimizing the amount of equipment required in the field in one compact package. When coupled with a device management software package, there are additional gains in efficiency.

The “electronic birth certificate” is the initial entry in a device management software package, and includes the configuration and calibration starting point for the device. Once a device has an “electronic birth certificate”, the tolerance and calibration frequency may be included in the record. When the device is due for calibration, it is automatically scheduled and downloaded into the DPC for execution. At this point, the DPC becomes a PDA – it contains a listing of all devices scheduled for calibration, the procedures, and the necessary calibration standards, DVM and if you chose wisely, a built-in class 5 HART Host. The DPC steps the technician through the calibration procedure, electronically capturing and evaluating each “As-found” point for tolerance verification on a point by point basis. If the device is in tolerance across the entire range, the data may be saved As-Left. If not, the calibrator can immediately execute any selected trim – zero offset, URV, LRV, 4 mA and or 20 mA – provided you have built-in class 5 Hart Host. Once the devices are calibrated, the unit is reconnected to the device management software, and the data is immediately transferred as an “electronic bill of health”. If configurations were changed, due to re-ranging or calibration, this data is also recorded and transferred, minimizing the post calibration to a couple of keystrokes. The net result is that by coupling a DPC with a competent device management software (DMS) package, the user can calibrate more devices during a given outage with the same manpower – by working smarter!

Connectivity from DPC to DMS:

ISA, with the coordination of a number of vendors, has created a FCINTF (Field Calibrator Interface) standard for downloading test procedures into the DPC, and uploading the test results from the DPC to a device management software package. See the chart for compatibility

http://www.isa.org/~pmcd/FCTC/FieldCalbrIntf/FCINTF.PDF

Table 4 DPC products with HART HOST functionality

Vendor	Model	mA/V Source Simulate	Temperature Calibrate Simulate	Pressure Calibration	Commands-HART Host Capable		
					Universal	Common Practice	Device Specific
Meriam Process Technologies	MFT401X	✔	✔	✔	✔	✔	✔

Connectivity to the Enterprise

Some things to consider when purchasing a DMS/DPC complete device management system:

- Is there a requirement to communicate with the Plant automation system (DCS/PLC)
- Is there a requirement to communicate with an MRO package?
- Is there a requirement to communicate directly with field devices from the DMS, and if so, what is the charge for both the hardware and software – is it by tag?
- Does the DMS handle manage both calibration and configuration? This is important for two reasons – some devices may change configuration slightly when calibrated, and in the event of a device failure, having the latest configuration simplifies cloning.

Scalability and Costs of calibrators

The test and calibrator market is wide and varied – but you generally can find value if you know where to look and understand your requirements. Industrial grade devices are primarily limited to test functions, and are generally below $1,000. Instrument grade devices are typically $500 to several thousand dollars, depending upon options. Laboratory instruments, while having the highest accuracy, also have a high price and tight environmental constraints – something not everyone can afford.

Table 5 Cost/Scalability of Equipment Grades

Grade	Category	Price range	Precision (vs field device)
Laboratory	Dedicated function, dedicated personnel, controlled conditions	>$7,000	Accuracy $\geq 10:1$ Resolution to at least five decimal places
Instrument	Multi-function Single Function	$1200 to $8000 $500 to $1200	Accuracy ratio $\geq 4:1$ Resolution to at least three decimal places
Industrial	Multi-function Single Function	$400 to $900 $200 to $600	Accuracy $\geq 1:1$ Resolution to one decimal place

Conclusion

Effective preventive maintenance dictates the regular testing and calibration of instrumentation. The trend toward in situ (field) calibration has produced significant savings and reduced down time. Manufacturers of test and calibration equipment responded by designing portable, intelligent, field calibrators, from small dedicated purpose hand-held calibrators to multi-function testers and documenting process calibrators. A complete device management solution is realized when these DPCs are linked with a calibration and configuration management software package, maximizing efficiency, quality, safety, compliance and payback.

Biography:
Louis Szabo has been involved in automation for 20 years, in process automation and factory automation, on the user side and the supplier side. 10 of those years were with Bailey Controls (now ABB) and Rockwell Automation. Currently, Louis is Vice President of Marketing and Sales for Meriam Process Technologies. He has a master's degree in electrical engineering, with major in control systems.

Bibliography:

Transcat Catalog

FCINTF by SW research

HART Communication Foundation