Calibration **Essentials**

Managing Your Program

ISA | beamex

Introduction

In the first edition of *Calibration Essentials*, we discussed many of the tools and strategies that could alleviate many of the labor-intensive processes that facilitated calibration in industrial plants and factories. Yet, as technology continues to evolve at a rapid pace, and innovative minds continue to find better ways to reduce workload and increase efficiency, it is constantly necessary to keep informed of these new trends in order to keep your facilities on the cutting edge.

To this end, the calibration team at Beamex has partnered once again with the International Society of Automation to produce *Calibration Essentials: Managing Your Program*. This follow-up resource will provide readers with even more insight into calibration strategies and technologies, for the executive and technician alike to ensure both efficient and effective calibration in order to help facilitate continuous productivity for your organization.

Calibration Essentials: Managing Your Program consists of multiple articles and resources for today's industry professionals, including:

- A discussion of the top reasons why many companies today are deciding to update their calibration processes and management
- A top-level look at how integrated calibration solutions are helping some companies find a quicker return on their investment
- Strategic overviews of calibration schedules, and how the answer may depend on your organization and instrumentation
- A technical review of metrology and the impact of proper fundamentals in ensuring continued function of process control equipment.
- An in-depth guide for technicians, discussing calibration characteristics and criteria to help evaluate instrumentation and ensure that all calibrations meet the required tolerance standards.

With this edition, from Beamex and ISA, you continue to have the latest information on innovation and instrumentation to ensure your calibration efforts remain as efficient as possible. The two organizations continue to work together with the goal of helping to standardize calibration efforts and maintain a continuous automated production environment.

Contents

Top 5 reasons why companies update their calibration systems

By: Villy Lindfelt

As many as every fourth company in the process industry is at the moment considering to make some kind of update to its calibration process and systems. I admit, the number sounds quite high, but it is based on a specific study we recently made with the International Society of Automation (www.isa.org) concerning calibration process changes.

So, why do companies plan or decide to update their calibration processes? By an update in the calibration process I mean, in this context, making a change in the tools, systems, and work procedures for performing, documenting, and managing calibration of process instruments. Any change must of course happen for a reason. Most likely the reason is a challenge or problem in the current way of doing things that the company wants to fix. If there's no problem, there's no clear reason or justification to update anything. So what are the top five reasons or problems causing calibration process updates?

The most common reason why companies decide to update their calibration systems is to make technicians work faster and more efficient. 42% of companies state this as one of the key reasons to implement changes in their calibration processes. The key

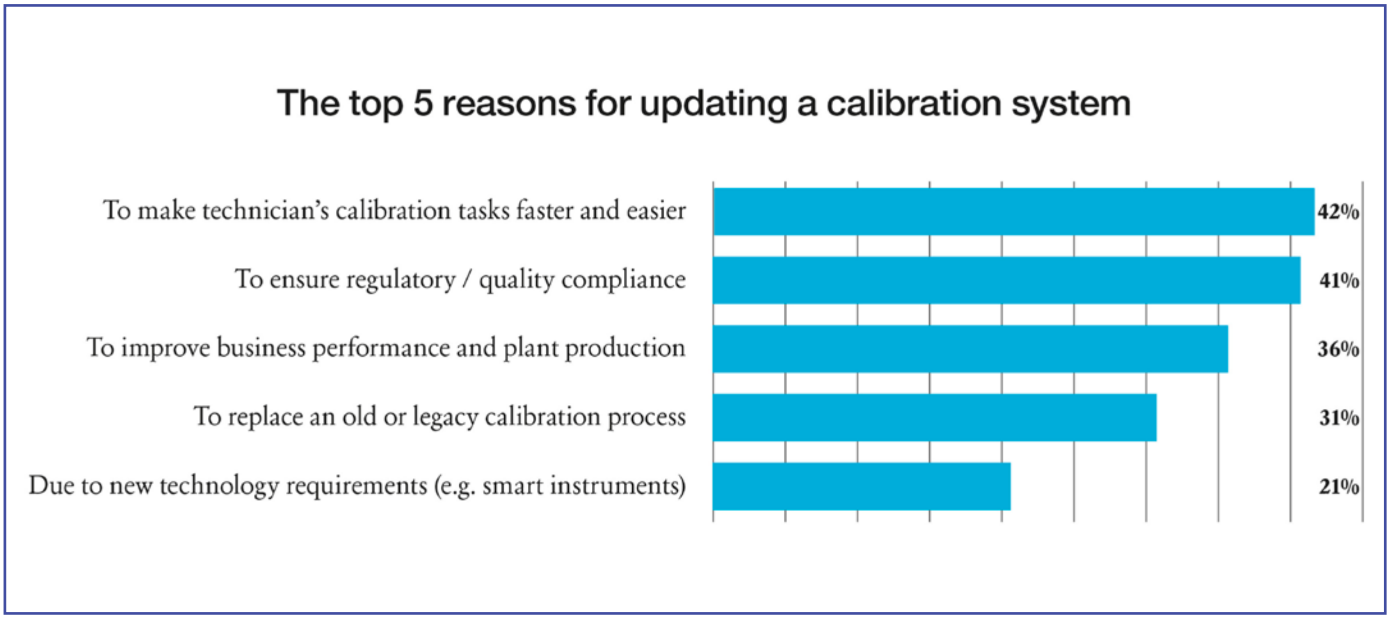


Figure 1: *Results from a study concerning calibration process change, conducted by Beamex and ISA in 2015*

reason is therefore related to gaining economic and productivity efficiency through making a change in the calibration system.

Almost as many people state that the key reason for making a change is to ensure compliance with regulatory and quality requirements. The return on investment of compliance is maybe more difficult to calculate compared to calculating time-savings of a calibration engineer between current and new calibration processes, but you can always ask yourself: what is the price of non-compliance? Ultimately, non-compliance could even mean shutdown of a manufacturing site by a regulatory authority, and we can all understand what kind of economic impact that would have on a business.

The third most common reason for making a process change is to improve business performance and plant production. Again, gaining economic and productivity efficiency is at the heart of a process change, but now the reasons are maybe even on a broader scale, to improve plant- or even company-level performance through smarter calibration.

The fourth most common reason to implement a process change is to replace and old and outdated legacy system. Instead of just gaining economic or compliance improvements, companies are therefore also "forced" to update their calibration systems based on technological necessities and risks, such as managing currently calibrations with software that is not supported or maintained anymore with new releases. The fifth most common reason is also technology-related, as companies also decide to update their calibration processes due to new technological requirements, such as smart instruments being used at a manufacturing site.

As said, every change requires a reason and the reason is often in the form of a problem or challenge that requires fixing. The top five reasons for making a calibration process change are economical, compliance, and technology related.

Do more with less and generate ROI with an **Integrated Calibration Solution**

By: Heikki Laurila

Process instrument calibration is just one of the many maintenance related activities in a process plant. The last thing you want to do is to have your limited resources wasting time performing unnecessary calibrations or using time-consuming, ineffective calibration procedures.

Yet, you need to make sure that all critical calibrations are completed, ensuring the site stays running efficiently with minimal downtime, product quality is maintained, while the plant remains regulatory and safety compliant, and audit-ready.

Most often you can't just go and hire an army of external calibration specialists, so you need to get more done with your existing resources.

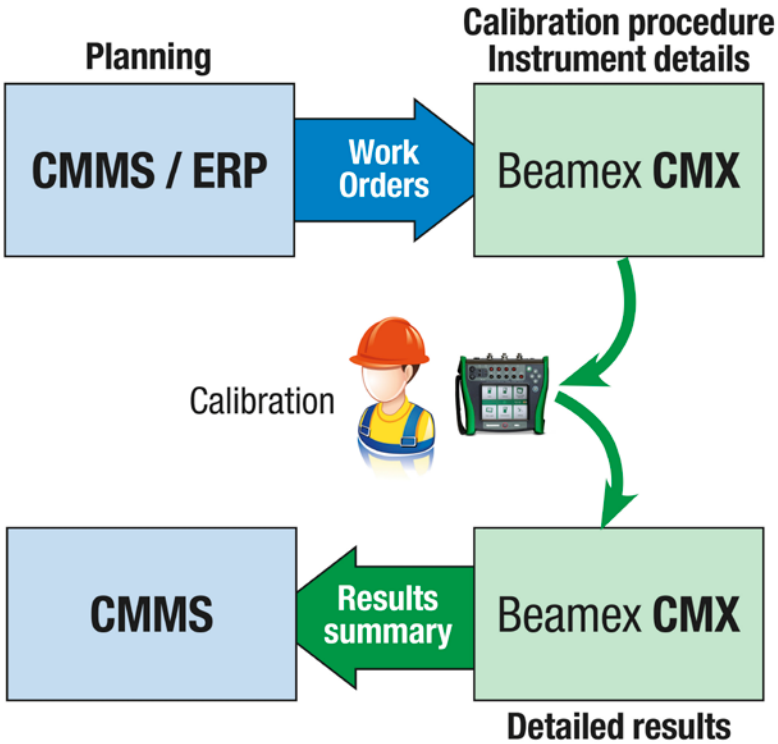
In this article, let's examine at what an "Integrated Calibration Solution" is and how it can help you with your challenges – make your calibration process more effective, save time and money, and improve the quality and integrity of the results. We will also discuss how it can quickly generate a great return your investment.

If any of that sounds interesting to you, please continue reading …

Improve the whole calibration process with an Integrated Calibration Solution

It is not enough to just buy some new calibration equipment or calibration software – that does not make your calibration process leaner and more effective. Instead, you should analyze at all the steps of your calibration process, and with the help of a suitable solution and expertise, find ways to improve the whole calibration process.

Let's quickly look at a typical calibration process from the beginning to the end and explore how an integrated system could help:



Typically, work is planned, and work orders are created in the maintenance management system. With an integrated solution, these work orders move automatically and digitally from the maintenance management system to the calibration software. There is no need to print work orders and distribute them manually.

The necessary calibration details are handled by the dedicated calibration software and it sends the work orders to the mobile calibration equipment. Again, this happens digitally.

While the technicians are out in the field performing the calibration activities, the results are automatically stored in the mobile devices, and users signs off the results using an electronic signature. From the mobile device the results are automatically transferred back to the calibration software to save and analyze.

Once the work orders are completed, the calibration software automatically sends an acknowledgement to the maintenance management software and work orders are closed.

So, the whole process is paperless and there is no need for manual entry of data at any point. This

makes the process far more effective and saves time. This also helps minimize mistakes typically related with manual data entry, so it improves the quality and integrity of the calibration data. Furthermore, calibration results are safely stored and easily accessible in the calibration software for review for example in case of audits and for analysis purposes.

As mentioned, improving the calibration process is not just about buying some new equipment or software, but the project should also include improvement of the whole calibration process together with the new tools supporting it. Implementing a new process is a project with a formal implementation plan, ensuring that the new system/process is adopted by the users.

The key benefits of an integrated calibration solution

Here are listed some of the key benefits of an integrated calibration solution:

Improve operation efficiency – do more with less

- Automate calibrations and calibration documentation. Eliminate all manual entry steps in the calibration process. Use multifunctional tools to carry less equipment in the field and lower equipment life-cycle costs

Save time and reduce costs – get a great ROI

- With automated processes, get more done in shorter time. Don't waste time on unnecessary calibrations. Let the data from the system guide you to determine the most important calibrations at appropriate intervals.

Improve quality

- With electronic documentation, avoid all errors in manual entry, transcriptions, and pass/fail calculations.

Guides non-experienced users

- Let the system guide even your non-experienced users to perform like professionals.

Avoid system failures and out-of-tolerance risks

- Use a calibration system that automatically ensures you meet required tolerance limits, to avoid system downtime and expensive out-of-tolerance situations.

Be compliant

- Use a system that helps you meet regulations and internal standards of excellence.

Ensure safety

- Ensure safety of the plant workers, and customers, using a calibration system that helps you navigate through safety critical calibrations.

Safeguard the integrity of calibration data

- Use a calibration system that ensures the integrity of the calibration data with automatic electronic data storage and transfer and relevant user authorization.

Make audits and access data easy

- Use a system that makes it easy to locate any record an auditor asks for.

What do the users say?

Here are just a few testimonials on what the users have said about the Beamex Integrated Calibration Solution:

"With the Beamex integrated calibration solution, the plant has experienced a dramatic time savings and implemented a more reliable calibration strategy while realizing a 100% return on investment in the first year.

Using the Beamex tools for pressure calibrations has decreased the time it takes to conduct the calibration procedure itself in the field by over 80%."

- DC Water, Washington, D.C., USA

"Time is of the essence during an outage and the Beamex Integrated Calibration Solution allows technicians to maximize the amount of work accomplished in the shortest amount of time, while effectively performing vital tasks and managing workflows."

- Senior Control Engineer, Alabama Power, USA

"After the incorporation of Beamex's integrated calibration solutions, calibrations that would take all day are now performed in a couple hours."

- E&I Technician, Monsanto, USA

"With this software integration project, we were able to realize a significant return on investment during the first unit overhaul. It's unusual, since ROI on software projects is usually nonexistent at first."

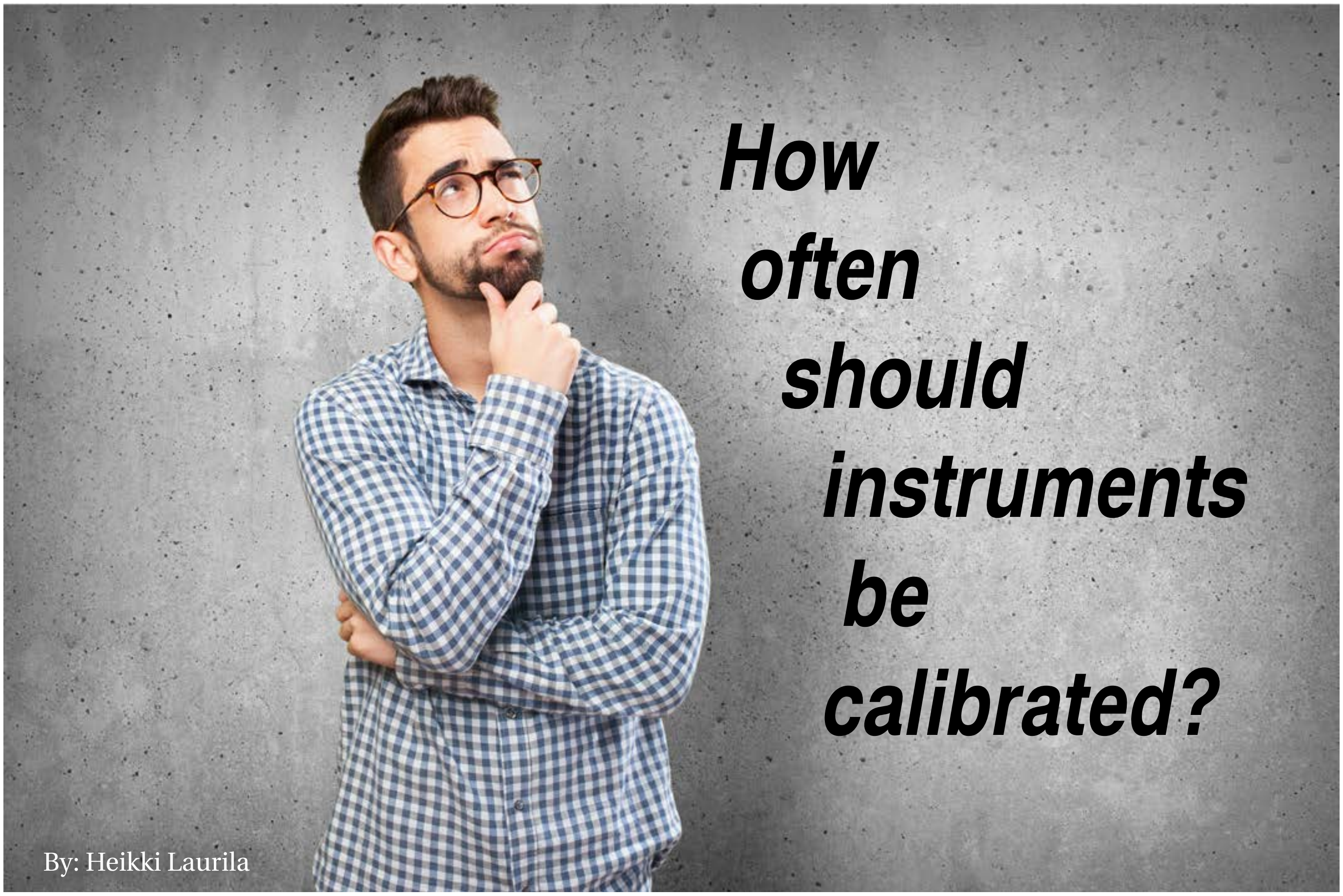
- Business Analyst, Salt River Project, USA

"After implementing the Beamex CMX calibration management system, GSK will be able to eliminate 21,000 sheets of printed paper on a yearly basis, as the entire flow of data occurs electronically, from measurement to signing, and archiving."

- GlaxoSmithKline Ltd, Ireland

RELATED LINK

More about integrated calibration solutions:
https://www.beamex.com/us/solutions/integrated-calibration-solution/



How often should instruments be calibrated? That is a question we get asked often. It would be nice to give a simple answer to that question, but unfortunately, that is not possible. Instead, there are several considerations that affect the answer of a correct calibration period. In this post, I will discuss these considerations.

The question of how to determine the correct calibration interval remains one of our most frequently asked questions. In this post, I want to discuss both process instruments and reference standards (calibrators).

Of course, it would be nice to give one answer for the calibration interval that would be valid for all situations, but unfortunately, ***there is not a magic answer***. Sure, on many occasions you hear that instruments should be calibrated once a year and while that can be the correct answer in some situations, it may not be fit for all purposes. There is no straight answer to this question. Instead, there are several considerations that affect the answer of the correct calibration period.

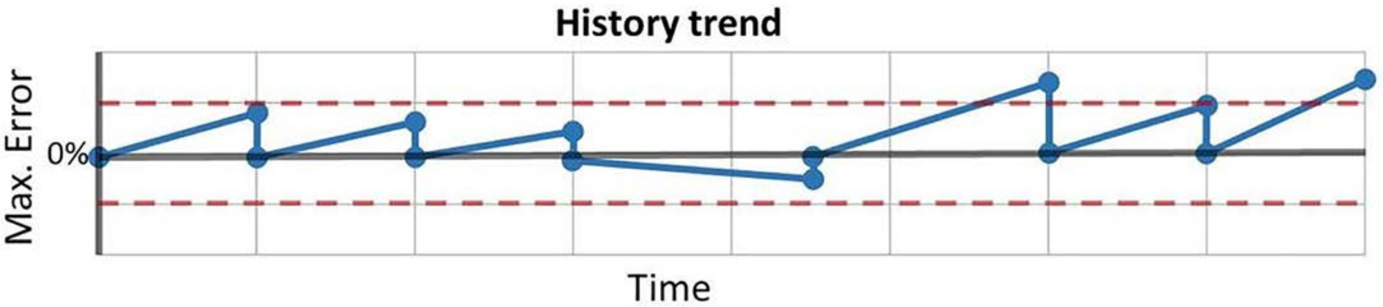
Let's take a look at these considerations:

Process tolerance need vs. instrument accuracy

To start with, there is one thing that often bothers me. Let's say in a process plant you have purchased a number of similar process instruments/transmitters. Sure, it makes sense to standardize the models. Then, you install these transmitters in all the different locations that need this quantity measured. The transmitter has an accuracy specification and it may also have a long-term stability specification from the manufacturer. Then you use the manufacturer's transmitter tolerance as the calibration tolerance no matter where the transmitter is installed. This is a bad practice. The ***tolerance requirements of the process*** should always be taken into account!

Measurement criticality

The ***criticality of measurement*** should be considered when determining the calibration period.



In some cases, the measurement instruments may be calibrated prior to an important measurement. It may also be calibrated after that measurement, to assure that it has remained accurate throughout the measurement.

Some locations are ***non-critical*** and do not require as accurate of a measurement as the transmitter's specifications are, so these locations can be calibrated less often and the tolerance limit for those locations can be bigger than the transmitter's specification.

But also, the other way around; some locations are very ***critical*** for the process – these locations require very accurate measurements. If the same transmitters are installed in these critical locations, they should be calibrated more often and their calibration acceptance tolerance should be kept tight enough for the critical location. The calibration tolerance can be even tighter than the transmitter's specifications, but then you need to calibrate it often enough and follow that it remains within these tight tolerance limits.

Of course, you could also buy different accuracy level transmitters for different process locations, but that is not very convenient or practical. Anyhow, the persons in the plant that best knows the accuracy requirements of different locations in the process should be consulted to make the right decision.

The tolerance of measurements should be based on ***process requirements***, not on the specifications of the transmitter that is installed.

How accurate is accurate enough?

In the previous chapter, we discussed process instruments. The same consideration is valid also for the reference standards or calibrators.

This also works both ways; before you buy any calibrator or reference standard, you should make sure that it is accurate enough for all your most critical calibration needs. Not only for today but also in the years to come. There is no point in purchasing a calibrator that won't be accurate enough next year or that does not suit the job; it's just money wasted.

On the other hand, you don't always need to buy the most accurate device in the universe. Depending on your accuracy needs, the reference standard needs to be accurate enough, but not an over-kill. Metrologically, of course, it is not harmful to buy a reference standard that is too accurate, but it may be on the expensive side.

The usability of the standard is one thing to consider. Also, some references may have multiple quantities, while others have only one.

Manufacturer's recommendation

For many instruments, the manufacturers have a recommendation for calibration period. This is especially the case for reference standards and calibrators. Often, manufacturers know best about how their equipment behaves and drifts over time. Also, manufacturers often have specified a typical long-term stability for a given time, like for one year.

So, the manufacturer's recommendation is an ***easy and good starting point*** when deciding the initial calibration period. Of course, over time, ***you should follow the stability*** of the device and adjust the calibration interval accordingly.

Also, depending on how good the accuracy specification of the reference standard is, you may alter the manufacturer's recommendation. I mean that if the reference standard has a very good accuracy compared to your needs, you may calibrate it less often. Even if it fails to stay within its specifications, it may not be that critical to you. Also, the other way around – if the reference standard is on the limit of being accurate enough for you, you may want to calibrate it more often than the manufacturer recommends, as you may want to keep it in tighter tolerance than the manufacturer's specifications are.

Stability history

The stability history of any measurement device is very precious information. You should always follow the stability of your measurement devices. In case the device needs to be adjusted during a recalibration, you should always save the calibration results before (As Found) and after (As Left) adjustment. If you only adjust the instrument and make a new calibration certificate, it will look like the instrument was very stable and there was drift, although that is not the truth.

If you send your instrument out for recalibration, make sure you get the calibration results before and after adjustment, if an adjustment was made. Also, make sure you know if it was adjusted.

After you acquire a longer stability history of the measurement device, you may start making changes to the calibration period. If the instrument drifts too much and often fails to meet the tolerance in recalibration, then you naturally need to make the calibration period shorter. Also, if it clearly meets the tolerance limit in every recalibration, without any need for adjustment, you can consider making the calibration period longer.

You should have an accepted, written procedure in your quality system for changing calibration periods, and also defined responsibilities.
Typically, if the stability of an instrument looks good in the first recalibration, you should still wait for a few recalibrations before making the period longer. If you plan on making the period longer, the costs for a

failed recalibration should be also considered. With some industries (like pharmaceutical) or with some critical measurements the costs of a failed recalibration are so high that is much cheaper to calibrate "too often."

On the other hand, if a recalibration fails, you should shorten the calibration period immediately. Naturally, that also depends on how much it fails and how critical it is.

If you use the **[Beamex CMX Calibration Manager software]**, it will generate you history trend graphics automatically with a push of a button.

Previous experience

In the previous chapter, the stability history was discussed as an important consideration. Sometimes you already have previous experience with the stability of the instrument type that you need to set the calibration period for. Often the same types of instruments have similarities in their stability and long-term drift. So, the **past experience of similar measuring instruments** should be taken into account.

Similar types of instruments can have similar calibration periods, but this is not always true, as different measurement locations have different criticality, different needs for accuracy, and may also have different environmental conditions.

Regulatory requirements, quality system

For certain industry measurements, there can be regulatory requirements, based on a standard or regulation, that stipulate the accepted length of the calibration period. It is difficult to argue with that one.

I've heard customers say that it is difficult to change the calibration period as it is written in their quality system. It should, of course, be possible for you to change your quality system if needed.

The cost of an out-of-tolerance (fail) calibration

A proper risk analysis should be performed when determining the calibration period of instruments. One thing to consider when deciding on a calibration period of any instrument is the cost and consequences if the calibration fails. It is to find a good balance between the costs of the calibration program versus the costs of not calibrating enough. You should ask yourself "what will happen if this instrument fails the recalibration?"

If it is the case of a ***non-critical*** application and a fail in recalibration is not that important, then it is ok that the calibration fails from time to time. Sure, you should still adjust the instrument during the calibration to measure it correctly and to have more room for drift before the next recalibration.

If it is a ***critical*** measurement/instrument/application, then the consequences of a failure in recalibration can be really large. In the worst case, it may result in a warning letter from a regulatory body (like the FDA in the pharmaceutical industry), loss of license to produce a product, negative reputation, loss of customer confidence, physical injury to persons on the job or to those who receive a bad end product and so on. Also, one really alarming consequence is if you need to recall delivered products from the market because of an error found in calibration. For many industries, this kind of product recall is obviously a very big issue.

As an example, with the heat treatment industry, you don't easily see if the final product is properly heat treated, but a fault in heat treatment can have a dramatic effect in the properties of the metal parts, that typically go to aerospace or automobile industry. An erroneous heat treatment can cause very severe consequences.

Certainly, pharmaceutical and food industries will also face huge consequences if poor quality products are delivered because of poor calibration or lack of calibration.

Other aspects that effect the calibration period

There are also many other aspects that will influence the calibration period, such as:

- The **workload** of the instrument: if the instrument is used a lot, it should be calibrated more often than one that is being used very seldom.
- **Environmental conditions**: an instrument used in extreme environmental conditions should be calibrated more often than one used in stable conditions.
- **Transportation**: if an instrument is transported frequently, you should consider calibrating it more often.
- **Accidental drop/shock**: if you drop or otherwise shock an instrument, it may be wise to have it calibrated afterward.
- **Intermediate checks**: in some cases, the instrument can be checked by comparing it against another instrument, or against some internal reference. For example, for temperature sensors, an ice-bath is a way to make relatively accurate one-point check. This kind of intermediate checks between the actual full recalibrations adds certainty to the measurement and can be used to extend the calibration period.

Traceability and calibration uncertainty

Finally, a couple of vital things you should remember with any calibration are traceability and uncertainty.

Shortly said, ***traceability*** means that all your calibrations (measurement instruments) must have a valid traceability to relevant national standards.

Whenever you make a measurement, you should be aware of the uncertainty related to that measurement.

If the traceability and uncertainty are not considered, the measurement does not have much value.

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Using Metrology Fundamentals in Calibration ***to Drive Long-Term Value***

By: Chuck Boyd

This article discusses some critical items to address for a calibration program based on sound metrology fundamentals without a complete overhaul of the calibration program. Having properly calibrated process control instrumentation provides a high quality of process control, a process that will operate to design specifications, and prevents the process from being stressed as it compensates for inaccurate measurement data feeding the DCS. Realization of these benefits may be challenging to quantify and attribute to implementing any of the suggested changes, but conversely, implementation of the changes should not be extraordinarily burdensome on resources.

Introduction

The science of metrology is seemingly calm on the surface but has extensive depth of very technical concepts. Metrology is the science of measurement and incorporates aspects of many diverse fields such as mathematics, statistics, physics, quality, chemistry, and computer science-all applied with a little common sense. Because metrology work is interspersed with other job duties, many rely on knowledge of metrology, but the science is intimately understood by only a small percentage. Most often a diverse educational background is found across the maintenance stakeholders in a power plant and most, if not all, of the metrology knowledge, is learned on-the-job.

Many times calibration programs are based on the minimal definition of calibration, which is comparing an instrument's measurement to a known standard, followed by documentation of the results. With the lean staffing levels typical in for example power plant maintenance groups today, it's natural for these programs to evolve out of expediency. This expediency, and the lack of defined metrologist roles on these staffs, inhibits the development of a program that includes additional metrology fundamentals above and beyond what is needed to get the job done.

The typical Electrical & Instrumentation (E&I) Manager has responsibility over a wide range of electrical equipment and instrumentation to support operations of the plant. The Manager's purview includes management of E&I department staff, safety and environmental leadership, preventive maintenance, predictive maintenance, and critical repair activities, and working with internal and external groups on special projects among many other areas of accountability. While instrument calibration is a critical activity, completion of the task requires a relatively small amount of focus, all else being considered. There are instrument calibration requirements critical to maintaining compliance with environmental regulations defined by the Environmental Protection Agency such as Mercury and Air Toxics Standards (the MATS rule) and regulation of greenhouse gases (GHGs) under the Clean Air Act, employer responsibility to protect workers from hazardous conditions defined by the Occupational Safety and Health Administration, and reliability standards defined by the North American Electric Reliability Corporation. Of course, nuclear-fueled generators must comply with additional regulatory requirements, but outside of complying with these requirements, natural gas and coal fueled generators are self-governed with regard to the balance of their instrumentation.

At a minimum, a competent calibration program insures instruments are calibrated on a schedule, the results are documented for audit purposes, and there is traceability. A competent calibration program helps maintain safety and production, but calibration is also a matter of profitability. Instruments measuring more accurately can improve safety, allow increased energy production, and reduce the stress on equipment. Unfortunately, the nature of the benefits presents a major challenge; unlike a metric such as labor savings, these benefits are extremely difficult to quantify for use in justifying the cost of change.

When instruments are calibrated with a traceable standard and the results are documented, many consider this to be adequate and no change is necessary. This position is bolstered by the very nature of how maintenance is scheduled. Months of planning go into an outage and when time to execute arrives, challenged with tight resources and tight schedules, the work must be accomplished as expeditiously as possible. All unnecessary steps must be eliminated as to not jeopardize the outage schedule. Therefore, adding steps to the process is counter-intuitive to this, which may be necessary to improve the process. E&I leadership must have the foresight to implement strategic change in order to realize the benefits of improvement.

Implementing metrology-based principles does not have to be a dramatic change. A substantial positive impact to quality can be realized by making some

adjustments and tweaking the existing calibration program. These changes are easy to implement and simultaneously will reinforce a culture change focusing more on metrology aspects of calibration. Metrology as a science has an immense number of elements to consider, but initially focusing on the following areas will provide huge strides in building and maintaining a calibration program that provides confidence in measurement accuracy for process control instrumentation:

- Measurement tolerance and pass/fail determination
- Test strategy including hysteresis
- Maintaining acceptable Test Uncertainty Ratios
- Securing information assets

Measurement tolerance and pass/fail determination

The calibration tolerance assigned to each instrument is the defining value used to determine how much measurement error is acceptable. This subject is one that should rely heavily on the requirements of the process and not by looking at what the instrument is capable of performing. Ideally, the tolerance is a parameter that is set in process development where the effect of variation is measured. Unfortunately, there is no hard-and-fast formula for developing a tolerance value, it should be based on some combination of the process requirement, manufacturers' stated accuracy of the instrument, criticality of the instrument, and intended use. Care should be taken not to set a range too tight as it will put pressure on the measurement to be unnecessarily accurate.

Tolerance can be stated as a unit of measure, percentage of span, or percentage of reading. It is critical during calibration to mathematically calculate the error value in order to determine pass/fail status. This calculation is an additional step in the process and particularly with tolerances defined as a percentage of span or reading, mathematical calculations invite opportunities for errors. As calibration programs evolve this aspect of the calibration process will get relegated to the calibration technician's discretion. There have been occasions where the decision on pass/fail is relegated to technician experience, or gut feel, or asking another technician for his input. This is a practice that provides questionable results and although the resulting calibration certificate may show the measurement is within tolerance, the instrument is recorded as within tolerance in perpetuity when in fact this result was not mathematically confirmed. More importantly, plant operators could be making decisions based on wrong data. This method of determining pass/fail should not be allowed and enforced either procedurally, which should require recording of the error limits as well as the calculated error, or enforced programmatically, having the inputs entered into a computer-based system where the pass/fail is indicated automatically.

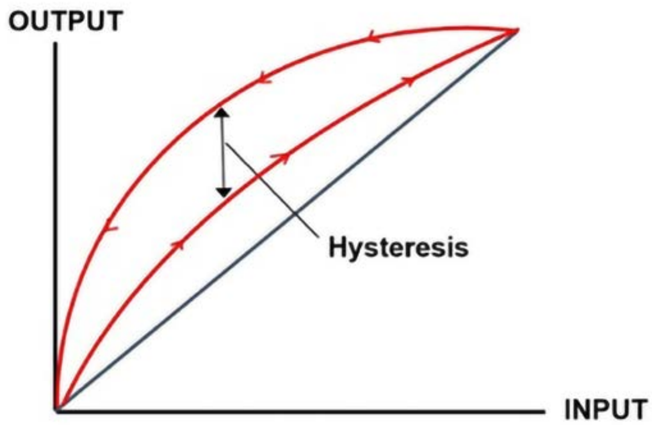
Input [in$H_2$0]	Output [mA]	Output Error [% of span]	Reject If Error > [% of span]
-0.01	3.9932	-0.0400	0.5000
197.56	11.8776	-0.1550	0.5000
399.75	19.9745	-0.0969	0.5000
208.58	12.3135	-0.1856	0.5000
-0.01	3.9838	-0.0988	0.5000

Calculated Error *Defined tolerance*

Test strategy including Hysteresis

Hysteresis errors occur when the instrument responds differently to an increasing input compared to a decreasing input and is almost always caused by mechanical friction on some moving element. (See Figure 1) These types of errors rarely can be rectified by simply making calibration adjustments and typically require replacement of the instrument or correction of the mechanical element that is causing friction against a moving element. This is a critical error due to the probability that the instrument is failing.

Most calibration test strategies will include a test point at zero (0%) and a test point at span (100%), and typically is at least another test point at mid-range (50%). This 3-point test can be considered a good balance between efficiency and practicality during an outage. The only way to detect hysteresis is to use a testing strategy that includes test points up



the span and test points back down the span. Critical in this approach is that the technician not overshoot the test point and reverse the source signal, approaching the test point from the wrong direction. Technicians should be instructed to return to previous test point and approach the target point from the proper direction.

Maintaining acceptable Test Uncertainty Ratios

Measurement uncertainty is an estimate of the error associated with a measurement. In general, the smaller the uncertainty, the higher the accuracy of the measurement. The uncertainty of the measurement standard (i.e. – calibrator) is the primary factor considered along with potential errors introduced in the calibration process to get an estimation of the calibration uncertainty, typically stated at a 95% confidence level (k=2). The comparison between the accuracy of the instrument under test and the estimated calibration uncertainty is known as a Test Uncertainty Ratio (TUR).

The instrument measurement is within tolerance if the uncertainty of the standard used to calibrate the instrument is known. Once the tolerance is defined, a good rule of thumb is that the measurement standard does not exceed 25% of the acceptable tolerance. This

25% equates to a TUR of 4:1; the standard used is four times more accurate than the instrument being checked. With today's technology, a TUR of 4:1 is becoming more difficult to achieve, so accepting the risk of a lower TUR of 3:1 or 2:1 may have to be considered.

Another challenge in many plants are legacy measurement standards. These are standards with acceptable measurement uncertainty compared to the process control instruments of its day, but have very low ratios today. These standards have not been replaced throughout multiple automation system upgrades over the years. Automation suppliers continue to evolve technology yielding more and more accurate measurement capability to the point where some plants may struggle to get a 1:1 TUR, or less. It should be determined if the standards used in the calibration program are fit for purpose by confirming the unit's uncertainty, defining tolerances, and using the two values to mathematically calculate TUR. This exercise will provide the confidence that the standard being used is sufficient for the measurement being made.

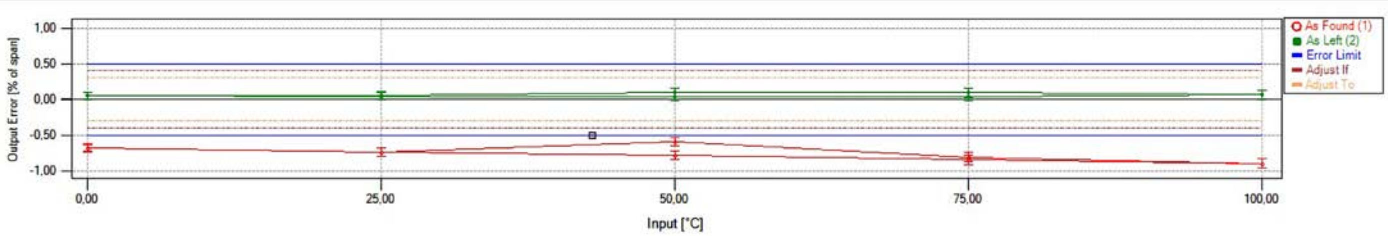
Securing information assets

Information is one of the company's most valuable assets, but less so if activity is not fully documented, organized efficiently, and easily accessed by those that need the information. Not meeting these characteristics carries a cost to the business in the amount of time and resources to gather the information, and the errors/mistakes made due to inaccurate, incomplete, or outdated data. These costs are magnified with regard to calibration data where defined metrology-based parameters directly impact the quality of process control. For a sustainable calibration program, there must be a point of reference to serve as a definition or benchmark for applying metrology principles.

Harnessing this type of information should be a top priority as the metrology data clearly provides competitive advantage in higher quality calibration work and higher efficiency in execution. An exacerbating circumstance for this issue is the loss of personnel, who are responsible for development and management of the calibration program and in possession of the knowledge base. These losses occur when they leave the company or make internal job changes. This includes the phenomenon of the aging workforce such as baby boomers leaving the workforce at an accelerated rate. With the exit of experienced, skilled workers, critical knowledge will slowly be drained from E&I groups. The industrialized world is transitioning into what is known as the knowledge economy; the concept that success is increasingly based on effective utilization of knowledge as the key resource for competitive advantage. With the attrition of highly skilled workers requiring the

Repeat 2 - As Left 7.2.2012 10:14:51 / Bob Brown

Input [°C]	Output [mA]	Output Error [% of span]	Reject If Error > [% of span]	Error Significance [% of Error Limit]	Input Uncertainty [°C]	Output Uncertainty [mA]	Expanded Uncertainty [% of span]	Input Calibrator	Input Module	Output Calibrator	Output Module
0,000	4,0075	0,05	0,50	10,0	0,05	0,0014	0,05076	MC6 : 601261	TC-R-OUT/ R1 : 6	MC6 : 601261	IN : 20256
25,000	8,0063	0,04	0,50	8,0	0,0535	0,0018	0,05467	MC6 : 601261	TC-R-OUT/ R1 : 6	MC6 : 601261	IN : 20256
50,000	12,0060	0,04	0,50	8,0	0,057	0,0022	0,05863	MC6 : 601261	TC-R-OUT/ R1 : 6	MC6 : 601261	IN : 20256
75,000	16,0058	0,04	0,50	8,0	0,0605	0,0026	0,06264	MC6 : 601261	TC-R-OUT/ R1 : 6	MC6 : 601261	IN : 20256
100,000	20,0094	0,06	0,50	12,0	0,064	0,003	0,06669	MC6 : 601261	TC-R-OUT/ R1 : 6	MC6 : 601261	IN : 20256
75,000	16,0146	0,09	0,50	18,0	0,0605	0,0026	0,06264	MC6 : 601261	TC-R-OUT/ R1 : 6	MC6 : 601261	IN : 20256
50,000	12,0151	0,09	0,50	18,0	0,057	0,0022	0,05863	MC6 : 601261	TC-R-OUT/ R1 : 6	MC6 : 601261	IN : 20256
25,000	8,0074	0,05	0,50	10,0	0,0535	0,0018	0,05467	MC6 : 601261	TC-R-OUT/ R1 : 6	MC6 : 601261	IN : 20256
0,000	4,0074	0,05	0,50	10,0	0,05	0,0014	0,05076	MC6 : 601261	TC-R-OUT/ R1 : 6	MC6 : 601261	IN : 20256



$$\text{T.U.R.} = \frac{0.5\ \text{Tolerance}}{0.06669\ \text{Uncertainty}} = 7.497\ \ (\sim 7.5:1)$$

replacement with much less experienced workers, this knowledge will be critical in getting them productive as quickly as possible.

Conclusion

The novelty of calibration and metrology alone has inherent complexities. Metrology is a specialized and highly technical subject, and metrology subject matter experts make up a fraction of the overall population of maintenance personnel in the power generation industry. Whereas the desire to maximize electrical output requires maximum availability, reliability, and efficiency of the plant, the drive in the industry is to reduce costs in part by running lean with little chance of a dedicated metrologist role. The health and accuracy of measurement and control devices directly impacts the plant's reliability and uptime, so the resolve to make quality improvements to the calibration program is justified.

Transforming the calibration program doesn't have to be a resource intensive, immense undertaking. In the absence of a dedicated project, formally managed and resourced, implementing a high-performing calibration program progressively by strategically focusing on specific weaknesses is possible. The effort will require dedicating some time on behalf of select E&I stakeholders to see the initiative through, but weak areas of the metrology program and corrective actions can be documented to show progress.

The specific subject areas highlighted in this paper were selected because they are often overlooked, based on Beamex experience working with various power plants. Corrective action taken on these areas will provide solid strategic improvement in measurement accuracy and enhance the plant's ability to control its process within design limits. Failure to address these areas will continue the plant on a trajectory that will incur avoidable cost due to additional stress on the plant and lost revenue due to substandard heat rate.

What are the **Characterisctics** *of a* Calibration?

By: Subburaj Ramasamy

Calibration Tolerance: Every calibration should be performed to a specified tolerance. The terms tolerance and accuracy are often used incorrectly. In ISA's ***The Automation, Systems, and Instrumentation Dictionary***, the definitions for each are as follows:

Accuracy: The ratio of the error to the full scale output or the ratio of the error to the output, expressed in percent span or percent reading, respectively.

Tolerance: Permissible deviation from a specified value; may be expressed in measurement units, percent of span, or percent of reading.

As you can see from the definitions, there are subtle differences between the terms. It is recommended that the tolerance, specified in measurement units, is used for the calibration requirements performed at your facility. By specifying an actual value, mistakes caused by calculating percentages of span or reading are eliminated. Also, tolerances should be specified in the units measured for the calibration.

For example, you are assigned to perform the calibration of the previously mentioned 0-to-300 psig pressure transmitter with a specified calibration tolerance of ±2 psig. The output tolerance would be:

$$\begin{array}{r} 2 \text{ psig} \\ \div\ 300 \text{ psig} \\ \times\ 16 \text{ mA} \\ \hline 0.1067 \text{ mA} \end{array}$$

The calculated tolerance is rounded down to 0.10 mA, because rounding to 0.11 mA would exceed the calculated tolerance. It is recommended that both ±2 psig and ±0.10 mA tolerances appear on the calibration data sheet if the remote indications and output milliamp signal are recorded.

Note the manufacturer's specified accuracy for this instrument may be 0.25% full scale (FS). Calibration tolerances should not be assigned based on the manufacturer's specification only. Calibration tolerances should be determined from a combination of factors. These factors include:

- Requirements of the process
- Capability of available test equipment
- Consistency with similar instruments at your facility
- Manufacturer's specified tolerance

Example: The process requires ±5°C; available test equipment is capable of ±0.25°C; and manufacturer's stated accuracy is ±0.25°C. The specified calibration tolerance must be between the process requirement and manufacturer's specified tolerance. Additionally, the test equipment must be capable of the tolerance needed. A calibration tolerance of ±1°C might be assigned for consistency with similar instruments and to meet the recommended accuracy ratio of 4:1.

Accuracy Ratio: This term was used in the past to describe the relationship between the accuracy of the test standard and the accuracy of the instrument under test. The term is still used by those that do not understand uncertainty calculations (uncertainty is described below). A good rule of thumb is to ensure an accuracy ratio of 4:1 when performing calibrations. This means the instrument or standard used should be four times more accurate than the instrument being checked. Therefore, the test equipment (such as a field standard) used to calibrate the process instrument should be four times more accurate than the process instrument, the laboratory standard used to calibrate the field standard should be four times more accurate than the field standard, and so on.

With today's technology, an accuracy ratio of 4:1 is becoming more difficult to achieve. Why is a 4:1 ratio recommended? Ensuring a 4:1 ratio will minimize the effect of the accuracy of the standard on the overall calibration accuracy. If a higher level standard is found to be out of tolerance by a factor of two, for example, the calibrations performed using that standard are less likely to be compromised.

Suppose we use our previous example of the test equipment with a tolerance of ±0.25°C and it is found to be 0.5°C out of tolerance during a scheduled calibration. Since we took into consideration an accuracy ratio of 4:1 and assigned a calibration tolerance of ±1°C to the process instrument, it is less likely that our calibration performed using that standard is compromised.

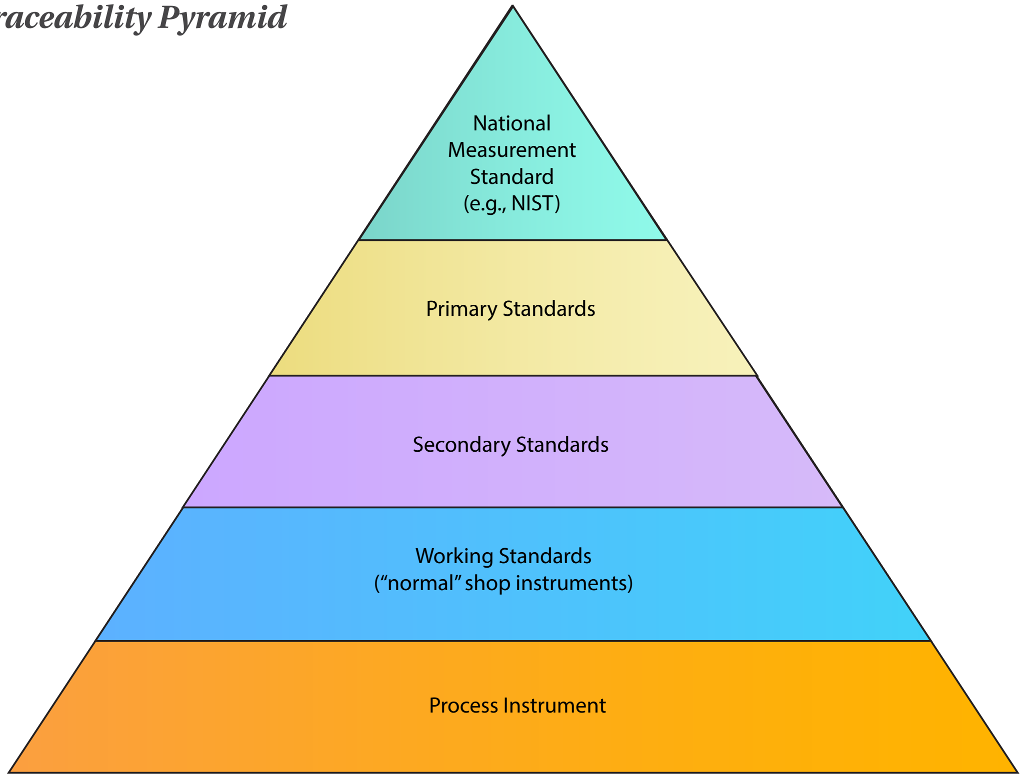
The out-of-tolerance standard still needs to be investigated by reverse traceability of all calibrations performed using the test standard. However, our assurance is high that the process instrument is within tolerance. If we had arbitrarily assigned a calibration tolerance of ±0.25°C to the process instrument, or used test equipment with a calibration tolerance of ±1°C, we would not have the assurance that our process instrument is within calibration tolerance. This leads us to traceability.

Traceability: All calibrations should be performed traceable to a nationally or internationally recognized standard. For example, in the United States, the National Institute of Standards and Technology (NIST), formerly National Bureau of Standards (NBS), maintains the nationally recognized standards. ***Traceability*** is defined by ANSI/NCSL Z540-1-1994 (which replaced MIL-STD-45662A) as "the property of a result of a measurement whereby it can be related to appropriate standards, generally national or international standards, through an unbroken chain of comparisons." Note this does not mean a calibration shop needs to have its standards calibrated with a primary standard. It means that the calibrations performed are traceable to NIST through all the standards used to calibrate the standards, no matter how many levels exist between the shop and NIST.

Traceability is accomplished by ensuring the test standards we use are routinely calibrated by "higher level" reference standards. Typically the standards we use from the shop are sent out periodically to a standards lab which has more accurate test equipment. The standards from the calibration lab are periodically checked for calibration by "higher level" standards, and so on until eventually the standards are tested against Primary Standards maintained by NIST or another internationally recognized standard.

The calibration technician's role in maintaining traceability is to ensure the test standard is within its calibration interval and the unique identifier is recorded on the applicable calibration data sheet when

Figure 1-1. ***Traceability Pyramid***



the instrument calibration is performed. Additionally, when test standards are calibrated, the calibration documentation must be reviewed for accuracy and to ensure it was performed using NIST traceable equipment.

Uncertainty: Parameter, associated with the result of a measurement that characterizes the dispersion of the values that could reasonably be attributed to the measurand. Uncertainty analysis is required for calibration labs conforming to ISO 17025 requirements. Uncertainty analysis is performed to evaluate and identify factors associated with the calibration equipment and process instrument that affect the calibration accuracy. Calibration technicians should be aware of basic uncertainty analysis factors, such as environmental effects and how to combine multiple calibration equipment accuracies to arrive at a single calibration equipment accuracy. Combining multiple calibration equipment or process instrument accuracies is done by calculating the square root of the sum of the squares, illustrated below:

Calibration equipment combined accuracy

$$\sqrt{(\text{calibrator1 error})^2+(\text{calibrator2 error})^2+(\text{etc. error})^2}$$

Process instrument combined accuracy

$$\sqrt{(\text{sensor error})^2+(\text{transmitter error})^2+(\text{indicator error})^2+(\text{etc. error})^2}$$

Six Keys for an Effective Process Change

By: Chuck Boyd

You probably use dozens of business processes every day. When processes work well, they can significantly improve efficiency, productivity, and customer satisfaction. You have also likely realized the results of inefficient processes that cause frustration, delays, and financial loss. That is why it is so important to improve processes that are not working well.

Processes can be formal or informal. Formal processes are documented and have well-established steps. Informal processes are more likely to be ones that you have created yourself, and you may not have written them down. These different kinds of processes have one thing in common: they are designed to streamline the way that you and your team work.

Keep in mind that you will need to improve most processes at some point. New goals, new technology, and changes in the business environment can all cause established processes to become inefficient or outdated. In practice, few organizations have the luxury of redesigning their processes from "a clean sheet of paper." People, equipment, and business knowledge cannot be easily scrapped.

The path to change can be a stumbling block if we assume technology is independent of the environment and organizational structure in which it is to be implemented. By some estimates, 70 percent of such projects fail to reach their intended goals. The program that seeks to become a "house of quality" can turn out to be a "house of cards" without recognition of interdependencies among technology, processes, and people. Manufacturers cannot, and will not, be experts in every aspect of software that can improve their businesses, so they must find the most suitable system and, most importantly, the best vendor as a partner to guide them through the implementation process.

Let's look at a calibration system implementation where 70 to 80 percent of the implementation is focused on process and business culture and a relatively small portion on the technology itself. The first step is to outline a system implementation process. There are a few overarching fundamentals:

- There will be a large number of interrelated tasks, carried out in a particular sequence, with decisions being made throughout.
- A proven implementation model will yield quicker results than developing a model from scratch.
- The project must be overseen by a dedicated project manager with committed involvement by key resources.
- Poor planning and inadequate resourcing are the cause of problems such as scope creep and budget and schedule overruns.

You can successfully implement a new calibration process by following a well-defined, step-by-step implementation process:

1 **Initiation:** Define the entire framework for the project. Define the scope of the new system and launch date, appoint a project team, prepare a project plan, define change management procedures and testing/approval procedures, and establish the roles and responsibilities of both the manufacturer and vendor.

2 **Process blueprinting:** Map the existing calibration process and reengineer it for the target system. Explore each phase in detail, as some processes may have substeps that you are not aware of. It is critical to consult people who use the system regularly, as well as cross-functional experts such as information technology, compliance, and quality. At this point, the project can still be canceled.

3 **Specification:** Using the blueprint as the basis, define the user requirements, functional design, and test specifications. In this step, it is imperative that the manufacturer and vendor clearly understand the technical specifications and functionalities they are agreeing to.

4 **Execution:** Execute the plans prepared during the specification phase. This phase is where change management procedures may be used.

5 **Deployment:** Deliver all software, equipment, and documentation as well as the customer's acceptance of delivery. Train target groups, and complete and make standard operating procedures, work instructions, and process descriptions available. The system is transferred from the project team to the operational team.

6 **Operation:** Use the new system in production and realize the improved process. Support agreements become effective.

Efficient business processes could not be more important in the current climate of competitive global markets, subdued demand, and competitive pricing. Where processes heavily involve interaction with the workforce, such as the calibration implementation example, efficiency becomes even more critical. As a final note, there is no end point; optimizing business process efficiency will always be an ongoing process.

About Beamex

Beamex is a leading, worldwide provider of calibration solutions that meet even the most demanding requirements of process instrumentation. Beamex offers a comprehensive range of products and services--from portable calibrators to workstations, calibration accessories, calibration software, industry-specific solutions and professional services. Through Beamex's subsidiaries, branch offices and an extensive network of independent distributors, the company's products and services are available in more than 130 countries. Beamex has more than 12,000 customers worldwide.

For more information about Beamex and its suite of calibration solutions, visit http://www.beamex.com/us.

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The International Society of Automation (www.isa.org) is a nonprofit professional association founded in 1945 to create a better world through automation. ISA advances technical competence by connecting the automation community to achieve operational excellence. The organization develops widely used global standards; certifies industry professionals; provides education and training; publishes books and technical articles; hosts conferences and exhibits; and provides networking and career development programs for its 40,000 members and 400,000 customers around the world.

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