What do Customers Want to Know About Calibration?

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ABSTRACT

The people who are customers of calibration often do not have the same understanding of calibration that we do. While many understand that calibration is required by quality standards, regulations or laws, they often do not understand the larger reasons for having instruments calibrated, or the benefits to them or society. Some of the problems include different understandings of what "calibration" means, or what is involved in the calibration process; and lack of understanding of the problems of interval analysis or equipment substitution. This presentation will give some examples of customer questions and ideas we can use for increasing their understanding of the calibration process.

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1. Introduction

Almost everyone at this conference works in metrology or a closely related area. All of us know what "calibration" and other technical terms mean, and if we have any doubt we can pick up our handy copy of the VIM [1] or the NCSL Glossary [2] to verify the definition. Most of us also have customers who are not educated or trained in the measurement sciences and don't have the same level of understanding as we do. We can easily get wrapped up in the science of our work. Our typical customers, though, don't know and may not care about the details – they just want a new sticker on their equipment. In many cases we need to be better at communicating information about calibration and its importance to a non-technical audience.

There are several questions that customers usually have, even if they don't ask them directly.

- What is calibration?
- Why is calibration important?
- Does this item really need to be calibrated?
- What type of calibration do I need?
- How often should it be calibrated?
- The maintenance manual says to use a XYZ but I don't have one. Can I use something else instead, and what should I choose?

These and other questions come to the calibration laboratory staff because, correctly or not, the average customer has the expectation that we have **"the"** answer. For good customer service, the lab should be prepared to give some reasonable answers or explanations even if it is not formally part of the organization's mission or the individual's job description.

2. What is calibration?

Many customers know they have a requirement for calibration, but they don't really know what it is. If the customer uses a standard dictionary to find out what calibration is they will almost always find a definition that is partially or wholly at odds with the definition in the VIM. If not explained, this can lead to false expectations and a dissatisfied customer.

The article on “dictionary” in the World Book Encyclopedia [3] reminds us that common standard dictionaries are descriptive rather than prescriptive, and are intended for a non-technical audience. The purpose of a standard dictionary is to record the way a word is actually used in society, without making any judgment or prescribing any particular meaning or usage. This has several implications. Only the most commonly used technical terms are usually included, especially in abridged versions of dictionaries. The definitions are listed in order of common usage in society, not technical accuracy. It is entirely likely that the applicable technical meaning may even be omitted.

In contrast, a technical glossary is a specialized dictionary that does contain authoritative technical definitions of terms. The VIM and the NCSL Glossary are two examples. Another example that is particularly relevant to many calibration customers, though many don't realize it, is ISO 9000:2000 [4].

A typical customer looking for the meaning of “calibration” by referring to the primary definition in a common dictionary is going to see that it means checking, adjusting, marking or engraving a scale on a measuring instrument, or to determine the inside diameter of a tube [5, 6, 7, 8]. Almost all include the concept of adjustment in the primary definition, because that is how most people use the term. Only a few include the concept of comparison to a standard in the primary definition, and that is usually *in addition to* adjustment [8]. Some people may look at a more technical reference for a definition, but even then there can be surprises. The *Macmillan Dictionary of Measurement* [9] for example, does not include “calibrate” or “calibration” – or “metrology”, either.

The technical definition that we use is quite different. The primary definition is the concept of comparison to a known standard in order to determine the difference. Adjustment, if it is addressed at all, is in a note rather that the main definition.

What does this mean for the calibration laboratories? We need to educate our customers so that we and they have the same – or at least similar – expectations.

- ◆ We should be explaining to our customers what our profession means by calibration, using the definition in the current edition of the VIM.
- ◆ If your customer operates under a quality system based on ISO 9001, you should definitely refer them to the definition of calibration that is in the VIM. The conformance standard, ISO 9001:2000, refers to ISO 9000:2000 and ISO/IEC 17025 as reference documents and both of those standards refer to the VIM. Therefore, the definition in the VIM is the one they and their auditors should be using.

◆ Customers should understand that a calibration procedure normally does not include any adjustment or maintenance actions [10]. Therefore the usual work flow is

- Perform the calibration procedure,
- If the calibration results indicate a need for it, adjust or repair the unit under calibration (UUC),
- If the UUC was adjusted or repaired, repeat the calibration procedure.

◆ If you routinely adjust <u>in-tolerance</u> instruments <u>as a value-added service</u>, you should be sure your customers know it is something extra you are giving them for free and not something they would normally expect from other suppliers. (We will leave the issue of adjusting too frequently for another time.)

3. Why is calibration important?

Other than conformance to a quality management standard or compliance with a regulatory requirement, many customers have no idea why calibration is important. The historical context has been described elsewhere by Redgrave and Henson [11], Bennett [12], Payne [13] and many others. The primary drivers have been ease of commerce, civil engineering and scientific inquiry. But in the popular mind, calibrated measuring instruments are often associated with a manufacturing workplace or a well-lit and climate-controlled laboratory. Most people would think of a balance, micrometer or a voltmeter as examples of calibrated instruments before they would think of others that are more widespread and used more frequently. The common electricity meter is quite likely the most commonly used calibrated instrument, because there is one on almost every building that has an electricity supply, and it is in use all of the time. In fact, it is so common it is ignored most of the time – except when the bill has to be paid. As another example, every time a person refuels their automobile, they are personally using a calibrated measuring instrument. But because the gasoline pumps are so common, outdoors and anyone (with enough money) can use them any time, they do not fit the stereotype of "calibrated measuring instrument".

Calibration is important because of the standardization of weights and measures. It facilitates global commerce, improves health and safety, and is essential for any meaningful scientific measurements or technical work.

4. Does this item really need to be calibrated?

If customer questions had been listed in order of frequency, then "does this need to be calibrated" would surely be at the top of the list – especially for in-house calibration laboratories. A simple yet effective test for this question was suggested by Stein [14] and is shown graphically in Figure 1.

> "*Ask the question: does it matter whether the answer from this measurement is correct? If it does matter, then calibration is needed. If it doesn't matter, then why is the measurement being made in the first place?*"

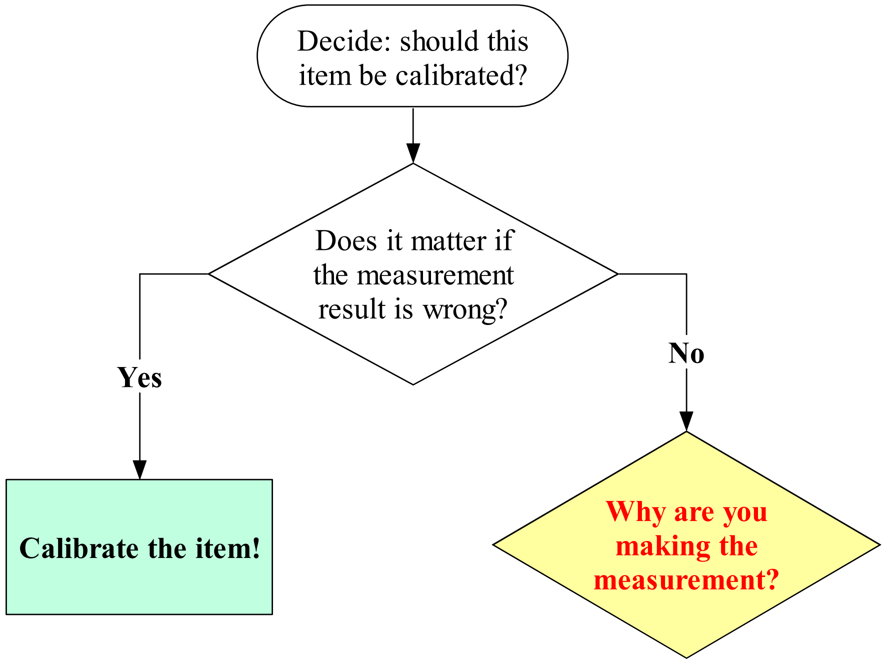

Figure 1. Stein's test for calibration requirements.

When explained this way, many customers seem to grasp the concept more readily. If the result of the measurement is going to be used for a decision, and it matters if the decision is wrong, then the measurement should be made with a calibrated instrument (or a calibrated tool should be used). If it makes no difference, then the customer should re-evaluate why the measurement is being made. If it truly does not matter, then it is likely that time and resources could be saved by eliminating the measurement.

5. What type of calibration do I need?

Once a customer understands what calibration is and is not, why it is important, and what needs to be calibrated, they often want to know what to expect from a calibration. Many customers seem to believe that there is "<u>only one authoritative calibration procedure</u>" for each of every type, model or variant of inspection, measuring and test equipment (IM&TE). To some extent, this is even an implicit assumption in ISO/IEC 17025 [15]. In some cases this is actually true, particularly for physical, dimensional and some electrical calibrations. For *testing* organizations, there are standard test methods that can be purchased from ASTM and other standards bodies.

For many *calibrations*, however, particularly for multi-function multi-range electrical instruments, it is common to find several different procedures for the same item. The biggest reason for this is that each organization writes a procedure to calibrate an instrument (or class of instruments) for their particular uses in that organization.

A calibration procedure may not test every function and range of the UUC, and the parts that are tested may not be tested to the manufacturer's published specification. If a function or range is never used, there is no reason to spend money calibrating it – but the items must be labeled to indicate what parts are not calibrated.

A lot of customers think "*the government*" publishes standard calibration procedures. In the United States, at least, the government does publish a lot of calibration procedures but not all are available to the public, and there often is not one "standard" calibration procedure for each instrument. The largest number of calibration procedures in the Department of Defense Government-Industry Data Exchange Program (GIDEP) system are written by the Navy, Air Force or Army. But for a given model number each service may have its own procedure (or more than one!) because each of them may have different mission requirements for that model of equipment. Those mission requirements may or may not meet your customer's needs.

Most customers also believe that equipment manufacturers provide calibration procedures for their equipment, and that those are automatically the best available. The top-tier IM&TE manufacturers generally do provide very complete calibration procedures, but they are not necessarily the best for every one of your customers. Many manufacturers, though, only provide the alignment and adjustment procedures used at the end of their production lines. Those may be useful as a guide for developing a calibration procedure but do not, by themselves, meet the definition of a calibration procedure presented in NCSL RP-3 [16]. Finally, there are still a few manufacturers who consider all information of that type to be proprietary.

This means that whenever possible, the calibration laboratory should attempt to verify that the calibration procedure they use will meet the customer's needs.

Customers may also be confused by differences between standard, standard with data, accredited or other types of calibration service that are offered. The differences in your offerings need to be explained in a non-technical way, with good examples of when each type of calibration may be required.

6. How often should it be calibrated?

Another very common question is how often an item should be calibrated. Typical customers expect the calibration lab to have "the answer". They don't want to hear "it depends" and they *really* don't want to hear "ISO/IEC 17025 says I can't tell you".

If your calibration lab is part of the organization asking the question, then you may actually have the data you need to answer this question. You have all of the calibration records, the inventory database, and other data that may be needed. You may even have appropriate software to make the calculations easy for you. The rest of us are not so lucky.

As we know from even a casual study of NCSL RP-1 [17], the problem of interval analysis has been around for a long time and is not easy. We know that obtaining a statistically valid result requires a stated end-of-interval reliability goal, and a pool of calibration results from a homogeneous group of similar instruments all calibrated using the same procedure at least once, and preferably several consecutive times. The amount of data has to be large enough to obtain a statistically significant result. In many cases, a calibration laboratory does not have the data that is required. Also in many cases, the customer does not have a large enough inventory of any given model or class for a statistically valid analysis.

Historically, the default interval has been the one recommended by the IM&TE manufacturer. It is now increasingly common for manufacturers to not have a recommended interval, particularly for lower-cost equipment. The next fallback might be the warranty period, since that is usually assumed to be based on reliability calculations. However, the reliability assumed for warranty period determination is not necessarily the same as what you would wish to use for calibration intervals. Also, neither of these periods may be appropriate for the environment the customer actually uses the equipment in.

Regulatory agencies have a stake in this issue as well. The US Federal Aviation Administration (FAA), for example, prefers the interval suggested by the equipment manufacturer [18], but gives no guidance for what to do if the manufacturer does not suggest an interval. Again, the manufacturer's interval may not be appropriate for the equipment in the conditions experienced by a specific airline operator. For example, an international airline may have a model of equipment that is used to service aircraft in environmental extremes that range from summer days in Phoenix, Arizona to winter nights in Moscow, Russia. A smaller airline may use the same model under a much narrower range of environmental conditions, which could lead to a different calibration interval. However, the FAA also requires that interval analysis be done using statistical analysis of calibration results and a reliability target, and specifically prohibits using only counts of pass and fail information [19]. This last condition means that the two most common methods, A1 and A2 in RP-1, cannot be used by an airline or an airline repair station. (The other deficiencies and issues with methods A1 and A2 are beyond the scope of this work, and are well documented in RP-1 and other places.)

Where does this leave the calibration lab – you with the customer who has just asked how often this item should be calibrated? This is something that should be addressed in your quality procedures and at contract review with the customer. At this point there are no easy answers, but your customer still expects some kind of answer.

Fortunately, it is much easier, and justifiable, to *reduce* a calibration interval on much less data than would be required to *increase* the interval. For example, suppose your customer has one of a model of meter that is on a six month interval, it has failed the previous two calibrations, and the customer desires a 90% end-of-interval reliability (defined by passing the calibration without an out of tolerance condition.) At this point you could suggest reducing the calibration interval by some amount, because you already know it will have to pass at least the next 20 consecutive calibrations in order to meet the goal. The problems are that this doesn't tell you *how much* to reduce the interval, and it will take more than 20 calibrations to collect enough data on one unit to *increase* the interval with any statistical validity.

7. The maintenance manual says to use a XYZ ...

“The maintenance manual says to use a XYZ but I don't have one. Can I use something else instead, and what should I choose?” Corporate in-house labs are most likely to hear this question. There are many environments where an organization is maintaining equipment with a very long life cycle, so the maintenance manuals may have been written several decades ago. The Boeing 737 aircraft, for example, has been in production since 1965 and in service since 1968 [20], and design work started in the early 1960's. Test and maintenance equipment that was cutting-edge in 1965 are now candidates for museums – if you can find it. If the organization is in a regulated industry such as aviation, pharmaceuticals or nuclear energy, the regulating agency may have strict rules about using items other than what the original manufacturer stated.

The FAA, for example, requires that airline operators and repair stations use the tools or test equipment listed in the aircraft or component maintenance manual, or approved equivalent tools. While each operator and repair station has their own procedures, determining equivalency can sometimes be an involved process because the FAA requires that the determination of equivalency be a documented process and based on evaluation of appropriate technical data [21]. That can be a problem, especially if neither the manufacturer of the component being worked on or the listed test equipment exist any more, and there's no useful data to work from ... that is why the customer is asking you for help, because they regard you as the measurement expert.

As previously shown by Payne [22], the most useful tactic is to determine what is being measured, and what the nominal value and performance limits are. You can then recommend an instrument that is capable of the measurement with a 4:1 or better test accuracy ratio, or if that is not possible suggest what is available with a calculation of a suitable guardband.

8. Conclusion

For many of reasons the calibration laboratory has to be prepared to field any question the customer may have. The typical questions presented here are probably the most common, and are based on experience dealing with customers' perceptions and beliefs regarding the calibration process, the calibration lab and the calibration technicians and engineers. Some of the questions are hard to answer, because the calibration lab is often in a position where they do not and cannot have all of the required information. The task then is to explain this to the customer, and try to come up with a solution that both parties can live with and support to their respective auditors. Successfully communicating with your customers on these and other questions will help the customer gain a better understanding of the services they are buying, and help you gain a better understanding of your customers' needs.

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