CALIBRATION OR VERIFICATION OF MEASURING INSTRUMENTS – WHAT NEEDS FOR INDUSTRY?

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Abstract: For a long time the terms calibration and verification and verification have often been used as synonyms. Sometimes the difference of meaning is connected with the application in legal metrology or in industry. Today the international Vocabulary of Basic and General Terms in Metrology (second edition – 1993) doesn't speak about verification but other standards make its definition clear. In industry what is to be done in the context of Quality assurance implementation? From our point view the user has to choose between 'calibration" and "verification" in order to demonstrate the traceability to national or international standards.

The purpose of this paper is to propose a clear scheme of application in industry taking in consideration a third possibility: the application of Statistical Process Control Techniques in place of – or together with – calibration or verification.

Keywords: Metrology, calibration, verification

1 INTRODUCTION

Everybody is always commonly measuring something in everyday life. People measure lengths, weights, speeds, time and they expect the indications of their measuring instruments to be reliable. In industry, for the manufacturing of products as well as for the provision of services, careful measuring is an element of the quality of the manufactured product or of the service provided.

To carry out measurements, instruments are used, which no matter how sophisticated and modern they may be, have hall a common drawback: their readings are not constant in time. The causes of this drifting are many and the major one is definitely obsolescence. But there are other reasons: mechanical wear, oxidation, wrong handling…

A typical example shows that responsible manufacturers are aware of the drift and they can find how large it is. Figure 1 represents the specifications of a multimeter. If can be noted that its accuracy decreases with time and that it will be roughly 3 times less good after one year's operation than after three months.

Accuracy: ± (% of Rdg + Counts)

Range	24 Hours	90 Days	1 Year
10 Ω	0.003 + 20	0.005 + 20	0.01 + 20
100 Ω	0.002 + 2	0.003 + 2	0.006 + 2
1 kΩ	0.002 + 1	0.003 + 1	0.006 + 1
10 kΩ	0.002 + 1	0.003 + 1	0.006 + 1
100 kΩ	0.002 + 1	0.003+ 1	0.006 + 1
1 MΩ	0.002 + 1	0.003+ 1	0.006 + 1
10 MΩ	0.01 + 1	0.02 + 1	0.04 + 1
100 MΩ	0.03 + 1	0.05 + 1	0.1 + 1

Figure 1. Evolution of the accuracy of a multimeter

Another example can be mentioned. If is about the burettes which are used to measure volumes of liquids. Undeniably this measuring instrument- a bit special – drifts more slowly than a multimeter, but there is one question that after it has been used five or ten years glass distortion may occur and the graduations may be altered, thus producing erroneous measurements.

2 MEASUREMENT AND QUALITY OF INDUSTRIAL PRODUCTS

Measurements, in industry, are carried out at the four stages of the elaboration of a product:

- Beforehand, at the stage of research often linked to applied research in a laboratory.
- When prototypes are tested or the qualification of products is tested.
- When the products are manufactured.
- When these products are verified.

At these different stages, the operator has to be able to rely on the reading of the measuring instrument, he has to have evidence that instrument has not drifted beyond some limits. The must, in other words, be in a position to show that the traceability of the measurement to national standards is complied with. What does this person need not to remain in doubt? The language of the metrologists of the various countries makes use of the following terms:

- Calibration
- Verification
- Confirmation
- Validation
- Qualification.

For some authors, these different terms are equivalent, or more exactly each one of these terms is used indifferently to describe the fact there is traceability to national standards. This confusion, or lack of clarity, has been going on for time, at least some thirty years, probably more. During this period, the "International Vocabulary of Metrology" was published by ISO, it has the advantage of giving a clear definition of the word calibration, but it doesn't mention the other terms (verification, confirmation…).

Let us then try to analyse the definitions of each term, when they exist, and attempt to draw a conclusion about the real needs for industry, the one and only aim being to make sure of the quality of measurements to guarantee the quality of products.

3 CALIBRATION

This is the definition from the V.I.M:

Set of operation that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or a reference material, and the corresponding values realized by standards.

NOTES

1. The result of a calibration permits either the assignment of values of measurands to the indications or the determination of corrections with respect to indications.

2. A calibration may also determine other metrological properties such as the effect of influence quantities.

*3. The result of a calibration may be recorded in a document, sometimes called a **calibration certificate or a calibration report**.*

Therefore

- a calibrated operation does not entail any conclusion of conformity or non-conformity to a specification
- a calibrated instrument, even if its deviation from the standard is big, can be used on condition a correction is applied.
- a calibrated instrument cannot be used without its calibration certificate.

It goes without saying that a metrology laboratory which makes measurements for which each influencing parameter is important to reduce the ultimate measurement uncertainty will use calibrated references which by the way are called standards.

On the other hand in a workshop where the major influencing factor will be temperature for instance, the operator will only need to rely on his measuring instrument, then to know whether it is good or bad. Hence the notions of verification, confirmation, validation…

4 VERIFICATION

Three definitions taken from two ISO documents and an American norm deserve full quotation.

ISO 8402 Quality management and quality assurance vocabulary.

*Verification: Confirmation by examination and provision of **objective evidence** that specified requirements have bee fulfilled.*

NOTES

1. In design and development, verification concerns the process of examining the result of a given activity to determine conformity with the stated requirements for that activity..

2. The term "verified" is used to designate the corresponding status.

ISO Guide 25   general requirements for the competence of calibration and testing laboratories.

Verification: confirmation by examination and provision of evidence that specified requirements have been met.

NOTE

- *In connection with the management of measuring equipment, verification provides a means for checking that the deviations between values indicated by a measuring instrument and corresponding known values of a measured quantity are consistently smaller than the maximum allowable error defined in a standard, regulation or specification peculiar to the management of the measuring equipment.*
- *The result of verification leads to a decision either to restore to service, or to perform adjustments, or to repair, or to downgrade, or to declare obsolete. In all cases it is required that a written trace of the verification performed be kept on the measuring instrument's individual record.*

ANSI/NCSL 2540-1 – 1994

American National Standard for Calibration.

Calibration Laboratories and measuring and test equipment. General requirements.

Verification: Evidence by calibration that specified requirements have been met..

NOTES

1 and 2 ..identical to the note of ISO guide 25

3. *The term "verification" as defined in this standard is frequently referred to as "calibration" in the United States*.

The first two definitions are very close, the one of ISO guide 25 has the advantage to be specific to measuring equipment. On the contrary, the American definition reveals that in the United States the amalgam "calibration – verification" is solid and that the norm is likely to maintain the confusion for a long time!

Then if we consider the definition of ISO guide 25 verification permits to decide whether a measuring instrument satisfies its specifications, if it does not it should be either repaired or corrected, or downgraded, or even decommissioned.

It must be noted that in the definition of ISO guide 25 the word "calibration" is not used. This means that you can verify a measuring instrument without calibrating it. This seems obvious, but unfortunately this evidence is not accepted in every country.

5 METROLOGICAL CONFIRMATION

Only one document defines the term "confirmation", it is Project ISO 10012 (CD1). Its title is "Measurement Control System" and the definition is:

- *Set of operations required to ensure that an item of measuring equipment is in a state of compliance with the requirements for intended use.*

NOTES

1. *Metrological confirmation normally includes calibration and/or verification, any necessary adjustment or repair, and subsequent recalibration, comparison with the metrological requirements for the intended use of the equipment as well as any required sealing and labeling.*
2. *Metrological confirmation is not achieved until and unless the fitness of the measuring equipment for the intended use has been demonstrated and documented.*
3. *The requirements for intended use may include such considerations as range, resolution, maximum permissible errors, etc.*
4. *Metrological confirmation requirements are usually distinct from and are not specified in product quality requirements.*
5. *A diagram of the processes involved in metrological confirmation is given.*
6. *For brevity in ISO 10012, this term may be referred to as "confirmation"*

A new element is introduced, it is the notion of "intended use". Is the measuring instrument, either verified or calibrated, fit to do the job the user wants it to do or, more precisely, is it reliable to make the measurement intended? For instance, is the uncertainty provided by the instrument sufficient with the measurement margins compared?

Figure 2 Simply illustrates the difference between the two notions of calibration and verification.

This diagram was first published in the French norm NFX 07010 entitled "The metrological function in the firm", it has been taken up again and supplemented in the revision draft of norm ISO 10012-1 in a slightly different form, introducing the notion of metrological confirmation. This latter version has not been published.

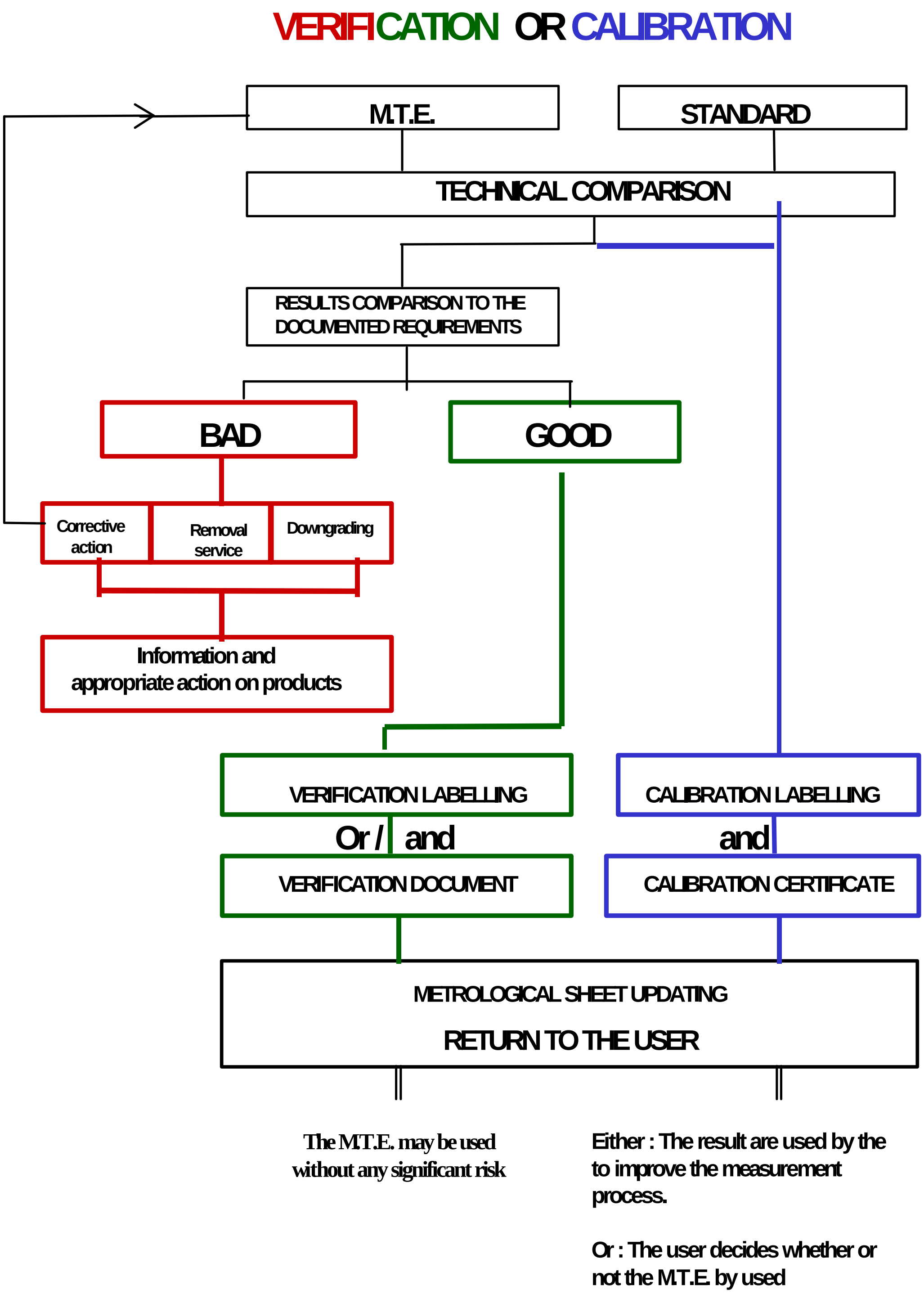

Figure 2. Verification and Calibration

6 QUALIFICATION, VALIDATION…

These terms which are sometimes used are defined in norm ISO 8402. To my mind, they are synonyms of verification in metrological language; “validation” is close to “confirmation” as it brings in the notion of distinctive specifications for a specific use.

7 CONTROL OF MEASUREMENT PROCESSES

Another concept developed in norm ISO 10012-2 entitled “Control of measurement processes”. If is based on the SPC (Statistical Process Control) type supervision principle; it consists in regular “controls” of the measuring equipment over short periods (once a day or once a week for instance) using a check standard. Keeping track of the evolution of the result, within upper and lower limits, makes it possible to undertake either a correcting action or a repair of the measuring instrument. (Figure 3)

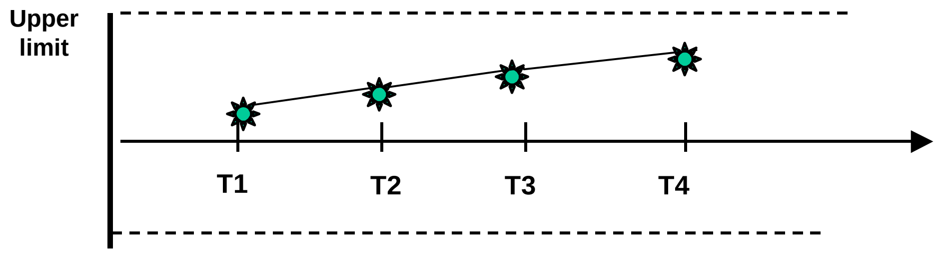

Figure 3.

Interesting result are obtained by this method for laboratory scales or three dimensional measuring machines, for instance.

8 WHAT NEEDS FOR INDUSTRY

After over 30 years of experience, watching the metrology problems which rise in industry, there are good reasons to believe it is advisable to minutely analyse the requirements before deciding what is the best solution to ensure the quality of the measurements made.

A choice has to be made between four possible solutions

- Calibration
- Verification
- Confirmation
- Control of measurement processes

Calibration - for the firm’s standards and the transfer standards used as references.

Verification - for most measuring instruments that the user needs to know they are reliable, regardless of the specifications of the measurement to carry out.

Confirmation - for the measuring instruments used to make measurements allowing a margin, when the ratio between margin and measurement uncertainty is low, lower than 4 or 3, for example.

Control of measurement processes – every time it can be done and the user is motivated, trained and takes part in the follow up of result.

A possible division of the different cases in a firm manufacturing aeronautical materials is a follows :

3% calibration
2% metrological confirmation
4% control of measurement processes
93% verification.

9 CONCLUSION

There is still a long way to go before the concepts exposed in this paper are accepted by metrologists all over the world. The different cultures, the countries’ economic past, custom, the practices of legal metrology cause that the different notions mentioned are not accepted by all.

It is unquestionably the role of normalization organization, ISO especially, to attempt to make clear these various concepts, with the purpose of improving the quality of measurements and lowering the costs of metrology. Work is being done in this direction by the TC 176 of ISO. It is to be wished that it will soon show results, and particularly that the documents produced will be clear for everybody.

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