Calibration intervals : a practical approach ?

Speaker / Author

Gilbert BRIGODIOT
EADS Launch Vehicles
Rue du General NIOX BP 11, 33165 Saint Medard en Jalles CEDEX
France
Phone: +33 5 56 57 35 95 Email: gilbert.brigodiot@launchers.eads.net

Abstract

This paper describes a method elaborated to optimize the periodicity of the calibrations / verifications of the measuring equipment in EADS-LV. The acronym of this methodology is OPPERET, for "OPtimisation des PERiodicités d'ETalonnage" (in American, "Optimization of calibration periodicities".)
This new approach is being tested, favouring the experience of the metrology lab and the objective satisfaction of the needs of the measuring equipment user. The methodology focuses on the increase of the risk in the measurement process versus the increase of the drift of the equipment. A software has been developed to help for decision making, balancing the pro and the con for extension of a calibration interval.

1. WHEN DO WE CALIBRATE / VERIFY ?

Too early, when at the end of the verification, we notice that the equipment is still fit for use,
Too late, when at the end of the verification, we notice that the equipment in no longer fit for use !

In fact, most people use periodic calibration, and choose the period according to tradition : generally, a multiple of a year, or the manufacturer's recommendation. This tradition comes from old rules that have been established in the Defense Industry and that have been kept as they were the only model available for auditors. Some attempts have been made to find rational methods, the oldest one (and the best one) RP 1, from NCSL. (first version in 89). In Industry, they didn't get the recognition they deserve.

Why do people prefer the yearly interval ?

It's the easiest choice, it's like sowing and harvest : annual. Just copy what the others do, the auditor will be pleased !. There is no choice but to accept that the methods give advice, but too general (they bring no help) or too complicated (see statistical methods !).
It is amazing that you get thrashed if you use a piece of equipment that the due date has been exceeded, but no one asks you why you chose a year as the periodicity.

"Metrology is not our core business" our managers repeat all day long, even in leading edge companies. In metrology, significant savings have been obtained during these past five years, but these types of actions now seem to have reached their limits. It is now suitable to work on other fields such as periodicity

Now ISO 9001:2000, and ISO/IEC 17025:1999 ask you to become more competent than disciplined, and so, it is time to save more money.

It is time to exploit the knowledge we gained for years of calibrations and to go back to the root : Clause 5.5.2 of ISO/IEC 17025:1999 contains the requirement: "Calibration programmes shall be established for key quantities or values of the instruments where these properties have a significant effect on the results". OPPERET follows from this key requirement.

Goals

The economic target is to reduce the global cost of metrology 20 % by the end of 2003.

The quality target is to maintain the reliability level of the calibrated instrument population, expressed in number of declared anomalies . The present rate is 2 %.

2. OPPERET METHODOLOGY

2.1 The reasoning

The key point to determine in the review of periodicity of calibration is the risk due to an erroneous measurement, that is the product of the gravity by the probability of an erroneous measurement.

As the number of anomalies attributable to the measuring equipment that is calibrated at the presently fixed periodicity is low (less then 2 %), we think that this periodicity is low enough for the worst cases of risk. We are sure that with the periodicity that we established, we practice "over quality".

So, first conclusion : the periodicity can be stretched for the equipment that have better intrinsic quality, that are used in better situations, that do not suffer of transportation and so on.

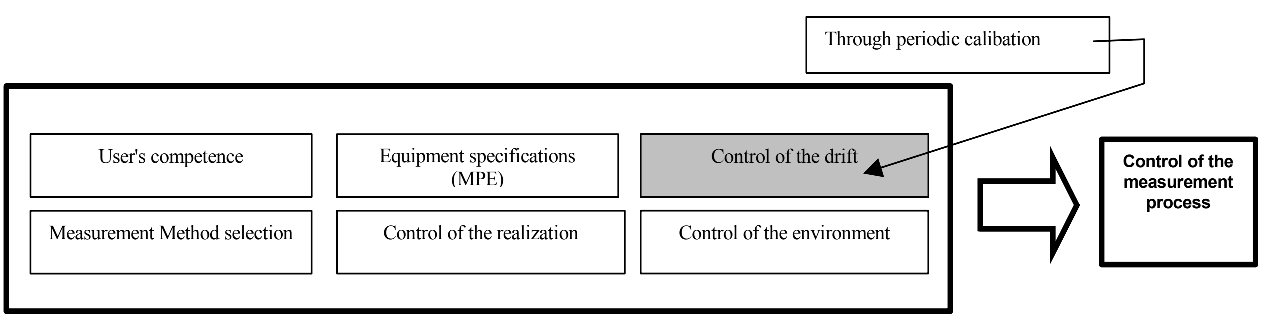
The problem is to identify the situations where we practice "over quality" and to measure how far we are from the quality level we need.

2.2 The basic information needed

As we mentioned above, the parameters that must be taken into account in the periodicity review are :

- the gravity of the consequences of an erroneous measurement, which depends on the final product that is measured,
- the probability of the occurrence of a false result, which depends on the ratio : uncertainty of the measurement process to tolerance of the product : **$U_{process}$ / product tolerance**

Using the ISHIKAWA method, the uncertainty of the measurement process may be broken down into different components :



The intent of periodic calibration is to limit the drift of the equipment (drift must be understood either continuous or erratic). What is important for decision making about periodicity is the ratio : Drift / product tolerance and can be expressed as the product of 3 ratios :

Drift / product tolerance = (Drift / MPE) x (MPE / $U_{process}$) x ($U_{process}$ / product tolerance)

In addition to the estimation of gravity, we need 3 ratios , and 4 pieces of data:

1. the drift, that can be obtained by the examination of the technical results of the previous calibrations and by the expertise of the metrologist,
2. the MPE that has been chosen as the capability of the equipment,
3. the uncertainty of the measurement process
4. the tolerance for the product.

This factorization is useful to get the ratio : U_{drift} / product tolerance, because :
The first ratio (Drift / MPE) is evaluated by the metrologist, whose job is to compare the equipment error to the MPE, and knows the variations of the error at each calibration (the drift),
The second ratio, (MPE / $U_{process}$), can be evaluated by on site assessment, by examination of the choice of measurement method, the competence of the user, the environmental conditions, the respect of procedures, ….
The third ratio, ($U_{process}$ / product tolerance), can be evaluated with the manager of the Design Department.
In conclusion, the evaluation of the impact of an extension of the calibration needs participation by 3 people : the metrologist, the user on site and the Design Department.

2.3 Additional parameters needed

In a probability study, we must consider the factors that increase or decrease the risk by increasing or decreasing the probability,. For most of equipment, an intensive use of the equipment increases the drift. At the contrary, redundancy is a probability reduction factor and prevents the risk.

We also have to take into account 2 constraints : the cost of calibration and the constraints of organization, like versatility.

So, if we add gravity, 3 ratios needed to reach the Drift / product tolerance ratio, the 2 additional factors and the 2 constraints, 8 parameters must be evaluated.

2.4 How to measure these parameters :

Some of these parameters can be quantitatively measured : for example Drift / MPE, but most of them can only be evaluated qualitatively : gravity, contribution of the equipment in the process uncertainty, contribution of the drift in the equipment contribution, aggravation and reduction factors, weight of the constraints.

So each of this contributors are evaluated on a 5 grade scale, very low, low, medium, high and very high. For gravity, the scale has only 3 grades (low, medium, high).

These judgments will be transformed into numeric values, such as –2, -1, 0, +1, +2.

2.5 How to characterize the population

Each family of measuring equipment can be characterized by the mean and the standard deviation for each parameter. For example, for 68 piece family of caliper :

i	68 caliper population	Mean m_i	Standard deviation σ_i
1	Gravity	-0,8437	1,8057
2	Process capability	-0,875	1,9724
3	Equipment capability	-0,0781	0,3986
4	Drift	-0,1562	0,7362
5	Usage rate	1,687	3,4702
6	Redundancy	0,7656	1,8855
7	Cost constraint	-0,9375	2,0184
8	Polyvalence constraint	-1,617	3,2768

2.6 How to characterize a particular equipment in the population

One particular equipment can be compared to the population regarding each of the 8 parameters. The measure is the normalized distance from the mean of the population minus one standard deviation : $x_{i=1\,\text{to}\,8} = \dfrac{X_{i=1\,\text{to}\,8} - (m_i - \sigma_i)}{\sigma_i}$

i	68 caliper population	Mean m_i	Standard deviation σ_i	Caliper N° 69 Normalized distance $x_{i=1\,\text{to}\,8}$		
				Xi	Xi-(mi-σ_i)	x_i
1	Gravity	-0,8437	1,8057	-2	0,65	0,36
2	Process capability	-0,875	1,9724	2	4,85	2,46
3	Equipment capability	-0,0781	0,3986	1	1,48	3,70
4	Drift	-0,1562	0,7362	1	1,89	2,57
5	Usage rate	1,687	3,4702	-2	-0,22	-0,06
6	Redundancy	0,7656	1,8855	-1	0,12	0,06
7	Cost constraint	-0,9375	2,0184	2	4,96	2,46
8	Polyvalence constraint	-1,617	3,2768	2	6,89	2,10

2.7 How to weigh the impact of the parameters

As the parameters have not the same impact, they must be weighted. For example, gravity is much more important that the impact of the cost of calibration, so its weighting factor w_i is for example 2 times the weighting of the cost. We obtain 8 grades for 8 different parameters

i	68 caliper population	Caliper N° 69 Normalized distanced	Weighting factor	grade
		x_i	w_i	$x_i w_i$
1	Gravity	0,36	4	1,44
2	Process capability	2,46	4	9,84
3	Equipment capability	3,70	3	11,1
4	Drift	2,57	2	5,14
5	Usage rate	-0,06	3	-0,18
6	Redundancy	0,06	3	0,18
7	Cost constraint	2,46	2	4,92
8	Polyvalence	2,10	2	4,2

The overall grade is the sum of the 8 grades. In this example, 36.64 points. Some unfavorable parameters (like high usage rate) are counterbalanced by favorable ones (good equipment capability and low drift)

If we compute the global grade for various situations, all X_i equal to –2, -1, …+2, +3

	all X_i	**Corresponding global grade**
	-2	-10,2
Worst situation (but acceptable)	-1	8,4
medium	0	26,9
	1	45,4
Best situation	2	64,0

Now we can choose a decision rule such as :

if the global grade is above	under	**Decision for the particular equipment :**
	8,4	Danger, reduce the periodicity
8,4	45,4	The experience shows that it works, don't modify
45,4	64,0	Double the periodicity
64,0		Triple the periodicity

3. SOME QUESTIONS ABOUT OPPERET

3.1 Is this methodology complicated ?

No, it converts into figures the evaluations a competent person can perform, and follows a simple reasoning !

3.2 What are the pro's and con's ?

The main advantage of the method is that it can be adapted to any kind of measuring equipment because many "trimmers" can be adjusted :

- the scale converting qualitative evaluation to figures
- the weighting factors,
- the decision rule.

After these adjustments, the method is repeatable and give the same judgment for the same parameters evaluation.

Another positive point is the use of information that is fundamental for the periodicity review, such as the drift, but also the needs regarding the product (the risk evaluation), the measurement process on site, the factors that modify the probability of erroneous measurement, the constraints (such as the costs). No other method but this one takes into account all the parameters !

The disadvantage is need of gathering a lot of information : it takes time and the need of adjusting the "trimmers" depending on the type of equipment : it also takes time !

3.3 Does it really work ?

Yes, it seems to. The methodology has been applied in the length measurement domain, in thermometry and electricity, and gives results in perfect harmony with the wisdom of a metrologist and of the managers. Th savings are about 20 % of the cost of calibration in these fields. Some periodicities have been multiplied by three.

There have been no negative comments coming from our auditors : they appreciate the reasoning, the use of a complete set of data and the repeatability. We can explain how we adjusted the "trimmers".

4. CONCLUSION

We at EADS are convinced that we are on the right track with this approach; we will save money; and maintain a high confidence in the reliability of the instruments we calibrate under this program.

Try it! We think you will like it!

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