

State of the art of uncertainty and traceability management in Italian NDT-Laboratories

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Testing Laboratories compliance assessment to ISO IEC 17025 raised wide interest in test results' uncertainty and traceability, while, in the past, only Calibration Laboratories managed them.

Nondestructive Tests (NDT) in Italy are not acknowledged as laboratory-tests; therefore only three laboratories performing NDT are accredited in conformity to ISO IEC 17025, while hundreds of Laboratories performing NDT are, at most, certified in conformity with ISO 9000.

Nevertheless, in some industry sectors where the need for safety is strong and non-quality costs are high, interesting experiences have been made.

The report, based upon thirty interviews with NDT specialists, reviews and updates Italian NDT Laboratories management of uncertainty and traceability.

Introduction

Measurement uncertainty is an intuitive concept, yet one that entails great mathematical/statistical commitment in the field of metrology. The concept of measurement uncertainty is intuitive for non-destructive tests (NDT) too, but its definition is a mathematical/statistical problem only for a small part (i.e. measuring thickness using ultrasonic methods), while most of the times it depends on many other parameters, which make a guide to measuring uncertainty quite a challenge [8] [17].

In these situations, item 5.6 of the ISO/IEC 17025 [15] requires for a reasonable estimate of the uncertainty to be provided, and for the expression of the result to not give a wrong impression of the uncertainty. The standard also specifies that the reasonable estimate must be based, among other things, on data validation, from which the great significance of inter-laboratory tests (round-robin). The estimate of measurement uncertainty of NDTs has developed since the very origin of these tests, whose final result entails an acceptability opinion based not only on the size of defects, but also on their nature, position in the piece, operating conditions, etc. Gradually, the term uncertainty has become associated with the term detection: Probability of Detection (POD) and consequently Probability of False Indication (PFI) or Classification (PFC), when there is a false indication or when the nature of the defect is unknown [11] [13] [19].

The attention of NDT technicians and researchers has largely focused on procedure validation programs by means of inter-laboratory tests (round robin) with defective samples: the oldest and most popular one is the PISC (Programme for the Inspection of Steel Components) which began in 1974, within the scope of nuclear programmes, and in which Italy participates not only because it is developed in the European Research Centre of Ispra, but also because Italian laboratories take part in it, the most important one being the ENEL DCO Laboratory in Piacenza, [9] [10] run by Dr. Giorgio Maciga. Since then, the practice of estimating uncertainty has spread to many other sectors of the PND, and today it is even more topical for several reasons:

- Digital techniques that have changed all instrumentations and the relevant measuring techniques: Measurement uncertainty is consequently very important in terms of test **validation**.
- Moreover, **standard ISO/IEC 17025** [15] applied by the Accreditation Bodies of laboratories that carry out NDTs expressly requires the validation of procedures and the uncertainty estimate.
- **POD** is highly important in defining acceptability criteria and the frequency of in-Service inspections of machines and plants, and this is obviously associated with costs for improperly scrapped materials and maintenance costs.
- **POD** is an essential parameter when it comes to new techniques too, in order to evaluate their utilization limits [2]

Contributions by Italian authors

As mentioned above, the Italian world of NDTs has taken part since the very beginning in the definition of uncertainty parameters in the NDTs and in the organisation of inter-laboratory tests [9] [10]. Subsequently, interest waned and I could not find any Italian contribution to this research in literature, while attention is being paid by other NDT communities, old and new [12] [17].

This unconcern seems to be largely due to the disappearance of important breeding grounds of NDT specialists, such as the ENEL laboratories, strongly downsized by short-sighted rationalisation policies.

We focus more on the POD in new measurement techniques [1][2][5][6][14][16] and in the definition of acceptability criteria and time intervals between one inspection and the next [1].

Even in the field of civil engineering, where NDT are only at the beginning, there is already talk of measurement uncertainty, thanks to the fact that often it is University Professors who deal with it [4].

The situation in Italy

For an in-depth discussion on the level of interest in the topic of the NDT world in Italy, we interviewed approximately thirty Italian experts in the sector and level 3-certified technician who are especially active, asking them a few questions:

1. In your organization, do NDT test procedures include an estimate of uncertainties?
2. In the certification of companies who perform NDTs, do you find that the provisions of standard ISO/IEC 17025 are being taken into account?
3. Do you participate in / organise inter-laboratory NDTs (round-robin)?

One fourth of the interviewees gave an affirmative answer to questions 1 and 3, in other words whether or not uncertainty is taken into account in their work and if they participate in round-robin tests, while only 10% was aware of standard ISO/IEC 17025. These interviewees belong to the only three Italian companies accredited for NDTs, two of which for methods for which the Accreditation Body (SINAL) admits that the uncertainty estimate does not have to be included in test procedures (MT, PT and RT).

The third Laboratory, on the other hand, also accredited for UTs and LTs, felt the need to both assign criteria for estimating uncertainty to all procedures and to organise internal round-robins and participate in international round-robins. Specifically, internal round-robins were used to define uncertainty in the field of ultrasounds, while the international round-robins (China NIL Research Center for Proficiency Testing), again concerning ultrasounds, were a useful comparison with other laboratories. Concerning the LT, this technique has considerable metrological implications, so much so that the reference experts for these tests in Italy work for the Primary Metrological Institute (INRIM) [3]. Please note that most of the Service Companies to whom NDTs are outsourced refuse to be accredited, choosing instead an ISO 9001 certification. In the authors' opinion, this position is incorrect, since it does not provide any guarantee nor added value to the tests carried out, so much so that the Certification Bodies do not even take into account standard ISO/IEC 17025, which should nevertheless be the basis of any test activity.

This is probably the reason for such a high degree of unconcern among Italian NDT laboratories for problems related to the estimate of measurement uncertainty and inter-laboratory tests (round-robin).

The situation is different outside of Italy, where Accreditation and Certification bodies contribute to spreading a testing culture, and they provide guidelines on the application of reference standards [7] [8] and encourage the organisation of inter-laboratory tests (Proficiency Tests) [18].

Finally, please note that in European Standards (EN) on NDTs, even the recently adopted ones, we did not find any mention of measurement uncertainty, not even in standards concerning the calibration of instruments.

The above concerns the large number of Italian Laboratories that carry out NDTs, with the exception of those operating in the aeronautical sector, as they were standardised long ago to NADCAP standards, which are not too different from standard ISO/IEC 17025 about these topics.

Final remarks

In our opinion, the little interest in Italy in the application of the standard concerning the competence of testing laboratories is basically due to a cultural delay brought about by the disappearance of a large portion of the electro-mechanical industry and of its laboratories, a driving force in the sector of NDTs since they were first introduced.

In these fields, however, standards have achieved a high level of completion and perfection, consequently whoever performs the tests by properly following the standards rarely overlooks serious defects. On the other hand, non-serious defects or even false indications may cause the piece to be scrapped or repaired, with additional times and costs that could have been avoided through careful validation of the testing procedures. In confirmation of the above, we can observe that the more in-depth examination of topics concerning measurement uncertainty and POD come from the petrochemical industry, where there is an extremely high need for safety but also great focus on costs, and specifically from the pipeline checks[19] in which Italian companies are also involved [20]. At the same time, we are witnessing in Italy the development of other sectors, often side by side with university research, for the most part in new fields (i.e. civil) or in niche areas (i.e. thermography), where there is greater focus on proper validation of the uncertainty of test results.

Meanwhile, whoever enters new fields, such as for example the inspection of underground tanks, aqueduct piping or district heating [2], has to necessarily provide an estimate of the measurement uncertainty in order to prove that the test is valid.

Conclusions

The introduction of the uncertainty estimate in NDTs is a sign of technical progress and it is far from being a whim of idle laboratory scholars or certification bureaucrats; most importantly, it is a powerful tool for test rationalisation and for the reduction in overall machinery and plant construction and management costs.

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Summary of the performed interview:

Questions to Italian NDT experts:

1. In your organization, do NDT test procedures include an estimate of uncertainties?
2. In the certification of companies who perform NDTs, do you find that the provisions of standard ISO/IEC 17025 are being taken into account?
3. Do you participate in / organise inter-laboratory NDTs (round-robin)?

Answers:

Question 1	Question 2	Question 3	Notes
	Yes		ISO 17025 accredited
Yes	Yes (Nadcap)	Yes (UT,RX)	Aeronautic
No	No	No	
No	No	Yes (EA)	
No	No	No	
No	No	No	Instrumentation supplier
Yes	Yes	Yes	ISO 17025 accredited
No	No	No	
No	No	No	
No	No	No	Metallic structures manufacturer
Yes (validation)	No	Yes (ET,UT)	Pressure equipment manufacturer
No	No	No	(*)
No	No	Yes (UT,RT)	
No	No	No	<<..not required by NDT standards..>>
No	Yes	No	ISO 17025 accredited
-	No	No	Certification body
Yes	No	Yes (UT;ET)	
No	No	No	
Yes (POD)	No	No	Petrochemical industry
No	No	No	
No	No	No	Pressure equipment manufacturer
No	No	No	
Yes (**)	No	No	Instrumentation supplier
Yes (**)	No	No	Instrumentation supplier
Total:	Total:	Total:	
Yes 30%	Yes 12%	Yes 25%	

(*) estimated answers

(**) in the instruments calibration procedures