

# Accreditation of Ultrasonic Thickness Measurement Methods – Practical Aspects

Damir MARKUČIĆ, Vjera KRSTELJ, Faculty of Mechanical Engineering and Naval  
Architecture, Zagreb, Croatia  
Ana LYPOLT, Croatian Society of NDT, Zagreb, Croatia

**Abstract.** Basic requirement in accreditation of laboratories that perform ultrasonic thickness measurement is to provide evidence that method is performed according approved procedure. The most relevant general prerequisites are that NDT personnel have adequate certificates while instruments and equipment have to be traceable. In the process of accreditation these two unavoidable prerequisites could be tested by assessors in a very administrative way.

Some remarks on assessment procedure will be presented in this paper. The comments are regarding to inspection bodies that prove implementation of the method and particularly about demands considering ultrasonic thickness measurement uncertainty.

Given examples are mainly based on practice from Croatian shipyards and from process and petrochemical plants in which manual ultrasonic thickness measurement method is frequently and regularly utilized. Review on the extent of requests and criteria applied by assessors will be given, particularly concerning required certificates, referent standards, performance demonstration and measurement uncertainty. Final approval solely relies on assessors' (inspectors') technical competence and knowledge whereas NDT competence is not enough involved in procedure. Experience from practice shows that measurements are performed according to the procedure with reliable results but out of possible technical achievement. The results could be frozen by measurement capabilities depending on the assessors' competence. It will be evidently presented that professionals in the field are crucial in accreditation process and should be the part of the assessment team.

## Introduction

In a number of industrial applications, during pre-service and in-service inspection, the monitoring of component wall thickness is required. Since the most of ultrasonic thickness measurement instruments available on the market are simple for usage and user friendly, many potential users have an impression that it is enough to switch on the instrument and record the readouts. "It is so simple like using pocket calculator, so any qualification or certification of personnel performing ultrasonic thickness measurement is completely unnecessary" is the common response of employers.

On the other hand experts involved in NDT are completely aware that effectiveness and reliability of ultrasonic thickness measurements rely on competences and capabilities of personnel who perform or who are responsible for ultrasonic thickness measurement.

There is a number of liable employers who recognize necessity that operators who perform "only" ultrasonic thickness measurements also must have adequate NDT knowledge, skills and competences. These employers seek for certification of operators' competences, but exclusively for ultrasonic thickness measurement method therefore

usually called limited application certification. From the employers' point of view such limited application qualification and certification means also significantly reduced total expenses in comparison with i.e. qualification and certification for level 1 in ultrasonic testing method. That is due to the following facts:

- training courses are significantly shorter what reflects on courses' prices,
- corresponding expenses for the candidate are therefore also reduced (i.e. accommodation),
- and probably the most important reason is that the employee (candidate) will be absent from his everyday job during shorter period of time.

Additional reason that could force down employers to seek certification for personnel performing ultrasonic thickness measurements is the case when a laboratory applies for accreditation of this testing method. Primary relevant standard is EN ISO/IEC 17 025 [1] providing general requirements for the competence of testing and calibration laboratories. European standard that provides requirements and specifies the principles for ultrasonic thickness measurements of metallic and non-metallic materials based on measurement of time-of-flight of ultrasonic pulses is EN 14127 [2]. In Clause 5.6 (Qualification of personnel) the basic requirements regarding knowledge and skills are specified. In order to prove adequate qualification of personnel, it is recommended to certify the personnel in accordance with EN 473 [3]. Equivalent certification is also allowed while no required level of certification is specified.

For the employers this is satisfactory basis not to seek extensive qualification and certification for ultrasonic method but to look for qualification of limited application. Available international standard providing provisions for limited applications of non-destructive testing is ISO 20 807 [4]. System established by ISO 20 807 is not intended to substitute qualification and certification within the scope of ISO 9712 [5] or EN 473. Qualification system may be applied to the qualification of personnel only for limited or repetitive or automated NDT applications such as:

- eddy current and electromagnetic sorting of materials;
- eddy current and electromagnetic testing of tubular products during manufacture;
- normal beam ultrasonic testing of plate materials during manufacture;
- ultrasonic thickness testing,

which are not the only range of qualifications that could be covered by standard.

In Croatia there are fields of application of ultrasonic thickness testing where no formal accreditation according to EN ISO/IEC 17 025 [1] is necessary. The approval delivered by relevant inspection body is relevant like it is in shipbuilding industry where requirements are set by Registers of shipping.

In all mentioned circumstances there is quite wide range of requests and criteria applied, from almost none to those identifying measurement uncertainty of ultrasonic thickness measurements. But in all circumstances the measurements performed must ensure reliable results within the scope of the thickness measurement application.

The essential prerequisites for ensuring **reliable and complete information on measured thicknesses** is going to be discussed.

## Instruments

For the purpose of ultrasonic thickness measurement the following three types of instruments are available as it is also specified in standard EN 14 127 [2]:

- ultrasonic thickness measurement instruments with only numerical display showing the measured values;
- ultrasonic thickness measurement instruments with numerical display showing the measured values and A-scan presentation displaying waveform;
- flaw detectors with A-scan presentation of ultrasonic signals with optional numerical display of measured signal distance (thickness value).

The first type of instrument is dedicated particularly for thickness measurements and no additional evaluation of reflected ultrasonic signals is available. Digitally displayed results of measurements are very simple for readouts or to be logged in proper sequence or raster in memory of the instrument. Instruments usually has option to display tenths or hundredths of millimeter. Each result for particular measuring point is regularly reported with decimal appearance it was logged. If measurement uncertainty is not declared in the report, what is practically common for ultrasonic thickness measurement reports, the final user of report is going to believe that thickness values of tested component are exactly as specified in report. Since the operator has no other information for interpretation rather than only digitally displayed value, he has to accept displayed value as true thickness he is measuring. This can very often mislead the operator if he is not properly qualified.

Additionally, in some circumstances in practice, it has also been noticed that lack of A-scan presentation could give rise to systematic error of thickness measurement results. Therefore a second type of instrument has been developed and appeared available on the market. These instruments are usually larger than the first type of instrument, at least because of A-scan display, but still very suitable for everyday practice. To benefit from additional A-scan display operators must have sufficient knowledge on basics of ultrasonics. This is adequately specified in Annex A of ISO 20 807 standard [4] where content of syllabus for ultrasonic thickness measurement is given.

In the Clause A.4.1 of this standard it is anticipated that a candidate will achieve the training module purpose **for use of digital instruments only in 16 h to 24 h**, while the **full module purpose** will be achieved **in 24 h to 40 h** of training with corresponding supervised experience in both cases. Unfortunately it is not explicitly specified whether the shorter module, purpose of which is usage of "digital instruments only", means that the whole content of syllabus is going to be accomplished in shorter period of time, or it is anticipated that some of the issues in the content is going or are to be allowed to be skip over.

Taking into account all mentioned comments and examples from the practice and experience gained in Croatia, our opinion is that the training of candidates for "digital instruments only" should be of the same extent as for those using instruments with A-scan display. Otherwise, beside the specified extent of qualification in hours, in the certificate of the qualification it has to be stated whether the training and qualification has been carried out only for digital instruments or for "full module". In that case it will be transparent for any auditor or inspector to trace if the personnel in laboratory is qualified exactly for the type of instrument they use for ultrasonic thickness measurement within the scope of accreditation.

Usage of the third type of instrument for thickness measurements is certain but it implies more extensive theoretical and practical knowledge of operator than it is necessary when the second type of instrument is used. These instruments have large number of

settings that can significantly influence on the reliability and uncertainty of results. Also it is at least doubtful if there is during the accreditation a flaw detector with A-scan presentation in laboratory and without personnel with ultrasonic testing method qualification but personnel with limited qualification for ultrasonic thickness testing. Therefore we would recommend the following:

- Limited qualification for ultrasonic thickness measurement with flaw detectors with A-scan presentation of ultrasonic signals with optional numerical display of measured signal distance (thickness value) could be acceptable within the accreditation of laboratory if there is also personnel with certificates for ultrasonic testing method.
- Pretty small difference between terms "ultrasonic testing", determined as NDT method, and "ultrasonic thickness testing", specified in standard ISO 20 807 [4], in certain circumstances allows to be misused. Instead of "ultrasonic thickness testing" we would recommend term "ultrasonic thickness measurement" as it is a measurement and testing only in a wider sense.

In the Clause 9.3.a of standard ISO 20 807 [4] it is written that the certificate of limited qualification shall be invalid for any specific applications other than that for which it was issued. According to the above discussion we find it necessary that also the type of instrument used for ultrasonic thickness measurement has to be specified in the certificate of limited qualification.

In the standard for ultrasonic thickness measurement (EN 14 127) four measurement modes are specified which correspond to the type of instrument used and the scope (application) of the measurement:

- measuring the transit time from an initial excitation pulse to a first returning echo, minus zero correction to account for the thickness of the transducer wear surface and the couplant layer (single echo mode);
- measuring the transit time from the end of a delay line to the first backwall echo (single echo delay line mode);
- measuring the transit time between backwall echoes (multiple echoes);
- measuring the transit time for a pulse traveling from the transmitter to a receiver in contact with the backwall (through transmission mode).

If the certificate of limited qualification limits the type of instrument used than also a particular measurement mode has to be specified but this is the issue of the scope of the laboratory accreditation and methods to be considered.

### **Measurement uncertainty**

Many users we have contacted tend to assume that number of digitals displayed on the instrument corresponds to measurement accuracy. When they are asked to specify measurement uncertainty according to the requirements of the standard EN ISO/IEC 17 025 [1] than "digital display resolution" specified by the manufacturer of the instrument is commonly cited. This clearly demonstrates the lack of knowledge and competence.

In the Clause 6.2.1.d of the standard EN 14 127 [2] some influencing factors on the accuracy of the thickness measurement are mentioned:

- how to measure accurate the time-of-flight,
- mode of time measuring (zero crossing, flank to flank, peak to peak);
- measurement mode chosen (four modes available);
- frequencies used.

In the Clause 8 requirements regarding operational conditions, equipment and evaluation regarding accuracy are presented more in detail. In Annex C.2 the methods for calculation of inaccuracy of a reading is given. It serves more as a guideline.

In the standard ISO 20 807 [4] within the content of syllabus for ultrasonic thickness measurement, under the topic Codes and Standards, "order of accuracy" is also specified.

When a testing or measurement laboratory seeks for accreditation, according to the requirement of the standard EN ISO/IEC 17 025 [1] one has to estimate measurement uncertainty for the method under the scope of accreditation. Estimation of uncertainty of ultrasonic thickness measurement is very demanding and it cannot be done by the person which undergo only limited qualification for ultrasonic thickness measurement. It is almost hard to be done by level II certified NDT personnel. Lack of a consequent knowledge leads to a too conservative uncertainty estimation which would subsequently result with a quite wide interval of measurement uncertainty that is practically useless.

The importance of knowing estimated uncertainty for the results of thickness measurement is apparent when one has to reliably assess integrity of the measured component or judge on its acceptability.

## **Concluding remarks**

In the process of accreditation of laboratory performing ultrasonic thickness measurements a special care has to be dedicated to the issues regarding adequate personnel qualification and measurement uncertainty.

Recommendations and explanations based on examples from the practice and experience gained in Croatia are presented.

Limited qualification of personnel for ultrasonic thickness measurements is highly correlated with the type of instrument that is used for the measurements.

Results of ultrasonic thickness measurements with no statement on measurement uncertainty cannot provide to the final user a complete and reliable information about true thickness of measured component.

## **References**

- [1] EN ISO/IEC 17025:2005, General requirements for the competence of testing and calibration laboratories
- [2] EN 14 127:2004, Non-destructive testing – Ultrasonic thickness measurement
- [3] EN 473:2000, Non-destructive testing – Qualification and certification of NDT personnel – General principles
- [4] ISO 20 807:2004, Non-destructive testing – Qualification of personnel for limited applications of non-destructive testing
- [5] ISO 9712:2005, Non-destructive testing -- Qualification and certification of personnel
- [6] Markučić, Damir; Runje, Biserka; Stepanić, Josip.: Uncertainty estimation of ultrasonic thickness measurement // Welding in Maritime Engineering / Kožuh, Zoran (ed.). Zagreb, CWS, 2004. 351-359