SLOVENSKI STANDARD
SIST EN 61161:2002/A1:2002

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Ultrasonic power measurement in liquids in the frequency range 0,5 MHz to 25 MHz (IEC 61161:1992/A1:1998)

Ultrasonic power measurement in liquids in the frequency range 0,5 MHz to 25 MHz

Ultraschall-Leistungsmessung in Flüssigkeiten im Frequenzbereich von 0,5 MHz bis 25 MHz

Mesurage de puissance ultrasonore dans les liquides dans la gamme de fréquences de 0,5 MHz à 25 MHz

Ta slovenski standard je istoveten z: **EN 61161:1994/A1:1998**

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This amendment A1 modifies the European Standard EN 61161:1994;it was approved by CENELEC on 1998-01-01.CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this amendment the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This amendment exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC
European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 87/113/FDIS, future amendment 1 to IEC 61161:1992, prepared by IEC TC 87, Ultrasonics, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 61161:1994 on 1998-01-01.

The following dates were fixed:

- latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1998-10-01
- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 1998-10-01

Endorsement notice

The text of amendment 1:1998 to the International Standard IEC 61161:1992 was approved by CENELEC as an amendment to the European Standard without any modification.

NORME INTERNATIONALE
INTERNATIONAL STANDARD

CEI
IEC
61161
1992

AMENDEMENT 1
AMENDMENT 1

1998-01

Amendement 1

Mesurage de puissance ultrasonore dans les liquides dans la gamme de fréquences de 0,5 MHz à 25 MHz

Amendment 1

Ultrasonic power measurement in liquids in the frequency range 0,5 MHz to 25 MHz

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FOREWORD

This amendment has been prepared by IEC technical committee 87: Ultrasonics.

The text of this amendment is based on the following documents:

FDIS	Report on voting
87/113/FDIS	87/116/RVD

Full information on the voting for the approval of this amendment can be found in the report on voting indicated in the above table.

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CONTENTS

Add the title of the new subclause 7.1 as follows:

7.1 Assessment of measurement uncertainties

Page 7

INTRODUCTION

Add the following text:

This standard enumerates the sources of errors and describes a systematic step-by-step procedure needed to assess overall measurement uncertainties.

Page 9

Scope

Add at the end of the first paragraph, the following third dash:

– provides information on assessment of overall measurement uncertainties.

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7 Measurement uncertainty

Replace the existing text of this clause by the following new text:

7.1 Assessment of measurement uncertainties

Due to the great variety of measurement arrangements used, an uncertainty analysis valid for all possible arrangements is not immediately possible. Therefore, an estimation of the overall measurement uncertainty or accuracy assessment shall be determined individually for each set-up used. This assessment should include the following elements.

7.1.1 Balance system including target suspension

As a rule, prior to the measurement, the balance system shall be checked or calibrated using small weights of known mass. It is important that this be done with the whole system prepared for radiation force measurements, i.e., with the **target** suspended in water. Thus, any potential influence of the suspension wire penetrating the water surface is automatically taken into account.

This procedure shall be repeated several times with each weight in order to obtain an indication of the random scatter of results. An uncertainty estimate for the balance calibration factor can be derived from the results of this calibration and from the mass uncertainty of the weights used.

The results of these checks should be filed in order to enable a judgment of the long-term stability of the balance calibration factor.

7.1.2 Linearity of the balance system

The linearity of the balance system shall be checked at least every two months as follows.

The measurements described in 7.1.1 shall be done with at least three weights of different masses within the balance output range of interest. The balance readout as a function of input mass can be represented in a graph in accordance with figure 5. The resulting points in this graph should ideally be on a straight line starting at the origin of the coordinates. If deviations from this line occur, an additional uncertainty contribution shall be derived from these.

Since weights of less than 10 mg are difficult to handle, the balance linearity check can also be done by means of an **ultrasonic transducer** with known properties, activated by various levels of voltage amplitude and thus producing radiation forces of various magnitudes. In this case the input quantity at the abscissa of figure 5 is the ultrasonic **output power** of the transducer.

7.1.3 Extrapolation to the moment of switching the ultrasonic transducer

In the case of an electronic balance, in order to obtain the **radiation force** value, the balance output signal is usually recorded as a function of time and extrapolated back to the moment of switching the **ultrasonic transducer**. This extrapolation involves an uncertainty, depending mainly on the amount of scatter in the balance output signal (signal-to-noise ratio). The uncertainty of the extrapolation result can be estimated by means of standard mathematical procedures in utilizing the regression algorithm.

7.1.4 Target imperfections

Strictly speaking, a knowledge of the momentum carried by all undesirable waves emanating from the **target** in all directions would be required to assess the influence of the **target** imperfections on the accuracy of the **radiation force** balance measurements. Since this knowledge is unavailable, in practice, a simplified plane-wave approach described below is considered to be sufficient. With the plane-wave assumption, the **acoustic radiation pressure** is equal to the total acoustic energy density. The wave transmitted by an absorbing **target** (see figure 1) in the forward direction leads to a reduction in the **radiation force**, the reduction being determined by the transmitted energy density, i.e., by the energy density existing behind the **target**. The magnitude of this effect can be determined by using the **target** as an obstacle and carrying out a **radiation force** measurement by means of an additional **target**, positioned immediately behind the original one. It should be noted that the reflection of the transmitted wave at the water surface in the arrangement shown in figure 1 will double the decrease in the measured **radiation force**.

The wave reflected or scattered back by an absorbing **target** leads to a **radiation force** increase that is determined by the reflected energy density. For a plane absorbing **target**, this effect can be assessed by comparing the pulse-echo signal with that from a perfect reflector. For a **target** with surface structure, however, this measurement determines only the spatially coherent component, and does not indicate the total reflected energy. In this case, the reflected energy would have to be assessed by scanning a hydrophone and integrating the square of the measured pressure over the reflected field (see IEC 61101). Alternatively, other information about the properties of the absorber could be used to give an upper limit to the reflection (e.g. the reflectivity of an equivalent, plane version). In addition to increasing the measured radiation force, the reflection from the **target** can also act back on the **ultrasonic transducer** to change its output characteristics [10]. This interference effect can be minimised by slightly tilting the **target** or by using a better **target**. If the interference occurs, it will give rise to oscillations in the **radiation force**, which can be observed by varying the frequency or the **target/ultrasonic transducer** distance [10]. The uncertainty due to any residual interference effects can be assessed from the oscillation amplitudes.

For the case of reflecting **targets**, the previous discussion of the transmitted wave and its influence is also valid. The reflected waves, however, may come both from the **target** and from any lateral absorbers (see figure 3) and so shall be considered more carefully.

Overall, the most reliable assessment of accuracy will be obtained by comparing measurements made with different **target** types. The acoustical properties of **targets** vary significantly with frequency and so any uncertainty assessment shall be made separately for each frequency of interest. It is particularly difficult to obtain a good **target** design for frequencies below 2 MHz.

7.1.5 Reflecting target geometry

As discussed in A.2 the cone angle of a conical reflecting **target** has an influence on the measurement result. More specifically, if the cone half-angle of a convex-type reflector of nominally 45° lies within 45° ± 1°, the resulting power uncertainty is ±3,5 %. If the cone half-angle of a concave-type reflector of nominally 63° (which means $\theta = 27°$, following the notation given in A.2) lies within 63° ± 1°, the resulting power uncertainty is ±1,8 %.

7.1.6 Lateral absorbers in the case of reflecting target measurements

Imperfections of the lateral absorbers in the arrangement of figure 3 give rise to reflected waves which return to the **target** and lead to an increase in the value of the measured **radiation force**. Here again, the reflected energy density is relevant under incoherent conditions and again, interference effects may occur (see 7.1.4).

7.1.7 Target misalignment

This subclause applies if the **ultrasonic transducer** and the force-measuring device are collinear to each other but the angular alignment of the **target** is incorrect.

While the **radiation force** on a perfectly absorbing **target** according to the formula given in clause A.2 is insensitive to a **target** tilt, in the case of the reflecting **target**, the measurement depends on the correct **target** orientation. For example, an angle uncertainty of ±1° for a plane reflector at 45° leads to a power measurement uncertainty of ±3,5 %. The influence of a misalignment in the case of a conical reflecting **target** cannot be given by a universal formula, but it will, in general, be much lower than that of a plane reflecting **target**, particularly when the **target** is centred over the beam. For a cylindrically symmetrical beam centred with respect to a 45° conical reflecting **target**, the sensitivity to angular misalignment is reduced still further.

7.1.8 Ultrasonic transducer misalignment

This subclause applies if the **target** and the force-measuring device are collinear to each other but the **ultrasonic transducer** has an incorrect orientation or position.

In case of a perfectly absorbing **target** of sufficient size, the apparent **radiation force** is proportional to the cosine of the misalignment angle. In case of a 45° convex conical reflecting **target**, a maximum uncertainty due to misalignment of ±3 % can be expected if maximum positioning and angular alignment errors of ±3 mm and ±3° are assumed [32], which appears to be realistic for an alignment by eye.

7.1.9 Water temperature

As a result of the temperature dependence of the velocity of sound in water, an uncertainty in the temperature measurement of ±1 °C will result in a power measurement uncertainty of ±0,2 %.

7.1.10 Ultrasonic attenuation and acoustic streaming

The power value as derived from the **radiation force** balance measurement refers to the **target** position at a given axial distance from the **ultrasonic transducer**. The quantity of interest, however, is often the radiated power with reference to the **ultrasonic transducer** surface. The additional uncertainty inferred in this case is discussed below.

There are two basic models accounting for the difference between the above-noted power values. The first one considers the influence of ultrasonic attenuation alone. In this case, the correction is made by including the exponential correction factor (see A.3.2). The second one includes the effects of the **acoustic streaming** along the free propagation path in front of the **target**. For an absorbing **target** under certain ideal conditions, the Borgnis theorem [33] states that the effects of attenuation and **acoustic streaming** cancel each other, and consequently no correction is necessary. The behaviour of real **targets** (both absorbing and reflecting ones) has been found to lie somewhere in between these two basic models [9]. It is therefore recommended to consider an uncertainty span which ranges from the uncorrected power value as measured by the balance to the value with the full attenuation correction [17]. This uncertainty contribution depends on the **target** distance and is particularly critical when the measurements are performed in the higher megahertz frequency range.

An alternative way is to measure the apparent power as a function of the **target** distance and to extrapolate the result back to zero distance by means of a regression algorithm based on a linear or exponential distance law. The measured values will not exactly fit the assumed distance law, i.e., there will be some experimental scatter, and so standard mathematical procedures can be used to estimate the uncertainty of the extrapolation result.

In the case of a non-planar **target** surface, it is difficult to define the effective **target** distance. Here, it is helpful to recall that the average height of a cone or pyramid is 1/3 of the peak height when measured from the base or 2/3 when measured from the apex. This rule can be applied when conically shaped reflecting **targets** or absorbing **targets** with pyramid-like shaped