

Specification for

Ultrasonic power measurement in liquids in the frequency range 0.5 MHz to 25 MHz

The European Standard EN 61161:1994, with the incorporation of its amendment A1:1998, has the status of a British Standard

UDC 534.6-8:534.83:534.321.9

Cooperating organizations

The European Committee for Electrotechnical Standardization (CENELEC), under whose supervision this European Standard was prepared, comprises the national committees of the following countries:

Austria	Italy
Belgium	Luxembourg
Denmark	Netherlands
Finland	Norway
France	Portugal
Germany	Spain
Greece	Sweden
Iceland	Switzerland
Ireland	United Kingdom

This British Standard, having been prepared under the direction of the Electrotechnical Sector Board, was published under the authority of the Standards Board and comes into effect on 15 February 1995

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National foreword

This British Standard has been prepared under the direction of the Electrotechnical Sector Board and is the English language version of EN 61161:1994 *Ultrasonic power measurement in liquids in the frequency range 0,5 MHz to 25 MHz*, including Amendment A1, published by the European Committee for Electrotechnical Standardization (CENELEC). It is identical with IEC 61161:1992, including Amendment 1, published by the International Electrotechnical Commission (IEC).

Amendment No. 1 introduces the following changes:

- a) new second paragraph in the introduction;
- b) new line 8, paragraph 1 (after the note) in the Scope;
- c) revised clause 7;
- d) inclusion of Figure 1 and Figure 2 (deleted from BS EN 61161:1995 by error);
- e) new Figure 5;
- f) new references 32, 33 and 34 in Annex C.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 18, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 61161

August 1994

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English version

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

(includes amendment A1:1998)

(IEC 61161:1992 + A1:1998)

Mesurage de puissance ultrasonore dans les
liquides dans la gamme de
fréquences de 0,5 MHz à 25 MHz
(inclut l'amendement A1:1998)
(CEI 61161:1992 + A1:1998)

Ultraschall-Leistungsmessung in Flüssigkeiten
im Frequenzbereich 0,5 MHz bis 25 MHz
(enthält Änderung A1:1998)
(IEC 61161:1992 + A1:1998)

This European Standard was approved by CENELEC on 1994-03-08; amendment A1 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 European Standard 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 European Standard 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.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The CENELEC questionnaire procedure, performed for finding out whether or not the International Standard IEC 1161:1992 could be accepted without textual changes, has shown that no common modifications were necessary for the acceptance as a European Standard.

The reference document was submitted to the CENELEC members for formal vote and was approved by CENELEC as EN 61161 on 8 March 1994.

The following dates were fixed:

- latest date of publication of an identical national standard (dop) 1995-03-15
- latest date of withdrawal of conflicting national standards (dow) 1995-03-15

Annexes designated “normative” are part of the body of the standard. Annexes designated “informative” are given only for information. In this standard, Annex A and Annex ZA are normative and Annex B and Annex C are informative.

Foreword to EN 61161:1994/A1:1998

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

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Introduction

A number of measuring methods exist for the determination of the total radiated power of ultrasonic transducers ([1]¹⁾ to [3]¹⁾, see also Annex B). The purpose of this International Standard is to establish methods of measurement of ultrasonic power in liquids in the megahertz frequency range based on the measurement of the radiation force using a gravimetric balance. The great advantage of radiation force measurements is that a value for the total radiated power is obtained without the need to integrate field data over the cross-section of the radiated sound beam. In addition, the radiation force measuring devices are easy to handle and to calibrate.

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

1 Scope

This International Standard

- specifies a method of determining the total radiated acoustic power of ultrasonic transducers based on the use of a radiation force balance;
- establishes general principles for the use of radiation force balances in which an obstacle (target) intercepts the sound field to be measured;

NOTE The radiation force is equal to the change in the time-averaged momentum flow and is thus related to ultrasonic intensity and power.

- provides information on assessment of overall measurement uncertainties.

This International Standard is applicable to:

- the measurement of ultrasonic power based on the use of a radiation force balance in the frequency range from 0,5 MHz to 25 MHz;
- the measurement of total ultrasonic power of transducers with well-collimated beams;
- the use of radiation force balances of the gravimetric type.

NOTE The titles of other publications referred to in this Standard are listed in Annex C.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards. IEC 50(801):1984, *International Electrotechnical Vocabulary (IEV), Chapter 801: Acoustics and electro-acoustics*.

IEC 150:1963, *Testing and calibration of ultrasonic therapeutic equipment*.

IEC 1101:1991, *The absolute calibration of hydrophones using the planar scanning technique in the frequency range 0,5 MHz to 15 MHz*.

3 Definitions

3.1

acoustic streaming

steady-state fluid motion which develops under certain conditions in a sound field

3.2

far field

sound field at a distance from the source where the sound pressure decreases monotonically with increasing distance from the source. In general, this is the region of the sound field where the specific acoustic impedance, i.e. the complex ratio of sound pressure to particle velocity, is substantially equal to ρc , ρ being the density and c the velocity of sound in the sound-propagating medium

3.3

free field

a sound field in a homogeneous isotropic medium whose boundaries exert a negligible effect on the sound waves [IEV 801-03-28 modified.]

3.4

near field

sound field at distances from the source smaller than the distance at which the **far field** begins. In general, this is the region of the sound field where the complex specific acoustic impedance differs appreciably from ρc

¹⁾ The figures in square brackets refer to Annex C — Bibliography.

3.5**output power**

time-average ultrasonic power radiated by an **ultrasonic transducer** into an approximately **free field** under specified conditions in a specified medium, preferably water

Symbol: P

Unit: watt, W

3.6**radiation force; acoustic radiation force**

time-average force acting on a body in a sound field and caused by the sound field; or, more generally: time-average force in a sound field, appearing at the boundary surface between two media of different acoustic properties

Symbol: F

Unit: newton, N

3.7**radiation pressure; acoustic radiation pressure****radiation force per unit area****3.8****target**

a device specially designed to be inserted into the ultrasonic field and to serve as the object on which the **radiation force** is to be measured

3.9**ultrasonic transducer**

device capable of converting electrical energy to mechanical energy within the ultrasonic frequency range and/or reciprocally of converting mechanical energy to electrical energy

4 List of symbols

- a = radius of a source **ultrasonic transducer**
- c = speed of sound (usually in water)
- d = geometrical focal length of a focused **ultrasonic transducer**
- F = **radiation force** on a **target** in the propagation direction of an ultrasonic wave
- g = acceleration due to gravity
- k = $(= 2\pi/\lambda)$ circular wavenumber
- P = **output power** of an **ultrasonic transducer**
- s = $(= x/\lambda a^2)$ distance normalized to the **near-field** length
- x = distance between a **target** and an **ultrasonic transducer**
- α = amplitude attenuation coefficient of plane waves in a medium (usually water)
- γ $(= \arcsin a/d)$ focus angle of a focused **ultrasonic transducer**

- θ = angle between propagation direction of an ultrasonic wave and the normal to a reflecting surface of a **target**
- λ = ultrasonic wavelength.

5 Requirements for radiation force balances**5.1 General**

The **radiation force** balance shall consist of a **target** which is connected to a balance. The ultrasonic beam shall be directed vertically upwards or downwards on the **target** and the **radiation force** exerted by the ultrasonic beam shall be measured by the balance. The ultrasonic power shall be determined from the difference between the force measured with and without ultrasonic radiation, according to the formulae given in Annex A. Calibration can be carried out by means of small precision weights of known mass.

5.2 Target type

The **target** shall have known acoustic properties, these being relevant to the details of the relation between ultrasonic power and **radiation force**. Usually, the aim is to approach most closely one of the two extreme cases: perfect absorber or perfect reflector [4]. The compressibility should be as low as possible in order to avoid buoyancy changes due to variations of the ambient pressure. Care should be taken in other respects to maximize the stability of buoyancy of the **target**.

5.2.1 Absorbing target

An absorbing **target** (see Figure 1) shall have:

- an amplitude reflection factor of less than 5 %;
- an acoustic energy absorption within the **target** of at least 99 %.

Circular discs of appropriate elastic rubber material with or without wedges are normally used as absorbing **targets**. To increase the absorbing properties, the material should contain inhomogeneities.

Figure 2 shows an example of a set-up of a wedge-type absorber. In this case the concentration of the inhomogeneities increases from zero at the wedges to 30 % by volume at the rear surface. Hollow glass spheres of diameter of the order of one-tenth millimetre behave satisfactorily as inhomogeneities, since they have only little influence on the density and compressibility of the elastic rubber material.