

Ultrasonics — Fields — Guidance for the measurement and characterization of ultrasonic fields generated by medical ultrasonic equipment using hydrophones in the frequency range 0.5 MHz to 15 MHz

The European Standard EN 61220:1995 has the status of a British Standard

ICS 11.040.50; 19.080

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Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee EPL/87, Ultrasonics, upon which the following bodies were represented:

- British Dental Association
- British Institute of Radiology
- British Medical Ultrasound Society
- British Society for Rheumatology
- Department of Health
- Department of Trade and Industry (National Physical Laboratory)
- Institute of Laryngology and Otology
- Institute of Physical Sciences in Medicine
- Institution of Electrical Engineers

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National foreword

This British Standard has been prepared by EPL/87 and is the English language version of EN 61220:1995 *Ultrasonics — Fields — Guidance for the measurement and characterization of ultrasonic fields generated by medical ultrasonic equipment using hydrophones in the frequency range 0,5 MHz to 15 MHz*, published by the European Committee for Electrotechnical Standardization (CENELEC). It is identical with Technical Report IEC 1220:1993, published by the International Electrotechnical Commission (IEC).

The United Kingdom voted against this document being harmonized as an EN, as the IEC Technical Report Type 2 was not intended to be regarded as an International Standard but only as a prospective standard for provisional application for guidance on how standards in this field should be used to meet and identified need. The IEC Technical Report is due for further review three years after publication, with the options of either extension for a further three years or conversion to an International Standard or withdrawal. The EN will correspondingly be automatically reviewed after a period of five years or earlier depending on the outcome of the IEC review.

Cross-references

Publication referred to	Corresponding British Standard
EN 61101:1993 (IEC 1101:1991)	BS EN 61101:1994 <i>Specification for absolute calibration of hydrophones using the planar scanning technique in the frequency range 0.5 MHz to 15 MHz</i>
EN 61102:1993 + A1:1994 (IEC 1102:1991 + Amd 1:1993)	BS EN 61102:1994 + Amendment No. 1:1994 <i>Specification for measurement and characterization of ultrasonic fields using hydrophones in the frequency range 0.5 MHz to 15 MHz</i>
EN 61161:1994 (IEC 1161:1992)	BS EN 61161:1995 <i>Specification for ultrasonic power measurement in liquids in the frequency range 0.5 MHz to 25 MHz</i>

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 20, 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.

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Descriptors: Ultrasound, ultrasonic field, medical electrical equipment, measurement, characterization

English version

Ultrasonics — Fields — Guidance for the measurement and characterization of ultrasonic fields generated by medical ultrasonic equipment using hydrophones in the frequency range 0,5 MHz to 15 MHz

(IEC 1220:1993)

Ultrasons — Champs Guide pour les mesures et caractéristiques des champs ultrasonores produits par des appareils médicaux à ultrasons utilisant des hydrophones dans la gamme de fréquences de 0,5 MHz à 15 MHz (CEI 1220:1993)

Ultraschall — Felder Anleitung für die Messung und Kennzeichnung der durch medizinische Ultraschallgeräte erzeugten Ultraschallfelder mittels Hydrophonen im Frequenzbereich 0,5 MHz bis 15 MHz (IEC 1220:1993)

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

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Foreword

The text of the International Standard IEC 1220:1993, prepared by IEC TC 87, Ultrasonics, was submitted to the formal vote and was approved by CENELEC as EN 61220 on 1994-12-06 without any modification.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1995-12-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 1995-12-01

Annexes designated “normative” are part of the body of the standard. Annexes designated “informative” are given for information only. In this standard, Annex A and Annex ZA are normative and Annex B is informative. Annex ZA has been added by CENELEC.

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Introduction

IEC 1102 deals with ultrasonic fields in general. For medical ultrasound, there is a need to provide guidance for the choice of the most appropriate and scientifically meaningful group of acoustic parameters for the characterization of the various types of ultrasonic fields. This requirement arises from the fact that pulse-echo diagnostic, Doppler and therapeutic transducers emit ultrasound at different acoustic pressures and with different spatial and temporal characteristics. Consequently, some of the parameters referred to in IEC 1102 are appropriate to all equipment whilst others are appropriate to only certain types of equipment. This technical report provides general information on the measurement of ultrasonic fields generated by medical ultrasonic equipment. It also provides guidance for the choice of the most appropriate hydrophone to use and the most appropriate acoustical parameters to be measured.

Measurement procedures described in clauses 5 and 6 of IEC 1102 are believed to provide the most accurate results, but are particularly demanding on precision and degrees of freedom required for the hydrophone or transducer positioning systems. For certain measurements these requirements may be relaxed, thereby enabling simpler characterization systems to be used. This technical report provides guidance for these various aspects.

Finally, it is often necessary to use hydrophones which may have limited bandwidth or ones with active elements which are too large. This technical report gives guidance for estimating bandwidth and spatial-averaging corrections.

1 Scope

This technical report provides guidance on the practical measurement of the acoustic output of various types of medical ultrasonic equipment in the frequency range 0,5 MHz to 15 MHz based on the use of hydrophones.

It gives simplified procedures and guidelines for the measurement of the acoustic output of medical ultrasonic equipment.

Procedures for correcting for limitations caused by the use of hydrophones with finite bandwidth and finite active element size are also given.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this technical report. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this technical report 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 1101:1991, *The absolute calibration of hydrophones using the planar scanning technique in the frequency range 0,5 MHz to 15 MHz.*

IEC 1102:1991, *Measurement and characterization of ultrasonic fields using hydrophones in frequency range of 0,5 MHz to 15 MHz*

Amendment 1, Definitions of additional terms and specific requirements for the characterization of fields from ultrasonic transducers having cylindrical or spherical active elements.
(under consideration)

IEC 1161:1992, *Ultrasonic power measurement in liquids in the frequency range 0,5 MHz to 25 MHz.*

3 List of symbols

$a_{\max}$	Maximum effective radius of a hydrophone active element
a_1	Effective radius of an ultrasonic transducer
C	Spatial-averaging correction factor
I_{spta}	Spatial-peak temporal-average intensity
I_{sppa}	Spatial-peak pulse-average intensity
l	Distance between a transducer and a measuring hydrophone
p_-	Peak-negative acoustic pressure
p_+	Peak-positive acoustic pressure
p_i	Pulse-pressure-squared integral
p_{spr}	Spatial-peak r.m.s. acoustic pressure
p_{spp}	Spatial-peak pulse acoustic pressure
p	Total ultrasonic power
p_{beam}	Total power emitted by one acoustic scan line for an automatic scanner
prr	Pulse repetition rate
s_s	Separation between ultrasonic scan lines in the plane considered
t_d	Pulse duration
α	Ratio of the – 6 dB beam-width to the effective hydrophone diameter
σ	Non-linear propagation parameter

4 Types of medical ultrasonic equipment

4.1 Pulse-echo and pulsed Doppler equipment

The acoustic output of pulse-echo diagnostic equipment usually consists of a single pulse of ultrasound at an acoustic working frequency in the range 1 MHz to 12 MHz, and at pulse repetition rates of between 1 kHz and 5 kHz. Pulsed Doppler equipment usually has an acoustic pulse consisting of a number of cycles at pulse repetition rates similar to or perhaps higher than pulse-echo equipment. In both types of equipment, the ultrasound is usually focused at distances from the transducer of between a few centimetres and 20 cm, and the peak acoustic pressure at the focus is usually between 0,2 MPa and 10 MPa. Whilst linear-array, sector and phased-array scanners emit consecutive pulses along different ultrasonic scan lines, the acoustic pulse waveform remains approximately constant.

For pulse-echo equipment, the focal diameter is usually less than about 3 mm and, as seen from 5.1, a hydrophone with an active element of diameter approximately 0,5 mm is required and a relatively precise alignment of the hydrophone is necessary. IEC 1102 specifies reproducibility of the positioning systems of $\pm 0,01$ mm for three orthogonal adjustments for the hydrophone (or transducer if the latter is the item that is scanned). In practice, the accuracy and reproducibility of positioning systems is most important in the direction perpendicular to the propagation direction and in most cases $\pm 0,05$ mm is often adequate. In the propagation direction, an accuracy of $\pm 0,1$ mm is often adequate for most measurement situations. The highest accuracy would be required for highly focused fields (wide aperture) and at high frequencies (see 5.4).

As the acoustic pressures are high, the non-linear propagation parameter σ_m (see 3.25 of IEC 1102) will usually be greater than 0,5, in which case the bandwidth requirement for the hydrophone is greater and additional demands are placed on the angular alignment because of the dependence of this directional response on frequency. Under these conditions, it is important to optimise the rotation of the hydrophone to ensure the maximum received signal (see 5.3).

In general, diagnostic equipment places the greatest demand on the hydrophone bandwidth and on the coordinate positioning system. PVDF hydrophones of the membrane or probe type are essential (see A.1.4 of IEC 1102).

As measurements for the purpose of determining the maximum output are undertaken in the plane containing the spatial-peak temporal-peak acoustic pressure, this plane is expected to be close to the focus of the transducer. At typical focal distances, the square law relationship between acoustic pressure and intensity is usually assumed in order to derive intensity parameters. This assumption is made despite the uncertainty associated with the non-linear distortion that can take place.