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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Ultrasonics – Hydrophones –
Part 1: Measurement and characterization of medical ultrasonic fields up to 40 MHz

Ultrasons – Hydrophones –
Partie 1: Mesurage et caractérisation des champs ultrasoniques médicaux jusqu'à 40 MHz

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ULTRASONICS – HYDROPHONES –

Part 1: Measurement and characterization of medical ultrasonic fields up to 40 MHz

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 62127-1 edition 1.1 contains the first edition (2007) [documents 87/352/CDV and 87/371/RVC], its amendment 1 (2013) [documents 87/518/FDIS and 87/524/RVD] and its corrigendum (2008-08).

A vertical line in the margin shows where the base publication has been modified by amendment 1. Additions and deletions are displayed in red, with deletions being struck through.

International Standard IEC 62127-1 has been prepared by IEC technical committee 87: Ultrasonics.

IEC 62127-1, IEC 62127-2 and IEC 62127-3 are being published simultaneously. Together these cancel and replace IEC 60866:1987, IEC 61101:1991, IEC 61102:1991, IEC 61220:1993 and IEC 62092:2001.

This bilingual version (2012-06) corresponds to the monolingual English version, published in 2007-08.

The French version of this standard has not been voted upon.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of IEC 62127 series, published under the general title *Ultrasonics – Hydrophones,* can be found on the IEC website**.**

NOTE Words in **bold** in the text are defined in Clause 3.

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The "colour inside" logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

INTRODUCTION

The main purpose of this part of IEC 62127 is to define various acoustic parameters that can be used to specify and characterize ultrasonic fields propagating in liquids, and, in particular, water, using hydrophones. Measurement procedures are outlined that may be used to determine these parameters. Specific device related measurement standards, for example IEC 61689, IEC 61157, IEC 61847 or IEC 62359, can refer to this standard for appropriate acoustic parameters.

The philosophy behind this standard is the specification of the acoustic field in terms of acoustic pressure parameters, acoustic pressure being the primary measurement quantity when piezoelectric hydrophones are used to characterize the field. Of course, if other measurement devices come into use in the future, a new standard with additional definitions and procedures will be necessary. Examples of such devices would be thermistors, thermocouples or optical hydrophones.

Intensity parameters are specified in this standard, but these are regarded as derived quantities that are meaningful only under certain assumptions related to the ultrasonic field being measured.

ULTRASONICS – HYDROPHONES –

Part 1: Measurement and characterization of medical ultrasonic fields up to 40 MHz

1 Scope and object

This part of IEC 62127 specifies methods of use of calibrated hydrophones for the measurement in liquids of acoustic fields generated by ultrasonic medical equipment operating in the frequency range up to 40 MHz.

The objectives of this standard are:

– to define a group of acoustic parameters that can be measured on a physically sound basis;
– to define a second group of parameters that can be derived under certain assumptions from these measurements, and called derived intensity parameters;
– to define a measurement procedure that may be used for the determination of acoustic pressure parameters;
– to define the conditions under which the measurements of acoustic parameters can be made in the frequency range up to 40 MHz using calibrated hydrophones;
– to define procedures for correcting, for limitations caused by the use of hydrophones with finite bandwidth and finite active element size.

NOTE 1 Throughout this standard, SI units are used. In the specification of certain parameters, such as beam areas and intensities, it may be convenient to use decimal multiples or submultiples. For example beam area may be specified in cm^2 and intensities in W/cm^2 or mW/cm^2.

NOTE 2 The hydrophone as defined may be of a piezoelectric or an optic type. ~~The introduction however implies that optical hydrophones are not covered.~~

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-801:1994, *International Electrotechnical Vocabulary – Chapter 801: Acoustics and electroacoustics*

IEC 60565, *Underwater acoustics – Hydrophones – Calibration in the frequency range 0,01 Hz to 1 MHz*

IEC/TR 60854:1986, *Methods of measuring the performance of ultrasonic pulse-echo diagnostic equipment*

IEC 61689, *Ultrasonics – Physiotherapy systems – Performance requirements and methods of measurement in the frequency range 0,5 MHz to 5 MHz*

IEC 61828, *Ultrasonics – Focusing transducers – Definitions and measurement methods for the transmitted fields*

IEC 61846, *Ultrasonics – Pressure pulse lithotripters – Characteristics of fields*

IEC 61847, *Ultrasonics – Surgical systems – Measurement and declaration of the basic output characteristics*

IEC 62127-2, *Ultrasonics – Hydrophones – Part 2: Calibration for ultrasonic fields up to 40 MHz*

IEC 62127-3, *Ultrasonics – Hydrophones – Part 3: Properties of hydrophones for ultrasonic fields up to 40 MHz*

ISO 16269-6:2005, *Statistical interpretation of data – Part 6: Determination of statistical tolerance intervals*

ISO, *Guide to the expression of uncertainty in measurement*. Geneva, Switzerland: International Organization for Standardization (ISO), 1995

ISO/IEC Guide 98-3, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

NOTE The following standards rely on the proper use of this document.

IEC 61157, *Standard means for the reporting of the acoustic output of medical diagnostic ultrasonic equipment*

IEC 62359, *Ultrasonics – Field characterization – Test methods for the determination of thermal and mechanical indices related to medical diagnostic ultrasonic fields*

IEC 61847, *Ultrasonics – Surgical systems – Measurement and declaration of the basic output characteristics*.

3 Terms, definitions and symbols

For the purposes of this document, the terms and definitions given in IEC 62127-2, IEC 62127-3 and the following apply. It also includes definitions related to subjects in this document to be used in particular medical ultrasound device standards.

3.1
acoustic pulse waveform
temporal waveform of the instantaneous acoustic pressure at a specified position in an acoustic field and displayed over a period sufficiently long to include all significant acoustic information in a single pulse or tone-burst, or one or more cycles in a continuous wave

NOTE 1 Temporal waveform is a representation (e.g oscilloscope presentation or equation) of the **instantaneous acoustic pressure**.

NOTE 2 Definition adopted from IEC 60469-1.

3.2
acoustic repetition period
arp
pulse repetition period for non-automatic scanning systems and the **scan repetition period** for automatic scanning systems, equal to the time interval between corresponding points of consecutive cycles for continuous wave systems

NOTE The **acoustic repetition period** is expressed in seconds (s).

3.3
acoustic frequency
acoustic-working frequency
frequency of an acoustic signal based on the observation of the output of a **hydrophone** placed in an acoustic field at the position corresponding to the **spatial-peak temporal-peak acoustic pressure**

NOTE 1 The signal is analysed using either the **zero-crossing acoustic-working frequency** technique or a spectrum analysis method. Acoustic-working frequencies are defined in 3.3.1, 3.3.2, 3.3.3 and 3.3.4.

NOTE 2 In a number of cases the present definition is not very helpful or convenient, especially for **broadband transducers**. In that case, a full description of the frequency spectrum should be given in order to enable any frequency-dependent correction to the signal.

NOTE 3 **Acoustic frequency** is expressed in hertz (Hz).

3.3.1
zero-crossing acoustic-working frequency
f_{awf}
number, *n*, of consecutive half-cycles (irrespective of polarity) divided by twice the time between the commencement of the first half-cycle and the end of the *n*-th half-cycle

NOTE 1 None of the *n* consecutive half-cycles should show evidence of phase change.

NOTE 2 The measurement should be performed at terminals in the receiver that are as close as possible to the receiving transducer (**hydrophone**) and, in all cases, before rectification.

NOTE 3 This frequency is determined according to the procedure specified in IEC/TR 60854.

NOTE 4 This frequency is intended for continuous-wave systems only.

3.3.2
arithmetic-mean acoustic-working frequency
f_{awf}
arithmetic mean of the most widely separated frequencies f_1 and f_2, within the range of three times f_1, at which the magnitude of the acoustic pressure spectrum is 3 dB below the peak magnitude

NOTE 1 This frequency is intended for pulse-wave systems only.

NOTE 2 It is assumed that $f_1 < f_2$.

NOTE 3 If f_2 is not found within the range $< 3f_1$, f_2 is to be understood as the lowest frequency above this range at which the spectrum magnitude is 3 dB below the peak magnitude.

3.3.3
peak pulse acoustic frequency
f_p
arithmetic-mean acoustic-working frequency **of the pulse with the largest** peak negative acoustic pressure **measured at the point of maximum** peak negative acoustic pressure

NOTE **Peak pulse acoustic frequency** is expressed in hertz (Hz).

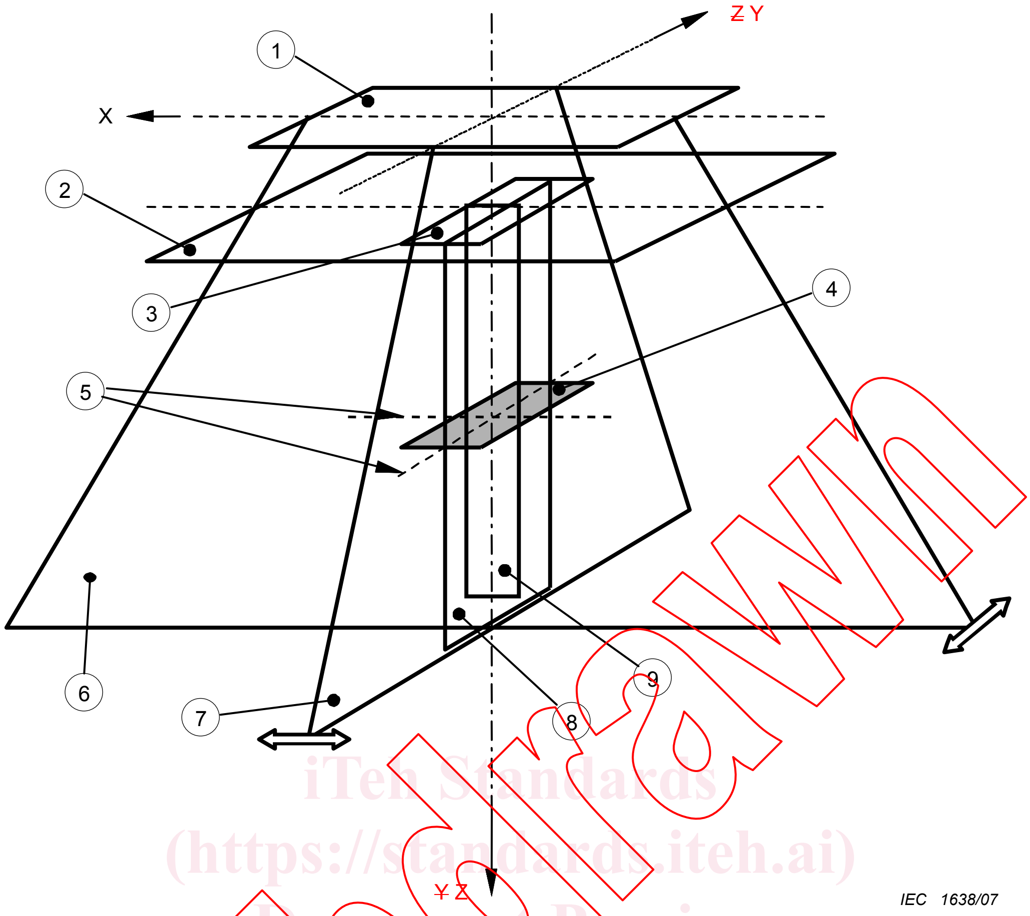
3.3.4
time average acoustic frequency
f_t
arithmetic-mean acoustic-working frequency of the time averaged acoustic pressure spectrum of the acoustic signal measured at the point of maximum **temporal average intensity**

NOTE **Time average acoustic frequency** is expressed in hertz (Hz).

3.4
azimuth axis
axis formed by the junction of the **azimuth plane** and the **source aperture plane** (measurement) or **transducer aperture plane** (design)

NOTE 1 Definition adopted from IEC 61828:2001.

NOTE 2 See Figure 1.



Key

X azimuth axis

Y ~~beam~~ elevation axis

Z ~~elevation~~ beam axis

1 external transducer aperture plane

2 source aperture plane

3 aperture plane

4 beam area plane

5 beamwidth lines

6 azimuth plane, scan plane

7 elevation plane

8 longitudinal plane

9 principle longitudinal plane

Figure 1 – Schematic diagram of the different planes and lines in an ultrasonic field (see also IEC 61828)

3.5
azimuth plane
for a scanning **ultrasonic transducer**: this is the **scan plane**; for a non-scanning **ultrasonic transducer:** this is the **principal longitudinal plane**

NOTE 1 Definition adopted from IEC 61828:2001.

NOTE 2 See Figure 1.

3.6
bandwidth
BW
difference in the most widely separated frequencies f_1 and f_2 at which the magnitude of the acoustic pressure spectrum becomes 3 dB below the peak magnitude, at a specified point in the acoustic field

NOTE **Bandwidth** is expressed in hertz (Hz).

3.7
beam area
~~A_b~~ $A_{b,6}$, $A_{b,20}$
area in a specified plane perpendicular to the **beam axis** consisting of all points at which the **pulse-pressure-squared integral** is greater than a specified fraction of the maximum value of the **pulse-pressure-squared integral** in that plane

NOTE 1 If the position of the plane is not specified, it is the plane passing through the point corresponding to the ~~**spatial-peak temporal-peak acoustic pressure**~~ maximum value of the **pulse-pressure-squared integral** in the whole acoustic field.

NOTE 2 In a number of cases, the term **pulse-pressure-squared integral** is replaced everywhere in the above definition by any linearly related quantity, for example
a) in the case of a continuous wave signal the term **pulse-pressure-squared integral** is replaced by mean square acoustic pressure as defined in IEC 61689,
b) in cases where signal synchronisation with the scanframe is not available the term **pulse-pressure-squared integral** may be replaced by **temporal average intensity.**

NOTE 3 Some specified ~~levels~~ fractions are 0,25 and 0,01 for the −6 dB and −20 dB beam areas, respectively.

NOTE 4 Beam area is expressed in square metres ~~squared~~ (m^2).

NOTE 5 Definition is modified compared to that used in IEC 61828:2001.

3.8
beam axis
straight line that passes through the **beam centrepoints** of two planes perpendicular to the line which connects the point of maximal **pulse-pressure-squared integral** with the centre of the **external transducer aperture**

NOTE 1 The location of the first plane is the location of the plane containing the maximum **pulse-pressure-squared integral** or, alternatively, is one containing a single main lobe which is in the focal Fraunhofer zone. The location of the second plane is as far as is practicable from the first plane and parallel to the first with the same two orthogonal scan lines (x and y axes) used for the first plane.

NOTE 2 In a number of cases, the term **pulse-pressure-squared integral** is replaced in the above definition by any linearly related quantity, for example

a) in the case of a continuous wave signal the term **pulse-pressure-squared integral** is replaced by mean square acoustic pressure as defined in IEC 61689,

b) in cases where signal synchronisation with the scanframe is not available the term **pulse-pressure-squared integral** may be replaced by **temporal average intensity**.

NOTE 3 See Figure 1.

NOTE 4 Definition is modified compared to that used in IEC 61828:2001.

3.9
beam centrepoint
position determined by the intersection of two lines passing through the **beamwidth midpoints** of two orthogonal planes, *xz* and *yz*

NOTE Definition adopted from IEC 61828:2001.