IEC 62127-2

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Ultrasonics – Hydrophones –
Part 2: Calibration for ultrasonic fields up to 40 MHz

Ultrasons – Hydrophones –
Partie 2: Etalonnage des champs ultrasoniques jusqu'à 40 MHz

IEC 62127-2:2007-08+AMD1:2013-02+AMD2:2017-03 CSV(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ULTRASONICS – HYDROPHONES –

Part 2: Calibration for ultrasonic fields up to 40 MHz

FOREWORD

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IEC 62127-2 edition 1.2 contains the first edition (2007-08) [documents 87/353/CDV and 87/372/RVC] and its corrigendum 1 (2008-08), its amendment 1 (2013-02) [documents 87/519/FDIS and 87/527/RVD] and its amendment 2 (2017-03) [documents 87/612/CDV and 87/639/RVC].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendments 1 and 2. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

International Standard IEC 62127-2 has been prepared by IEC technical committee 87: Ultrasonics.

IEC 62127-1, IEC 62127-2 and IEC 62127-3 are being published simultaneously.

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- withdrawn,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.

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INTRODUCTION

The spatial and temporal distribution of acoustic pressure in an ultrasonic field in a liquid medium is commonly determined using miniature ultrasonic **hydrophones**. These devices are not absolute measurement instruments and require calibration. The purpose of this part of IEC 62127 is to specify those calibration methods to be used in determining the response of a **hydrophone** in the ultrasonic range, i.e. above 20 kHz up to a frequency of 40 MHz. The main **hydrophone** application in this context lies in the measurement of ultrasonic fields emitted by medical diagnostic equipment in water. **Hydrophone** behaviour over this wide frequency band is required in order to reliably characterize the acoustic parameters of the applied acoustic field. In particular, the frequency range above 15 MHz is important to fully characterize this equipment, primarily due to the increased appearance of high-frequency components in the ultrasonic signals, caused by ~~non-linear~~ nonlinear propagation. In addition, the number of medical ultrasonic systems that use frequencies above 15 MHz, particularly intra-operative probes, is growing. It has turned out in recent years that the **hydrophone** response below 0,5 MHz is also required to reliably determine the peak-negative (rarefactional) acoustic pressure.

While the term "**hydrophone**" can be used in a wider sense, it is understood here as referring to miniature piezoelectric **hydrophones**. It is this instrument type that is used today in various areas of medical ultrasonics and, in particular, to characterize quantitatively the field structure of medical diagnostic instruments. With regard to other pressure sensor types, such as those based on fibre optics, some of the requirements of this standard are applicable to these as well but others are not. If in the future these other "**hydrophone**" types gain more importance in field measurement practice, their characteristics and calibration will have to be dealt with in a revised version of this standard or in a separate one.

NOTE This standard covers the ultrasonic frequency range, from 20 kHz to an upper frequency of 40 MHz. Standards dealing with **hydrophone** properties (IEC 62127-3) and **hydrophone** use (IEC 62127-1) are being developed in parallel as part of a programme of maintenance activities aimed at restructuring and merging, where possible, all existing ultrasonic **hydrophone** standards. This will eventually lead to unified standards covering the whole field of practical **hydrophone** application.

ULTRASONICS – HYDROPHONES –

Part 2: Calibration for ultrasonic fields up to 40 MHz

1 Scope

This part of IEC 62127 specifies:

- absolute **hydrophone** calibration methods;
- relative (comparative) **hydrophone** calibration methods.

Recommendations and references to accepted literature are made for the various relative and absolute calibration methods in the frequency range covered by this standard.

This standard is applicable to

- **hydrophones** used for measurements made in water and in the ultrasonic frequency range up to 40 MHz;

  NOTE 1 Although some physiotherapy medical applications of medical ultrasound are developing which operate in the frequency range 40 kHz to 100 kHz, the primary frequency range of diagnostic imaging remains above 2 MHz. It has recently been established that, even in the latter case, the **hydrophone** response at substantially lower frequencies can influence measurements made of key acoustic parameters [1].

- **hydrophones** employing circular piezoelectric sensor elements, designed to measure the pulsed wave and continuous wave ultrasonic fields generated by ultrasonic equipment;

  NOTE 2 Some hydrophones can have non-circular active elements, arising from slight deviations from a circular structure caused, for example by electrode structure, or conversely, the active elements can actually be squares. The clauses within this standard remain valid, although, in these cases, special attention should be paid to the directional response and to the effective radii of the active element through various axes of rotation.

- **hydrophones** with or without a hydrophone pre-amplifier.

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 61161~~:2006~~, *Ultrasonics – Power measurement – Radiation force balances and performance requirements*

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

IEC 61828~~:2006~~, *Ultrasonics – Focusing transducers – Definitions and measurement methods for the transmitted fields*

IEC 62127-1:2007, *Ultrasonics – Hydrophones – Part 1: Measurement and characterization of medical ultrasonic fields up to 40 MHz*
Amendment 1:2013

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

3 Terms, definitions and symbols

For the purposes of this document, the terms and definitions given in IEC 62127-1 and the following apply.

3.1
acoustic centre
point on or near a transducer from which the spherically divergent sound waves emitted by the transducer, and observable at remote points, appear to diverge

3.2
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 of IEC 62127-1.

NOTE 4 Definition adopted from IEC 62127-1.

3.3
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.

3.4
beamwidth
w_6, w_{12}, w_{20}

greatest distance between two points on a specified axis perpendicular to the **beam axis** where the **pulse-pressure-squared integral** falls below its maximum on the specified axis by a specified amount

NOTE 1 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 2 Commonly used **beamwidth**s are specified at – 6 dB, –12 dB and –20 dB levels below the maximum. The decibel calculation implies taking 10 times the logarithm of the ratios of the integrals.

NOTE 3 **Beamwidth** is expressed in metres (m).

NOTE 4 Definition adopted from IEC 62127-1.

3.5
beamwidth midpoint
linear average of the location of the centres of **beamwidth**s in a plane

NOTE 1 The average is taken over 20 beamwidth levels corresponding to intervals in the −0,1 dB to −26 dB range (see IEC 61828, Clause B.2).

NOTE 2 Definition adopted from IEC 61828:2001.

3.6
beam centre
point in a plane in the **far field**, usually perpendicular to the **beam axis**, at which the **spatial-peak temporal-peak acoustic pressure** occurs

3.7
diametrical beam scan
set of measurements of the hydrophone output voltage made while moving the hydrophone in a straight line passing through a point on the beam axis and in a direction normal to the beam axis

NOTE 1 The **diametrical beam scan** may extend to different distances on either side of the **beam axis**.

NOTE 2 Definition adopted from IEC 62127-1.

3.8
directional response
description, generally presented graphically, of the response of a **hydrophone**, as a function of direction of propagation of the incident plane sound wave, in a specified plane through the **reference centre** and at a specified frequency

NOTE Definition adopted from IEC 60565.

3.9
effective radius of a ~~non-focused~~ non-focusing ultrasonic transducer
a_t
radius of a perfect disc piston-like ultrasonic source transducer that has a predicted axial acoustic pressure distribution approximately equivalent to the observed axial acoustic pressure distribution over an axial distance until at least the last axial maximum has passed

NOTE 1 The **effective radius of a ~~non-focused~~ non-focusing ultrasonic transducer** is expressed in metres (m).

NOTE 2 Definition adopted from IEC 62127-1.

3.10
effective hydrophone radius
a_h, a_{h3}, a_{h6}

radius of a stiff disc receiver **hydrophone** that has a predicted **directional response** function with an angular width equal to the observed angular width

NOTE 1 The angular width is determined at a specified level below the peak of the **directional response** function. For the specified levels of 3 dB and 6 dB, the radii are denoted by a_{h3} and a_{h6} respectively.

NOTE 2 The **effective hydrophone radius** is expressed in metres (m).