IEC 62127-3

Edition 1.0 2007-08

INTERNATIONAL STANDARD

Ultrasonics – Hydrophones – Part 3: Properties of hydrophones for ultrasonic fields up to 40 MHz

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub
The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub
Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: www.electropedia.org
The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv
If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: csc@iec.ch
Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00

IEC 62127-3

Edition 1.0 2007-08

INTERNATIONAL STANDARD

Ultrasonics – Hydrophones – Part 3: Properties of hydrophones for ultrasonic fields up to 40 MHz

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PRICE CODE S

ICS 17.140.50

ISBN 2-8318-9278-3

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ULTRASONICS – HYDROPHONES –

Part 3: Properties of hydrophones for 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.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 62127-3 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.

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

Enquiry draft	Report on voting
87/354/CDV	87/373/RVC

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

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 this publication will remain unchanged until the maintenance result date indicated on the IEC website 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.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

The spatial and temporal distribution of acoustic pressure in an ultrasonic field in a liquid medium is commonly determined using miniature ultrasonic **hydrophones**. The properties of these **hydrophones** have been dealt with in a number of IEC standards in various aspects. The purpose of this part of IEC 62127 is to bring together all these specifications and to establish a common standard on the properties of ultrasonic **hydrophones**. The main **hydrophone** application in this context is the measurement of ultrasonic fields emitted by medical diagnostic equipment in water. Other medical applications are field measurements for therapy equipment such as that used in lithotripsy, high-intensity focused ultrasound (HIFU) and physiotherapy. Hydrophones are also used extensively in non-medical applications for both product development and quality control including:

– mapping of the ultrasound field within ultrasonic cleaning baths;

– characterization of acoustic fields used in transmission measurement systems (e.g. ultrasonic spectrometers, ultrasonic attenuation meters and velocimeters);

– characterization of acoustic fields used in reflection measurement systems (e.g. Doppler flowmeters).

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 ultrasonics and, in particular, to quantitatively characterize 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 properties will have to be dealt with in a revised version of this standard or in a separate one.

Underwater **hydrophones** as covered by IEC 60500 and IEC 60565 are not included in this standard, although there is an overlap in the frequency ranges. Underwater **hydrophones** are used in natural waters, even in the ocean, and this leads to different technical concepts and requirements. In addition, the main direction of acoustic incidence in underwater applications is typically at right angles to the **hydrophone axis**, whereas it is assumed in this standard that it is in the direction of the **hydrophone axis**.

In the past, ultrasonic **hydrophones** have been applied almost exclusively as amplitude sensors. At present a change can be seen and it is increasingly considered useful to have additional phase information, which, however, is only possible if the phase characteristics of the **hydrophone** have been determined during calibration. In this standard, therefore, requirements are specified for the amplitude aspect of the **hydrophone** sensitivity, and recommendations are provided for the phase aspect, as an option to be considered.

ULTRASONICS – HYDROPHONES –

Part 3: Properties of hydrophones for ultrasonic fields up to 40 MHz

1 Scope

This part of IEC 62127 specifies relevant **hydrophone** characteristics.

This standard is applicable to:

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

– **hydrophones** used for measurements made in water;

– **hydrophones** with or without an associated 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 62127-1, *Ultrasonics – Hydrophones – Part 1: Measurement and characterization of medical ultrasonic fields up to 40 MHz*

IEC 62127-2, *Ultrasonics – Hydrophones – Part 2: Calibration 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, IEC 62127-2 and the following apply.

3.1
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 60565:2006.

3.2
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 radius is usually the function of frequency. For representative experimental data, see [1].

NOTE 3 The **effective hydrophone radius** is expressed in metres (m).

3.3
electric load impedance
$\underline{Z}_L$
complex electric input impedance (consisting of a real and an imaginary part) to which the **hydrophone** or **hydrophone assembly** output is connected or is to be connected

NOTE The **electric load impedance** is expressed in ohms (Ω).

3.4
end-of-cable
specification that relates to the end of the integral output cable if the **hydrophone** or **hydrophone assembly** is provided with such a cable; if the **hydrophone** or **hydrophone assembly** is not provided with an integral output cable, the specification relates to the output connector firmly connected with the **hydrophone** or **hydrophone assembly**, not to an extra cable

3.5
end-of-cable loaded sensitivity
end-of-cable loaded sensitivity of a **hydrophone** or **hydrophone assembly**
M_L
ratio of the instantaneous voltage at the end of any integral cable or output connector of a **hydrophone** or **hydrophone assembly**, when connected to a specified **electric load impedance**, to the instantaneous acoustic pressure in the undisturbed **free field** of a plane wave in the position of the **reference centre** of the **hydrophone** if the **hydrophone** were removed

NOTE **End-of-cable loaded sensitivity** is expressed in volts per pascal (V/Pa).

3.6
end-of-cable open-circuit sensitivity
end-of-cable open-circuit sensitivity of a hydrophone
M_C
ratio of the instantaneous, open-circuit voltage at the end of any integral cable or output connector of a **hydrophone** to the instantaneous acoustic pressure in the undisturbed **free field** of a plane wave in the position of the **reference centre** of the **hydrophone** if the **hydrophone** were removed

NOTE 1 **End-of-cable open-circuit sensitivity** is expressed in volts per pascal (V/Pa).

NOTE 2 This corresponds to the free field sensitivity as defined in IEC 60565:2006, 3.15.

3.7
free field
sound field in a homogeneous and isotropic medium in which the effects of boundaries are negligible

NOTE Definition adopted from IEC 60565:2006, 3.13.

3.8
hydrophone geometrical radius
geometrical radius of a hydrophone active element
a_g
radius defined by the dimensions of the active element of a **hydrophone**

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

3.9
hydrophone
transducer that produces electric signals in response to waterborne acoustic signals

[IEV 801-32-26]

3.10
hydrophone assembly
combination of **hydrophone** and **hydrophone pre-amplifier**

3.11
hydrophone axis
nominal symmetry axis of the **hydrophone** active element

NOTE Unless stated otherwise (explicitly and quantitatively) by the manufacturer, it is understood for the purposes of this standard that this is given by the apparent geometrical symmetry axis of the **hydrophone**.

3.12
hydrophone pre-amplifier
active electronic device connected to, or to be connected to, a particular hydrophone and reducing its output impedance

NOTE 1 A **hydrophone pre-amplifier** requires a supply voltage (or supply voltages).

NOTE 2 The **hydrophone pre-amplifier** may have a forward voltage transmission factor of less than one, i.e. it need not necessarily be a voltage amplifier in the strict sense.

3.13
reference centre
point on or near a **hydrophone** about which its acoustic receiving sensitivity is defined

NOTE 1 Unless stated otherwise (explicitly and quantitatively) by the manufacturer, it is understood for the purposes of this standard that this is given by the geometrical centre of the front surface of the **hydrophone** active element.

NOTE 2 Definition adopted from IEC 60565, 3.25.

3.14
uncertainty
parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand

NOTE 1 See the ISO *Guide to the Expression of Uncertainty in Measurement* [2], 2.2.3

NOTE 2 Definition adopted from IEC 62127-1.

4 List of symbols

a_g hydrophone geometrical radius

a_h **effective hydrophone radius** (a_{h3}, a_{h6}: with special reference to a 3 dB or 6 dB definition, respectively)

c speed of sound in a medium

f frequency

$\underline{M}$ general symbol for the complex **hydrophone** sensitivity, $M = |\underline{M}|$ being its modulus and arg($\underline{M}$) being its argument (= phase angle)

M_c end-of-cable open-circuit sensitivity

M_L end-of-cable loaded sensitivity

$\underline{Z}_h$ complex electric output impedance of a **hydrophone** or **hydrophone assembly**

$\underline{Z}_L$ electric load impedance

θ angle of incidence of an ultrasonic wave with respect to the **hydrophone axis** (θ_3, θ_6: with special reference to 3 dB and 6 dB defined levels)