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INTERNATIONAL STANDARD





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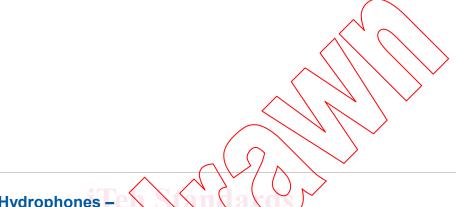
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INTERNATIONAL STANDARD



Ultrasonics - Hydrophones -

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



INTERNATIONAL ELECTROTECHNICAL COMMISSION

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CONTENTS

1 :	Scop	oe	6
2	Norn	native references	6
3	Term	ns, definitions and symbols	6
	List of symbols		
		ophone characteristics	
	5.1	General	
	5.2	Basic information	
	5.3		
	5.4	•	10
		Frequency response	` 1(
		5.4.2 Frequency dependence	1(
	5.5	Directional response 5.5.1 General	1
		5.5.1 General	1
		5.5.2 Symmetry of directional response \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	1.
;	5.6	Effective radius	1
:	5.7	Dynamic range, linearity and electromagnetic interference	12
	5.8	Electric output characteristics 5.8.1 General	13
		5.8.2 Hydrophone without pre-amplifier	13
		5.8.3 Hydrophone assembly	13
		5.8.4 Output lead configuration.	14
	5.9	Environmental aspects	14
		5.9.1 Vemperature range	.ec:.0.4.1.4.7.43
		5.9.2 Water tightness	
		5.9.3 Water properties and incompatible materials	
	E 10	Guidance manual	
,	J. 1 1	List of hydrophone characteristics	
Anne	ex A	(informative) Examples of information on hydrophone properties	16
Bibli	ogra	phy	2
Figu	re A.	1 – Frequency response of 0,2 mm needle hydrophone	1

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ULTRASONICS - HYDROPHONES -

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

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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.

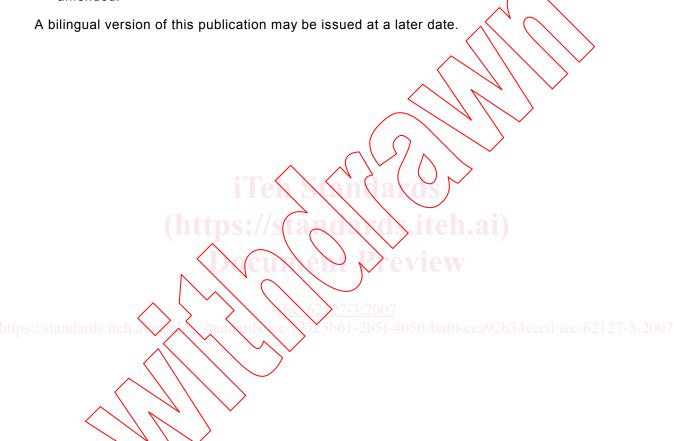
This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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



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

$a_{\rm h}, a_{\rm h3}, a_{\rm h6}$

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

Z١

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 ML

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 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

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 VEC 62127-1

4 List of symbols

- a_q 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
- <u>M</u> general symbol for the complex **hydrophone** sensitivity, $M = |\underline{M}|$ being its modulus and $arg(\underline{M})$ being its argument (= phase angle)
- $M_{\rm c}$ end-of-cable open-circuit sensitivity
- $M_{\rm L}$ end-of-cable loaded sensitivity
- Z_h complex electric output impedance of a hydrophone or hydrophone assembly
- 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)