SIST

SLOVENSKI STANDARD
oSIST prEN IEC 63305:2022

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Podvodna akustika - Kalibracija zvočnega vala vektorskih sprejemnikov v frekvenčnem območju od 5 Hz do 10 kHz

Underwater Acoustics - Calibration of acoustic wave vector receivers in the frequency range 5 Hz to 10 kHz

Ta slovenski standard je istoveten z: **prEN IEC 63305:2022**

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OF INTEREST TO THE FOLLOWING COMMITTEES:		PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.	
FUNCTIONS CONCERNED:			
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TITLE:

Underwater Acoustics – Calibration of acoustic wave vector receivers in the frequency range 5 Hz to 10 kHz

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NOTE FROM TC/SC OFFICERS:

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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UNDERWATER ACOUSTICS – CALIBRATION OF ACOUSTIC WAVE VECTOR RECEIVERS IN THE FREQUENCY RANGE 5 Hz TO 10 kHz

FOREWORD

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

FDIS	Report on voting
XX/XX/FDIS	XX/XX/RVD

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.

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 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- withdrawn,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.

The National Committees are requested to note that for this publication the stability date is 20XX. THIS TEXT IS INCLUDED FOR THE INFORMATION OF THE NATIONAL COMMITTEES AND WILL BE DELETED AT THE PUBLICATION STAGE.

INTRODUCTION

Usually, **acoustic wave vector receiver**s (sometimes referred to simply as **vector receiver**s) are designed and constructed based on two kinds of principles. One is the sound pressure difference (gradient) principle. When measuring, it is rigidly fixed on a mount and supporting in water. Another is the co-vibrating (**inertial**) principle. When measuring, it is suspended on a mount and supporting in water, which makes the **vector receiver** co-vibrating in the same direction with the **sound particle** in the sound wave field.

Unlike the traditional piezoelectric **hydrophone**s which are sensitive to the sound pressure, **acoustic wave vector receiver**s measure **sound particle** motion (velocity, acceleration or displacement) or **sound pressure gradient**, and have strongly directional response in their working frequency range. The calibration of these **vector receiver**s which measure **sound particle** motion or **sound pressure gradient** are considered in this standard.

The output voltage of an **acoustic wave vector receiver** channel to be calibrated is proportional to the **sound particle** motion or **sound pressure gradient** at the reference centre of the receiver. And the directivity of the **acoustic wave vector receiver** channel is independent of acoustical frequency, with a cardioid pattern similar to the shape of Arabic figure "8" shown in Figure 1, and the ratio of the output voltage of the receiver channel at angle θ to the maximum output voltage on the axial direction is equal to $\cos\theta$. [1]

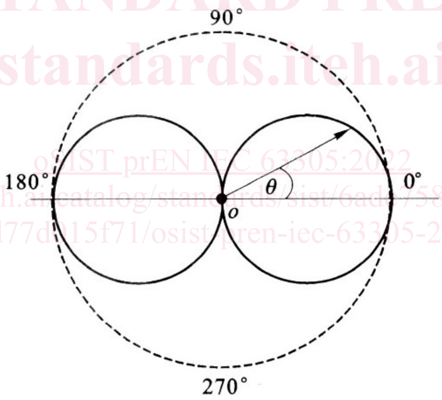

Figure 1 – Ideal directivity pattern of a vector receiver channel

UNDERWATER ACOUSTICS – CALIBRATION OF ACOUSTIC WAVE VECTOR RECEIVERS IN THE FREQUENCY RANGE 5 Hz TO 10 kHz

1 Scope

This International Standard specifies the calibration methods of **acoustic wave vector receiver**s (sometimes referred to simply as **vector receiver**s) in the frequency range 5 Hz to 10 kHz.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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, *International Electrotechnical Vocabulary – Chapter 801: Acoustics and electroacoustics*

IEC 60500:2017, *Underwater acoustics – Hydrophones – Properties of hydrophones in the frequency range 1 Hz to 500 kHz*

IEC 60565-1:2020, *Underwater acoustics – Hydrophones – Calibration of hydrophones, Part 1: Procedures for free-field calibration of hydrophones*

IEC 60565-2:2019, *Underwater acoustics – Hydrophones – Calibration of hydrophones, Part 2: Procedures for low frequency pressure calibration*

ISO 266:1997, *Acoustics – Preferred frequencies*

ISO 18405:2017, *Underwater acoustics – Terminology*

JCGM 100:2008, *Evaluation of measurement data – Guide to the expression of uncertainty in measurement*

JCGM 200:2012, *International vocabulary of metrology basic and general concepts and associated terms*

3 Terms and definitions

For the purposes of this document, the following terms and definitions given in IEC 60050-801, IEC 60500:2017, ISO 18405:2017, JCGM 200:2012 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1

acoustic wave vector receiver
vector receiver

receiving transducer whose output voltage of its receiving channel is proportional to the **sound particle** motion (displacement, velocity or acceleration) or **sound pressure gradient** on the position of the reference centre of the **vector receiver** in water

Note 1 to entry: Due to the different constructions, the **vector receiver** may be one-dimensional **vector receiver**, two-dimensional orthogonal **vector receiver** or three-dimensional orthogonal **vector receiver**, and it has different receiving channels. For three-dimensional orthogonal **vector receiver**, whose channels are usually named as *x*-channel, *y*-channel and *z*-channel.

Note 2 to entry: The receiving channel of the **vector receiver** has very strong **directional response** (see Figure 1), which is independent of the frequency.

Note 3 to entry: According to the vector values which perceived, there are different **vector receiver**s, including **inertial vector receiver** and **sound pressure gradient receiver**.

Note 4 to entry: Sometimes, the **vector receiver** has sound pressure (scalar) receiving channel, and open-circuit voltage of the sound pressure channel is proportional to the sound pressure on the position of the reference centre of the **vector receiver**.

3.2

inertial vector receiver

receiving transducer that senses **sound particle** motion by measuring the reaction of a proof mass in response to acceleration of the sensor body (e.g., accelerometer, geophone)

3.3

sound pressure gradient receiver

receiving transducer that senses the gradient of sound pressure using two or more **hydrophone**s separated by distances that are small relative to the wavelength

3.4

axial angular deviation loss

the larger value of **directional response** of a **vector receiver** channel on the principal axis minus another value of **directional response** on the symmetrical direction

Note 1 to entry: The **axial angular deviation loss** is expressed as a (relative) level in decibel, dB.

Note 2 to entry: Sometimes, the **axial angular deviation loss** is named as asymmetry or maximum heterogeneity of **directional response** on the principal axis of a **vector receiver** channel.

3.5

directional response

<of a **vector receiver** channel> description, generally presented graphically, of the response of a **vector receiver** channel, as a function of the direction of propagation of the incident plane sound wave, in a given channel direction through the reference centre, at a specified frequency

Note 1 to entry: The **directional response** pattern is usually presented in the form of a two-dimensional polar graph. The scale of the polar may be in terms of sensitivity level or in angular deviation loss.

Note 2 to entry: The **directional response** pattern of the **vector receiver** channel is a cosine function, that is the ratio of the output voltage of the **vector receiver** channel in the direction of angle θ to the maximum output voltage in the axial direction is equal to $\cos\theta$.

[SOURCE: IEC 60500:2017, 3.4, modified – Replace “hydrophone” with “vector receiver channel”, “a specified plan” with “a given channel direction”].

3.6

hydrophone

electroacoustic transducer that produces electrical voltages in response to water borne **sound pressure signals**

[SOURCE IEC 60500:2017, 3.4, modified – Replace “electrical signals” with “electrical voltages”, “pressure signals” with “sound pressure signals”]

3.7

lateral angular deviation loss

the larger value of **directional response** of a **vector receiver** channel on the principal axis minus the smaller value of **directional response** on the lateral axis

Note to entry: The **lateral angular deviation loss** is expressed as a (relative) level in decibels (dB).

3.8

material element
sound particle

smallest element of the medium that represents the medium’s mean density

Note to entry: The characteristic length scale of this element is of the order of several times the mean free molecular path.

[SOURCE: ISO 18405:2017, 3.1.1.5][2]

3.9

sound particle acceleration

$\boldsymbol{a}$

contribution to acceleration of a **sound particle** caused by the action of sound

Note 1 to entry: **Sound particle acceleration** is a function of time, *t*, which may be indicated by means of an argument *t*, as in $\boldsymbol{a}(t)$.

Note 2 to entry: For small-amplitude sound waves in an otherwise stationary medium, the **sound particle acceleration** and **sound particle velocity** are related by

$$\boldsymbol{a} = \frac{\partial \boldsymbol{u}}{\partial t} \quad (1)$$

where $\boldsymbol{u}(t)$ is the **sound particle velocity** at time, *t*, and the partial derivative is evaluated at a fixed position.

Note 3 to entry: **Sound particle acceleration** is expressed in units of metre per second squared, $\text{m}\cdot\text{s}^{-2}$.

Note 4 to entry: **Sound particle acceleration** is a vector quantity. Spatial components of the **sound particle acceleration** may be indicated by assigning subscripts to the symbol. For example, in Cartesian coordinates, $\boldsymbol{a} = (a_\text{x}, a_\text{y}, a_\text{z})$. By convention in underwater acoustics, the z axis is usually chosen to point vertically down from the sea surface, with x and y axes in the horizontal plane.

[SOURCE: ISO 18405:2017, 3.1.2.11][2]

3.10

sound particle acceleration sensitivity

$\underline{M}_\text{a}$

<of a **vector receiver** channel> quotient of the Fourier transform of the output voltage signal $\mathcal{F}(U_\text{VR}(t))$ of a **vector receiver** channel to the Fourier transform of the **sound particle acceleration** signal $\mathcal{F}(a(t))$, for specified frequency and specified direction of plane wave sound incidence on the position of the reference centre of the **vector receiver** in the undisturbed free field if the **vector receiver** was removed

$$\underline{M}_\text{a} = \frac{\mathcal{F}(U_\text{VR}(t))}{\mathcal{F}(a(t))} \quad (2)$$

Note to entry: The modulus of the **sound particle acceleration sensitivity** is expressed in units of volt second squared per metre, $\text{V}\cdot\text{s}^2\cdot\text{m}^{-1}$. The phase angle of the sensitivity is expressed in degrees and represents the phase difference between the electrical voltage and the **sound particle acceleration**.

3.11

sound particle acceleration sensitivity level

$L_\text{M,a}$

twenty times the logarithm to the base 10 of the ratio of the modulus of the **sound particle acceleration sensitivity** $\left|\underline{M}_{\mathrm{a}}\right|$ of a **vector receiver** channel to a reference value of sensitivity, $M_{\mathrm{a,ref}}$, in decibels

$$L_{\mathrm{M,a}} = 20\log_{10}\frac{\left|\underline{M}_{\mathrm{a}}\right|}{M_{\mathrm{a,ref}}}\ \mathrm{dB} \qquad (3)$$

Note 1 to entry: The unit of **sound particle acceleration sensitivity level** is expressed as a (relative) level in decibels (dB).

Note 2 to entry: The reference value of sensitivity, $M_{\mathrm{a,ref}}$, is 1 $\mathrm{V{\cdot}s^2{\cdot}\mu m^{-1}}$.

3.12

sound particle displacement

$\boldsymbol{\delta}$

displacement of a **sound particle** caused by the action of sound

Note 1 to entry: **Sound particle displacement** is a function of time, *t*, which may be indicated by means of an argument *t*, as in $\boldsymbol{\delta}(t)$.

Note 2 to entry: **Sound particle displacement** is expressed in metres, m.

Note 3 to entry: **Sound particle displacement** is a vector quantity. Spatial components of the **sound particle displacement** may be indicated by assigning subscripts to the symbol. For example, in Cartesian coordinates, $\boldsymbol{\delta}=(\delta_{\mathrm{x}},\delta_{\mathrm{y}},\delta_{z})$. By convention in underwater acoustics, the z axis is usually chosen to point vertically down from the sea surface, with x and y axes in the horizontal plane.

[SOURCE: ISO 18405:2017, 3.1.2.9][2]

3.13

sound particle displacement sensitivity

$\underline{M}_{\delta}$

<of a **vector receiver** channel> quotient of the Fourier transform of the output voltage signal $\mathcal{F}\left(U_{\mathrm{VR}}(t)\right)$ of a **vector receiver** channel to the Fourier transform of the **sound particle displacement** signal $\mathcal{F}\left(\delta(t)\right)$, for specified frequency and specified direction of plane wave sound incidence on the position of the reference centre of the **vector receiver** in the undisturbed free field if the **vector receiver** was removed

$$\underline{M}_{\delta} = \frac{\mathcal{F}\left(U_{\mathrm{VR}}(t)\right)}{\mathcal{F}\left(\delta(t)\right)} \qquad (4)$$

Note to entry: The modulus of the **sound particle displacement sensitivity** is expressed in units of volt per metre, $\mathrm{V{\cdot}m^{-1}}$. The phase angle of the sensitivity is expressed in degrees and represents the phase difference between the electrical voltage and the **sound particle displacement**.

3.14

sound particle displacement sensitivity level

$L_{\mathrm{M},\delta}$

twenty times the logarithm to the base 10 of the ratio of the modulus of the **sound particle displacement sensitivity** $\left|\underline{M}_{\delta}\right|$ of a **vector receiver** channel to a reference value of sensitivity, $M_{\delta,\mathrm{ref}}$, in decibels

$$L_{M,\delta} = 20\log_{10}\frac{|\underline{M}_{\delta}|}{M_{\delta,\mathrm{ref}}}\ \mathrm{dB} \qquad (5)$$

Note 1 to entry: The unit of **sound particle displacement sensitivity level** is expressed as a (relative) level in decibels (dB).

Note 2 to entry: The reference value of sensitivity, $M_{\delta,\mathrm{ref}}$, is 1 V·pm^{-1}.

3.15

sound particle velocity

$\boldsymbol{u}$

contribution to velocity of a **sound particle** caused by the action of sound

Note 1 to entry: **Sound particle velocity** is a function of time, *t*, which may be indicated by means of an argument *t*, as in $\boldsymbol{u}(t)$.

Note 2 to entry: For small-amplitude sound waves in an otherwise stationary medium, the **sound particle velocity** and **sound particle displacement** are related by

$$\boldsymbol{u} = \frac{\partial \boldsymbol{\delta}}{\partial t} \qquad (6)$$

where $\boldsymbol{\delta}(t)$ is the **sound particle displacement** at time, *t*, and the partial derivative is evaluated at a fixed position.

Note 3 to entry: **Sound particle velocity** is expressed in units of metre per second, m·s^{-1}.

Note 4 to entry: **Sound particle velocity** is a vector quantity. Spatial components of the **sound particle velocity** may be indicated by assigning subscripts to the symbol. For example, in Cartesian coordinates, $\boldsymbol{u} = (u_x, u_y, u_z)$. By convention in underwater acoustics, the z axis is usually chosen to point vertically down from the sea surface, with x and y axes in the horizontal plane.

[SOURCE: ISO 18405:2017, 3.1.2.10][2]

3.16

sound particle velocity sensitivity

$\underline{M}_{\mathrm{u}}$

<of a **vector receiver** channel> quotient of the Fourier transform of the output voltage signal $\mathcal{F}(U_{\mathrm{VR}}(t))$ of a **vector receiver** channel to the Fourier transform of the **sound particle velocity** signal $\mathcal{F}(u(t))$, for specified frequency and specified direction of plane wave sound incidence on the position of the reference centre of the **vector receiver** in the undisturbed free field if the **vector receiver** was removed

$$\underline{M}_{u} = \frac{\mathcal{F}(U_{\mathrm{VR}}(t))}{\mathcal{F}(u(t))} \qquad (7)$$

Note to entry: The modulus of the **sound particle velocity sensitivity** is expressed in units of volt second per metre, V·s·m^{-1}. The phase angle of the sensitivity is expressed in degrees and represents the phase difference between the electrical voltage and the **sound particle velocity**.

3.17

sound particle velocity sensitivity level

$L_{\mathrm{M,u}}$

twenty times the logarithm to the base 10 of the ratio of the modulus of the **sound particle velocity sensitivity** $|\underline{M}_{\mathrm{u}}|$ of a **vector receiver** channel to a reference value of sensitivity, $M_{\mathrm{u,ref}}$, in decibels

$$L_{\mathrm{M,u}} = 20\log_{10}\frac{|\underline{M}_{\mathrm{u}}|}{M_{\mathrm{u,ref}}}\ \mathrm{dB} \qquad (8)$$

Note 1 to entry: The unit of **sound particle velocity sensitivity level** is expressed as a (relative) level in decibels (dB).

Note 2 to entry: The reference value of sensitivity, $M_{\mathrm{u,ref}}$, is 1 V·s·nm^{-1}.

3.18

sound pressure gradient

$\nabla \boldsymbol{p}$

spatial derivative of sound pressure with respect to distance in a given direction caused by the action of sound

Note 1 to entry: Sound pressure gradient is a function of time, *t*, which may be indicated by means of an argument *t*, as in $\nabla \boldsymbol{p}(t)$.

Note 2 to entry: For small-amplitude sound waves in an otherwise stationary medium, the **sound pressure gradient** and **sound pressure** are related by

$$\nabla \boldsymbol{p} = \frac{\partial p}{\partial \boldsymbol{r}} \qquad (9)$$

where $\partial p/\partial \boldsymbol{r}$ is the **sound pressure gradient** at time, *t*, and the partial derivative is evaluated at a fixed position.

Note 3 to entry: Sound pressure gradient is expressed in units of Pascal per metre, Pa·m^{-1}.

Note 4 to entry: Sound pressure gradient is a vector quantity. In Cartesian coordinates, spatial components of the sound pressure gradient may be indicated as $\partial p/\partial \boldsymbol{r} = (\partial p/\partial x, \partial p/\partial y, \partial p/\partial z)$. By convention in underwater acoustics, the z axis is usually chosen to point vertically down from the sea surface, with x and y axes in the horizontal plane.

3.19

sound pressure gradient sensitivity

$\underline{M}_{\mathrm{pg}}$

<of a **vector receiver** channel> quotient of the Fourier transform of the output voltage signal $\mathcal{F}(U_{\mathrm{VR}}(t))$ of a **vector receiver** channel to Fourier transform of the **sound pressure gradient** signal $\mathcal{F}(\nabla p(t))$, for specified frequency and specified direction of plane wave sound incidence on the position of the reference centre of the **vector receiver** in the undisturbed free field if the **vector receiver** was removed

$$\underline{M}_{\mathrm{pg}} = \frac{\mathcal{F}(U_{\mathrm{VR}}(t))}{\mathcal{F}(\nabla p(t))} \qquad (10)$$

Note to entry: The modulus of the **sound pressure gradient sensitivity** is expressed in units of volt metre per pascal, V·m·Pa^{-1}.

3.20

sound pressure gradient sensitivity level

$L_{\mathrm{M,pg}}$

twenty times the logarithm to the base 10 of the ratio of the modulus of the **sound pressure gradient sensitivity** $|\underline{M}_{\mathrm{pg}}|$ of a **vector receiver** channel to a reference value of sensitivity, $M_{\mathrm{pg,ref}}$, in decibels