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Ships and marine technology — Marine echo-sounding equipment

Navires et technologie maritime — Appareils de sondage par écho

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 6, *Navigation and ship operations*.

This fourth edition cancels and replaces the third edition (ISO 9875:2000), which has been technically revised. It also incorporates the Technical Corrigendum ISO 9875:2000/Cor 1:2006.

The main changes are as follows:

— the normative references have been updated;

— bridge alert management requirements have been added in 5.6 and the test method in 6.8;

— interface requirements have been added in 5.9;

— Annex B has been replaced with a new Annex on alerts definition, including alert identifiers

— added new Annex C on IEC 61162 interfaces overview.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The purpose of echo-sounding equipment is to provide reliable information on the depth of water under a ship to aid navigation in particular in shallow water.

This document is aligned with IMO Resolutions, in particular IMO Resolution A.694(17), IMO Resolution A.224(VII), IMO Resolution MSC.74(69) and IMO Resolution MSC.302(87).

Any text in this document which is a citation from the IMO Resolution MSC.74(69), Annex 4, appears in italics. Within these citations, any changes to the original wording of the IMO Resolution MSC.74(69), Annex 4, are written in upright font.

In this document, the following verbal forms are used:

— “shall” indicates a requirement;

— “should” indicates a recommendation;

— “may” indicates a permission;

— “can” indicates a possibility or a capability.

Ships and marine technology — Marine echo-sounding equipment

1 Scope

This document specifies the minimum operational and performance requirements, methods of testing and test results of marine echo-sounding equipment required to comply with the performance standards adopted by the IMO Resolution A.224(VII) as amended by IMO Resolution MSC.74(69), Annex 4.

This document is intended to be used in conjunction with IMO Resolution A.694(17) and with IEC 60945.

For bridge alert management, IMO Resolution MSC.302(87) supersedes IMO Resolution MSC.74(69), Annex 4. Accordingly, this document incorporates references to IEC 62923-1 and IEC 62923-2 which are associated with Resolution MSC.302(87) for requirements and tests where applicable.

In accordance with IMO Resolution MSC.74(69), Annex 4, Articles 1 and 2, *the purpose of echo-sounding equipment is to provide reliable information on the depth of water under a ship to aid navigation in particular in shallow water*. This document is *applicable for ship speeds from 0 kn to 30 kn*.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60945, *Maritime navigation and radiocommunication equipment and systems — General requirements — Methods of testing and required test results*

IEC 61162-1, *Maritime navigation and radiocommunication equipment and systems — Digital interfaces — Part 1: Single talker and multiple listeners*

IEC 61162-2, *Maritime navigation and radiocommunication equipment and systems — Digital interfaces — Part 2: Single talker and multiple listeners, high-speed transmission*

IEC 61162-450, *Maritime navigation and radiocommunication equipment and systems — Digital interfaces — Part 450: Multiple talkers and multiple listeners — Ethernet interconnection*

IEC 62288, *Maritime navigation and radiocommunication equipment and systems — Presentation of navigation-related information on shipborne navigational displays — General requirements, methods of testing and required test results*

IEC 62923-1:2018, *Maritime navigation and radiocommunication equipment and systems — Bridge alert management — Part 1: Operational and performance requirements, methods of testing and required test results*

IEC 62923-2, *Maritime navigation and radiocommunication equipment and systems — Bridge alert management — Part 2: Alert and cluster identifiers and other additional features*

IMO Resolution MSC 74(69), *Adoption of New and Amended Performance Standards,* Annex 4, *Amendments to Resolution A.224(VII) — Performance standard for echo sounding equipment*, May 1998

IMO Resolution MSC 302(87), *Adoption of Performance standards for bridge alert management*, May 2010

IMO Resolution A. 694(17), *General requirements for shipborne radio equipment forming part of the global maritime distress and safety system (GMDSS) and for electronic navigational*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
source level
S
maximum root mean square sound pressure level at a point on the principal axis of the *transducer* (3.5), as measured in the far field but referred to the distance of 1 m

Note 1 to entry: This value is expressed in decibels.

3.2
receiving directivity index
D
ratio of the acoustic power density at a distant point on the principal axis of the *transducer* (3.5), when used as a transmitter, to that of an omnidirectional transducer, with the same total radiated acoustic power

Note 1 to entry: This value is expressed in decibels.

3.3
receiving bandwidth
B
bandwidth at which the response of the overall system, measured through water, is 3 dB below the maximum response of the system

$$B = 10 \lg(f_1 - f_2)$$

where f_1 and f_2 are respectively the upper and lower frequencies, expressed in hertz.

Note 1 to entry: This value is expressed in decibels.

3.4
minimum detectable signal-to-noise ratio
E
ratio of the signal level, expressed in decibels, to the background noise level, expressed in decibels, in the bandwidth of the receiver required to give a minimum detectable signal on the display

3.5
transducer
substance or device, such as a piezoelectric element, that converts an input electrical energy into an acoustic energy and vice versa, installed on the ship's hull and exposed to the sea water

3.6
performance check
short test to confirm compliance with the essential requirements specified in the equipment standards

Note 1 to entry: In this document, a performance check is a non-quantitative visual check confirming that the system is still operative for the purpose of IEC 60945.

3.7
inspection
visual check of the equipment or documentation

3.8
pre-conditioning
treatment of a specimen with the objective of removing or partly counteracting the effects of its previous history

3.9
bridge alert management
BAM
overall concept for management, handling and harmonized presentation of alerts on the bridge

3.10
central alert management
CAM
functionality for the management of the presentation of alerts on the *central alert management human machine interface (CAM-HMI)* (3.11), the communication of alert states between CAM-HMI and navigational systems and sensors

[SOURCE: IMO Resolution MSC.302(87), Appendix 1]

Note 1 to entry: The functions can be centralized or partly centralized in subsystems and interconnected via a standardized alert-related communication.

3.11
central alert management human machine interface
CAM-HMI
human machine interface for centralized presentation and handling of alerts on the bridge

[SOURCE: IMO Resolution MSC.302(87), Appendix 1]

3.12
central alert management system
CAM system
combined functionality of *central alert management* (3.10) and *central alert management human machine interface* (3.11)

[SOURCE: IEC 62923-1:2018, 3.1.18]

4 Abbreviated terms

DPT	depth
ECDIS	electronic chart display and information system
ES	echo-sounding equipment
EUT	equipment under test
BAM	bridge alert management
CAM	central alert management
CAM-HMI	central alert management human machine interface
VDR	voyage data recorder

5 Performance requirements

5.1 General

Echo-sounding equipment shall comply with IMO Resolution MSC.74(69), Annex 4 and with the general requirements of IEC 60945, where applicable.

Echo-sounding equipment shall comply with IEC 62288.

5.2 Functionality

5.2.1 Range performance

In accordance with IMO Resolution MSC.74(69), Annex 4, Article 5.1.1, *under normal propagation and sea bed reflectibility conditions, the equipment* shall *be capable of measuring any clearance under the transducer between 2 m and 200 m.*

5.2.2 Range scales

In accordance with IMO Resolution MSC.74(69), Annex 4, Article 5.1.2, *the equipment* shall *provide a minimum of two range scales one of which, the shallow range,* shall *cover a range of 20 m, and the other, the deep range,* shall *cover a range of 200 m.*

Where an automatic range is provided, a device to select these ranges manually shall be available to override the automatic range.

Where phased ranges, not starting from zero, are available, an indication shall be provided to show that such a range is in use.

Positive indication of the range in use shall be provided in all cases.

Where depth measurement relative to the sea surface is provided, in addition to measurement of the depth of water under the ship, there shall be a positive indication of a draught value.

5.2.3 Main display

In accordance with IMO Resolution MSC.74(69), Annex 4, Article 5.1.3, *the primary presentation* shall *be a suitable graphical display which provides the immediate depth and a visible record of soundings.*

The displayed record shall *show at least 15 min of soundings* on the deep range scale.

Multi-colour display may be used. In this case, the colour assignment shall be clearly explained in the manual.

5.2.4 Other displays

In accordance with IMO Resolution MSC.74(69), Annex 4, Article 5.1.4, *other forms of display may be added, but these* shall *not affect the normal operation of the main display.*

5.2.5 Pulse repetition rate

In accordance with IMO Resolution MSC.74(69), Annex 4, Article 5.1.5, *the pulse repetition rate* shall *not be slower than 12 pulses per minute on the deep range and 36 pulses per minute on the shallow range.*

5.2.6 Roll and pitch

In accordance with IMO Resolution MSC.74(69), Annex 4, Article 5.1.6, *the performance of the equipment* shall *be such that it will meet the requirements of* this document *when the ship is rolling ±10° and/or pitching ±5°.*

5.3 Multiple installation

In accordance with IMO Resolution MSC.74(69), Annex 4, Article 5.1.7, *more than one transducer and associated transmitter-receiver may be fitted.*

If more than one transducer is used:

— *means* shall *be available to display the depths from the different transducers separately; and*

— *a clear indication of the transducer(s) in use* shall *be provided.*

5.4 Data storage

In accordance with IMO Resolution MSC.74(69), Annex 4, Article 5.1.8, *it* shall *be possible to record on paper recording or other means the information about:*

— *the depth(s), and*

— *the associated time for 12 h.*

There shall *be means to retrieve the recorded information.* The information may be recorded and retrieved in the form of graphics or digital readouts at intervals of 1 min.

5.5 Accuracy

5.5.1 Accuracy of measurement

In accordance with IMO Resolution MSC.74(69), Annex 4, Article 5.2.1, *based on a sound speed in water of 1 500 m/s, the tolerance of the indicated depth* shall *be either:*

— *±0,5 m on the* shallow *range scale, respectively ±5 m on the* deep range *scale; or*

— *±2,5 % of the indicated depth,*

whichever is the greater.

NOTE These tolerances take no account of the ship's roll and pitch.

5.5.2 Discrimination

In accordance with IMO Resolution MSC.74(69), Annex 4, Article 5.2.2, *the scale of display* shall *not be smaller than 5,0 mm per metre depth on the shallow range scale and 0,5 mm per metre depth on the deep range scale.*

5.6 Malfunctions and alert and indications

5.6.1 General

The general presentation, handling and communication for alerts shall comply with the requirements stated in IMO Resolution MSC.302(87); IEC 62923-1:2018, Module A and Module C; and in IEC 62923-2, as a minimum.

The alerts with a standard alert identifier for echo-sounding equipment are specified in Table B.1.

NOTE 1 The alert title and alert description texts which are used in Table B.1 and in the body text of this document are not mandatory but are regarded as guidance. Alert titles and alert description texts used in the body text of this document are therefore indicated between double quotation marks (" ").

Manufacturers of echo-sounding equipment shall declare the EUT function type for BAM compliance test.

NOTE 2 According to the EUT function type, the relevant test set-up and test items are specified in BAM test standards. Refer to the following clauses in IEC 62923-1:2018: 4.2 (EUT function types); Clause 5 (Test methods); Clause 6 (Module A - Presentation and handling of alerts on the bridge) and Clause 8 (Module C – Interfacing).

All specific audible indication of echo-sounder equipment shall be described in the operational manual and shall be distinguishable from a BAM alert.

5.6.2 Depth alarm

In accordance with IMO Resolution MSC.74(69), Annex 4, Article 5.3.1, *an alarm signal — both visual and audible with* temporary silence *function,* in accordance with the requirements of IEC 62923-1 — shall *be provided when the water depth is below a preset value.* If the preset alert depth is not referenced to the transducer position, there shall be an indication of the reference position.

5.6.3 Failure or reduction in power supply ("power fail" alert)

In accordance with IMO Resolution MSC.74(69), Annex 4, Article 5.3.2, alert *signals, both visual and audible (with* temporary silence *function) to the navigator on the watch,* shall *be provided to indicate failure or a reduction in the power supply to the echo sounder which would affect the safe operation of the equipment.*

When the echo-sounding equipment is able to detect failure or reduction in power supply and thus remains in operation after failure of one power supply due to the presence of another power supply (e.g. internal UPS), it shall, upon failure of power supply, activate a "power fail" alert of the priority caution, as specified in Table B.1.

In case of total power failure to the echo-sounding equipment, it shall provide a status signal (for instance, by normally closed contact) to enable external equipment to raise the appropriate alert.

This connection with external equipment shall be clearly described in the operator's manual or installation manual.

5.6.4 System failure

An alert, both visual and audible with temporary silence function, shall be provided in order to indicate any malfunction of the echo-sounding equipment which would affect the normal operation of the equipment.

The echo-sounding equipment shall provide the system failure alert ("Fault") with an appropriate priority and description as specified in Table B.1.

Where the echo-sounding equipment has a stand-by mode, this alert does not provide during a stand-by mode.

The echo-sounding equipment shall be fully operation from standby mode with a single action.

5.7 Ergonomic criteria

5.7.1 Operational controls

In accordance with IMO Resolution MSC.74(69), Annex 4, Article 6.1, *the function of range scale selection* shall *be directly accessible*. Other functions shall be directly accessible and immediately effected by dedicated controls or primary access in an associated menu.

The settings for the following functions shall *be recognizable in all light conditions:*

— *range scale; and*

— *preset depth alarm.*

5.7.2 Presentation of information

5.7.2.1 Marks

In accordance with IMO Resolution MSC.74(69), Annex 4, Article 6.2.1, *the graphical display* shall *be capable of showing:*

— *depth marks at intervals not larger than one-tenth of the range/scale in use; and*

— *time marks at intervals not exceeding 5 min.*

5.7.2.2 Paper recording

In accordance with IMO Resolution MSC.74(69), Annex 4, Article 6.2.2, *if paper is used for recording either by marks on the recording paper or by other means, there* shall *be a clear indication when the paper remaining is less than 1 m.*

5.8 Design and installation

In accordance with IMO Resolution MSC.74(69), Annex 4, Article 7, *the equipment* shall *comply with IMO resolution A.694(17).*

5.9 Interfacing

In accordance with IMO Resolution MSC.74(69), Annex 4, Article 8, *output(s)* shall *be available from which depth information may be supplied to other equipment such as remote digital displays, voyage data recorder and a track control system.*

These outputs shall include depth under keel, the depth scale currently being displayed, the transducer in use in multiple installations and other status information where available.

These outputs shall *be digital, serial communication, facilities which* shall *comply with the relevant International Standards* (such as IEC 61162).

Interfaces required in this document shall meet the requirements prescribed in IEC 61162-1, IEC 61162-2 or IEC 61162-450.

6 Methods of testing and required test results

6.1 General

Any requirement in Clause 5, for which no test is specified in this clause or in IEC 60945, shall be checked by inspection of the equipment, the manufacturer's drawing or the relevant documents. The results of the inspection shall be stated in the test report.

Confirm by inspection of documented evidence that the EUT complies with IEC 62288.

6.2 General conditions of measurement

All the general requirements of IEC 60945 shall be carried out before tests to verify whether the equipment under test (EUT) meets these technical requirements. The equipment shall comply with those requirements of IEC 60945 appropriate to its category, that is "protected" (from the weather), "exposed" (to the weather), or "submerged" (in continuous contact with sea water).

The manufacturer shall declare which equipment or units are "protected", "exposed" or "submerged". The manufacturer shall declare the "pre-conditioning" required before environmental checks.

Where pre-conditioning is called for, it is the first process in the test procedure. It may be affected by subjecting the specimen to climatic, electrical, or any other conditions required by the relevant specification. This enables the properties of the specimen to be stabilized before measurements and test.

6.3 General underwater test conditions

The equipment transducer in its housing, complete with acoustic window if provided, shall be attached underwater to a clamp calibrated in degrees. This enables the transducer to be rotated to any required angle about the major axis of the face of its element (i.e. about the longer axis, which will run parallel to the ship fore-and-aft line) and about the minor axis (the athwartships axis) where the element is rectangular or elliptical, or about any facial axis where the element is circular.

A calibrated hydrophone, which can be replaced by a calibrated projector (or, alternatively, a single instrument capable of being used in either role as required), shall be mounted under the water at a suitable known distance, *d*, from the transducer and directed towards it. Initially, the transducer shall be directed towards the calibrated hydrophone.

NOTE See IEC 60500 and IEC 60565-1.

Formula (1) shows that, in order to minimize near-field effects, distance, *d*, in metres, shall not be less than

$$1{,}25a^2 f / c \tag{1}$$

where

- a is the largest active dimension of the transducer element, in metres, appropriate to the mode of use, that is transmission or reception (usually the same figure for either);
- f is the highest operation frequency of the echo-sounding equipment, in hertz;
- c is the speed of sound in water, equal to 1 500 m/s, according to IMO Resolution MSC.74(69), Annex 4, Article 4.

Precautions shall be taken to minimize the effects of reverberation in the water. These precautions shall include the use of gated pulse measurement techniques. These techniques are essential in the case of some echo-sounding equipment receivers that operate in a nonlinear mode.

6.4 Functionality

6.4.1 Range performance

6.4.1.1 Minimum depth test method

NOTE See 5.2.1.

The transducer in its housing, complete with an acoustic window if provided, shall be immersed in water with its axis of maximum response directed towards a test target, such as the bottom or side of the tank holding the water. It shall be possible to adjust the physical distance between the transducer and the target.

The test shall be conducted such that no other object or discontinuity shall be capable of affecting the result significantly.

The equipment shall be set to the shallow scale with the longest pulse length available on that scale, and the physical distance between the transducer and the test target shall be adjusted until the echo from the target is displayed separately and distinctly. This physical distance shall be measured and noted as the minimum depth indication.

6.4.1.2 Result required

The minimum depth shall not be greater than 2 m.

6.4.1.3 Maximum required measurable depth detection using the figure of merit system

The equipment shall be tested by the assessment, under laboratory conditions, of the system figure of merit, for a water depth of 200 m.

The figure of merit, L', expressed in decibels, is defined in Formula (2) as:

$$L' = S - 2r + D - B - E \tag{2}$$

and shall exceed L_0 as indicated by the following relationship in Formula (3):

$$L_0 = L + 2\alpha R + K + N + x + y + z \tag{3}$$

where

S is the source level, in decibels relative to 1 µPa at 1 m;

R is the one-way loss figure due to roll and pitch, in decibels;

D is the receiving directivity index, in decibels;

B is the receiving bandwidth, in decibels relative to 1 Hz;

E is the minimum detectable signal-to-noise ratio, in decibels;

L is the spreading loss due to divergence, equal to 20 lg(2 000R);

R is the depth, in kilometres;

α is the sound absorption coefficient of sea water in decibels per kilometre (see Annex A): combining R and α gives $2\alpha R$, as the total water attenuation loss, in decibels;

K is the bottom reflection loss at normal incidence and is taken to be 25 dB;

N is the background noise level, in decibels relative to 1 µPa in a 1 Hz bandwidth, equal to 82,5 – (50/3) lg$f$, f in kHz ;

x is the transmission loss in the case when the transducer is mounted inside the hull, in decibels;

y is a signal excess of 10 dB above the minimum detectable signal-to-noise ratio to provide a practical working level under all conditions;

z is a manufacturing tolerance of 3 dB.

The value of $L' = S - 2r + D - B - E$ shall be calculated and shall exceed the value of L_0 calculated for the appropriate operating frequency, a depth R of 200 m and the value of x declared by the manufacturer.

6.4.1.4 Test methods

6.4.1.4.1 Source level, S

Immerse the transducer in water with its principal axis directed towards a calibrated hydrophone and lead (also immersed in the water) and situated at a known distance, d, in metres, in the far sound field from the transducer. Switch on the equipment.

The source level, S, is given by Formula (4):

$$S = (V + 120) - M + 20 \lg d \tag{4}$$

where

M is the known response of the hydrophone and lead, in decibels relative to 1 µV/µPa;

V is the root mean square output voltage of the hydrophone and lead, in decibels relative to 1 V, measured during the pulse and averaged over its duration.

6.4.1.4.2 Roll and pitch, *r*

This test may be waived where suitable transducer beam direction stabilization is provided and can be demonstrated. Otherwise, the one-way loss figure described below shall be determined to allow for the roll and pitch criteria specified in 5.2.6. The one-way loss figure, *r*, shall be the greatest reduction in response obtained when the source level measurement in 6.4.1.4.1 is repeated with the transducer element rotated by up to ±10° about its roll axis and at the same time by up to ±5° about its pitch axis.

6.4.1.4.3 Receiving directivity index, *D*

This test may be carried out, at the discretion of the type test authority, with the transducer used in the transmitting mode as in 6.4.1.1 and 6.4.1.4.1 but, whenever practicable, the receiving mode described as follows shall be used.

The transmitter shall be disabled, but the trigger shall be available for external use. With the transducer and a test projector directed towards each other and the projector energized from a suitable pulsed signal source, the output voltage of the receiver of the echo-sounding equipment shall be monitored.

The pulse from the pulsed signal source shall be triggered by the echo-sounding equipment and delayed suitably to correspond with a definite depth within the scale. This pulse shall simulate the pulse normally transmitted by the equipment with regard to duration. The carrier frequency shall be adjusted to give maximum response on the echo-sounding equipment.

Using the method of maintaining constant receiver output voltage by varying the signal source voltage suitably, a pattern shall be plotted of transducer response against positive and negative angles of rotation of the transducer about each of its appropriate axes. This is done in order to find the angular beam width θ in degrees, between the two points giving a level 3 dB below maximum response.

The receiving directivity index D shall be calculated using Formulae (5) and (6):

a) for circular transducers,

$$D = 45{,}5 - 20 \lg \theta, \tag{5}$$

b) for rectangular or elliptical transducers,

$$\mathrm{D} = 45{,}5 - 10 \lg(\theta_1) - 10 \lg(\theta_2), \tag{6}$$

where θ_1 and θ_2 are the 3 dB beamwidths about the major and minor axes measured as specified above.

The type test authority shall take due note of the suitability of this method of calculating D from the measured beam patterns in the light of the patterns found. As a guide, the above method of calculating D is suitable, provided that no narrow side lobe exceeds a level of 8 dB below the maximum of the main lobe. Extended side lobes, even at a much lower level, may render this method unsuitable.

6.4.1.4.4 Receiving bandwidth, B

The equipment shall be set up on the deep range with the transducer in water and with its principal axis directed towards a calibrated projector fed by a continuous wave signal source. The transmitter of the equipment shall be disabled, but not the transmitting trigger pulse where this is required to initiate the display trace.

The carrier frequency of the signal source shall be varied, and the level suitably adjusted and noted, and weighted by reference to the frequency calibration of the projector, in order to plot the frequency response of the equipment receiving system by the method of maintaining constant receiver output level. From the results, the upper and lower frequencies, f_1 and f_2 respectively, in hertz, shall be found where the receiver response is 3 dB below maximum, as shown in Formula (7):

$$B = 10 \lg (f_1 - f_2). \tag{7}$$

6.4.1.4.5 Minimum detectable signal-to-noise ratio, E

The transmitter shall be disabled while the trigger shall be available for external use. However, the test projector is not required, and the transducer is not required to be immersed in water.

A continuous random noise voltage, of bandwidth equal to the bandwidth of the equipment receiving system and at a level well below saturation, shall be added to a simulated echo pulse of variable amplitude. This shall be triggered from the equipment delayed suitably to correspond with a definite depth within the shallow range scale. The combined signal shall be applied from a low-impedance source in series with the transducer. The level of the echo shall be adjusted to give a minimum detectable signal on the display of the equipment. E is then the ratio of the root mean square (rms) voltage of the echo pulse to the rms noise voltage.

6.4.2 Receiver sensitivity

6.4.2.1 Test method

Apply a simulated transmission pulse through the water at the transmission frequency while the equipment is set to receive only, giving a pressure level at the face of the transducer of the equipment of 10 dB less than the value of ($S - 2r - 2\alpha R - L - K - x$). Observe the effect at the display, and measure and record the pulse amplitude at the input terminals of the equipment for use in the test specified in 6.4.3.3.

6.4.2.2 Result required

An indication shall appear on the display at the appropriate depth.

6.4.3 Performance checks

6.4.3.1 General

The following performance checks shall be carried out under normal conditions at room temperature. The results shall be recorded and retained for comparison with the results obtained from similar checks carried out when the equipment is being subjected to tests required by the relevant clauses in IEC 60945.

6.4.3.2 Transmitter

6.4.3.2.1 Test method

Measure the value of each of the following parameters for the deep range scale:

a) transmission frequency;

b) transmission rms voltage during the pulse.

Feed the output of the transmitter through the normal cable to the transducer, either in air or immersed in water, at the discretion of the type test authority, in consultation with the manufacturer.

6.4.3.2.2 Result required

The transmitter frequency shall fall within the receiver pass band by a margin sufficient to accommodate the pulse spectrum defined by the reciprocal of the pulse duration.

During the tests specified in IEC 60945, any decrease in the transmission rms voltage below that recorded in 6.4.3.2.1 under normal conditions shall not cause the figure of merit to fall below its required value.

6.4.3.3 Receiver

6.4.3.3.1 Test method

The transmitter (but not the internal trigger) shall be disabled. A simulated signal pulse of amplitude equal to that recorded in 6.4.2.1, delayed to correspond to a depth of approximately 200 m, shall be injected in series with the transducer. This test shall be repeated during each relevant test in IEC 60945.

6.4.3.3.2 Result required

An indication shall appear on the display at the appropriate depth.

6.4.3.4 Transducer

6.4.3.4.1 Test method

The output of the transmitter shall be fed through the normal cable to the transducer. The transducer shall be either in air or immersed in water, as agreed by the type test authority and the manufacturer. The arrangement agreed shall be used for all transducer performance checks. With the equipment operating, the transducer shall be directed at a suitable target. This test shall be repeated immediately after each relevant test in IEC 60945.

6.4.3.4.2 Result required

Confirm by observation that an indication of the EUT appears on the display related to the distance separating the transducer and the target.

6.4.4 Range scales

Confirm by observation that the EUT complies with the range scale requirements in 5.2.2.

6.4.5 Main display

The main display requirements laid down in 5.2.3 shall be checked by inspection.

6.4.6 Other display

The other display requirements laid down in 5.2.4 shall be checked by inspection.

6.4.7 Pulse repetition rate

6.4.7.1 Test method

NOTE See 5.2.5.

The transmitter pulse repetition rate shall be averaged over not less than 1 min on the deep range. The same process shall be repeated on the shallow range.

6.4.7.2 Result required

The pulse repetition rate shall not be less than 12 pulses per minute on the deep range and not less than 36 pulses on the shallow range.

6.4.8 Roll and pitch

NOTE See 5.2.6.

This shall be determined by measurement of the transducer beam widths in the ship's fore-aft line and athwartships. Alternatively, compliance with the requirements of 5.2.6 may be demonstrated by tilting the transducer first in the fore-aft axis and then in the port-starboard axis at sea or in the tank, wherever is considered appropriate.

6.5 Multiple installation

The multiple installation requirements laid down in 5.3 shall be checked by inspection.

6.6 Data storage

6.6.1 Method of test

The data storage requirements laid down in 5.4 shall be checked by inspection for the recording means. The means to retrieve recorded information shall be checked by inspection. If the equipment is provided with a built-in storage media, the performance shall be tested as an entity. If the EUT uses external means, such as ECDIS, radar or other displays, the applicant shall supply an entity and demonstrate the instrument is compliant with the requirements of 5.4 and 5.7.2.

6.6.2 Required result

Water depths shall be recorded on the paper with depth and time marks as specified in 5.7.2.1 for the duration of 12 h. Where other means are used, this information shall be recorded at intervals of 1 min or less, for the duration of 12 h and shall be retrievable.

6.7 Accuracy

6.7.1 Method of test

NOTE See 5.5.

With the equipment set up normally, a signal pulse, whose delay from the trigger pulse of the equipment can be controlled to an accuracy of ±100 µs or better, shall be fed into the receiver. It shall be adjusted to represent echoes at intervals of 1 m on the shallow range scale and 10 m on the deep range scale, by

progressing in increments of 4/3 ms and 40/3 ms, respectively. Suitable intervals of not less than 1 m (4/3 ms) shall be used on other scales.

The apparent depth of the leading edge of each pulse shall be read off the scale.

6.7.2 Required result

The difference between the simulated depth being fed into the receiver and the reading of the display shall not exceed:

a) ±0,5 m on the shallow range scale, and ±5 m on the deep range scale; or

b) ±2,5 % of the indicated depth,

whichever is the greater.

6.7.3 Discrimination

The discrimination requirements laid down in 5.5.2 shall be checked by inspection.

6.8 Malfunctions, alert and indications

6.8.1 General

NOTE See 5.6.

Confirm by inspection of the manufacturer's document that the EUT complies with IEC 62923-1:2018, Module A and Module C, and with IEC 62923-2.

All tests shall be performed in accordance with IEC 62923-1:2018, Module A and Module C, while taking into account the alert identifiers specified in IEC 62923-2.

6.8.2, 6.8.3 and 6.8.4 specify the tests for the alerts with a standard identifier specified in Table B.1.

Confirm by inspection that a specific audible indication is sufficiently described in the operation manual and is distinguishable from a BAM alert.

Alerts and indications for this inspection may be generated by the EUT based on suitable dummy signals that are enabled for these tests according to manufacturer's documentation.

6.8.2 Depth alarm

6.8.2.1 Method of test

Refer to the manufacturer's documentation on how the EUT detects a depth alert.

See Figure 1.

In addition, an example of a test procedure is as follows:

a) Set a range scale of display to 20 m.

b) Set a value of depth alarm to 10 m.

c) Input a dummy signal representing a depth 15 m from the outside, and gradually make the depth shallower.

d) When the detected water depth is below the pre-set alert-set value, confirm that the alarm is generated.

e) Where the echo-sounder equipment has a function to set the offset value from the transducer position to the waterline and/or the keel, it is also confirmed by observation the offset value works correctly.

NOTE The offset value is defined in IEC 61162-1. Positive offset numbers provide the distance from the transducer to the waterline. Negative offset numbers provide the distance from the transducer to the part of the keel of interest.

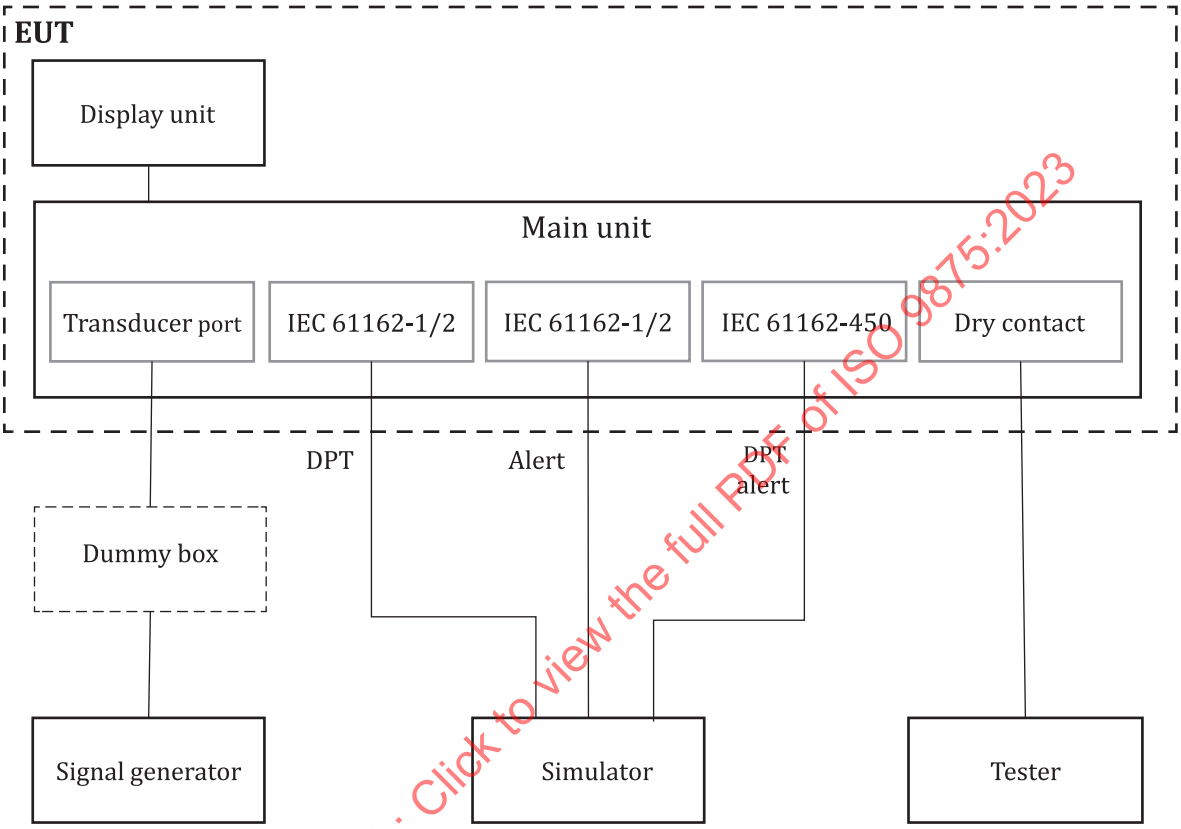

Figure 1 — Example of EUT and test configuration

6.8.2.2 Required results

Confirm by observation that the EUT presents "Depth unsafe" and output alert message to CAM-HMI as required in 5.6.2 and as specified in Table B.1.

The behaviour of the alarm shall comply with the applicable requirement in IEC 62923-1 and IEC 62923-2.

When the offset value is applied to the EUT, confirm by observation that the offset value works correctly and the indication the reference point of depth value.

6.8.3 Failure or reduction in power supply

6.8.3.1 General

Refer to the manufacturer's documentation on how the EUT detects failure or reduction of power supply.

6.8.3.2 Method of test

When the EUT has multiple power supplies, disconnect one power supply of the EUT.

Disconnect the power supply of the EUT.

6.8.3.3 Required results

a) In case the EUT remains under operation after disconnecting the power supply, confirm by observation the following results:

   1) the relay output is active;

   2) the EUT activates "power system fail" and output alert message as required in 5.6.3 and as specified in Table B.1;

   The behaviour of the warning shall comply with IEC 62923-1 and IEC 62923-2 applicable requirement.

b) In case the EUT blacks out after disconnecting the power supply, confirm by observation that the relay output is active.

6.8.4 System failure

6.8.4.1 General

Refer to the manufacturer's documentation on how the EUT detects system failure.

6.8.4.2 Method of test

System failures conditions are generated by a dummy signal enabled by the manufacturer.

6.8.4.3 Required results

The EUT activates "ES Fault" alert with an appropriate priority and an output alert message as required in 5.6.4 and as specified in Table B.1.

Where the EUT is stand-by mode, an alert shall not be activated.

The behaviour of the warning and caution shall comply with the applicable requirement specified in IEC 62923-1 and IEC 62923-2.

6.9 Ergonomic criteria

6.9.1 Operational controls

The requirements laid down in 5.7.1 shall be checked by inspection.

6.9.2 Presentation of information

6.9.2.1 Marks

The requirements laid down in 5.7.2.1 shall be checked by inspection.

6.9.2.2 Paper end mark

The requirements laid down in 5.7.2.2 shall be checked by inspection.

6.10 Design and installation (test of environment and interference)

NOTE See 5.8.

The equipment shall be tested in accordance with IEC 60945.

6.11 Interfacing

NOTE See 5.9 and Annex C.

Confirm by inspection of the manufacturer's documents that depth data are available under a formatter of DPT in IEC 61162-1. If other data are provided additionally in another format, the manufacturer shall clarify them.

Confirm by inspection of documented evidence that the EUT complies with IEC 62923-1:2018, Module A and Module C, and with IEC 62923-2.

The IEC 61162-1 sentences for transmitting and receiving data for the echo-sounding equipment shall be as specified in Annex C.

Annex A
(informative)

Sound absorption coefficient

This annex is a description of the sound absorption coefficient used in 6.4.1.3.

a) The value of the sound absorption coefficient, α, in decibels per kilometre, for sea water is given by the Formula (A.1):

$$\alpha = \frac{A_1 P_1 f_1 f^2}{f^2 + f_1^2} + \frac{A_2 P_2 f_2 f^2}{f^2 + f_2^2} + A_3 P_3 f^2 \tag{A.1}$$

for frequency, f, in kilohertz, and where coefficients $A_1, A_2, A_3, P_1, P_2, P_3, f_1$, and f_2 are each functions of a sub-set of the parameters, water temperature, salinity, pH value and depth. The three expressions in the formula give, respectively, the contributions due to boric acid, magnesium sulfate and pure water. These are widely accepted as being the only three contributions to absorption which shall be considered, as the only other contribution identified by researchers is insignificant by comparison.

b) Two articles (see References [9] and [10]) are the basis for the determination of expressions for the coefficients $A_1, A_2, A_3, P_1, P_2, P_3, f_1$, and f_2. They are quoted in Formulae (A.1) to (A.10) and are used to calculate the values of α given in Table A.2 and Table A.3.

$$A_1 = \frac{8{,}86}{c} \times 10^{(0{,}78\mathrm{pH}-5)} \tag{A.2}$$

$$A_2 = 21{,}44 \times \frac{s}{c} \times (1 + 0{,}025T) \tag{A.3}$$

For $T \leq 20$ °C:

$$A_3 = 4{,}937 \times 10^{-4} - 2{,}59 \times 10^{-5} T + 9{,}11 \times 10^{-7} T^2 - 1{,}5 \times 10^{-8} T^3 \tag{A.4}$$

For $T > 20$ °C:

$$A_3 = 3{,}964 \times 10^{-4} - 1{,}146 \times 10^{-5} T + 1{,}45 \times 10^{-7} T^2 - 6{,}5 \times 10^{-8} T^3 \tag{A.5}$$

$$P_1 = 1 \tag{A.6}$$

$$P_2 = 1 - 1{,}37 \times 10^{-4} D + 6{,}2 \times 10^{-9} D^2 \tag{A.7}$$

$$P_3 = 1 - 3{,}83 \times 10^{-5} D + 4{,}9 \times 10^{-10} D^2 \tag{A.8}$$

$$f_1 = 2{,}8 \times \left(\frac{s}{35}\right)^{0{,}5} \times 10^{(4-1\,245/\theta)} \tag{A.9}$$

$$f_2 = \frac{8{,}17 \times 10^{(8-1\,990/\theta)}}{1 + 0{,}001\,8 \times (s - 35)} \tag{A.10}$$

where

A_1 is the coefficient, expressed in dB × km^{-1} × kHz^{-1};

A_2, A_3 are the coefficients, expressed in dB × km^{-1} × kHz^{-2};

f_1, f_2 are the coefficients, expressed in kHz;

c = 1 412 + 3,21T + 1,19s + 0,016 7D, equal to the speed of sound in metres per second;

T is the temperature, in degrees Celsius;

θ = 273 + T, in kelvins;

s is the salinity, in milligrams per gram;

D is the depth, in metres.

c) Consideration is given to the need for echo-sounding equipment, which is intended to meet the IMO requirements to operate satisfactorily worldwide. Accordingly, for each frequency, values of α are calculated for several sea areas used by a significant number of merchant ships and in which water depths of at least 400 m exist. Specifically, these areas are:

1) Pacific Ocean near Japan (south of Tokyo);
2) Pacific Ocean near the northwest coast of the USA;
3) Atlantic Ocean near the east coast of the USA;
4) Atlantic Ocean south of Newfoundland;
5) Indian Ocean south of India;
6) Western approaches to the English Channel;
7) Gulf of Mexico;
8) Red Sea.

d) The data on the relevant parameters (water temperature, salinity and pH value) are obtained from the library of the Marine Information and Advisory Service (MIAS) of the Institute of Oceanographic Sciences. MIAS is the British Oceanographic Data Centre of the Inter-governmental Oceanographic Commission of UNESCO and obtains the data from participating countries which have made measurements of the parameters.

e) For areas where the values of any of the parameters are found to vary significantly throughout the year (this applied particularly to water temperature), more than one calculation of the value of α is made to allow for such seasonal changes. During initial investigations, it is found that variation of the value of pH has an insignificant effect on the value of α. It is therefore treated as a constant with a value of 8.

f) Investigation of the salinity of the sea worldwide indicates that the Red Sea (area 8) in c) above) is an isolated case. In the Red Sea, the salinity tends to be greater than 40 mg/g, while in coastal areas of the rest of the world, it is generally between 30 mg/g and 36,5 mg/g. It is considered that this, coupled with the high-water temperature in the Red Sea, placed a requirement more stringent than is strictly necessary on echo-sounding equipment operating at frequencies higher than 100 kHz. Accordingly, the values of α calculated for the Red Sea are excluded from further consideration.

g) For the other seven areas listed in c) above, a total of 22 calculations are made at each of the 24 frequencies (10 kHz to 240 kHz in steps of 10 kHz). In these calculations, account is taken of the variation of water temperature and salinity with depth.

h) Recognizing that the seven areas considered may well not have produced the maximum value of α that would otherwise result from a fully comprehensive worldwide study, the maximum value of α calculated for each operating frequency is used for calculation of the corresponding figure of merit.

i) Table A.1 gives, for the seven areas [indicated in c) above], the temperature and salinity values versus depth, which provide the values of α quoted in Table A.2. The maximum value calculated (for each operating frequency) is underlined in Table A.2. These values are listed in Table A.3. The other 15 sets of data used in the calculations produce, for all operating frequencies, values of α less than those listed in Table A.3.

Table A.1 — Temperature and salinity values versus depth for the seven areas

Depth	Area 1		Area 2		Area 3		Area 4		Area 5		Area 6		Area 7	
	Temperature	Salinity	Temperature	Salinity	Temperature	Salinity	Temperature	Salinity	Temperature	Salinity	Temperature	Salinity	Temperature	Salinity
m	°C	mg/g	°C	mg/g	°C	mg/g	°C	mg/g	°C	mg/g	°C	mg/g	°C	mg/g
0	– 1,4	32,86	5,7	35,5	14,2	35,9	20,1	35,9	25,64	36,4	29,9	36,35	30,57	36,74
10	– 1,37	32,87	5,95		13,8		19,4		25,62	36,41	29,67	36,32	30,27	36,68
15			6			35,75		35,75						
20	– 1,36	32,9							25,53	36,41	29,67	36,31	30,3	36,58
30	– 1,37	32,9	6			35,7		35,7	25,55	36,42	29,31	36,33	29,47	36,36
50	– 1,35	32,95	6,8		11,4	35,95		35,95	25,31	36,46	28,69	36,36	28,42	36,33
70							15,4							
75	– 1,47	33,09							25,03	36,51	27,94	36,46	27,28	36,44
80					10,6	36		36						
100	– 1,54	33,52	6,8		10,2	36		36	24,85	36,6	26,82	36,62	26,5	36,52
125	– 1,27	33,67							24,27	36,69	25,51	36,79	25,74	36,6
150	– 1,26	34,28	7,8						23,68	36,77	23,99	36,86	25,17	36,76
180						35,9		35,9						
200	1,38	34,63							21,91	36,81	21,21	36,78	22,56	36,8
250	3,5	34,56							20,08	36,7	19,62	36,69	20,47	36,63
300	3,69	34,43			9,9	35,9		35,9	18,45	36,53	18,74	36,57	17,99	36,46
320							12,5							
325			7,8											
400	3,69	34,43	8,6		9,4	35,7	11,9	35,7	16,58	36,26	16,58	36,26	15,27	36,01
600				35,45										
NOTE The seven areas in this table are defined in c) above.														

Table A.2 — Values of sound absorption coefficient

Frequency	Sound absorption coefficient dB/km						
KHz	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7
10	1,3 [a]	1,02	0,95	0,85	0,72	0,71	0,71
20	4,14 [a]	3,55	3,3	2,93	2,37	2,31	2,31
30	7,48 [a]	7,14	6,77	6,12	4,99	4,87	4,85
40	10,7	11,2 [a]	10,9	10,1	8,46	8,26	8,22
50	13,6	15,2	15,3 [a]	14,5	12,6	12,3	12,3
60	16,1	19	19,5 [a]	19,2	17,3	16,9	16,8
70	18,3	22,5	23,6	23,8 [a]	22,3	21,8	21,7
80	20,2	25,5	27,3	28,2 [a]	27,4	26,9	26,8
90	21,9	28,3	30,7	32,4	32,7 [a]	32,1	31,9
100	23,5	30,7	33,7	36,3	37,9 [a]	37,4	37,2
110	25,1	32,9	36,5	40	43 [a]	42,5	42,3
120	26,7	35	39,1	43,3	48 [a]	47,6	47,3
130	28,2	36,9	41,4	46,5	52,8 [a]	52,5	52,2
140	29,8	38,7	43,6	49,3	57,4 [a]	57,2	57
150	31,4	40,5	45,7	52,1	61,8 [a]	61,8 [a]	61,6
160	33,1	42,2	47,6	54,6	66	66,1 [a]	65,9
170	34,8	43,9	49,5	57	70	70,3 [a]	70,2
180	36,6	45,5	51,4	59,3	73,8	74,3 [a]	74,2
190	38,5	47,2	53,2	61,5	77,4	78,2 [a]	78,1
200	40,4	48,9	55	63,6	80,9	81,9 [a]	81,8
210	42,5	50,6	56,7	65,7	84,2	85,4 [a]	85,3
220	44,6	52,4	58,5	67,7	87,3	88,8 [a]	88,8 [a]
230	46,7	54,2	60,3	69,7	90,4	92	92,1 [a]
240	49	56	62,1	71,6	93,3	95,2	95,3

The values in this table are calculated from data in Table A.1.

[a] These values are calculated maximum values [see i) above].

j) When used in conjunction with the expressions for L and N and the values given for R, K, y and z in 6.4.1.3, the values of α given in Table A.3 produce the values for L_0, i.e. the figure of merit given in Table A.4.

k) The values in Table A.4 are plotted in Figure A.1. It is recommended that type test authorities use Figure A.1 for the determination of the required figure of merit for the echo-sounding equipment under test.

Table A.3 — Values of maximum sound absorption coefficient, α

Operating frequencies kHz	Maximum sound absorption coefficient dB/km
10	1,3
20	4,14
30	7,48
40	11,2
50	15,3
60	19,5
70	23,8
80	28,2
90	32,7
100	37,9
110	43
120	48
130	52,8
140	57,4
150	61,8
160	66,1
170	70,3
180	74,3
190	78,2
200	81,9
210	85,4
220	88,8
230	92,1
240	95,3