INTERNATIONAL STANDARD

ISO 22804

First edition
2023-08

Marine technology — General technical requirement of marine conductivity-temperature-depth (CTD) measuring instrument

Technologie maritime — Exigence technique générale de l'instrument de mesure de la conductivité, de la température et de la profondeur (CTP) en milieu marin

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Foreword

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This document was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 13, *Marine technology*.

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

Oceans are closely related to climate change and disasters, which directly affect human survival. In order to master the law of ocean change, it is necessary to obtain hydrologic information of ocean profile. The accuracy of this information depends on the temperature conductivity manometer used, often called a conductivity-temperature-depth (CTD) measuring instrument. CTD measuring instruments directly measure the temperature, conductivity and pressure of seawater. The information data of salinity, density and depth are derived and calculated according to the international equation of seawater state.

This document is specifically for CTD measuring instruments. Using the method of classification for CTD measuring instruments, this document defines the measurement technical indicators of CTD measuring instruments of different grades and the CTD measuring instrument's environmental adaptability requirements. It also defines the testing methods of CTD measuring technical indicators and of environmental adaptability. This document can be used to guide manufacturers in the development and testing of CTD measuring instruments, and to help CTD users select suitable CTD measuring instruments. At the time of publication, there are a variety of technical index grade CTD measuring instruments on the market. This document is divided into three levels according to the temperature, conductivity and pressure measurement performance of CTD measuring instruments, which is convenient for the selection of CTD measuring instruments and the promotion and application of this document.

In June 2009, a new Thermodynamic Equation of Seawater, referred to as TEOS-10, was adopted by the Intergovernmental Oceanographic Commission (IOC), and used to replace International Equation of State of Sea Water (EOS-80). At the time of publication, the calculation of derived values such as salinity is required to use EOS-80 or TEOS-10, which have no direct influence on the CTD measuring instrument. Compared with the practical salinity, S_p, of EOS-80, the absolute salinity, S_A, is proposed in TEOS-10 (see Reference [6] for the corresponding TEOS-10 calculation software code). The IOC recommends that the practical salinity, S_p, remain in the database to avoid possible confusion between different types of salinity. Therefore, this document recommends that CTD manufacturers support both EOS-80 and TEOS-10 algorithms in their accompanying user software.

Marine technology — General technical requirement of marine conductivity-temperature-depth (CTD) measuring instrument

1 Scope

This document specifies the technical requirements to ensure consistent reporting on the test method, inspection rules, marks, packaging, transportation and storage of conductivity-temperature-depth (CTD) profilers.

This document is applicable to marine fixed-point and mobile observation, monitoring platform and the various types of shipborne CTD measuring instruments.

NOTE   A CTD directly measures conductivity, temperature, pressure of seawater. Depth is the conversion of pressure according to the Formula (C.1).

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 60068-2-1, *Environmental testing — Part 2: Tests-Test A: Cold*

IEC 60068-2-2, *Environmental testing — Part 2-2: Tests-Test B: Dry heat*

IEC 60068-2-6, *Environmental testing — Part 2-6: Tests-Test Fc: Vibration (sinusoidal)*

IEC 60068-2-27, *Environmental testing — Part 2-27: Test-Test Ea and Guidance: Shock*

IEC 60068-2-30, *Environmental testing — Part 2-30: Tests-Test Db: Damp heat, cyclic (12 h+12 h cycle)*

IEC 60092-504, *Electrical installations in ships — Part 504: Automation, control and instrumentation*

ISO 21173, *Submersibles — Hydrostatic pressure test — Pressure hull and buoyancy materials*

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
conductivity-temperature-depth measuring instrument
CTD measuring instrument
electronic devices applied to automatically measure the conductivity, temperature and pressure of seawater

1

3.2
user software
software used to complete the special programs of measuring management, parameter calculation and data processing of *conductivity-temperature-depth measuring instruments* (3.1) by users

3.3
measurement unit
unit
real scalar quantity, defined and adopted by convention, with which any other quantity of the same kind can be compared to express the ratio of the two quantities as a number

[SOURCE: ISO 22013:2021, 3.6, modified — Notes to entry and the examples have been removed.]

3.4
accuracy
closeness of agreement between a measured quantity value (or test result) and a true quantity value of a measurand (or accepted reference value) in the stable experimental condition

EXAMPLE   Pressure accuracy = [*measurement error* (3.9) of pressure] / (the value of the difference between the upper and lower limits of pressure measurement) *100 %

3.5
resolution
capability of c*onductivity-temperature-depth measuring instrument* (3.1) to sense minimum temperature, conductivity and pressure changes

3.6
stability
duration which describes the property of a *conductivity-temperature-depth measuring instrument* (3.1), whereby its metrological properties remain constant in time

3.7
environmental adaptability
ability of a *conductivity-temperature-depth measuring instrument* (3.1) to maintain its performance and function without being damaged under the action of different environmental factors during its life cycle

3.8
full scale
FS
algebraic absolute value of the difference between the measured upper output value and the measured lower output value of the pressure sensor in a *conductivity-temperature-depth measuring instrument* (3.1)

3.9
measurement error
error between a *conductivity-temperature-depth measuring instrument* (3.1) and standard value (reference standard)

EXAMPLE   Temperature error, conductivity error and pressure error.

3.10
fiducial error
measuring instrument within the full range of the maximum absolute *measurement error* (3.9) and the ratio of the full scale value of the percentage

4 Technical specifications

4.1 General

This clause lists specifications and requirements for sensors during the development and production process.

4.2 Instrument appearance

4.2.1 Cosmetic requirements

The surface of a conductivity-temperature-depth (CTD) measuring instrument shall be free of wear and rust. At the same time, this instrument shall not have any apparent damage which can affect its testing performance.

Marine plankton and algae attached to the CTD during use shall be removed, as well as damaged sacrificial anodes to avoid affecting the water quality of the tank. At the same time, CTD shall not have leakage problem.

4.2.2 Product identification

The CTD measuring instrument shall have the following identification: name and model of instrument, manufacturer's name, production date and factory number. The spare parts and documents shall be complete. The CTD measuring instrument shall have the manufacturer's product certificate.

4.2.3 Instrument fastener

The fastener of the CTD measuring instrument shall not be loosened, and all parts of instrument shall be well sealed.

4.3 Measuring performance of instrument and product

The accuracy, resolution and stability of CTD measuring instrument shall meet the requirements of Table 1.

Table 1 — Measuring requirement of CTD measuring instrument

Measuring performance grade		First-level	Second-level	Third-level
Temperature (°C)	Accuracy	±0,003	±0,02	±0,1
	Stability	0,003/year	0,02/year	0,1 /year
	Resolution	0,001	0,006	0,03
Conductivity (mS/cm)	Accuracy	±0,005	±0,02	±0,1
	Stability	0,005/month	0,02/month	0,1/month
	Resolution	0,001	0,006	0,03
pressure[a] (MPa)	Accuracy	±0,05 %	±0,1 % FS	±0,5 % FS
	Stability	0,05 % FS/year	0,1 % FS/year	0,5 % FS/year
	Resolution	0,02 % FS	0,03 % FS	0,2 % FS
Key				
FS full scale				
[a] Pressure measurement performance of the CTD measuring instrument is described using fiducial error.				

4.4 Instrument and product environmental adaptability

According to the environmental conditions of the CTD measuring instrument, the specific environmental test items are determined. The CTD measuring instrument shall pass the corresponding environmental test.

4.5 Instrument and product interface and data format

The interface and data format of the CTD measuring instrument shall conform to the requirements of Table 2.

The general hardware communication software shall include the following functions:

a)   Query working status command

b)   Display instrument status command

c)   Set the date command

d)   Set the time command

e)   Set the measuring station position command

f)   Acquisition mode command

g)   Measurement start command

h)   Measurement end command

The data format is separated by comma-separated values (CSV). This format is used for the technical specifications of CTD measurement instruments to determine the measurement data byte length.

Table 2 — CTD measuring instrument interface and data format requirements

Test parameter	Length	Usage and meaning	unit
Temperature	8	-/+xx,xxx x	°C
Conductivity	8	-/+xx,xxx x	mS/cm
Pressure	9	-/+xx xxx,xx	dbar [a]
Data interface	RS232/RS485/USB		
[a] 1 dbar = 0,01 MPa = 10^4 Pa; 1 MPa = 1 N/mm^2.			

The plus or minus symbol shall be reserved. The plus sign is not displayed by default, and the minus sign shall be displayed.

EXAMPLE   When the temperature is +24,245 6 °C, it shows the format "24,245 6". When the temperature is −0,214 5 °C, it shows the format "−0,214 5".

5   Test methods

5.1   Test instrument and equipment

The standard instrument, standard material and special equipment shall be applied in the test. The resolution of the standard instrument shall be superior to the data from Table 1. The accuracy shall be three times higher than that specified in Table 1. The standard instruments and special equipment recommended by this document are shown in Table 3.

Table 3 — Recommended standard instruments and special equipment

Test parameter	Standard instrument	Accuracy	Special equipment	Test environment
Salt	Laboratory salinity meter	±0,002	Large isothermal salt tank	Environmental temperature: (20 ± 5) °C Relative humidity: (20–80) %
Salt	IAPSO Standard seawater	K15[a] ≥ 0,999	Large isothermal salt tank	Environmental temperature: (20 ± 5) °C Relative humidity: (20–80) %
Temperature	Platinum resistance thermometer	±0,001 °C	Large isothermal salt tank	Environmental temperature: (20 ± 5) °C Relative humidity: (20–80) %
Temperature	Bridge temperature measure system	±0,001 °C	Large isothermal salt tank	Environmental temperature: (20 ± 5) °C Relative humidity: (20–80) %
Pressure	Standard piston precision manometer	±0,005 % FS	Constant temperature laboratory	Environmental temperature: (20 ± 5) °C Relative humidity: (20–80) %

Key

FS full scale

[a]K15 = (Conductivity of standard seawater at 15 °C and 101 325 Pa)/ [Conductivity of KCl solution (32,4356 g/kg) at 15°C and 101 325 Pa].

5.2 Appearance inspection

CTD measuring instrument shall be checked by visual or manual method. The appearance of CTD measuring instrument shall conform to the requirement in 4.2.1.

5.3 Instrument and product interface and data format checking

The test process consists of connecting CTD measuring instrument to the computer and performing interface and data format checking. The test content is specified in 4.5.

5.4 Measurement performance test

5.4.1 Test requirements

The measurements of temperature and conductivity shall be carried out in a large isothermal seawater tank. The pressure test shall be conducted in a thermostatic laboratory. The tested CTD measuring instrument is fully immersed in a constant temperature seawater tank. The temperature and conductivity probes of the CTD measuring instrument shall be submerged more than 300 mm below the water surface. The standard platinum resistance thermometer and seawater sampling tube is inserted as close as possible to the detected sensor. The heat preservation cover of the thermostatic seawater tank is closed.

Follow the operation rule of this tank to control the temperature, i.e.:

— Ambient temperature: (20 ± 5) °C, the detection environment temperature for the pressure of first-level CTD measuring instrument is (20 ± 1) °C;

— Relative humidity: (20~80) %.

5.4.2 Selected test points

The selected test points of temperature, conductivity and pressure are shown in Table 4. The general temperature points are 0 °C, 5 °C, 10 °C, 15 °C, 20 °C, 25 °C, 30 °C and 35 °C.

Table 4 — Test points

Parameter	Test points	Remarks
Temperature	In the temperature measurement range, determine 6 or 8 test point with a roughly evenly distributed form	Cooling test
Conductivity	In the temperature measurement range, determine 6 or 8 test point with a roughly evenly distributed form	According to the reference of salinity 35, take the cooling test
Pressure	In the pressure measurement range, determine 6 or 8 test point with a roughly evenly distributed form	Take the process of rising pressure and lowering pressure

5.4.3 Test preparation

Temperature drop test is usually adopted in the test process (from 35 °C to 0 °C). The accuracy of conductivity test shall be carried out in the order of cooling. When the temperature and conductivity are measured, the seawater with salinity of about 35 is injected into a large isothermal seawater tank. The amount of seawater injected shall ensure that the probe of CTD measuring instrument is fully immersed. For the CTD measuring instrument without water pump, it shall wash the conductivity probe three or five times with seawater. Before the test, the temperature of seawater in the large isothermal tank shall be increased to about 35 °C, and this temperature shall remain constant.

5.4.4 Accuracy measurement of temperature and conductivity

5.4.4.1 Conditions of testing

Before testing, it shall be ensured that the temperature of the seawater thermostatic bath reaches the equilibrium state. The first temperature point with 35 °C is carried out. When the temperature of large isothermal seawater tank reaches the test temperature point, it is required to take the temperature control. When the temperature fluctuation is less or equal to 0,000 5 °C (1/6 for the temperature accuracy requirement), the temperature equilibrium state has arrived.

5.4.4.2 Conditions for recording test data

Recording and sampling at test process shall be carried out in a temperature equilibrium state. Take 10 sets of indication values from the temperature sensor and conductivity sensor within 3 minutes, which are considered as temperature and conductivity indications, respectively. At the same time, take 10 sets of indication values from platinum resistance thermometers, which are considered as the standard temperature value at the test point. Before taking the conductivity data, the brush shall be applied to the inductive conductivity probe three times. For the long electrode conductivity probe, the instrument shall also be cleaned. When taking the temperature standard value, the seawater shall be sampled. The inner wall and cap of the bottle is flushed with seawater in the tank two or three times. Two or three bottles of seawater sample are taken with the sampling tube.

The seawater in the sampling bottle shall not be too full. When the volume is about 3/4 full, the sampling bottle shall be sealed and numbered quickly. The seawater sample is measured by using the laboratory salinometer, and each sample shall take 10 sets of indication values. According to the formula provided by UNESCO No. 44,[3] the conductivity is calculated as a standard value of conductivity at the test point. See Annex A for examples of tables of data record.

Cooling test-move on the next test point. Repeat the measure approach specified in 5.4.4.1 and 5.4.4.2, until all the required points have been tested.

5.4.5 Temperature and conductivity accuracy test

5.4.5.1 Processing method of temperature accuracy test data

According to Formula (1), the temperature measurement error can be calculated as:

$$\Delta T_j = t_j - T_j \tag{1}$$

where

ΔT_j is the temperature measurement error of CTD measuring instrument at j point of the testing process;

t_j is the arithmetic mean of 10 sets of temperature indication values of CTD measuring instrument at j point of the testing process.;

T_j is the arithmetic mean of 10 sets of temperature standard values at j point of the testing process;

j are the 8 points in the testing process, j = 1, 2, 3, 4, 5, 6, 7, 8.

The ΔT_j is the temperature measurement error, whose maximum absolute value is considered as measurement accuracy. ΔT_j shall meet the requirements of temperature accuracy in Table 1.

5.4.5.2 Processing method of conductivity accuracy test data

According to Formula (2), the conductivity measurement error can be calculated as:

$$\Delta C_j = c_j - C_j \tag{2}$$

where

ΔC_j is the conductivity measurement error of CTD measuring instrument for at j point of the testing process;

c_j is the arithmetic mean of 10 sets of conductivity indication values of CTD instrument for at j point of the testing process;

C_j is the arithmetic mean of 10 sets of conductivity standard values for at j point of the testing process;

j are the 8 points in the testing process, j = 1, 2, 3, 4, 5, 6, 7, 8.

The ΔC_j is the conductivity measurement error, whose maximum absolute value is considered as measurement accuracy. ΔC_j shall meet the requirements of conductivity accuracy in Table 1.

5.4.6 Pressure accuracy test

5.4.6.1 Test method of pressure accuracy

The pressure sensor is connected to the standard piston precision pressure gauge. According to the test points in Table 4, from low pressure to high pressure, the pressure test is carried out. After that, the pressure test is taken from high pressure to low pressure. At each test point, the data of 10 sets from the standard piston pressure gauge and pressure sensor are taken, which are considered as pressure standard value and indication value from the CTD measuring instrument. See Annex A for examples of tables of data record.

5.4.6.2 Processing method of pressure test data

Formula (3) shows how to calculate the pressure measurement error:

$$\Delta P_j = p_j - P_j \tag{3}$$

$$P_{\text{err}} = \frac{\Delta P_j}{P_{\text{FS}}} \times 100\,\% \tag{4}$$

where

ΔP_j is the pressure measurement error of CTD measuring instrument at j point of the testing process.;

p_j is the arithmetic mean of 10 sets of pressure indication values of CTD measuring instrument No. j point of the testing process;

P_j is the arithmetic mean of 10 sets of pressure standard values No. j point of the testing process;

j are the 8 points in the testing process, $j = 1, 2, 3, 4, 5, 6, 7, 8$;

P_{err} is pressure's fiducial error;

P_{FS} is full scale pressure of the CTD measuring instrument.

The P_{err} is pressure's fiducial error, whose maximum absolute value is considered as measurement accuracy. P_{err} shall meet the requirements of pressure accuracy in Table 1.

5.4.7 Resolution test

The resolution of the CTD measuring instrument shall be tested at each test point. When the temperature of the large isothermal seawater tank is in equilibrium, it means that the temperature fluctuation is controlled at about 0,000 5 °C, and that the tests for resolution of conductivity and temperature are performed. Resolution tests for pressure are performed in a constant temperature and humidity laboratory using a ±0,005 % full scale rating of the manometer. The resolution value of conductivity, pressure and temperature sensors shall meet the requirements of 4.3.

5.4.8 Stability test

Refer to the accuracy test method for experiments, based on the conductivity monthly stability test requirements, with at least 30 days interval for a stability retest test. The repeated measurement shall last for more than one year. The annual stability of the temperature and pressure measurements of the sensors is calculated using a retest of the accuracy in the laboratory after one year. The monthly stability of conductivity is taken from the maximum error value of retesting accuracy in the laboratory every month after one year. The stability value of conductivity, temperature and pressure sensors shall meet the requirement of 4.3.

5.5 Environmental adaptability test

Table 5 shows the items of environmental adaptability test for CTD instrument, and the reference of standard and test conditions.

Table 5 — Environment test of CTD

Item	Requirement
Low temperature storage test	Low temperature storage environmental adaptability shall conform to the low temperature storage test specified in IEC 60068-2–1
High temperature storage test	High temperature storage environmental adaptability shall conform to the high temperature storage test specified in IEC 60068-2–2
Cyclic damp heat test	Cyclic damp heat environmental adaptability shall conform to the test conditions specified in IEC 60068-2–30
Impact test	The impact test shall conform to test conditions specified in IEC 60068-2–27
Vibration test	Vibration test shall conform to specified test conditions specified in IEC 60068-2–6

Table 5 *(continued)*

Item	Requirement
Inclinations and swings test	Inclinations and swings test shall conform to specified test conditions by IEC 60092-504: ±22,5°, 0,1 Hz, longitudinal includes front and back, horizontal includes left and right, duration of test not less than 15 min
Hydrostatic pressure test	Hydrostatic pressure test shall conform to specified test conditions by ISO 21173

Criterion rule: After performing the high temperature storage test and low temperature storage test, the CTD instrument shall have no scratches, abrasion, rust and obvious exfoliation. Fasteners and connectors shall not be loosened or damaged. The CTD instrument shall be able to realize the functions of measurement and communication after electrification. After performing the shock test, vibration test and hydrostatic pressure test, the CTD instrument shall have no scratches, abrasion, rust and obvious exfoliation.

6 Test requirements

6.1 Number of instruments to be tested

Every CTD instrument should be tested before it is delivered from the factory.

6.2 Test process

The tests specified in 5.2 to 5.5 shall be carried out, of which 5.5 shall be carried out only at the time of type test.

6.3 Qualification requirements

If one of the inspection items in the test is not qualified, the instrument will be judged to be unqualified.

6.4 Delivery requirements

Only after the instrument has passed the tests, it can be considered to be used.

6.5 Supporting documents

The instrument shall be accompanied by a test report, which shall be accurate and clearly give the results of test. It shall include:

a)   the name, model, number and fabrication unit;

b)   the reference of the technical document;

c)   the status description of the CTD instrument;

d)   the name of the standards measuring instrument and its measuring range;

e)   the technical specification, certificate number, validity period;

f)   the test time, place, environmental conditions.

7 Marking, packaging, transportation, storage

7.1 Marking

7.1.1 Nameplate mark

Each CTD instrument shall have a nameplate on its shell, and the nameplate logo shall include at least the following:

a) name and model;

b) principle parameters;

c) fabrication unit;

d) number and time.

7.1.2 Packing mark

The box surface of CTD instrument shall include at least the following:

a) name, model and quantity;

b) dimension: length, width, height (mm);

c) total mass (kg);

d) safety signs for transportation.

7.2 Packaging

7.2.1 Packaging requirements

The CTD instrument shall use a special packing box. This box shall be solid, reliable, cost-effective and tidy. At the same time, the internal structure shall have the function of strengthening and reducing vibration.

7.2.2 Supporting items

The following accessories and documents shall be attached to the CTD measuring instrument:

a) test reports;

b) user software CD/DVD;

c) usage manual;

d) packing list;

e) special tools and necessary spare parts;

f) technical documents.

7.3 Transportation

7.3.1 Means of transport

The packaged CTD measuring instrument shall be suitable for any transportation.

7.3.2 Transport requirement

During transportation, the CTD instrument shall be handled with care and sheltered from the dust and rain.

7.4 Storage

7.4.1 Storage environment

The CTD measuring instrument shall be stored in the temperature range of −20 °C to 40 °C. The indoor relative humidity is less than 95 %. There shall be no corrosive gas and dust in the surroundings, nor strong electromagnetic field and strong vibration. The instrument shall avoid the strong impact or collision. The instrument shall not stand upside down.

7.4.2 Storage requirements

When the temperature is below 0 °C, ensure that the probe of conductivity is dry and free of any moisture.

8 User software

8.1 General

The user software of CTD measuring instruments shall have the functions of measurement management, parameter calculation and data processing.

8.2 Measurement management

Measurement management shall include the following functions:

a) set working parameters and display instrument status;

b) play back the measurement data and edit the archive;

c) generate three types of files: table head files, initialization files and original data file.

The head files mainly include the information of station, time, location and instrument status.

The initialization files mainly include the information of calibration parameter.

The original data files mainly include all the measurement parameter and the time information corresponding to each measurement.

8.3 Parameter calculation

The parameter calculation shall perform the following functions:

a) convert the original data file to engineering volume files, which include the engineering digital quantity such as voltage and frequency, with the time or pressure coordinate;

b) convert the engineering volume files to a physical quantity document, which include the physical quantity such as conductivity, temperature and pressure with time or pressure coordinate;

c) convert the physical quantity document to derivative files, which include the derived quantities such as salinity, depth density and sound velocity with time or pressure coordinate.

8.4 Data processing

The data processing shall have the following functions:

a) eliminate the gross errors;

b) digital filtering;

c) average;

d) hysteresis correction;

e) eliminate the inverse pressure

NOTE   Inverse pressure is the situation where pressure data measured by CTD measuring instrument goes up and down repeatedly, under the condition of non-fixed platforms such as shipboard.

The data processing shall meet the following requirements:

f)   The measurement unit of parameter is determined as follows:

temperature –––––°C

conductivity–––––mS/cm

pressure–––––––dbar

g)   The formula is determined as:

The temperature values of the CTD measurement instrument are based on the 1990 International Standard for Practical Temperature (ITS-90).[8]

The Practical Salinity Scale of 1978 (PSS-78) shall be adopted for seawater practical salinity, S_p, calculation (see Annex B).

The depth of seawater is calculated by the formulae in Annex C.

The density of seawater is calculated with the Formula from EOS-80.[2]

h)   The conversion relation in the Formula is:

Pressure:

1 dbar = 0,01 MPa

Annex A
(informative)

Examples of record tables for CTD measuring instrument accuracy test data

The following table can be used when testing the accuracy of CTD measuring instruments, or the following record sheet can be modified to match the use requirements. Table A.1 shows an example of data tables used for conductivity sensor, Table A.2 shows an example of data tables used for temperature sensor and Table A.3 shows an example of data tables used for pressure sensor.

Table A.1 — Test data table for conductivity sensor

Name		Instrument serial number			Origin of instrument		
Salinometer		Type of salinometer					
Test points	Temperature of test points (°C)	Indication of conductivity sensor (mS/cm)	Mean value (x) (mS/cm)	Standard salinometer value (mS/cm)	Mean value (mS/cm)	Standard conductivity value (y) (mS/cm)	error (x-y) (mS/cm)
1							
.....							
X							
Recorder				Check		Time	

Table A.2 — Test data table for temperature sensor

Name			Instrument serial number		Origin of instrument	
Temperature measurement bridge			Type of temperature measurement bridge			
Test points	Temperature of test points (°C)	Indication of temperature sensor (°C)	Mean value (x) (°C)	Standard temperature value (°C)	Standard temperature mean value(y) (°C)	Error (x-y) (°C)
1						
......						
X						
Recorder		Check			Time	

Table A.3 — Test data table for pressure sensor

Name			Instrument serial number		Origin of instrument		
Pressure meter			Type of pressure meter				
Test points	Pressure of test points (MPa)	Indication of pressure sensor (MPa)	Mean value (x) (MPa)	Standard Pressure value (MPa)	Standard Pressure Mean value(y) (MPa)		Fiducial error (x-y)/FS*100 %
1							
.....							
X							
Recorder		Check			Time		

Annex B
(informative)

Calculation of practical salinity

The practical salinity, S_p, is calculated as shown in Formula (B.1):

$$S_p = \sum_{i=0}^{5} a_i R_t^{i/2} + \frac{t_{68} - 15}{1 + k(t - 15)} \sum_{i=0}^{5} b_i R_t^{i/2}$$ (B.1)

where,

S_p is the practical salinity based on IPTS-68[7];

a_i is the constant coefficient, i = 1, 2, 3, 4, 5;

a_0 0,008 0;

a_1 −0,169 2;

a_2 25,385 1;

a_3 14,094 1;

a_4 −7,026 1;

a_5 2,708 1;

k is constant coefficient, 0,016 2;

b_i is constant coefficient, i = 1, 2, 3, 4, 5;

b_0 0,000 5;

b_1 −0,005 6;

b_2 −0,006 6;

b_3 −0,037 5;

b_4 0,063 6;

b_5 −0,014 4;

t_{68} is the seawater temperature value in the field based on IPTS-68[7].

     Validity range: 2 < S_p < 42.

In the Formula (B.2), R_t is represented by:

$$R_t = \frac{R}{R_p \cdot r_t}$$ (B.2)

In the Formula (B.3), R is represented by:

$$R = \frac{C_{field}}{C_{std}}$$ (B.3)