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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

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 *conductivity-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) %
	IAPSO Standard seawater	K15[a] ≥ 0,999		
Temperature	Platinum resistance thermometer	±0,001 °C	Large isothermal salt tank	
	Bridge temperature measure system	±0,001 °C		
Pressure	Standard piston precision manometer	±0,005 % FS	Constant temperature laboratory	

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.