National Verification Regulation of Metrology of the People's Republic of China

JJG 763-2019

Conductivity-temperature-depth Measuring Instruments

温盐深测量仪

(English Translation)

Issue date: 2019-09-27 Implementation date: 2020-03-27

Issued by General Administration of Quality Supervision, Inspection and Quarantine

Verification Regulation of CTD Measuring Instruments

JJG763-2019
replaces
JJG763-2002

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Contents

Introduction

In comparison with version JJG763-2002, the changes in the technical part of this regulation (with the exception of editorial modifications) are mainly:

-- Added references (see 2).

-- Added terms and units of measurement (see 3).

-- Modifications to the principle, structure, usage and schematic diagram of the instrument (see 4).

-- Modifications to the metrological performance requirements of the instruments (see 5).

-- Modifications to the general technical requirements (see 6).

-- Modifications to the requirements and verification regulations of metrological standard instruments used for pressure verification (see 7).

-- Modifications to the verification record format (see Annex A).

-- Modifications to the inside information and format of the verification certificate/notice of verification results (see Annex B).

-- Refined reduction formula between salinity and conductivity (see Annex C).

-- Delete Annex B in the previous version.

The previous edition was:

-- JJG763-2002.

Verification Regulation of CTD Measuring Instruments

1 Scope

This regulation is applicable to the initial verification, subsequent verification and in-use inspection of conductivity-temperature-depth (CTD) measuring instruments.

2 References

This regulation references the following documents:

JJG875 verification regulation of digital pressure gauge

For dated references, only the edition cited applies. For an undated reference, the latest edition of the referenced document referred to (including any amendments) applies.

3 Terms and Units of Measurement

3.1 Terms

3.1.1 CTD measuring instrument

An instrument that automatically measures the temperature, conductivity (or salinity) and depth of seawater.

3.1.2 Conductivity of seawater

The physical quantity of seawater electrical conductivity, defined as the conductivity of seawater with a length of 1 m and a cross-sectional area of 1 m^2, related to seawater salinity, temperature, pressure and other factors.

3.2 Units of measurement

Temperature unit: Celsius degree (℃);

Conductivity unit: siemens per meter (S/m); millisiemens per centimeter (mS/cm); and

Pressure unit: Pascal (Pa).

4 Overview

CTD is mainly used for the field measurement of seawater temperature, conductivity (salinity) and depth. It is divided into self-contained and direct-

reading types according to the different forms of recording. Self-contained CTD is equipped with storage and an independent power supply; its data can be read in the laboratory after measurement; and it is normally applied in long-term use in shallow coastal areas. Underwater, direct-reading CTD is not provided with storage and an independent power supply: the power is supplied through an armored cable from the water units on the deck. The parameters measured by an underwater vehicle are transmitted to the water vehicle for display and recording in real time, and they are often combined with a multi-channel sampler for rapid profile measurement. It is mainly applied for short-term use at every site of marine research activity.

The appearance and structure of self-contained and direct-reading CTD are basically the same (Figure 1).

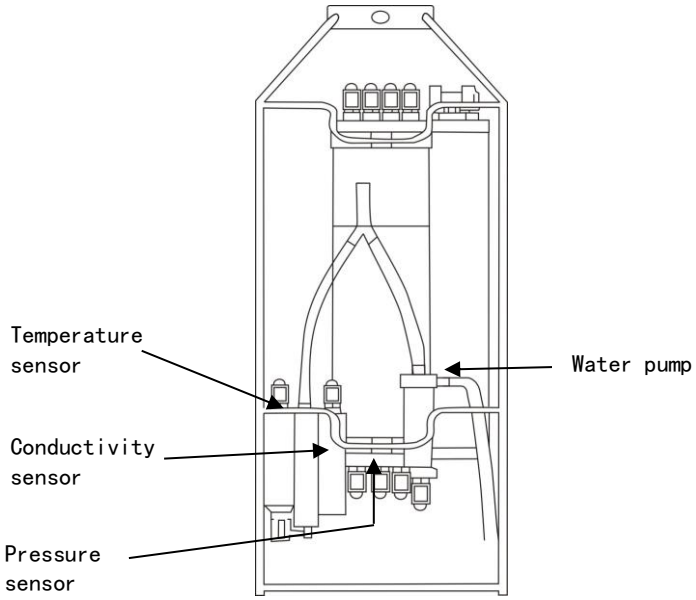

Figure 1 Sketch of the CTD Underwater Unit Working Structure

5 Metrological Performance Requirements

5.1 Indication error

The different grades of CTD temperature indication, conductivity indication and pressure indication errors shall not exceed the maximum permissible error requirements in Table 1.

5.2 Repeatability of measurement

The repeatability of temperature, conductivity and pressure shall not exceed the repeatability of measurement requirements shown in Table 1.

Table 1 CTD Metrological Performance Requirements

Accuracy class		Level 1	Level 2	Level 3
Temperature ℃	Range	-2 to 40	-2 to 40	-2 to 40
	Maximum permissible error	± 0.003	± 0.02	± 0.1
	Repeatability of measurement	≤ 0.001	≤ 0.006	≤ 0.03
Conductivity mS/cm	Range	0 to 70	0 to 70	0 to 70
	Maximum permissible error	± 0.005	± 0.02	± 0.1
	Repeatability of measurement	≤ 0.0016	≤ 0.006	≤ 0.03
Pressure MPa	Maximum permissible error	± 0.05% FS	± 0.1% FS	± 0.5% FS
	Repeatability of measurement	≤ 0.016% FS	≤ 0.03% FS	≤ 0.16% FS
Note: FS in Table 1 is the abbreviation of “full scale.”				

6 General Technical Requirements

The surface coating of the CTD shell shall be even and firm without any apparent damage that may affect normal performance testing. The CTD shall be labeled with its name and model, manufacturer, date of manufacture and serial number. The fasteners and connectors of the CTD shall be neither loose nor damaged.

7 Metrological Instrument Controls

Metrological instrument controls include initial verification, subsequent verification and in-use inspection of CTD.

7.1 Verification conditions

7.1.1 Metrological standard instrument and supporting equipment

7.1.1.1 Metrological standard instrument and supporting equipment used for temperature and conductivity verification of CTD

Main metrological standard instruments and supporting equipment used for temperature and conductivity verification of different grades of CTD are shown in Table 2.

Table 2 Technical Index of Main Metrological Standard Instruments and Supporting Equipment Used for Temperature and Conductivity Verification of CTD

Accuracy class	Equipment name	Technical index
Level 1 CTD	Standard platinum resistance thermometer	Working standard
	Bridge for measuring temperature	Resistance ratio: $\pm 5 \times 10^{-7}$
	Seawater thermostatic bath	Temperature-controlled fluctuation: ≤ 0.001 ° C Temperature field homogeneity: ≤ 0.001 ° C
	Water triple point cell	Uncertainty < 0.4 mK
	Chinese primary standard seawater	Level 1
	Laboratory salinometer	MPE: ± 0.002
Level 2 CTD	Standard platinum resistance thermometer	First-class
	Bridge for measuring temperature	Resistance ratio: $\pm 2\times 10^{-6}$
	Seawater thermostatic bath	Temperature-controlled fluctuation: ≤ 0.005 ° C Temperature field homogeneity: ≤ 0.005 °C
	Chinese series standard seawater	Level 2
	Laboratory salinometer	MPE: ± 0.002
Level 3 CTD	Standard platinum resistance thermometer	Second-class
	Bridge for measuring temperature	Resistance ratio: $\pm 1\times 10^{-5}$
	Seawater thermostatic bath	Temperature-controlled fluctuation: ≤ 0.02 °C Temperature field homogeneity: ≤ 0.02 °C
	Chinese series standard seawater	Level 2
	Laboratory salinometer	MPE: ± 0.005

Note: 1. Standard platinum resistance thermometer, Chinese primary standard seawater and Chinese series standard seawater are the main metrological instruments for verification; bridge for measuring temperature, seawater thermostatic bath and laboratory salinometer are the main supporting equipment.

2. Seawater thermostatic bath contains natural ocean water with a salinity of 35.

3. MPE in Table 2 is the abbreviation of "maximum permissible error."

7.1.1.2 Metrological standard instrument and supporting equipment used for pressure verification of CTD

Standard instruments for CTD pressure verification are chosen according to JJG875 *Verification Regulation of Digital Pressure Gauge*, and the piston pressure gauge or digital pressure gauge can be selected. The measurement range of the selected pressure standard instrument shall be greater than or equal to the measurement range of the CTD pressure. The absolute value of maximum permissible error for the pressure standard instrument shall not be greater than one-third of the absolute value of the maximum permissible error for the CTD pressure.

For measurement instruments of atmospheric pressure, the measurement range shall not be less than 600 to 1100 hPa, and the maximum permissible error shall not be greater than ± 0.3 hPa.

An air thermostat can be used for temperature compensation performance verification. The measurement range shall not be less than −2 to 35 ° C, and the temperature fluctuation shall not be greater than 1 ° C.

7.1.2 Verification environment

Ambient temperature: (20 ± 5) ° C, in which the ambient environment for Level 1 CTD pressure verification is (20 ± 1) ° C;

Relative humidity: 20% to 80%.

Supply voltage: (220 ± 22) V.

Supply frequency: (50± 2) Hz.

7.2 Verification items

Verification items are shown in Table 3.

Table 3 List of Verification Items

Serial number	Verification items	Initial verification	Subsequent verification	In-use inspection
1	Appearance inspection	+	+	+
2	Temperature indication error	+	+	+
3	Repeatability of temperature measurement	+	-	-

4	Conductivity indication error	+	+	+
5	Repeatability of conductivity measurement	+	-	-
6	Pressure indication error	+	+	+
7	Repeatability of pressure measurement	+	-	-
Note: 1. “+” represents items to be verified; “-” represents items not to be verified. 2. If maintenance has a significant impact on the metrological performance of CTD, its subsequent verification shall be carried out according to the initial verification items.				

7.3 Verification methods

7.3.1 Inspection of appearance

Visually and manually check the appearance of the CTD; it should comply with the requirements in clause 6 *General Technical Requirements* of this regulation.

7.3.2 Indication error and repeatability of temperature

7.3.2.1 The verification points of Grade 1 CTD temperature indication error are 35 °C, 30 °C, 25 °C, 20 °C, 15 °C, 10 °C, 5 °C, 0 °C and −2 °C. No fewer than five temperature points shall be selected for Grades 2 and 3 CTD.

7.3.2.2 The temperature of seawater in the thermostatic bath shall be controlled at 35 °C. The standard platinum resistance thermometer and CTD are placed in the seawater thermostatic bath at the same time, with the standard platinum resistance thermometer as close as possible to the position of the CTD temperature sensor.

7.3.2.3 When the temperature at the verification points are stabilized, the data are recorded for 3 min by the bridge and CTD at the same time, with no fewer than 10 sets of readings. The arithmetic mean value of the corresponding temperature readings shall be taken as the standard temperature value and CTD temperature indication at the verification point, respectively, and recorded in the format shown in Annex A.

7.3.2.4 The next verification point is performed in the order of cooling until all temperature points are completed.

7.3.2.5 Calculate the indication error as per Formula (1):

$$\Delta t_i = t_i - t_{is} \qquad (1)$$

where:

Δt_i -- Temperature indication error of CTD at the i^{th} verification point, °C;

t_i -- CTD temperature indication at the i^{th} verification point, °C; and

t_{is} -- Standard temperature value at the i^{th} verification point, °C.

Take the maximum absolute value of Δt_i as the temperature indication error of CTD.

7.3.2.6 The verification point of the instrument temperature repeatability is 15 °C. When the temperature at the verification point has stabilized, repeat step 7.3.2.3 and complete six measurements.

7.3.2.7 Calculate the instrument temperature repeatability as per Formula (2):

$$\sigma_t = \sqrt{\frac{\sum_{i=1}^{n}(t_i - \bar{t})^2}{n-1}} \qquad (2)$$

where:

σ_t -- Temperature repeatability of CTD, °C;

t_i -- CTD temperature indication at the i^{th} measurement, °C;

$\bar{t}$ -- Arithmetic mean value of CTD at the n^{th} measurement, °C; and

n -- Number of measurements (n = 6).

7.3.3 Indication error and repeatability of conductivity

7.3.3.1 Conductivity indication errors and temperature indication errors shall be carried out simultaneously in the thermostatic seawater bath.

7.3.3.2 When the temperature at the verification point described in 7.3.2.3 is stable, measure the CTD conductivity for 3 min with no fewer than 10 sets of readings. At the same time, number and set aside one bottle of the seawater sample with its sampling tube and plug-in bottle cap.

7.3.3.3 The seawater samples are measured by a laboratory salinometer, with each sample bottle of seawater being measured twice. Arithmetic mean value is taken as the standard salinity value of the verification point, and the standard conductivity value is calculated at the corresponding temperature in accordance with Annex C.

7.3.3.4 Calculate the indication error as per Formula (3):

$$\Delta c_i = c_i - c_{is} \quad (3)$$

where:

Δc_i -- Conductivity indication error of CTD at the i^{th} verification point, mS/cm;

c_i -- CTD conductivity indication at the i^{th} verification point, mS/cm; and

c_{is} -- Standard conductivity value at the i^{th} verification point, mS/cm.

Take the maximum absolute value of Δc_i as the conductivity indication error of CTD.

7.3.3.5 Conductivity and temperature repeatability are carried out simultaneously. When the temperature of the verification point has stabilized, repeat steps 7.3.3.2–7.3.3.3 and complete six measurements.

7.3.3.6 Calculate the instrument conductivity repeatability as per Formula (4):

$$\sigma_c = \sqrt{\frac{\sum_{i=1}^{n}(c_i - \bar{c})^2}{n-1}} \quad (4)$$

where:

σ_c -- Conductivity repeatability of CTD, mS/cm;

c_i -- Conductivity of CTD at the i^{th} measurement, mS/cm;

$\bar{c}$-- Arithmetic mean value of CTD at the n^{th} measurement, mS/cm; and

n -- Number of measurements (n=6).

7.3.4 Indication error and repeatability of pressure

7.3.4.1 The pressure verification points shall be uniformly selected with no fewer than seven points within the pressure range of the CTD. Pressure verification shall be carried out in the order of step-up and then step-down.

7.3.4.2 The CTD is placed on the workbench of the pressure standard instrument and the lift platform is adjusted so that the position of the CTD pressure sensor is consistent with the reference position of the pressure standard instrument (especially for the pressure standard instrument using oil medium). The pressure standard instrument and CTD pressure sensor are connected. If the CTD has a zero correction function, it shall be set to zero before connection; if the CTD does not have a zero correction function, this operation is not required.

7.3.4.3 After each pressure verification point has stabilized, CTD measurement data shall be no fewer than 10 sets, and the arithmetic mean value shall be taken as the pressure indication.

7.3.4.4 When CTD pressure measurement has temperature compensation, temperature compensation performance verification shall be carried out. The CTD is placed in the air thermostat and the instrument position is adjusted so that the pressure sensor is consistent with the reference position of the pressure standard instrument (especially for the pressure standard instrument using oil medium). The pressure standard instrument and the CTD pressure sensor are connected. The compensation temperature points are selected at 30 °C and 0 °C and a step-up and step-down process shall be performed at each compensation temperature point. The operational procedures are the same as in 7.3.4.3.

7.3.4.5 Calculate the indication error as per Formula (5):

$$\Delta p_i = p_i - p_{is} \qquad (5)$$

where:

Δp_i -- Pressure indication error of CTD at the i^{th} pressure verification point, Pa;

p_i -- CTD pressure indication at the i^{th} pressure verification point, Pa; and

p_{is} -- Standard pressure value at the i^{th} pressure verification point, Pa.

Take the maximum absolute value of Δp_i as the pressure indication error of CTD.

7.3.4.6 For instrument pressure repeatability, select the maximum pressure value as the verification point, repeat step 7.3.4.3 and complete six measurements. After each measurement, the pressure standard instrument needs to be rebalanced before the next measurement.

7.3.4.7 Calculate the instrument pressure repeatability as per Formula (6):

$$\sigma_p = \sqrt{\frac{\sum_{i=1}^{n}(p_i - \bar{p})^2}{n-1}} \qquad (6)$$

where:

σ_p -- Pressure repeatability of CTD, Pa;

p_i -- CTD pressure value at the i^{th} measurement, Pa;

$\bar{p}$ -- Arithmetic mean value of CTD at the n^{th} measurement, Pa; and

n -- Number of measurements (n = 6).

7.4 Processing of verification results

A CTD that meets all indexes is qualified; any CTD with one non-conformance is unqualified after verification. A certificate of verification shall be issued to those that qualified.

A CTD that is unqualified after verification can be degraded to a lower level, but must meet all technical indexes of the CTD at the next level. If the CTD is still unqualified after degradation, a notice of verification results shall be issued to indicate the non-conformance item.

7.5 Verification period

The CTD verification period is generally less than 1 year. To ensure the quality of CTD measurement data, it is suggested that subsequent verification is carried out before and after going out to sea.

Annex A

Reference Format of Verification Record

Table A.1 Verification Record of Temperature Indication Error

Product name		Serial no.	
Model		Sensor no.	
Instrument measurement range		Uncertainty or accuracy class or maximum permissible error	
Verification basis			
Verification items			
No.	Verification items		Conclusion
Main metrological instrument and equipment used for verification			
Name	Measurement range	Uncertainty or accuracy class or maximum permissible error	Certificate no.	Valid until
Verification date, location and environmental conditions			
Date:		Location:	
Temperature:		Relative humidity:	
Verification results			
Verification point (℃)	Standard temperature value (℃)	Instrument temperature indication (℃)	Indication error (℃)

Table A.2 Verification Record of Temperature Repeatability

Verification results			
No.	Instrument temperature value (℃)	Mean temperature (℃)	Measurement repeatability (℃)

Verified by: Checked by:

Table A.3 Verification Record of Conductivity Indication Error

Product name		Serial no.	
Model		Sensor no.	
Instrument measurement range		Uncertainty or accuracy class or maximum permissible error	
Verification basis			

Verification items		
No.	Verification items	Conclusion

Main metrological instrument and equipment used for verification				
Name	Measurement range	Uncertainty or accuracy class or maximum permissible error	Certificate no.	Valid until

Verification date, location and environmental conditions	
Date:	Location:
Temperature:	Relative humidity:

Verification results				
Verification point (℃)	Standard temperature value (℃)	Standard conductivity value (mS/cm)	Instrument conductivity indication (mS/cm)	Indication error (mS/cm)

Table A.4 Verification Record of Conductivity Repeatability

Verification results			
No.	Instrument conductivity value (mS/cm)	Mean conductivity (mS/cm)	Measurement repeatability (mS/cm)

Verified by: Checked by:

Table A.5 Verification Record of Pressure Indication Error

<table>
<tr><td>Product name</td><td colspan="2"></td><td>Serial no.</td><td colspan="2"></td></tr>
<tr><td>Model</td><td colspan="2"></td><td>Sensor no.</td><td colspan="2"></td></tr>
<tr><td>Instrument measurement range</td><td colspan="2"></td><td>Uncertainty or accuracy class or maximum permissible error</td><td colspan="2"></td></tr>
<tr><td>Verification basis</td><td colspan="5"></td></tr>
<tr><td colspan="6">Verification items</td></tr>
<tr><td colspan="2">No.</td><td colspan="2">Verification items</td><td colspan="2">Conclusion</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="6">Main metrological instrument and equipment used for verification</td></tr>
<tr><td>Name</td><td>Measurement range</td><td>Uncertainty or accuracy class or maximum permissible error</td><td>Certificate no.</td><td colspan="2">Valid until</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="6">Verification date, location and environmental conditions</td></tr>
<tr><td colspan="3">Date:</td><td colspan="3">Location:</td></tr>
<tr><td colspan="2">Temperature:</td><td colspan="2">Relative humidity:</td><td colspan="2">Pressure:</td></tr>
<tr><td colspan="2">Temperature compensation verification</td><td colspan="4">☐None (room temperature) ☐0 ℃ ☐30 ℃</td></tr>
<tr><td colspan="6">Verification results</td></tr>
<tr><td colspan="3">Step-up</td><td colspan="3">Step-down</td></tr>
<tr><td>Standard pressure value (Pa)</td><td>Instrument pressure indication (Pa)</td><td>Indication error (Pa)</td><td>Standard pressure value (Pa)</td><td>Instrument pressure indication (Pa)</td><td>Indication error (Pa)</td></tr>
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</table>

Table A.6 Verification Record of Pressure Repeatability

Test results			
No.	Instrument pressure value (Pa)	Mean pressure (Pa)	Measurement repeatability (Pa)

Verified by: Checked by:

Annex B

Reference Format of Inside Information for Verification Certificate/Notice of Verification Results

Table B.1 Reference Format of Inside Information for Verification Certificate

(Page 2)

Certificate No.:				
Main metrological instruments used for verification				
Name	Measurement range	Uncertainty/accuracy class/maximum permissible error	Certificate no.	Valid until
Verification location and environmental conditions				
Location:				
Ambient temperature: ℃		Relative humidity: %		Pressure: hPa
Verification results				
Verification items	Technical index	Verification results	Conclusion	
Appearance inspection				
Temperature indication error				
Temperature repeatability				
Conductivity indication error				
Conductivity repeatability				
Pressure indication error				
Pressure repeatability				

Table B.2 Reference Format of Inside Information for Notice of Verification Results (Page 2)

<table>
<tr><td colspan="5">Certificate No.:</td></tr>
<tr><td colspan="5">Main metrological instruments used for verification</td></tr>
<tr><td>Name</td><td>Measurement range</td><td>Uncertainty/accuracy class/maximum permissible error</td><td>Certificate no.</td><td>Valid until</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">Verification site and environmental conditions</td></tr>
<tr><td colspan="5">Location:</td></tr>
<tr><td colspan="2">Ambient temperature: °C</td><td colspan="2">Relative humidity: %</td><td>Pressure: hPa</td></tr>
<tr><td colspan="5">Verification results</td></tr>
<tr><td>Verification items</td><td colspan="2">Technical index</td><td>Verification results</td><td>Conclusion</td></tr>
<tr><td>Appearance inspection</td><td colspan="2"></td><td></td><td></td></tr>
<tr><td>Temperature indication error</td><td colspan="2"></td><td></td><td></td></tr>
<tr><td>Temperature repeatability</td><td colspan="2"></td><td></td><td></td></tr>
<tr><td>Conductivity indication error</td><td colspan="2"></td><td></td><td></td></tr>
<tr><td>Conductivity repeatability</td><td colspan="2"></td><td></td><td></td></tr>
<tr><td>Pressure indication error</td><td colspan="2"></td><td></td><td></td></tr>
<tr><td>Pressure repeatability</td><td colspan="2"></td><td></td><td></td></tr>
<tr><td colspan="5">Non-conformance item of verification results:</td></tr>
</table>

Annex C

Reduction Formula between Salinity and Conductivity

C.1 According to PSS-78, calculate the standard salinity value as per Formula (C.2):

$$S = a_0 + a_1 R_t^{1/2} + a_2 R_t + a_3 R_t^{3/2} + a_4 R_t^2 + a_5 R_t^{5/2} + \frac{t-15}{1+k(t-15)}(b_0 + b_1 R_t^{\frac{1}{2}} + b_2 R_t + b_3 R_t^{3/2} + b_4 R_t^2 + b_5 R_t^{5/2}) \quad (C.2)$$

where:

Coefficient, k = 0.0162;

a_0 = 0.0080, a_1 = −0.16 92, a_2 = 25.3851, a_3 = 14.0941, a_4 = −7.0261, a_5 = 2.7081;

b_0 = 0.0005, b_1 = −0.0056, b_2 = −0.0066, b_3 = −0.0375, b_4 = 0.0636, b_5= −0.0144;

S -- Standard salinity value (PSS-78) of the seawater samples;

R_t -- Conductivity ratio of seawater sample measured by laboratory salinometer; and

t -- Temperature value of the measured seawater sample; that is, salinometer water bath temperature, °C.

C.2 With the standard salinity value S of the seawater sample and the standard temperature value t_s, according to C.1, use the Newton iteration method or the third volume of the *International Oceanographic Common Table* to calculate the conductivity ratio R_{ts} of the seawater sample and seawater with salinity of 35.000 at each standard temperature.

C.3 The formula for the conductivity ratio R of seawater samples at standard temperature value t_s and pressure p in standard seawater with practical salinity of 35.000 at a temperature of 15 °C and seawater pressure of 0 is shown in Formula C.3:

$$R = \frac{C(S,t_S,P)}{C(35,15,0)} = R_{t_s} R_p r_{t_s} \quad (C.3)$$

where:

R_{t_s}-- Conductivity ratio of seawater at standard temperature value t_s; and

R_p -- Function of seawater depth (pressure), R_p= 1+ α, where:

$a = (A_1 p + A_2 P^2 + A_3 P^3)/(1 + \beta_1 t + \beta_2 t^2 + \beta_3 R + \beta_4 tR)$;

p -- Pressure value measured by seawater conductivity instrument, kPa;

$A_1 = 2.070\times10^{-6}$, $A_2 = -6.370\times10^{-12}$, $A_3 = 3.989\times10^{-18}$,

$\beta_1 = 3.426\times10^{-2}$, $\beta_2 = 4.464\times10^{-4}$, $\beta_3 = 4.215\times10^{-1}$,

$\beta_4 = -3.107\times10^{-3}$.

In the actual verification, the depth of the CTD conductivity sensor submerged in seawater is less than 1 m. Under these conditions, the seawater pressure has little influence on the conductivity measurement. Therefore, $R_p = 1$.

r_{t_s} -- Function of standard seawater temperature, $r_t = C_0 + C_1 t_s + C_2 t_s^2 + C_3 t_s^3 + C_4 t_s^4$, where:

$C_0 = 0.6766097$, $C_1 = 2.00564\times10^{-2}$, $C_2 = 1.104259\times10^{-4}$,

$C_3 = -6.9698\times10^{-7}$, $C_4 = 1.0031\times10^{-9}$.

$C(S, t, p)$ -- Standard conductivity value of seawater sample at standard temperature (t_s) and salinity (S), mS/cm; and

C (35, 15, 0) -- Constant, 42.914 mS/cm.

Therefore, standard conductivity value $C(S,t,p) = C(35,15,0)R_{t_s}r_{t_s}$

Note: The practical salinity scale 1978 (PSS-78) is based on the 1968 international practical temperature scale (IPTS-68). Therefore, the measured temperature shall be converted before calculation, and in the temperature range of -5 to 40 °C, the conversion factor is δ_t=1.00024.