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Operating instructions for the determination of salinity with an inductively coupled salinometer

By

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Contents

1. Introduction

These instructions are meant to give a brief outline of measurement practice. For details we refer to 7. References. The books named under 7.1 and 7.2 should be kept ready to hand during measurements with the salinometer. A check of temperature compensation is not included in these instructions.

The first edition of this report was written in Dutch in 1970. A number of alterations and additions are added in this English version. Chapters 4.5 and 5.1 have been written after considering information received from Bissett - Berman Corporation via The Plessey Company Limited, Electronics Group, Ilford, Essex U.K. and consultation of Dr. F. Culkin, staffmember of the National Institute of Oceanography, Wormley, Sussex, U.K.

2. Sampling

- in bottles of at least 200 ml, tightly stoppered to prevent evaporation
- before the bottle is filled it should be rinsed at least twice with the collected water.

3. Instrumentation and appliances

Naturally an inductively coupled salinometer is used. The author's experience is limited to the Autolab Industries salinometer type 601-M III.

The following appliances are needed:

Standard seawater (I.A.P.S.O. Standard Sea-water Service, Charlottenlund Slot, Charlottenlund, Denmark, 300 ml tubes), and substandard seawater. The latter is collected in the open sea, required salinity 35 ‰, a salinity between 34.5 ‰ and 35,5 ‰ is acceptable.

For the storage of substandard seawater and the relative positions of storage tank and salinometer see 7.1.

The inlet/outlet opening of the measuring cell is connected with a silicone rubber tubing of 20 cm length. The simplest way of setting-up the salinometer is over or beside a sink.

The room in which the measurements are carried out should be provided with a thermometer for reading ambient temperature. Furthermore a glass cutting-knife and observation sheets should be laid out. (Appendix 1).

4. Use of salinometer

4.1 Checking the salinometer for reproducibility

(1) - Turn "aspirator" on (adjustment see 7.1.).

(2) - Fill cell with sub-standard, turn "stirrer + detector" on for 5 seconds, switch it off and empty cell.

(3) - Fill cell with sub-standard, turn "stirrer + detector" on, switch "temperature" on and balance the bridge with "temperature dial". Read temperature by means of the diagram enclosed with the salinometer (sometimes the temperature may be read directly from an extra scale on the temperature dial) and check the correct value of "temperature compensation". Switch to "salinity", use the "conductivity ratio" reading of the previous measuring set, balance the bridge with "standardize", turn "stirrer + detector" off and empty cell.

(4) - Fill cell again with sub-standard, turn "stirrer and detector" on, switch "temperature" on, balance bridge with "temperature dial". Check "temperature compensation" reading switch to "salinity" and balance bridge with "conductivity ratio". Turn "stirrer + detector" off and empty cell.

(5) - Repeat (4).

(6) - If the values for "conductivity ratio" obtained under (4) and (5) differ less than 3 units in the last digit the salinometer is ready for the proper adjustment with standard seawater. Otherwise (5) should be repeated till this condition is fulfilled.

4.2 Adjusting the salinometer with standard seawater

(1) - Flush cell with standard seawater that has been used once (see below).

(2) - Take tube with standard seawater, cut the top, push the tubing at B (Figure 1) on it. Cut the other end and fasten the tube in the tool clamp. Fill cell by sucking, close the cell. Turn "stirrer + detector" on for 5 seconds, turn it off, and empty cell to waste.

(3) - Fill cell in the same way. Turn on "stirrer + detector", turn "temperature on, balance bridge and read temperature. The temperature of the standard seawater should not differ more than 2° C from the temperature of the sub-standard. Switch to "salinity", adjust "Conductivity ratio" to the known value (from table I) and balance bridge with "standardize". Turn off "stirrer + detector" and empty cell.

(4) - Repeat (3)

(5) - Repeat (3). The readings for "standardize" obtained in (3) (4) and (5) should not differ more than 6 units in the last digit. If they do, let contents of cell flow back into ampoule, fill cell again and repeat measurement. Enter data in the heading of the observation sheet as well as first "standardize" value. When sub-standard seawater is used the adjustment of the salinometer with standard seawater is carried out twice a week. The standard seawater used (4) and (5) is collected in a special bottle and used the next time.

4.3. Measurement of sub-standard seawater

(1) - Fill cell with sub-standard seawater by gravity flow. Apply measuring procedure as described under 4.2, except that now the "standardize" value remains unaltered and the bridge is balanced with "conductivity ratio". Enter data into observation sheet and add "sub. st." to the column : sample nr.

(2) - Repeat this measurement at least twice with fresh sub-standard seawater. The extremes of the last three R_t values should not differ more than three units in the last digit. A correction for drift is of course not applied. Write down R_{20} value, together with salinity and date, on the label attached to the storage tank with sub-standard seawater.

4.4. Measurement of seawater samples

The samples must be allowed to stand 24 hours in the laboratory before analysis, to reach the same temperature as the substandard and to allow dissolved gasses to escape.

(1) - Enter data of the first ten bottles in column 1-3 and shake the bottles.

(2) - Remove stopper of first bottle and wipe the upper side clean with some absorbing matter, e.g. dry tissue paper.

(3) - Clean outer side of filling tubing.

(4) - Fill cell by putting tubing into bottle and sucking. As soon as it is full turn "stirrer + detector" on for 5 seconds, empty cell to waste.

(5) - Fill cell again, turn "stirrer + detector" on, balance bridge with "temperature", switch to "salinity" and balance bridge with "conductivity ratio", enter data on sheet (1st det.). Turn "stirrer + detector" off, empty cell to waste.

(6) - Repeat (5), (2nd det.). In case of 200 ml bottles empty cell into bottle. The values for R_t obtained by (5) and (6) should not differ more than 10 units in the last two digits, if they do the second measurement should be repeated.

(7) - Repeat (2) to (6) with the other nine bottles of the first series.

4.5. Determination of salinometer drift

After every series of ten salinity measurements the drift of the salinometer is determined.

(1) - Determine R_{20} of the sub-standard by the procedure as described in 4.3, without changing the adjustment of "standardize". The difference with the first value found is the drift of the salinometer. In the column "Drift corr. 10^5" this difference is entered with a - or + sign for increase or decrease resp. (this is the Drift corr. $10^5_{\text{Subst.}}$). If this difference is more than 15, it means that the drift of the salinometer is too great and probably not linear and the salinities measured should be quoted only to two decimal places. If the difference is less than 15 a drift correction is applied by linear interpolation to the ten preceding measurements of seawater samples according to the procedure described under 5.1.

(2) - Now, keeping in mind a possible change in temperature correction, the "conductivity ratio" is switched to the original value corresponding to the salinity of the sub-standard, the bridge balanced with "temperature", if necessary the "temperature comp. dial" is adjusted, then switch to "salinity" and balance bridge with "standardize". Enter this new value in the record.

(3) - After this, the next series of ten salinity determinations is carried out according to 4.4.

4.6. Remarks

(1) - Never use the heater, as this may lead to temporary or permament changes in the dimensions of the cell

(2) - If it should be necessary to go over to a different value of "temperature compensation", then readjustment of "standardize" by means of sub-standard seawater a according to 4.2 is unavoidably.

5. Calculation of salinity

5.1. The correction for temperature, Δ_{20} is derived from Table IIb given in 7.2. here Δ_{20} is given as a function of R_t and temperature (sample).

The drift correction is calculated with the formula

"Drift Corr. x 10^5" = 0.1 n x "Drift Corr. x $10^5_{\text{Subst.}}$"x R_t sample

in which n is the serial number of the sample in the series of ten.

Finally R_{20} is calculated from the formula

$$R_{20} = R_t + \Delta_{20} \times 10^{-5} + \text{Drift Corr.}$$

In Table IIa given in 7.2 salinity (S) is found as a function of R_{20}.

5.2. Using the polynoms given in 7.2. The method according to 5.1. sometimes gives rise to reading and interpolation errors. These can be avoided, starting from drift corrected R_t values and temperature (t) values, calculating Δ_{15} and thereafter salinity from the polynoms given in the introduction to Table Ia in 7.2.

$$S(‰) = -0{,}08996 + 28.29720\, R_{15} + 12.80832\, R_{15}^2 - 10.67869\, R_{15}^3 + 5{,}98624\, R_{15}^4 - 1.32311\, R_{15}^5$$

$$\Delta_{15} = R_{15} - R_t = 10^{-5}\, R_t\, (R_t - 1)(t-15)\left\{96.7 - 72.0R_t + 37.3\, R_t^2 - (0.63 + 0.21\, R_t^2)(t - 15)\right\}.$$

These calculations can be performed on a table computer with only a small memory like the Olivetti P 101. The programme given in Appendix 2 was written by Mr. J.J.A. v. Weereld.

6. Longterm maintenance of the salinometer

Besides the points already mentioned in 7.1. a few other points deserve attention.

Intensive use of the meter gives rise to wear of stirrer axis and bearing. This in turn gives an enhanced chance of bubble trouble by air sucked in along the running stirrer. Replacement of bearing (and sometimes stirrer axis) is needed, if this happens to be the case.

Experience has learned that after a few years use the zero-balance meter may show mechanical hysteresis of up to 0,5 μA resulting in a zero-balance - uncertainly of 3 to 4 digits in the last dial. A routine user of the salinometer does not easily manage to indicate this cause. However vague complaints of not really well-functioning of the meter occur. Replacement of zero-balance meter cures this malfunctioning.

7. References

7.1. Anonymous, Handbook for the installation and use of the (Model 601 M III) Auto-lab salinometer and the use of Unesco Tables. (Supplementary to Makers' Handbook). Handbook reference No.: H24 National Institute of Oceanography, Wormley, Godalming, Surrey.

7.2. 1966, International Oceanographic Tables, National Institute of Oceanography Surrey, England - Unesco.

7.3. Brown, N.L. & B.V. Hamon, 1961. An inductive salinometer. Deep Sea Research 8: 65-75.

7.4. Cox, R.A., F. Culkin & J.P. Riley, 1967. The electrical conductivity/chlorinity relationship in natural seawater. Deep Sea Research 14 (2): 203 - 220.

7.5. Tijssen, S.B., 1972. Substandard Seawater in tubes and a semiclosed system for transferring seawater from tubes to the cell of an inductively coupled salinometer. ICES C.M. 1972/C23.

Table I

Conductivity ratio corresponding to various chlorinities.

Chlorinity	Salinity	Conductivity ratio
19.368	34.989	0.99973
19.369	34.991	0.99977
19.370	34.993	0.99982
19.371	34.995	0.99986
19.372	34.996	0.99991
19.373	34.998	0.99995
19.374	35.000	1.00000
19.375	35.002	1.00005
19.376	35.004	1.00009
19.377	35.006	1.00014
19.378	35.007	1.00018
19.379	35.009	1.00023
19.380	35.011	1.00027

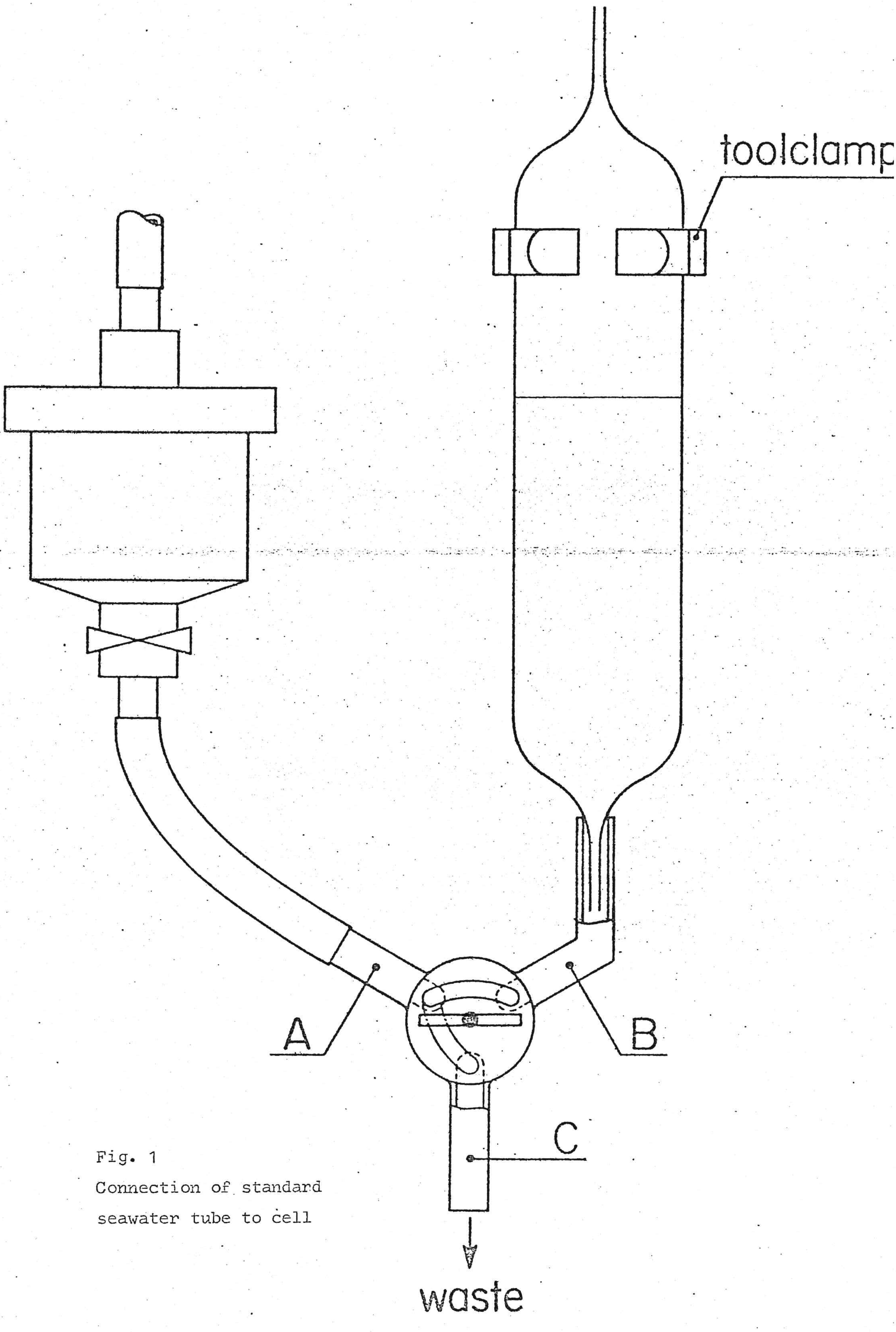

Fig. 1
Connection of standard
seawater tube to cell

Appendix 2

Programme for calculation of salinity, S in ‰, starting from drift corrected conductivity ratio R_t and sample temperature t on an Olivetti P 101 tablecomputer.

Operation

Decimal indicator setting 6

1. Insert card
2. Press V
3. Enter t, press S
4. Enter R_t, press S
5. Machine prints S in ‰ with A (values given are to be rounded off by hand, omitting the last three digits)
6. To repeat calculations return to step 3.

<u>Programme instructions</u>

Register 1.	Register 2.	Register F.	Register E.	Register D.
A V	+	R S	+	R :
S	B X	R S	B X	R ✳
↓	A/↑	R S	A/↑	R ↑
A/↑	R :	R S	F ✳	R/◇
R/—	R/X	D/S	F X	D ↑
D ↓	D ✳	X	F ◇	+
—	+	B +	F :	B X
B/↕	C ↕	B ↕	F X	A/↑
S	B ↓	A/↑	F/S	F X
B ↑	A X	F ↓	E ↓	F ✳
↓	A/↑	F ↓	+	F ✳
X	D/↕	F ↕	B X	F ◇
—	+	F ↑	A/↑	F S
B/X	A/↑	F ↕	R ↑	E/S
C/↕	R ↓	E/↓	R ↕	+
A/↑	R ↑	↓	R ◇	A ◇
R ↕	D/S	B X	R S	/◇
R/:	X	A/↑	R ◇	V
D ↕	B/X	R +	R/↑	
↓	C ↕	R ↑	D ↓	
B X	C —	R X	+	
A/↑	C/X	R ◇	B X	
F/↑	A/↑	R ✳	A/↑	
E :	R ↓	D/—	R ↑	

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RECORD OF SALINOMETER

APPENDIX 1

HIP :
RUISE :
TATION :
ATE :

SHEET NR.

OR GENERAL INFORMATION SEE

AST NR.	BOX NR.	SAMPLE NR.	ST. DIAL SETTING	SAMPLE TEMPERATURE				CONDUCTIVITY RATIO F		
				1st DET.		2nd DET.		1st DET.	2nd DET.	A

)METER MEASUREMENTS

(1

ANALYST :
DATE ANALYSED :
LAB. TEMP. START :
FINISH :
TEMP.COMP.DIAL.SETTING:
STANDARD SEAWATER
BATCHNR.: ,S= ‰ R_t =

IVITY RATIO R_t		Δ_{20}	DRIFT CORR. $.10^5$	CORR. COND. RATIO R_{20}	S ‰	REMARKS
d DET.	AVERAGE					