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Indian Standard

METHODS OF SAMPLING AND TEST (PHYSICAL AND CHEMICAL) FOR WATER AND WASTE WATER

PART 14 SPECIFIC CONDUCTANCE (WHEATSTONE BRIDGE, CONDUCTANCE CELL)

(First Revision)

1. Scope — Prescribes a method for the determination of specific conductance of water. This method is applicable to all types of water.

2. Principle — Specific conductance is determined by using a wheatstone bridge in which a variable resistance is adjusted so that it is equal to the resistance of the unknown solution between platinized electrodes of a standard conductivity cell. The cell constant is determined by the following relationship:

$$\text{Specific conductance} = \text{Conductance} \times \text{Cell constant, or}$$

$$\text{Specific conductance} = \frac{\text{Cell constant}}{\text{Resistance}}$$

The cell constant is determined experimentally with a standard solution of known conductance.

3. Interference

3.1 Temperature affects conductivity, which varies by about 2 percent per degree Celsius. The temperature of 25°C is taken as standard. It is desirable to observe the conductivity at 25°C or as near to this temperature as possible, although compensation for variations from it can be made. In some instruments, this is made automatically.

3.2 Dissolved carbon dioxide increases conductivity without increasing the mineral salt content. However, the effect is not large and it is usual to ignore it. In low *p*H water, H^+ ions and in high *p*H water OH^- ions, may contribute substantially to conductivity owing to high equivalent conductivity of these ions. Water with high silica (SiO_2) content give relatively low values of electrical conductivity to total dissolved solids ratio as SiO_2 (H_4SiO_4) does not contribute significantly to electrical conductance values.

3.3 It is not convenient to use water containing large amount of suspended matter. It should be settled or filtered. High suspended matter also affects electrical conductance values.

3.4 Samples containing fat, grease, oil, tar, etc, may contaminate the electrodes causing erratic results.

4. Apparatus

4.1 *Conductivity Meter* — Wheatstone bridge type or equivalent direct reading meter.

4.2 *Conductivity Cells* — Cells of at least two different cell constants, for measurement of wide range of conductivities. Specific conductance ranges and corresponding values of cell constants are given below:

Specific Conductance µs/cm at 25°C	*Cell Constant*
20 — 1 000	0·2
40 — 2 000	0·5
100 — 4 000	1·0
200 — 10 000	2·0
400 — 20 000	5·0
10 000 — 40 000	10·0

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Water Sectional Committee, CDC 26; Panel for Methods of Test for Water and Effluents, CDC 26 : P1 [Ref : Doc : CDC 26 (8852)]

4.3 *Thermometer* — 0 to 50°C, graduated in 0·1°C.

Note — Some direct reading conductivity meters have automatic temperature compensation built into the instrument.

5. Reagents

5.1 *Standard Potassium Chloride Solution* — Dissolve 0·523 2 g potassium chloride, dried at 180°C for 1 hour in demineralised water and dilute to 1 000 ml. The distilled water used for preparing standard solutions should have a very low conductivity. The specific conductance of this solution at 25°C is 1 000 µs/cm and the concentration of this solution is 0·007 02 N. Alternatively, dissolve 0·745 6 g of anhydrous potassium chloride, dried at 180°C for 1 hour in distilled water and make up to 1 000 ml at 25°C. The specific conductance of this solution at 25°C is 1 408 µs/cm and the concentration of this solution is 0·01 N.

6. Procedure

6.1 *Platinizing of Cell* — Platinizing of cell is required when readings become erratic. For platinizing, clean the cell in chromic acid solution once and rinse several times with distilled water. Place the cell in a commercial platinizing solution or dissolve 3 g of chloroplatinic acid (H_2PtCl_6) in 10 ml water to which 20 mg lead acetate has been added. Connect it with two dry cells of 1·5 volts each in parallel and reverse the direction of the current once a minute for 6 minutes or till the shining platinum surface is covered. Repeat the electrolytic process using 10 percent sulphuric acid to remove chlorine. Wash with distilled water and keep the cell immersed in distilled water when not in use.

6.2 Set the instrument according to manufacturer's instruction. In some instruments correction for cell constant and temperature factor is provided. If this arrangement is not there, cell constant may be separately determined and values of specific conductance should be converted to 25°C by multiplying with the factor given in Table 1.

$$\text{Cell constant, } L = \frac{K_1 + K_2}{K_x \times f}$$

where

K_1 = conductivity in µs/cm of the potassium chloride solution at 25°C;

K_2 = conductivity in µs/cm of distilled water, at 25°C, used for preparing the reference solution;

K_x = measured conductance in µs/cm; and

f = temperature factor for converting specific conductance value to that at 25°C (*see* Table 1).

Note — If K_2 is very low, it may be ignored.

6.3 Determine conductivity of 0·007 02 N potassium chloride or 0·01 N. Potassium chloride solution by use of instrument in accordance with manufacturer's instructions. Measure the temperature of the solution before and after the test and take the mean value (t°C).

6.4 Because the cell constants are subject to slow change even under ideal conditions and sometimes to more rapid change under adverse conditions, it is recommended that cell constant be periodically established.

6.5 Determine conductance of the unknown sample.

7. Calculation — Calculate specific conductance as follows:

$$\text{Specific conductance at 25°C, µs/cm} = K\,L\,f$$

where

K = conductivity, µs/cm;

L = cell constant; and

f = factor for converting specific conductance value to that at 25°C.

8. Precision and Accuracy — Precision and accuracy depend on the instrument used. Generally a precision and accuracy of about ±3 percent or less are possible with good quality instruments.

TABLE 1 MULTIPLICATION FACTOR TO CONVERT SPECIFIC CONDUCTANCE VALUES TO 25°C

(*Clause* 6.2)

Temperature °C	Factor *f*	Temperature °C	Factor *f*	Temperature °C	Factor *f*
15·0	1·247	23·0	1·043	30·2	0·904
16·0	1·218	23·2	1·038	30·4	0·901
16·2	1·212	23·4	1·034	30·6	0·897
16·4	1·206	23·6	1·029	30·8	0·894
16·6	1·200	23·8	1·025	31·0	0·890
16·8	1·194	24·0	1·020	31·2	0·887
17·0	1·189	24·2	1·016	31·4	0·884
17·2	1·184	24·4	1·012	31·6	0·880
17·4	1·179	24·6	1·008	31·8	0·877
17·6	1·174	24·8	1·004	32·0	0·873
17·8	1·169	25·0	1·000	32·2	0·870
18·0	1·163	25·2	0·996	32·6	0·864
18·2	1·157	25·4	0·992	32·8	0·861
18·4	1·152	25·6	0·988	33·0	0·858
18·6	1·147	25·8	0·983	33·2	0·855
18·8	1·142	26·0	0·979	33·4	0·852
19·0	1·136	26·2	0·975	33·6	0·849
19·2	1·131	26·4	0·971	33·8	0·846
19·4	1·127	26·6	0·967	34·0	0·843
19·6	1·122	26·8	0·964	35·0	0·829
19·8	1·117	27·0	0·960	36·0	0·815
20·0	1·112	27·2	0·956	37·0	0·801
20·2	1·107	27·4	0·953	38·0	0·788
20·4	1·102	27·6	0·950	39·0	0·775
20·6	1·097	27·8	0·947	40·0	0·763
20·8	1·092	28·0	0·943	41·0	0·750
21·0	1·087	28·2	0·940	42·0	0·739
21·2	1·082	28·4	0·936	43·0	0·727
21·4	1·076	28·6	0·932	44·0	0·715
21·6	1·073	28·8	0·929	45·0	0·705
21·8	1·068	29·0	0·925	46·0	0·694
22·0	1·064	29·2	0·921	47·0	0·683
22·2	1·060	29·4	0·918		
22·4	1·055	29·6	0·914		
22·6	1·051	29·8	0·911		
22·8	1·047	30·0	0·907		

9. Relationship Between Conductivity and Total Dissolved Solids

9.1 The ability of a solution to conduct an electric current is a function of the concentration and charge of ions in solution and also depends on ionic mobility. Ionic mobility decreases with increase in number of ions per unit volume of solution due to interionic effect and other factors. Broadly, the relationship between conductivity and dissolved solids and conductivity and soluble cations is given by the following equations:

$$AK = S$$

and,

$$K = 100\,C$$

where

A = multiplication factor for converting conductivity values to total dissolved solids;
K = conductivity in µs/cm,
S = total dissolved solids in mg/l, and
C = total soluble cations in meq/l.

Note — The value of A varies from 0·54 to 0·96 depending on the nature of ion present in water, and is usually taken as 0·65.

9.2 The relationships given in **9.1** are approximate and are used for broad checking only and should not be used for accurate calculations. Types of ions present in solution affect these relationships. A pure solution of sodium bicarbonate with total dissolved solids 980 mg/l will have a conductivity of 1 000 µs/cm and a solution of sodium chloride with total dissolved solids 500 mg/l will have the same conductivity. Presence of relatively low conductivity particles or molecules like silicic acid and the presence of $H^{\pm}$ and OH^{-} ions also effect the ratio between conductivity and total dissolved solids.

EXPLANATORY NOTE

Specific conductance is the conductance across a column of liquid one square centime e in area and one centimetre long at a specific temperature. It is a measure of capacity of water to convey an electric current and is related to the nature of various dissolved substances and their activities. Its value is affected by the temperature of measurement. The standard unit of electrical conductance is Siemen per litre (s/l). In practice, smaller units such as microsiemens per litre (µs/l) are used. A conductance cell and a Wheatstone bridge are used for measuring the electrical resistances of the sample and of potassium chloride solution of known specific conductance at the same temperature. As specific conductance varies directly with the temperature of the sample, the results are reported at 25°C. In general, specific conductance increases approximately by about 2 percent per degree Celsius. Factors based on 0·01 M potassium chloride are applied to convey specific conductance values at 25°C.

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