# MicroScale Conductivity Temperature Instrument

Model 125

Operator’s Manual

Precision Measurement Engineering, Inc.
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# MicroScale Conductivity-Temperature Instrument
# Model 125

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## INTRODUCTION

The Model 125 MicroScale Conductivity-Temperature Instrument (MSCTI) is designed to measure the temperature and electrical conductivity of water solutions containing conductive ions. The MSCTI provides analog voltage outputs that are functions of the solution's electrical conductivity and temperature. The instrument is intended for use in moving solutions where spatial resolution and time response are important.

## DOs AND DON'Ts

Always use fresh, clean solutions. Large contaminants such as algae flakes can become caught on the sensor's electrodes and cause calibration shifts. If possible, position the sensor so that it points directly upstream in the flow. This orientation is less susceptible to contamination.

Debris caught on the electrodes can sometimes be removed by gently rinsing them under a faucet or using a squeeze bottle. Never tap the stainless steel shaft. This causes vibrations that can cause the glass sensor to become cracked.

Avoid solutions that contain oil or slime. The conductivity electrodes are platinized to increase their ability to pass electrical current into the solution. This plating is sponge-like. If the plating becomes fouled with oil or slime, then the electrodes will have difficulty conducting electricity. The 'PHASE ERROR' light on the electronic bridge's front panel comes on when this condition occurs.


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Minimize the time the sensor is exposed to air after calibration. Calibration shifts will occur if the air exposure time is longer than a few seconds. When moving the sensor from one solution to another, take advantage of the fact that a small drop of solution will cling to the sensor's electrodes and protect them.

Always rinse the sensor with fresh water after use.

Never expose the sensor to water unnecessarily.

The preamplifier is watertight and may be submerged. The cable may also be submerged. The connector to the electronic bridge is not watertight. Do not allow water to get into this connector. If this happens, then the instrument will not operate properly and can be permanently damaged. When storing or transporting a wet sensor assembly, be sure that the connector is kept at the highest point. Small drops of water tend to run down along the cable and into the connector if allowed.

The preamplifier cable is a complicated instrumentation cable. It is important that the cable jacket not allow water to enter the cable. Never allow the cable to be damaged. Don't allow it to lay on the floor where it can be stepped on or have equipment rolled over it.

## SPECIFICATIONS

| CONDUCTIVITY | |
|---|---|
| Measurement equation | Vo = G * C + Voff |
| 8 hour calibration stability | Better than 1% of C reading |
| Time response | -3db at approx. 800 hz |
| Spatial response | -3db at approx. 4 cyc/cm |
| Noise | < 1mV RMS 10 Hz to 1 kHz |
| Output voltage range | +/- 5 volts |
| Linear conductivity range | 0.5 to 800 mS/cm |

| TEMPERATURE | |
|---|---|
| Measurement equation | Vo = G exp (A+B/T) + Voff |
| 8 hour calibration stability | Better than 0.01 deg C |
| Time response | Approx. 7E-3 seconds |
| Noise | < 1mV RMS 10 Hz to 200 Hz |
| Output voltage range | +/- 5 volts |
| Temperature range | -10 to 100 deg C |

## PANEL FUNCTIONS

The Model 125 front panel has several displays and controls. Each of these is described below:

**POWER –** This switch controls power to the electronic bridge and preamplifier assembly. The adjacent light is 'on' when power is applied. Note that the switch simply interrupts power from the power supply module and does not control the power supply module in any way.

**GAIN - TEMPERATURE –** This controls 'G' in the temperature measurement equation mentioned above. 'CW' operation of this adjustment increases 'G'.

**GAIN - CONDUCTIVITY –** This controls 'G' in the conductivity measurement equation mentioned above. 'CW' operation of this adjustment increases 'G'.

**PHASE ERROR –** This lamp comes on when the sensor's electrodes have become damaged or fouled and indicates that the conductivity cell is having difficulty passing current into the solution. Momentary phase errors cause this lamp's output to latch for about one second.

**OVER RANGE –** This lamp comes on when either the conductivity or temperature circuits have voltages within them that are outside of the operating range. Having 'G' settings that are too high usually causes this condition. Momentary over ranges cause this lamp's output to latch for about one second.

The Model 125 back panel contains several connectors. The function of each is fairly obvious except for the circuit outputs that are BNCs. The outer BNC supplies Conductivity Vo. The inner BNC supplies Temperature Vo.

## GROUNDING

The Model 125 must always be used with grounded solutions. You have the option of grounding the solution yourself or using the ground supplied by the preamplifier-sensor shaft. The preamplifier-sensor shaft is wired through the cable to JMP 1 on the main bridge's circuit board, near the preamp connector. JMP 1 is accessible by removing the two screws that hold the bridge's cover. The Model 125 is shipped with JMP 1 shorted, connecting the preamp-sensor shaft to circuit ground. If you break this connection, then the preamp-sensor shaft and the sensor float free of circuit ground. This allows you to provide ground to the solution in whatever way that is required. The Model 125 circuit ground must be connected to this ground through the outer side of either BNC on the back panel.

## CALIBRATION

Precision Measurement Engineering (PME) performs temperature calibration when the Model 125 is initially supplied. In this condition, a small piece of tape is placed over the GAIN-TEMPERATURE potentiometer access hole. This is intended to prevent accidental adjustment of this potentiometer creating an uncalibrated condition. The conductivity channel is not calibrated by PME. When a new sensor is installed, the customer must perform both calibrations.

Calibration of the Model 125 is performed in three stages: 'G' setup for proper range, calibration data acquisition, and numerical analysis. Each of these is discussed below:

**G SETUP** - It is important that the instrument does not go out of range during an experiment. To insure that it does not, you must first set both 'G' adjustments at the maximum experimental conditions. The procedure is:

1. Turn both gain pots fully CCW. The over range lamp should be dark.
2. Place the sensor in a solution at the lowest temperature expected during the experiment. Adjust the temperature gain pot CW until the over range light comes on. Back the pot off CCW ½ to 1 turn. If the light does not come on, then leave the pot set fully CW.
3. Place the sensor in a solution at the highest

conductivity expected. Adjust the conductivity gain pot CW until the over range light comes on. Back the pot off CCW ½ to 1 turn. If the light does not come on, then leave the post set fully CW.

**CALIBRATION DATA ACQUISITION-** This process depends on the accuracy that you need in your experiment. Calibration of the Model 125 depends on laboratory standards for temperature and conductivity that you supply. The Model 125 will not measure more accurately than these standards. The procedure for simple calibration using a 0.1 deg C resolution thermometer and one solution of know conductivity is given below.

1. Turn the electronic bridge off. Disconnect the preamplifier-sensor cable. Turn the electronic bridge on. Record the voltage at the temperature output. This voltage is temperature Voff. It should be approximately -5 volts. Turn the power off and reconnect the cable. Turn the power on.

2. Expose the sensor to two stirred solutions at temperatures approximately bracketing the expected temperature span of the experiment. Record the temperature from the reference thermometer and the voltage at the temperature output.

3. Hold the sensor with the tip up and gently shake the water from the electrodes. Record the voltage at the conductivity output. This voltage is conductivity Voff. It should be approximately -5 volts.

4. Place the sensor in a solution of known conductivity that is near the highest conductivity expected. (Conductivity can be calculated from density and temperature or salt concentration and temperature or otherwise known.) Record the conductivity and the voltage at the conductivity output.

**NUMERICAL ANALYSIS-** A numerical means for connecting voltage outputs from the Model 125 with their corresponding conductivity and temperatures is described below.

1. Use the temperature response equation given in the Specifications section. Include 'G' in the coefficients 'A' and 'B'. Find a simultaneous solution to the equation:

   $$1n\ (V(T)-Voff) = A + B/T \quad (T \text{ in deg K})$$

   for 'A' and 'B' by using the two data points. If your reference measurement of 'T' was absolutely certain, then this equation will give fit errors of about 0.05 deg C over a 20 deg C span.

2. Use the conductivity response equation given in the Specifications section. Solve:

   V(C) - Voff = G * C

   for ‘G’ using the data point measured above. If your measurement of conductivity was absolutely certain, then this equation will give fit errors of less than 1% of the reading over the linear range of conductivity.

## MAINTENANCE

Maintenance of the Model 125 consists of keeping the sensor, preamplifier, and cable assembly free from physical damage, rinsed off, and dry.

From time to time a sensor assembly will need to be replaced. The procedures are:

1. Remove the outer screw (screw #1) nearest the cable end of the preamplifier. Place it in a cup to prevent loss. It is very small. Refer to Sensor Replacement drawing.

2. Grip the stainless steel shaft and carefully slide the preamplifier cover toward the sensor until all the interior parts are exposed.

3. Clip the six wires (4 - conductivity and 2 - temperature) about 1 cm from each connecting point on the circuit board. Do this so that some of the color from each wire remains connected to the circuit board. This will help when soldering the new wires.

4. Loosen the set-screw (screw #2) in the shaft retaining bracket at the shaft end of the preamplifier circuit board.

5. Withdraw the stainless steel shaft. Slide the preamplifier cover off the stainless steel shaft. Discard the used shaft.

6. Inspect the o-ring at the cable end of the preamplifier for any cuts or debris. If detected, then replace. Next, apply a small amount of silicon oil around the o-ring.

7. Remove the outer screw (screw #3) on the preamplifier cover that holds the nosepiece. Inspect

the o-ring for cuts or debris. If detected, then replace. Apply a small amount of silicon oil around the o-ring.

8. The nosepiece has a smaller, inner o-ring. Carefully remove it and inspect for cuts or debris. If detected, then replace. Apply a small amount of silicon oil around the o-ring before replacing it back into the nosepiece.

9. Slide the nosepiece onto the preamplifier cover. Be sure not to cut the outer o-ring with the cover. Install the outer screw (screw #3). Be careful not to over tighten.

10. Insert the o-ring expander into the stainless steel shaft where the wires protrude. Insert the wires through the clear, plastic tubing. The fit is not tight and the expander will fall to the side. See the Sensor Insertion drawing.

11. Apply a small amount of silicon oil to the end of the new stainless steel shaft and to the o-ring expander. **Do not put silicone oil on the clear, plastic tubing since it will be inserted into the shaft.**

12. Insert the wires through the nosepiece and carefully slide the preamplifier cover onto the o-ring expander. While holding the preamplifier cover, position the o-ring expander so that it is flush with the stainless steel shaft. Keep the expander and shaft in a straight, horizontal position. Gently push the preamplifier cover over the expander/shaft section and onto the shaft being careful not to cut the inner o-ring. See the Shaft Insertion drawing.

13. Once the preamplifier cover is on the shaft, remove the o-ring expander and insert the wires through the shaft-retaining bracket. Insert the shaft fully into the bracket and tighten the set-screw (screw #2).

14. One at time, unsolder the old wire on the circuit board and solder the new wire (that has been stripped) onto the connecting point. Be careful not to switch the colors. If you become confused, then refer to the Sensor Connection drawing. If you coat the stripped end of the wire with solder flux, then it becomes much easier to solder.

15. Be sure to inspect the solders and cut any exposed-stripped wire.

16. Carefully slide the preamplifier cover back into place over the circuit board. To insure that the cover does not cut the wires, be sure that they are

positioned near the center of the circuit board. Be careful not to cut the o-ring near the cable end as the cover slides over it.

17. Install the outer screw (screw #1). Be careful not to over tighten. Wipe off any remaining silicon oil on the shaft or preamplifier cover.

## REFERENCES


Thermistor Calibration: Thermometrics (1995), **Thermistors Catalog**, Thermometrics, Inc., 808 U.S. Hwy 1, Edison, New Jersey 08817, Phone 1(800) 246-7019. This catalog is free upon request from Thermometrics.

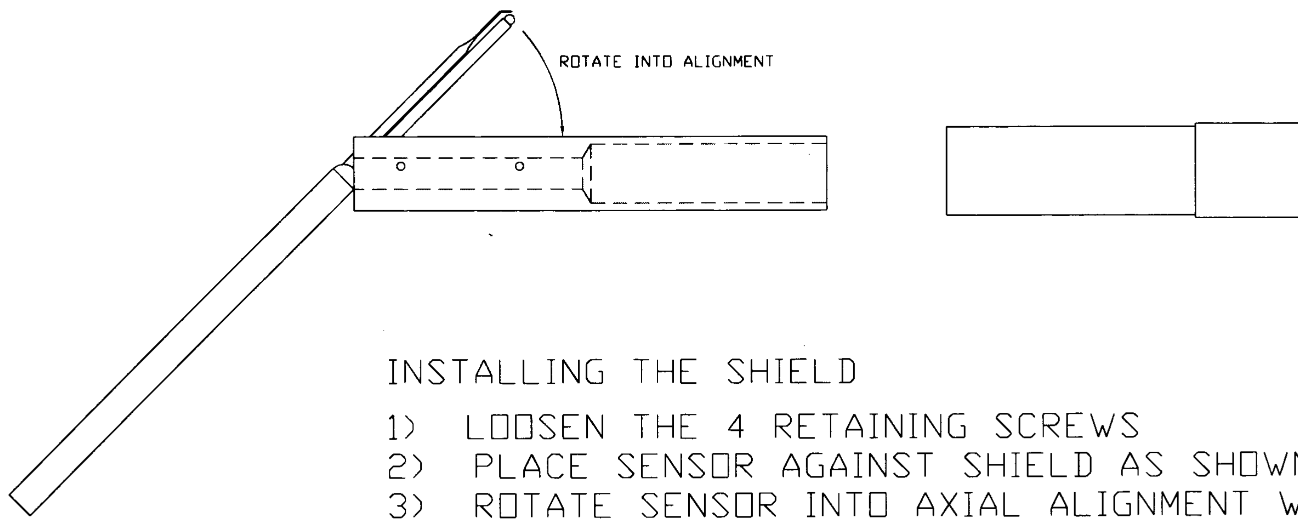
Conductivity for Sodium Chloride Solutions: Chiu, Ying-Check and Fuoss, Raymond M., “Conductance of the Alkali Halides XII. Sodium and Potassium Chloride in Water at 25 C.” **Journal of Physical Chemistry**, Vol. 72, # 12, (1968), pp. 4123 - 4129.

Hewitt, G.F., “Tables of the Resistivity of Aqueous Sodium Chloride Solutions”, Atomic Energy Research Establishment (Great Britain), **Report R3497**, (1960).

Surdo, Antonio Lo, Alzda, E.M. and Millero, F.J., “The PVT Properties of Concentrated Aqueous Electrolytes. I. Densities and Apparent Molal Volumes of NaCl, Na2SO4, MgC12, and MgSO4 solutions from 0.1 to Saturation and from 273.15 to 323.15 K”, **Journal of Chemical Thermodynamics**, Vol. 14 (1982), pp. 649 - 662.

Conductivity for Seawater: “Special Issue on the Practical Salinity Scale”, **IEEE J. of Oceanic Engineering**, Vol. OE-5, #1 (1980).

MSCTI Instrument: Head, M. J., “The Use of Miniature Four-Electrode Conductivity Probes for High Resolution Measurement of Turbulent Density or Temperature Variations in Salt-Stratified Water Flow”, **Ph.D. Thesis, University of California, San Diego**, 1983.




# INSTALLING THE SHIELD

1) LOOSEN THE 4 RETAINING SCREWS
2) PLACE SENSOR AGAINST SHIELD AS SHOWN
3) ROTATE SENSOR INTO AXIAL ALIGNMENT WITH SHIELD CENTER HOLE
4) GENTLY SLIDE SENSOR INTO SHIELD UNTIL WITHIN 1/4" FROM SHIELD END
5) GENTLY TIGHTEN ALL 4 RETAINING SCREWS
6) WHILE HOLDING SHIELD (NOT SENSOR SHAFT) SLIDE COVER OVER SHIELD
7) AVOID SHARP TAPS ON SENSOR - THEY RESONATE THE CONDUCTIVITY SENSOR AND WILL DAMAGE IT.

| REVISIONS | | |
|---|---|---|
| REV | DESCRIPTION | DATE |

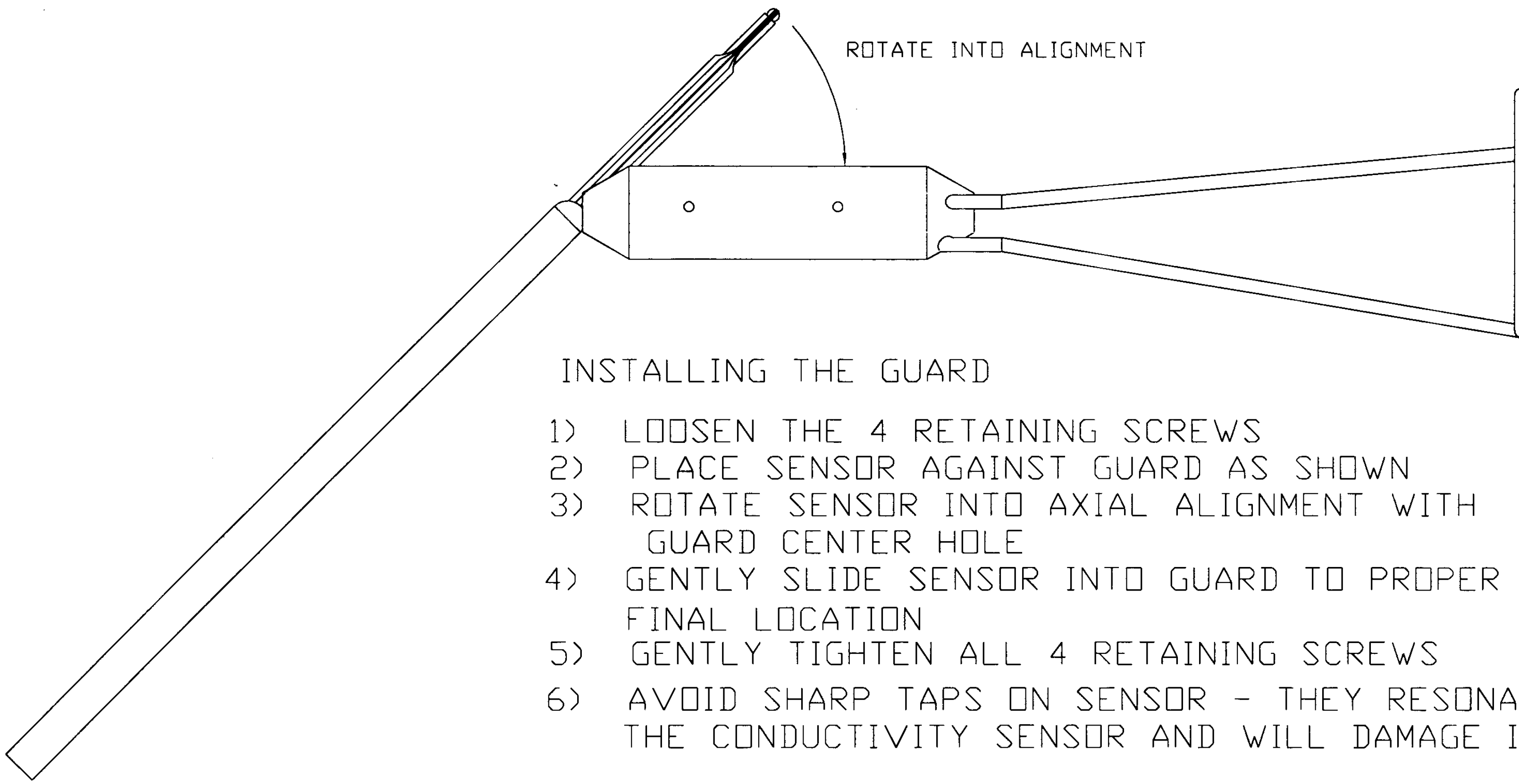
TOLERANCES (unless otherwise noted)
.x
.xx
.xxx

PRECISION MEASUREMENT ENGINEERING
1827 HAWK VIEW DRIVE
ENCINITAS, CA 92024

SENSOR SHIELD

4250

DATE | SHEET | OF




## INSTALLING THE GUARD

1) LOOSEN THE 4 RETAINING SCREWS
2) PLACE SENSOR AGAINST GUARD AS SHOWN
3) ROTATE SENSOR INTO AXIAL ALIGNMENT WITH GUARD CENTER HOLE
4) GENTLY SLIDE SENSOR INTO GUARD TO PROPER FINAL LOCATION
5) GENTLY TIGHTEN ALL 4 RETAINING SCREWS
6) AVOID SHARP TAPS ON SENSOR - THEY RESONATE THE CONDUCTIVITY SENSOR AND WILL DAMAGE IT

| REVISIONS | | |
|---|---|---|
| REV | DESCRIPTION | DATE |

TOLERANCES (unless otherwise noted)
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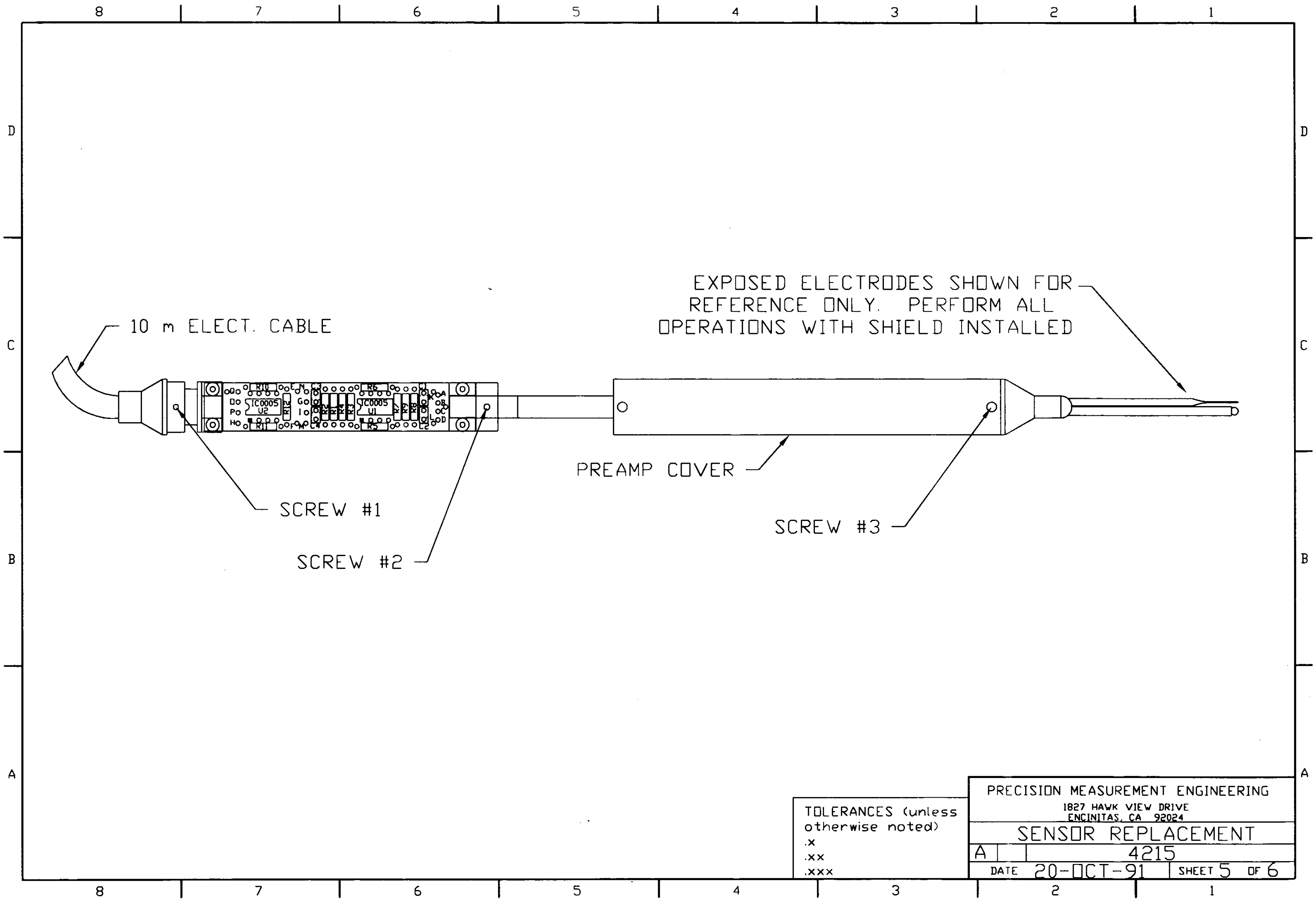
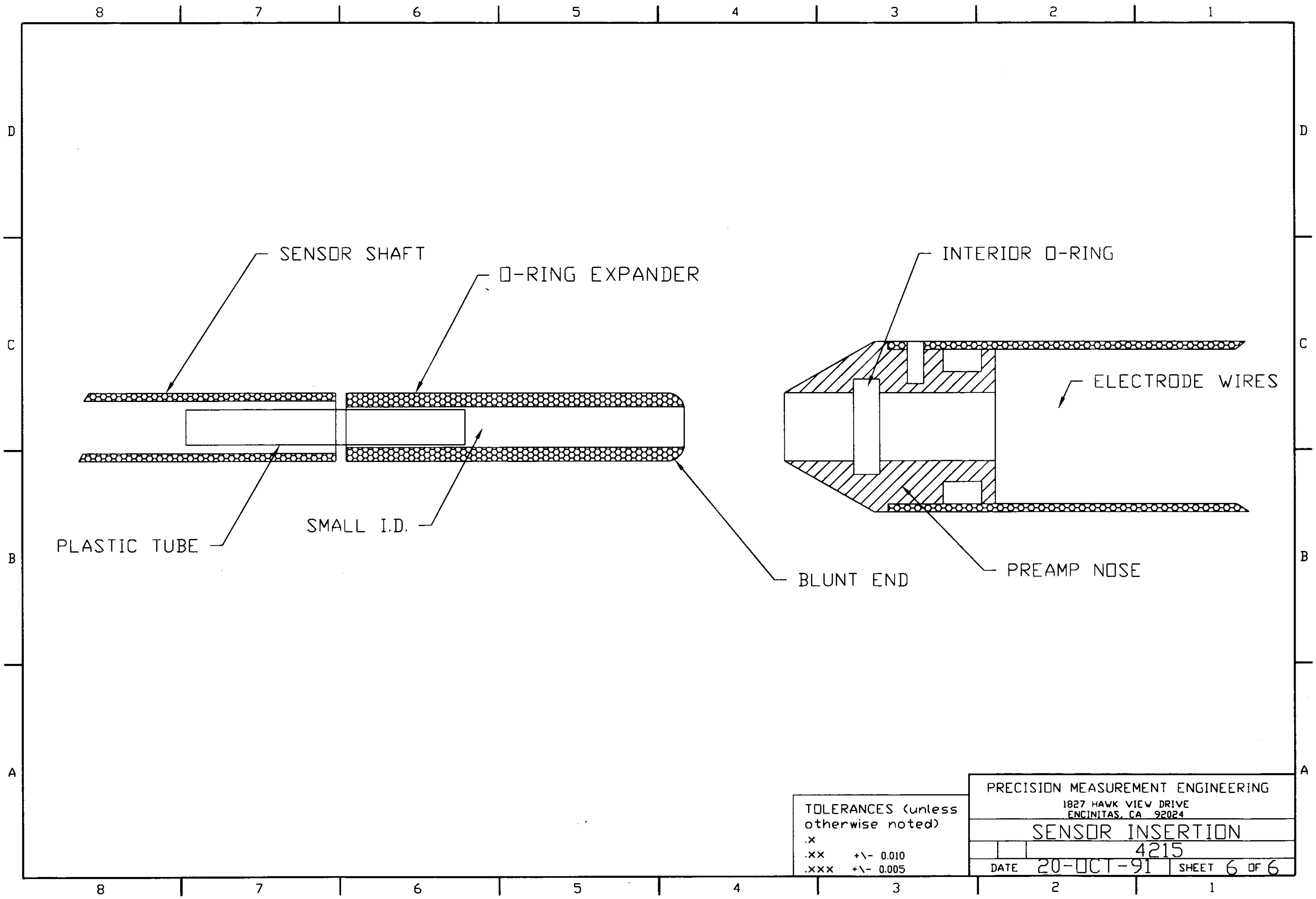
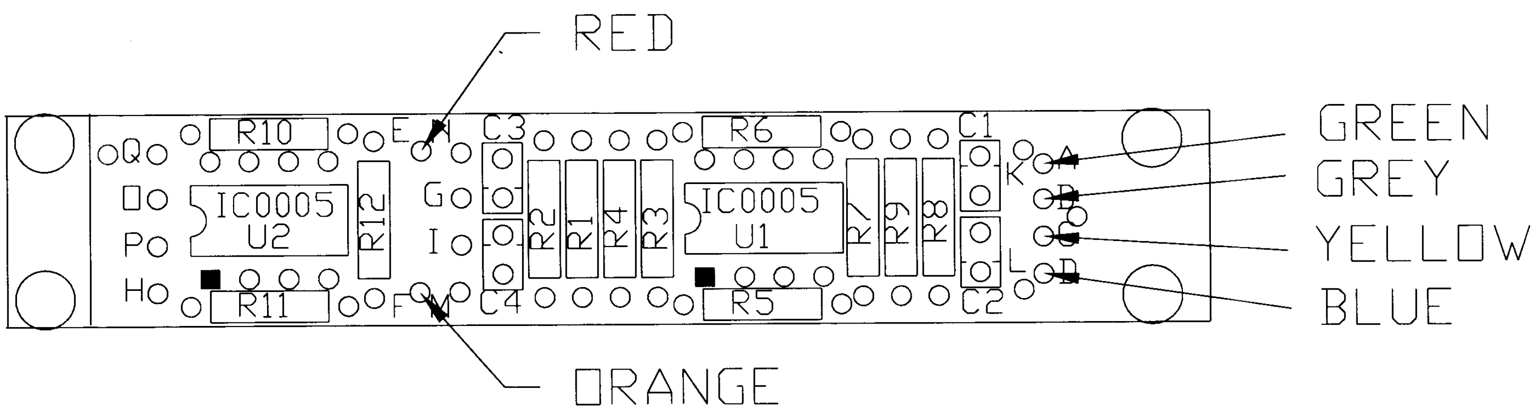
PRECISION MEASUREMENT ENGINEERING
1827 HAWK VIEW DRIVE
ENCINITAS, CA 92024

SENSOR GUARD
5065

DATE | SHEET OF


10 m ELECT. CABLE
EXPOSED ELECTRODES SHOWN FOR REFERENCE ONLY. PERFORM ALL OPERATIONS WITH SHIELD INSTALLED
SCREW #1
SCREW #2
PREAMP COVER
SCREW #3
TOLERANCES (unless otherwise noted)
.x
.xx
.xxx
PRECISION MEASUREMENT ENGINEERING
1827 HAWK VIEW DRIVE
ENCINITAS, CA 92024
SENSOR REPLACEMENT
A
4215
DATE 20-OCT-91
SHEET 5 OF 6


SENSOR SHAFT
O-RING EXPANDER
PLASTIC TUBE
SMALL I.D.
BLUNT END
INTERIOR O-RING
ELECTRODE WIRES
PREAMP NOSE
TOLERANCES (unless otherwise noted)
.x
.xx +\- 0.010
.xxx +\- 0.005
PRECISION MEASUREMENT ENGINEERING
1827 HAWK VIEW DRIVE
ENCINITAS, CA 92024
SENSOR INSERTION
4215
DATE 20-OCT-91
SHEET 6 OF 6




TOLERANCES (unless otherwise noted)
.x
.xx
.xxx

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1827 HAWK VIEW DRIVE
ENCINITAS, CA 92024

SENSOR CONNECTION

4215

DATE 27-APRIL-89

SHEET 3 OF 3

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(Approved for sale)

AERE - R 3497

4215

## TABLES OF THE RESISTIVITY OF AQUEOUS SODIUM CHLORIDE SOLUTIONS

BY

G. F. HEWITT

## ABSTRACT

Tables of the specific resistivity of NaCl solution at 18°C in terms of weight percentage have been derived and are presented. A method of correction for temperature is suggested and tables of temperature coefficient given.

Chemical Engineering Division,
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Atomic Energy Research Establishment,
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October, 1960

HL 60/5450 (S.C. 2)

## CONTENTS



## TABLES

1. Introduction

In work previously reported (1) the author made a critical assessment of the data on the resistivity of sodium chloride solutions and suggested methods of using these data for the interpretation of practical measurements. The above work involved the conversion of the data from the usual molar form to the temperature - invariant form of weight percentage. Graphs were prepared of the data at 18$^\circ$C and temperature coefficient ($b_t$) defined by the equation:

$$R_{18} = R_t\ [1 + b_t(t - 18)] \qquad \sigma_t = \sigma_{18}(1 + b_t(t-18)) \qquad (1)$$

where $R_{18}$, the specific resistivity at 18$^\circ$C, and $R_t$, the value at temperature t$^\circ$C, were correlated. Sodium chloride solutions have recently been extensively used by the author in studying two-phase gas-liquid flow in pipes. In this work conducto-metric methods have been used for the determination of film thickness and it was found useful to prepare a tabulation of resistivities and temperature coefficients making use of the authors earlier work. This tabulation was accomplished by writing simple programmes for the Harwell "Mercury" computer. The object of the present report is to present these tables and the equations used in their derivation.

2. Tabulation of data at 18$^\circ$C

To facilitate interpolation a factor X was defined:

$$X = \%\ \text{NaCl} \times \text{Specific resistivity} \qquad (2)$$

X varied more slowly with concentration than did specific resistivity. The following polynomial expression were obtained for X:

$p(= \%\ \text{NaCl}) < 0.1$     0 - .01 Good

0 < 0.01     .01 - .1 not so good

$$X = \sum_{n=0}^{n=3} a_n(\sqrt{p})^n \qquad (3)$$

where
$a_0$ = 53.5590
$a_1$ = 24.2130
$a_2$ = - 138.3184
$a_3$ = 745.0609

$\frac{\sigma_{25}}{\sigma_{18}} = 1.162067$

$0.1 < p < 1.0$

$$X = \sum_{n=0}^{n=4} a_n (\sqrt{p})^n \qquad (4)$$

where
$a_0 = 53.6508$
$a_1 = 17.7272$
$a_2 = -6.9940$
$a_3 = -2.0216$
$a_4 = 3.0262$

✓ $1.0 < p < 10.0$

$$X = \sum_{n=0}^{n=3} a_n \ln(p)^n \qquad (5)$$

where
$a_0 = 65.3068$
$a_1 = 7.0523$
$a_2 = -3.1346$
$a_3 = 1.4293$

✓ $10 < p < 26$

$$X = \sum_{n=0}^{n=4} a_n \ln(p)^n \qquad (6)$$

where
$a_0 = -923.8866$
$a_1 = 1241.9749$
$a_2 = -546.7730$
$a_3 = 96.6712$
$a_4 = -4.8034$

← corrected by me

Using the above equations a table of specific resistivity against concentration was prepared by means of the computer. This is presented here as table I. The accuracy of the data presented is about ± 4% after taking into account the accuracy of the original data.

3. Temperature coefficient

Coefficients ($b_t$), as defined by equation 1, were calculated for all the available data. The coefficients were independant of concentration for concentration below 0.1% and increased continuously from 0.021 - 0.027 in the temperature range 0 - 140°C. The variation with temperature was fitted by the equation:

$$b_t = \sum_{n=0}^{n=4} a_n t^n \qquad (7)$$

where

$$a_0 = 2.1179818 \times 10^{-2}$$
$$a_1 = 7.8601061 \times 10^{-5}$$
$$a_2 = 1.5439826 \times 10^{-7}$$
$$a_3 = -6.2634979 \times 10^{-9}$$
$$a_4 = 2.2794885 \times 10^{-11}$$

Values of $b_t$ are tabulated in table II. The effect of concentrations on $b_t$ is only slight at moderate concentrations. Tentative corrections for the effect of concentration on $b_t$ are given in table III - insufficient data exists to give more accurate figures.

4. Summary of methods of use:

The use of the tables is best illustrated by taking two examples as follows:

(a) What is the specific resistivity of a sodium chloride solution containing 0.024% NaCl at 63.4°C?

Resistivity at 18°C (Table I) = 2342.6 ohm. cm.

Value of $b_t$ at 63.4°C (Table II) = 0.02552

Concentration correction to $b_t$ (Table III) = 0

Resistivity at 63.4°C (Equation 1)

$$= \frac{2342.6}{1 + 0.02552\,(63.4 - 18)} = 1085.2 \text{ ohm. cm.}$$

(b) What is the concentration of a sodium chloride solution which has a specific resistivity of 110.4 ohm. cm. at 31.7°C?

$b_t$ at 31.7°C = 0.02364

Resistivity at 18°C = 110.4 x (1 + 0.02364 (31.7 - 18))

= 146.16 ohm. cm.

Concentration (Table I) = 0.425%

Concentration correction to $b_t$ (Table III) = -0.0004

New value of $b_t$ = 0.02324

Resistivity at 18°C = 110.4 x (1 + 0.02324 (31.7 - 18)

= 145.56 ohm. cm.

Concentration = 0.428%

The overall accuracy of calculations as described above is about ± ½%.

<u>Reference</u>


(1) Hewitt, G.F. Ph.D. Thesis, Manchester, 1957.

TABLE I.

SODIUM CHLORIDE SOLUTION RESISTIVITIES AT 18°C. (OHM.CM.)

| %NaCl | 0 | 2 | 4 | 6 | 8 | 10 |
|---|---|---|---|---|---|---|
| 0.0010 | 54210 | 53152 | 52136 | 51157 | 50215 | 49306 |
| 0.0011 | 49306 | 48431 | 47586 | 46770 | 45981 | 45219 |
| 0.0012 | 45219 | 44482 | 43768 | 43077 | 42408 | 41759 |
| 0.0013 | 41759 | 41130 | 40520 | 39927 | 39352 | 38793 |
| 0.0014 | 38793 | 38250 | 37722 | 37208 | 36708 | 36222 |
| 0.0015 | 36222 | 35748 | 35287 | 34837 | 34399 | 33971 |
| 0.0016 | 33971 | 33554 | 33148 | 32751 | 32363 | 31985 |
| 0.0017 | 31985 | 31615 | 31254 | 30901 | 30556 | 30219 |
| 0.0018 | 30219 | 29889 | 29566 | 29250 | 28941 | 28639 |
| 0.0019 | 28639 | 28342 | 28052 | 27768 | 27489 | 27216 |
| 0.0020 | 27216 | 26948 | 26686 | 26428 | 26176 | 25928 |
| 0.0021 | 25928 | 25686 | 25447 | 25213 | 24983 | 24758 |
| 0.0022 | 24758 | 24536 | 24319 | 24105 | 23895 | 23689 |
| 0.0023 | 23689 | 23486 | 23287 | 23091 | 22898 | 22709 |
| 0.0024 | 22709 | 22522 | 22339 | 22159 | 21981 | 21807 |
| 0.0025 | 21807 | 21635 | 21466 | 21299 | 21136 | 20974 |
| 0.0026 | 20974 | 20815 | 20659 | 20505 | 20353 | 20203 |
| 0.0027 | 20203 | 20056 | 19910 | 19767 | 19626 | 19487 |
| 0.0028 | 19487 | 19350 | 19215 | 19081 | 18950 | 18820 |
| 0.0029 | 18820 | 18692 | 18566 | 18442 | 18319 | 18198 |
| 0.0030 | 18198 | 18078 | 17960 | 17844 | 17729 | 17615 |
| 0.0031 | 17615 | 17503 | 17393 | 17283 | 17176 | 17069 |
| 0.0032 | 17069 | 16964 | 16860 | 16757 | 16656 | 16556 |
| 0.0033 | 16556 | 16457 | 16359 | 16263 | 16167 | 16073 |
| 0.0034 | 16073 | 15980 | 15888 | 15797 | 15707 | 15618 |
| 0.0035 | 15618 | 15530 | 15443 | 15357 | 15272 | 15187 |
| 0.0036 | 15187 | 15104 | 15022 | 14941 | 14860 | 14780 |
| 0.0037 | 14780 | 14702 | 14624 | 14547 | 14470 | 14395 |
| 0.0038 | 14395 | 14320 | 14246 | 14173 | 14101 | 14029 |
| 0.0039 | 14029 | 13958 | 13888 | 13818 | 13750 | 13681 |
| 0.0040 | 13681 | 13614 | 13547 | 13481 | 13416 | 13351 |
| 0.0041 | 13351 | 13286 | 13223 | 13160 | 13098 | 13036 |
| 0.0042 | 13036 | 12975 | 12914 | 12854 | 12794 | 12735 |
| 0.0043 | 12735 | 12677 | 12619 | 12562 | 12505 | 12449 |
| 0.0044 | 12449 | 12393 | 12338 | 12283 | 12228 | 12175 |
| 0.0045 | 12175 | 12121 | 12068 | 12016 | 11964 | 11912 |
| 0.0046 | 11912 | 11861 | 11811 | 11761 | 11711 | 11661 |
| 0.0047 | 11661 | 11613 | 11564 | 11516 | 11468 | 11421 |
| 0.0048 | 11421 | 11374 | 11327 | 11281 | 11236 | 11190 |
| 0.0049 | 11190 | 11145 | 11100 | 11056 | 11012 | 10969 |
| 0.0050 | 10969 | 10925 | 10882 | 10840 | 10798 | 10756 |
| 0.0051 | 10756 | 10714 | 10673 | 10632 | 10591 | 10551 |
| 0.0052 | 10551 | 10511 | 10471 | 10432 | 10393 | 10354 |
| 0.0053 | 10354 | 10315 | 10277 | 10239 | 10202 | 10164 |
| 0.0054 | 10164 | 10127 | 10090 | 10054 | 10017 | 9981 |

# TABLE I CONTINUED

| °/oNaCl | 0 | 2 | 4 | 6 | 8 | 10 |
|---|---|---|---|---|---|---|
| 0.0055 | 9981 | 9946 | 9910 | 9875 | 9840 | 9805 |
| 0.0056 | 9805 | 9771 | 9736 | 9702 | 9669 | 9635 |
| 0.0057 | 9635 | 9602 | 9569 | 9536 | 9503 | 9471 |
| 0.0058 | 9471 | 9438 | 9407 | 9375 | 9343 | 9312 |
| 0.0059 | 9312 | 9281 | 9250 | 9219 | 9189 | 9158 |
| 0.0060 | 9158 | 9128 | 9099 | 9069 | 9039 | 9010 |
| 0.0061 | 9010 | 8981 | 8952 | 8923 | 8895 | 8866 |
| 0.0062 | 8866 | 8838 | 8810 | 8782 | 8755 | 8727 |
| 0.0063 | 8727 | 8700 | 8673 | 8646 | 8619 | 8593 |
| 0.0064 | 8593 | 8566 | 8540 | 8514 | 8488 | 8462 |
| 0.0065 | 8462 | 8436 | 8411 | 8385 | 8360 | 8335 |
| 0.0066 | 8335 | 8310 | 8286 | 8261 | 8237 | 8212 |
| 0.0067 | 8212 | 8188 | 8164 | 8140 | 8117 | 8093 |
| 0.0068 | 8093 | 8070 | 8046 | 8023 | 8000 | 7977 |
| 0.0069 | 7977 | 7954 | 7932 | 7909 | 7887 | 7865 |
| 0.0070 | 7865 | 7843 | 7821 | 7799 | 7777 | 7755 |
| 0.0071 | 7755 | 7734 | 7712 | 7691 | 7670 | 7649 |
| 0.0072 | 7649 | 7628 | 7607 | 7587 | 7566 | 7546 |
| 0.0073 | 7546 | 7525 | 7505 | 7485 | 7465 | 7445 |
| 0.0074 | 7445 | 7425 | 7405 | 7386 | 7366 | 7347 |
| 0.0075 | 7347 | 7328 | 7309 | 7289 | 7270 | 7252 |
| 0.0076 | 7252 | 7233 | 7214 | 7196 | 7177 | 7159 |
| 0.0077 | 7159 | 7140 | 7122 | 7104 | 7086 | 7068 |
| 0.0078 | 7068 | 7050 | 7033 | 7015 | 6997 | 6980 |
| 0.0079 | 6980 | 6963 | 6945 | 6928 | 6911 | 6894 |
| 0.0080 | 6894 | 6877 | 6860 | 6843 | 6827 | 6810 |
| 0.0081 | 6810 | 6793 | 6777 | 6761 | 6744 | 6728 |
| 0.0082 | 6728 | 6712 | 6696 | 6680 | 6664 | 6648 |
| 0.0083 | 6648 | 6632 | 6617 | 6601 | 6586 | 6570 |
| 0.0084 | 6570 | 6555 | 6540 | 6524 | 6509 | 6494 |
| 0.0085 | 6494 | 6479 | 6464 | 6449 | 6434 | 6420 |
| 0.0086 | 6420 | 6405 | 6390 | 6376 | 6361 | 6347 |
| 0.0087 | 6347 | 6333 | 6318 | 6304 | 6290 | 6276 |
| 0.0088 | 6276 | 6262 | 6248 | 6234 | 6220 | 6206 |
| 0.0089 | 6206 | 6193 | 6179 | 6166 | 6152 | 6139 |
| 0.0090 | 6139 | 6125 | 6112 | 6099 | 6085 | 6072 |
| 0.0091 | 6072 | 6059 | 6046 | 6033 | 6020 | 6007 |
| 0.0092 | 6007 | 5994 | 5982 | 5969 | 5956 | 5944 |
| 0.0093 | 5944 | 5931 | 5919 | 5906 | 5894 | 5881 |
| 0.0094 | 5881 | 5869 | 5857 | 5845 | 5833 | 5821 |
| 0.0095 | 5821 | 5808 | 5797 | 5785 | 5773 | 5761 |
| 0.0096 | 5761 | 5749 | 5737 | 5726 | 5714 | 5702 |
| 0.0097 | 5702 | 5691 | 5679 | 5668 | 5657 | 5645 |
| 0.0098 | 5645 | 5634 | 5623 | 5611 | 5600 | 5589 |
| 0.0099 | 5589 | 5578 | 5567 | 5556 | 5545 | 5534 |

## TABLE I CONTINUED

| % NaCl | 0 | 2 | 4 | 6 | 8 | 10 |
|---|---|---|---|---|---|---|
| 0.010 | 5534.2 | 5428.2 | 5325.4 | 5226.4 | 5131.1 | 5039.2 |
| 0.011 | 5039.2 | 4950.6 | 4865.1 | 4782.5 | 4702.7 | 4625.5 |
| 0.012 | 4625.5 | 4550.9 | 4478.7 | 4408.7 | 4341.0 | 4275.3 |
| 0.013 | 4275.3 | 4211.6 | 4149.7 | 4089.7 | 4031.5 | 3974.8 |
| 0.014 | 3974.8 | 3919.8 | 3866.3 | 3814.2 | 3763.6 | 3714.3 |
| 0.015 | 3714.3 | 3666.2 | 3619.5 | 3573.9 | 3529.4 | 3486.1 |
| 0.016 | 3486.1 | 3443.9 | 3402.6 | 3362.4 | 3323.1 | 3284.7 |
| 0.017 | 3284.7 | 3247.2 | 3210.6 | 3174.8 | 3139.7 | 3105.5 |
| 0.018 | 3105.5 | 3072.0 | 3039.3 | 3007.2 | 2975.8 | 2945.1 |
| 0.019 | 2945.1 | 2915.0 | 2885.6 | 2856.7 | 2828.4 | 2800.7 |
| 0.020 | 2800.7 | 2773.5 | 2746.8 | 2720.7 | 2695.1 | 2669.9 |
| 0.021 | 2669.9 | 2645.2 | 2621.0 | 2597.2 | 2573.9 | 2551.0 |
| 0.022 | 2551.0 | 2528.5 | 2506.3 | 2484.6 | 2463.3 | 2442.3 |
| 0.023 | 2442.3 | 2421.7 | 2401.4 | 2381.5 | 2361.9 | 2342.6 |
| 0.024 | 2342.6 | 2323.7 | 2305.1 | 2286.7 | 2268.7 | 2250.9 |
| 0.025 | 2250.9 | 2233.4 | 2216.2 | 2199.3 | 2182.6 | 2166.2 |
| 0.026 | 2166.2 | 2150.0 | 2134.1 | 2118.4 | 2102.9 | 2087.7 |
| 0.027 | 2087.7 | 2072.7 | 2057.9 | 2043.3 | 2029.0 | 2014.8 |
| 0.028 | 2014.8 | 2000.8 | 1987.1 | 1973.5 | 1960.1 | 1946.9 |
| 0.029 | 1946.9 | 1933.8 | 1921.0 | 1908.3 | 1895.8 | 1883.5 |
| 0.030 | 1883.5 | 1871.3 | 1859.2 | 1847.4 | 1835.7 | 1824.1 |
| 0.031 | 1824.1 | 1812.7 | 1801.4 | 1790.3 | 1779.3 | 1768.4 |
| 0.032 | 1768.4 | 1757.7 | 1747.1 | 1736.7 | 1726.3 | 1716.1 |
| 0.033 | 1716.1 | 1706.0 | 1696.0 | 1686.2 | 1676.5 | 1666.8 |
| 0.034 | 1666.8 | 1657.3 | 1647.9 | 1638.6 | 1629.5 | 1620.4 |
| 0.035 | 1620.4 | 1611.4 | 1602.5 | 1593.7 | 1585.0 | 1576.5 |
| 0.036 | 1576.5 | 1568.0 | 1559.6 | 1551.3 | 1543.0 | 1534.9 |
| 0.037 | 1534.9 | 1526.9 | 1518.9 | 1511.0 | 1503.2 | 1495.5 |
| 0.038 | 1495.5 | 1487.9 | 1480.3 | 1472.9 | 1465.5 | 1458.2 |
| 0.039 | 1458.2 | 1450.9 | 1443.7 | 1436.6 | 1429.6 | 1422.6 |
| 0.040 | 1422.6 | 1415.7 | 1408.9 | 1402.1 | 1395.5 | 1388.8 |
| 0.041 | 1388.8 | 1382.3 | 1375.8 | 1369.3 | 1362.9 | 1356.6 |
| 0.042 | 1356.6 | 1350.4 | 1344.2 | 1338.0 | 1331.9 | 1325.9 |
| 0.043 | 1325.9 | 1319.9 | 1314.0 | 1308.1 | 1302.3 | 1296.6 |
| 0.044 | 1296.6 | 1290.9 | 1285.2 | 1279.6 | 1274.0 | 1268.5 |
| 0.045 | 1268.5 | 1263.1 | 1257.6 | 1252.3 | 1247.0 | 1241.7 |
| 0.046 | 1241.7 | 1236.5 | 1231.3 | 1226.1 | 1221.0 | 1216.0 |
| 0.047 | 1216.0 | 1211.0 | 1206.0 | 1201.1 | 1196.2 | 1191.3 |
| 0.048 | 1191.3 | 1186.5 | 1181.8 | 1177.0 | 1172.4 | 1167.7 |
| 0.049 | 1167.7 | 1163.1 | 1158.5 | 1154.0 | 1149.5 | 1145.0 |
| 0.050 | 1145.0 | 1140.6 | 1136.2 | 1131.8 | 1127.5 | 1123.2 |
| 0.051 | 1123.2 | 1118.9 | 1114.7 | 1110.5 | 1106.3 | 1102.2 |
| 0.052 | 1102.2 | 1098.1 | 1094.0 | 1090.0 | 1086.0 | 1082.0 |
| 0.053 | 1082.0 | 1078.0 | 1074.1 | 1070.2 | 1066.4 | 1062.5 |
| 0.054 | 1062.5 | 1058.7 | 1054.9 | 1051.2 | 1047.5 | 1043.8 |

## TABLE I CONTINUED

| % NaCl | 0 | 2 | 4 | 6 | 8 | 10 |
|---|---|---|---|---|---|---|
| 0.055 | 1043.8 | 1040.1 | 1036.4 | 1032.8 | 1029.2 | 1025.7 |
| 0.056 | 1025.7 | 1022.1 | 1018.6 | 1015.1 | 1011.6 | 1008.2 |
| 0.057 | 1008.2 | 1004.8 | 1001.4 | 998.0 | 994.6 | 991.3 |
| 0.058 | 991.3 | 988.0 | 984.7 | 981.5 | 978.2 | 975.0 |
| 0.059 | 975.0 | 971.8 | 968.6 | 965.5 | 962.4 | 959.2 |
| 0.060 | 959.2 | 956.2 | 953.1 | 950.0 | 947.0 | 944.0 |
| 0.061 | 944.0 | 941.0 | 938.0 | 935.1 | 932.1 | 929.2 |
| 0.062 | 929.2 | 926.3 | 923.4 | 920.6 | 917.7 | 914.9 |
| 0.063 | 914.9 | 912.1 | 909.3 | 906.5 | 903.8 | 901.1 |
| 0.064 | 901.1 | 898.3 | 895.6 | 892.9 | 890.3 | 887.6 |
| 0.065 | 887.6 | 885.0 | 882.4 | 879.7 | 877.2 | 874.6 |
| 0.066 | 874.6 | 872.0 | 869.5 | 866.9 | 864.4 | 861.9 |
| 0.067 | 861.9 | 859.4 | 857.0 | 854.5 | 852.1 | 849.6 |
| 0.068 | 849.6 | 847.2 | 844.8 | 842.4 | 840.1 | 837.7 |
| 0.069 | 837.7 | 835.4 | 833.0 | 830.7 | 828.4 | 826.1 |
| 0.070 | 826.1 | 823.8 | 821.6 | 819.3 | 817.1 | 814.9 |
| 0.071 | 814.9 | 812.6 | 810.4 | 808.2 | 806.1 | 803.9 |
| 0.072 | 803.9 | 801.7 | 799.6 | 797.5 | 795.3 | 793.2 |
| 0.073 | 793.2 | 791.1 | 789.0 | 787.0 | 784.9 | 782.9 |
| 0.074 | 782.9 | 780.8 | 778.8 | 776.8 | 774.8 | 772.8 |
| 0.075 | 772.8 | 770.8 | 768.8 | 766.8 | 764.9 | 762.9 |
| 0.076 | 762.9 | 761.0 | 759.0 | 757.1 | 755.2 | 753.3 |
| 0.077 | 753.3 | 751.4 | 749.6 | 747.7 | 745.8 | 744.0 |
| 0.078 | 744.0 | 742.1 | 740.3 | 738.5 | 736.7 | 734.9 |
| 0.079 | 734.9 | 733.1 | 731.3 | 729.5 | 727.7 | 726.0 |
| 0.080 | 726.0 | 724.2 | 722.5 | 720.8 | 719.0 | 717.3 |
| 0.081 | 717.3 | 715.6 | 713.9 | 712.2 | 710.5 | 708.9 |
| 0.082 | 708.9 | 707.2 | 705.5 | 703.9 | 702.2 | 700.6 |
| 0.083 | 700.6 | 699.0 | 697.4 | 695.7 | 694.1 | 692.5 |
| 0.084 | 692.5 | 690.9 | 689.4 | 687.8 | 686.2 | 684.7 |
| 0.085 | 684.7 | 683.1 | 681.6 | 680.0 | 678.5 | 677.0 |
| 0.086 | 677.0 | 675.5 | 673.9 | 672.4 | 670.9 | 669.4 |
| 0.087 | 669.4 | 668.0 | 666.5 | 665.0 | 663.6 | 662.1 |
| 0.088 | 662.1 | 660.6 | 659.2 | 657.8 | 656.3 | 654.9 |
| 0.089 | 654.9 | 653.5 | 652.1 | 650.7 | 649.3 | 647.9 |
| 0.090 | 647.9 | 646.5 | 645.1 | 643.7 | 642.4 | 641.0 |
| 0.091 | 641.0 | 639.6 | 638.3 | 637.0 | 635.6 | 634.3 |
| 0.092 | 634.3 | 632.9 | 631.6 | 630.3 | 629.0 | 627.7 |
| 0.093 | 627.7 | 626.4 | 625.1 | 623.8 | 622.5 | 621.2 |
| 0.094 | 621.2 | 620.0 | 618.7 | 617.4 | 616.2 | 614.9 |
| 0.095 | 614.9 | 613.7 | 612.4 | 611.2 | 610.0 | 608.7 |
| 0.096 | 608.7 | 607.5 | 606.3 | 605.1 | 603.9 | 602.7 |
| 0.097 | 602.7 | 601.5 | 600.3 | 599.1 | 597.9 | 596.8 |
| 0.098 | 596.8 | 595.6 | 594.4 | 593.2 | 592.1 | 590.9 |
| 0.099 | 590.9 | 589.8 | 588.6 | 587.5 | 586.4 | 585.2 |

# TABLE I CONTINUED

| % NaCl | 0 | 2 | 4 | 6 | 8 | 10 |
|---|---|---|---|---|---|---|
| 0.10 | 585.24 | 574.16 | 563.51 | 553.26 | 543.38 | 533.85 |
| 0.11 | 533.85 | 524.66 | 515.79 | 507.22 | 498.94 | 490.93 |
| 0.12 | 490.93 | 483.18 | 475.68 | 468.41 | 461.37 | 454.54 |
| 0.13 | 454.54 | 447.91 | 441.48 | 435.23 | 429.17 | 423.27 |
| 0.14 | 423.27 | 417.54 | 411.96 | 406.54 | 401.26 | 396.12 |
| 0.15 | 396.12 | 391.11 | 386.23 | 381.48 | 376.84 | 372.32 |
| 0.16 | 372.32 | 367.90 | 363.60 | 359.39 | 355.29 | 351.27 |
| 0.17 | 351.27 | 347.36 | 343.52 | 339.78 | 336.12 | 332.54 |
| 0.18 | 332.54 | 329.03 | 325.60 | 322.25 | 318.96 | 315.74 |
| 0.19 | 315.74 | 312.59 | 309.50 | 306.47 | 303.51 | 300.60 |
| 0.20 | 300.60 | 297.75 | 294.95 | 292.21 | 289.52 | 286.88 |
| 0.21 | 286.88 | 284.29 | 281.74 | 279.25 | 276.79 | 274.39 |
| 0.22 | 274.39 | 272.02 | 269.69 | 267.41 | 265.17 | 262.96 |
| 0.23 | 262.96 | 260.79 | 258.66 | 256.56 | 254.50 | 252.47 |
| 0.24 | 252.47 | 250.48 | 248.51 | 246.58 | 244.68 | 242.81 |
| 0.25 | 242.81 | 240.97 | 239.15 | 237.37 | 235.61 | 233.88 |
| 0.26 | 233.88 | 232.17 | 230.49 | 228.83 | 227.20 | 225.60 |
| 0.27 | 225.60 | 224.01 | 222.45 | 220.91 | 219.39 | 217.89 |
| 0.28 | 217.89 | 216.42 | 214.96 | 213.53 | 212.11 | 210.72 |
| 0.29 | 210.72 | 209.34 | 207.98 | 206.64 | 205.31 | 204.01 |
| 0.30 | 204.01 | 202.72 | 201.45 | 200.19 | 198.95 | 197.72 |
| 0.31 | 197.72 | 196.52 | 195.32 | 194.14 | 192.98 | 191.83 |
| 0.32 | 191.83 | 190.69 | 189.57 | 188.46 | 187.36 | 186.28 |
| 0.33 | 186.28 | 185.21 | 184.15 | 183.11 | 182.08 | 181.05 |
| 0.34 | 181.05 | 180.05 | 179.05 | 178.06 | 177.09 | 176.12 |
| 0.35 | 176.12 | 175.17 | 174.22 | 173.29 | 172.37 | 171.46 |
| 0.36 | 171.46 | 170.56 | 169.66 | 168.78 | 167.91 | 167.04 |
| 0.37 | 167.04 | 166.19 | 165.34 | 164.50 | 163.67 | 162.85 |
| 0.38 | 162.85 | 162.04 | 161.24 | 160.44 | 159.66 | 158.88 |
| 0.39 | 158.88 | 158.10 | 157.34 | 156.58 | 155.84 | 155.09 |
| 0.40 | 155.09 | 154.36 | 153.63 | 152.91 | 152.20 | 151.49 |
| 0.41 | 151.49 | 150.79 | 150.10 | 149.41 | 148.73 | 148.06 |
| 0.42 | 148.06 | 147.39 | 146.73 | 146.08 | 145.43 | 144.78 |
| 0.43 | 144.78 | 144.15 | 143.52 | 142.89 | 142.27 | 141.65 |
| 0.44 | 141.65 | 141.05 | 140.44 | 139.84 | 139.25 | 138.66 |
| 0.45 | 138.66 | 138.08 | 137.50 | 136.93 | 136.36 | 135.80 |
| 0.46 | 135.80 | 135.24 | 134.68 | 134.14 | 133.59 | 133.05 |
| 0.47 | 133.05 | 132.52 | 131.98 | 131.46 | 130.94 | 130.42 |
| 0.48 | 130.42 | 129.90 | 129.39 | 128.89 | 128.39 | 127.89 |
| 0.49 | 127.89 | 127.40 | 126.91 | 126.42 | 125.94 | 125.46 |
| 0.50 | 125.46 | 124.99 | 124.52 | 124.05 | 123.59 | 123.13 |
| 0.51 | 123.13 | 122.67 | 122.22 | 121.77 | 121.32 | 120.88 |
| 0.52 | 120.88 | 120.44 | 120.00 | 119.57 | 119.14 | 118.72 |
| 0.53 | 118.72 | 118.29 | 117.87 | 117.46 | 117.04 | 116.63 |
| 0.54 | 116.63 | 116.22 | 115.82 | 115.42 | 115.02 | 114.62 |

# TABLE I CONTINUED

| % NaCl | 0 | 2 | 4 | 6 | 8 | 10 |
|---|---|---|---|---|---|---|
| 0.55 | 114.62 | 114.23 | 113.84 | 113.45 | 113.06 | 112.68 |
| 0.56 | 112.68 | 112.30 | 111.92 | 111.55 | 111.18 | 110.81 |
| 0.57 | 110.81 | 110.44 | 110.08 | 109.72 | 109.36 | 109.00 |
| 0.58 | 109.00 | 108.65 | 108.29 | 107.94 | 107.60 | 107.25 |
| 0.59 | 107.25 | 106.91 | 106.57 | 106.23 | 105.89 | 105.56 |
| 0.60 | 105.56 | 105.23 | 104.90 | 104.57 | 104.25 | 103.92 |
| 0.61 | 103.92 | 103.60 | 103.28 | 102.97 | 102.65 | 102.34 |
| 0.62 | 102.34 | 102.03 | 101.72 | 101.41 | 101.11 | 100.80 |
| 0.63 | 100.80 | 100.50 | 100.20 | 99.90 | 99.61 | 99.31 |
| 0.64 | 99.31 | 99.02 | 98.73 | 98.44 | 98.16 | 97.87 |
| 0.65 | 97.87 | 97.59 | 97.31 | 97.03 | 96.75 | 96.47 |
| 0.66 | 96.47 | 96.20 | 95.92 | 95.65 | 95.38 | 95.11 |
| 0.67 | 95.11 | 94.84 | 94.58 | 94.32 | 94.05 | 93.79 |
| 0.68 | 93.79 | 93.53 | 93.28 | 93.02 | 92.76 | 92.51 |
| 0.69 | 92.51 | 92.26 | 92.01 | 91.76 | 91.51 | 91.26 |
| 0.70 | 91.26 | 91.02 | 90.78 | 90.53 | 90.29 | 90.05 |
| 0.71 | 90.05 | 89.82 | 89.58 | 89.34 | 89.11 | 88.88 |
| 0.72 | 88.88 | 88.64 | 88.41 | 88.18 | 87.96 | 87.73 |
| 0.73 | 87.73 | 87.50 | 87.28 | 87.06 | 86.84 | 86.61 |
| 0.74 | 86.61 | 86.40 | 86.18 | 85.96 | 85.74 | 85.53 |
| 0.75 | 85.53 | 85.32 | 85.10 | 84.89 | 84.68 | 84.47 |
| 0.76 | 84.47 | 84.26 | 84.06 | 83.85 | 83.64 | 83.44 |
| 0.77 | 83.44 | 83.24 | 83.04 | 82.83 | 82.63 | 82.44 |
| 0.78 | 82.44 | 82.24 | 82.04 | 81.85 | 81.65 | 81.46 |
| 0.79 | 81.46 | 81.26 | 81.07 | 80.88 | 80.69 | 80.50 |
| 0.80 | 80.50 | 80.31 | 80.13 | 79.94 | 79.75 | 79.57 |
| 0.81 | 79.57 | 79.39 | 79.20 | 79.02 | 78.84 | 78.66 |
| 0.82 | 78.66 | 78.48 | 78.30 | 78.13 | 77.95 | 77.77 |
| 0.83 | 77.77 | 77.60 | 77.42 | 77.25 | 77.08 | 76.91 |
| 0.84 | 76.91 | 76.74 | 76.57 | 76.40 | 76.23 | 76.06 |
| 0.85 | 76.06 | 75.89 | 75.73 | 75.56 | 75.40 | 75.23 |
| 0.86 | 75.23 | 75.07 | 74.91 | 74.75 | 74.59 | 74.43 |
| 0.87 | 74.43 | 74.27 | 74.11 | 73.95 | 73.79 | 73.64 |
| 0.88 | 73.64 | 73.48 | 73.33 | 73.17 | 73.02 | 72.86 |
| 0.89 | 72.86 | 72.71 | 72.56 | 72.41 | 72.26 | 72.11 |
| 0.90 | 72.11 | 71.96 | 71.81 | 71.66 | 71.52 | 71.37 |
| 0.91 | 71.37 | 71.23 | 71.08 | 70.94 | 70.79 | 70.65 |
| 0.92 | 70.65 | 70.51 | 70.36 | 70.22 | 70.08 | 69.94 |
| 0.93 | 69.94 | 69.80 | 69.66 | 69.53 | 69.39 | 69.25 |
| 0.94 | 69.25 | 69.11 | 68.98 | 68.84 | 68.71 | 68.57 |
| 0.95 | 68.57 | 68.44 | 68.31 | 68.17 | 68.04 | 67.91 |
| 0.96 | 67.91 | 67.78 | 67.65 | 67.52 | 67.39 | 67.26 |
| 0.97 | 67.26 | 67.13 | 67.00 | 66.88 | 66.75 | 66.62 |
| 0.98 | 66.62 | 66.50 | 66.37 | 66.25 | 66.12 | 66.00 |
| 0.99 | 66.00 | 65.88 | [illegible] | [illegible] | [illegible] | [illegible] |

# TABLE I CONTINUED

| %NaCl | 0 | 2 | 4 | 6 | 8 | 10 |
|---|---|---|---|---|---|---|
| 1.0 | 65.387 | 64.162 | 63.056 | 61.988 | 60.955 | 59.956 |
| 1.1 | 59.956 | 58.989 | 58.053 | 57.146 | 56.267 | 55.414 |
| 1.2 | 55.414 | 54.587 | 53.785 | 53.005 | 52.249 | 51.513 |
| 1.3 | 51.513 | 50.798 | 50.103 | 49.427 | 48.769 | 48.128 |
| 1.4 | 48.128 | 47.504 | 46.896 | 46.304 | 45.727 | 45.164 |
| 1.5 | 45.164 | 44.615 | 44.080 | 43.557 | 43.047 | 42.548 |
| 1.6 | 42.548 | 42.062 | 41.586 | 41.122 | 40.667 | 40.223 |
| 1.7 | 40.223 | 39.789 | 39.364 | 38.949 | 38.542 | 38.144 |
| 1.8 | 38.144 | 37.754 | 37.373 | 36.999 | 36.633 | 36.274 |
| 1.9 | 36.274 | 35.922 | 35.577 | 35.239 | 34.908 | 34.583 |
| 2.0 | 34.583 | 34.264 | 33.951 | 33.644 | 33.342 | 33.046 |
| 2.1 | 33.046 | 32.756 | 32.471 | 32.191 | 31.915 | 31.645 |
| 2.2 | 31.645 | 31.379 | 31.118 | 30.862 | 30.610 | 30.362 |
| 2.3 | 30.362 | 30.118 | 29.878 | 29.642 | 29.410 | 29.182 |
| 2.4 | 29.182 | 28.958 | 28.737 | 28.519 | 28.305 | 28.095 |
| 2.5 | 28.095 | 27.887 | 27.683 | 27.482 | 27.284 | 27.089 |
| 2.6 | 27.089 | 26.896 | 26.707 | 26.520 | 26.337 | 26.155 |
| 2.7 | 26.155 | 25.977 | 25.801 | 25.627 | 25.456 | 25.288 |
| 2.8 | 25.288 | 25.121 | 24.957 | 24.795 | 24.636 | 24.478 |
| 2.9 | 24.478 | 24.323 | 24.170 | 24.019 | 23.869 | 23.722 |
| 3.0 | 23.722 | 23.577 | 23.433 | 23.292 | 23.152 | 23.014 |
| 3.1 | 23.014 | 22.878 | 22.743 | 22.610 | 22.479 | 22.349 |
| 3.2 | 22.349 | 22.221 | 22.095 | 21.970 | 21.846 | 21.725 |
| 3.3 | 21.725 | 21.604 | 21.485 | 21.367 | 21.251 | 21.136 |
| 3.4 | 21.136 | 21.022 | 20.910 | 20.799 | 20.689 | 20.581 |
| 3.5 | 20.581 | 20.473 | 20.367 | 20.262 | 20.159 | 20.056 |
| 3.6 | 20.056 | 19.954 | 19.854 | 19.755 | 19.656 | 19.559 |
| 3.7 | 19.559 | 19.463 | 19.368 | 19.274 | 19.181 | 19.088 |
| 3.8 | 19.088 | 18.997 | 18.907 | 18.817 | 18.729 | 18.641 |
| 3.9 | 18.641 | 18.555 | 18.469 | 18.384 | 18.300 | 18.217 |
| 4.0 | 18.217 | 18.134 | 18.053 | 17.972 | 17.892 | 17.813 |
| 4.1 | 17.813 | 17.734 | 17.656 | 17.579 | 17.503 | 17.428 |
| 4.2 | 17.428 | 17.353 | 17.279 | 17.205 | 17.133 | 17.060 |
| 4.3 | 17.060 | 16.989 | 16.918 | 16.848 | 16.779 | 16.710 |
| 4.4 | 16.710 | 16.642 | 16.574 | 16.507 | 16.441 | 16.375 |
| 4.5 | 16.375 | 16.309 | 16.245 | 16.181 | 16.117 | 16.054 |
| 4.6 | 16.054 | 15.992 | 15.930 | 15.868 | 15.807 | 15.747 |
| 4.7 | 15.747 | 15.687 | 15.628 | 15.569 | 15.511 | 15.453 |
| 4.8 | 15.453 | 15.395 | 15.338 | 15.282 | 15.226 | 15.170 |
| 4.9 | 15.170 | 15.115 | 15.061 | 15.006 | 14.953 | 14.899 |
| 5.0 | 14.899 | 14.846 | 14.794 | 14.742 | 14.690 | 14.639 |
| 5.1 | 14.639 | 14.588 | 14.537 | 14.487 | 14.438 | 14.388 |
| 5.2 | 14.388 | 14.339 | 14.291 | 14.242 | 14.195 | 14.147 |
| 5.3 | 14.147 | 14.100 | 14.053 | 14.007 | 13.961 | 13.915 |
| 5.4 | 13.915 | 13.869 | 13.824 | 13.780 | 13.735 | 13.691 |

## TABLE I CONTINUED

| %NaCl | 0 | 2 | 4 | 6 | 8 | 10 |
|---|---|---|---|---|---|---|
| 5.5 | 13.691 | 13.647 | 13.604 | 13.561 | 13.518 | 13.475 |
| 5.6 | 13.475 | 13.433 | 13.391 | 13.349 | 13.308 | 13.267 |
| 5.7 | 13.267 | 13.226 | 13.186 | 13.145 | 13.105 | 13.066 |
| 5.8 | 13.066 | 13.026 | 12.987 | 12.948 | 12.910 | 12.871 |
| 5.9 | 12.871 | 12.833 | 12.796 | 12.758 | 12.721 | 12.684 |
| 6.0 | 12.684 | 12.647 | 12.610 | 12.574 | 12.538 | 12.502 |
| 6.1 | 12.502 | 12.466 | 12.431 | 12.396 | 12.361 | 12.326 |
| 6.2 | 12.326 | 12.291 | 12.257 | 12.223 | 12.189 | 12.156 |
| 6.3 | 12.156 | 12.122 | 12.089 | 12.056 | 12.023 | 11.990 |
| 6.4 | 11.990 | 11.958 | 11.926 | 11.894 | 11.862 | 11.831 |
| 6.5 | 11.831 | 11.799 | 11.768 | 11.737 | 11.706 | 11.675 |
| 6.6 | 11.675 | 11.645 | 11.615 | 11.584 | 11.555 | 11.525 |
| 6.7 | 11.525 | 11.495 | 11.466 | 11.437 | 11.408 | 11.379 |
| 6.8 | 11.379 | 11.350 | 11.321 | 11.293 | 11.265 | 11.237 |
| 6.9 | 11.237 | 11.209 | 11.181 | 11.154 | 11.126 | 11.099 |
| 7.0 | 11.099 | 11.072 | 11.045 | 11.018 | 10.991 | 10.965 |
| 7.1 | 10.965 | 10.938 | 10.912 | 10.886 | 10.860 | 10.835 |
| 7.2 | 10.835 | 10.809 | 10.783 | 10.758 | 10.733 | 10.708 |
| 7.3 | 10.708 | 10.683 | 10.658 | 10.633 | 10.609 | 10.584 |
| 7.4 | 10.584 | 10.560 | 10.536 | 10.512 | 10.488 | 10.464 |
| 7.5 | 10.464 | 10.441 | 10.417 | 10.394 | 10.371 | 10.347 |
| 7.6 | 10.347 | 10.324 | 10.301 | 10.279 | 10.256 | 10.233 |
| 7.7 | 10.233 | 10.211 | 10.189 | 10.166 | 10.144 | 10.122 |
| 7.8 | 10.122 | 10.101 | 10.079 | 10.057 | 10.036 | 10.014 |
| 7.9 | 10.014 | 9.993 | 9.972 | 9.951 | 9.930 | 9.909 |
| 8.0 | 9.909 | 9.888 | 9.867 | 9.847 | 9.826 | 9.806 |
| 8.1 | 9.806 | 9.785 | 9.765 | 9.745 | 9.725 | 9.705 |
| 8.2 | 9.705 | 9.685 | 9.666 | 9.646 | 9.627 | 9.607 |
| 8.3 | 9.607 | 9.588 | 9.569 | 9.549 | 9.530 | 9.511 |
| 8.4 | 9.511 | 9.493 | 9.474 | 9.455 | 9.436 | 9.418 |
| 8.5 | 9.418 | 9.399 | 9.381 | 9.363 | 9.345 | 9.327 |
| 8.6 | 9.327 | 9.308 | 9.291 | 9.273 | 9.255 | 9.237 |
| 8.7 | 9.237 | 9.220 | 9.202 | 9.185 | 9.167 | 9.150 |
| 8.8 | 9.150 | 9.133 | 9.116 | 9.099 | 9.082 | 9.065 |
| 8.9 | 9.065 | 9.048 | 9.031 | 9.014 | 8.998 | 8.981 |
| 9.0 | 8.981 | 8.965 | 8.948 | 8.932 | 8.916 | 8.900 |
| 9.1 | 8.900 | 8.883 | 8.867 | 8.851 | 8.836 | 8.820 |
| 9.2 | 8.820 | 8.804 | 8.788 | 8.773 | 8.757 | 8.741 |
| 9.3 | 8.741 | 8.726 | 8.711 | 8.695 | 8.680 | 8.665 |
| 9.4 | 8.665 | 8.650 | 8.635 | 8.620 | 8.605 | 8.590 |
| 9.5 | 8.590 | 8.575 | 8.560 | 8.546 | 8.531 | 8.517 |
| 9.6 | 8.517 | 8.502 | 8.488 | 8.473 | 8.459 | 8.445 |
| 9.7 | 8.445 | 8.430 | 8.416 | 8.402 | 8.388 | 8.374 |
| 9.8 | 8.374 | 8.360 | 8.346 | 8.333 | 8.319 | 8.305 |
| 9.9 | 8.305 | 8.292 | 8.278 | 8.264 | 8.251 | 8.237 |

# TABLE I CONTINUED

| % NaCl | 0 | 2 | 4 | 8 | 8 | 10 |
|---|---|---|---|---|---|---|
| 10 | 8.237 | 8.123 | 8.010 | 7.898 | 7.787 | 7.679 |
| 11 | 7.674 | 7.572 | 7.473 | 7.376 | 7.281 | 7.189 |
| 12 | 7.189 | 7.099 | 7.011 | 6.926 | 6.843 | 6.762 |
| 13 | 6.762 | 6.684 | 6.608 | 6.535 | 6.463 | 6.394 |
| 14 | 6.394 | 6.327 | 6.262 | 6.199 | 6.138 | 6.079 |
| 15 | 6.079 | 6.022 | 5.966 | 5.913 | 5.861 | 5.811 |
| 16 | 5.811 | 5.763 | 5.716 | 5.670 | 5.627 | 5.584 |
| 17 | 5.584 | 5.543 | 5.504 | 5.465 | 5.428 | 5.393 |
| 18 | 5.393 | 5.358 | 5.325 | 5.292 | 5.261 | 5.231 |
| 19 | 5.231 | 5.202 | 5.174 | 5.147 | 5.120 | 5.095 |
| 20 | 5.095 | 5.071 | 5.047 | 5.024 | 5.002 | 4.981 |
| 21 | 4.981 | 4.961 | 4.941 | 4.922 | 4.903 | 4.886 |
| 22 | 4.886 | 4.868 | 4.852 | 4.836 | 4.821 | 4.806 |
| 23 | 4.806 | 4.792 | 4.778 | 4.765 | 4.752 | 4.740 |
| 24 | 4.740 | 4.728 | 4.716 | 4.705 | 4.695 | 4.685 |
| 25 | 4.685 | 4.675 | 4.666 | 4.657 | 4.648 | 4.640 |
| 26 | 4.640 | 4.632 | 4.624 | | | |

## TABLE 2 Values of bT

## TEMPERATURE COEFFICIENTS FOR LOW-CONCENTRATION SODIUM CHLORIDE SOLUTIONS

| TEMP °C. | 0 | 2 | 4 | 6 | 8 | 10 |
|---|---|---|---|---|---|---|
| 0 | 0.02118 | 0.02134 | 0.02150 | 0.02166 | 0.02182 | 0.02198 |
| 10 | 0.02198 | 0.02213 | 0.02229 | 0.02245 | 0.02261 | 0.02277 |
| 20 | 0.02277 | 0.02292 | 0.02308 | 0.02323 | 0.02338 | 0.02353 |
| 30 | 0.02353 | 0.02367 | 0.02382 | 0.02396 | 0.02409 | 0.02423 |
| 40 | 0.02423 | 0.02436 | 0.02449 | 0.02461 | 0.02474 | 0.02486 |
| 50 | 0.02486 | 0.02497 | 0.02508 | 0.02519 | 0.02529 | 0.02539 |
| 60 | 0.02539 | 0.02549 | 0.02558 | 0.02567 | 0.02576 | 0.02584 |
| 70 | 0.02584 | 0.02591 | 0.02599 | 0.02606 | 0.02612 | 0.02618 |
| 80 | 0.02618 | 0.02624 | 0.02629 | 0.02634 | 0.02639 | 0.02643 |
| 90 | 0.02643 | 0.02647 | 0.02651 | 0.02654 | 0.02657 | 0.02660 |
| 100 | 0.02660 | 0.02662 | 0.02665 | 0.02666 | 0.02668 | 0.02669 |
| 110 | 0.02669 | 0.02671 | 0.02672 | 0.02673 | 0.02673 | 0.02674 |
| 120 | 0.02674 | 0.02674 | 0.02675 | 0.02675 | 0.02675 | 0.02676 |
| 130 | 0.02676 | 0.02676 | 0.02676 | 0.02677 | 0.02677 | 0.02678 |
| 140 | 0.02678 | 0.02679 | 0.02680 | 0.02681 | 0.02683 | 0.02684 |

## TABLE 3

## TENTATIVE CORRECTIONS TO SODIUM CHLORIDE SOLUTION TEMPERATURE COEFFICIENTS

| TEMP °C. | %NaCl | | | |
|---|---|---|---|---|
| | 0.1 | 0.5 | 1.0 | 5.0 |
| 0 | −0.0001 | −0.0004 | −0.0009 | −0.0011 |
| 50 | −0.0001 | −0.0007 | −0.0007 | −0.0004 |
| 100 | −0.0002 | −0.0012 | −0.0004 | +0.0004 |