Volume 8 | 08-S-04-104

Section 04 | Revision 6

Date: 4-21-83

CHEMISTRY INSTRUCTION

OPERATION OF CONDUCTIVITY BRIDGE

SAFETY RELATED

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List of Effective Pages:

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List of TCN's Incorporated:

Rev.	TCN No.
0	None
1	None
2	None
3	None
4	None
5	None
6	None

FOR INFORMATION ONLY
WORD PROCESSING

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1.0 INSTRUMENT DESCRIPTION

Leeds & Northrup Conductivity Bridge Model No. 4959

2.0 REFERENCES

2.1 Leeds and Northrup Instruction Manual - Model 4959 (177335)

2.2 Chemistry Procedure No. 08-S-03-01, Qualification of Chemistry Program

2.3 Chemistry Procedure No. 08-S-03-7, Control of Chemistry Support Equipment

3.0 DEFINITIONS

None

4.0 PREREQUISITES

4.1 Apparatus Required

4.1.1 Unknown cell (Dip or flow)

4.2 Reagents Required

4.2.1 Potassium Chloride Standard (0.001, 0.01 or 0.1N)

4.3 Resistors of certified values

4.4 Attachments

4.4.1 Attachment I - Temperature Ratio vs Temperature

4.4.2 Attachment II - Conductivity Correction

4.4.3 Attachment III - Cell Constant Log

5.0 PRECAUTIONS

5.1 Avoid sudden introduction of very hot or very cold water to avoid possible cracking of glass parts.

5.2 When used in battery mode, ensure case of instrument is grounded.

5.3 Replace battery every 8 to 10 months regardless of usage to minimize the possibility of instrument damage from leakage.

5.4 Allow the conductivity cell to remain in the electrolyte under test for one minute to reach electrolyte temperature.

6.0 INSTRUCTIONS

6.1 Instrument Startup

NOTE

The following procedure applies to a conductivity bridge utilizing a dip cell, except where indicated.

6.1.1 Select power source to be used. For line voltage operation, plug line cord into a nominal 120-volt 50/60 hertz power supply having a grounded third wire. For portable operation, power is provided by the internal battery source.

6.1.2 Adjust the mechanical zero of the galvanometer by setting the BRIDGE SUPPLY switch to the OFF position and unclamping the galvanometer. Turn the galvanometer zero adjuster until the pointer comes to rest at zero.

6.1.3 Adjust the electrical zero of the instrument by placing the BRIDGE SUPPLY switch at the frequency to be used for measuring; normally 50-60 Hz.

6.1.4 Set the MULTIPLIER to the CK position.

6.1.5 Set the ohms scale at 2.000.

6.1.6 Adjust the ZERO knob until the galvanometer needle indicates zero.

6.1.7 Set the compensator by locking down the detector key and adjusting the compensator knob until the galvanometer pointer comes to rest at the zero position.

6.1.8 Restore the instrument to a standby condition by placing the BRIDGE SUPPLY switch to OFF.

6.2 Functional Check

6.2.1 Conductivity Bridge

a. Functional check frequency specified in the Calibration/Functional Check Log Book.

b. Ensure instrument start-up in accordance with 6.1.

c. Verify instrument is within prescribed calibration due-dates.

d. Connect the leads from the certified resistor panel to the instrument CELL BINDING posts.

e. Place the Bridge Supply switch to the 50/60 Hz position.

f. Select any resistor value on the certified resistor panel.

g. Depress the DETECTOR KEY, and select the multiplier range that most closely corresponds to the resistor selected in 6.2.1.f. (i.e., a 500 ohm resistor would correspond to the multiplier range marked 10^2).

h. Rotate the SCALE SETTER until the galvanometer needle rests at zero. This value should correspond to the certified resistor value, within a tolerance of $\leq$ 2%. Note the reading.

i Repeat steps 6.2.1g. and 6.2.1h. with resistors covering the expected range of analyses. Note the results.

j. After the necessary resistor ranges have been checked, place the BRIDGE SUPPLY switch to OFF, release the DETECTOR knob to the up position, return the MULTIPLIER to the CK position, and disconnect the leads from the CELL BINDING posts.

k. If any reading does not fall within the acceptable limits, contact the CHEMISTRY Supervisor

6.2.2 Constant Determinations

a. Cell constants will be determined upon initial use, then semi-annually. Results are recorded on Attachment III and inserted in the proper section of the Functional Check Log Book required by Reference 2.3. All laboratory conductivity cells will have cell constant checks run prior to placing in service. Also, any new cells that may be used for demin quality water (<10 umho's) will be checked against a reference cell in accordance with Step 6.2.3 of this instruction.

All conductivity cells will have a form (similar to Attachment III) filled out on each cell (including reference cells) in the Functional Check Log. Conductivity cells will also have a permanent tag attached stating the following:

(1) MP&L number assigned sequentially to which that cell may be cross-referenced with Attachment III in the Functional Check Log.

(2) Date/time of last cell constant and reference cell check if applicable.

(3) Date the next cell constant check is due.

(4) The actual cell constant calculated for the cell.

All cells will be numbered sequentially and when the cell is broken or defective, it will be retired/removed from use and a statement stating why written on bottom of Attachment III.

b. Ensure instrument start-up in accordance with 6.1.

c. Verify instrument is within prescribed calibration due dates.

d. Connect the Cell to the conductivity bridge.

e. Rinse the cell in the Potassium Chloride solution to be used for cell constant determination.

f. Immerse the dip cell, or if using a flow cell, provide a flowing stream of the proper Potassium Chloride solution (0.001N for 0.01 cell constant, 0.01N for 0.1 cell constant or 0.1N for 1.0 cell constant).

g. Measure the temperature of the Potassium Chloride solution and determine the specific conductance from the respective graph similar to Attachment IV. The graphs were plotted from the following information:

Normality (KCI)	Temp. C	Specific Conductance (Micromho/cm)
0.1N	0	7,138
	18	11,167
	25	12,856
0.01N	0	774
	18	1,220
	25	1,409
0.001N	0	80
	18	128
	25	147

h. Adjust the SCALE SETTER until a null condition is obtained on the galvanometer.

i. Calculate the cell constant using one of the following equations, depending upon whether the reading observed is in resistance or conductance values, respectively.

$$K = R_m G_s \qquad \text{or} \qquad K = \frac{G_s}{G_m}$$

Where K = Value of cell constant (CM^{-1})
Rm = Measured resistance of electrolyte (ohm)
Gm = Measured conductance of electrolyte (mho)
Gs = Specific conductance of electrolyte mho/cm at solution temp.

NOTE

There are 10^6 micromhos in a mho.

j. When the constant of a particular cell has been determined by the above instruction and falls within $\pm$ 10% of the manufactured value, it may then be used in normal evolutions. If not, it must be removed from service and destroyed.

k. Place the BRIDGE SUPPLY switch to OFF, release the DETECTOR knob to the up position and return the MULTIPLIER to the check position.

l. For COND cells that may be used for low conductivity samples, perform a Reference Cell check as per Step 6.2.3.

6.2.3 Reference Cell Check

a. Perform this check after cell constant check in 6.2.2 has been performed. These will be performed using a Reference Cell with the same cell constant as the one being checked (i.e., if going to check a 0.1 constant flow cell, use an identical reference cell).

b. Ensure the reference cell has had a cell constant check within the last six months.

c. Verify instrument is within the prescribed calibration due dates.

d. Verify instrument has been functionally checked within the prescribed time period.

e. Using the same instrument (Bridge) and pure demin water sample, read the sample with each cell (Reference and the cell being checked); in accordance with Section 6.3 of this instruction.

f. Calculate the % deviation as follows:

$$\% R = \frac{Rf - C}{Rf} \times 100$$

Where % R - % deviation between Reference Cell and cell being checked

Rf - conductivity on demin sample for Reference Cell

C - conductivity on same demin sample for cell being checked

g. Log the % R value on Attachment III (located in the Functional Check Log) in the % of Reference Cell slot. This value should be $\pm$ 10%; if not, take the cell out of service and retire it from the system.

h. Reference Cell checks need only be done for cells that may be used in systems where the water quality is 10 umho/cm or less.

i. All Reference Cells will have a permanent tag attached with the following info:

(1) Reference Cell and MPL #

(2) Statement as follows: "Not for Plant Use"

(3) Date/time of last cell constant check

(4) Actual cell constant of the cell

(5) Date next constant due

6.3 Analysis

6.3.1 Verify instrument start-up in accordance with 6.1.

6.3.2 Verify instrument is within prescribed calibration due-dates.

6.3.3 Verify functional check performed within proper time frame as stated in the Calibration/Functional Check Book.

6.3.4 If necessary, connect the leads from the conductivity cell to the instrument CELL BINDING posts.

6.3.5 Dip Cell

a. Rinse the cell in demineralized water, gently shake off the excess. Do not attempt to blot or blow dry.

b. Immerse the cell in the solution to be measured ensuring any entrapped air is removed.

6.3.6 Flow Cell

a. Connect the cell to the sample stream to be measured.

b. Start the sample flow and adjust the flow rates to approximately 100 ml/min. NOTE: High flow rates may damage flow cell.

6.3.7 Place the BRIDGE SUPPLY switch to the 50/60 Hz position. Depress the DETECTOR KEY. Note the position of the galvanometer needle as you rotate the MULTIPLIER switch from the CK position. (For conductance measurements, the rotation is toward decreasing values until the needle deflects to the left). Adjust the MULTIPLIER switch and rotate the SCALE SETTER until the galvanometer needle rests on zero. Note this reading and the multiplier setting.

NOTE

A sustained null (zero) reading may not be possible when using a dip cell on demineralized water samples due to carbon dioxide absorption.

6.3.8 Measure the temperature of the solution; note this reading.

6.3.9 Release the DETECTOR knob, restore the MULTIPLIER to the CK position, and place the BRIDGE SUPPLY switch to the OFF position.

6.3.10 Calculate the measured specific conductance by using the following formula:

$$Gs\ (T) = M \times S \times C \times 10^6\ \text{umho/mho}$$

Where

Gs (T) = Specific conductance at temperature T (umho/cm)
M = The multiplier setting (For conductance)
S = The scale setting (mho)
C = The cell constant (cm^{-1})

a. If the measured specific conductance is greater than 1 umho/cm, the specific conductance may be calculated by using the following formula.

$$Gs\ (25^\circ C) = \frac{Gs(T)}{TCF}$$

Where
Gs (25°C) = Specific conductance at 25°C (umho/cm)
Gs (T) = Specific conductance at temperature T (umho/cm) TCF = Temperature compensation factor obtained by taking the temperature reading of step 6.3.8 and finding factor from the table in Attachment I.

b. If the measured specific conductance is less than 1 umho/cm, the specific conductance at 25°C may be read from the graph in Attachment II.

c. The specific conductance also may be found using the CHCOND computer program and entering the temperature and measured conductivity when requested.

7.0 <u>DOCUMENTATION/CORRECTIVE ACTION</u>

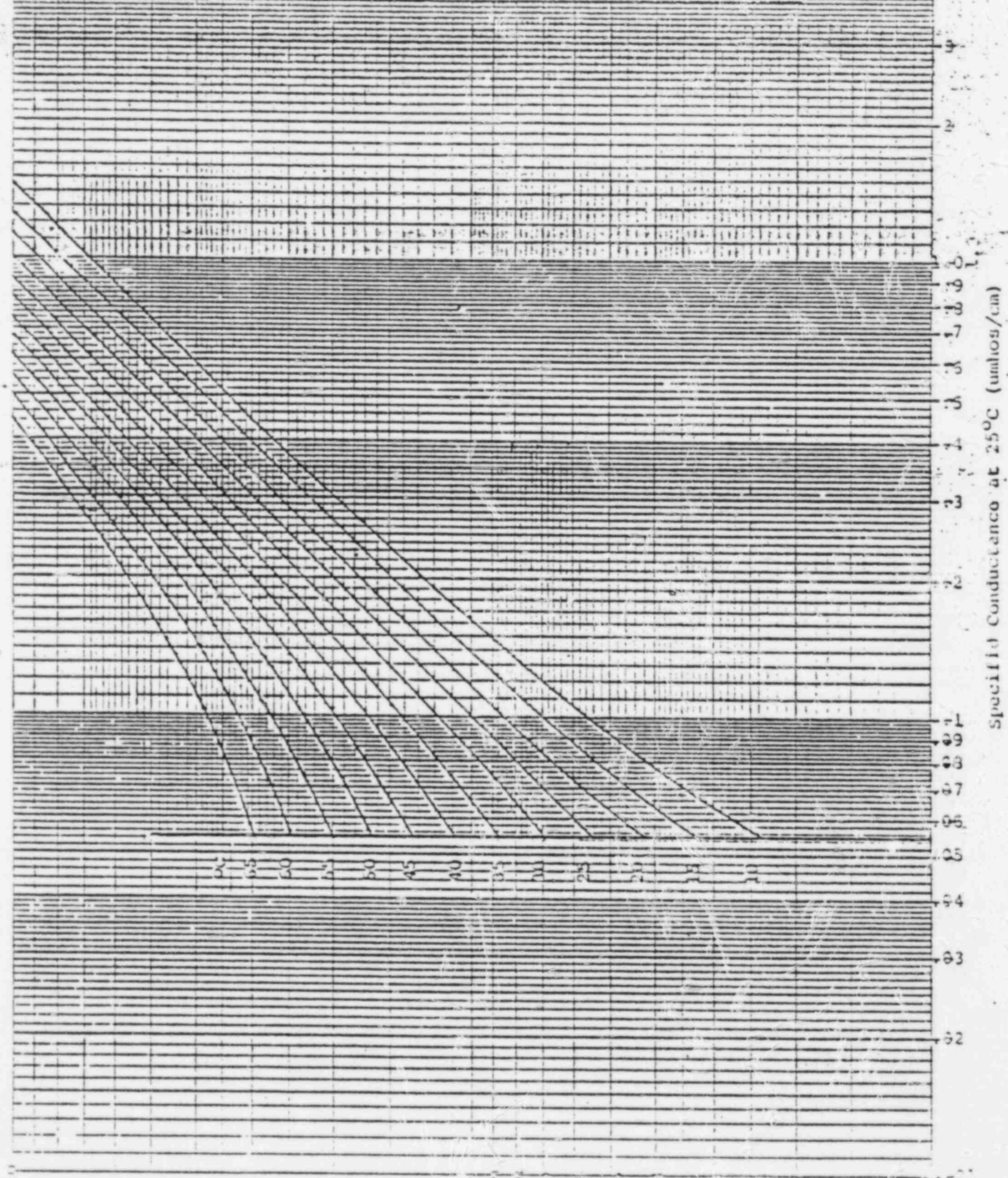
7.1 Documentation of functional check data shall be in accordance with Chemistry Procedure 08-S-03-7. Results shall be documented for the respective samples per Chemistry Procedure 08-S-03-10.

7.2 A label must be affixed to the respective cells used, to identify a serial number, the cell constant, and the date next due.

TEMPERATURE RATIO vs TEMPERATURE
(for water ranging from 1 to 10 umhos/cm at 25 C (77F)

Temperature C	Temperature Ratio	Temperature C	Temperature Ratio
0	0.523	51	1.619
1	0.539	52	1.644
2	0.555	53	1.671
3	0.572	54	1.698
4	0.589	55	1.723
5	0.607	56	1.749
6	0.625	57	1.775
7	0.643	58	1.802
8	0.661	59	1.827
9	0.679	60	1.852
10	0.698	61	1.877
11	0.718	62	1.903
12	0.737	63	1.930
13	0.756	64	1.956
14	0.776	65	1.982
15	0.796	66	1.009
16	0.816	67	1.035
17	0.836	68	1.063
18	0.855	69	2.090
19	0.875	70	2.117
20	0.897	71	2.144
21	0.918	72	2.170
22	0.938	73	2.198
23	0.959	74	2.226
24	0.980	75	2.255
25	1.000	76	2.284
26	1.022	77	2.312
27	1.046	78	2.340
28	1.069	79	2.369
29	1.092	80	2.398
30	1.114	81	2.427
31	1.137	82	2.456
32	1.161	83	2.484
33	1.184	84	2.513
34	1.208	85	2.544
35	1.231	86	2.573
36	1.254	87	2.603
37	1.278	88	2.633
38	1.302	89	2.663
39	1.325	90	2.693
40	1.349	91	2.724
41	1.373	92	2.754
42	1.398	93	2.785
43	1.422	94	2.815
44	1.446	95	2.846
45	1.470	96	2.878
46	1.494	97	2.910
47	1.519	98	2.940
48	1.545	99	2.970
49	1.570	100	3.000
50	1.595		

$$G_s(25^oC) = \frac{G_s(T) - (0.0545\,(0.55e^{0.0363T} - 0.356))}{1 + 0.02(T - 25)} + 0.0545$$



GRAND GULF NUCLEAR STATION

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CELL CONSTANT AND REFERENCE CHECK LOG

Conductivity Cell No.__________________________Cell type DIP/FLOW

Date Placed in Service__________________________Cell Constant 0.01/0.1/1.0

Cell Constant Limits(± 10%) - .009 - .011 Reference Cell Limits ± 10%
.09 - .11
.90 - 1.1

DATE	LOCATION	CELL CONSTANT	% of REF. CELL	INITIALS