BORIN® Manufacturing, Inc.

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TBE-0007

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Technical Bulletin 0007

Subject: Reference Electrode Potentials As Measured Against The Standard (Normal) Hydrogen (SHE) And The Calomel (SCE) References.

In the table below, represented is the theoretical Potentials and the actual "Stelth" Potentials versus the standard or normal hydrogen electrode and the saturated calomel electrode at 25º C. They are not corrected for placement of the reference electrode in seawater or for any liquid junction potentials.

Reference Electrodes	Theoretical Potential vs. Hydrogen (SHE)	Actual Potential vs. Hydrogen (SHE)	Actual Potential vs. Calomel (SCE)
Standard (Normal) Hydrogen (SHE)	0.000 v	0.000 v	- 0.241 v
Saturated Silver/Silver Chloride (AgCl)	+ 0.225 v	+ 0.198 v	- 0.0429 v
Saturated (KCl) Calomel (SCE)	+ 0.241 v	+ 0.241 v	0.000 v
Saturated Copper/Copper Sulfate ($CuSO_4$)	+ 0.300 v	+ 0.303 v	+ 0.0624 v
Saturated Zinc/Zinc Sulfate ($ZnSO_4$)	- 0.780 v	- 0.789 v	- 1.0295 v

Reference Electrode Potentials at 25°C (77°F)

You will notice that the actual values against the theoretical values are slightly lower in the Copper and higher in the Zinc. This is by design and intentional. When the pure metal in the reference cells begins to mature in saturated environments, the potentials will slightly decrease in about 2 to 3 years. Our intent, therefore, is to have each reference electrode move closer to the theoretical ideal as it ages.

The silver electrode is 0.027 higher. This is not only by design (see above), but is also due to being tested in actual seawater conditions in our facilities.

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If you wish to check the values of an actual "Stelth" reference electrode against a standard (Normal) Hydrogen reference electrode (SHE), you begin by measuring the potential versus a saturated calomel reference electrode (SCE). Take this measurement in potable water for the Copper and Zinc and in saturated sodium chloride for the silver. Then adjust the measured potentials to the standard hydrogen scale. You can use the table below for your calculations.

The silver/silver chloride reference electrode should be approximately 0.0429 volts more negative than the saturated calomel reference electrode. This gives you the correct "polarity" for the readings in the "Measured Potential" column.

The potential of the copper/copper sulfate reference electrode should be more positive than the saturated calomel reference electrode by about 0.0624 volts.

The zinc/zinc sulfate reference electrode should be more negative than the saturated calomel reference electrode by about 1.0295 volts.

Reference Electrode	Measured Potential to Calomel (SCE)	Add	Calculated Potential to Hydrogen (SHE)
Saturated Silver/Silver Chloride (AgCl)		**+ 0.241 v**	
Saturated Copper/Copper Sulfate ($CuSO_4$)		**+ 0.241 v**	
Saturated Zinc/Zinc Sulfate ($ZnSO_4$)		**+ 0.241 v**	

It is generally accepted that a commercial reference electrode must be within 10 millivolts plus or minus of published Calomel readings. At Borin Manufacturing, we have accepted the following standard:

Reference Electrode	Plus Limit	Standard Calomel Values	Negative Limit
Saturated Silver/Silver Chloride (AgCl)	**- 50 mV**	**- 40 mV**	**- 30 mV**
Saturated Copper/Copper Sulfate ($CuSO_4$)	**+ 50 mV**	**+ 60 mV**	**+ 70 mV**
Saturated Zinc/Zinc Sulfate ($ZnSO_4$)	**- 1025 mV**	**- 1015 mV**	**- 1035 mV**