BORIN ® Manufacturing, Inc.

5741 Buckingham Parkway, Unit B, Culver City, California 90230, USA
Telephone: +1-310-822-1000, Facsimile: +1-310-338-3434
Email borin@borin.com - Web Site www.borin.com

TECNOLOGÍA TOTAL www.tecnologiatotal.net

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Technical Bulletin 0002

Subject: Chemical and PH Tolerances that the Stelth® Reference Electrodes can withstand and still Provide a 30 year Life

Soil conditions do affect all reference electrodes, regardless of who manufactures them.

All reference electrodes, are extremely sensitive to their environments. The acidity, alkalinity and chemical makeup of the environment will determine the life expectancy, stability and accuracy that the reference electrode will provide as it monitors your cathodic protection system.

The ***Stelth® Technology*** incorporates integral ion trapping chemistries to provide protection from intermittent exposures to hydrogen sulfide and various chlorides commonly found in soil and fluid environments. These ***Chemical Sponges™*** are very effective in protecting the ***Stelth®*** reference electrodes under normal operating conditions which exist in the majority of cathodic protection systems.

When a reference electrode is exposed to massive doses of harmful chemicals or is exposed to continuous low levels of these chemicals, the performance and life expectancy of the reference electrode will be affected.

In an effort to provide a bench mark that will allow the designer to specify a specific reference electrode chemistry, the following table will show the limits in PPM (**P**arts **P**er **M**illion) that are tolerable for $Cu-CuSO_4$ (copper) $Zn-ZnSO_4$ (zinc) and Ag-AgCI (silver) reference electrodes.

Soil Constituent	Level for $Cu\text{-}CuSO_4$ & $Zn\text{-}ZnSO_4$	Level for Ag-AgCl
Sulfide	Maximum 100 ppm	Maximum 100 ppm
Chloride + Bromide	Maximum 1000 ppm	Unlimited
Hydrocarbons	None	None
Acidity	pH > 4	pH > 4
Alkalinity	pH <9	pH <9
*Temperature	-10º F (-23º C) to 176º F (80º C)	-10º F (-23º C) to 176º F (80º C)

Hydrocarbons are the worst offenders*.** They are absolutely deadly to the life of a reference electrode. Any appreciable amount of hydrocarbon chemistry in a reference electrode's immediate environment will cause that reference electrode to fail in less than one year. Through the use of ***Electric Mud™ System the life of the reference electrode can be extended significantly as this system provides a barrier that will shield the reference electrode from the hydrocarbons for varying lengths of time depending on the concentration of the hydrocarbon material present. This system also provides the ability to remove and replace your reference electrode in a matter of just a few minutes should it eventually succumb to the hydrocarbons present in the environment.

***Sulfides are next in line as agents of doom for all reference electrodes*.** Sulfide exposure at a continuous 100 ppm will reduce the life expectancy of a $Cu\text{-}CuSO_4$ (copper), $Zn\text{-}ZnSO_4$ (zinc) and Ag-AgCl (silver) reference electrode approximately to half of the published period. Greater sulfide levels will further reduce the life in proportion to the amount of sulfide present.

Sulfides are found more and more in the environment, as industrial expansion continues in our urban areas, and as garbage is used to produce ever expanding land fill areas. Both of these sources produce significant amounts of Hydrogen Sulfide (H_2S), a poison gas that destroys almost any material that it comes in contact with, especially reference electrodes. It is incidentally, lethal in small amounts to both human and animal life.

***Chlorides + Bromides follow as the killer of more reference electrodes than any other chemistry*.** This is due to the ubiquitous nature of these materials. The deicing programs in our cold weather cities combined with the massive use of fertilizers and other lawn and garden chemicals has spread these chemistries everywhere. Chloride + Bromide exposure at a continuous 1000 ppm will reduce the life expectancy of a Cu-$CuSO_4$ (copper) and Zn-$ZnSO_4$ (zinc) reference electrode approximately to half of the published period.

In contrast to this, Ag-AgCI (silver) reference electrodes require a chloride and/or bromide environment to successfully achieve an ion exchange to produce a valid potential reading. When chloride + bromide levels are greater than 1000 ppm and up to 10,000 ppm a Ag-AgCI (silver) reference electrode with a solid chemical state chloride reservoir is recommended. Environments which have from 10,000 ppm (brackish water and environs) up to 27,000 ppm (sea water, sea walls and environs) would only require a Ag-AgCI (silver) reference electrode that has a treated silver element with a balanced starter reservoir of chlorides. Chloride levels above 27,000 require only a solid junction reference electrode which is a treated Silver element and no reservoir.

Acid soils become a consideration as the pH of the environment approaches 4. In acid soils with pH 4, or less the life of the reference electrode will be a function of pH. At pH 4, the life expectancy of Cu-$CuSO_4$ (copper), Zn-$ZnSO_4$ (zinc) and Ag-AgCI (silver) reference electrodes will be reduced to approximately 50% of the manufacture's published period. At pH 3, the life expectancy will be cut to approximately 25% and at pH 2, the life expectancy will be cut to approximately 10% of the manufacture's published period.

Alkaline soils become a consideration as the pH of the environment approaches 9. In alkaline soils with pH 9, or more the life of the reference electrode will be a function of pH. At pH 9, the life expectancy of Cu-$CuSO_4$ (copper) Zn-$ZnSO_4$ (zinc) and Ag-AgCl (silver) reference electrodes will be reduced to approximately 50% of the manufacture's published period. At pH 10, the life expectancy will be cut to approximately 25% and at pH 11, the life expectancy will be cut to approximately 10% of the manufacture's published period.

Temperature is a consideration when designing reference electrodes in a cathodic protection system. At temperatures below 32ºF (0ºC), the freezing of the soil around the ***Stelth®*** reference electrode will render it inoperative. This is due to the fact, that when the soil and the reference electrode freeze an open circuit is created and therefore no electrical potential can be measured. When the ***Stelth®*** reference electrode is exposed to temperatures between -10ºF (-23ºC) and 32ºF (0ºC), the ***Stelth®*** reference electrode will recover to its full working capacity (calibration, stability, et cetera) as soon as the ground thaws.

At temperatures below about -10ºF (-23ºC), the electrolyte in the ***Stelth®*** reference electrode will freeze and may cause physical damage to the ceramic of the ***Stelth®*** reference electrode by expansion. It is important to note that this **will not** affect the performance of the reference electrode in any manner whatsoever. It will continue to operate with full capacity year after year providing the environment has not been unusually disturbed.

At temperatures above 135ºF (57ºC), the life expectancy of all reference electrodes, no matter who manufactures them, will be reduced as a function of temperature. The life expectancy of these reference electrodes will be reduced by approximately 50% for each 20ºF (11ºC) above 135ºF (57ºC) that the reference electrodes are operated at.

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For more in depth information on the relationship between temperature and reference electrodes please review technical bulletins:

*TB-0009 Temperature Correction Chart for Cu-$CuSO_4$, Zn-$ZnSO_4$ and Ag-AgCl chemistries of References Electrodes.

*TB-0011 High Temperature Operation of the **Stelth®** Ag-AgCl and **Stelth®** 8 Ag-AgCl reference electrodes in water immersion conditions

*TB-0016 High Temperature Operation of the **Stelth® 2** Cu-CuSO4, Zn-ZnSO4 and Ag-AgCl reference electrodes and the **Stelth® 7 IR Free Probe** in Soil Conditions

The useful life of *the Stelth® reference electrodes* in soil environments with adverse chemistries can be extended through the use of the *Electric Mud™ gelatin backfill* with casing. The *Electric Mud™ gelatin backfill* will increase the time it takes for the chemicals in the soil to reach high levels in the vicinity of the reference electrode. The *Electric Mud™ backfill* and the *Stelth® reference electrodes* can also be easily replaced if necessary in a matter of minutes.