Reference Cells — They're Pretty Cool

By Levi McCullough · reprinted as the companion reading for EC-013, Reference Electrodes. Lightly corrected for current RCS guidance; notes marked below.

In this piece I'll touch on everything I know about reference cells — the types, their applications, the factors that affect them, and how to calibrate and maintain them.

What they are, and why we use them

Reference cell, half-cell, survey stick, portable reference electrode — they're all the same thing. A reference cell holds a known, steady potential and lets you measure the potential of the structure against it. They're inexpensive and critical for test-station readings, corrosion surveys, and interference testing. There are different types, so always match the cell to the environment it'll be used in.

The types worth knowing

- **Copper–copper sulfate (CSE):** the default for buried structures and fresh water — the only cell I was ever handed as a tech in West Virginia.
- **Silver–silver chloride (Ag/AgCl):** seawater, brackish water, and concrete.
- **Saturated calomel (SCE):** a bench cell, used in the lab — and, as the module explains, the stable standard you check other cells against.
- **Zinc:** rugged; used in soil or water, especially as a permanent buried cell.

Every cell has its own potential against the standard hydrogen electrode (SHE), and that's what lets you convert a reading taken on one cell into the reading you'd get on another. If someone hands you a reading of, say, +0.250 V taken on a zinc cell, don't panic — convert it to the cell you actually use before you judge it.

Conversions: an easier way

Some folks find cell-to-cell conversion fiddly. A classmate from my CP-1 and CP-2 courses (shout-out to Adam) gave me a formula that made it click:

$$X = E(m)_1 + E(s)_1 - E(s)_2$$

- **X** — the reading you want, on the cell you need it in.
- **$E(m)_1$** — the reading you have, on the cell it was taken with.
- **$E(s)_1$** — that cell's standard potential vs SHE.
- **$E(s)_2$** — the target cell's standard potential vs SHE.

In plain terms: take your reading, add the standard potential of the cell it came from, subtract the standard potential of the cell you want. Since copper sulfate is where our records live, most of us just carry the one offset straight to copper (from zinc, subtract about 1.1 volts).

Factors that affect accuracy

Temperature. A copper-sulfate cell's potential drifts with temperature — about half a millivolt per degree Fahrenheit, reading more positive as it warms. Keep cells near room temperature before use (the cab, not a baking or frozen toolbox), and record daily temperature with your readings.

Light. Copper-sulfate cells with a clear window are photosensitive — direct sun on the electrolyte shifts the reading. Cover the clear window with electrical tape during measurements.

> **RCS note (2026):** the measurement standards (NACE/AMPP TM0497 and SP0207) flag this photovoltaic effect and require covering the window, but publish no set magnitude for the shift. Treat it as real, cover the window, and don't rely on a specific number — the earlier "−0.5 mV" figure isn't well-founded and has been removed here.

Electrolyte. The solution inside has to stay clean and saturated. In a CSE, keep the copper rod clean and the copper-sulfate solution saturated (we use MCMiller-grade solution and crystals) to hold a stable potential and slow contamination.

Calibration — critical

A cell you're collecting potentials with is useless if it isn't calibrated. Gearing up for a close-interval survey, I compare my two survey cells against each other on a multimeter — one on the positive port, one on the negative, set to DC millivolts, porous tips touched together — and look for close agreement. Everyone's checks and balances differ, so follow your company's SOP first.

RCS note (2026): a perfect one-millivolt match is a clean-bench ideal, not the daily bar — cells that live in the dirt won’t hold it. Field programs typically spec **5 to 10 mV**, and many hold field cells within about 5 mV of a clean office “master” cell that never goes in the ground. Go by your written spec; what you’re hunting is a cell drifted well outside the pack.

Maintenance

- Clean the porous tip before use — wipe off mud and debris.
- Cap the cell after use so it stays saturated and doesn’t leak or contaminate.
- Store out of direct sunlight and harsh conditions.
- Check crystal and solution levels before you head out. Clean a crusted copper rod with non-metallic sandpaper only.

Reference cells run through the whole cathodic-protection world. Choose the right type, calibrate it, and take care of it — that’s what turns a reading into data you (and your boss) can trust.