Calibration for the Watermark 200SS Soil Water Potential Sensor to fit the 7-19-96 “Calibration #3” Table from Irrometer

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The calibration data from calibration table “#3” of Irrometer1 utilize a linear relationship between resistance (R) and Potential (P) for P > -10 kPa. A curvilinear relationship with much flatter initial slope is used for greater (more negative) potentials. A similar, steep relationship between P and R was observed experimentally by Shock et al. (1998).

The best procedure for reproducing the Irrometer data table, which represents a sensor temperature of 24 °C (75 °F) was to divide the resistance range into 0 ≤ R ≤ 1 kOhm, 1 kOhm < R ≤ 8 kOhm, and 8 kOhm < R. A linear function is used for 0 ≤ R ≤ 1 kOhm, an equation (no. 8) by Shock et al., (1998) is used for 1 kOhm < R ≤ 8 kOhm, and a quadratic equation developed here is used for resistance greater than 8 kOhms.

The equation 8 by Shock fit the 1 kOhm < R ≤ 8 kOhm range better than any other equations developed and tested. However, the Shock equation, developed using experimental data in the range of –10 kPa ≥ P ≥ -75 kPa, deviated from the Irrometer table (the Irrometer table included data in the range of 0 kPa ≥ P ≥ -200 kPa) at values of P less than about –100 kPa.

The three equations are as follow:

For R ≤ 1 kOhm:

\[ P = -20 \times [R \times (1 + 0.018 \times (T - 24)) - 0.55] \]  

[eqn. 1]

where

P is soil water potential in kPa
R is measured resistance in kiloOhms
T is sensor (soil) temperature in Celsius

The 0.018*(T-24) term represents the 1.8% shift in resistance reading per one degree C change in temperature from the 24°C base that is recommended by Irrometer. The 1.8% per C is equivalent to 1% per degree F.

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1 From Irrometer Company, Inc., Riverside, CA via M.K. Hansen Company, E. Wanatchee, WA, October, 2000
For $1 \text{kOhm} < R \leq 8 \text{kOhm}$, equation 8 of Shock et al. (1998) is used:

$$P = \frac{(-3.213 * R - 4.093)}{(1 - 0.009733 * R - 0.01205 * T)}$$  \[\text{[eqn. 2]}\]

For measured resistance $> 8 \text{kOhm}$, the following quadratic equation is used:

$$P = -2.246 - 5.239 * R * (1 + 0.018 * (T - 24)) - 0.06756 * R^2 * (1 + 0.018 * (T - 24))^2$$  \[\text{[eqn. 3]}\]

where, again, the $1 + 0.018 * (T - 24)$ adjusts for sensor temperature. Equation 3 was determined by least squares regression from the Irrometer table for the range of $-10 \text{kPa} > P > -200 \text{kPa}$. The equation had a coefficient of determination $r^2 = 0.9996$ and standard error of estimate of 1.07 kPa.

Reference:

Figures showing the fit of the various calibration equations for different graphical scales (these are all of the same plot), where the “segment” curve is the combination of equations 1-3.