DECAGON DEVICES

Effect of Soil Moisture on Ground Hardness for Snowmobile Pass-by Noise Testing

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SNOWMOBILE PASS-BY noise testing is the current method used to determine how well different snowmobiles meet government regulations. One form of pass-by testing is defined by operating a machine to travel past a stationary microphone located at a specified position from the vehicle path. An example of a pass-by noise course is provided in Figure 1 (SAEJ192).

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Figure 2: Pass-by Noise Test Run

Electrical Conductivity of Soil as a Predictor of Plant Response

PLANTS REQUIRE NUTRIENTS to grow, and, if we fail to supply the proper nutrients in the proper concentrations, plant function is affected. Fertilizer in too high a concentration can also affect plant function, and is sometimes fatal. Most of us have had the experience of fertilizing some part of a lawn too heavily, perhaps by accident, and killing grass in that part of the lawn. Generally it isn't the nutrients themselves that cause the damage, it is their effect on the water. Salt in the water reduces its water potential making it less available to the plant. The salt therefore causes water stress in the plant.

Salt in soil comes from the fertilizer we apply, but also from irrigation water and dissolving soil minerals. Relatively small amounts are removed with the plants that are harvested, but most leaches with the water out of the bottom of the soil profile. When water evaporates at the soil surface, or from leaves, it is pure, containing no salt, so evapotranspiration concentrates the salts in the soil. If more salt is applied in the irrigation water than is leached or taken off in harvested plants the soil becomes more saline, and eventually will cease to support agricultural production.

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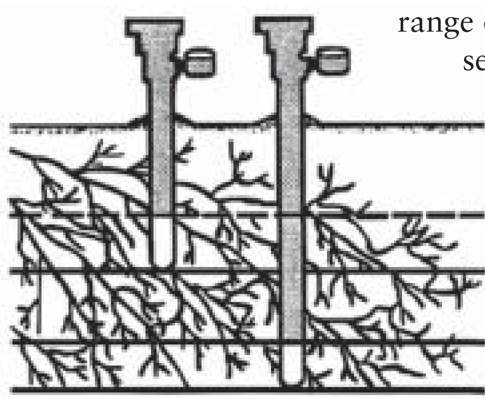
INSIDE ►

Are you tired of refilling tensiometers?

Water Potential Sensor

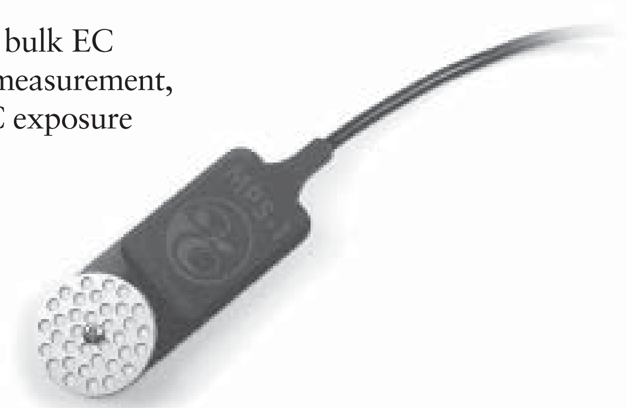
WASTING TIME CALIBRATING each sensor you buy? Do your soil water potential sensors really give you the measurement range and accuracy you want? Sensors currently being used to measure water potential in the field generally have poor accuracy, temperature sensitivity, and sensitivity to soil salinity. More accurate sensors have problems including measurement range, user calibration requirements, and time consuming routine maintenance. Decagon has created a new water potential sensor to address many of the problems.



The MPS-1 water potential sensor applies new measurement technology to the tried and true technique of solid matrix equilibration to measure water potential. The MPS-1 measures the water content of two ceramic discs in contact with the soil. By the second law of thermodynamics, the water potential of the ceramic must come into equilibrium with the water potential of the soil. Since the characteristics of the ceramic are carefully controlled, its soil water characteristic curve - the relationship between water content and matric potential - is precisely known. Therefore, the matric potential of the ceramic is obtained indirectly by measuring the water content of the ceramic. The water potential of the ceramic is equal to the water potential of the soil around the sensor.

Why is this technique better than the gypsum block, granular matrix, or heat dissipation sensors currently available and using similar techniques? Several key improvements differentiate the MPS-1. Utilizing the ECH_2O dielectric technology to measure the water content of the ceramic matrix makes the MPS-1 exceptionally insensitive to soil salinity. The ceramic discs, designed at Washington State University, have a wide pore size distribution, which allows water to drain from the ceramic gradually over a wide range of water potentials. The MPS-1 will effectively measure a larger range of soil water potentials (0 to -500 kPa) than tensiometers, which are limited to a range of 0 to -85 kPa. Each MPS-1 sensor contains a precision voltage regulator, meaning that it will give identical output of any power supply from 2 to 5V DC. Combining these improvements allows all MPS-1s to share a single calibration equation for all soil types, salinity ranges[1] and temperatures[2]; even with an unstable power supply. The single calibration equation enables Decagon to calibrate each MPS-1 and provide the end user the same sensor reading no matter which MPS-1 they use. These characteristics coupled with a simple and robust single ended three wire interface makes the MPS-1 the most user friendly and accurate out-of-the-box field water potential sensor available. ■

[1] 0 to 6 dS/m bulk EC
[2] 0 to 40 °C measurement, -20 to 40 °C exposure



New MPS-1 Water Potential Sensor

- Pre-calibrated continuous measurement of soil water potential in all soil types.
- No complicated programming.
- No maintenance required after installation.

Electrical Conductivity of Soil as a Predictor of Plant Response

continued from cover

Thousands of acres have been lost from production in this way, and production has been drastically reduced on tens of thousands of additional acres.

Soil Salinity and Electrical Conductivity

Soil salinity has been measured using electrical conductivity for more than 100 years. It is common knowledge that salty water conducts electricity. Whitney and Means (1897) made use of that fact to measure the concentration of salt in soil. Early methods made measurements directly on a soil paste, but the influence of the soil in the paste on the measurement was not fully understood until recently, leading to uncertainty in the measurements. By about 1940 the accepted method for determining soil salinity was to make a saturated paste by a specified procedure, extract solution from the paste, and measure the electrical conductivity of the solution (Richards, 1954). The measurement is referred to as the electrical conductivity of the saturation extract. These values were then correlated with crop response.

Richards (1954) defined 4 soil salinity classes, as shown in Table 1. Crops suitable for these classes are also listed by Richards, but a much more extensive list is given by Rhoades and Lovejoy (1990). For example, bean is listed as a sensitive crop. It can only be grown without

► Continued at www.decagon.com/Ebrochures/ECpredictor

Temperature Dependence of Electrical Conductivity

Electrical conductivity, of solutions or soils, changes by about 2% per Celsius degree. Because of this, measurements must be corrected for temperature in order to be useful. Richards (1954) provides a table for correcting the readings taken at any temperature to readings at 25°C. The following polynomial summarizes the table:

$$\sigma_{(25)} = \sigma(-6.04 \times 10^{-6} T^3 + 8.511 \times 10^{-4} T^2 - 0.0515\ T + 1.849)$$

where t is the Celsius temperature. This equation is programmed into the ECH$_2$O-TE, so temperature corrections are automatic. ■

Units of Electrical Conductivity

The SI unit for electrical conductance is the Siemen, so electrical conductivity has units of S/m. Units used in older literature are mho/cm, (mho is reciprocal ohm), which have the same value as S/cm. Soil electrical conductivities were typically reported in mmho/cm so 1 mmho/cm equals 1 mS/cm. Since SI discourages the use of submultiples in the denominator, this unit is changed to deciSiemen per meter (dS/m), which is numerically the same as mmho/cm or mS/cm. Occasionally EC is reported as mS/m or µS/m. 1 dS/m is 100 mS/m or 10^5 µS/m. ■

USDA Class	Conductivity Range dS/m	Salt inSoil g/100g	Osmotic Potential kPa	Crop Salt Tolerance	Example Crop
A	0–2	0–0.13	0to -70	Sensitive	Bean
B	2–4	0.13–0.26	-70 to -140	Moderately Sensitive	Corn
C	4–8	0.26–0.51	-140 to -280	Moderately Tolerant	Wheat
D	8–16	0.51–1.02	-280 to -560	Tolerant	Barley

Table 1. Salinity classes for soils

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Ground Hardness for Snowmobile Pass-by Noise Testing

Current standards exist for noise testing of snowmobiles to be conducted on both snow and grass surfaces. The standards also allow the snowmobiles to be tested on any grass surface which is relatively flat with a grass height of no more than 3 inches. An example of a typical pass-by run with a machine is provided in Figure 2.

Little is known of the effects of the different contributors to the ground conditions for this testing. Current research involves testing across varying ground and environmental conditions to determine the different contributing factors. A speaker sound source is used to determine how sound propagation is affected due to the various environmental factors while eight different snowmobiles are tested to determine how machine operation is affected by the conditions. Many different parameters are measured during the tests including: air temperature, barometric pressure, relative humidity, grass height, wind speed, wind direction, ground hardness and soil moisture. The EC-5 coupled with the ECH_2O Check were selected for the soil moisture readings. Ground hardness was measured with a device of unique design to the project, the device measures the amount of force required to push a probe in a set distance. Both measurement tools are shown during field use in Figure 3.

A distinct trend between soil moisture and ground hardness exists as shown in Figure 4. Different test locations were used throughout the summer months as history has shown that sound test results vary greatly from location to location. Although there does not appear to be any significant differences in the relationship between soil moisture and ground hardness from site to site, a useful conclusion can still be made with these results.

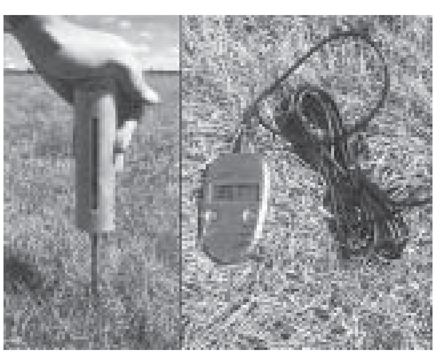


Figure 3 Ground Hardness Tester

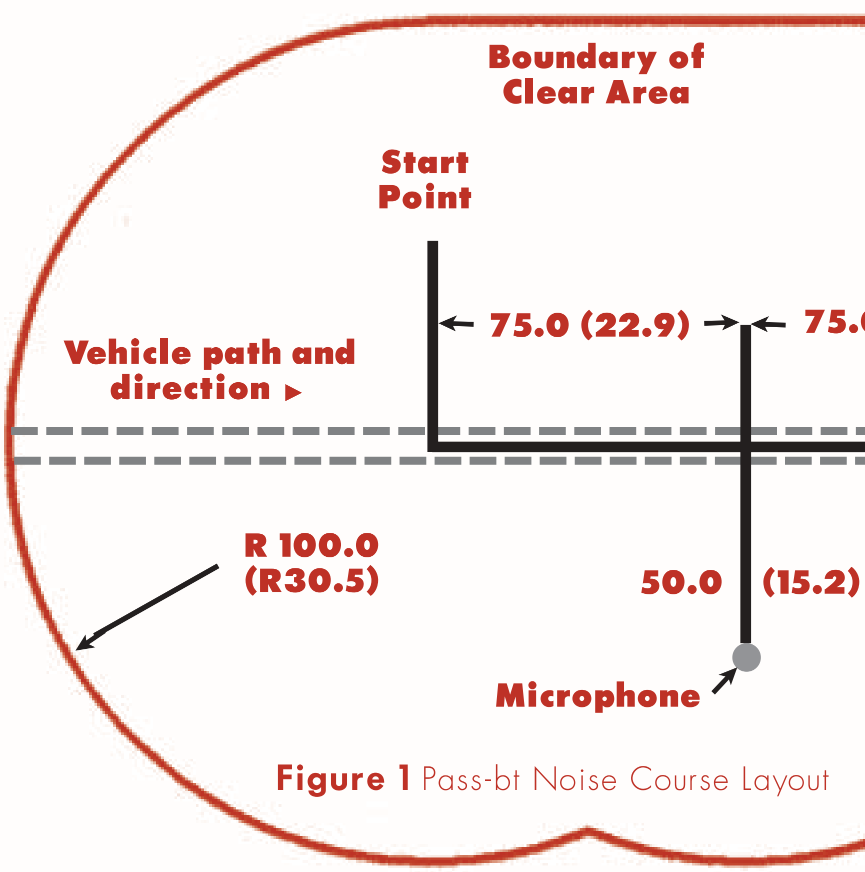


Figure 1 Pass-bt Noise Course Layout

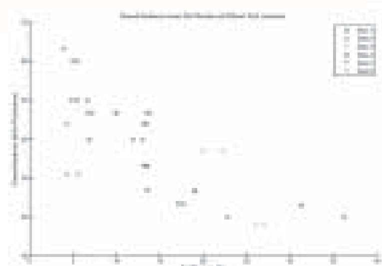
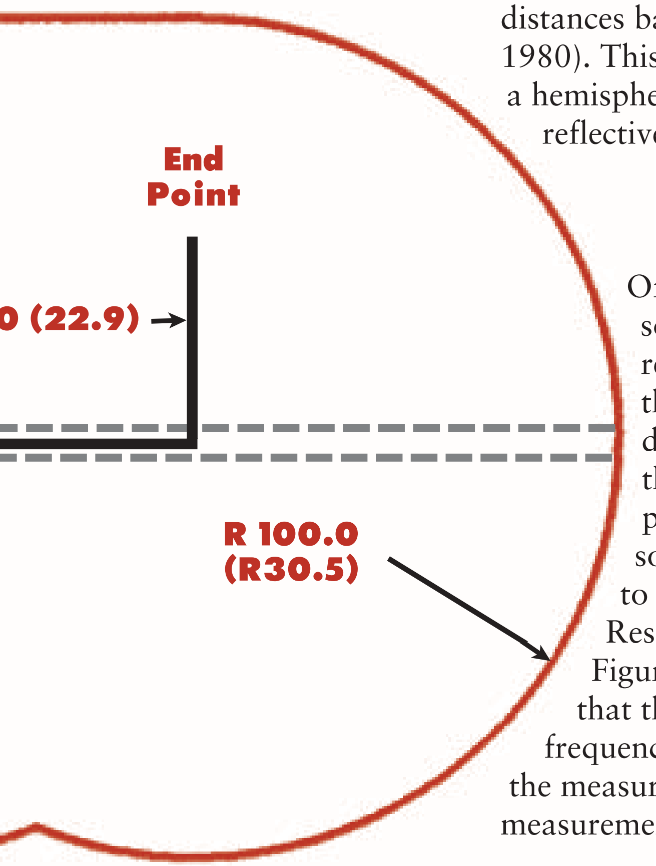


Figure 4 Ground Hardness versus Soil Moisture at Different Test Locations

Test sites 1, 4, and 5 were in a similar region within upper Wisconsin and upper Michigan. Test site 2 and 3 were in Northwest Minnesota. Test site 6 was a grass area near a parking lot where most of the sound field was over an asphalt surface.

Speaker testing was conducted using a known sound power omnidirectional sound source. The speaker remained stationary for the duration of the test and microphone recordings were made at specific locations from the speaker. Using a known sound power source allows for the prediction of sound pressure levels at given distances based on the equation below (Lord, 1980). This equation relies on the assumption of a hemispherical sound field with a perfectly reflective bottom surface.



$$p^2_{rms} = W\rho_0 c \;/\; 2\pi R^2$$

where:
p = pressure
W = sound power of source
ρ_0 = air density
c = speed of sound
R = radius from source

Of course, grass and soil are not perfectly reflective surfaces, therefore the differences between the predicted sound pressure levels and the measured sound pressure levels can be attributed to ground and environmental effects. Results from Site 1 are provided in Figure 5. The significant observation is that there is little variance in the lower frequency ranges (100–600 Hz) across all of the measured soil moisture and ground hardness measurements for that location.

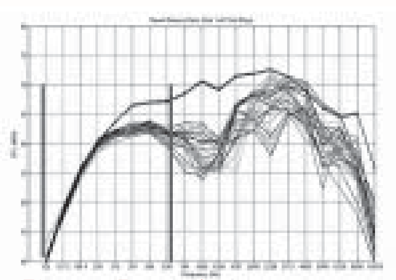


Figure 5 Sound Source Data: Site 1 All Test Days

Typical sound source test results for different test locations are presented in Figure 6. Frequencies of interest in the snowmobile testing are in the 100–600 Hz range, where a large amount of variability is observed from site to site.

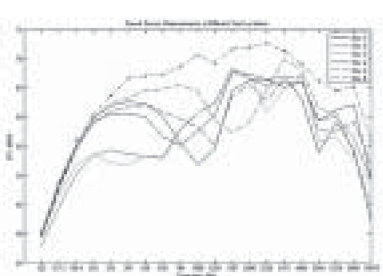


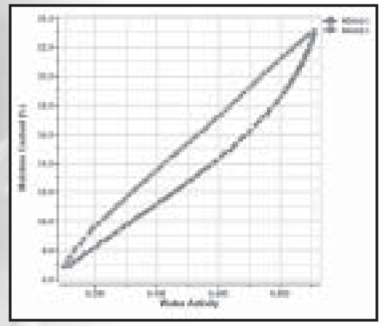
Figure 6 Sound Source Measurements at Different Test Locations

These data suggest that the soil moisture or ground hardness levels alone are not a dominant factor in the sound propagation at different test locations. However, these data suggest that soil type is a dominant factor in the same frequency region where snowmobiles operate. It is noted that soil types can vary greatly from region to region and the data shows that sound propagation has different trends at different test locations. The ability to measure soil moisture at each location was critical in making the conclusion that soil type is more critical than just soil moisture or ground hardness alone. ■

References:
SAEJ192, 2004, Maximum Exterior Sound Level for Snowmobiles
Lord, H., William, G., Evensen, H., 1980, Noise Control for Engineers, Krieger Publishing Company.

SOIL MOISTURE RELEASE CURVE GENERATOR

Available 2nd quarter of 2008



Faster Moisture Release Curves

Dry soil moisture characteristic curves are notoriously difficult to generate but with the new AquaSorp IG, creating a water potential versus water content curve is as easy as inputting a few parameters and waiting for the results; AquaSorp does all the work. While running, data are displayed on the computer (included) showing each individual point as collected by the instrument. Moisture characteristics are taken in the wetting and drying direction so hysteresis can be clearly seen in the 100 to 200 data points taken per cycle. Don't worry about waiting for results either, AquaSorp runs most moisture characteristics in 24 to 48 hours, and can even run multiple times through the same sample if you tell it to do so. AquaSorp works in the dry range of water potential (-10 to -300 MPa) which makes it best suited to dry soils. Whether you are studying water flow characteristics in dry soil or characterizing soil expansion, AquaSorp will provide the information you need with a fraction of the time and effort. ■

▲ **Specifications**

Range -10 to -300 MPa.
Accuracy ±1MPa ±1%
Temperature Operating Range 15 to 40° C
Size 44 w x 38 d x 28 h cm
Weight 19 kg

Benefits

- Insert sample, press start and walk away.
- Rapid moisture release curve generation.
- Fast expansive soil characterization.

NEW PRODUCTS

Want to measure the water content of a large volume of soil?

▲ Available First Quarter 2008 Sensor 10HS *(shown actual size)*

- Sample volume 12x larger than EC-5.
- Accuracy same as EC-5, over all textural classes and soil salinities.
- Larger sampling volume means less sensitivity to soil heterogeneity.

CALENDAR OF DECAGON EVENTS

TRADESHOWS

American Society of Agronomy
November 4–8, 2007, New Orleans, Louisiana

- *"Modeling Temperature and Salinity Response of EC-5 Dielectric Soil Moisture Sensors"* presented by Dr. Gaylon Campbell on Monday 10:15am.
- Poster *"Advances in Determining Soil Matric Potential Using an Engineered Porous Ceramic and Dielectric Permittivity"* by Dr. Colin Campbell.

European Geosciences Union
April 13–18, 2008, Vienna, Austria

15th International Congress of the International Soil Conservation Organization
May 18–23, 2008, Budapest, Hungary

American Society of Agricultural & Biological Engineers International Meeting
June 29–July 2, 2008, Providence, Rhode Island

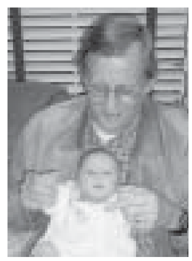
Ecological Society of America
August 3–9, 2008. Milwaukee, Wisconsin

Eurosoil 2008
August 25–29, 2008, Vienna, Austria

American Society of Agronomy Joint meeting with Geological Society of America
October 5–9, 2008 , Houston, Texas

New Face at Decagon

Lauren Bissey is the new ECH$_2$O Line Product Manager at Decagon. While studying at Clemson University and for her Master's at Washington State University she took great interest in plant-soil-water relations. Lauren has a unique perspective as a Decagon customer, utilizing Decagon's soil moisture sensors and porometer for her own research prior to joining the Decagon team. This experience gives Lauren a researcher's viewpoint and the ability to give technical support as well as ideas for new products.



Martin G. Buehler joined the Decagon Research & Development team as a Senior Scientist focusing his efforts on developing moisture monitors for agriculture and foods industries. Martin received the BSEE and MSEE from Duke University in 1961 and 1963, respectively and a Ph.D. in EE from Stanford University in 1966 specializing in Solid State Electronics under G. L. Pearson and W. Shockley. He worked at Texas Instruments for six years, at National Bureau of Standards (now NIST) for eight years, and since 1981 had been at the Jet Propulsion Laboratory where he is a Senior Research Scientist. At JPL he has developed p-FET radiation monitors for CRRES, Clementine, TELSTAR and STRV, E-nose which flew on STS-95 with John Glenn, an electrometer for the Mars '01 robot arm, and E-Tongue for ISS water quality. He served for ten years on the staff of the New Millennium Program as a technical analyst specializing in space instruments. Martin is a Life Member of the IEEE, and a member of Tau Beta Pi, and Sigma Nu. He holds 16 patents and has published over one hundred papers. In the picture is Martin's sixth grandchild Linnea Nalley at one month. ■

DECAGON DEVICES

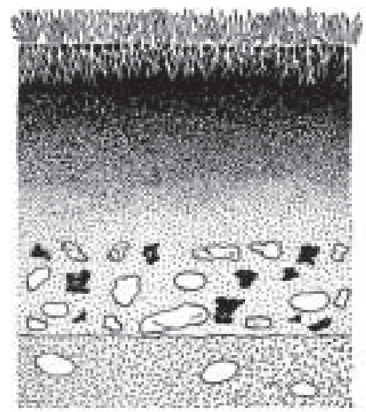
Soils News

UPCOMING 2008 VIRTUAL SEMINARS

- Methods for Measuring Water Potential
- Soil Moisture Sensors and Irrigation Control: Separating Fact from Fiction
- Steps to a Better Data Set: Installing Soil Moisture Sensors
- Steps to a Better Data Set: Creating a Moisture Release Curve
- Water Potential: Soil and Plant Dynamics
- No Wires No Limits: Wireless System Installation for Measuring Soil Moisture
- Making Thermal Measurements

Letter from Bryan

Nothing like thinking about putting in a lawn to start you worrying. There are all the elements of environmental biophysics and soil physics you need to take into account to be successful. Next, the equipment you need to have to make the measurements and till the soil. Compound the worries with my father's admonitions regarding tractor safety and my family tree of Wackers deceased and maimed while at the wheel of tractors on the flat fields of Minnesota. Not concentrating while driving wheel tractors on the hilly Palouse might just kill you. Luckily, worrying about soil type, fertility, texture, pedology, infiltration, water potential/moisture content, the compaction, erosion and finally abysmal lawn failure isn't fatal. Thank goodness the Decagon equipment is simple to use. And if it tips over on you, the worst that could happen is a trip to Decagon's customer service department—for your instrument.



Bryan's lawn- solid rock!

Bryan T. Wacker
Soils Product Manager

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