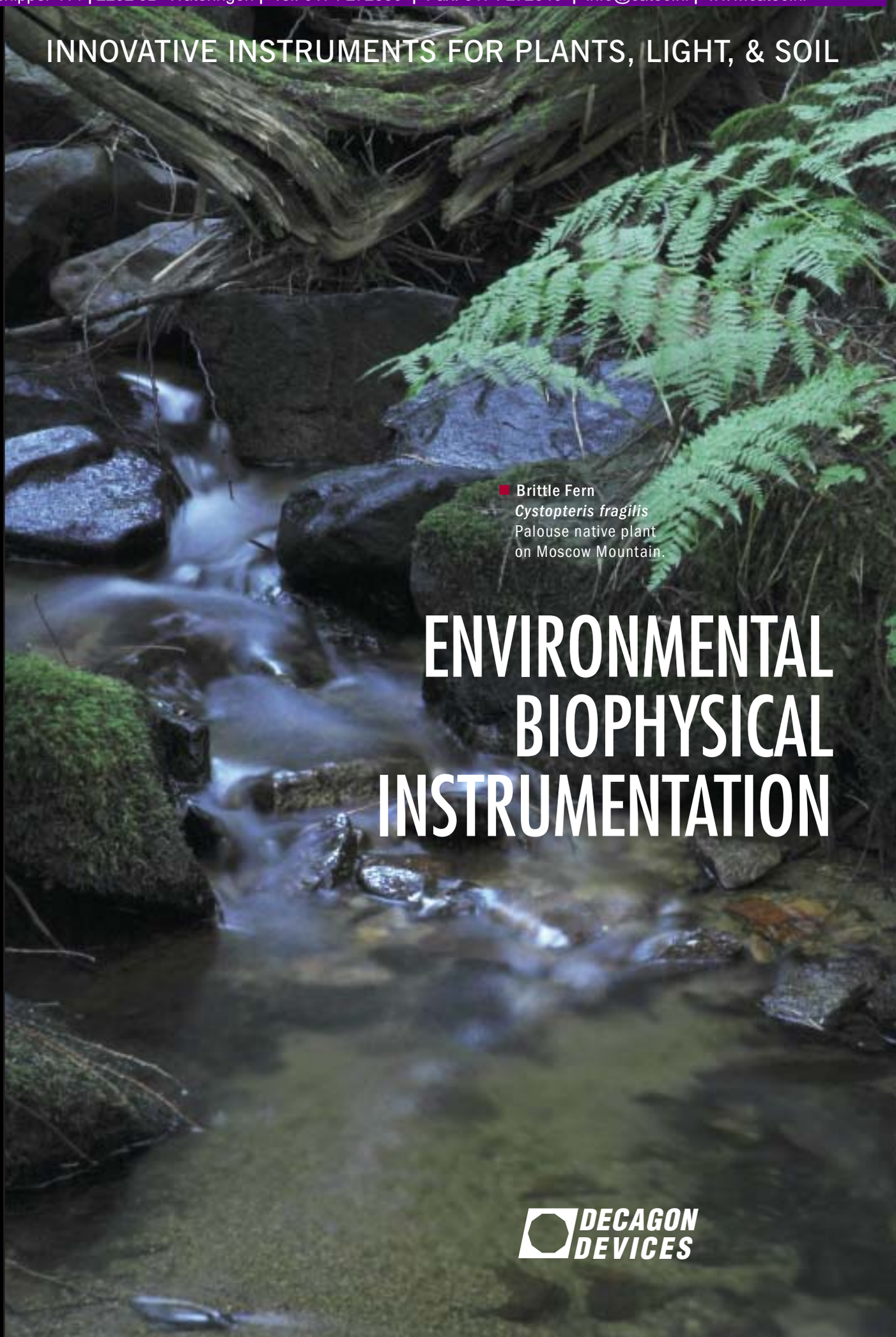
INNOVATIVE INSTRUMENTS FOR PLANTS, LIGHT, & SOIL

DECAGON CATALOG VOLUME 9 NUMBER 1

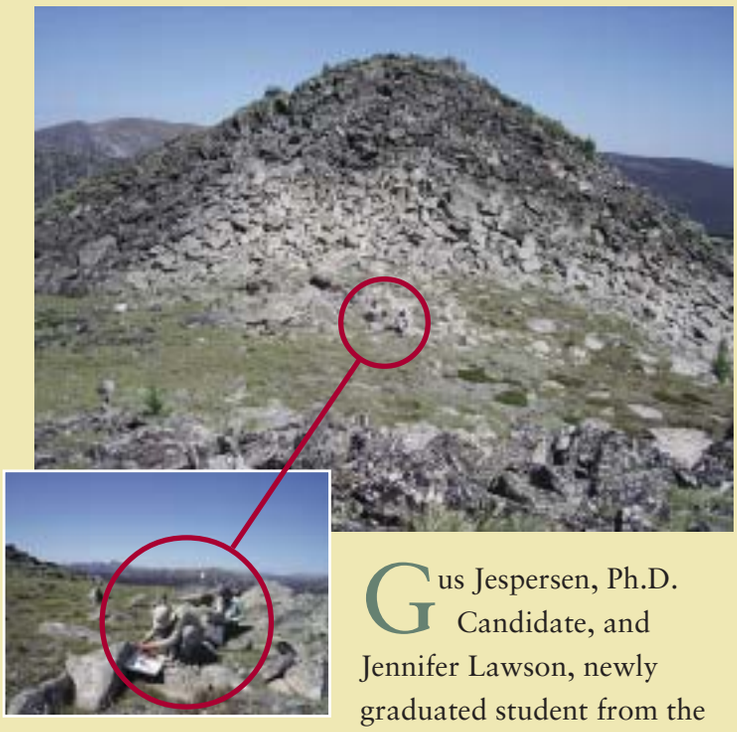


Brittle Fern
Cystopteris fragilis
Palouse native plant
on Moscow Mountain.

ENVIRONMENTAL BIOPHYSICAL INSTRUMENTATION

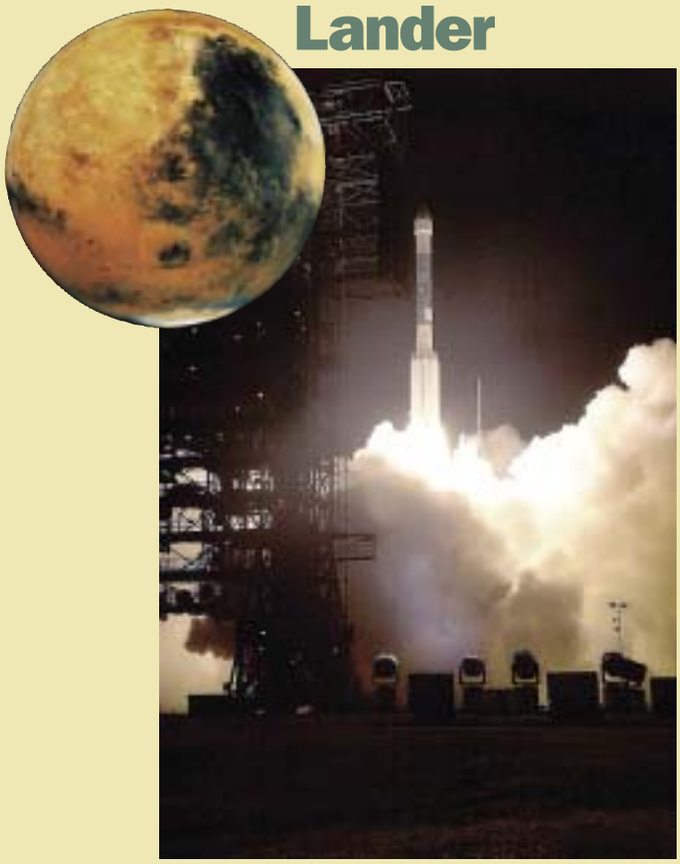
DECAGON DEVICES

Cryptobiotic Crusts



Gus Jespersen, Ph.D. Candidate, and Jennifer Lawson, newly graduated student from the University of Washington, are conducting research on cryptobiotic crusts found in the subalpine and alpine environments of the Washington Cascades. Gus and Jennifer are carefully wiring Decagon sensors to the Campbell Scientific data logger in order to monitor soil temperature and moisture below bare soil and soil covered with a crust near the summit of Snowshoe Peak (7823 feet) in the Loomis Management Unit of northeast most part of the Pasaytens. ■

Phoenix Mars Lander



On August 4, 2007, the Phoenix Mars Lander blasted off from Kennedy Space Center. Next May, Phoenix will hopefully set its feet down firmly on the northern polar region of Mars. Soon after that, Phoenix's robotic arm will push four short, fat probes into the Martian regolith and, if all goes well, find quantitative answers to some of our oldest questions about Mars. Those four probes and the instrument that runs them were designed and built by Decagon's engineering team. ■

PRODUCT APPLICATION NOTES ONLINE

AccuPAR LP-80, ECH$_2$O Soil Moisture Sensors, Leaf Porometer, Mini-disk Infiltrometer, Rain Gauges, Tensiometers, WP4, WP4-T, Software, Thermal Properties KD2 & KD2 Pro

http://www.decagon.com/literature

A listing of recently published papers utilizing Decagon equipment are also available at http://www.decagon.com/literature

DECAGON DEVICES

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NEW PRODUCTS

▲ **New Dielectric Water Potential Sensor** The Dielectric Water Potential Sensor easily and accurately measures the water potential of the surrounding soil. This maintenance free, pre-calibrated sensor allows for continuous measurement of soils water potential in all soil types.

▲ **The New ProCheck** instantaneously displays calibrated readings of any Decagon soil moisture or environmental sensor. **SEE PAGE 12 FOR MORE DETAILS.**

■ **See more new or upcoming products on page 28** ▶

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Leaf Porometer

Stomatal Conductance

The Leaf Porometer measures stomatal conductance using a steady-state technique. This technique places a leaf in series with two known conductance elements, measures the humidity at two different locations along the diffusion path, and computes the flux and gradient of the vapor measurements to determine stomatal conductance. The automatic read mode eliminates the subjectivity of determining the end point and allows for fast measurement of stomatal conductance in 30 seconds. The hand-held, lightweight readout displays either conductance or resistance, which can be saved and exported to your computer.

Applications

- Water Stress Measurements
- Variety Testing & Comparison
- Fundamental Research on Stomatal Function
- Teaching and Student Labs
- Uptake of Herbicides, Ozone, & Other Pollutants

Leaf Porometer Specifications

Conductance range
0 to 1000 mmol m^{-2} s^{-1}

Accuracy 10%

Operating Environment
5 to 40ºC, 10 to 90% RH, non-condensing

Power 4 AA alkaline cells

Battery life
3 years (battery drain in sleep mode $< 50\mu A$)

Units mmol $m^{-2}s^{-1}$, m^2s mol^{-1}, s/m

Case size 15.5 x 9.5 x 3.5 cm (6.1 x 3.7 x 1.4 in.)

Data storage
4095 annotated measurements in flash memory

Interface 9 pin serial RS232 interface

Measurement aperture 6.3 mm

Sensor head cable length 1.2 m (4 ft.)

Measurement time in Auto mode 30 s

Benefits

The Leaf Porometer has an easy-to-use menu-driven interface that simplifies data management. Users can save up to 4095 data points between downloads and add notes and comments to saved data for future analysis. The Leaf Porometer includes a user-friendly software utility for downloading data to your computer.

- Automatic sampling mode eliminates user subjectivity.
- Accurate Steady-State measurement.
- No subjective daily calibration needed.*
- No tubes, pumps, fans or dessicant.
- Simple, easy-to-use interface.
- Lightweight handheld readout.

**Sensor Head requires annual calibration*

DECAGON DEVICES

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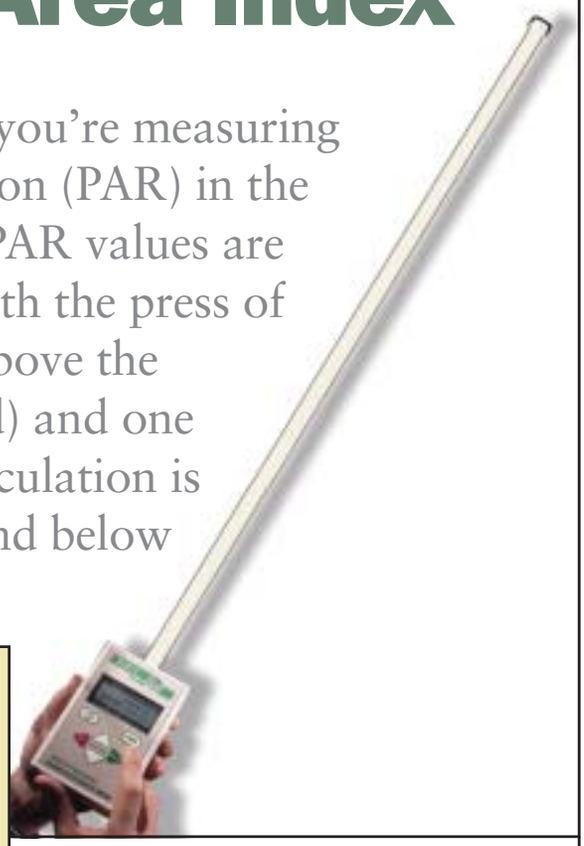
LP-80
AccuPAR
232
2009 ±1
402 ±1
MENU
ESC
ENTER
PAR/LAI Ceptometer
DECAGON DEVICES, INC.

Photosynthetically Active Radiation & Leaf Area Index

As soon as you turn the LP-80 on, you're measuring Photosynthetically Active Radiation (PAR) in the PAR sampling mode. Real-time PAR values are displayed on screen, and can be stored with the press of a button. Simply take one PAR reading above the canopy with the external sensor (included) and one below it, and a Leaf Area Index (LAI) calculation is displayed along with the average above and below canopy PAR.



BENEFITS

- Increased memory size (1MB of data storage.) Stores about 9,000 readings.
- Easy to use 6-key interface with 4 menus to navigate.
- 80 sensors, more than any competitor.

AccuPAR LP-80 SPECIFICATIONS

Operating environment
0° to 50°C (32°-122°F),
0 to 100% relative humidity

Probe length 86.5 cm

Number of sensors 80

Overall length 102 cm (40.25 in)

Microcontroller dimensions
15.8 x 9.5 x 3.3 cm (6.2 x 3.75 x 1.3 in)

PAR range 0 to >2,500 µmol $m^{-2}s^{-1}$

Resolution 1 µmol $m^{-2}s^{-1}$

Minimum spatial resolution 1 cm

Data storage capacity 1MB RAM, 9000 readings

Unattended logging interval
User selectable, between 1 and 60 minutes

Instrument weight 1.22 kg (2.7 lbs)

Data retrieval Direct via RS-232 cable

Power Four AA Alkaline cells.

External PAR sensor connector
Locking 3-pin circular connector (2 m cable)

Extension cable option 7.6 m (25 ft)

LP-80 ACCESSORIES (INCLUDED)

- **EXTERNAL PAR SENSOR**
  2 meter cable with connector for direct connection to the ceptometer's external port. Calibrated to provide an output of about 0.1 mV per µmol m^{-2} s^{-1} (calibration label provided). 1/4 x 20 threaded insert for mounting; domed top.
- **Non-magnetic Screwdriver.**
- **RS-232 CABLE—** for interfacing between your computer and the AccuPAR.
- **LP-80 User's Manual**
- **CARRYING CASE**
  Polyethylene hardened case. Foam cutouts allow the instrument and its accessories to be safely stored inside. 3.6 kg, 11.8 x 24 x 109 cm.

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Leaf Wetness

Many diseases affect plants only when moisture is present on the leaf surface. The Dielectric Leaf Wetness Sensor determines the presence and duration of wetness on a leaf's surface, enabling researchers and growers to forecast disease and protect plant canopies. The Leaf Wetness Sensor approximates the thermal mass and radiative properties of leaves to closely mimic the wetness state of a real leaf. Because the sensor does not take resistance-based measurements, it requires no painting or user calibration, and it can detect ice formation as well.

Leaf Wetness Sensor Specifications

Measurement time 10 ms

Power 2.5 VDC @ 10 mA to 5 VDC @ 7 mA

Output 250 to 1500 mV

Operating Environment -20 to 60°C

Expected Lifetime

2+ years continuous use

Probe Dimensions

11.2 x 5.8 x 0.075 cm (4.4 x 2.3 x 0.029 in)

Cable Length

5 m standard, extension cables available

Connector type 3.5 mm plug

Datalogger Compatibility *(not exclusive)*

Decagon Em50, Em50R

Campbell Scientific CR10, 10X, 21X, 23X, 1000, 3000, 5000

Applications

- Disease forecasting and modeling
- Ecological and Agricultural Research

Benefits

- No user manipulation or painting required.
- High resolution detects trace amounts of water or ice on the sensor surface.
- No calibration necessary; factory calibration set at standard wetness threshold.
- Low power requirements enable long-term leaf wetness monitoring.

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ECH2O
Logger
ECH2O EC-5

High-frequency soil water content sensors.

MODEL	LENGTH	MEASUREMENT	ACCURACY	FREQUENCY	RANGE	ELECTRICAL INTERFACE	BENEFITS
EC-5 	5 cm	Volumetric Water Content (VWC)	MINERAL SOIL : ± 3% VWC up to 8 dS/m*, ± 1 to 2% with soil-specific calibration ROCKWOOL ± 3% VWC, 0.5 to 8 dS/m POTTING SOIL ± 3% VWC, 3 to 14 dS/m	70 MHz	0–100% VWC	3.5mm plug, 3-wire	Minimal textural and EC effects. Voltage output correlated linearly with VWC.
EC-TM 	5 cm	VWC and Temperature	MINERAL SOIL : ± 3% VWC up to 8 dS/m*, ± 1 to 2% with soil-specific calibration ROCKWOOL ± 3% VWC, 0.5 to 8 dS/m POTTING SOIL ± 3% VWC, 3 to 14 dS/m	70 MHz	0–100% VWC	3.5mm plug, 3-wire	Minimal textural and EC effects. Digital output.
ECH$_2$O-TE 	5 cm	VWC, Temperature, Electrical Conductivity	MINERAL SOIL : ± 3% VWC up to 8 dS/m*, ± 1 to 2% with soil-specific calibration ROCKWOOL ± 3% VWC, 0.5 to 8 dS/m POTTING SOIL ± 3% VWC, 3 to 14 dS/m	70 MHz	0–100% VWC	3.5mm plug, 3-wire	Minimal textural and EC effects. Digital output.

*Saturation Extract

θ SOILS

Classic soil water content sensors.

EC-20 	20 cm	Volumetric Water Content	± 4% typ. on low EC & medium-textured mineral soils, ± 1 to 2% w/ soil-specific cal	5 MHz	0–40% VWC	3.5mm plug, 3-wire	Larger soil volume, Output voltage correlated linearly w/soil VWC
EC-10 	10 cm	Volumetric Water Content	± 4% typ. on low EC & medium-textured mineral soils, ± 1 to 2% w/ soil-specific cal	5 MHz	0–40% VWC	3.5mm plug, 3-wire	Medium soils volume, Output voltage correlated linearly w/soil VWC
EA-10 	10 cm	Volumetric Water Content	± 4% typ. on low EC & medium-textured mineral soils, ± 1 to 2% w/ soil-specific cal	5 MHz	0–40% VWC	2-wire analog, 4–20mA	Industrial applications, Output current correlated linearly w/soil VWC

SOIL-SPECIFIC CALIBRATION SERVICE Contact Decagon to inquire about our soil specific calibration services.

BENEFITS

■ TDR accuracy in a compact size.

■ Low-power, durable sensor for long-term remote monitoring.

■ Additional measurements such as temperature and EC (nutrient content) available.

■ THE ECH$_2$O SENSORS are well-known for their durability and cost-effectiveness. Now they've just become more accurate for the same low price. Our new EC-5, ECH$_2$O-TE and EC-TM sensors operate at a higher frequency, giving them accuracy in all soil types with minimal salinity effects.

The following specifications are common to all sensors:
Cable Length 5m
Operating Environment -40 to 60°C
Sensor Technology Frequency Domain Reflectrometry

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DATA LOGGING AND COLLECTION

■ Gelox Case and hinged cover make it easy to collect data and replace batteries.

■ Improved O-ring seal for weather resistance.

■ Dedicated download port.

▲ Em50/50R logger is a highly weather resistant logger for all Decagon sensors.

Em50 / EM50R LOGGER

Channels 5.

Storage >36,000 scans Each scan includes logger name, date, time, and 5 measurements

Scan Interval

User-programmable from 1/minute to 1/day

Communication Serial RS232 with optional radio

Power 5 AA alkaline batteries

Battery service life 1 to 3 years logging only, 6+ months with radio telemetry

Dimensions 12.7 x 20.3 x 5.1 cm (5 x 8 x 2 in)

Enclosure Rating IP55, NEMA3

Download software included with Em50 purchase.

ProCheck

For all Decagon sensors.

Channel 1

Storage 5,000 readings each reading includes sensor type, date, time, raw value, calibrated value and calibration coefficients

Communication Serial RS232

Power 4 AA alkaline batteries

Dimensions 15.5 x 9.5 x 3.5 cm (6 x 3.7 x 1.4 in)

The ProCheck instantaneously displays calibrated readings of any Decagon soil moisture or environmental sensor.

PROCHECK FEATURES
- Continuous or unattended reading
- User Calibration
- Reads all Decagon Sensors

Em5b LOGGER

For EC-5, EC-10, EC-20, ECRN-50 & ECT

Storage 3,400 scans, 1/minute to 1/day

Communication RS232

Power 4 AAA alkaline batteries, life 3+ yrs

Dimensions
8.7 x 6.2 x 3.5 cm
(3.75 x 2.75 x 1.25 in)

Download software included with Em5b logger purchase.

◄ The Em5b has 5 channels that allow scientists on a tight budget to monitor soil moisture and other environmental parameters inexpensively.

ECH_2O CHECK

For EC-5, EC-10, & EC-20

Measurement speed <1s

Resolution 1mV, 0.1%, 0.01 in/ft

Meter accuracy 3%.

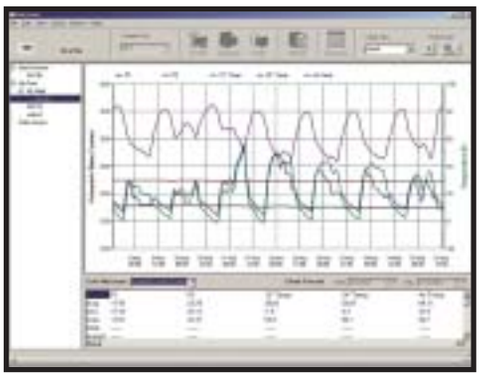
Power
3V CR2 lithium battery

Battery life 3–4 years

Operating environment
0–40° C

◄ The ECH_2O Check gives instantaneous readings of soil moisture (using EC-5, 10, or 20 sensors) in units of volume of percent (m^3/m^3), inches per foot (in/ft), or millivolts.

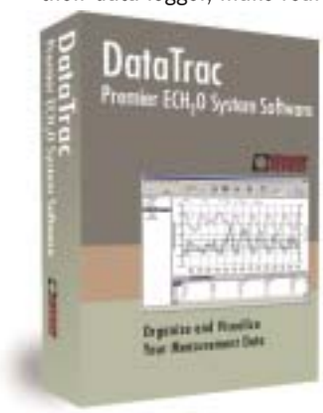
SYSTEM COMPONENTS



ECH$_2$O SYSTEM SOFTWARE

DataTrac is the premier ECH$_2$O system software designed to help users organize and visualize their measurement data. DataTrac automatically organizes and stores data for each data logger, and its powerful charting engine displays data graphically. DataTrac makes it easy for users to apply custom calibrations to individual sensors. Users can also view and edit data in table format, create reports, and transfer data to other DataTrac users.

ECH$_2$O Utility Mobile brings the usefulness of ECH$_2$O Utility to the Windows Mobile devices—enabling users to bring their PDA to the field instead of an expensive laptop. Like the desktop version, ECH$_2$O Utility Mobile allows users to configure their data logger, make real-time measurements, and download data.



ECH$_2$O Utility is free software that is included with the purchase of an Em5b, Em50 or Em50R data logger. ECH$_2$O Utility enables you to configure your data logger, make real-time sensor measurements, and download raw data to your computer.

Minimum System Requirements (DataTrac and ECH$_2$O Utility)
Microsoft Windows 98 or better
Monitor set to display 1024 x 768 pixels (minimum)

Minimum System Requirements (ECH$_2$O Utility Mobile)
Windows Mobile 5 (or higher) or PocketPC 2003 (or higher)
Serial Communications

DATASTATION

- **External antenna connector.**
- **RS232 serial cable connectivity.**
- **Storage for over 28,000 broadcast packets.**
- **Flexible 12–24 V AC/DC power.**

▶ The DataStation is a radio base station that allows you to remotely collect and store data from multiple Em50R data loggers. The DataStation is always on, receiving and saving data from Em50R loggers operating in confirm delivery mode. Data can then be downloaded directly from the DataStation to your computer at your convenience.

18.4cm L x 10.5cm W x 2.86cm H
(7.25"L x 4.125"W x 1.125"H)

ARCHER FIELD PC

▲ **The ergonomic Archer has ECH$_2$O Utility Mobile included.**

▶ The ultra-rugged Archer Field PC is our recommended platform for managing data in-the-field. The Archer is water-proof, shock-resisitant, and remarkably versatile. The Archer is capable of a wide range of adaptations, including:

- **Capture, map, or navigate using GPS options.**
- **Communicate wirelessly via Bluetooth, Wi-Fi.**
- **Custom configuration.**

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ENVIRONMENTAL AND CLIMATE SENSORS

LEAF WETNESS SENSOR

▼ **THE LEAF WETNESS SENSOR** requires no painting or calibration. The high resolution detects trace amounts of water or ice on the sensor surface.

Measurement time 10 ms
Operating Environment -20 to 60° C

For more information see page 9.

RH/TEMPERATURE SENSOR

▼ Durable sensor measures relative humidity and temperature and outputs both values as a digital signal. Used in conjunction with ECH_2O probes, this sensor is ideal for microclimate studies.

Probe RH Range
0 to 100% RH
RH Accuracy
±2% from 1–90% RH
±3% from 0–1% RH and 90–100% RH
Temperature Accuracy
±0.5° C from 5–40° C
±1.0° C from -40–5° C and 40–60° C

TIPPING-BUCKET RAIN GAUGES

THE ECRN-50 AND ECRN-100 are simple self-emptying electronic rain gauges for use with the Em50/50R and Em5b dataloggers. They are made of UV and water-resistant plastic. Configured as volume gauges, they are useful for measuring the output of irrigation systems in terms of gallons (or liters) per hour.

▲ The ECRN-100 is best for research applications and measuring rainfall.

Resolution 0.25 mm (0.01 in)

Dimensions 17 cm x 14.2 cm

Connector 3.5 mm plug

▲ The ECRN-50 is best for measuring irrigation events.

Resolution 1 mm

Dimensions 5 cm x 10 cm

Connector 3.5 mm plug

SOLAR RADIATION SENSOR

▼ **THE PYRANOMETER MODEL PYR** is completely water proof, submersible and designed for continuous outdoor use. A leveling plate is included.

Cable length 1m

Range 0 to 1500 W m^{-2}

Warranty
1 year parts and labor.

Dimensions
24mm diameter,
29 mm deep.

SOIL/AIR TEMPERATURE SENSOR

▼ **SOIL/AIR TEMPERATURE SENSOR** model ECT, 6mm diameter, 37.5mm long cylinder of molded plastic with a 3m cable, plug & play with logger.

► Monitor soil temperature with the model ECT while measuring water content. The model ECT also monitors ambient air temperature when used with a radiation shield.

► The stereo-style plug on all Decagon sensors is easy to use.

INSTALLATION AND PROTECTION

CABLE ARMOR

Threading the armor with cable.

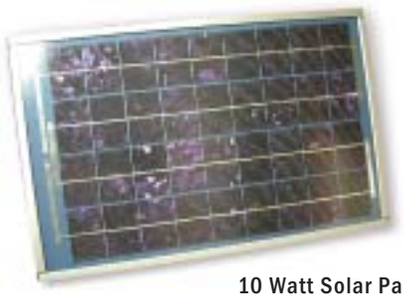
◄ RODENT-RESISTANT PLASTIC Rodents are a major problem in many locations. Rodents are drawn to the aromatic odors of polymers, the bright inner wire colors, and the polymer texture. These rodents destroy underground cable by chewing off cable insulation, which can expose bare wires and cause short circuits.

Cable Armor protects your cables by increasing the outer diameter of the cable with plastic shielding.

REMOTE OUTDOOR ENCLOSURE

◄ Protects your DataStation from the elements. Includes a weather-proof fiberglass case for the DataStation, Solar Power panel and all mounting hardware. The DataStation, outdoor antenna, antenna extension cable, and tripod are sold separately.

Enclosure
34.3 H x 24.1 W x 17.8 D. cm



10 Watt Solar Panel
27.9 H x 41.9 W x 2.5 D. cm

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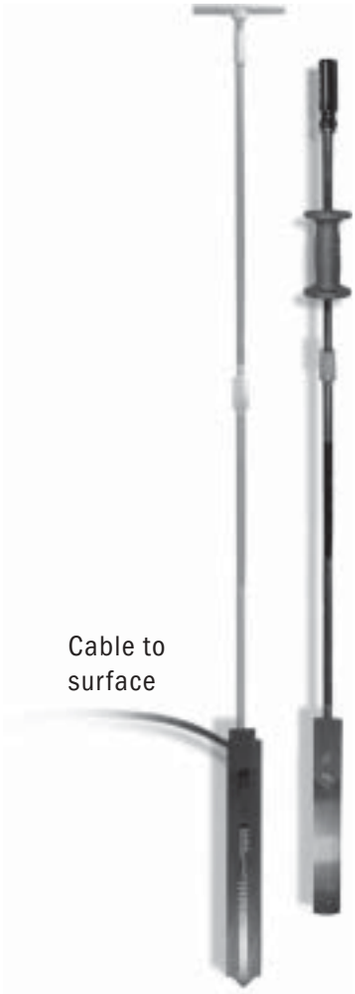
EC-10 AND EC-20 SENSOR INSTALLATION KIT

For both trench and bore hole installations.

View a short Apple Quicktime® movie about installing ECH_2O probes.
Online– http://www.decagon.com/multimedia/prbsmall.mp4

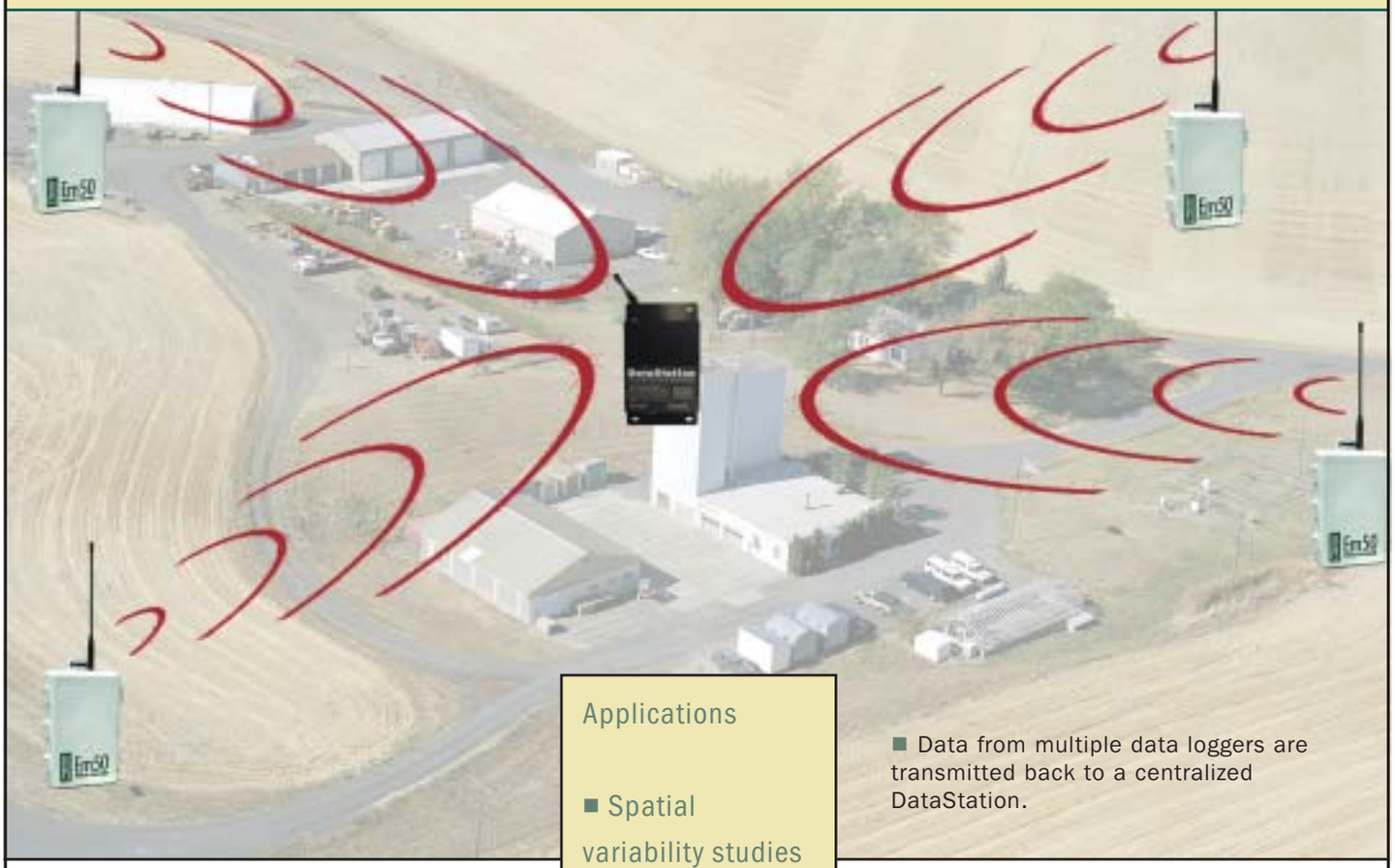


RADIATION SHIELD

▲ The solar radiation shield is highly recommended to protect the Temperature sensor and the RH/Temp sensor from ambient interference. Without proper protection, these sensitive devices can give inaccurate readings.


METER GROUP
Em50
ECH2O LOGGER
Em50

WIRELESS MONITORING



■ Data from multiple data loggers are transmitted back to a centralized DataStation.

Applications

■ Spatial variability studies

■ Watershed characterization

■ Agricultural Irrigation Monitoring

Benefits

- Monitor spatial variability with a variety of environmental parameters from one location
- No need to visit each site after initial installation
- No programming-only simple configuration

ECH_2O Wireless Monitoring System Specifications

Measurement Nodes Em50R logger

- 5 sensors per logger
- 5 AA power, supplies a logger for 6+ months
- Available sensors EC-5, ECH_2O-TE, EC-TM, EC-10, EC-20, MPS-1 water potential sensor, LWS leaf wetness sensors, pyranometer, PAR sensor, RH/Temperature sensor, ECT temperature sensor, ECRN-100 rain gauge, ECRN-50 rain gauge

Base Station DataStation

Transmission distance 3–4 miles*

**dependent upon topography, optional extended range antennas available*

Can receive up to 80 Em50R data loggers

Power 12-24V AC/DC

RS232 communication

Software DataTrac

Minimum System Requirements

Microsoft Windows 98 or better

Monitor display 1024 X768 pixels

While not required, it is beneficial to have a handheld computer during installation of the ECH_2O Wireless Monitoring System. These units are also available from Decagon.

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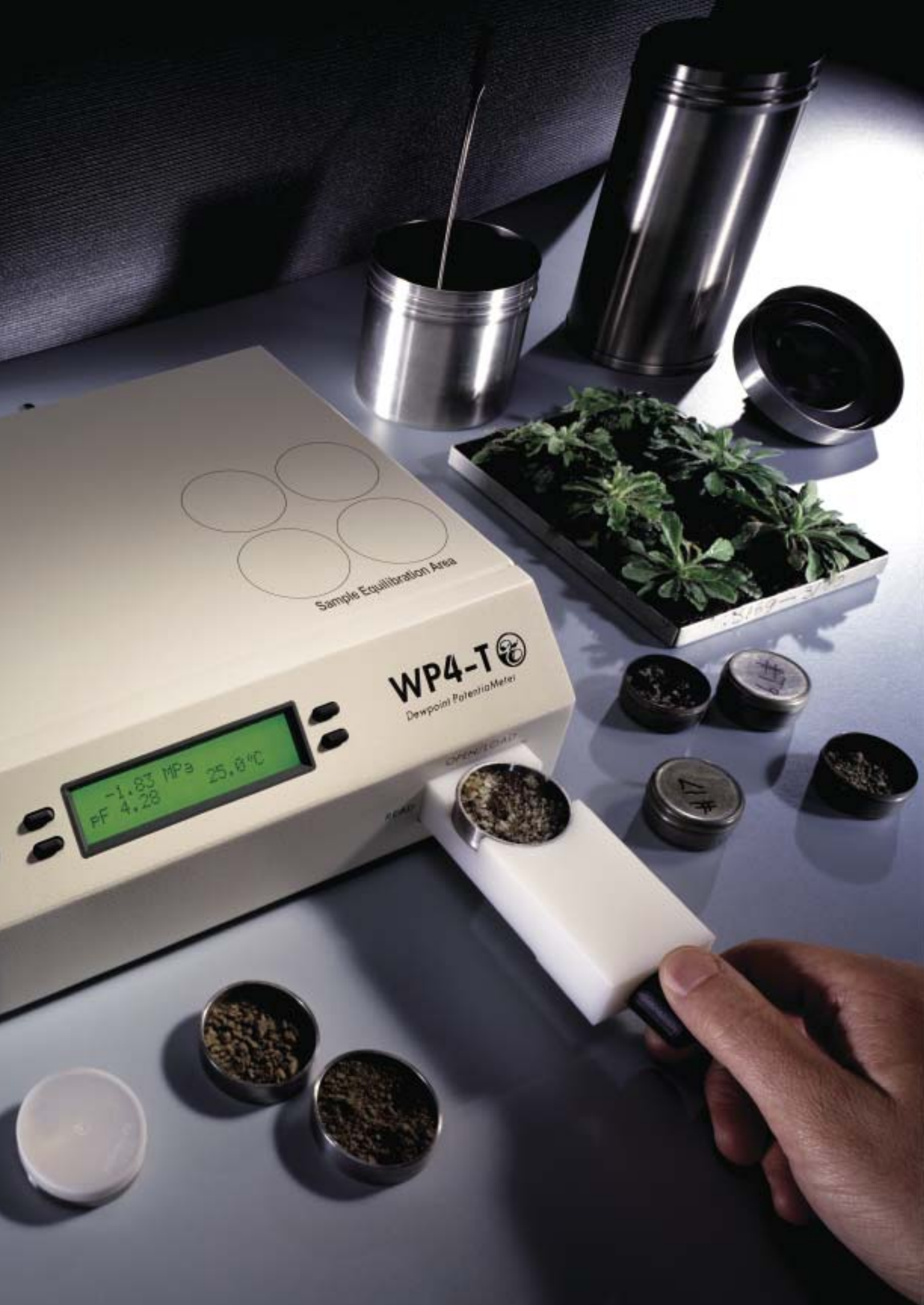
Sample Equilibration Area
WP4-T
Dewpoint PotentiaMeter
-1.83 MPa 25.6°C
pF 4.28

Soil Water Potential

■ Stainless steel sample cups are reusable and can be used in drying ovens. 10 cups per set, 15ml capacity, comes with 10 plastic cup lids.

The WP4 and WP4-T Dewpoint Potentiameters use a chilled mirror to accurately measure the dewpoint temperature of air in equilibrium with a soil or plant sample. Sample temperature is measured with an infrared thermometer. The sample water potential is then computed from these two measurements. An alphanumeric display shows the sample water potential in MPa and pF, along with sample temperature. Readings typically take 5 minutes or less. The WP4-T has internal temperature control, allowing the user to measure at any operating temperature between 15˚C and 40˚C.

■ Plastic sample cups and calibration standards included. Replacements available from Decagon.

Applications

- Soil moisture characteristics
- Root zone water potential profiles
- Leaf water potential
- Seed priming
- Seed water relations
- Expansive soil characterization

WP4 & WP4-T SPECIFICATIONS

Operating Environment

5 to 43°C (41 to 110°F)

Temperature Control (WP4-T only)
15° to 40°C ± 0.2 °C

Sensors 1. Infrared temperature.
2. Chilled-mirror dewpoint

Range 0 to -300 MPa

Accuracy ± 0.1 MPa from 0 to -10 MPa, ± 1% from -10 to -300 MPa

Read time 5 minutes or less

Interface Cable Serial cable (included)

Data Communications RS232 compatible, 8-bit ASCII code, 9600 baud, no parity, 1 stop bit

Weight 3.2 kg (5.2 kg shipping weight)

Universal Power 110/ 220V AC, 50/60Hz

Sample dish capacity 7ml recommended (15ml full) 100 plastic cups included

Calibration Standard 0.5 molal KCl (-2.19MPa)

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▼ EQUILIBRATION ACCESSORY

Temperature Equilibration Plate
50-watt Peltier (heat & chill)

anodized aluminum plate, 7.3cm x 11.1cm

- Simple push-button operation
- Stable, precise temperature control
- Compact size uses little bench space

Range -10°C to 90°C

Accuracy ± 1°C

Stability ± 1°C

Uniformity ± 0.5°C

Store 8,110 data points, retrieve via serial RS-232C

External 12VDC supply
110/230VAC, 50/60Hz, 5.6cm x 16.5cm x 8.1cm

Total shipping weight 2.9kg

■ Pre-heating or chilling soil samples accelerates water potential measurements.

Dielectric Water Potential

The new MPS-1 Water Potential Sensor is perfect for your *in situ* monitoring needs. Integrating a high performance ceramic with the new dielectric circuitry, the MPS-1 can measure a wide range of soil water potentials without user maintenance. No wasting precious time doing individual calibration. In the field, the MPS-1 can be quickly installed down-hole by inserting the sensor and packing wet soil around it. Measuring and recording data is also simple as the sensor is easily plugged into an Em50/Em5b port or any other capable datalogger. Factory calibration allows readout in soil water potential, regardless of the soil type it is in, while the high frequency dielectric circuit minimizes soil electrical conductivity sensitivity.

BENEFITS

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

MPS-1 SPECIFICATIONS (R2.07)

Range 0 to -500 kPa

Accuracy

±5 kPa from 0 to -40 kPa

±30% of reading from -40 to -500 kPa

Resolution

1 kPa from 0 to -100 kPa

4 kPa from -100 to -500 kPa

Measurement time 10 ms (milliseconds)

Power requirement 2 to 5 VDC @ ~10 mA

Output 525 to 925 mVDC independent of excitation voltage

Operating temperature -40 C to +50 C

Sensor dimensions 75 mm x 32 mm x 15 mm

Connector types 3.5 mm “stereo” plug

Cable length 5 m standard, extension cables available

Datalogger Compatibility (not exclusive)

Decagon Em5b, Em50, Em50R

Campbell Scientific CR10X, 21X, 23X, CR1000, CR3000, etc.

DIELECTRIC WATER POTENTIAL SENSOR APPLICATIONS

- Water potential monitoring in vadoze zone.
- Crop stress.
- Waste water drainage studies.
- Irrigation monitoring and control.
- Plant water availability.

DECAGON DEVICES

www.decagon.com

Extremely Fast Response Tensiometers

▲ **T5** mini-tensiometers are essential for the measurement of water potential in small spaces like soil columns, potted plants and in laboratory water flow experiments.

UMS designs and manufacturers tensiometers to make research easier. The pressure transducer based sensors allow for precise measurement of water potential. A variety if sizes give you options for deployment from field to lab. Their newest tensiometer the TS1, allows yearlong field deployment after installation.

▲ **T4 Tensiometer** Standard tensiometer. External refilling option.

▲ **T8 Tensiometer** Includes temperature measurement, water level indicator and external refilling option.

◄ **TS1** The world's first smart tensiometer. Designed to be deployed in the field and left, the TS1 logs water potential data, self refills, monitors temperature, and self-empties when the temperature nears freezing to avoid damage.

* FOR SALE IN USA ONLY.

◄ **Infield 7 Handheld digital display** interfaces with all UMS tensiometers for quick data collection.

TENSIOMETERS SPECIFICATIONS

Range 0 to -85 kPa

Accuracy ± 0.5 kPa

Resolution 0.1 kPa

Cable length 5m

Hysteresis typ. 0.1% FS

Stability over one year typ. 0.5% FS

Sensor Piezoresisitve pressure transducer, overpressure max ± 3000 hPa

Electronics Wheatstone full bridge

Compatible with Infield 7 and CSI dataloggers.

Passive Capillary Lysimeter

The Drain Gauge allows you to measure the flux of water and solutes through the soil profile. It sits below the root zone, collecting down-welling water into a duct and wick system. The collected water volume is recorded by a surface datalogger. A surface port allows you to draw out samples to analyze for chemicals, fertilizers, and other contaminants. Because there are no moving parts, the Drain Gauge is tough. It's built to be buried—and stay buried. You don't need to worry about digging it up for maintenance or inspection.

DRAIN GAUGE APPLICATIONS

- Waste landfill sites, to advise operators when drainage is occurring and where cover systems need to be improved.
- Maximization of food processing waste applications by monitoring water drainage rates and water quality below the root zone.
- Environmental research measuring percolation and recharge rates.
- Farming operations, to measure and control irrigation during a cropping season.
- Recreational facilities, such as golf courses, to measure and control excess water and nutrient losses.

DRAIN GAUGE SPECIFICATIONS

Reservoir drain volume 31 ml
Resolution 0.03 mm drainage
Measurement time 10 ms
Gauge power 2.5 VDC @ 3 mA, for 10 ms
Output Proportional mV-to-water-level
Operating temperature 0 to 50 ˚C
Cable length 3 m
Material Galvanized Steel
Overall length 147 cm including divergence control tube
Weight 10 kg boxed
Compatible dataloggers
DECAGON Loggers Em50, Em50R
CSI Loggers 21X, 23X, CR10X, CR1000

BENEFITS

- Galvanized steel exterior and inert plastic liner protect the intrument and guard the collected drained water in an inert receptacle.

DECAGON DEVICES
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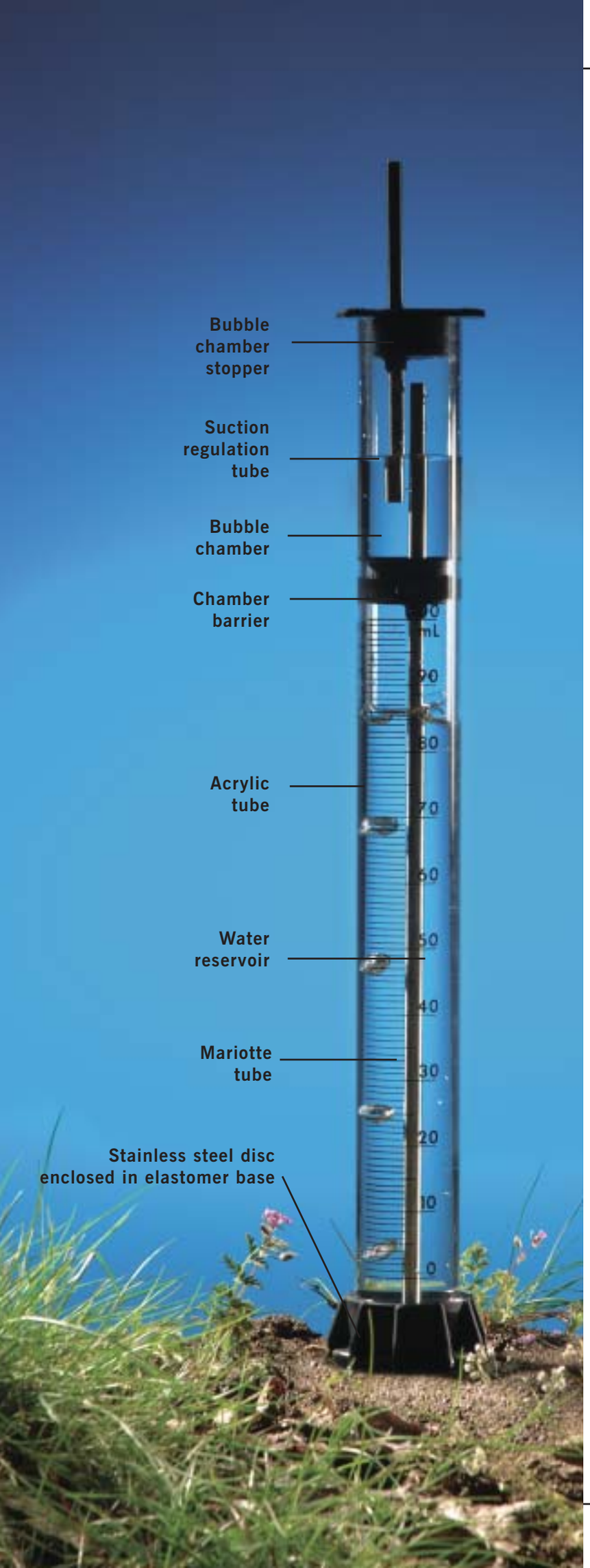
HYDROLOGY



Soil Hydraulic Conductivity

The Minidisk infiltrometer measures how quickly water will infiltrate when applied to a given field or soil type. The new minidisk infiltrometer (model S) features adjustable suction and porous stainless steel plate for contact with the soil. Infiltration under suction assures the water will not enter macropores such as cracks or wormholes, resulting in a less variable and more reliable determination of hydraulic conductivity of the soil matrix.

Infiltrometers are ideal for irrigation system design, classroom instruction, erosion hazard evaluation and many other applications.

Total length 32.7 cm

Suction range 0.5 to 7 cm of suction
Water Volume for Operation 135 ml

Diameter of stainless steel disc
4.5 cm dia., 3 mm thick

APPLICATIONS
Compact size for:

- Class room instruction.
- Field measurements with a limited water supply such as a canteen.
- Excel macro included, simply input the soil texture and the water level readings.

The resulting measurements of infiltration vs. transformed time are fit with a polynomial. The hydraulic conductivity is proportional to one of the coefficients.

DECAGON DEVICES
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Soil Water Analysis

Sampling and testing the pore water provides information about chemicals and chemical movement below the ground surface. Pore water samplers provide an early detection system for leaching, drainage, and leakage problems.

▲ **VPH-1**
Manual vacuum pump VPH-1 for field applications comes with reinforced handles.

▲ **VS-pro**
For long term monitoring, defined leachate measurements or pore water sampling; the VS-pro comes with two vacuum outputs, for constant or tension controlled vacuum. Keyboard display allows for status checks and configuration.

SINTERED AT 2500 °C, THE NEW SIC-20 SILICON CARBIDE TIP IS MORE CHEMICALLY PASSIVE THAN CERAMIC OR BOROSILICATE.

▲ **SIC-20**
The SIC20 allows for high permeability, low sorption and has a very low dead volume.
Dimension- suction tube length: 1.6 m
Bubble point: 0.1 bar

▲ **SKP-100**
pH range 4 to 9
Analytes compatible nitrate,chloride,sulphate,calcium, sodium,ammonium, phosphorus. Not suitable for heavy metals.
Dimensions- suction tube length: 1.6m
Bubble point: 1 bar

▲ **SKPE25**
Allows for water and analyte collection and storage in the ground before extraction and analysis at the lab.
Not suitable for heavy metals.
Dimensions- suction tube length: 1.6m
Bubble point: 1 bar

▲ **SPE20**
Optimized for the collection of herbicides, pesticides and heavy metals

The specialized membrane is specifically designed for tough applications where ceramic is not suitable.
Dimensions- suction tube length: 1.6m
Bubble point: 1 bar

HYDROLOGY

PORE WATER SAMPLER BENEFITS

Pore-water sampling allows the user to

- Monitor the presence of fertilizers and other chemicals in the soil.
- Adjust chemical applications to apply varying amounts as needed to satisfy root-zone requirements.
- Detect leakage from lagoons, ponds, and industrial waste facilities.

Pore water sampler standard shaft length is 30 cm.
Other lengths available are 60 cm, 90 cm, 120 cm, 160 cm, and 200 cm (200cm is the maximum one-piece length).

* FOR SALE IN USA ONLY.

Soil Thermal Properties

The pocket-sized KD2 uses a single sensor to measure thermal conductivity and thermal resistivity. It uses the transient line heat source method to calculate and display the thermal conductivity in 90-seconds. The small needle size results in very little compaction during installation and allows for a short heating time—minimizing thermally induced drying around the probe. ■

▲ Tradesman carrying case included.

- **Heated Needle Technology**
- **Requires No Calibration**
- **Displays in Engineering Units**
- **Small Needle Minimizes Soil Disturbance**

Specifications Thermal Analyzers

	KD2	KD2 Pro
Measurement	90 Seconds	90 Seconds
Accuracy*	5% Thermal Conductivity	7% Specific Heat
	5% Thermal Resistivity	5 to 10% Cndctvty/Rsstvty
		5% Thermal Diffusivity
Ranges*	K: 0.02 to 2 Wm^{-1} C^{-1}	K: 0.02 to 2 Wm^{-1} C^{-1}
	n/a	D: 0.1 to 1.0 mm^2s^{-1}
	R: 0.5 to 50 mC W^{-1}	R: 0.5 to 50 mC W^{-1}
	n/a	C: 0.5 to 4 MJ m^{-3} C^{-1}
Data Storage	none	4095 readings
Cable	0.8 m	0.8 m
Environment	-20 to 60°C	–50 to 150°C
Case Size	24.7 x 15.2 x 5 cm	15.5 x 9.5 x 3.5 cm
Power	3.0 V Lithium Battery	4 AA Batteries
Sensors	60 mm L, 1.27 mm Dia. needle	KS-1, 6 cm, 1.27 mm Dia. needle
		TR-1, 10 cm, 1.27 mm Dia. needle
		SH-1, 30 mm, 1.27 mm Dia. 2 needles

**Accuracy and measurement range vary with sensor type.*

▶ Each KD2 Pro comes factory calibrated and includes performance verification standards.

The KD2 Pro uses three interchangeable sensors to measure thermal diffusivity, specific heat (heat capacity), thermal conductivity and thermal resistivity. Using the transient line heat source method, the KD2 Pro takes measurements at 1-second intervals during a 90-second measurement cycle. It then analyzes the data and corrects for sample temperature drift—providing accurate thermal properties measurements.

Users can read values directly or download raw values for analysis as required by IEEE and ASTM Standards.
It also features an automated mode where users can set the measurement interval and collect unattended data. ■

▲ Pelican carrying case included.

■ **KS-1**
6cm needle length
Thermal conductivity specific.

■ **TR-1**
10cm needle length
ASTM and IEEE compliant.

■ **SH-1**
30mm dual needle length
3 parameters- Thermal Conductivity, Thermal diffusivity, and Specific Heat.

DECAGON DEVICES
www.decagon.com

SOIL ISOTHERM GENERATOR Available 2nd quarter of 2008

AquaSorp Isotherm Generator

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 isotherms 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 sorption isotherm generation.
- Fast expansive soil characterization.

NEW PRODUCTS

◄ **See more new or upcoming products on page 3.**

Large Soil Sensing Volume

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

- Large volume soil sensor.
- High frequency.
- Minimal salinity and textural effects.

History of the Porometer

The first work on measuring stomatal openings started in the late 1930's with scientists like M.C. Desai, F.G. Gregory, and H.L. Pearse. These pioneers would strip the leaf epidermis, make impressions with collodion, look at infiltration with liquids and observe stomata with direct microscopic investigation.

▲ **Ellis Wallihan's porometer design with the Dunmore electronic humidity sensor (circa 1960.)**

The 1960's opened new possibilities to make measurements with the advent of the Dunmore electronic humidity sensor. This sensor was not very good in retrospect, but it helped launch the concept of the hand-held porometer with Ellis Wallihan's research and design.

With the advent of the Vaisala fast-response capacitance humidity sensor in the 1970's another leap forward was made. At this point the commercialization of porometers by Licor and Delta-T put the measurement into the hands of researchers that could not build their own equipment. Licor's design was based on work by C. van Bavel , C. Tanner, and E. Kanemasu. Across the Atlantic, Delta-T used designs based on work by J. Monteith.

Further miniaturization has produced yet another lead forward in technology, and now new and improved humidity measurement technology is available, allowing Decagon to provide a new, low cost porometer. ■

Wallihan, E. F. 1964. Modification and Use of an Electric Hygrometer for Estimating Relative Stomatal Apertures. Plant Physiol. 39(1):86–90.

Contact Decagon for a PDF copy of the poster "An Inter-Comparison of Three Commercial Porometers" presented at ASA-CSSA-SSSA 2006 by Lauren Bissey.

▲ **Compact diffusion porometer prototype from the early 1970s.**

▲ **Newer prototype diffusion porometer based on the same principles as the 1970s prototype but with modern electronics.**

▲ **Commercial Leaf Porometer, first demonstrated at the 2002 ASA conference.**

DECAGON DEVICES

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DECAGON DEVICES
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■ Decagon Devices, Pullman, Washington

Dear Customers,

Our customers are at the heart of our efforts every day. Some time ago we began to wonder how to decrease delivery lead times. We turned our attention to the possibilities of lean manufacturing. Lean Manufacturing eliminates unnecessary steps out of processes to make them streamlined and efficient, thus reducing lead times.

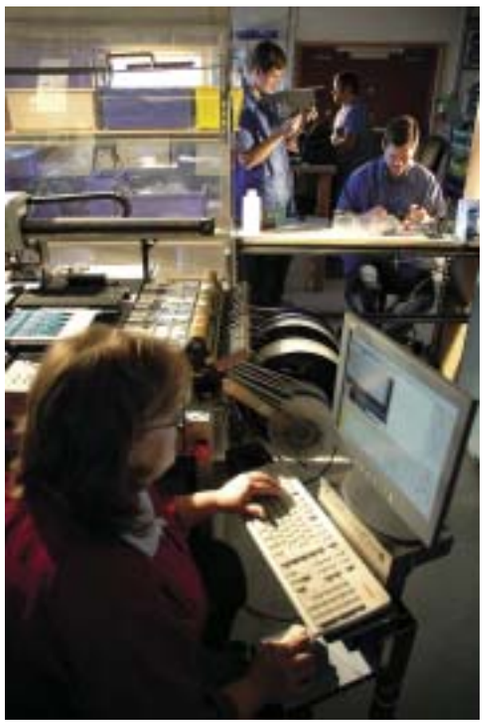
Implementing lean manufacturing principles has reduced the lead time of a WP4-T from 30–45 days to less than 2 weeks. We see this as a good start but realize that continuous improvement is necessary to better serve you.

We pledge our commitment to this continuous improvement.

Sincerely,

Tamsin Campbell

Tamsin Campbell
President



■ Decagon team members making soil moisture sensors.

TERMS & CONDITIONS

WARRANTY: One year, parts and labor.

SATISFACTION GUARANTEE: 30 days from delivery.

TECHNICAL SUPPORT: Unlimited technical support.

RETURNS AND REPAIRS: Please contact us for instructions before shipping to Decagon.

DELIVERY TIME: 30–45 days ARO.

SHIPPING POLICY: All shipments are FOB USA. Domestic orders FOB destination.

INTERNATIONAL ORDERS: CIP or EXW. Prices listed do not include freight and insurance. Freight and insurance costs are added to the invoice.

TERMS: Net 30 days to domestic universities and major institutions. Others prepay via credit card, bank draft, letter of credit, or wire transfer on approval of credit.

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