DualHead Infiltrometer

Operator's Manual

Decagon Devices, Inc.

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1 Introduction

Thank you for purchasing the Decagon Devices DualHead Infiltrometer. The DualHead Infiltrometer measures Field Saturated Hydraulic Conductivity (K_{fs}) in soil. This manual should help you understand the functions of your DualHead Infiltrometer, make high-quality K_{fs} measurements, and get the most out of your instrument.

1.1 Shipping Contents

- Control Unit
- Insertion Ring
- Driving Plate
- Infiltrometer Head
- Charging Adapter
- Collapsible Water Tank
- Three Tubes

1.2 Customer Support

If you ever need assistance with your DualHead Infiltrometer, or if you just have questions or feedback, there are several ways to contact us. Customer service representatives are available to speak with you Monday through Friday, between 8am and 5pm Pacific time.

Note: If you purchased your DualHead Infiltrometer through a distributor, please contact them for assistance.

E-mail:
support@decagon.com or **sales@decagon.com**

Phone:
509-332-5600

Fax:
509-332-5158

If contacting us by email or fax, please include as part of your message your instrument type, serial number, your name, address, phone, and fax number.

1.3 Warranty

The DualHead Infiltrometer has a one year warranty on parts and labor. The warranty activates when the instrument arrives at your location.

Seller's Liability

Seller warrants new equipment of its own manufacture against defective workmanship and materials for a period of one year from date of receipt of equipment (the results of ordinary wear and tear, neglect, misuse, accident and excessive deterioration due to corrosion from any cause are not to be considered a defect); but Seller's liability for defective parts shall in no event exceed the furnishing of replacement parts F.O.B. the factory where originally manufactured. Material and equipment covered hereby which is not manufactured by Seller shall be covered only by the warranty of its manufacturer.

Seller shall not be liable to Buyer for loss, damage or injuries to persons (including death), or to property or things of whatsoever kind (including, but not without limitation, loss of anticipated profits), occasioned by or arising out of the installation, operation, use, misuse, nonuse, repair, or replacement of said material and equipment, or out of the use of any method or process for which the same may be employed. The use of this equipment constitutes Buyer's acceptance of the terms set forth in this warranty.

There are no understandings, representations, or warranties of any kind, express, implied, statutory or otherwise (including, but without limitation, the implied warranties of merchantability and fitness for a particular purpose), not expressly set forth herein.

2 About the DualHead Infiltrometer

2.1 Specifications

Infiltration Rate Range: 0.0038 cm/hr to 115 cm/hr
Infiltration Rate Resolution: 0.0038 cm/hr
Infiltration Rate Accuracy: ±5 % of reading
K_{fs}: *(see explanation below)
Water Level: Maintained at 5 cm
Pressure Head Ranges: 0 to 40 cm
Operating Temperature: 0 to 50 °C
Charging Adapter: 18 V 2.2 Amps; Range 18 to 24 V DC
Output: USB

* The range of K_{fs} values that can be effectively measured by the DualHead Infiltrometer are limited by the minimum and maximum infiltration rates specified above. These depend not only on K_{fs}, but also on the pressure heads applied to the water during infiltration and to the 3-dimensional flow characteristics of the soil, so the measurement range of K_{fs} cannot be specified explicitly. The DualHead Infiltrometer will generally be able to make measurements on poorly to moderately structured soils as coarse as medium sand, but the maximum infiltration rate can be exceeded by soils with excessive structure and especially by soils with significant macropore flow.

2.2 Components

The DualHead Infiltrometer consists of four main components; the Infiltrometer Head, Control Unit, Insertion Ring and water supply. Customers can order additional water supply bladders for high infiltration applications.

Figure 1: Components

The DualHead Infiltrometer Control Unit has seven buttons that allow you to navigate through screens and configure different settings.

Power / Menu

The left side button below the display is the Power/Menu button that navigates between different screen tabs. This button also acts as a power button that turns the device on or off. When the device is off, press the button to turn on the device. Hold the button down for more than four seconds to power off the device.

Back

The upper right button is the Back button. Pressing Back returns the device to the parent screen. Pressing Back on a selection screen cancels any changes that have been made on that screen.

Directional Pad

The Up, Down, Left and Right buttons on the directional pad allow to navigate through lists and scroll wheels. Pressing left or right

in a list pages through items and holding down a directional button speeds up scrolling.

Enter

The middle button on the directional pad is the Enter button. Press the Enter button while highlighting an item to go to a sub menu or save the highlighted setting to memory.

Figure 2: Control Unit

2.3 Optional Accessories

10 cm insertion ring

The 10 cm insertion ring was designed for sites with a disturbed or loose soil surface. The deeper insertion ring can also be helpful in forest or organic soils with a deep duff or organic layer at the surface.

Figure 3: Image of 10 cm insertion ring

Collapsible 5 gallon water tank with Y-connector

Some sites with higher infiltration rates will use more than 5 gallons of water in the time necessary to complete a measurement. The secondary water tank with Y-connector allows you to connect up to 2 water tanks to the DualHead, doubling the water supply available for a measurement.

Figure 4: Additional Water Tank

3 Taking a Reading

3.1 Installation

Before installation, verify all of the contents shipped and appear in good condition. (see shipping contents list) Make sure to charge the Control Unit initially before taking your first measurements and renew the charge each day after returning from the field. Also, before you head to the field, verify you have access to a source of water or make arrangements to bring it with you. Be sure to bring a hammer or rubber mallet to pound in the insertion ring as described later in this section.

Begin installation by setting up the Control Unit. Place the Control Unit on a stable surface near your test location. Attach the corresponding hoses onto the three hose ports labeled in Figure 5. Wait until you install the Infiltrometer Head to plug in the sensor.

Note: There are three different hose sizes, each corresponding to a connector.

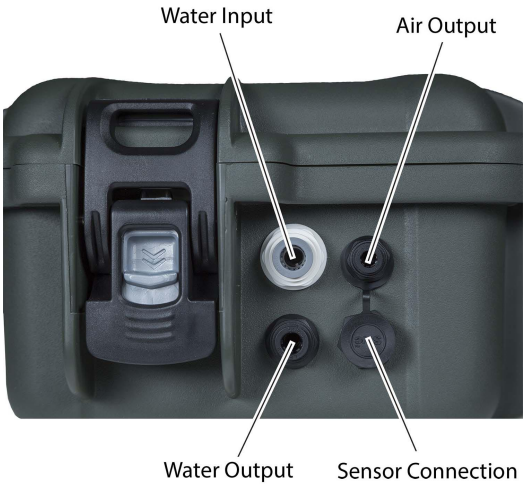


Figure 5: Controller Ports

Place the Insertion Ring on the ground at the desired test location.

Fit the Driving Plate on the Insertion Ring and drive it 5 cm into the soil surface or flush using a three pound plastic mallet or metal hammer (not included). Hammer straight on the mark in the center of the driving plate to ensure the ring goes straight down during insertion to avoid creating gaps around the edge of the ring. (Figure 6)

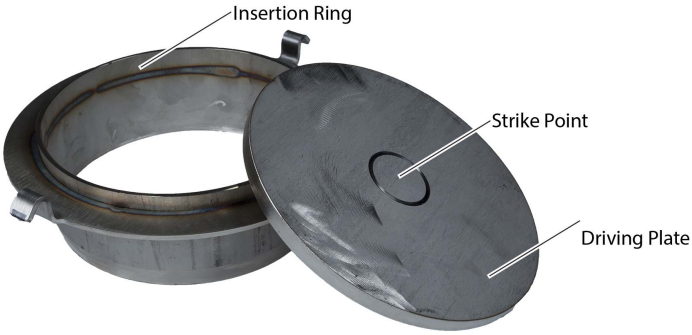


Figure 6: Insertion Ring and Driving Plate

Note: For hill installation, install Infiltrometer Head with interior sensor oriented to the left or right and perpendicular to the slope of the hill. (Figure 7)

Figure 7: Hill Install

Next, set up the Infiltrometer Head. The Infiltrometer Head houses the capacitance sensor (to control the water level), water connection, and air connection with push-to-connect fittings.

Figure 8: Upper and Insertion Rings

Clamp the Infiltrometer Head onto the Insertion Ring to form a seal. Do not clamp too tightly, as this can lead to warping of the Insertion Ring. Also, make sure you clear all grass and debris from the lip on the insertion ring before clamping the Infiltrometer Head in place. A clean seal ensures accurate pressure readings. Then, connect the two tubes for the air and water supply (Water Output) coming from the Control Unit to the designated fittings on the Infiltrometer Head. Next connect the sensor cable from the Infiltrometer Head to the Control Unit. (Figure 5 and 8)

Then, set your filled flexible water tank beside the controller, while ensuring the spout is oriented at the bottom of the tank for proper flow. Use the remaining tube to connect the water tank to the water input port on the Control Unit. (Figure 5) Fully open the water valve on the flexible tank to complete your setup.

Note: The collapsible water tank may not hold enough water for tests in high permeability soils. These instances may require a larger container. Simply place the hose at the bottom of any container and ensure the hose remains underwater.

3.2 Configuration

After installing your DualHead Infiltrometer you are ready to begin a test. Begin by powering on the device. Upon powerup, if the device has no data saved it goes to the Reading Screen, if it has data it powers up to the Data Returns screen. Press Enter to begin the test set up. First, you must enter a unique test name. You cannot use the same test name as previous saved tests. Then press Done to save the unique test name.

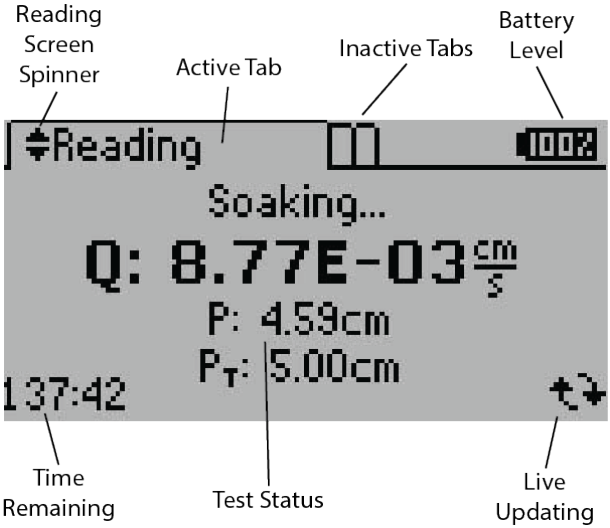


Figure 9: Reading Screen Breakdown

Once you have entered a test name and pressed Done, you can select the settings you would like to use for the test. Go to the Settings option to setup test parameters for Hydrostatic Pressure, Soak Time, Pressure Cycles, and Hold Time.

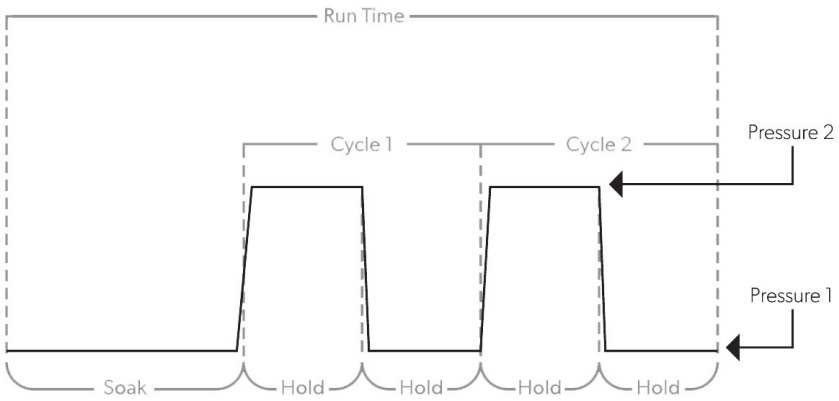


Figure 10: Run Time Diagram

In the settings window you can adjust the hydrostatic pressure for the low and high pressure heads between 0 and 40 cm. The low pressure head must always be set at least 5 cm lower than the high pressure head. Generally, soils with high infiltration rates require lower pressure head settings than soils with low infiltration rates. See Table 1 for rough guidelines to determine initial pressure head settings. Note that the values in Table 1 are rough starting points only and should be adjusted for your particular soil based on experience.

The Soak Time allows saturation of the soil before going into the pressure cycles. The Soak Time determines the quantity of time the Infiltrometer applies water to achieve saturation and depends largely on your soil type and specific application. A good introductory soak time is about 20 minutes, though you can adjust it according to your test needs. During the Soak Time the pressure is maintained at the pressure in the Lower Pressure head.

Table 1: Soak Time and Pressure Head Configurations

Soil Type	Soak Time (min)	Low Pressure Head (cm)	High Pressure Head (cm)	Hold Time @ Pressure Head (min)	Pressure Cycles	Total Run Time (min)
Dry Loamy Sand	25	5	10	15	3	115
Wet Loamy Sand	15	5	10	15	2	75
Dry Silt Loam	30	5	15	20	3	150
Wet Silt Loam	15	5	15	20	2	95
Dry Clay (Poor Structure)	30	5	20	25	3	180
Wet Clay (Poor Structure)	15	5	20	25	2	115
Dry Clay (Strong Structure)	25	5	15	20	3	145

Note: The values in Table 1 are a rough starting point only. Soil conditions dictate the optimal settings for your test.

You may also set the number of pressure cycles. The Infiltrometer can be set to run through multiple pressure cycles, but the Control Unit only uses the last cycle for computation. The Control Unit takes the average infiltration rates at the different pressure heads during the last pressure cycle to calculate K_{fs} from equation 4. Multiple pressure cycles help ensure you have reached the steady state infiltration rate. If the first cycle achieves steady state, cancel the test to save the calculation.

At first the infiltration rate is large, then you may achieve the steady state or "quasi-steady state" when the infiltration rate charted over time levels off into "infinite time."(Dane and Topp, 2002) For the DualHead Infiltrometer, wait for the Flux Chart to stabilize to define when you have reached quasi steady state. If you see a decrease in flux rate, redo the test or add another cycle. One pressure cycle is equivalent to a full run at the two different pressure heads.

You can adjust the hold time in the Test Settings as well. The hold time determines how long the pressure is held at each pressure head. This setting applies to both pressure cycles, i.e. if you set the hold time at 20, both the low and high pressure holds for 20 minutes.

Once you have configured the Test Settings press back to go to Test Setup and scroll down to Start a Test and Press Enter. The Infiltrometer displays a message to check tubing and connections, and then press Enter again. Once you start a test, the Infiltrometer begins pumping water from the reservoir until the water level reaches 5 cm. It then begins the soak time, while maintaining a level of 5 cm.

During a test, you can view incremental data acquisition with a graph feature by scrolling up and down with the keypad. The Infiltrometer records a data point every minute throughout the duration of the test. You may leave the unit running a test, but check the water level intermittently to ensure a constant supply.

Note: See Section 4 for details on viewing graphs of flux, water level, and pressure.

Once the test is complete, you can download data from the DualHead Infiltrometer using the Downloader Utility. See Section 4.4 for details on downloading your Infiltrometer data.

4 Menus

The DualHead Infiltrometer features three main menus designed for ease of use, the Reading Menu, Configuration Menu, and Data Menu.

4.1 Reading Menu

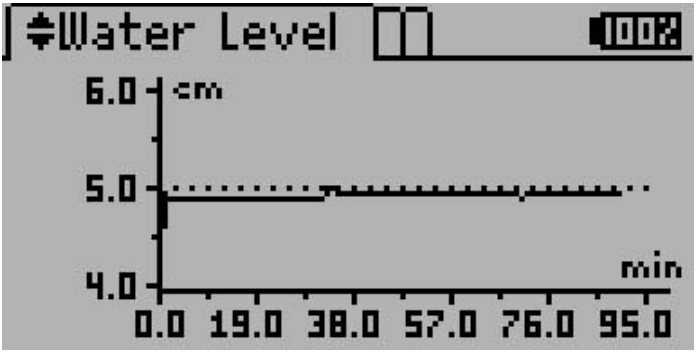
The Reading Menu appears when you power on the unit. Use it to set up tests and review screens related to the current tests. Use the up and down arrows to scroll through the available reading screens.

Status Screen

While the test is running, the Status screen shows the current test state and allows operators to scroll charts from the most recent flux, pressure, and water level readings. Press up and down to change reading screens or press Menu at any time to navigate to the Configuration menu.

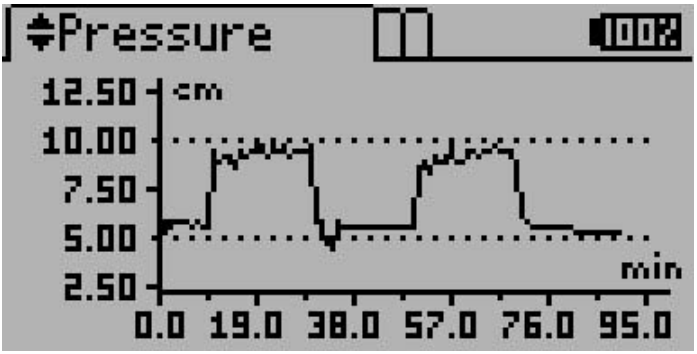
Water Level Screen

After a test is started, the water level above the soil quickly ramps up to 5 cm. The Water Level screen allows you to monitor the current water level. The screen flashes the current point and updates every minute. Press up and down to change graphs from the Status screen.



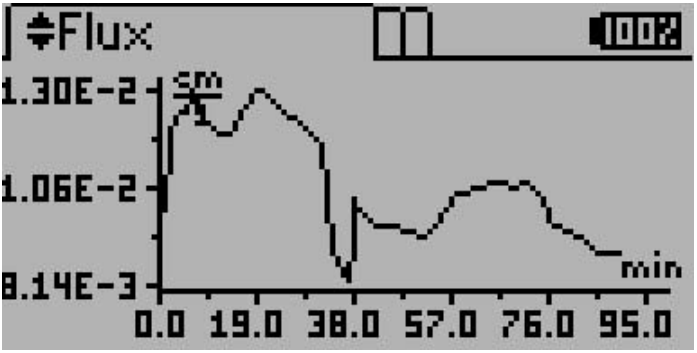
Pressure Screen

After the soak time elapses, the Pressure screen shows the hydrostatic pressure (combined air and water pressure) throughout the measurement. This screen allows you to monitor the current pressure by flashing the current point, and it updates every minute. Press up and down to change graphs from the Status screen.



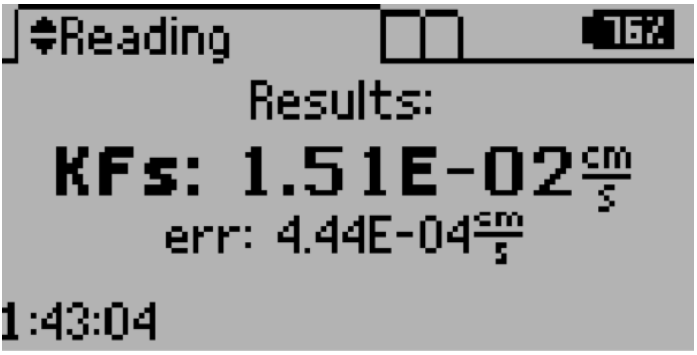
Flux Screen

The Flux screen shows the flow rate of water flow through the Infiltrometer. This screen allows you to monitor the current flow rate. The screen flashes the current point and it updates every minute. Press up and down to change graphs from the Status screen.



Results Screen

After a reading is complete, the Results menu shows the resulting K_{fs} of your test. The results appear in place of the Test Status information on the Results screen once the test is complete. Press Up and Down to change Reading screens or press Menu at any time to navigate to the Configuration menu. The error (err) value also appears on the Results Screen. The err is the standard error of the K_{fs} reading and represents the amount of noise in the measurement.



4.2 Test Functions

Starting a Test

Press Enter on any of the Reading screens to enter test setup and start a test.

Setting up a Test

On the Test Setup screen, you can name your test and configure test parameters. To begin the test, select Start Test and press Enter. Pressing Back at any time returns you to the Reading screens. The Name screen is also accessible when a test is running by pressing Enter on any of the Reading screens. From there you can review the settings for the currently running test or stop the test.

Annotating the Test

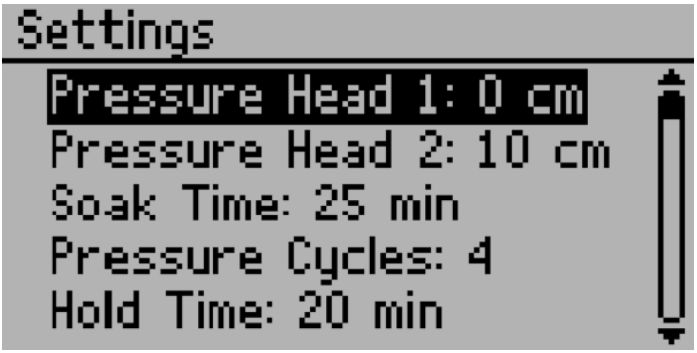
The test name can have up to 20 characters. Highlight the desired letter and press Enter to add the characters. To add a space or delete a character, navigate to the test name and use the right or left arrows respectively. To toggle between upper and lower case, use the boxed up arrow in the lower right hand side of the screen. Press Menu to save the new name or press Back to cancel without saving changes.

Note: A decimal point is not allowed as the first character of a test name.

Note: When downloading tests as a comma separated value file format (.csv), the degree symbol and "±" symbol is omitted from the test name in the test summary information.*

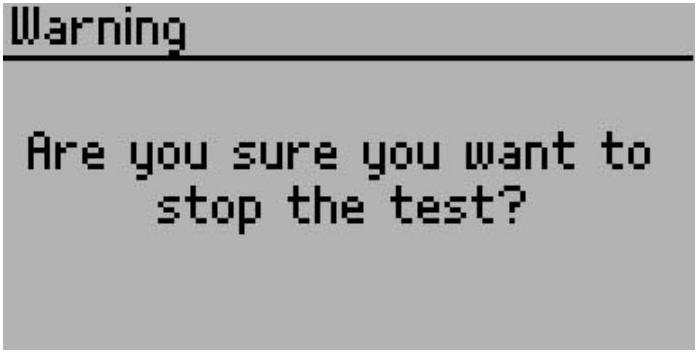
Configuring the Test

Different soil types may require different parameters for an optimum infiltration test. Adjust the Test Settings to change pressure, soak time, cycles and hold time for your test. Press Enter to modify the highlighted item. Press Back to return to the Test Setup menu. Figure 10 outlines the test settings.



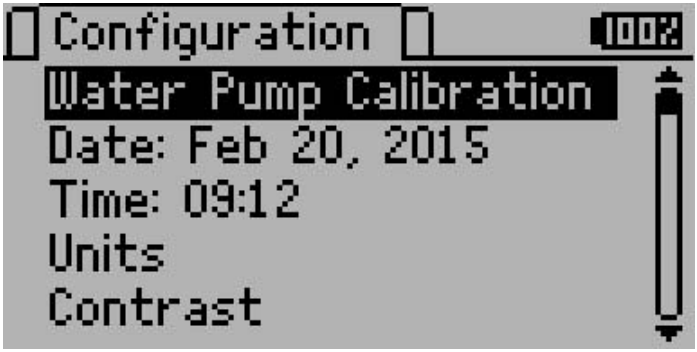
Stopping a Test

Once a test is started, if you press Back on any of the Reading screens, it prompts you to cancel the test. At the prompt, press Back to return to the Reading screen, or press Enter to cancel the test.



4.3 Configuration Menu

To navigate to the Configuration Menu, press Menu until Configuration is highlighted. The Configuration menu is where you can view or set global preferences for the DualHead Infiltrometer. To scroll through the available options, use the up and down arrows.



Date and Time Sub Menus

To set the date/time on the instrument follow the instructions:

1. Scroll to the Date option in the Configuration Menu and press Enter. You should see a screen similar to the one above. A pair of arrows are present above and below the first value.
2. Use the up and down arrow keys to change the current value. Press the right arrow to move to the next value or press the left

arrow to return to the previous value. Hold down the up/down arrows to scroll quickly.

3. Press Enter to save your changes or Back to cancel without saving.

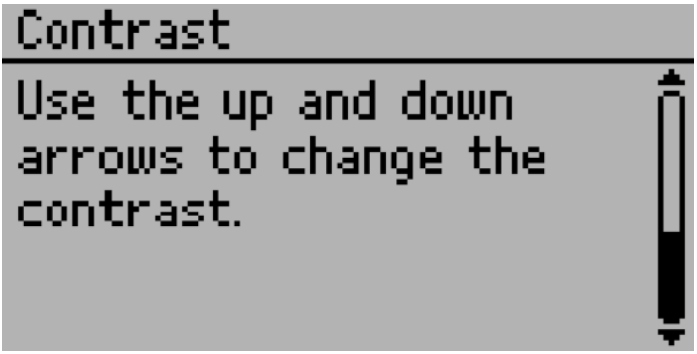
Units Sub Menu

This menu allows you to alter the preferred units on all device screens. This also alters the units that are used when downloading tests to the computer. The Infiltrometer cycles through the available options each time you press Enter on the selected unit. Press Back to return to the previous menu.

Contrast Sub Menu

This menu allows you to alter the screen lighting contrast settings.

Scroll to the contrast position in the Configuration menu and press Enter. Use the up and down arrows to change the contrast. Press Enter to save the new contrast setting or press Back to exit without saving changes.



About Sub Menu

This menu displays your instruments serial number, device name and firmware version.

4.4 Data Menu

To navigate to the Data menu, press Menu until the Data Tab is highlighted. Several different options are available within this menu.

Viewing Data

This menu allows you to view and delete previous tests. To view a test, highlight the View option and press Enter.

Viewing Previous Tests

After selecting the View option in the Data menu, a list of tests that have been run on the instrument appears. The tests are sorted most recent first. To view more information about a test, highlight it and press Enter.

Viewing Previous Test Options

After selecting the test in the Viewing Data screen, you have the choice of viewing the test results, settings or raw data. Select the desired option and press Enter.

Viewing Previous Test Results

The results of the test are formatted the same way that they are in the Reading screen. You can scroll through the available screens by pressing the up and down arrows. You can view the resulting K_{fs} value, water level chart, pressure chart or flux charts as well. Press Back to return to the previous screen.

Viewing Previous Test Settings

The settings of saved tests are formatted the same way that they are in the Test Setup Screen. You can scroll through the available settings by pressing the up and down arrows. Press Back to return to the previous screen.

Viewing Previous Test Raw Data

The Raw Data screen shows the minute elapsed, flux, and pressure of the system during the test. Use the up and down arrows (or left and right arrows to scroll faster). Press Back to return to the previous

screen.

Deleting Previous Test Data

You may delete data in the Data Menu. There is no way to delete individual items from the Infiltrometer, it erases all data when you select delete.

Warning: Deleting data permanently removes it from the Control Unit and it cannot be recovered.

Follow steps 1 through 3 to erase your data.

1. Navigate to the Data menu
2. Select the Delete option
3. Press Enter

Downloading Data

The DualHead Infiltrometer Downloader can be found in the included USB Drive or downloaded by going to software.decagon.com/dhidownloader. You can install the DualHead Infiltrometer Downloader directly on your PC, Mac, or you can run it directly from the USB Drive. The DualHead Infiltrometer Downloader can be used to download the data from you DualHead Infiltrometer, erase stored data, set the Date and Time, and check for firmware updates for the DualHead Infiltrometer.

To download data from your DualHead Infiltrometer connect the USB cable to a USB port on your computer and to the USB port on the DualHead Infiltrometer. Open the DualHead Infiltrometer Downloader. Select the proper Com Port, it should say "Decagon UCA," and press the Download button.

Figure 11: Downloader Home

After the download is complete you should receive a prompt that asks if you would like to erase the data stored on the device. Select "Yes" or "No."

Figure 12: Erase Data Prompt

You can download your data as *.xlsx* or *.csv* file. To change the file type go to Edit > Preferences > Data File and select the file type you would prefer.

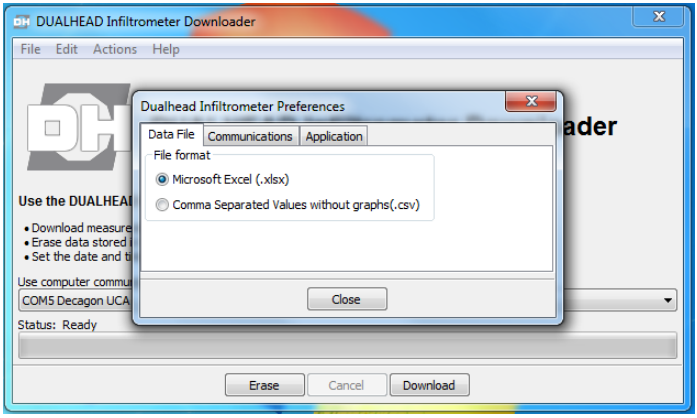


Figure 13: Change File Type Prompt

5 Theory

Field saturated hydraulic conductivity, K_{fs} $(cm\ s^{-1})$ is a fundamental soil hydraulic property that describes the ease with which a fluid (usually water) can move through pore spaces or fractures under field saturated conditions. One of the oldest and simplest methods for in situ determination of K_{fs} has involved the measurement of ponded infiltration from within a single ring pushed a small distance into the soil (Figure 14). The original analysis used the measured steady flow rate, $Q_s(cm^3 s^{-1})$, and assumed one-dimensional, vertical flow to obtain K_{fs} from Bouwer, 1986; Daniel, 1989.

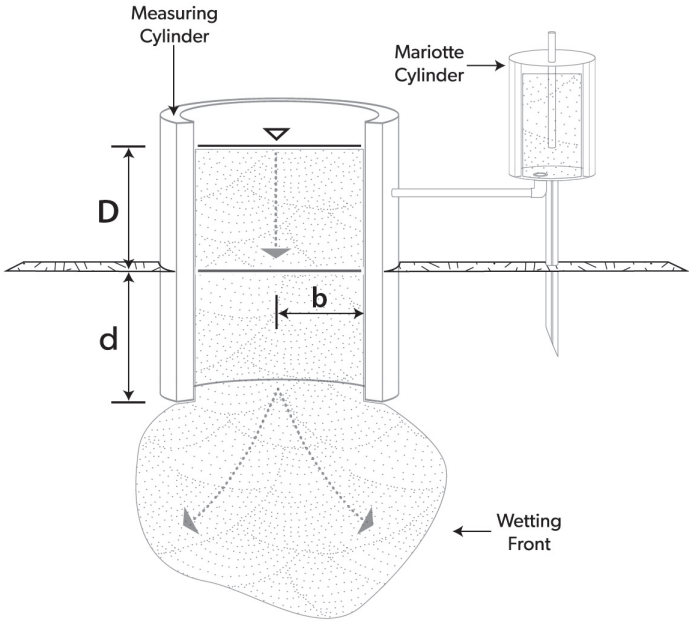


Figure 14: Cross Section of a Single-Ring Infiltrometer

It was soon discovered that this approach overestimated K_{fs} due to lateral divergence of flow resulting from the capillarity of the unsaturated soil and from the ponding in the ring (Bouwer, 1986). Attempts to eliminate flow divergence involved the addition of an outer ring

to buffer the flow in the inner ring (Figure 15). The dual ring infiltrometer technique was shown to be ineffective at preventing lateral flow from the inner ring (Swartzendruber and Olson, 1961 a,b).

More recent research has come up with new methods for correcting for lateral flow. Reynolds & Elrick (1990) presented a new analysis method of steady ponded infiltration into a single-ring which accounts for soil capillarity, depth of ponding, ring radius, depth of ring insertion and provides a means for calculating K_{fs}, matric flux (ϕ_m), and macroscopic capillary length ($\propto$).

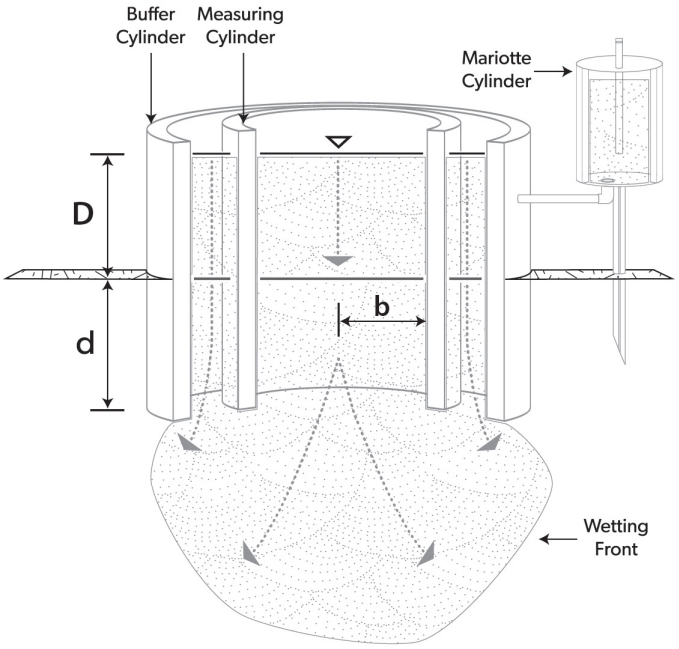


Figure 15: Cross Section of a Double-Ring Infiltrometer

The analysis that was proposed by Reynolds & Elrick (1990) is known as the two-ponding head approach and is the technique used by the DualHead Infiltrometer. Though we have modified and simplified the analysis to better meet our needs. The easiest equation to use for this calculation is from Nimmo et al. (2009). They compute K_{fs}

from:

$$K_{fs} = \frac{i}{F} \tag{1}$$

where i (cm/s) is the steady (final) infiltration rate (volume divided by area) and F is a function that corrects for sorptivity and geometrical effects. Nimmo et al. (2009) gives F as:

$$F = 1 + \frac{\lambda + D}{C_1 d + C_2 b} = 1 + \frac{\lambda + D}{\Delta} \tag{2}$$

where D is the ponding depth (cm), d is the insertion depth of the Infiltrometer (cm), b is the Infiltrometer radius (cm), Δ is $C_1 d + C_2 b$ (cm), C_1 is 0.993, C_2 is 0.578 and λ (cm) is the reciprocal of the Gardner $\propto$ which is a characteristic of the soil and its initial water content. Δ in equation 2 is simply equation 36 of Reynolds & Elrick (1990) multiplied by $b\pi$, which allows equations 1 and 2 above to be reconciled with equation 37 of Reynolds & Elrick (1990).

For two ponding depths we can write:

$$K_{fs} = \frac{i_1 \Delta}{\Delta + \lambda + D_1} = \frac{i_2 \Delta}{\Delta + \lambda + D_2} \tag{3}$$

Rearranging one of the right hand terms to solve for λ in terms of K_{fs}, and then substituting this for λ in the other right hand term and simplifying yields:

$$K_{fs} = \frac{\Delta(i_1 - i_2)}{D_1 - D_2} \tag{4}$$

which is equivalent to equation 41 from Reynolds & Elrick (1990) and removes the dependence on soil characteristics and initial water content described by λ. Δ is a constant for a given infiltrometer geometry, calculated as $0.993d + 0.578b$. For the DualHead Infiltrometer, $d = 5$ cm and $b = 7.5$ cm, so $\Delta = 9.3$ cm. The hydraulic conductivity is then 9.3 cm multiplied by the difference in quasi-steady-state infiltration rate for the last pressure cycle (where i_1 is the infiltration rate at the high pressure head and i_2 is the infiltration rate at the low pressure head) and divided by the difference in the measured pressure head from the last pressure cycle (where D_1 is the actual high pressure head and the D_2 is the actual low pressure head).

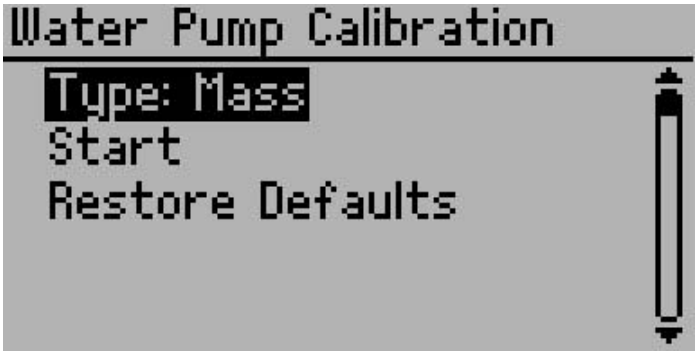
6 Maintenance and Troubleshooting

6.1 Maintenance

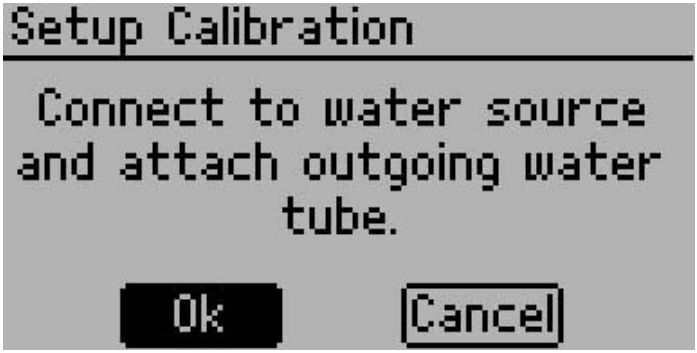
Water Pump Calibration

Typically, the water pump and tubing can wear, causing a change in the volume of water flowing through the pump. We advise that you calibrate your pump every 6 months to a year to ensure accurate measurements. The pump comes factory calibrated and is accurate to within ±5% of the reading.

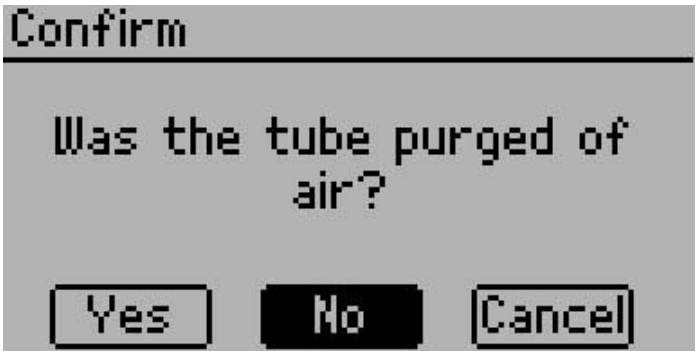
Operators can use two methods, based on either mass or volume, to calibrate the pump. Before beginning, ensure you have a scale accurate to 0.01 g or a 25 mL graduated cylinder depending on the method you choose. The mass method is the most accurate, but either method is acceptable for calibration.



To calibrate pump, first Select Menu > Configuration > Water Pump Calibration. Select Type, either mass or volume, highlight Start, and press Enter. You should receive a message to connect a water source and attach the outgoing water tube. Connect a source of water and press Enter.



Both methods require that you first purge the water line of any air before running the calibration. The screen reminds you to purge the tube, highlight purge, press Enter. Keep running water through until water runs clear with no bubbles. For the mass method, tare the scale with your water reservoir after you finish purging the line of all air.

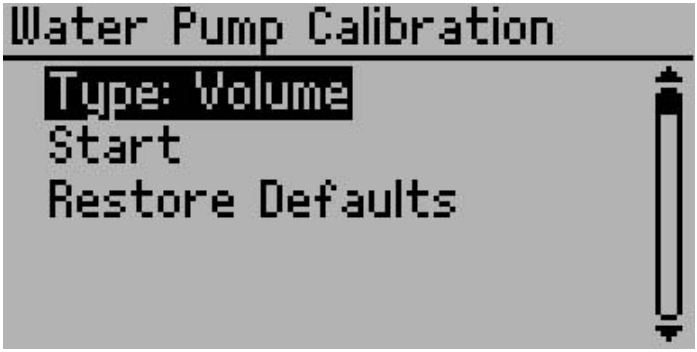


Once the line is clear begin running the calibration water flow. Compare the reading on the scale to the default value on the machine once the flow finishes. Enter the new value from the scale readings and this value becomes the new default water flow value. The Infiltrometer Control Unit uses this flow value to measure the flow of water into the Head.

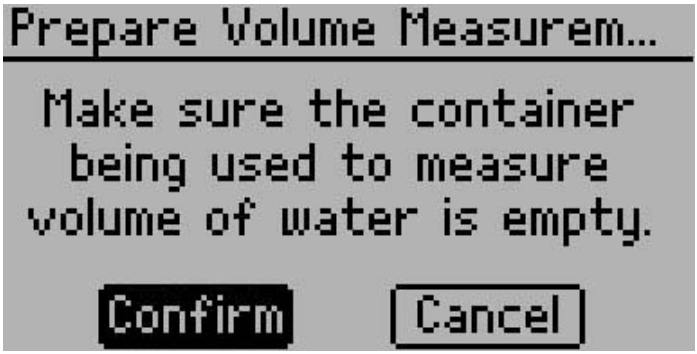
Volume Calibration Method

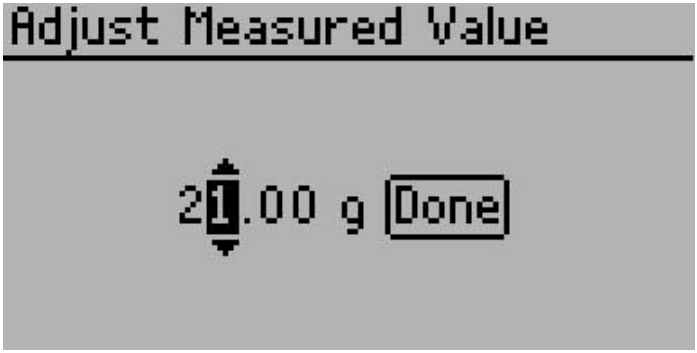
The instructions for the volume based method are similar. Select

Volume from the Configuration screen, rather than mass.

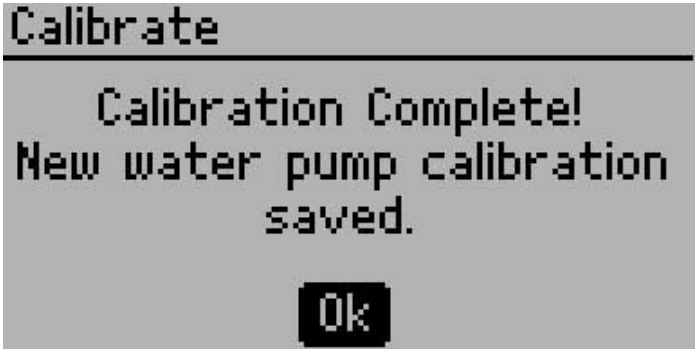


Grab a graduated cylinder with a max volume of at least 25 ml and follow the instructions to purge the air from the water line. Once you remove the air from the line, run the calibration sequence to fill the graduated cylinder. Compare the measurement on the cylinder to the Infiltrometer default value. Change the value in the "Adjust Measured Value" screen to the reading on the graduated cylinder and press Enter to update the default flow value. The volume method is less accurate than the mass method, but sometimes it is more convenient.





Operators may run the calibration sequence as frequently as necessary to ensure and verify they are taking accurate readings. Once the calibration is complete, the new value stores in the Infiltrometer Firmware and does not erase until you set a new calibration setting.



6.2 Routine Maintenance

Daily Cleaning

When you have finished a measurement in the field it is important to properly clean your equipment to ensure the longevity of your DualHead Infiltrometer.

- Remove any soil that is stuck on the insertion ring. This is important to reduce the amount of resistance when installing the insertion ring.

- Remove any soil particles and other materials that are stuck on the infiltrometer head.
- Wipe down the 3 tubes with a wet rag.

Long-term Maintenance

Water Pump

The water pump on the DualHead infiltrometer is a peristaltic pump with a replaceable cartridge that houses the tube and rollers. The tubing and rollers can wear out over time, typically around 5,000 hours of run time. The pump run time is tracked in the diagnostics screen of the DualHead Infiltrometer.

How do you know it needs to be replaced? If you begin to see a significant change in your pump calibration or it begins to become inconsistent it may need to be replaced.

To replace the cartridge, you can order replacement parts from Decagon. You also have the option to send the DualHead infiltrometer for maintenance and we will replace any parts that need to be replaced as a part of the maintenance program. Contact Decagon Support for more information.

Lead Acid Battery

The DualHead Infiltrometer is powered by 12 V 7 Ah Sealed Lead Acid Battery. The amount of charging cycle your battery will last depends on how hard the battery is discharged during each cycle. The less the battery is discharged prior to charging, the more cycles you will get out of the battery.

How will you know if your battery needs to be replaced? Over time you will see a decrease in the maximum charge value of your battery. If you battery does not appear to come up to full capacity after a full charge (typically 4 to 6 hrs) it may need to be replaced.

You can access your battery by removing the faceplate on the control

unit. When doing this you will want to be carefully not to damage any of the connectors on the motherboard. You can purchase replacement batteries from Decagon or a local electronics supplier. Make sure the battery you select is a 12 V 7 Ah Sealed Lead Acid battery. For more information on replacing your battery contact Decagon Support.

6.3 Troubleshooting

Table 2: Troubleshooting Quick Guide

If this problem occurs:	**Refer to:**
Infiltrometer does not turn on	Problem #1
Returns Error "Firmware is corrupted"	Problem #2
Returns Error "Crystal Failure"	Problem #3
Fails to reach target water level	Problem #4
Test name already exists	Problem #5
Data memory is full	Problem #6
Water seal leaking	Problem #7
Selected pressure heads not reached	Problem #8
Infiltrometer does not maintain pressure	Problem #9
Reports "No Depth Sensor"	Problem #10
Water level error	Problem #11
Pressure limit exceeded	Problem #12
Low battery error	Problem #13
Temperature too high	Problem #14
Temperature too low	Problem #15
No depth sensor	Problem #16
Water level warning!	Problem #17
User canceled!	Problem #18

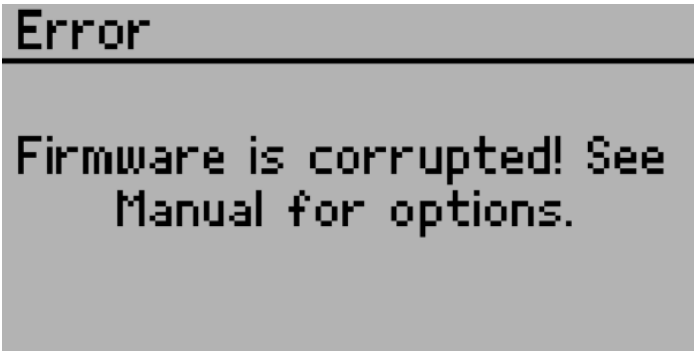
1. PROBLEM:

Infiltrometer does not turn on.

SOLUTIONS:

Make sure to fully charge the battery. If the battery should be charged or does not appear to be charging, check the fuse on the motherboard by removing the faceplate.

2. PROBLEM:
Message on the screen displays the error "Firmware is corrupted"

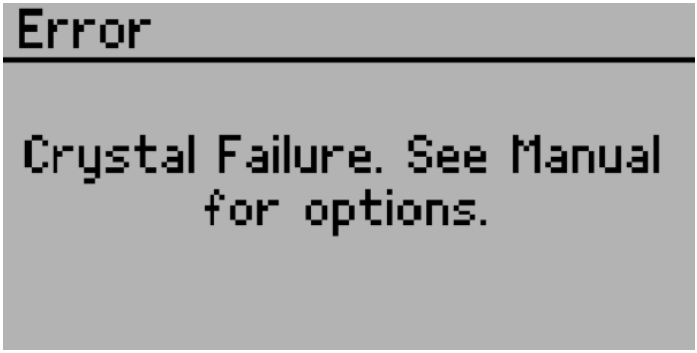


SOLUTION:

The firmware on the instrument is corrupted and needs to be reloaded. To download new firmware, go to http://www.decagon.com/products/hydrology/hydraulic-conductivity/dualhead-infiltrometer/. Connect your Infiltrometer to your computer and follow the instructions in the updater. Taking this action deletes all data from the unit.

3. PROBLEM:

Message on the screen displays the error: "Crystal Failure"

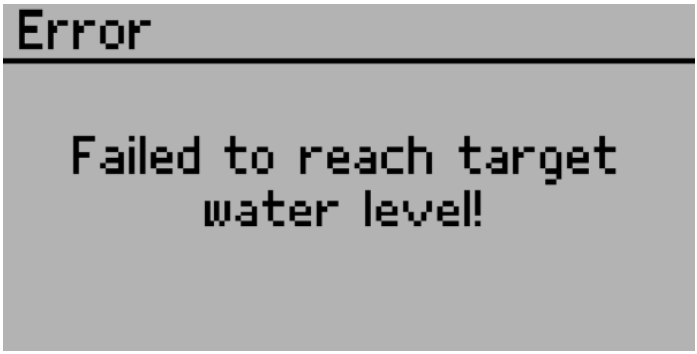


SOLUTION:

The crystal that runs the firmware is having trouble starting. Occasionally cycling the power solves the problem. If this message continues to appear, Decagon needs to service the instrument.

4. PROBLEM:

The test failed to reach the target water level.



SOLUTION:

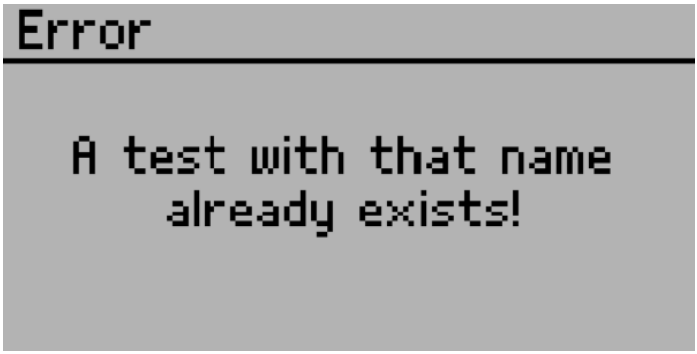
A failure to reach the target level can be attributed to several things.

1. Check to make sure the water supply is connected and water is able to easily flow from the water supply through the controller into the Infiltrometer Head.

2. Check to make sure there are no leaks around the seal of the Infiltrometer Head.
3. If there are no apparent leaks, then it is possible that the spot you are trying to measure has an infiltration rate that exceeds the capacity of the DualHead Infiltrometer. This could be due to large macropores that can transmit a high amount of water. Try picking a new location or adding a second water supply to proceed with your measurement.

5. PROBLEM:

A test name already exists.



SOLUTION:

After a test is completed it is stored into memory. If you try to create a test with the same name as one that is already in memory, then this message will appear. Rename your test and you should be able to proceed.

6. PROBLEM:

Data memory is full.

SOLUTION:

After taking multiple tests, the memory in the instrument can fill

up. Once the memory is full, you need to download any data from the Infiltrometer and erase the stored data on the Infiltrometer before performing a new test.

7. PROBLEM:

Water leaking between seal of Infiltrometer Head and Insertion ring.

SOLUTION:

Remove the Infiltrometer Head and check for debris (grass leaves, loose soil, etc) where the o-ring seals with the Insertion ring. Remove any debris and re-connect the Infiltrometer Head. If there is no apparent debris, check the tightness of the clamps. It is important that the clamps apply enough pressure to slightly compress the o-ring. If the clamps are too tight, they can deform the Insertion ring causing a poor seal. You can adjust the clamp pressure with the Phillips screw on top of the clamps.

8. PROBLEM:

Selected pressure heads are not being reached.

SOLUTION:

Check tubing connections to make sure tubes are pressed all the way into the push-to-connect fittings. When inserting tubes you should feel the tubes hitting the back of the fittings.

9. PROBLEM:

Infiltrometer does not maintain pressure.

SOLUTION:

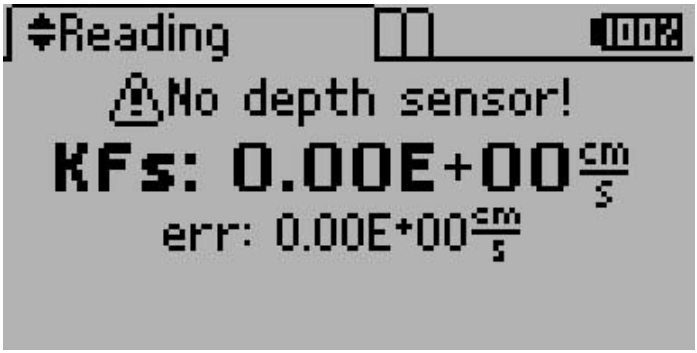
Check tubing connections to make sure tubes are pressed all the way into the push-to-connect fittings. If water is leaking from the Infiltrometer Head, check the seals for grass or debris. Then verify

that the clamps are not bent or deformed. If the Infiltrometer is clean, check the clamps and adjust the clamp screw with a Phillips screwdriver to the appropriate tightness to seal the ring.

Note: Do not screw the clamp adjustment screws too tight, as it deforms the metal.

10. PROBLEM:

Reports "No Depth Sensor!"



SOLUTION:

1. Check sensor connection to the control unit.
2. If the sensor is connected and not working, contact Decagon Support.

11. PROBLEM

Water level error!

SOLUTION:

Occurs during a test when the water level is below the minimum level of the water level sensor (4.3 cm) for more than 10 min. Stops the test when it occurs.

Make sure the water reservoir has sufficient water.

Note: Soils with extremely high infiltration rates could cause the water inside the chamber to remain below 4.3 cm, if the water pump can't fill the chamber at a rate greater than the soil's infiltration rate.

12. PROBLEM:

Pressure limit exceeded.

SOLUTION:

Occurs when the air pressure in the chamber is over 60.0 cm or below 0.0 cm. Stops the test when it occurs.

Check tubing for possible kinks or blockages.

13. PROBLEM:

Low battery error.

SOLUTION:

Occurs when the battery voltage drops below the minimum voltage at which the water pump can operate (11.1 V) during a test. Stops the test when it occurs.

Charge the battery

14. PROBLEM:

Temperature too high.

SOLUTION:

Occurs when the air temperature is above the minimum operating temperature (50 °C) while a test is running. Stops the test when this occurs.

Move the system into a cooler environment. Make sure it is out of direct sunlight.

15. PROBLEM:

Temperature too low.

SOLUTION:

Occurs when the air temperature is below the minimum operating temperature (0 °C) while a test is running. Water frozen in the system could cause damage. Stops the test when it occurs.

Move the system into a warmer environment.

16. PROBLEM:

No depth sensor.

SOLUTION:

Occurs during a test if the depth sensor is not detected within 30 seconds.

Make sure a depth sensor is connected. Verify it is measuring correctly by checking the Depth value on the Diagnostics screen. If it is, you can start a new test.

17. PROBLEM:

Water level warning!

SOLUTION:

Occurs when the water level in the chamber is below the minimum depth the water level sensor can read (4.3 cm).

Make sure the water reservoir has sufficient water. The test will

stop after ten minutes if the water level is not above 4.3 cm.

Note: Soils with extremely high infiltration rates could cause the water inside the chamber to remain below 4.3 cm, if the water pump can't fill the chamber at a rate greater than the soil infiltration rate.

18. PROBLEM:

User canceled!

SOLUTION:

Occurs when the user cancels a test.

7 References

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8 Declaration of Conformity

8.1 DualHead Infiltrometer Compliance

Application of Council Directive:	2004/108/EC and 2011/65/EU
Standards to which conformity is declared:	EN 61326-1:2013 and EN 50581:2012
Manufacturer's Name:	Decagon Devices, Inc 2365 NE Hopkins Ct. Pullman, WA 99163 USA
Type of Equipment:	DualHead Infiltrometer
Model Number:	N/A
Year of First Manufacture:	2015

This is to certify that the DualHead Infiltrometer, manufactured by Decagon Devices, Inc., a corporation based in Pullman, Washington, USA meets or exceeds the standards for CE compliance as per the Council Directives noted above. All instruments are built at the factory at Decagon and pertinent testing documentation is freely available for verification.

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