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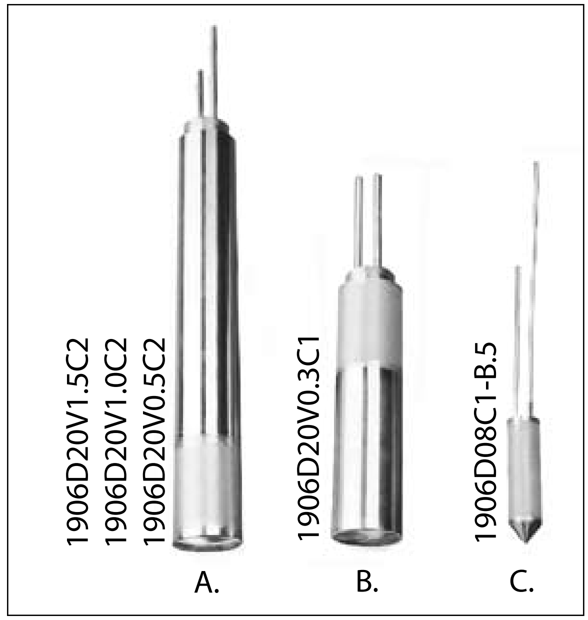
OPERATING INSTRUCTIONS

Stainless Steel Lysimeters

Feb 2010

Soils and other geologic materials above the groundwater table are generally unsaturated, i.e. some of the pore space between soil particles is filled with air, while the remainder of the pore space is filled with water. Due to capillary action and other forces, water in the unsaturated or vadose zone is held tightly to the soil. This means that one has to apply suction on the soil material to extract pore water for chemical analysis. Unfortunately, one cannot simply insert an open pipe into unsaturated soil and expect to collect pore water by applying suction on the pipe.

Although sampling of shallow groundwater can be accomplished by placing an open-ended pipe in the groundwater, for sampling of pore water in the unsaturated zone, the open the pipe has to be closed with a porous membrane. In moist soil the fine pores in the porous membrane, when in close contact with the moist soil, fill with pore water by capillary action. When all pores in the membrane are filled with water air cannot move through when suction is applied on the pipe.



(Figure 1) A. 2" OD, Dual Chamber Lysimeter
B. 2" OD, Single Chamber Lysimeter
C. 7/8" OD, Single Chamber Lysimeter

However, water can, and does move through the porous membrane. By applying suction on the pipe, water from the soil, in contact with the porous membrane, will flow through the water filled pores in the membrane. The water collects inside the pipe and can be brought to the soil surface by vacuuming it up through a tube (may not work for depths greater than 6 -8 meter), or by forcing it up with air pressure.

Note: When air pressure (either positive or negative) applied to SEC lysimeters is greater than 9 psi (0.6 bars), water held in the pores of the porous steel tips is forced out and air can move through. This pressure is called bubbling pressure. Thus at no time should the negative pressure applied to lysimeters (to extract fluid from the unsaturated soil) exceed 9 psi (0.6 bars).

For successful operation, the negative pressure should be kept between 4.5 and 6 psi (0.3 and 0.4 bars).

The above-described "pipes with porous membranes" are in fact called suction lysimeters. Suction lysimeters are available with porous stainless steel, ceramic or PTFE membranes.

WARRANTY & LIABILITY

Soilmoisture Equipment Corp. (SEC) warrants all products manufactured by SEC to be free from defects in materials and workmanship under normal use and service for twelve (12) months from the date of invoice provided the section below has been met.

Soilmoisture Equipment Corp. (SEC) is not liable for any damages, actual or inferred, caused by misuse or improper handling of its products. SEC products are designed to be used solely as described in these product operating instructions by a prudent individual under normal operating conditions in applications intended for use by this product.

DESCRIPTION & OPERATION

The lysimeters available from Soilmoisture Equipment Corp. (SEC) are made of stainless steel. Stainless steel is the preferred material for sampling groundwater, and is also an excellent material for vadose zone sampling. Soilmoisture Equipment Corp. uses high quality porous stainless steel to allow flow of pore fluid into the lysimeter.

The lysimeters are of welded construction with no glue or plastic. They are extremely strong and durable, and not easily damaged during installation in boreholes. The bubbling pressure of the porous steel is 0.6 bars. The dual chamber models have an outside diameter of 2.0 inches, and have a porous steel section of 3.7" in length.

The lysimeters are recommended for sampling at depths greater than 12 feet, but they have been used for sampling the vadose zone down to 300 feet (91 m). The lysimeters have a threaded collar on top, which allows easy connection of plastic pipe to the lysimeter. Such a pipe facilitates installation of the lysimeters, and also protects the two 1/4" tubes leading to the soil surface.

Each model has two stainless steel, 0.25" OD, tube outlets. The longer of the two tubes is for vacuum/ pressure, and the shorter tube is the fluid return tube. The steel outlet tubes are connected with stainless steel unions to 1/4 " OD tubing (high density polyethylene, PTFE or stainless steel) leading from the lysimeter to the surface. During operation vacuum is applied to the vacuum / pressure tubing, while the other tubing is kept closed at ground surface. (Unions sold separately)

When vacuum is applied to the vacuum/ pressure tube of a dual chamber lysimeter, fluid first enters through the porous stainless steel into the lower chamber of the lysimeter. From there the fluid moves up through a short section of 1/4" OD tubing with a one-way valve, into the upper chamber. After sufficient fluid has collected in the upper chamber of the lysimeter, air pressure is applied to the vacuum/ pressure tube, and the fluid return tube is opened and its end connected to a sample collection bottle. The increased air pressure forces the fluid up from the lysimeter into the sample collection bottle. The one-way valve prevents air escaping into the lower chamber. If no more pore water flows into the sample bottle, all fluid has been transferred to the sample bottle.

Dual chamber models can be used at great depth. Note however, that when the pore water is forced to the surface by applying pressure to the vacuum /pressure tube, the fluid return tube fills with pore water. This causes a backpressure to develop in the fluid return tube, which must be overcome by the applied air pressure in order for the fluid to reach the sample bottle at ground surface. For great depths the applied pressure can be quite significant (i.e. a lysimeter placed at 300 ft (91m) can develop a back pressure of 9.1 bar or 137 psi). In that case the air pressure needed must be greater than 137 psi in order to bring the pore water to ground surface. The two chamber design with a one-way valve between the two chambers makes it possible to use large air pressures to bring the sample to the surface without blowing the air out of the pores in the lower chamber with the porous steel walls. Without the one-way valve a pressure greater than 9 psi (0.6 bar) applied to a lysimeter, would blow the air out of the porous steel and cause it to leak air. All dual chamber lysimeters have a one-way valve to prevent this from happening.

LYSIMETER TESTING

It is recommended to clean the lysimeters before installation. This is done submerging the porous part of the lysimeter for several hours in 70% isopropyl alcohol or denatured alcohol, followed by a rinse with distilled or de-ionized water.

For a more thorough cleaning it is recommended to draw the isopropyl alcohol through the porous steel. This can be done by submerging the porous part of the lysimeter in the alcohol, then close one outlet and apply a vacuum to the other outlet. Keep the porous part of the lysimeter submerged in isopropyl alcohol. After 30 minutes remove the lysimeter from the alcohol, remove all alcohol from the lysimeter by holding it upside downs and letting the alcohol drain out, and repeat the latter procedure with distilled water.

Although all lysimeters are thoroughly tested for air leaks before shipment, it is recommended that they be tested again before installation in the borehole. Submerge the lysimeter with its porous part for up to 4 hours in distilled water. Then remove the lysimeter from the water and hold it upside down to let the water drain out. Now close one of the outlets, and apply a positive pressure of about 6 psi (0.4 bar) to the other outlet. Place the lysimeter back in the water so that all parts are submerged. If there are no consistent air bubbles coming from the pressurized lysimeter there are no welding leaks.

It is important to test the lysimeter assembly in the field once the vacuum/pressure tubes and the fluid return tubes are attached to the lysimeter with stainless steel unions. This needs to be done before lowering the lysimeters in the boreholes. After soaking the lysimeters in distilled water, and/ or drawing distilled water through the porous parts of the lysimeters, apply air pressure (about 0.4 bar or 6 psi) to the assembly, and check for air leaks by holding the various parts (unions etc.) under water.

CONNECTING AND PROTECTING THE TUBING

Each lysimeter has two 1/4 inch stainless steel tubes protruding from the top of the lysimeter. The longer tube needs to connect to the vacuum/ pressure tube, and the shorter tube to the sample collection tube. Black polyethylene tubing (1/4 inch OD, 1/8 inch ID) is generally used for the vacuum / pressure tube, while PTFE is sometimes used for the sample collection tube. The latter tubing is more expensive, but is often advised when sampling for dissolved organics. Stainless steel unions (1/4 inch) are used for connecting the tubing to the lysimeters.

For protection of the tubing and the unions, and to facilitate correct installation at greater depths, the tubing can be fed through 1.5" OD PVC pipe. The pipe can be glued to a 1 x 1.25" male adapter, which can be screwed onto the female connector welded to the top of the lysimeter. Additional lengths of 1.5" OD pipe can be glued on to reach the soil surface.

In many instances glue cannot be used. In that case it is best to use threaded PVC pipe which can be bought at SEC (Model MWT014). An adapter to go from machine threads on the lysimeter to PVC threads on the pipe is needed to connect the pipe to each lysimeter.

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INSTALLATION

The following are general suggestions for installation of the 2 inch OD lysimeters. Additional information can be found in ASTM D4696.

Geologic conditions differ greatly from location to location. Knowledge of the local conditions should be available before installation is to begin.

Correct installation of suction lysimeters requires ensuring good contact between the porous stainless steel, and the surrounding soil. It is also important that the potential for vertical migration of fluid through the borehole annulus be prevented. The following techniques assume that the borehole is constructed to the desired sampling depth using a hollow-stem auger.

1. Raise the auger flight about 2-feet from the base of the borehole (this ensures that the sampler will not become wedged within the auger).

2. Pour about 10 kilograms of silica-flour slurry (prepared by adding one pound of 200 mesh silica flour per 150 ml distilled water) through a tremie pipe extending to the base of the borehole. Silica flour is not recommended if the water sample is to be tested for virus. Slurry prepared from the soil removed from the bottom of the borehole and screened(2mm recommended), can also be used. However, it is important that the slurry material makes good contact with the porous steel, and has good water permeability.

3. Lower the pre-wetted lysimeter assembly through the hollow-stem auger to the base of the bore hole and gently press the lysimeter into the silica flour slurry. A stainless steel or PVC centralizer may be used to ensure proper placement of the sampler within the borehole.

4. Form additional slurry of silica flour and distilled water and tremie the mixture to the base of the hole to ensure embedding the unit to a depth of about one foot above the cup.

5. Hold the unit in place within the hole until the water drains from the slurry.

6. Test the lysimeter to ensure that it is capable of holding a vacuum of about 400 centimeters water pressure (0.4 bar or 6 psi); if the unit fails, remove it and replace it with a backup unit.

7. Using a second, dry tremie pipe, add a small amount of sieved native material to the hole, then add about 12 kilograms of 3/8 or 1/4 inch bentonite. A dry tremie pipe should be used for adding the bentonite to prevent swelling of the bentonite inside the tremie pipe.

Add distilled water through the first (wet) tremie pipe to the bentonite tablets, causing them to swell and form a seal above the lysimeter unit.

8. Gently back out the auger flight, adding backfill of native material. Tamp the backfill between additions of backfill.

9. On the surface, the PTFE sampling tubing should be connected to the collection bottle. If vacuum is used to collect samples from the lysimeters (can only be done for shallow lysimeters), a tube with valve or tubing clamp is installed between the collection bottle and an overflow bottle. The overflow bottle is in tum connected with a tube to the vacuum pump.

The overflow bottle prevents fluid from entering the vacuum pump.

SAMPLE COLLECTION

Sample collection can be done in three ways.

1. The most common method is to apply vacuum to the vacuum/ pressure line while keeping the fluid return line closed. This draws the pore water into the lysimeter. After a given time, often 24 hours, the fluid return line is opened and pressure is applied to the vacuum/ pressure line. This forces the fluid up to the soil surface and into the collection bottle. In very wet soils the time it takes to bring sufficient water into the lysimeter can be significantly shorter than 24 hours. In dry soil it will be difficult or impossible, depending on how dry the soil is, to draw sufficient water into the lysimeter

Note that with this method the vacuum in the lysimeter drops as the lysimeter is filling with pore water.

2. The second method uses a vacuum pump that runs continuously during the sampling period. The pump makes it possible to maintain a constant vacuum or negative pressure inside the lysimeter. Generally a negative pressure between 300 and 400 mbar is optimal. A source of electricity is necessary for this method. The pump is connected to the vacuum/pressure tubing. Leave the pump on for a long enough time to collect an adequate volume of pore water. The time it takes for sampling depends on the moisture content of the soil, and can vary between 30 minutes and 24 hours. If the soil is too dry (if the tension in the soil around the lysimeter is greater than 500 em water pressure (0.5 bar)), most likely no pore water will be collected. After turning the pump off, connect a manual or electric pressure pump to the vacuum/ pressure line. This forces the fluid up to the soil surface into the sample collection bottle.

SEC Model 2006G2 vaccuum pump can be used for changing and extraction of sample.

3. The third way is to use 1900K3 as a 1000 ml reservoir of. . ... . on something bigger. Evacuate lysimeter and reservoir in series together.

Note: In very moist soil the lysimeter could fill up quickly. The pump would then draw the fluid up in the vacuum/pressure line and into the vacuum pump. This would ruin the pump. To prevent this from happening always install an overflow vessel between the collection bottle and the pump.

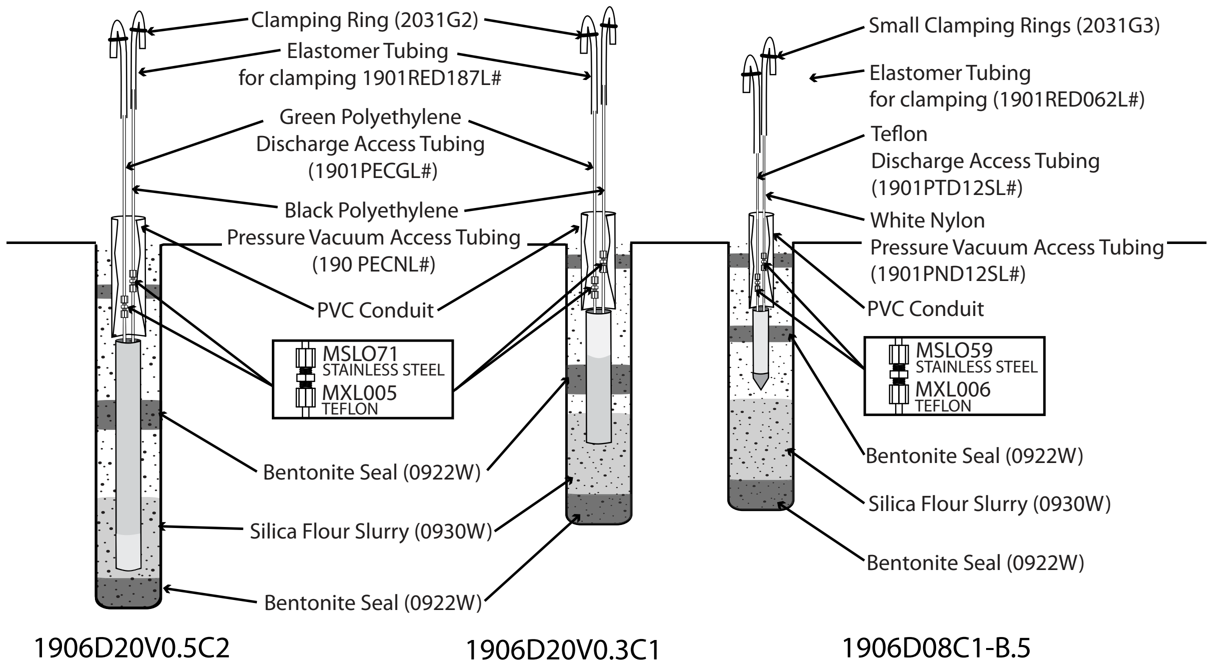
It is also recommended to run the pump about 15 minutes after each use, without being connected to the lysimeter system. Pumping ambient air through the pump will remove any accumulated water from the pump head. This will prolong its life.

As explained above, the vacuum applied to the lysimeters should be no greater than 6 psi (0.4 bar). If for some reason a large vacuum was applied to the lysimeters the lysimeters could have lost the water held in the porous steel. The porous steel can also loose its water if the soil around the porous steel is so dry that it draws all the water out of the porous steel.

The only way to rewet the porous steel is by rewetting the soil or silica flour around the lysimeter. This may possibly be accomplished with a watering tube going from the soil surface directly to the outer wall of the porous steel section of the lysimeter.

Installing such a tube during lysimeter installation would be a good preventive measure. At this time, SEC does not know of data that show that adequate rewetting through a tube from ground surface can be done.

ACCESORIES LIST



ITEM PART #	DESCRIPTION
0922W#	Bentonite / 5 lb., 10 lb., or 50 lb. bag
0930W#	Silica Flour / 5 lb., 10 lb., or 50 lb. bag
1900K3	Extraction Kit / 1000ml capacity flask, associated tubing and stoppers
1907	Sieve Set
2006G2	Pressure-Vacuum Hand Pump (with gauge)
MWT014	Thread pipe for lysimeter / 5 Foot Length (sold per foot)
1/4" Tubing Assessories (1906D20V0.5C2 / 1906D20V0.3C1) BELOW	
1901PECBL#	0050, 0100, 0500, 1000 Blue / 1/4' OD Polyethylene
1901PECGL#	0050, 0100, 0500, 1000 Green / 1/4' OD Polyethylene
1901PECNL#	0050, 0100, 0500, 1000 Black / 1/4' OD Polyethylene
1901PTD250L#	025,050,100,500 / 1/4" OD Teflon
1901RED187L#	10, 25, 50 / Elastomer Tubing for Termination
2031G2	Clamping Rings (per doz.)
1902K3	Centralizer with Centralizer Adapter Kit
1902K4	1-1/2" Stainless Steel Coupling Assembly
MSL071	1/4" Stainless Steel Union
MXL005	1/4" Teflon Union
1/8" Tubing Assessories (1906D08C1-B.5) BELOW	
1901PND12SL#	025,50,100,500 / 1/8" White Nylon
1901PTD12SL#	025, 050, 100, 500 / 1/8" Teflon
1901RED062L#	010, 025, 050 / Elastomer Tubing
2031G3	Small Clamping Rings
MSL059	1/8" Stainless Steel Union
MXL006	1/8" Teflon Union

Notes:

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