1000

OPERATING INSTRUCTIONS

Pressure Membrane Extractor March 2002

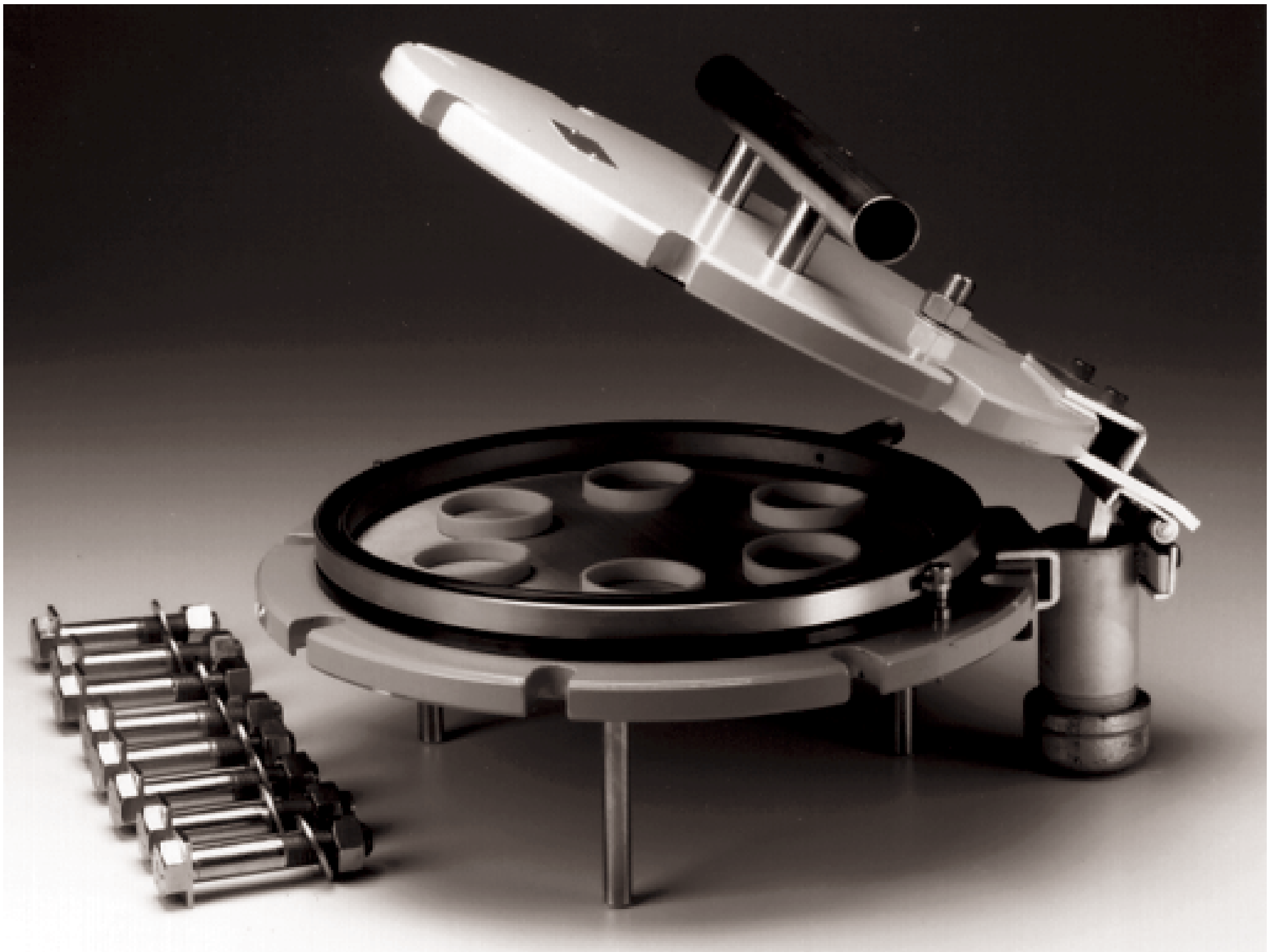

Fig. 1. Model 1000 Pressure Membrane Extractor, shown with accessory Model 1080G1 PM Hinge mounted.

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SOILMOISTURE

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SOILMOISTURE®

1. HISTORY/GENERAL USES

The idea for a pressure membrane extractor had its origins back in 1939 at the U.S. Salinity Laboratory in Riverside, California. The Salinity Laboratory was established to study saline conditions in the Southwest United States where there was heavy irrigation in a low rainfall, but very productive, growing area. The Salinity Lab's objective was to study the salinity problems and make recommendations for changes in irrigation and farming practices that would reduce the detrimental accumulation of salts in the soil; reclaim soils that had become too saline for plant growth; and to concurrently develop plants that were more resistant to saline conditions.

At the laboratory it was necessary to know what salts were present in the soil in order to determine effective corrective measures. At that time the methods available for removing moisture from soil for chemical analysis were quite limited and, in some cases, not too reliable. What was needed was a means of extracting the soil solution from all types of soils under all soil moisture conditions in which plants grow.

Dr. Lorenzo A. Richards was in charge of the soils research work at the Salinity Lab at the time. Soilmoisture's founder, P.E. Skaling, had joined the Salinity Lab a short time earlier and worked closely with Dr. Richards on his projects. A special pressure chamber was designed that used a fine pore cellulose membrane material that let water flow through its pores, but not air, thereby keeping the constant pressure levels inside the chamber.

This innovative design allowed them to readily remove moisture from soil samples under controlled conditions throughout the whole moisture range from saturation to the dry "wilting point", where plants wilt and die.

Although the new "Pressure Membrane Extractor" was originally designed to remove moisture from soils for chemical analysis, it soon became evident that this was a powerful, unique tool to study the fundamental relationships of the amount of moisture in the soil compared to the force with which it is held by the soil. The Pressure Membrane Extractor has made it possible to characterize soils by their moisture-holding capacities which has revolutionized irrigation practices throughout the world.

Currently, the Pressure Membrane Extractor finds a number of uses:

1. Developing moisture retention curves for all types of prepared soil samples as well as undisturbed soil cores. This can be done, when required, in conformance with American Society of Testing Methods (ASTM) standard test methods.
2. Bringing soil samples or samples of other porous materials such as paper pulp, for example, to known moisture conditions for testing purposes.
3. Studying moisture flow problems in unsaturated soils.
4. Extracting soil solution for chemical analysis.
5. Ultra filtration to remove higher molecular weight materials from solution, such as proteins and bacteria.
6. Calibrating various types of electrical/moisture measuring devices.

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2. YOUR NEW PRESSURE MEMBRANE EXTRACTOR

Unpacking

Remove all packing materials and check the Extractor for any damage that may have occurred during shipment.

If the Extractor is damaged, call the carrier immediately to report it. Keep the shipping container and all evidence to support your claim.

Assembly

The Pressure Membrane Extractor was assembled before shipment. Only the Extractor Legs and Outflow Tube will need to be installed. To attach the three Extractor Legs, carefully set the Extractor on its side and screw the Legs into the threaded leg support holes. Then set the Extractor right side up.

Included in the same bag with these instructions you will find a small clear plastic nylon tube. This is the Outflow Tube. The Outflow Tube is inserted from underneath the Bottom Plate and up into the Outflow Port of the Screen Drain Plate. Hold the Screen Drain Plate in place and gently push the Outflow Tube upward into the Outflow Port until it will go no further.

Remove the Thread Protector Caps from the inlet stems on the Top Plate and the Extractor Cylinder. We suggest you keep these Thread Protector Caps should you need to store the Extractor for any length of time.

Any damage found upon receipt should be reported immediately to the transport carrier for claim. It is important that you save the shipping container and all evidence to support your claim.

Not Liable for Improper Use

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 subject to the following conditions:

SEC's obligation under this warranty is limited to repairing or replacing (at SEC's option) products which have been returned prepaid to SEC or SEC's agent in the user's country. SEC will return warranted equipment prepaid.

This warranty shall not apply to any SEC products which have been modified, misused, neglected, involved in accidents of nature, or sustained shipping damage. Under no circumstances will SEC reimburse the claimant for costs incurred in removing and/or reinstalling equipment. This warranty, and SEC's obligation thereunder, is in lieu of all other warranties, expressed or implied, including warranties of suitability and fitness for a particular purpose.

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 the product operating instructions by a prudent individual under normal conditions in applications intended for each product.

Products may NOT be returned without prior authorization from SEC. A Return Merchandise Authorization (RMA) must be obtained from the factory prior to shipping products to SEC.

Soilmoisture Equipment Corp. is not responsible for any damage, either actual or inferred, for misuse or improper handling of this equipment. The 1000 Pressure Membrane Extractor is designed to be used solely as directed by a prudent individual under normal conditions in the applications intended for this instrument.

Specifications

Operating Range
0-15 Bars (0-220 psi)

Pressure Supply
Compressed air from a compressor or compressed air or nitrogen in tanks.

Connecting Ports
The inlet stem on the Top Plate and on the Extractor Cylinder accept standard CGA No. 022 hose connector fittings, thread size 9/16 - 18 UNF.

Top & Bottom Plates
Manufactured from hot rolled steel plate, ASTM Spec. A-36. Tensile strength 58,000 - 80,000 psi. Yield point 36,000 psi minimum. Surface Blanchard ground to clean up. Polyurethane enamel coated.

Extractor Cylinder
Manufactured from centrifugally cast aluminum bronze, copper alloy, CA#952 (S.A.E., ASTM). Tensile strength 75,000 psi. Yield strength 30,000 psi. Nickel plated.

Clamping Bolts
Hex head cap screw, thread size 5/8 inch-18, length 3 inch, cold headed, grade 5, fabricated to ASTM A-546 standards, using UNS -g-10380 (1038 S.A.E. Steel). Proof load 85,000 psi minimum, tensile strength 120,000 psi minimum. Pad, 1.25 inches long by .87 inches wide by .13 inches thick from 1018 steel, copper furnace brazed to head of cap screw. Nickel plated.

Clamping Nuts
Hex nut, thread size 5/8 inch -18, conforms to ASTM Spec. A-563, Grade A steel. Nickel plated.

Pressure/Vacuum Equivalents

1 Bar is the equivalent of:
100 centibars (cb)
100 kiloPascals (kPa)
.1 MegaPascals (MPa)
.987 atmospheres (atm)
10^6 dynes/cm^2
33.5 ft. of water
401.6 inches of water
1020.0 cm of water
29.5 inches of Hg
75 cm of Hg
750 mm of Hg
14.5 pounds per square inch (psi)

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3. OPERATING PRINCIPLES

The Pressure Membrane Extractor is able to extract moisture from soil samples because of the microscopic pores in the wetted Cellulose Membrane which forms the bottom of the Extractor chamber.

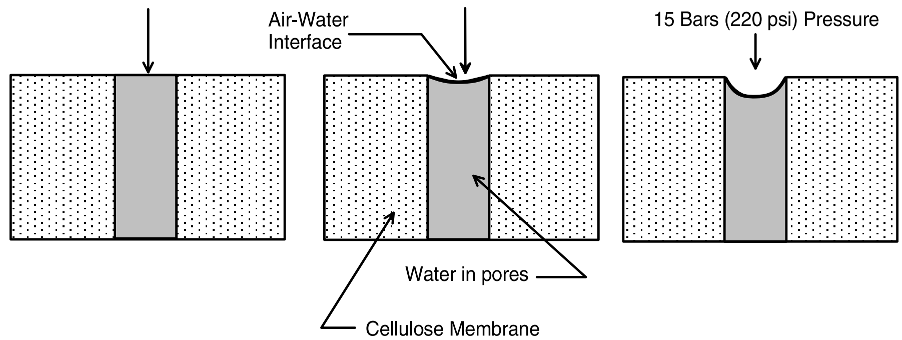

Fig. 2. Changes in radius of curvature of air-water interface with pressure

When air pressure inside the Pressure Membrane Extractor is raised above atmospheric pressure, the higher pressure inside the Extractor chamber forces excess water through the microscopic pores of the Cellulose Membrane and out of the Extractor. The high pressure air will not flow through the pores of the Cellulose Membrane since they are filled with water. The surface tension of the water in the pores at the air-water interface supports the pressure, much the same as a flexible rubber diaphragm. When the air pressure inside the Extractor is increased, the radius of curvature of this interface decreases (Figure 2). Water films will not break and allow air to pass through, even at maximum extractor pressure because of the minute pore diameter (24 angstroms). There is an exact relationship between the amount of air pressure in the Extractor and the radius of curvature of the air-water interface of the water in the pores of the Cellulose Membrane.

When soil samples are placed on the Cellulose Membrane in the Extractor and saturated with water and the air pressure in the Extractor is raised above atmospheric pressure, water will flow from around each of the soil particles and out through the pores of the Cellulose Membrane. At any given air pressure inside the Extractor, water will flow until the curvature of the water films at the junction of each of the soil particles is the same as in the pores of the Cellulose Membrane and corresponds to the curvature associated with that pressure (Fig. 3).

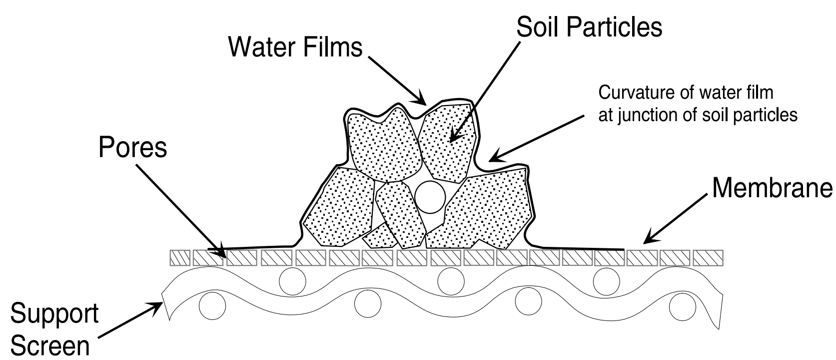

Fig. 3. Section view showing water films surrounding soil particles in the Pressure Membrane Extractor

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For example, if the air pressure inside the Extractor is maintained at 1 Bar (14.5 psi) and flow from the Extractor has ceased, the sample is described as being at “a soil suction of 1 Bar”. The volumetric water remaining in the sample at that pressure would, in field conditions, represent a 1 Bar soil suction to surrounding plants. If the air pressure in the Extractor is maintained at 15 Bars (220 psi), the soil suction at equilibrium would be 15 Bars, the approximate wilting point of plants.

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4. ACQUAINT YOURSELF WITH THE PARTS

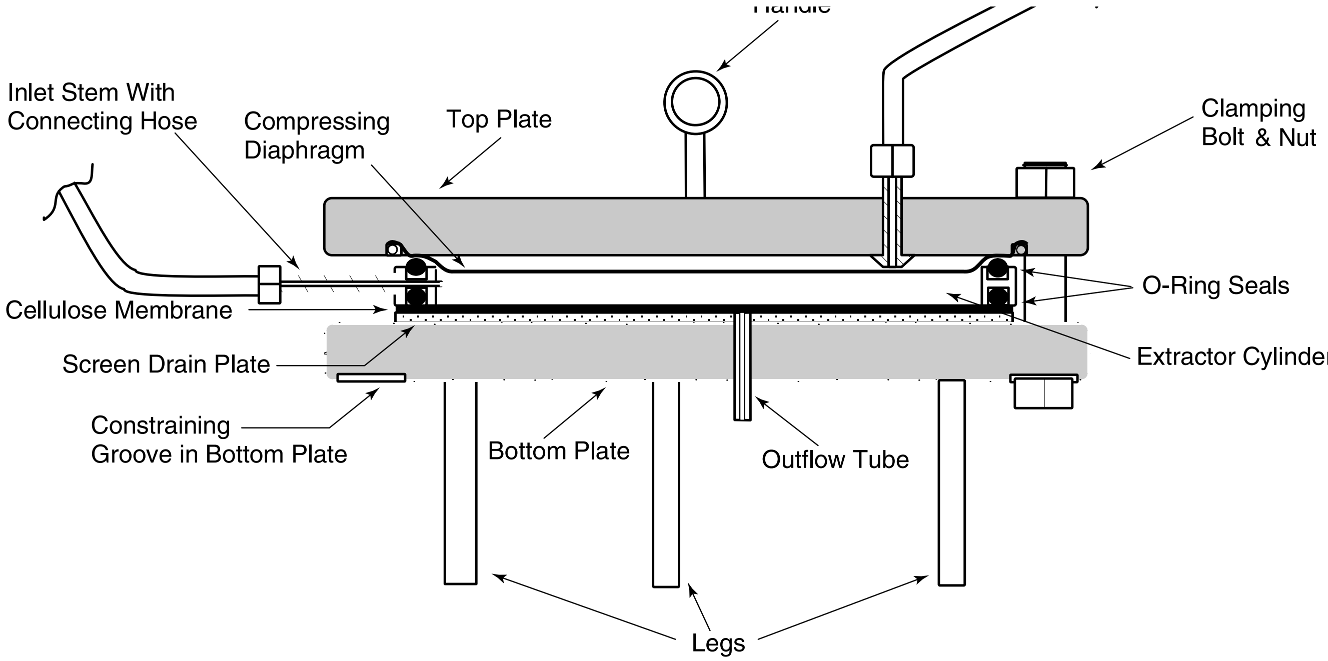

Fig. 4. Cross section view of Pressure Membrane Extractor

Clamping Bolts

When you receive your Extractor, the Clamping Bolts will already be installed, holding both the Bottom Plate and Top Plate together. The eight Clamping Bolts have special rectangular heads that fit in a constraining groove on the underside rim of the Bottom Plate. These special rectangular heads must always be properly fitted into this groove during operation.

Top Plate And Compressing Diaphragm

The Top Plate of the Pressure Membrane Extractor has a handle, an Inlet Stem, and a Compressing Diaphragm underneath (Fig. 4). The Inlet Stem on the Top Plate provides a pathway for higher pressure air, supplied by the accessory Mercury Differential Regulator, to enter behind the Compressing Diaphragm.

The Compressing Diaphragm is held in place mechanically with the Diaphragm Clamping Tube (a 1/8 inch nylon tube) in a groove machined in the Top Plate; no cements are used. The Compressing Diaphragm can be replaced if damaged or accidently pulled out of its groove. Please refer to Section 9, “General Care and Maintenance” of these instructions for proper replacement procedure.

When activated by the Mercury Differential Regulator during a run, the Compressing Diaphragm holds soil samples in tight contact with the Cellulose Membrane.

Extractor Cylinder and Cylinder O-Ring Seals

The Pressure Membrane Extractor is shipped with our standard 5/8 inch high Extractor Cylinder, see Fig. 5 (Other cylinder sizes are available. See Section 10 - “Spare Parts and Accessories List” at the end of these instructions). The Extractor Cylinder is an aluminum bronze ring that creates the working chamber of the Extractor. Note that the Extractor Cylinder has a groove on both its top and bottom. These grooves hold the two buna-n rubber Cylinder O-Ring Seals in place. The O-Rings provide an airtight seal between the Top Plate, Extractor Cylinder, and Screen Drain Plate.

The inlet stem that protrudes from the Extractor Cylinder provides the entry for pressure from the manifold source for the working chamber of the Extractor.

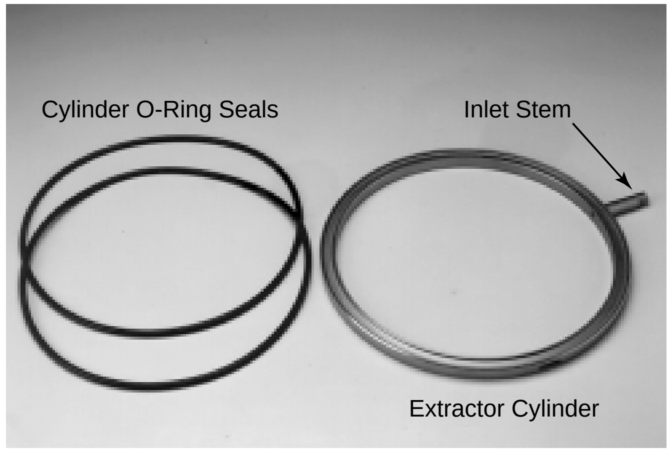

Figure 5. Extractor Cylinder and O-Ring Seals

Cellulose Membrane

The Cellulose Membrane discs, 1041D12, are required for operation of the Pressure Membrane Extractor, but are ordered separately.

The Cellulose Membrane discs are supplied folded in half (as a consequence of the manufacturing process). Care should be exercised in handling the cellulose material while it is in the stiff, dry condition to avoid sharp bends or creases which will cause tiny cracks that may later leak air during the course of a run. To further avoid troubles of this nature, it is advisable to store the cellulose material in a cool place in a moisture-tight container.

Before use, a Cellulose Membrane disc is thoroughly wetted by immersing in water.

The Cellulose Membrane discs, used with the Pressure Membrane Extractor, are made from a regenerated cellulose material with an average pore diameter of 24 angstroms. The “air entry value” or “bubbling pressure” for this material is well over 15 Bars (220 psi).

Screen Drain Plate

Fig. 6. Screen Drain Plate

The Screen Drain Plate (Fig. 6) consists of a stainless steel screen installed in a polycarbonate base. Take care in handling the Screen Drain Plate to prevent damage or breakage of the fine wires in the mesh which could puncture the Cellulose Membrane material and spoil a run. If damaged, the entire Screen Drain Plate needs to be replaced.

The Screen Drain Plate provides a support surface for the Cellulose Membrane and a means to channel moisture out of the Extractor through its Outflow Port in the center of the Plate and out the attached Outflow Tube. The small Outflow Port contains an O-ring that provides a seal for the Outflow Tube.

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Bottom Plate

The lower portion of the Extractor is called the Bottom Plate. If you turn the Bottom Plate over, you will see 3 threaded leg support holes for attaching the Extractor Legs, a 1-inch wide groove to hold the rectangular heads of the Extractor Bolts, and the hole for the Screen Drain Plate's Outflow Port.

Outflow Tube

When the Screen Drain Plate is positioned properly on the Bottom Plate, its Outflow Port will be centered over the hole in the Bottom Plate as described above. The Outflow Tube is inserted from underneath the Bottom Plate and up into the Outflow Port of the Screen Drain Plate. Hold the Screen Drain Plate in place and gently push the Outflow Tube upward until it will go no further. You can attach a small piece of rubber tubing to the protruding end of the Outflow Tube to connect to a buret, if desired, to monitor the outflow of soil solution.

Eccentric Clamping Screws

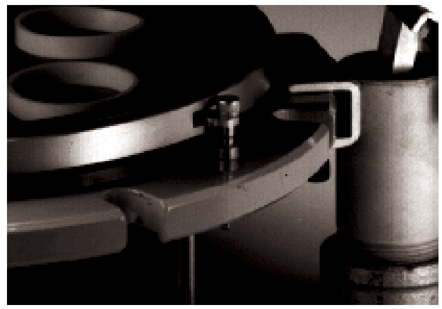

Fig. 7. Eccentric Head Screw

The Extractor Cylinder is held down by two Eccentric Head Screws. The heads of these screws fit into slots in the side of the cylinder wall (Fig. 7). To release the Cylinder, simply loosen the wing nuts on the underside of the Extractor Bottom Plate. The eccentric heads can then be readily rotated out of the cylinder slot. No handtools are required. Always be sure to reclamp the Extractor Cylinder with these Eccentric Screws when assembling the Extractor, so that when the Extractor is later disassembled and the Top Plate removed, the Extractor Cylinder will not break apart at the lower seal and, by so doing, disturb the samples. If the Extractor Cylinder is not clamped by the Eccentric Clamping Screws, it might also “stick” to the Top Plate on disassembly and subsequently fall and damage the Screen Drain Plate.

Connecting Hoses

Two accessory Connecting Hoses, 0775L60, are required for operation of the Pressure Membrane Extractor. The pressure seal at the hose connection is made when the round “nose” of the brass stem inside the hose nut is pressed against the recessed conical surface of the pressure fittings on the Extractor. This is a metal-to-metal seal and is very effective. The screw threads on the fitting and nut only serve as a means of holding the parts in contact. The threads themselves do not make a seal. Only a small amount of torque is required and should be used in connecting the hoses.

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Soil Sample Retaining Rings

Accessory 1093 Soil Sample Retaining Rings (Figs. 8 & 9) are available to hold samples during the extraction process. These are molded from a flexible plastic, are 1 cm high, and hold a 25 gram sample of soil. They are supplied by the dozen, in two groups of six. The rings are cut from the spokes, as shown above.

Fig. 8. Soil Sample Retaining Rings

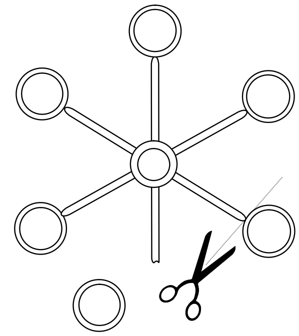

Fig. 9. Cut Rings from spoke

PM Hinge

The PM Hinge is an important accessory item that is normally ordered with the Pressure Membrane Extractor. The PM Hinge eliminates the problem of lifting the heavy Top Plate by hand, keeps the Top Plate in proper alignment, and counteracts the weight of the Top Plate (Fig. 10). It can be easily mounted to the Top and Bottom Plates of the Extractor. Separate mounting instructions are enclosed with the PM Hinge.

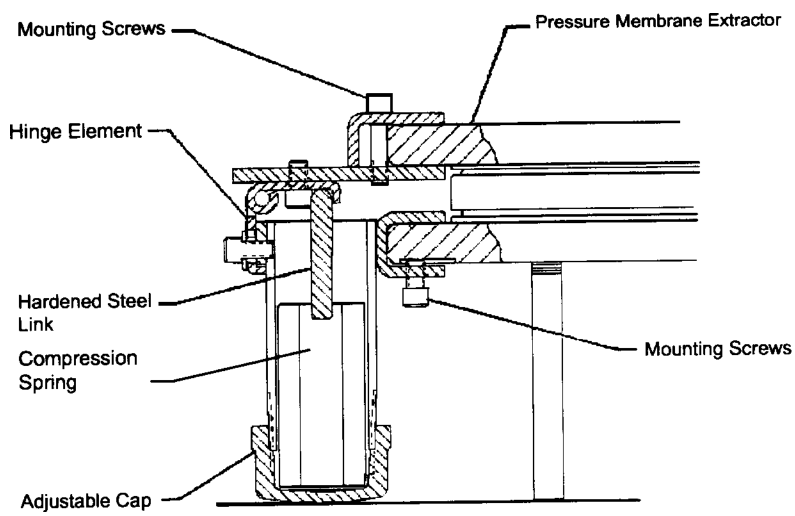

Fig. 10. Cross section view of PM Hinge mounted on Pressure Membrane Extractor

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Torque Wrench And Socket

Fig. 11. Accessory Torque Wrench and Socket

With the accessory Torque Wrench and Socket, 1090, (Fig. 11), you can make sure the Clamping Bolts are tightened with an equal amount of force. Preset to 60 inch lbs., the Torque Wrench is easy to use and fits comfortably in your hand. The Torque Wrench is supplied with a 5/8 inch socket that fits the Clamping Bolts on your Extractor. Use of the Torque Wrench provides proper sealing pressure for the Cylinder O-Ring Seals and avoids destructive overtightening.

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5. REQUIREMENTS PRIOR TO USE

Setup Pressure Supply Source

The Pressure Membrane Extractor requires a source of regulated gas pressure of up to 220 psi (15 Bars) for full range operation. The use of compressed gas is very small. Compressed air or nitrogen can be used for all moisture-retention studies. Where solutions are being extracted for chemical analysis, use water pumped nitrogen in tanks to avoid possible chemical disturbance which might come from compressed oxygen or CO^2 in the air.

If the Extractor is to be used extensively for moisture-retention studies, compressed air from a compressor is the most satisfactory source of supply. Our 500F Series Compressors are ideally suited for use with this Extractor, as well as with all of our Extractors. See Section 10, "Spare Parts and Accessories List", of these instructions.

Compressed nitrogen or air (2,000 psi) in tanks is suitable where the Extractor is operated on a limited basis, or where solution is being extracted for chemical analysis, as indicated above.

Accuracy of equilibrium values obtained from soil samples run in the Extractor will be no more accurate than the regulation of the air supplied to the Extractor. For this reason it is very important to have the proper pressure control manifold. Soilmoisture Equipment Corp. provides a complete range of pressure control manifolds designed specifically for use with this Extractor. Each of these manifolds incorporates our Mercury Differential Regulator, which is a specialized regulator designed to supply two levels of pressure to the Pressure Membrane Extractor. See Section 10, "Spare Parts and Accessories List", of these instructions.

Laboratory Setup Using A Compressor

(1) 0500F Series PM Compressor
(2) 1000 Pressure Membrane Extractor
(3) 0700G1 Manifold
(4) 0779G1 Connecting Hose Combination
(5) 0775L60 Connecting Hose (2 Required)
(6) 0772G01 Adapter

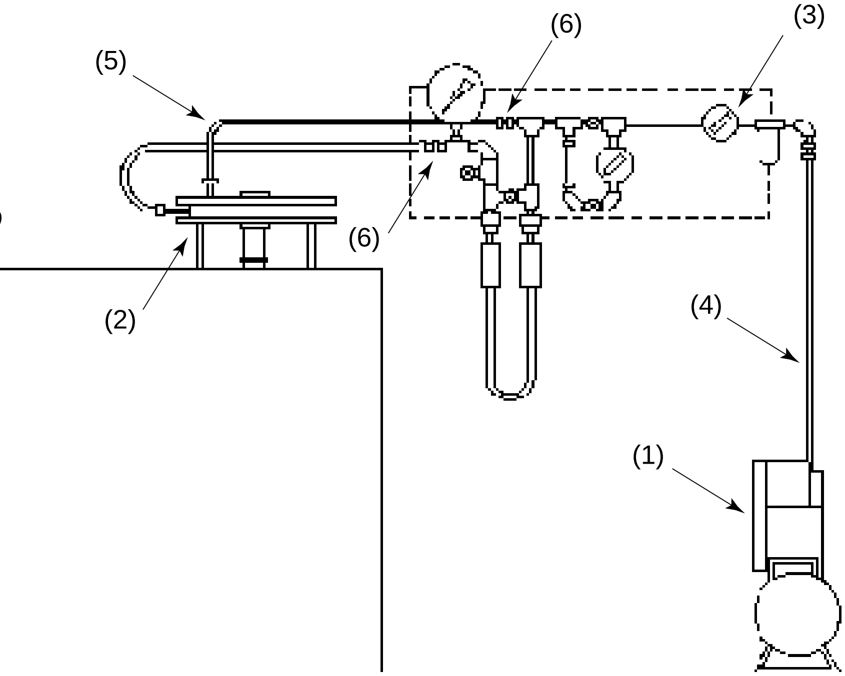

Fig. 12. Laboratory Setup for moisture-retention studies using the 1000 Pressure Membrane Extractor with the 500F Series Compressor as a pressure source

The diagrammatic view of the laboratory setup is shown above (Fig. 12) for the Pressure Membrane Extractor using regulated air pressure from the 0700G1 Manifold and the 500F Series PM Compressor as a pressure source. All parts required are itemized in the diagram. The Manifold is mounted on the wall of the laboratory above or adjacent to the laboratory bench. The PM Compressor is placed on the floor next to the bench. The 0779G1 Connecting Hose Combination is 60 inches long and is supplied with an elbow fitting and valve for connection to the PM Compressor. Pipe sealing tape or pipe dope must be used in connecting elbow fitting of the Connecting Hose Combination to the tank of the Compressor. Separate operating instructions are provided with the Manifold and the Compressor, giving complete information on the operation of these units. Additional operating information is also given under Section 6, "How to Operate - Making A Run For Moisture-Retention Studies..." in these instructions.

The setup shown in Fig. 12 is suitable for moisture-retention studies in the 0-15 Bars range of soil suction and it also applies where the 0700G1 Manifold is incorporated in combination manifolds such as the 0700CG12, 0700CG123, or 0700CG13 manifold setups, where several different types of extractors are being run independently from the same pressure source.

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Laboratory Setup Using Tank Gas

(1) 1000 Pressure Membrane Extractor
(2) 0750G1 Manifold
(3) 0775L60 Connecting Hose, 2 required
(4) 0767P0300G1 Regulator
(5) 0772G01 Adapter

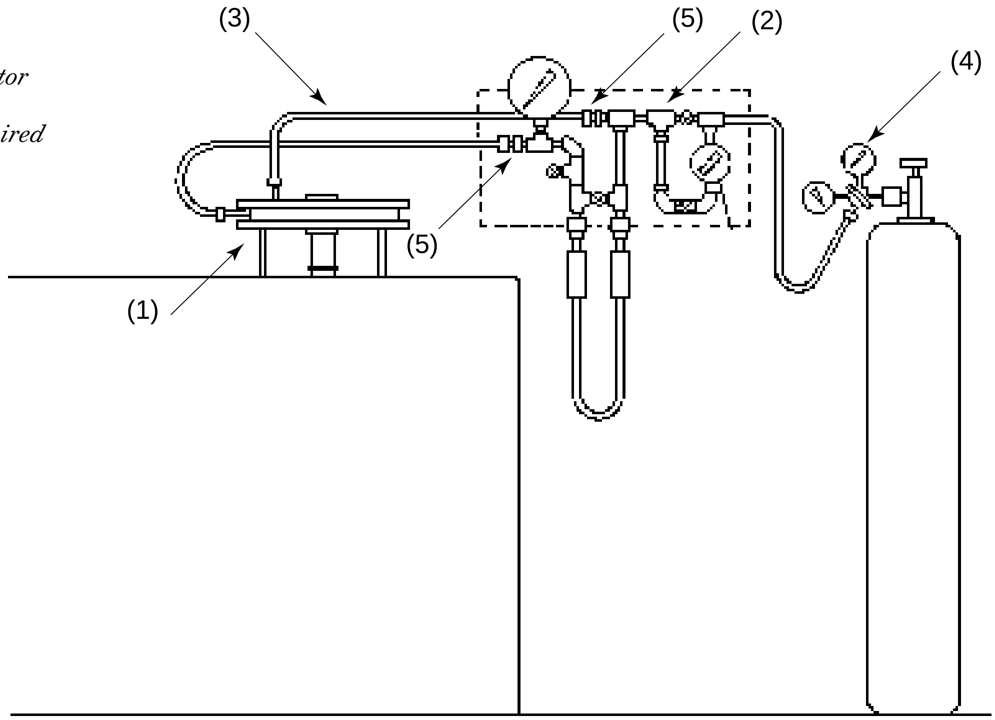

Fig. 13. Laboratory Setup for moisture-retention studies and extraction of soil solution using the Pressure Membrane Extractor with a tank of nitrogen as a pressure source.

Fig. 13 shows the laboratory setup for the Pressure Membrane Extractor provided with regulated air pressure from our 0750G1 Manifold with a tank of compressed nitrogen as a pressure source. All parts required are itemized on the diagram. The Manifold, as indicated in the diagram, is supplied with the 0767P0300G1 Regulator which couples directly to the nitrogen tank. This coupling fitting is designated as a CGA 580 and is a standard for nitrogen tanks and air tanks in the United States. A connecting hose is supplied with the Manifold to make connection between the Manifold and the Regulator mounted on the nitrogen tank. Separate operating instructions are provided with the Manifold.

The setup shown in Fig. 13 is suitable for moisture-retention studies in the 0-15 Bars range of soil suction and is recommended when the Extractor is used on a limited basis. This setup should be used when solution is being extracted from soils for chemical analysis. Our 0750G1 Manifold can also be supplied incorporated in combination manifolds such as the 0750CG12, 0750CG123, or 0750CG13, where several different types of extractors are being run independently from the same pressure source.

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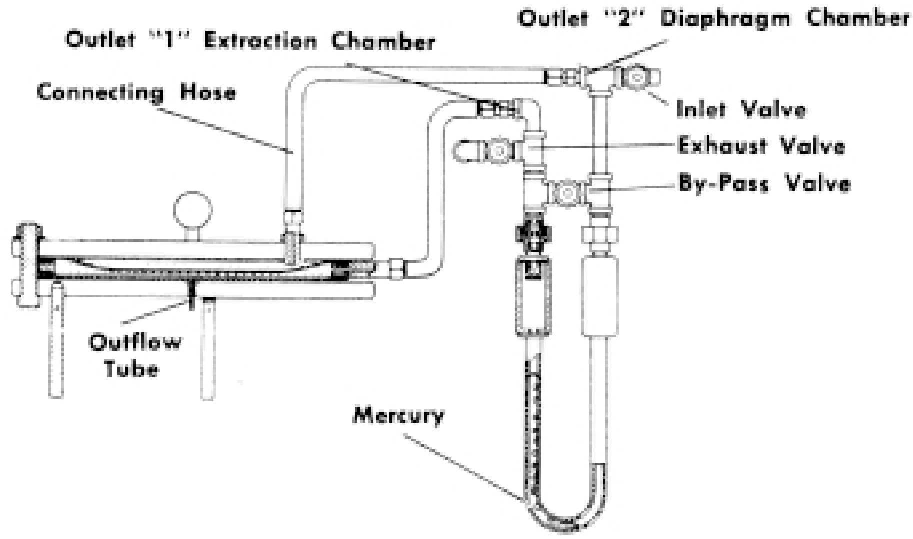

Fig. 14. Cross section view of Mercury Differential Regulator operating with the Pressure Membrane Extractor

The Mercury Differential Regulator provides the differential in pressure necessary to force the rubber Compressing Diaphragm down onto the soil samples and hold them in intimate contact with the Cellulose Membrane. Figure 14 above illustrates how this is accomplished.

The gas pressure on the right side of the U-tube pushes the mercury up in the opposite side of the tube until air bubbles past the bend in the U-tube, as shown. Thus, the pressure at outlet “1” is always lower than at outlet “2” by the height of the mercury column. This height is set to correspond to approximately 4 psi. By connecting outlet “2” behind the Compressing Diaphragm, and outlet “1” to the Extractor chamber, a pressure differential of 4 psi can always be maintained behind the Compressing Diaphragm regardless of the extracting pressure.

The Compressing Diaphragm is used primarily with clay soils to keep them from shrinking away from the Cellulose Membrane as moisture is removed from the samples. It is applied only after several hours of run time have elapsed.

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Preparation Of Soil Samples

Prior to running bulk soil samples in the Extractor for moisture-retention studies, “prepare” the samples by passing them through a 2 mm round-hole sieve to remove rocks larger than 2 mm and to reduce all aggregates to less than 2 mm. Usually, duplicate 25 gm samples for each soil type are prepared.

Undisturbed soil cores can also be run. Soil cores must be held in a retaining ring during the extraction process and the ends of the core must be carefully prepared to provide a flat surface to lay on the Cellulose Membrane.

For work with undisturbed soil cores, our 0200 Soil Core Sampler is a simple and effective sampler. The soil cores are retained in 2-1/4 inch O.D. brass cylinders available in several lengths.

There are a number of procedures developed for the preparation of soil samples by various workers in the field. The primary concern is that the samples tested are representative of the field soils so that moisture relationships developed can be applied to field conditions.

Detailed procedures for preparing samples are also given in the American Society of Testing Materials Standards (ASTM), Designation D421: “Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants”.

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6. HOW TO OPERATE

Operating Range

For moisture equilibrium studies, the Pressure Membrane Extractor is used primarily in the 1 Bar to 15 Bars range (0-220 psi). Due to the very small pore size of the Cellulose Membrane, the flow rate through the Membrane is very low at pressure differentials across the Membrane of 0 to 15 psi (1 Bar). This results in extremely long equilibrium times.

For moisture equilibrium studies in the 0 to 1 Bar range, our 1600 5 Bar Pressure Plate Extractor with the appropriate Pressure Plate Cell, should be used.

Sample Heights

For moisture equilibrium studies, it is desirable to keep sample heights small in order to keep the time to reach equilibrium reasonable. The time required to reach equilibrium varies with the square of the sample height. For example, a soil sample 2 cm high will take four times as long to reach equilibrium as a sample 1 cm high. Whenever possible, soil sample heights should be limited to 1 cm. The 1093 Soil Sample Retaining Rings, which will hold a 25 gram sample and are 1 cm high by 5-1/2 cm in diameter, are ideal for retaining prepared samples.

General Sample Mounting Requirements

In order for moisture to be extracted from samples of soil or other porous material, it is essential that the sample be in intimate contact with the Cellulose Membrane in the Extractor. It is also essential to saturate the sample with water after it is mounted on the Cellulose Membrane in order to "connect" the water films in the sample with those in the Cellulose Membrane. This procedure assures the maximum rate of water flow from the sample during the extraction process.

ASTM Standards

When desired, the Pressure Membrane Extractor can be operated in conformance to designation D3152 of the American Society of Testing Methods (ASTM), entitled, "Standard Test Method for Capillary-Moisture Relationship for Fine-Textured Soils by Pressure-Membrane Apparatus".

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Mounting The Cellulose Membrane

Remove the Clamping Bolts, Top Plate and Extractor Cylinder.

Center a disc of Cellulose Membrane, which has been thoroughly soaked in water for at least 10-15 minutes, on the Screen Drain Plate. Care should be exercised in handling the cellulose material while it is in the stiff, dry condition to avoid sharp bends or creases which will cause tiny cracks that can later leak air during the course of a run. To further avoid troubles of this nature, it is advisable to store the cellulose material in a cool place and in a moisture-tight container.

Now lay the Cylinder O-Ring Seal on the Cellulose Membrane disc and set the Extractor Cylinder on top of the Cylinder O-Ring Seal so that it fits into the groove of the Extractor Cylinder. Turn the two Eccentric Screws so that their heads hold the Extractor Cylinder in place and then tighten the wing nuts.

It is important to keep soil particles away from the Cylinder O-Ring Seal where it comes in contact with the Cellulose Membrane. Sand particles may get pushed into the Cellulose Membrane by the Cylinder O-Ring Seal when the Clamping Bolts are tightened and cause an air leak through the Cellulose Membrane. To avoid this, a narrow ring of cheesecloth or similar material may be placed just inside the Extractor Cylinder.

Placement Of Soil Samples In The Extractor

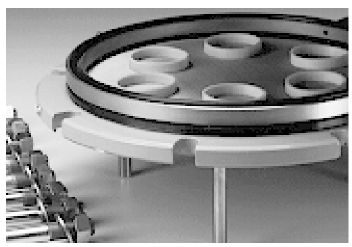

Fig. 15. Soil Sample Retaining Rings mounted on the Cellulose Membrane in the Extractor

When running prepared samples for moisture-retention studies, place Soilmoisture's Soil Sample Retaining Rings on the Cellulose Membrane inside the Extractor to receive the group of samples (Fig. 15). The Extractor will accommodate 14 samples when retained in these rings. Each ring will hold a 25 gm sample of soil.

Transfer the previously prepared 25 gm samples, that have been stored in individual sample containers, to the Soil Sample Retaining Rings in the Extractor. Pour all of the soil sample from each sample container into one ring.

Pour out all of the sample. Do not leave any sample in the container because this will give a nonrepresentative sample. Level the samples in the ring and cover with squares of waxed paper.

Carefully add water to the surface of the Cellulose Membrane in between the Soil Sample Retaining Rings until there is a surplus of "standing" water between all the Retaining Rings. Let this surplus water stand for at least 16 hours, until the samples are thoroughly saturated with water.

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Closing The Extractor

Remove the excess water from the Cellulose Membrane with a pipet or rubber syringe. Place the second Cylinder O-Ring Seal in the top groove of the Extractor Cylinder and then set the Top Plate on the Extractor Cylinder so that the top and bottom bolt slots line up. Insert the Clamping Bolts and tighten. Excessive clamping torques only tend to shorten the life of the Cylinder O-Ring Seals. The operator should use our Torque Wrench and Socket for this purpose.

Connection To A Buret To Monitor Outflow Of Water

Connect the small Outflow Tube in the Screen Drain Plate with a tight-fitting rubber sleeve to a piece of small diameter tubing that extends laterally and connects to the tip of a buret. Support the buret in a buret clamp screwed to one of the legs of the Extractor. Gas will diffuse through the Cellulose Membrane and pass continuously in small bubbles through this small Outflow Tube and transport the extracted liquid to the buret. The buret can be read periodically and the approach to equilibrium can thus be followed. If the pressure in the Extractor chamber is maintained at a constant, no measurable amount of change in the buret reading will be observed over a period of many hours or days once equilibrium is attained.

Turning On The Pressure

Before turning on the pressure, make sure that all hose connections are properly made to the Pressure Control Manifold.

Also be sure that the Mercury Differential Regulator Bypass Valve is opened full. This will prevent possible damage to the Compressing Diaphragm and/or disturbance to the samples in the Extractor. It will also prevent mercury from being blown to other parts of the Manifold system by a rush of air through the U-tube. The exhaust valve should be closed. See Section 5, "Requirements Prior to Use - Acquaint Yourself with the Operation of the Mercury Differential Regulator" in these instructions.

Now open the Pressure Regulator slowly and adjust the Regulator to the desired extraction pressure. In this case where we are determining the wilting point moisture content, the pressure is set at 15 Bars (220 psi). Note: Separate operating instructions come with each of our Pressure Control Manifolds.

Water will flow immediately from the Extractor into the buret attached to the Outflow Tube. The level of the water in the buret should be observed periodically.

After a few hours, the rate of outflow of water from the soil samples will fall off markedly, and the soil samples will attain sufficient rigidity so that the Compressing Diaphragm can be applied without appreciable deformation or compaction of the samples. To apply the Compressing Diaphragm, close the Bypass Valve (see Section 5, "Requirements Prior to Use - Acquaint Yourself with the Operation of the Mercury Differential Regulator"). Then open the Exhaust Valve slightly and exhaust air until you can hear it bubbling past the mercury in the U-tube. Then close the Exhaust Valve. The pressure behind the Compressing Diaphragm is now 4 psi more than the pressure in the Extractor chamber. This was accomplished by lowering the pressure in the Extractor chamber. It is now necessary to bring the pressure inside the Extractor chamber up to the original value. This is accomplished by simply adjusting the Pressure Regulator to the desired pressure on the gauge.

The diaphragm action holds the sample firmly in contact with the Cellulose Membrane and considerably hastens moisture extraction from fine-textured soils that shrink appreciably. The Compressing Diaphragm is not needed for medium and coarse-textured soils.

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During the extraction process, small amounts of air diffuse through the Cellulose Membrane. This is caused by air that dissolves in the water under high pressure inside the Extractor and then comes out of solution when the water flows out of the Extractor into normal atmospheric pressure. The rate of this air diffusion is approximately 2 ml/minute when the pressure in the Extractor is at 15 Bars (220 psi). At lower extraction pressures, the diffusion is appropriately less.

Removal Of Samples

Samples may be removed when the readings on the outflow buret indicate equilibrium has been attained. Most soils will approach hydraulic equilibrium with the Cellulose Membrane in 18 to 20 hours.

At the close of a run, open the Bypass Valve on the Mercury Differential Regulator first. Immediately thereafter shut off the Pressure Regulator and open the Exhaust Valve until all pressure is released from the Extractor. Remove the Clamping Bolts and Top Plate. Transfer the samples to moisture boxes as soon as possible after release of pressure in order to avoid changes in the moisture content. Discard the Cellulose Membrane discs at the end of each run.

Determination Of Moisture Content At The Wilting Point

After the samples are transferred to moisture boxes, carefully weigh the box and contained sample. Place the box with sample in an oven and dry at 105° C until there is no further loss of weight. Subtract the tare weight of the moisture box from both the moist weight and the dry weight. The difference in weight of the moist sample and the dry sample divided by the dry weight of the sample is the moisture content of the soil at the wilting point. This can be expressed as a percent of dry weight of the soil. Through knowledge of the bulk density of the soil, this can also be expressed as the volumetric moisture content of the soil at the wilting point.

Developing Moisture Retention Curves

You can develop moisture retention curves in the 1 Bar to 15 Bars range for all types of soils with the Pressure Membrane Extractor. Points on the curves can be determined in a manner similar to the wilting point moisture content given above.

Run samples of the same soil at various extraction pressures such as 1 Bar, 3 Bars, and 5 Bars. When equilibrium is reached at each extraction pressure, remove the samples and determine the moisture percentage in the same manner as for the 15 Bar percentage, given above. You can then plot these values on a graph to produce a moisture retention curve for that particular soil.

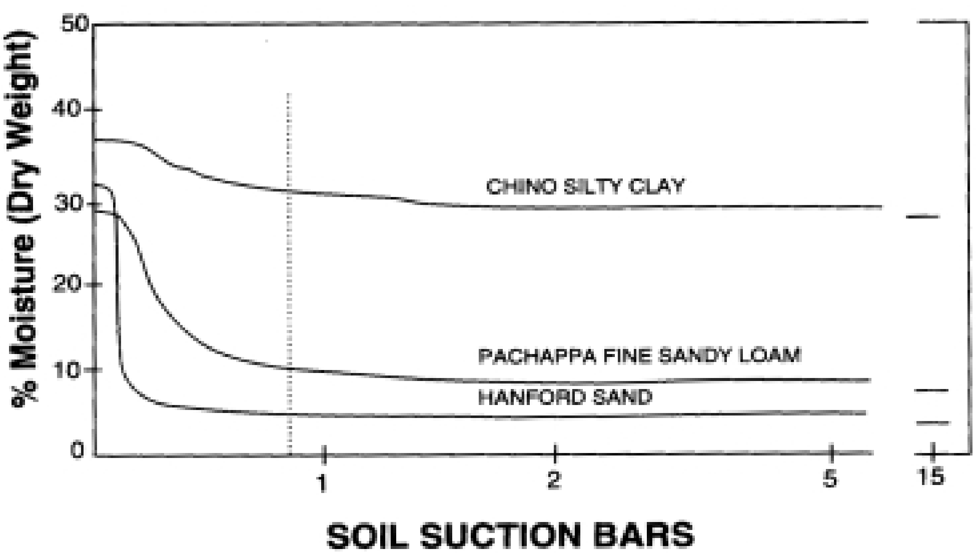

Fig. 16. Moisture retention curves for three types of soils, developed from Pressure Membrane and Pressure Plate Extractors, are shown above.

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7. HELPFUL HINTS IN NORMAL USE

Handling Large Quantities Of Samples

If you need to run large quantities of samples and you need to make full use of the Extractors, lay the Cellulose Membranes on flat sheets of metal which you, in turn, set in shallow pans. Allow the samples to stand for the required time with an excess of water on the Cellulose Membrane in the pan. Then, when you are ready to use the samples, carefully slide the Cellulose Membrane, together with soil samples, off the metal sheet and center the Cellulose Membrane on the Screen Drain Plate. Now the Cylinder O-Ring Seals and the Extractor Cylinder can be added.

Countering Bacterial Action On The Cellulose Membrane

When running extractions on certain types of soils and tall soil samples, where reaching equilibrium requires many days, bacteria may "eat" through the Cellulose Membrane and cause air leaks. In those cases where bacterial action is of importance, you can soak the Cellulose Membrane in a solution of copper sulfate or mercuric chloride prior to use.

Using The 0676 Soil Retainer Assembly

The 0676 Soil Retainer Assembly, in conjunction with the 0200 Soil Core Sampler, provides a convenient way of securing undisturbed soil cores and running these cores in our various pressure extractors to obtain moisture-retention curves for various soils.

When using the Soil Retainer Assembly in the Pressure Membrane Extractor our 1002G3 Cylinder, which is 1-7/8 inches high, is required.

The 3 cm long cylinder, 0206L03, which is a part of both the 0676 Soil Retainer Assembly - as well as the 0200 Soil Core Sampler - is used to retain the soil cores. These cylinders fit directly into the 0200 Soil Core Sampler and receive the cores as the sampler is pushed into the soil. After the sampling operation is completed, remove the 0206L03 Cylinder containing the soil core from the sampler. Protect the Cylinder with core in a moisture box or cover the ends of the Cylinder with the 0209 Cylinder Cap for transportation to the laboratory.

At the laboratory, carefully trim the ends of the soil core with a knife so that the Cylinder and core can be set on the porous ceramic plate of the 0676 Soil Retainer Assembly. Cover the opposite end of the Cylinder with the plastic cover plate provided and hold it in place with a rubber band. Then set the complete Soil Retainer Assembly with soil core in a shallow pan of water so that the water level comes approximately one-third of the way up on the porous ceramic plate, and allow it to remain there for some 24 hours in order to thoroughly saturate the soil core.

When running these soil cores in a Pressure Extractor, provisions need to be made to obtain good hydraulic contact between the ceramic plate of the Soil Retainer Assembly and the Cellulose Membrane of the Extractor. To do this, place a thin layer of fine, sandy loam on the surface of the Cellulose Membrane. A good capillary conductivity is obtained by using the fraction of a loam soil that passes through a 60-mesh screen. The thickness of the layer of soil on the pressure plate cell should be approximately 3 mm thick. Then cover this thin layer of soil with a single layer of cheesecloth and moisten carefully (Fig. 17).

It is desirable to treat the cheesecloth prior to use with a bactericide to limit bacterial growth during the extraction process. Set the Soil Retainer Assemblies on the cheesecloth, which should be in firm contact with the soil. Then seal the Pressure Membrane Extractor and apply pressure to remove the moisture to the desired soil suction value.

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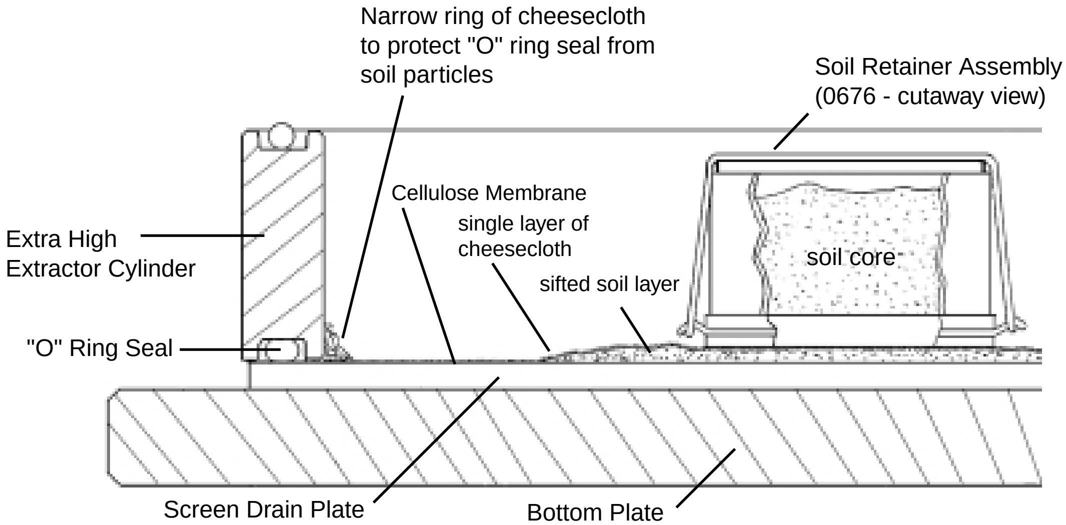

Fig. 17. Section view showing Soil Retainer Assembly mounted in the Pressure Membrane Extractor

In developing moisture-retention curves, readings are frequently made at the 1/10 Bar, 1/3 Bar, 1 Bar, 3 Bars, and 15 Bars pressure values. The Pressure Membrane Extractor is used to establish values at 1 Bar, 3 Bars, and 15 Bars. In making a run, set the pressure at the lowest pressure value desired first and allow the sample to come to equilibrium. The approach to hydraulic equilibrium at each pressure can be followed by connecting the Outflow Tube from the Extractor to the lower end of a buret. Buret readings are taken periodically until outflow ceases. At this point equilibrium has been reached. Exhaust the air pressure within the Extractor so that the Extractor can be opened. Carefully lift the individual Soil Retainer Assemblies from the pressure plate cell and brush off any adhering soil particles. Immediately weigh the complete assembly and return it to the Extractor, making sure again that firm contact is made with the soil layer on the surface of the Cellulose Membrane. Then close the Extractor and raise the pressure to the next highest level desired so that the soil core can come to equilibrium with the new pressure value. Repeat the process at each succeeding higher pressure value desired. At the end of the run, after the final weighing, remove the Cylinder - with soil core intact - from the Soil Retainer Assembly and dry it in an oven at 105° C until constant weight is obtained.

The weight of the porous ceramic plate of the Soil Retainer Assembly will not change significantly at extraction pressures ranging from 1/10 Bar through 3 Bars. However, when a run is made at 15 Bars it is necessary to compensate for the loss in moisture from the porous ceramic plate. To do this, remove and weight the porous ceramic plate separately immediately after the final weighing. Then saturate the porous ceramic plate with water, blot the surface, and reweigh. The difference in weight is then added to the final weight of the complete Soil Retainer Assembly and sample to get the correct final moist weight at 15 Bar equilibrium value.

With the weight measurements that were taken at the various equilibrium values, together with the weight of dry soil determined after the drying process is complete, one can develop the moisture-retention curves relating the percentage of moisture to the soil suction value for that particular soil sample. Since the volume of the soil is also known from the inside diameter of the 0206L03 Cylinder and its length, the bulk density of the soil in the core can be calculated by subtracting the tare weights of the various Soil Retainer Assembly parts. The dimensions of the 0206L06 Cylinder are as follows:

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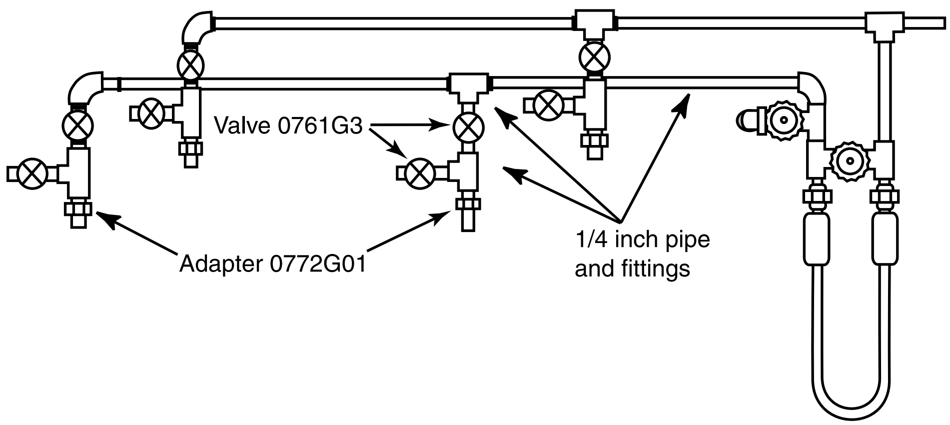
I.D.	2.13 inches (5.40 cm)
Length	1.18 inches (3.00 cm)
Internal Volume	4.20 cubic inches (68.7 cubic centimeters)

One can calculate both the mass and volume of water in the core at each suction value. From the foregoing data, one can also calculate the volume of water held per volume of soil at each soil suction value. This information, in turn, can be used in the scheduling of irrigation, since it will provide specific information as to the amount of water to be applied to a given soil area in order to maintain soil suction values within the limits desired.

Running Several Pressure Membrane Extractors From The Same Manifold

The laboratory setups described previously can be modified to run several extractors at the same time. The 0772G01 Adapter fittings on the outlets of the Mercury Differential Regulator are removed (See Figures 12 & 13 under Section 5, "Requirements Prior To Use". Two assemblies of standard 1/4 inch pipe and fittings, as indicated in Fig. 18, are connected to the Mercury Differential Regulator. Connecting Hoses, 0775L60, from the extractors couple directly to the 0772G01 Adapter fittings.



Where several extractors are being run at the same pressure from a Manifold, it is frequently desirable to start a new extractor while other extractors are in operation. The procedure for this is as follows. After the extractor has been loaded with samples and the Clamping Bolts tightened, open the valve at the Manifold to admit compressed gas only to the Extractor chamber. When extraction has sufficiently progressed so that the samples are firm, open the valve supplying air behind the Compressing Diaphragm. Then vent the Extractor chamber line slightly at the Exhaust Valve on the Mercury Differential Regulator to allow the Compressing Diaphragm to move down and come in contact with the soil. This will also take care of excess pressure brought about in the Extractor chamber during this downward motion. Close the Exhaust Valve as soon as you hear air bubbling past the mercury in the U-tube.

When soil samples have reached equilibrium in one Extractor and are ready to be removed, close the Manifold Valves to that Extractor. Open the Manifold Exhaust Valve for the Diaphragm chamber to exhaust air from behind the Compressing Diaphragm. Then open the Manifold Exhaust Valve for the Extractor chamber to exhaust air from the Extractor chamber. The Extractor may now be opened as indicated above and the soil samples removed.

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8. PRECAUTIONS

When Extractor Is Under Pressure

Never attempt to remove the lid of the Extractor until all pressure is released. Take equal care to securely fasten the Top Plate before applying air pressure.

Open The Bypass Valve

It is important to leave the Bypass Valve on the Mercury Differential Regulator open at all times except when the differential pressure is being applied. The mercury trap bulbs on either leg of the U-tube prevent normal mercury splatter from reaching other parts of the Manifold system. They will not be effective, however, if large volumes of high pressure air are allowed to pass through the U-tube. Be sure to carefully follow instructions for operating the Mercury Differential Regulator.

Keep System Leak Free

If you are using tank gas as a pressure source, it is very important to make sure that all piping is leak-free, since a small leak can waste a large volume of gas over the period of a run.

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9. GENERAL CARE AND MAINTENANCE

Pressure Vessel

The Extractor parts are ruggedly constructed, carefully plated and coated for maximum corrosion resistance. Little attention should be required except for removing excess moisture and soil particles from the interior surfaces after a run. Replacement Cylinder O-Ring Seals are available for immediate shipment from our stock.

Screen Drain Plate

Handle the Screen Drain Plate with care to prevent damaging or breaking the fine wire screen. If one of the fine wires is broken, it can puncture the Cellulose Membrane during a run and spoil it. At the close of a run, rinse the Screen Drain Plate in clear water and dry with a soft cloth. This procedure will minimize evaporation deposits in the screen which can eventually clog the screen and restrict flow of moisture.

Compressing Diaphragm

The Compressing Diaphragm is held mechanically to the Top Plate of the Extractor; no cements are used. The Diaphragm Clamping Tube, a 1/8 inch diameter nylon tube, clamps the edge of the diaphragm in a groove machined into the Top Plate. If this diaphragm is accidently ruptured or pulled from its mounting groove, it, or a new diaphragm, can be readily installed.

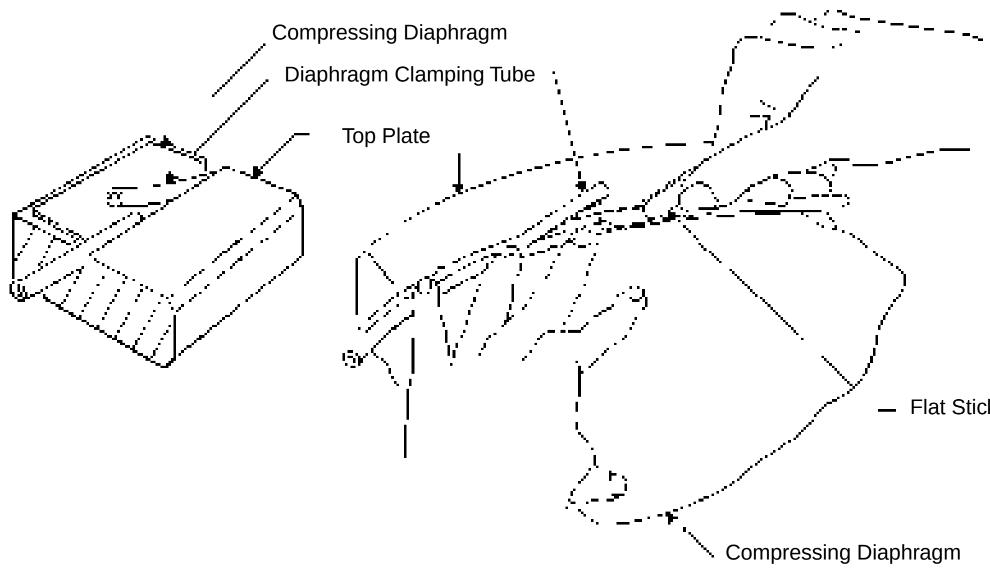

Fig. 19. Replacing the Compressing Diaphragm

To install a new Compressing Diaphragm, remove the Top Plate of the Extractor and lay it on the laboratory bench with grooved side facing up. Center the Compressing Diaphragm on the Top Plate. In an area between two of the Clamping Bolt slots, set the edge of the Compressing Diaphragm even with the outer edge of the groove. Force one end of the Diaphragm Clamping Tube into the groove so that it bends the edge of the Compressing Diaphragm into the groove and pinches it. While you work your way around the groove, pushing in the Diaphragm Clamping Tube, make sure to keep the edge of the Compressing Diaphragm even with the outer edge of the groove where the Tube enters the groove. A narrow, hardwood stick is useful in pressing the Tube and forcing it to the bottom of the groove (Fig. 19).

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10. SPARE PARTS AND ACCESSORIES LIST

Spare Parts List

Part No.	Description
1000-004	Extractor Leg
1001G1K1	Standard Clamping Bolt Set, 5/8" Cylinder
1002G1	Standard Cylinder, 5/8" high
1003	Eccentric Clamping Screw
1005FCR	Screen Drain Plate
1095K1	Compressing Diaphragm Kit
M802X452	O-Ring Cylinder Seal
MYT003	Nylon Tubing for Outflow Stem, sold by the foot

Accessories

Part No.	Description
0500FG3	PM Compressor, 110 volt - 50/60 Hz.
0500FG4	PM Compressor, 230 volt - 50/60 Hz.

Manifolds for use with 500F Series Compressors

0700G1	Manifold (accommodates 1000 Extractor only)
0700CG12	Manifold (accommodates 1000 + 1500 Extractor combin.)
0700CG13	Manifold (accommodates 1000 + 1600 Extractor combin.)
0700CG123	Manifold (accommodates 1000, 1500, 1600 Extractor combin.)

Manifolds for use with Gas Cylinders

0750G1	Manifold (accommodates 1000 Extractor only)
0750CG12	Manifold (accommodates 1000 + 1500 Extractor combin.)
0750CG13	Manifold (accommodates 1000 + 1600 Extractor combin.)
0750CG123	Manifold (accommodates 1000, 1500, 1600 Extractor combin.)

0676	Soil Retainer Assembly
1001G2K1	Standard Clamping Bolt Set, for 1-1/4 inch cylinder
1001G3K1	Standard Clamping Bolt Set, for 1-7/8 inch cylinder
1001G4K1	Standard Clamping Bolt Set, for 3-1/2 inch cylinder
1002G2	Cylinder, 1-1/4 inch high
1002G3	Cylinder, 1-7/8 inch high
1002G4	Cylinder 3-1/2 inch high
1041D12	Cut Cellulose Membrane Discs, per dozen
1080G1	PM Hinge
1090	Torque Wrench and Socket
1093	Soil Sample Retaining Rings, per dozen

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