1020

OPERATING INSTRUCTIONS

100 Bar Pressure Membrane Extractor

August 2000

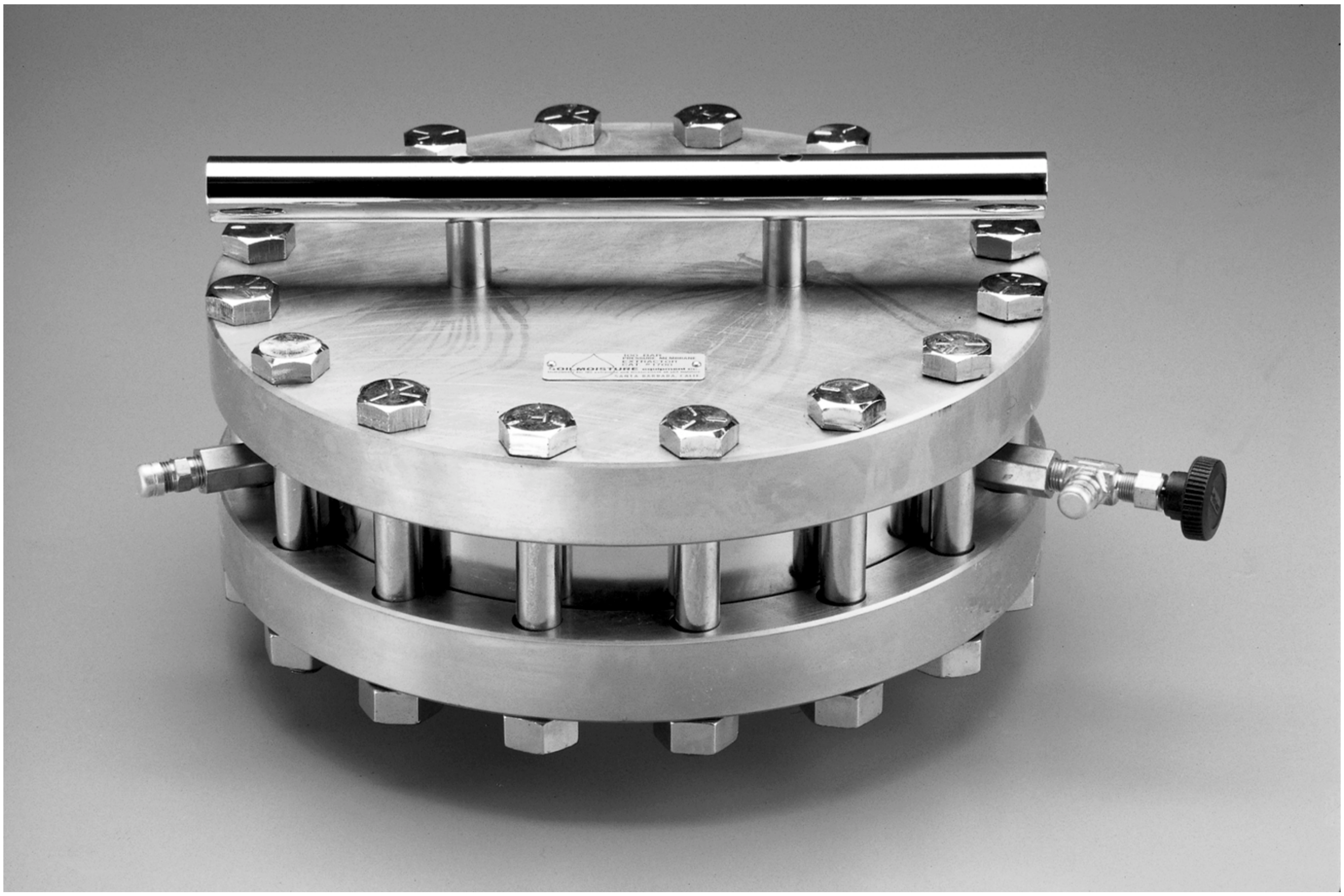

Fig. 1. Model 1020, 100 Bar Pressure Membrane Extractor

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SOILMOISTURE®

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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.

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.

Attention

The Model 1020 100 Bar Pressure Membrane Extractor is designed to operate at very high pressure. As a safety precaution, we highly recommend that all persons using this equipment read all instructions prior to using this instrument.

Assembly

The unit shipped to you has been carefully tested at the full operation range of 1450 psi (100 bar) and is in correct working order.

The Extractor was shipped completely assembled except for the three legs which were removed and packed in the same box. The Extractor is quite heavy due to the requirement of the high operating pressure. When removing the Extractor from the packing box, it can be set on ends of the clamping bolts on a bench.

The Extractor can now be set on its edge so that the three legs can be screwed securely into the three holes provided for them in the Bottom Plate. In setting the Extractor on its edge, be sure to secure it so that the fittings that project from the cylinder will not be damaged. The Extractor can now be set down on the bench on its three legs. The small 1/8" diameter drain tube will need to be inserted so that it projects from the center of the bottom plate.

After removing the 16 Clamping Bolts, the Top Plate can be lifted off. Since this is rather heavy we suggest that two people do this to avoid possibly banging or damaging the Extractor parts. You will note that the under side of the Clamping Bolts are slightly radiused as are both sides of the nuts. There is also a radiused depression around each of the clamping bolt holes on the Top and Bottom Plates. The purpose of this radius is to allow the Top and Bottom Plates to flex under pressure while still retaining full contact clamping area for each bolt. At full operating pressure of 1450 psi the Top and Bottom Plates will bulge approximately 1/16" at the center. This is normal flexing due to the pressure in the Extractor and is well within the elastic limits of the plate material. When the pressure is reduced to zero, the plates will again be flat. The Top and Bottom Plates are actually made of tool steel and are heat treated to a tensile strength of 125,000 psi.

A 1/4 NPT male flare fitting to accept the connecting hose from the Pressure Control Manifold is mounted in the cylinder wall for pressure connection. A 3/8" NPT pipe plug is also mounted in the cylinder and can be removed for installation of the 1066, High Pressure Electrical Leadthrough.

Not Liable for Improper Use

Soilmoisture Equipment Corp. is not responsible for any damage, actual or inferred, for misuse or improper handling of this equipment. The Model 1020 100 Bar Pressure Membrane Extractor is to be used solely as directed by a prudent individual under normal conditions in the applications intended for this equipment.

Specifications

Operating Range
0-100 Bars (0-1450 psi)

Pressure Supply
Compressed air or compressed nitrogen in tanks.

Connecting Ports
The Inlet Stem on the Extractor cylinder terminates in a 1/4-18 NPT male and therefore accepts a 1/4-18 NPT female.

Top & Bottom Plates
Manufactured from 14.5 inch diameter SAE 4140 Condition A steel. Blanchard ground, heat treated, and electroless nickel-plated. Tensile strength: 125,000 psi. Yield strength: 100,000 psi.

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 3/4-inch, 10 threads per inch, Grade 5, medium carbon steel, quenched and tempered. ASTM-A449 (SAE J429). Proof load 85,000 psi, tensile strength: 120,000 psi, nickel plated.

Clamping Nuts
Heavy hex nut, thread size 3/4 inch - 10 threads per inch. ANSI B18.22, nickel plated.

Pressure/Vacuum Equivalents

1 Bar is the equivalent of:
100 centibars (cb)
100 kiloPascals (kPa)
.1 MegaPascals (MPa)
.987 atmospheres (atm)
106 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 100 Bar Pressure Membrane Extractor is able to force moisture from soil samples because of the microscopic pores in the wetted Cellulose Membrane which forms the bottom of the Extractor chamber.

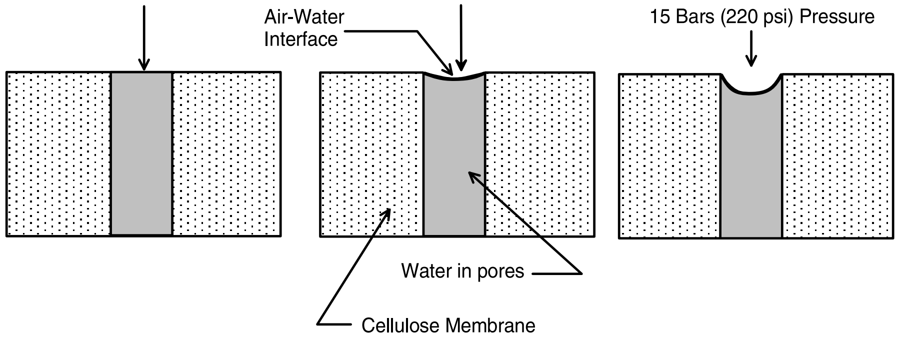

Fig. 2. Changes in radius of curvature of air-water interface with pressure

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 (Fig. 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).
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

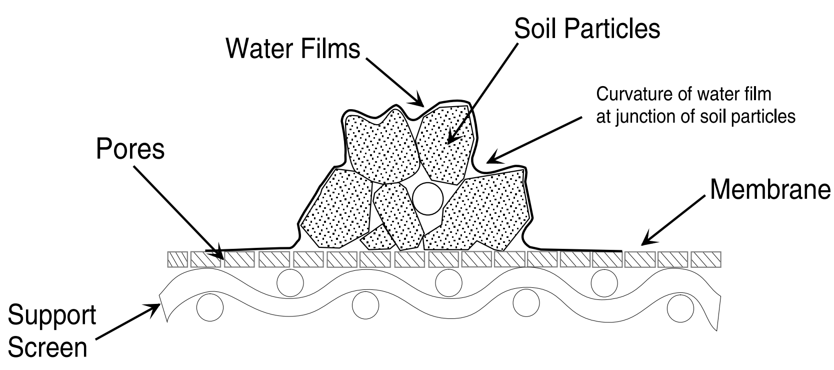

Fig. 3. Section view showing water films surrounding soil particles in the Pressure Membrane Extractor

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"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 (217.5 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

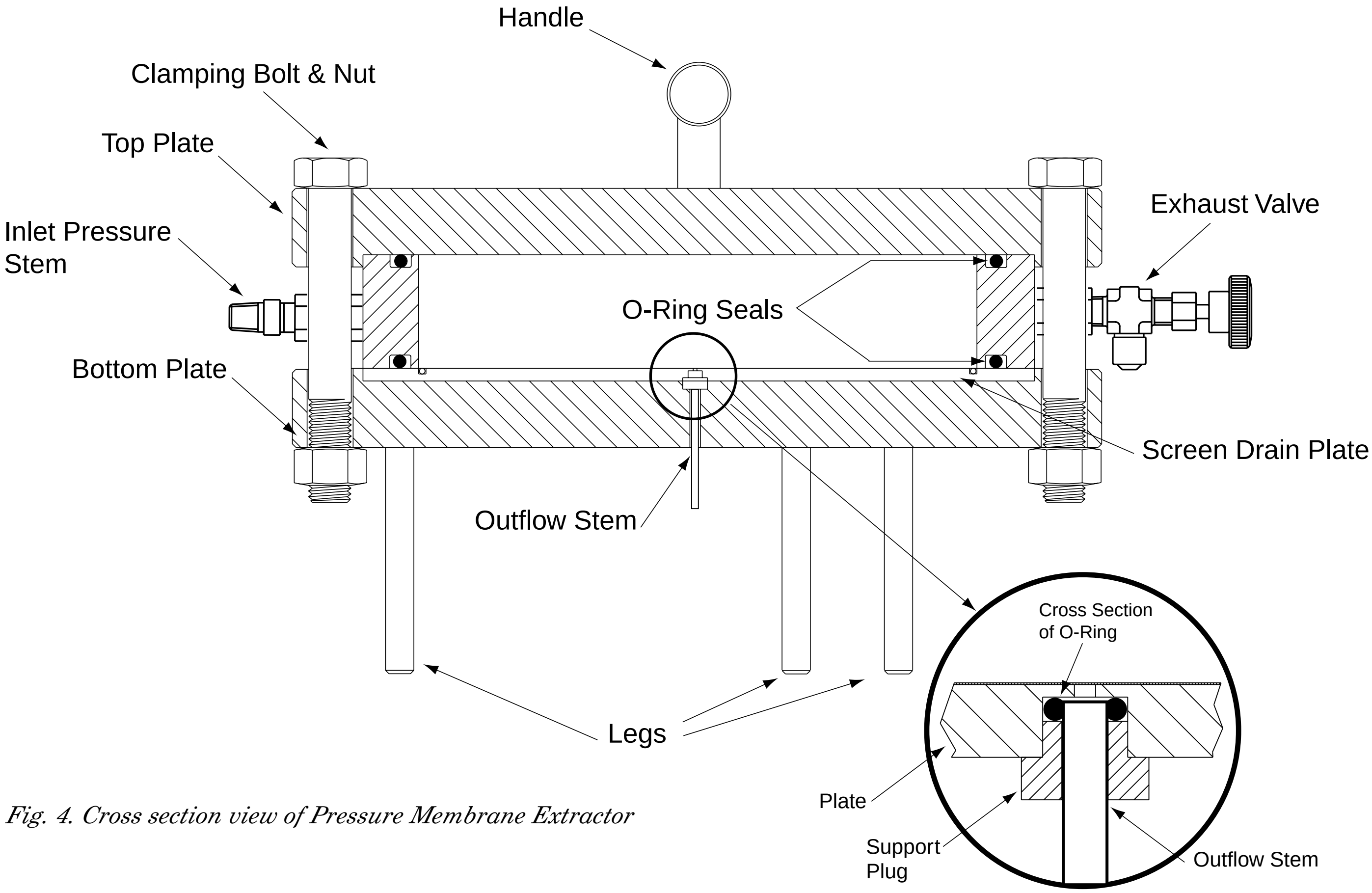

Fig. 4. Cross section view of Pressure Membrane Extractor

Clamping Bolts

When you receive your Extractor, the sixteen Clamping Bolts will already be installed, holding both the Bottom Plate and the Top Plate together.

Top Plate

The Top Plate of the Pressure Membrane Extractor has a handle.

Extractor Cylinder and Cylinder O-Ring Seals

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 Pressure Stem (Fig. 4) that protrudes from the Extractor Cylinder provides the entry for pressure from the manifold source for the working chamber of the Extractor. The Exhaust Valve (Fig. 4) is opposite to the inlet stem.

Cellulose Membrane Discs

The Cellulose Membrane Discs, Model No. 1041D12, are required for operation of the Pressure Membrane Extractor, but are ordered separately (not shown).

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.

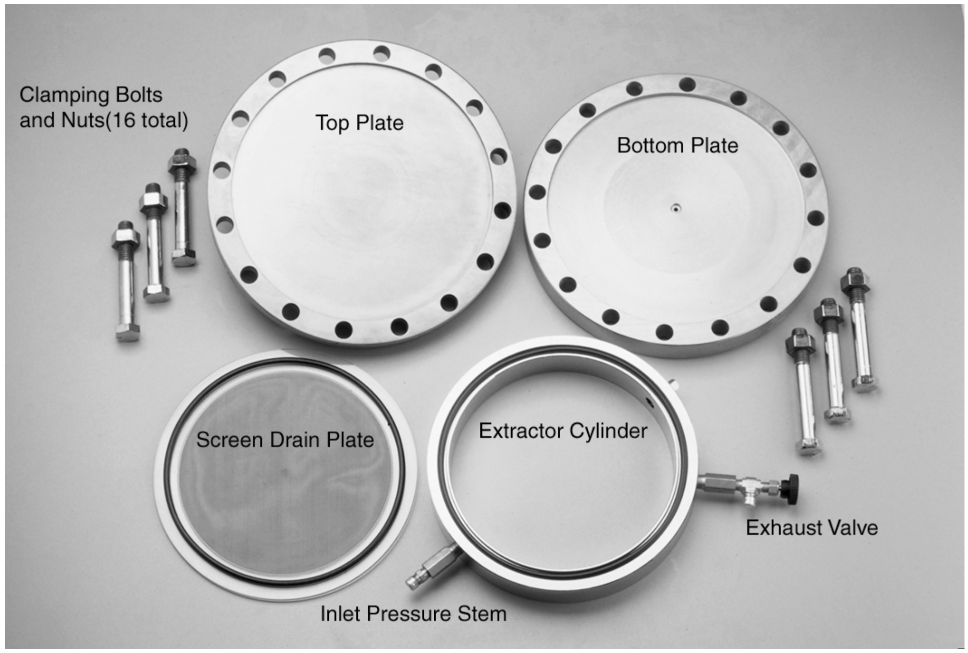

Fig. 5. 1020 Extractor Disassembled (support legs not shown)

Screen Drain Plate

The Screen Drain Plate (Figs. 5 and 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 during a run and spoil the 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.

Fig. 6. Screen Drain Plate

Bottom Plate

The lower portion of the Extractor is called the Bottom Plate (Fig. 5). If you turn the Bottom Plate over, you will see 3 threaded leg support holes for attaching the Extractor Legs, 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 (Fig. 4) 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. The outflow tube is made of standard 1/8" diameter nylon tubing.

Connecting Hose

The Model No. 3030L60, High Pressure Hose, from the Model 0750G4 Manifold is used for operation of the 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.

Soil Sample Retaining Rings

Fig. 7. Soil Sample Retaining Rings

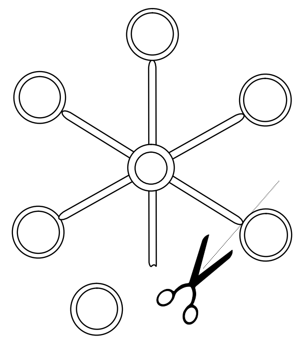

Fig. 8. Cut Rings from spoke

Accessory Model 1093 Soil Sample Retaining Rings (Figs. 7 & 8) 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.

5. REQUIREMENTS PRIOR TO USE

Setup Pressure Supply Source

The Model 1020, 100 Bar Pressure Membrane Extractor was designed for operation in the range from 15 Bars to 100 Bars. The source of this high pressure is compressed nitrogen in tanks provided by your local supplier of compressed gases. Tanks are normally supplied with tank pressures of 2,000 psi. Where the application of the extractor is to remove solutions for chemical analysis, water-pumped nitrogen is desireable to avoid possible chemical disturbances.

Manifold

Accuracy of moisture equilibrium values obtained from soils samples or other porous materials run in the Extractor will be no more accurate than the regulation of gas supplied to the Extractor. For this reason it is very important to have the proper pressure control manifold.

Soilmoisture Equipment Corp. provides the 0750G4 Manifold (Fig. 9) for this purpose.

Designed for operation of the 1020 100 Bar Pressure Membrane Extractor, output pressure can be regulated to 1450 psi (100 bars). Readout pressure test gauge is graduated from 0 to 1450 psi (0 to 100 bars) in 10 psi and 0.5 bar intervals. A flexible, stainless steel high-pressure connecting hose for connection to the1020 Extractor is supplied with the Manifold.

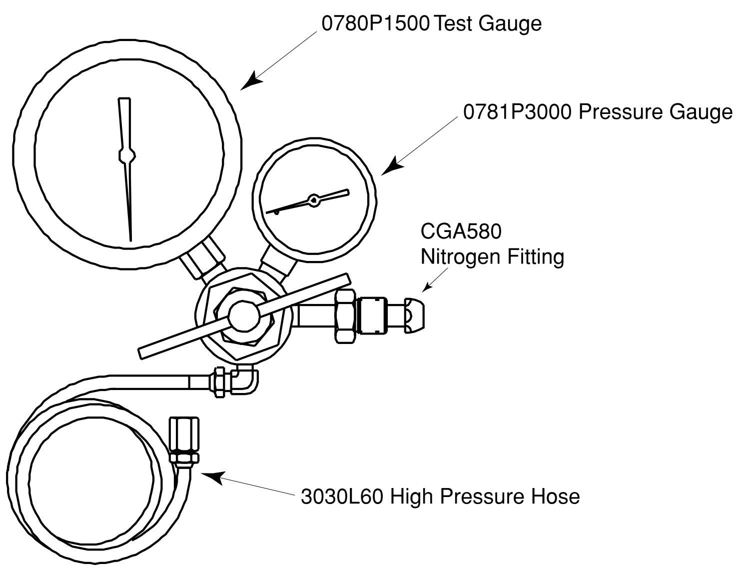

Fig. 9 - 0750G4 Manifold

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Laboratory Setup Using Tank Gas

(1) 1020 100 Bar Pressure Membrane Extractor
(2) 0750G4 Manifold
(3) 3030L60 High Pressure Hose

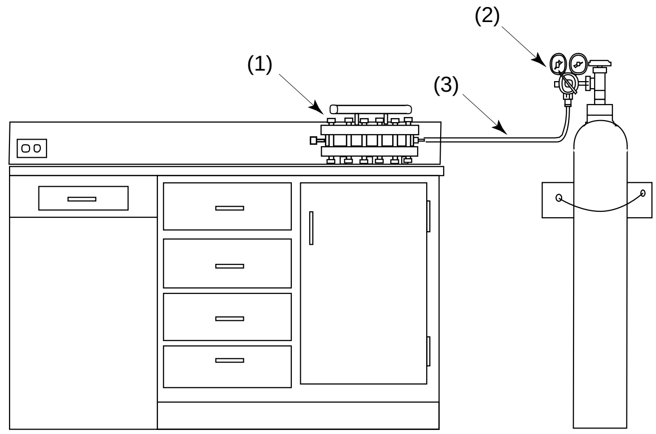


Fig. 10. Laboratory Setup for moisture-retention studies and extraction of soil solution using the Pressure Membrane Extractor with a tank of nitrogen as a pressure source.

Fig. 10 shows the laboratory setup for the 100 Bar Pressure Membrane Extractor provided with regulated air pressure from our 0750G4 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, has a 0767P2000G1 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. 10 is suitable for moisture-retention studies in the 15-100 Bars range of soil suction. This setup is also used when solution is being extracted from soils for chemical analysis, for ultra filtration work, and calibration of electrical moisture measuring devices in the high soil suction range.

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 coarse rock fragments 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. While up to a 3cm height core sample can be used, for use in the Model 1020 Extractor we recommend using the shortest cylinder height (1 cm), as the equilibrium time is a function of the square of the height of the soil core sample.

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 for Testing and Materials Standards (ASTM), Designation D421: “Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants”.

6. HOW TO OPERATE

Operating Range

For moisture equilibrium studies, the 100 Bar Pressure Membrane Extractor is used primarily in the 15 Bar to 100 Bar range (217-1450 psi).

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. Our Model 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 100 Bar Pressure Membrane Extractor can be operated in conformance to designation D3152 of the American Society for Testing and Materials (ASTM), entitled, "Standard Test Method for Capillary-Moisture Relationship for Fine-Textured Soils by Pressure-Membrane Apparatus".

Making A Run For Moisture-Retention Studies With Prepared Soil Samples

Mounting The Cellulose Membrane Disc

Remove 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.

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

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. The Extractor will accommodate 12 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.

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 holesline up. Insert the Clamping Bolts and tighten securely.

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.

Now open the Pressure Regulator slowly and adjust the Regulator to the desired extraction pressure.

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.

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 higher extraction pressures, the diffusion is appropriately larger.

Removal Of Samples

Samples may be removed when the readings on the outflow buret indicate equilibrium has been attained (i.e. hours or days with no change). Some coarse-textured soils will approach hydraulic equilibrium with the Cellulose Membrane in 18 to 20 hours. However, most soils will require 48 hours or more to reach equilibrium.

At the close of a run, 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

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. 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.

7. HELPFUL HINTS IN NORMAL USE

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 Model 0676 Soil Retainer Assembly

The Model 0676 Soil Retainer Assembly, in conjunction with the Model 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.

The 3 cm long cylinder, Model 0206L03, which is a part of both the Model 0676 Soil Retainer Assembly - as well as the Model 0200 Soil Core Sampler - is used to retain the soil cores. These cylinders fit directly into the Model 0200 Soil Core Sampler and receive the cores as the sampler is pushed into the soil. After the sampling operation is completed, remove the Model 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 Model 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 Model 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, you can place a thin layer of silica flour (75 μ) on the surface of the Cellulose Membrane. A good capillary conductivity is also obtained by using the fraction of a loam soil that passes through a 60-mesh screen. The thickness of the layer on the membrane should be approximately 3 mm thick. Then cover this thin layer of soil with a single layer of cheesecloth and moisten carefully (Fig. 11).

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.

In developing moisture-retention curves for values greater than 15 bars, 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 layer on the surface of the Cellulose Membrane. Carefully reapply water to make a good hydraulic contact between

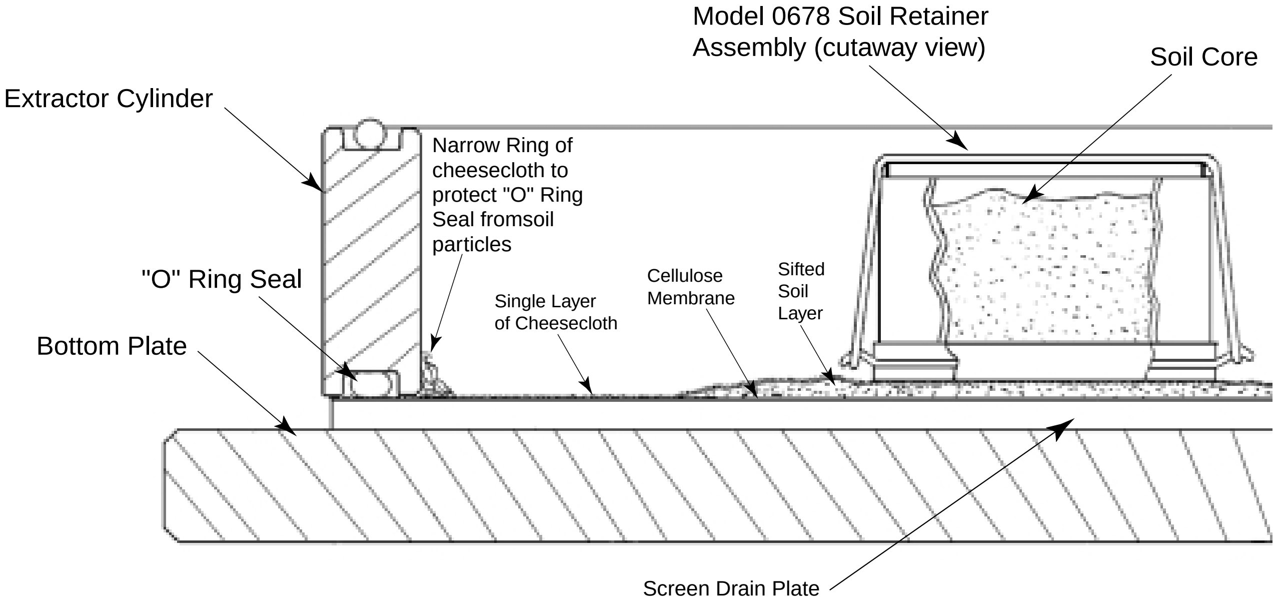


Fig. 11. Section view showing Soil Retainer Assembly mounted in the Pressure Membrane Extractor

the ceramic of the Soil Retainer Assembly and the silica flour/cheese cloth. Once you have assured hydraulic contact, then reseal the Pressure Membrane Extractor as before. 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.

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 Model 0206 Series 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 inside dimension of the Model 0206 Series Cylinders is:

I.D. 2.13 inches (5.40 cm)

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.

Using The Model 1066 High Pressure Electrical Leadthrough To Calibrate Electrical Moisture Measuring Devices

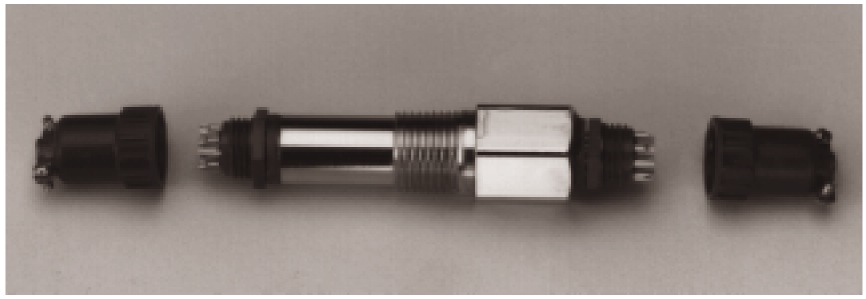


Fig. 12. Model 1066, High Pressure Electrical Leadthrough

The Model 1066 High Pressure Electrical Leadthrough (Fig. 12) is supplied with the male and female connectors plugged into the leadthrough assembly. These connectors must be removed before installation is made in the Extractor.

The cylinder of the Model 1020 100 Bar Pressure Membrane Extractor has a 3/8-inch NPT hole in the side of the cylinder. This is sealed with a 3/8-inch NPT pipe plug which must be unscrewed and removed to provide access for the Electrical Leadthrough.

Coat the threads of the High Pressure Electrical Leadthrough body with a pipe sealant tape or compound. Then screw the unit into the cylinder wall from the outside so that the electrical leads on the Leadthrough body project into the chamber of the Extractor. Take care to screw the body in securely, but without excessive torque that could twist the body of the Leadthrough and cause damage to the internal electrical connections and pressure seal. After the Leadthrough is in place, apply gas pressure to the Extractor and check the seal around the Leadthrough for possible leaks. In general, the High Pressure Electrical Leadthrough body is left permanently in place. The electrical leads project into the Extractor chamber only a short distance and will not interfere with other work that does not require the use of the Electrical Leadthrough. The connectors can now be plugged into either end of the Electrical Leadthrough body to make electrical connection. Nine separate electrical leads are provided. Permanent wires should be soldered to each of the connectors. From the male connector, which plugs into the outside end of the Leadthrough, these wires would terminate on a terminal board for ready access to measuring or recording instruments. Wires from the female connector, which plugs into the inside end of the Leadthrough, ordinarily terminate at alligator clips or other similar devices for convenient connection to the leads of the electrical moisture-measuring blocks or other equipment to be tested. Separate instructions are provided with the Model 1066 High Pressure Electrical Leadthrough giving detailed information on how to make electrical connections to the Leadthrough.

After all electrical connections are made, set or bury the moisture measuring devices, such as Gypsum Blocks, in a layer of soil that is laid on the Cellulose Membrane inside the Extractor. Then saturate the soil layer and measuring devices with water in the same manner as when making a run for moisture-retention studies.

Then close the Extractor and apply air pressure to match the first equilibrium value desired. As moisture flows from the Extractor, the electrical signal from the measuring device will change. At equilibrium the flow of moisture will stop and the electrical signal will reach a stable fixed value corresponding to the soil suction of the soil. Now raise the Pressure in the Extractor to the next higher equilibrium value desired. Repeat the process at increasing values until the complete range of soil moisture values desired are covered and you have a corresponding calibration of the electrical moisture measuring device.

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.

Keep System Leak Free

When 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.

9. GENERAL CARE AND MAINTENANCE

Pressure Vessel

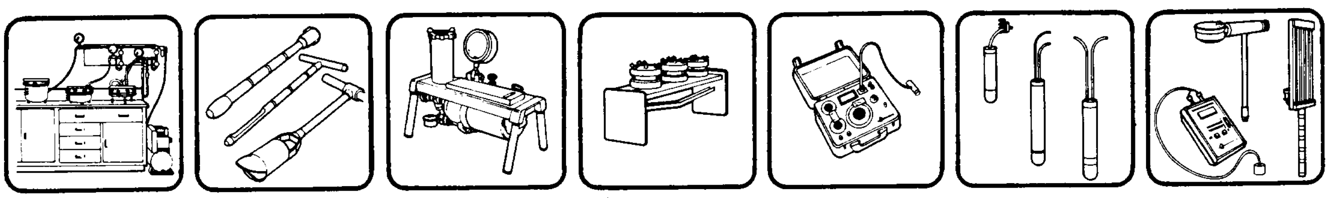
The Extractor parts are ruggedly constructed, carefully plated and coated for maximum corrosion resistance. Little attention should be required except for removing excess moisture and soil particles from the interior surfaces after a run. Replacement Cylinder O-Ring Seals are available for immediate shipment from our stock. As a general practice, use a mild detergent solution to wash the interior/exterior of the Extractor. Rinse well with clear water and hand dry for storage.

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.

10. REPLACEMENT PARTS LIST

Part No.	Description
1021K1	Clamping Bolt Set
1024FCR	Screen Drain Plate
M802X450	O-Ring Cylinder Set



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