Build Your Own Tensiometer

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Materials needed:

Ceramic cups
Vender: SoilMoisture Equipment Corporation, Santa Barbara CA (805-964-3525) Part Number 0655X01-B01M3, Dimensions: 0.875-inch OD x 2.75-inch length.

Fig. 1. Ceramic Cup

Vacuum gauge
Vender: Zoro.com/Grainger.com Part Number 4FMK3, Description: ¼ inch MNPT 2-inch diameter test vacuum gauge.

Fig. 2. Vacuum Gauge

#1 size rubber stopper
Vender: Grainger.com Part Number 8DWU6, model RST1-S, Description: 24 mm neck, bottom diam. = 14 mm. Top diam. = 20 mm.

Schedule 40 PVC pipe (½ inch diameter)

PVC "T" with ½ inch to ¼ inch reducer

PVC glue (gray) and purple primer

Gas pipe thread sealant (white or blue paste type)

Painter's masking tape

Petroleum Jelly (Vasoline)

Fig. 3. PVC "T"

Tools needed:

- PVC saw or PVC cutting tool
- Aluminum Oxide grinding stone, Manufacturer: Forney Part Number: A11 60028 Description: 7/8 in [23 mm] diam. x 2 inch [50.8mm] length
- Power handheld drill
- Miter box
- Pocket knife

Procedures

1. Cut PVC pipe sections in the following lengths

- 1-foot depth tensiometer: top shaft = 4 inches, bottom shaft = 17 inches
- 2-foot depth tensiometer: top shaft = 4 inches, bottom shaft = 30 inches

Tip: cut the bottom shaft about 1-inch longer than indicated above and then carefully cut the lower end of the shaft using the miter box or electric miter saw to assure that the PVC is cut at a 90-degree angle. The ceramic cup will fit crooked on the end of the shaft if the cut deviates from 90 degrees.

Fig. 4. Glue PVC

2. First, glue the top shaft and then the bottom shaft to the ½ PVC "T" using the PVC glue. Make sure that you do not glue the end of the bottom shaft that was trimmed to 90 degrees. Next, in a well-ventilated location, apply PVC primer to both the end of the shaft and the inside of the "slip" end of the "T". Then apply PVC glue to both sides, push the parts together, and hold in place for about 30 seconds to 1 minute.


Fig. 5. Bevel End

3. Slightly bevel the inside of the lower end of the bottom shaft using the handheld drill and grinding stone (Fig. 5). Alternatively, one can use a knife to bevel the end. Whether using a drill or a knife to bevel the inside of the pipe, stop periodically and test-fit the ceramic cup. This way, you will not remove too much material, and will quickly get a feel for the appropriate amount to remove.


Fig. 6. Tape ends before gluing

4. Use high strength epoxy to glue the ceramic cup to the lower end of the bottom PVC shaft. Protect the ceramic cup during the gluing process by covering the outside with painter's tape (Fig. 6). Check that the ceramic cup fits snuggly into the PVC tube and is aligned straight. If using the epoxy from SoilMoisture equipment epoxy, mix up 1-part epoxy with 1-part hardener. Mix thoroughly. Only a tiny amount of epoxy is needed to coat the throat of the ceramic cup and the inside of the PVC tube. It may be best to glue several tensiometers simultaneously so that the epoxy is not wasted. One can usually glue no more than 20 to 40 cups at a time because the epoxy begins to cure after an hour. Approximately 20 ml of epoxy is needed for 20 tensiometers. The cure time is temperature-dependent. The total cure time takes 8 hours at 77 °F. Therefore, it is best to allow more time for curing. After gluing, painter's tape can be used to secure the cup to the shaft. Take care when attaching the two with the tape to ensure that the cup is aligned with the PVC shaft. Let the glue set for at least 24 hours with the tensiometer supported with the cup-end up in a vertical position.

5. Coat the ¼ inch male thread of the gauge with pipe thread sealant and hand screw on the vacuum gauge.

6. Fill the tensiometer fully with degassed distilled water. The water can be degassed by boiling it and allowing it to cool.

7. Coat the lower end of the rubber stopper with a thin film of petroleum jelly and insert it into the top end of the tensiometer with a light twist to firmly seat the stopper.

Testing the tensiometer for air (vacuum) leaks:

After filling the tensiometer with water and sealing it with a rubber stopper, wrap a dry paper towel on the end of the ceramic cup and hold it tightly. If the tensiometer is filled with degassed water, the tension should quickly increase to about 20 to 30 kPa as the towel absorbs water from the cup. If the gauge does not increase above 0, air is likely leaking into the tensiometer. Check the glue joints and assure that the stopper is tightly in place.
If the tension quickly increases to more than 20 kPa, then leave the tensiometer out in the sun to assure that the tension rises to above 70 to 80 kPa. This may take some time, minutes to hours, depending on the ambient temperature. If the tension does not increase to a high value, then check glue joints and the stopper. Also check that the gauge is securely threaded into the PVC "T."

Installing tensiometers in the field:

Proper installation of a tensiometer in the field will achieve close contact between the ceramic cup and surrounding soil. Using a soil probe with a ½ inch diameter shaft, make a pilot hole to a depth a few inches shallower that the depth of installation. Make a soil water slurry by thoroughly mixing soil with the water to a pancake batter-like consistency. Add some slurry into the hole and push the tensiometer to the desired depth. The soil slurry assures that water can freely move between the ceramic cup and the surrounding soil and fills the voids between the hole and tensiometer shaft. Formation of air gaps between the ceramic cup and the soil will lessen the accuracy of tensiometer readings. After two days of equilibration, the tensiometer reading should accurately reflect the tension of the soil.

Reference:
Cahn, M. Do it Yourself (DIY) Tensiometer. UC Davis. 2019.
https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=30042. Accessed May 2021.