TEXAM^{e} PRESSUREMETER

INSTRUCTION MANUAL

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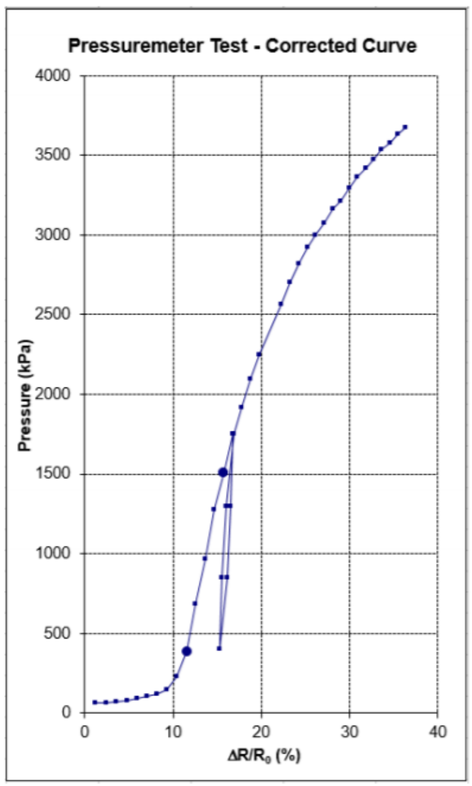
1 DEFINITION AND PURPOSE OF TEST

The pressuremeter test is a load test carried out in-situ in a borehole. An inflatable cylindrical probe is set at testing depth in a pre-drilled borehole within a soil or rock mass or by direct driving into the mass. The method depends on the materials' characteristics. The pressuremeter uses a hydraulic control unit to load and to monitor the tested material's response. The data collected defines the stress-strain (or volume/pressure) relationship of soil and rock with depth. The pressuremeter test data is used to determine the pressuremeter modulus and limit pressure. The pressuremeter modulus is used to evaluate settlements for specific foundation designs. The limit pressure is used to calculate the bearing capacity.

The probe is set at the test depth using the method that will produce the least disturbance to the test material with the tightest hole possible. Once in place, the probe is submitted to equal increments of increasing volume or pressure, and the pressure-volume data is plotted.

The graph below shows a typical curve obtained from a pressuremeter test.



The curve can be divided into three parts. The first portion of the curve corresponds to the probe seating against the borehole wall. The wall disturbance, induced by drilling or driving the probe into place, has considerable influence on this segment of the curve. The difference in borehole and probe diameters also affects this segment. The second segment represents the pseudo-elastic behavior of the tested material. The probe is in contact with the borehole walls. This segment is rather linear and defines the deformation modulus of the tested material. In the last segment, the loaded mass enters a plastic state during which deformation accelerates towards complete failure point i.e. the limit pressure.

2 EQUIPMENT DESCRIPTION

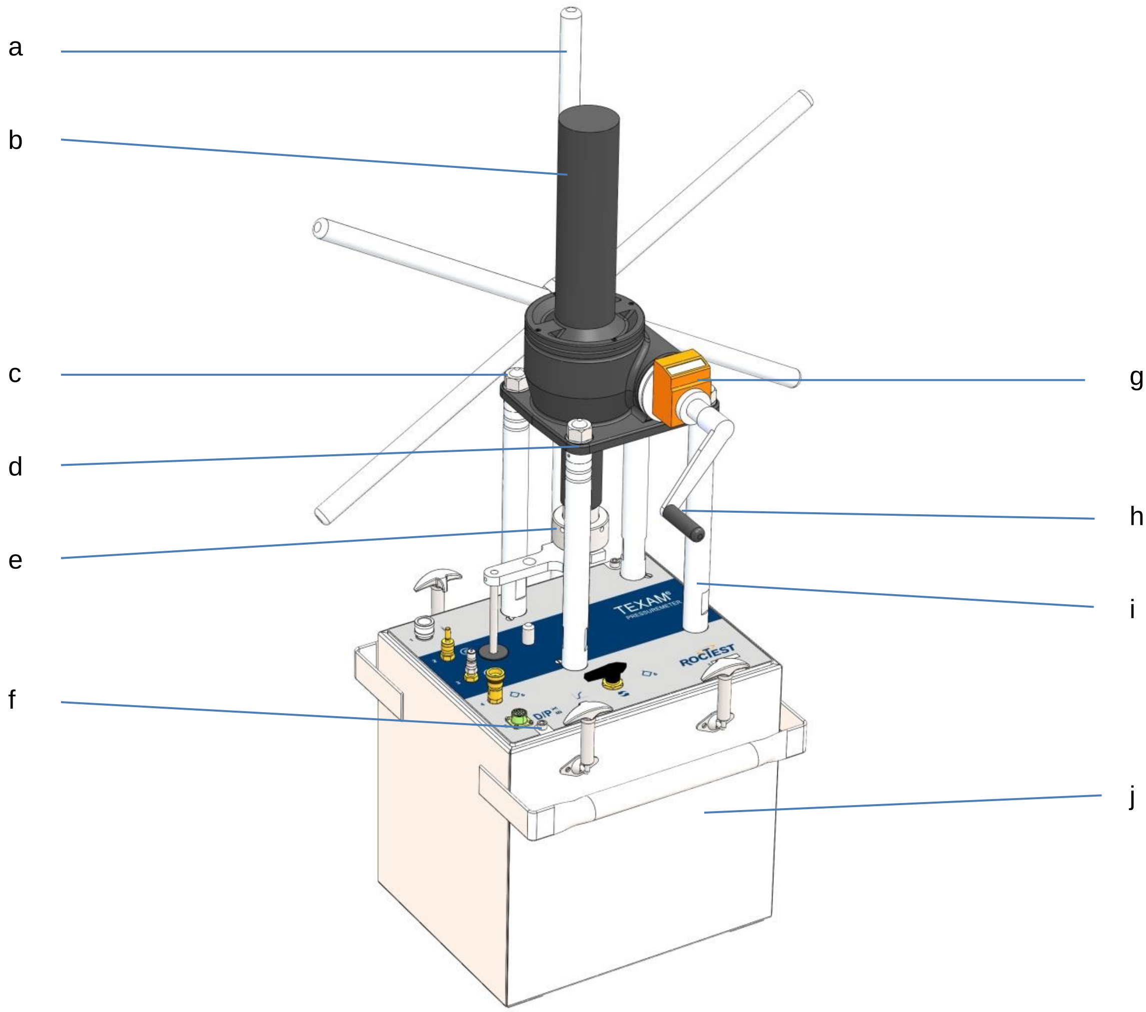
The TEXAM^{e} pressuremeter utilizes a monocell hydraulically inflated probe. A mechanical actuator is used to displace a piston which travels within a cylinder filled with the inflation fluid. The TEXAM^{e} is comprised of:

a) A control unit, which contains a cylinder, a piston, connectors, sensors, and a valve.
b) An actuator – mechanical jack -, its four support columns and two crank handles
c) An optional volume counter. The white numbers are cubic centimeter, the yellow numbers are 0.1 cc (cubic centimeter or cm^3) and the yellow marks are 0.01 cc.
d) One optional high precision digital gauge mounted on a quick coupler and vent valve assembly.
e) A 70/74-mm diameter probe or a 44-mm probe for use in a slotted casing. The probe consists of a cylindrical metallic body covered with an inflatable rubber sheath protected or not with metallic strips.
f) The high pressure black tubing, also called Tecalan
g) A steel pipe for calibrating the probe – not included.
h) One Readout Box for Pressure and Volume reading

The TEXAM^{e} design complies with the ASTM-4719 standard.

MAIN SPECIFICATIONS	
Working capacity	10 000 kPa
Modulus range	1 to 2000 MPa approx.
Volume Resolution	0.01 cm^3
Volume capacity	1 732 cm^3
Pressure resolution	1 kPa
Test Mode	Strain or stress controlled

UNITS
Pressure : 100 kPa = 1 kg/cm^2 = 1 bar and approximately 1 tsf, 2000 psf, and 15 psi
Length : 1 cm = 0.3937 inch



TEXAM Control Unit

a	Large handle
b	Screw jack (actuator)
c	Hexagonal Nut (4)
d	Washer (4)
e	Piston's shaft – screw adapter
f	8-32 Flat Head Screw (4)
g	Volume Counter (optional)
h	Handle
i	Support Column (4)
j	Control Box

Please see the appendix for additional components descriptions.

3 EQUIPMENT ASSEMBLY

1. The control unit comes in two separate boxes, one containing the actuator and the other containing the cylinder, piston and front plate. Remove the cover from the control unit case.
2. Screw in the 4 actuator support columns (i). The knurled portion of the columns points downward and the columns are hand tightened.
3. Remove the threaded PVC protective caps from the piston shaft and from the knurled nut (e)
4. Install the mechanical actuator (b) on its support columns. Make sure that the 4 washers (d) have been removed from the columns. Position the actuator so that the crank shaft is to the right of the control unit and perpendicular to the case handles. Put the 4 washers (d) and 4 nuts (c) in place. <u>Do not tighten the nuts yet.</u>
5. Connect the DP Box to port number 5. Make sure volume and pressure transducers read properly. Refer to section below on how to use the DP Box. Note that volume readings obtained from the electrical sensor must prevail over the one displayed by the mechanical volume counter. See section 13 for more details.
6. Place the small crank handle (h) on the crank shaft of the actuator. Turn the handle counter clockwise to bring the actuator screw in contact with the piston shaft. Couple the actuator screw with the piston shaft by threading the knurled nut (e) onto the male thread of the piston shaft. <u>Hand tighten the knurled nut</u>. <u>The volume should read close to 0 cc.</u>
7. Tighten the nuts (c) with a wrench.
8. If available, connect the optional digital gauge kit on the port number 3 and turn it on. Read the gauge operating procedures at the end of this manual to adjust the desired engineering units to perform the test – we recommend in kPa. Open the valve mounted on the assembly to vent the gauge, reset the zero, and then close the vent valve.

4 USING THE DP BOX

4.1 DESCRIPTION

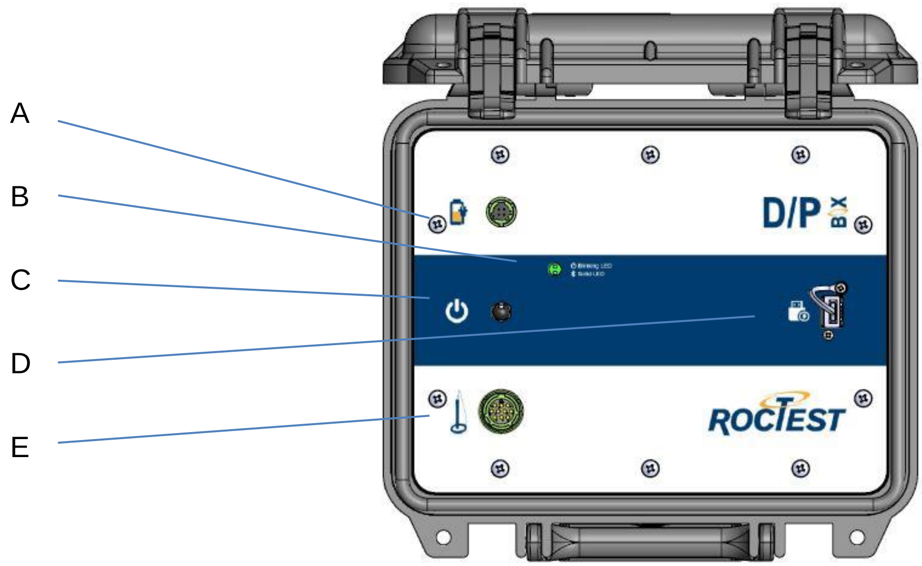
DP BOX communicating with a tablet by Bluetooth

The DP BOX is designed for reading and logging measurements obtained from pressuremeters and dilatometers manufactured by Roctest (including models DMP 95, TEXAM^{E} and PROBEX). Thanks to the Bluetooth communication feature and to the DP Box READER Application, the DP Box can be used in conjunction with a Tablet for reading the sensors, for configuring a calibration or a testing session, for visualizing and logging the test results in real time, and for reviewing any test data. These test data can be uploaded to a laptop via USB communication. The DP Box comes in a convenient water proof enclosure and is fitted with two 12-V rechargeable batteries providing over 8 hours of autonomy in normal conditions. The DP Box also comes with cable universal AC wall plug with US/Euro adapter + adapter cable for car (lighter) and for external battery. The battery can be charged every night. A charging circuit inside the readout limits charge time to a certain level.

The front panel is splash proof allowing the use the equipment in wet conditions. However, do not let the readout with the cover lifted up under the rain over extended period of time, otherwise water could get into the unit.

The DP Box is compatible with Android-based tablet model.

<u>**See DP Box specific instruction manual for more details**.</u>



DP BOX Front Panel

A	4-pin Cannon connector for charging the DP Box batteries
B	LED indicating communication status: blinking slowly when the Bluetooth radio waits for a connection, then glowing faster when the connection is established.
C	Switch for turning ON / OFF the unit
D	USB port for charging the Tablet (if necessary)
E	10-pin connector for connecting the dilatometer / pressuremeter

4.2 INSTALLING THE DP BOX READER APPS

Prior from using the DP Box, the DP Box READER Application should be installed on a Tablet. This application can be downloaded from Roctest web site.

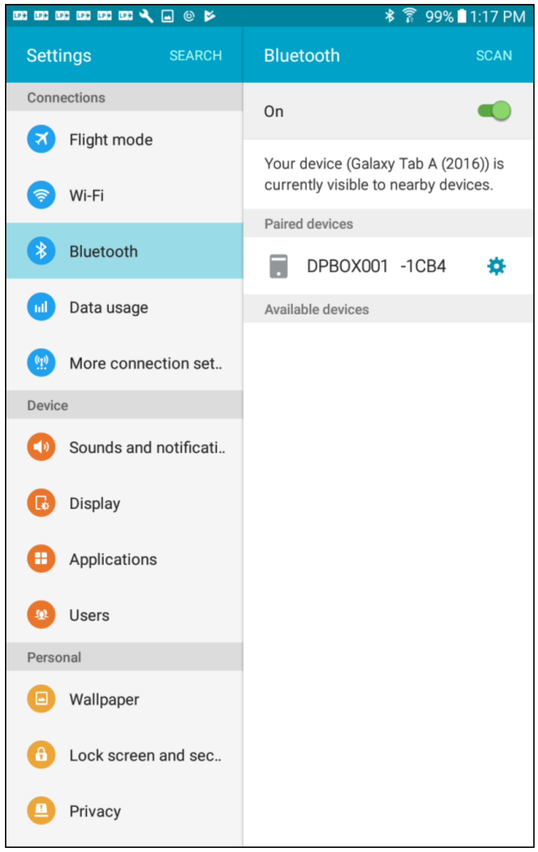
4.3 CONNECTING AND TURNING ON THE DP BOX

Connect the electrical cable of the testing equipment to the DP Box.

Turn on the DP Box. The LED on the front panel will then blink. Turn on the Tablet. Go in the Tablet Setup and make sure that the DP Box is available and paired with the Tablet.

Set up the Tablet as follows:

- Adjust the Display in ‘Outdoor Mode’ if necessary. But note that this will reduce the Tablet autonomy.
- Adjust the screen timeout (typically 5 min)
- Make sure Tablet is adjusted for dot-delimited numbers
- Make sure the battery voltage of the tablet is high enough for use.



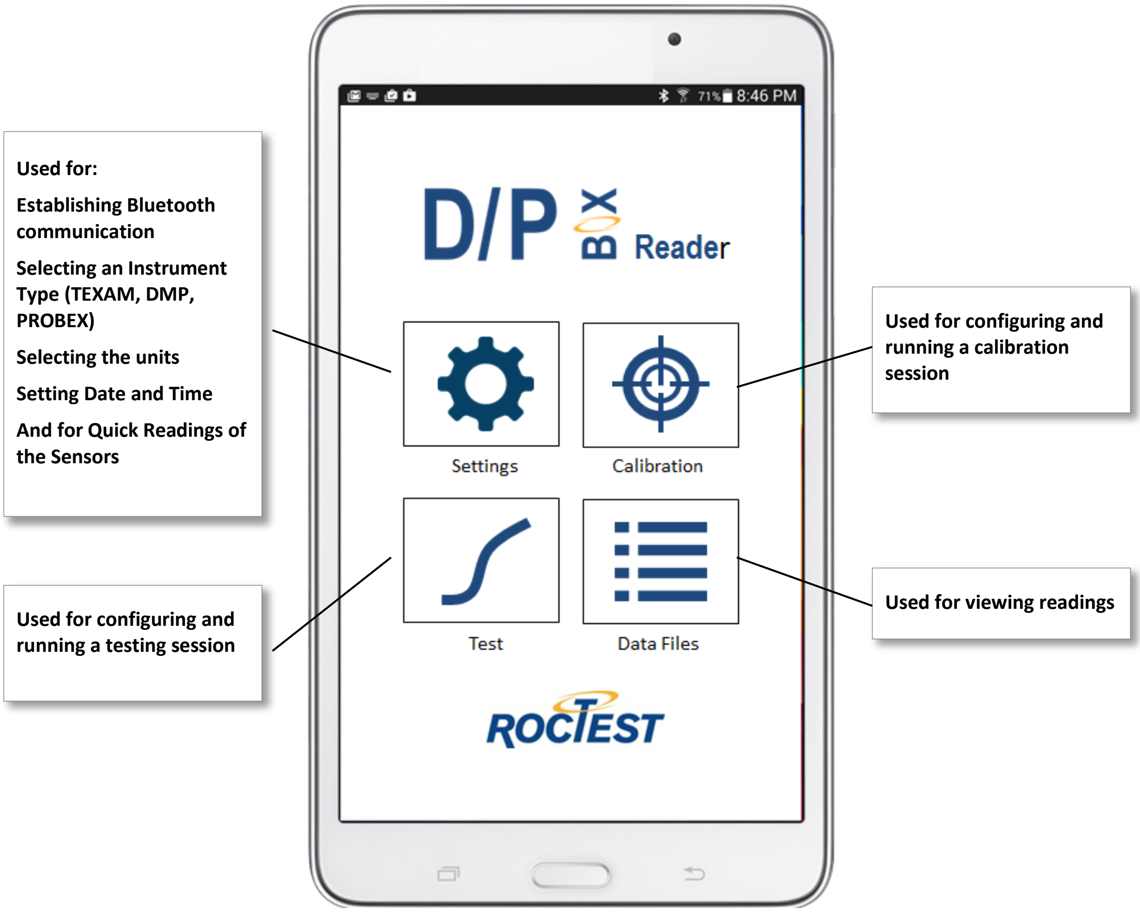
Open the DP Box Application and go in ‘Settings / Quick Reading’ for establishing Bluetooth communication between the DP Box and the Tablet, which will be confirmed when the DP box LED will blink quicker (see below for more information).

4.4 USING THE DP BOX READER APPS

The DP Box Application allows configuring the unit, to read and to log the data, and to review the results.

4.4.1 MAIN MENU

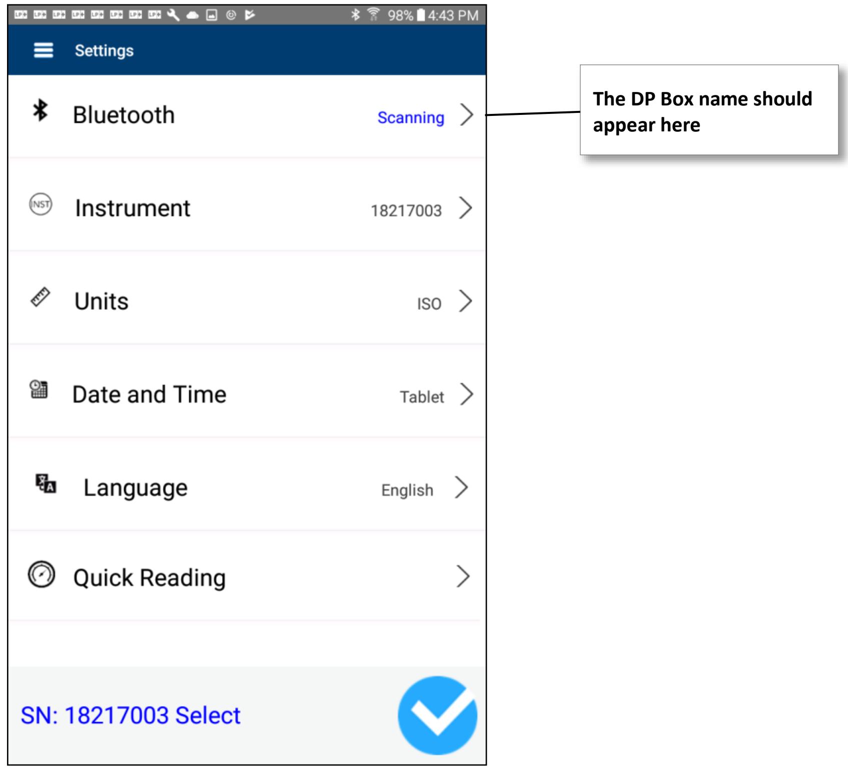
Main menu of the applications includes the following elements:



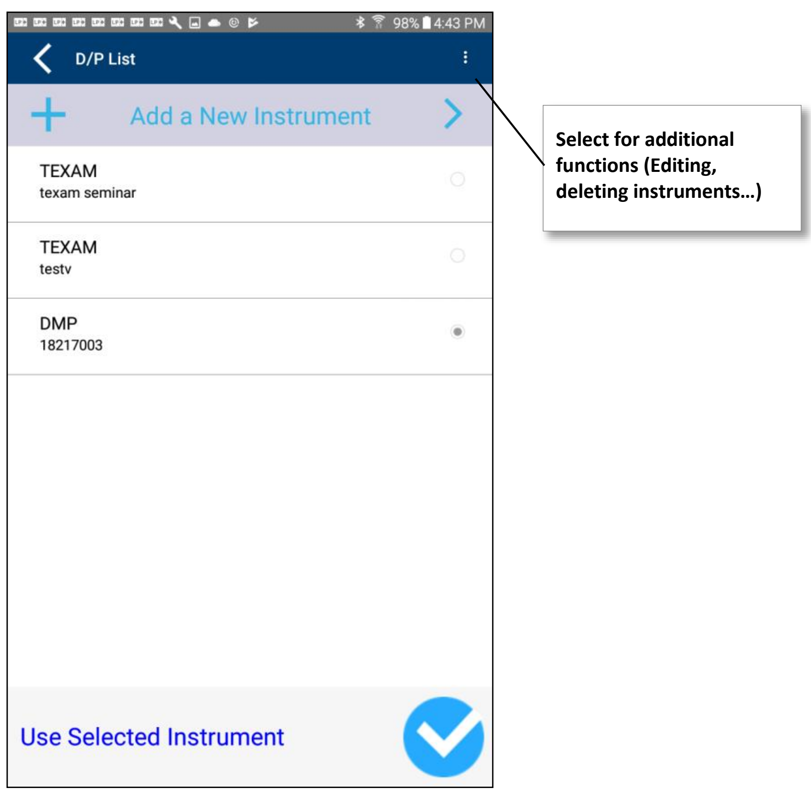
DP Box Application Main Menu

4.4.2 USING THE DP BOX READER APPS WITH THE TEXAM[E]

First Go to 'Settings'. The APPS will automatically scan for establishing Bluetooth communication with the DP BOX which takes a few seconds. The name of the DP Box will then replace the 'Scanning' inscription.



Go to 'Instrument / Add a New Instrument' and Select the 'Type of instrument' (TEXAM) and enter the serial number appearing on the control unit (e.g. 001A17003).



Make sure the conversion factors associated to this instrument have been entered. Refer to the calibration certificate. For changing these, select 'Calibration / Cal. Type / Review Factory Calibration' and select 'Change factory calibration', make the appropriate changes and select 'Save new factory calibration' at the bottom of the screen.

Set the units (typically ISO), then set the date and time of the Tablet if necessary.

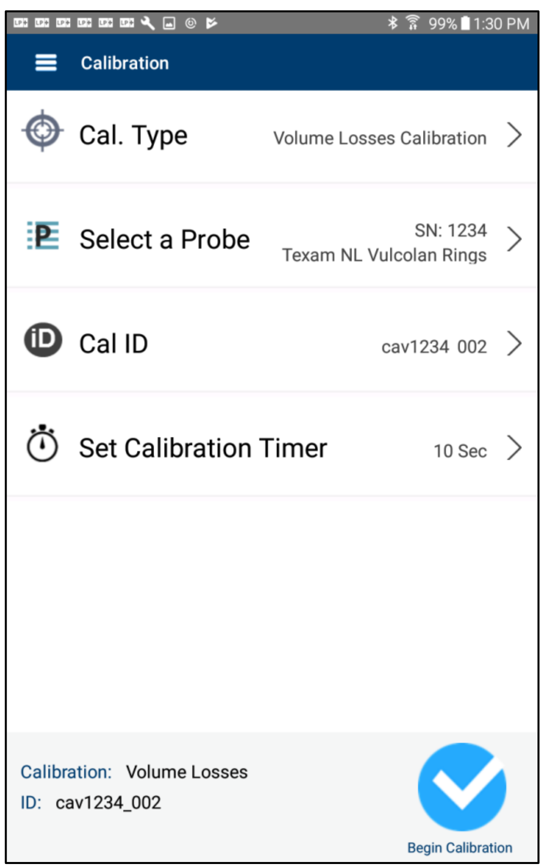
Go in 'Quick Readings' and press the green icon for reading the sensors.

Two types of calibrations can be done, one with the probe unconfined ('Pressure Loss Calibration') and one with the probe confined ('Volume Loss Calibration'). See next section for more details.

For configuring a calibration, go to 'Calibration' and :

- Select the type of calibration
- Select a probe (by giving a serial number – generally indicated on the probe itself – and by selecting 'Texam NL Vulcolan rings, NL steel rings A probe or slotted casing' probe)
- Dive a calibration ID
- Set the calibration timer

For configuring a test, go to 'Test' and proceed the same way.



Typical set up:

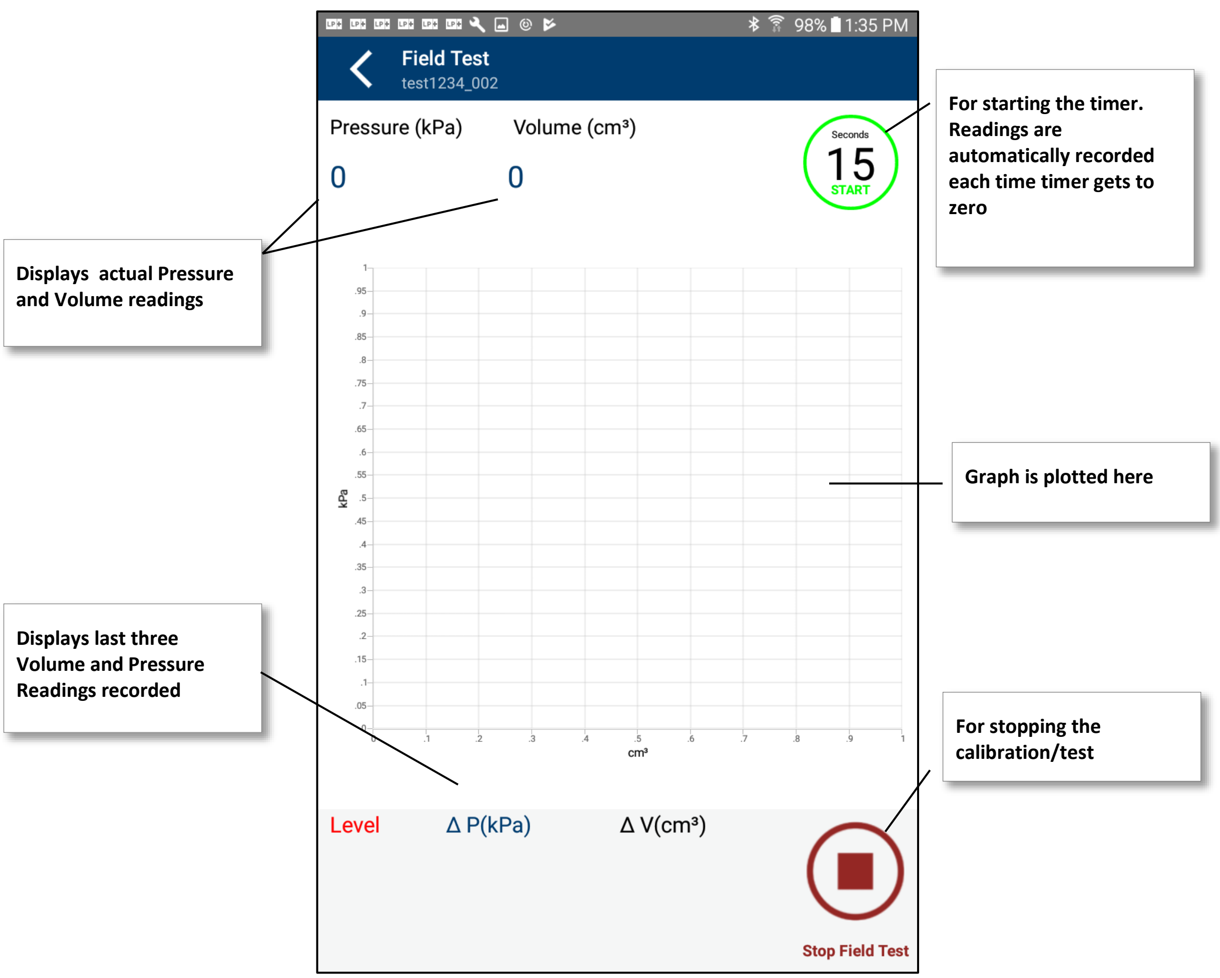
	ID [1]	Timer Typical (sec)
Pressure loss calibration	*'CAP*+Date'	30
Volume loss calibration	*'CAV*+Date'	60
Test	*'TE*+Date'	15

[1] *The Apps will automatically increment selected ID*

Once setup is completed, select: 'Begin Calibration or Test' to start.

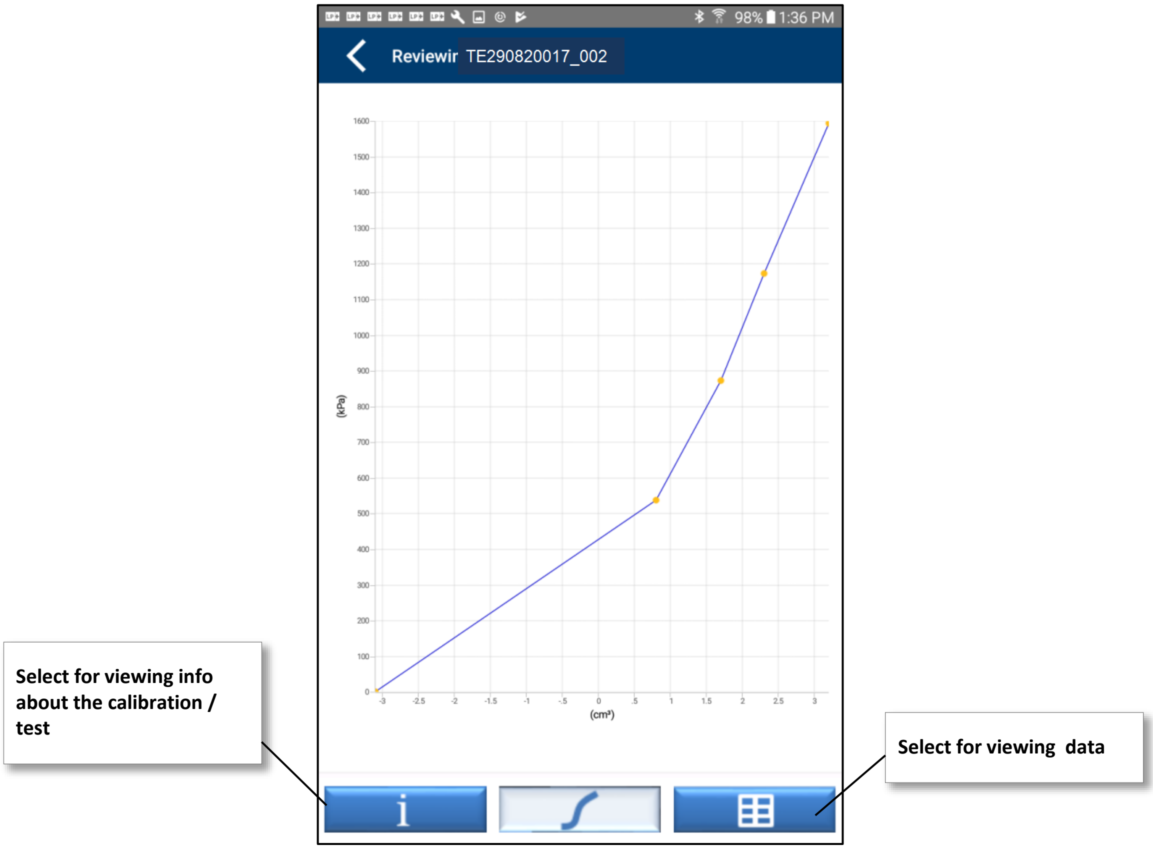
Once calibration or testing is started, a window like the one below will be displayed.

After saving the initial readings, the operator should press 'Start' for starting the timer. Readings will be recorded when timer gets to 0 second. Then the operator can increase the volume or pressure to the first step and then press 'Start' for starting the timer, and so on until completing the test.



When the calibration or test is over, press on : 

For reviewing results, go to ‘Data Files’, the select ‘Calibration’ or ‘Field Test’. Then select the specific file you want to see.

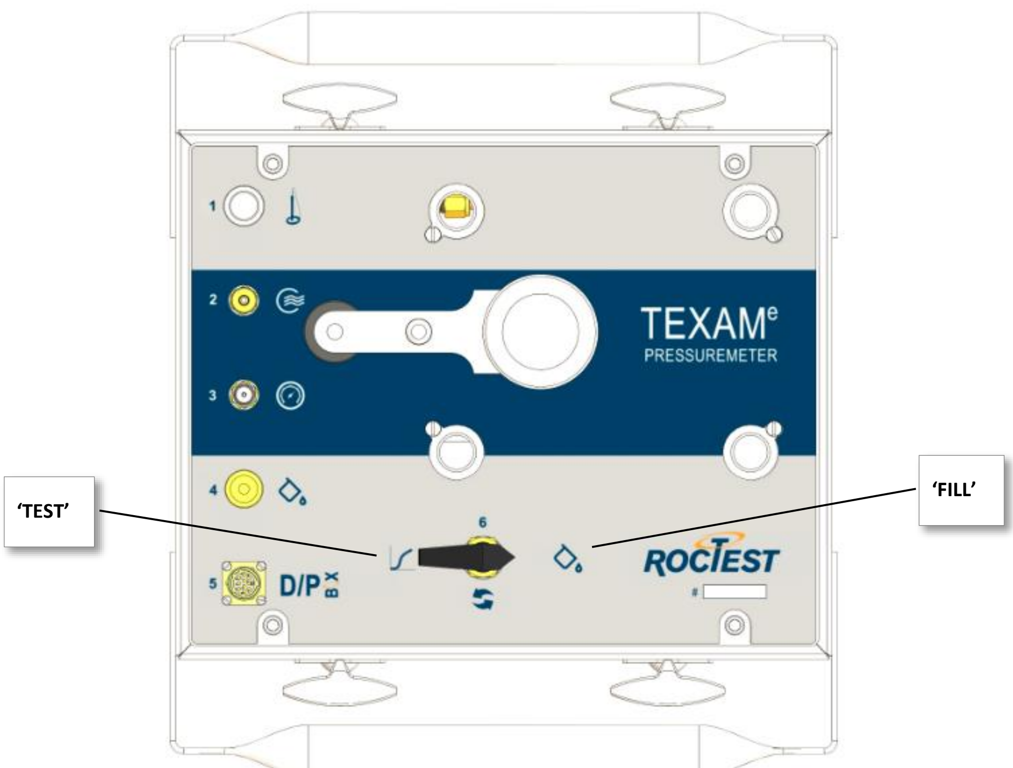


5 SATURATING THE EQUIPMENT

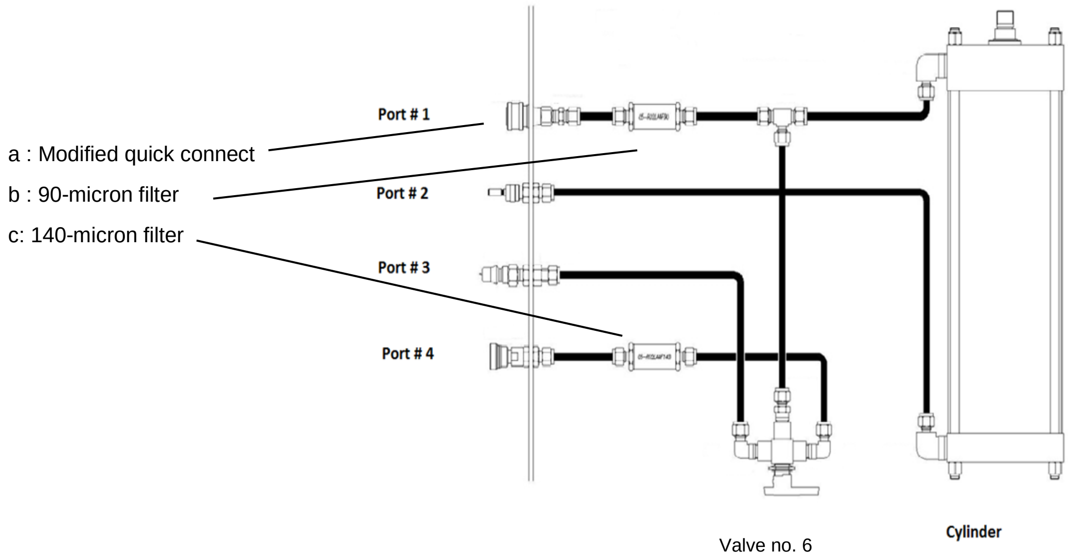
5.1 SATURATING THE CONTROL BOX CYLINDER

1. Connect the short length of flexible tubing to the "Fill" quick connect port No. 4. Push on the connector until you hear a ‘click’.
2. Place the free ends of the saturation tubings in a small container – we suggest a 1 gallon plastic bottle - of clean water or antifreeze solution. It is imperative to maintain the ends of the tubings submerged during the saturation. Otherwise, air will enter the TEXAM^e. You may tape the tubings to the bottle for ensuring that.
3. Set valve No. 6 on "FILL".
4. Turn the small crank handle clockwise to bring the cylinder piston to its uppermost position corresponding to about 1732 cc on the counter. The uppermost position is reached when resistance is felt when cranking. <u>Stop cranking then for not damaging the equipment.</u> While the piston is rising, the air in the cylinder is coming out from the tubing connected to the port No. 4. Bubbles should be observed in the bottle.

5. Lower the piston by turning the crank handle counter-clockwise at a rate of approximately 1 rotation per second. While the piston is lowering, water is pumped inside the cylinder via the tubing connected to the port No. 4.
6. When the piston has traveled to its lowermost position corresponding to 0 cc, stop the cranking operation and wait a few seconds for the suction to stop, as indicated by a 0-kPa reading.
7. Set valve No. 6 on "TEST".
8. Connect the short length of flexible tubing to the "Probe" quick connect port No. 1
9. Incline about 45 degrees the control unit toward yourself when facing the control unit. Turn the crank about 20 revolutions (240 cc) clockwise to expel any air that may have accumulated at the top of the cylinder. During this operation, watch closely to see that all entrapped air is evacuated and only bubble free water is flowing into the bottle by the tubing connected on the port No. 1.
10. Return the instrument to the vertical and disconnect tubing from the port No. 1.
11. Connect the hose to port No. 3.
12. Turn the crank until water comes out from the short tubing to expel the air trapped in the gauge line. Disconnect the hose from port no. 3.
13. When using the optional digital gauge kit, proceed the same way. But make sure to open the valve mounted on the pressure gauge assembly before cranking and to close it after cranking.
14. Set valve No. 6 on "FILL".
15. Bring the piston to 0 cc, by turning the crank handle counter clockwise. When fully lowered, wait a few seconds and perform the saturation check.



TEXAM Facia



Hydraulic Circuit Schematic Diagram

5.2 SATURATION CHECK

1. Set valve No. 6 on "TEST".
2. The volume and pressure should indicate around zero.
3. Install the large crank handle (a) on the rear side of the actuator and pressurize the unit up to 2,500 kPa by rotating the large crank handle clockwise. Read the volume. **If the volume indicated on the readout is more than <u>15 cc</u>, the instrument is not completely saturated** and the saturation procedure described in steps 5.1.7 to 5.1.14 must be repeated.

   <u>The instrument is completely saturated when the volume indicates less than 15 cc at 2,500 kPa</u>. Having determined that the instrument is completely saturated, rotate the large crank handle until the pressure reaches 10,000 kPa. <u>The pressure should stabilize after 2 minutes between 10,000 kPa and 9,500 kPa if there is no leak in the system.</u>

   Bring the pressure back to 0 kPa by returning the piston to its lowermost position.

5.3 SATURATING THE TUBING PROBE ASSEMBLY

1. Connect the extremity of the Tecalan tubing fitted with the quick connect to port No. 1. Thread the other end of the tubing through the probe to rod adaptor and connect it to the probe. Tighten the nut using two wrenches. <u>Do not over tighten: the brass nut is fragile and may crack.</u> Lay down the probe next to the control box.
2. Remove the plug located at the lower extremity of the probe. Hold the probe bottom end up slightly inclined and with the saturation outlet in the 12 o'clock position.
3. With the valve No. 6 on "TEST", inject water into the probe by rotating the crank handle clockwise until bubble free water only is flowing out of the saturation outlet of the probe. Stop turning the crank handle. Put the plug in place and tighten.

4. Inject 100 cc of fluid in the probe.
5. Disconnect the Tecalan tubing from port No. 1. Refill the cylinder by placing valve No. 6 on "FILL" and returning the piston to its lowermost position. Wait a few seconds.
6. Repeat step 5.2. 1-3 as a final check on the saturation of the unit.
7. Disconnect the tubing from port No. 4.
8. The instrument is ready to be calibrated. The instrument, probe and tubing can be saturated in advance and transported to the site ready for testing.

6 CALIBRATION

6.1 CALIBRATION FOR PRESSURE CORRECTION

This calibration must be done each time a new sheath is put on the probe. It allows to measure sheath resistance. Typically it ranges from 30 to 100 kPa at 1600 cc for an N-size probe.

1. The probe is placed at ground level and is unconfined.
2. Connect the Tecalan tubing to port No. 1.
3. Place valve No. 6 on "TEST".
4. Rotate the small crank handle clockwise at a rate of 1 revolution every 2 seconds, until 80 cc have been injected (long 70/74 mm probe) or 40 cc (44 mm probe).
5. Stop the injection, wait 30 seconds and record the pressure and the volume.
6. Continue this procedure until 1440 cc are injected for 70/74 mm probe or 720 cc for 44 mm probe. If it is intended to inject more liquid into the probe during the test, inject 1600 cc (70/74 mm probe) or 800 cc (44 mm probe).
7. Slowly rotate the crank handle counter clockwise to return the piston to its initial position.
8. Check the curve of injected volume versus pressure.

Warning: <u>Deflation of the probe must always be done slowly</u> (less than 1 revolution every 2 seconds) to prevent air infiltration in the pressuremeter. <u>Negative pressure should not go under - 50 kPa. Once in a while, stop cranking and wait for the pressure to come back close to 0 kPa before resuming cranking.</u>

6.2 CALIBRATION FOR VOLUME CORRECTION

This calibration must be done each time after assembling a membrane and saturating the system. <u>It is suggested to repeat this calibration every day of use of the pressuremeter to ensure that 1) there is no leak, 2) that air did not infiltrate the pressuremeter, and 3) that system expansion has not changed significantly.</u> This procedure allows determining the system expansion in order to calculate the net cavity volume change. The system expansion comes from tubing expansion, membrane squeezing and from the compression of the small quantity of air in the fluid. Typically it ranges from 0.006 to 0.016 cm^3 / kPa, depending on the Tecalan's length.

When a test with a special loading sequence is performed (cyclic test, creep consolidation test, stress level influence test…), it is suggested to perform a special calibration by following a similar loading sequence.

1. Connect the Tecalan tubing to port No. 1.
2. Place valve No. 6 on "TEST".
3. Place the probe inside a rigid steel pipe: NW or AW drill casing or equivalent for the 70/74 and 44 mm diameter probes respectively.
4. Rotating the crank handle clockwise until reaching 500 kPa. Start chronometer. Maintain pressure around 500 kPa by slightly rotating crank handle if necessary. Stop cranking at least 5 seconds prior to recording readings. Record volume and pressure after 60 seconds.
5. Install the large crank handle.
6. Increase pressure by another 500-kPa step and take readings after 60 seconds as described above. Repeat this procedure to 6,000 kPa.
7. When tests in very hard material are to be done – where it is expected to exceed 6,000 kPa during the test - follow the same calibration procedure but using 1,000 kPa pressure steps up to 10,000 kPa.
8. After reaching the highest pressure level, reduce pressure by half, take a reading after the stabilization period, go back to the highest pressure and take a last reading. This unload-reload cycle will be used for correcting an unload-reload cycle(s) performed during a test - if any.
9. Return the piston to its lowermost position to decrease the pressure and volume close to 0.

Warning: Deflation of the probe must be done slowly – see warning above.

7 TEST EXECUTION

7.1 MAKING OF THE BOREHOLE

The preparation of a quality borehole is essential for obtaining a satisfactory test. The two most important things are 1) to make a borehole with a proper diameter (between 1.03 and 1.15 x diameter of the probe); 2) to cause the least disturbance possible to the borehole wall. Various methods can be used depending on the type of soil and available equipment. Rotary drilling with axial injection of prepared mud is the most versatile method and is recommended for most cases. Methods using injection of fluids are especially suited for the TEXAM since this pressuremeter requires fluid in the borehole.

7.2 DE-AIRING THE UNIT

Proceed to this procedure prior to all tests / calibrations on site.

1. Disconnect the tecalan from the unit when applicable.
2. Make sure that the temperature of the unit has stabilized
3. Connect the saturation hoses to ports No. 1 & 4 and place their free-ends in the bottle filled with fluid.
4. Put the valve 6 on ‘FILL’
5. Incline the unit about 45 degrees towards you, then crank clockwise 10 revolutions (120 cc) to expel the air that may be trapped in the unit and hose.
6. Return the unit to the vertical, then bring the piston to 0 cc.
7. Repeat these two last steps until only bubble-free fluid is flowing into the bottle.
8. Wait a few seconds, disconnect the saturation hoses, and perform a saturation check as per 5.2.1 to 5.2.3.

9. **Initial readings**. Connect the Tecalan-probe assembly to the control box, put the valve 6 on 'TEST'. Make sure that the probe is at the same elevation then the pressure gauge of the pressuremeter and write down the initial Pressure and Volume readings.

Make sure that the borehole is filled with fluid, then lower the probe in place.

7.3 STRAIN CONTROLLED TEST

The strain controlled test is the recommended method for general applications.

1. With the probe set at the test depth, the pressuremeter test can begin. The test is carried out in 40 steps of equal volume increments. The volume increments are about 40 cc for the long 70/74-mm diameter probe and about 20 cc for the 44 mm diameter probe. Rotate the crank handle clockwise at a uniform rate of about 1 rotation per 4 seconds to inject water, stopping to record the pressure 15 seconds after each step of volume. The maximum volume injected is 1600 cc for long 70/74-mm probe and 800 cc for 44 mm probe; this is equivalent to 40 increments.
2. Stop the test : a) when a sufficient number of data have been collected for the intended purpose of the tests, typically for determining the limit pressure with a satisfactory accuracy (<u>typically between 1000 to 1200 cc for an NL probe</u>) ; b) or when risk of bursting the probe is high – see chart at the end of this manual.
3. It is possible and suggested to carry on an <u>unload-reload cycle</u> in the pseudo-elastic zone i.e. between Pf (creep pressure) and Po (in-situ horizontal earth pressure). This cycle can be performed different ways. The ASTM-D4719 standard suggests running this cycle in one step down to Pf / 2, and then back the same way up to Pf. Another method consists in reducing pressure in three equal-pressure steps down to a point slightly above Po, and then back the same way up to Pf. Roctest recommends using the latter method.

   During a test the end of the pseudo-elastic zone may be found by keeping track of Δp, which will start decreasing when the soil starts to yield. When the unload-reload cycle is completed, the test is resumed in the plastic zone as a normal test.
4. When the test is over, slowly return the piston to its initial position.

Warning: <u>Deflation of the probe must be done slowly</u> – see warning at section 6.1. Make sure that the borehole is filled with fluid for helping deflating the probe.

Warning: If the pressure drops to zero or close to zero, this means that the sheath is punctured. Do not bring volume back to 0 cc. Dirty water or mud would get into the unit.

5. <u>Withdraw the probe</u>. If this can't be done because the probe is sticking to stiff plastic clay or because of caving problem, follow this procedure: the probe is pulled up about 5 mm and pushed back by two persons with pipe wrenches on the rods. This is repeated until this up and down cycling process weakens the soil and frees the probe. It is also possible to apply some vegetable oil on the probe's membrane to prevent it from sticking to clayey soils.
6. After retrieving the probe, clean the probe (outside and inside) using a nylon brush and a bucket filled with water.

7.4 STRESS CONTROLLED TEST

This method is used during a creep test (see below). It can also be used for tests in very hard soils or in soft rock.

1. Lower the probe to the test depth.
2. Place valve No. 6 on "TEST".

3. Crank until reaching the first pressure step corresponding to about 1/10 of the estimated limit pressure.
4. Maintain the pressure at this value and record the counter readings 30 seconds, and 60 seconds after the pressure step has been reached. Always stop cranking at least 5 seconds before recording data.
5. When the test is over, slowly return the piston to initial position.

Additional comments:

- Pressure step is generally 0.25, 0.5, 1 or 2 bars in soils, and 5 bars in rock. Pressure step can be estimated with the following relation: Pressure step (bar) = N (blow per foot) /20. Example if N = 17, start with a 0.5-bar pressure increment.
- Check delta V 60 sec – 30 sec (cc) at each step in order to determine if you are in the pseudo-elastic zone or in the yielding zone. The first zone is characterized by rather constant delta V. The second zone is characterized by increasing delta V. If you still are in the pseudo-elastic zone after 7 steps, double pressure increment. Adjust pressure steps to try to get 7-14 steps total in the test with at least 2-3 steps in the yielding zone.
- An unload-reload cycle can be done. See instructions above.

Warning: Deflation of the probe must be done slowly – see warning at section 5.1. Make sure that the borehole is filled with fluid for helping deflating the probe.

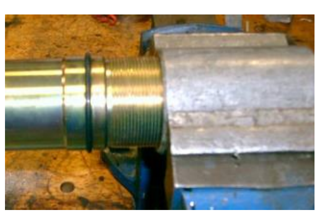
8 PROBE DISASSEMBLY AND ASSEMBLY

DISASSEMBLY :

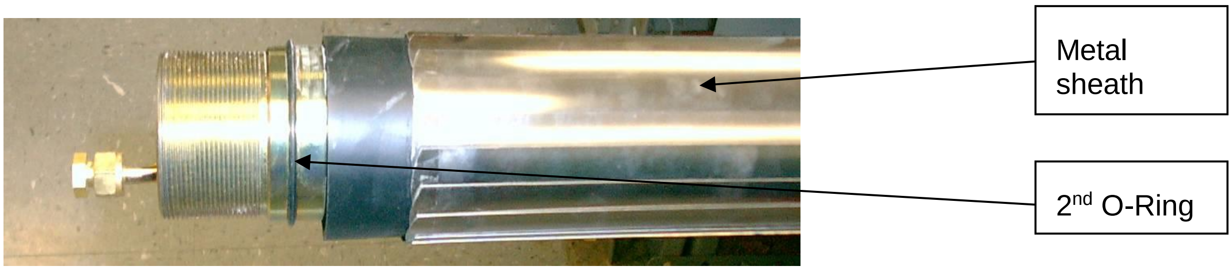
1- Screw the probe vise adaptor onto one end of the probe and clamp the adaptor in the jaws of a 4-inch bench vice.
2- Use a strap wrench to unscrew the knurled nut from the free extremity of the probe.
3- To extract Vulcolan tapered rings, use the extractor provided with the instrument. Insert and screw in the extractor pins into the two diametrically opposite holes located on the metal collar of the Vulcolan ring. Rotate the extractor in the direction of lamination of the metal strips and simultaneously pull the extractor outwards. In cases where removal of either type of tapered ring is difficult, the application of heat (using a propane torch or hot air gun, max. 65°C) uniformly over the rings will facilitate their removal.
4- Remove used sheath.
5- Clean all parts and probe's body and make sure o-rings are not damaged.

ASSEMBLY :

6- Put only one o-ring at the end close to the vice adaptor. Make sure probe's body is tightly fixed to the bench vice.



7- Do not grease the o-ring. Slide a metallic sheath on the probe's body. Make sure the electrical tape on each end of the sheath has been removed.
8- Place the second o-rind at the other end of the probe. Make sure the sheath is centered and that both o-rings are at their place.

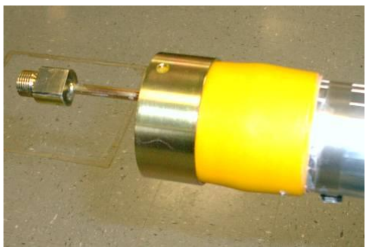


9- Make sure that the metallic strips are not twisted.
10- Put hose clamps over the sheath. Pay attention to the direction of these clamps for preventing them from damaging the metallic strips while tightening them. Put a hose clamp at about 1 to 1.25 in from the tip of the metallic strips.

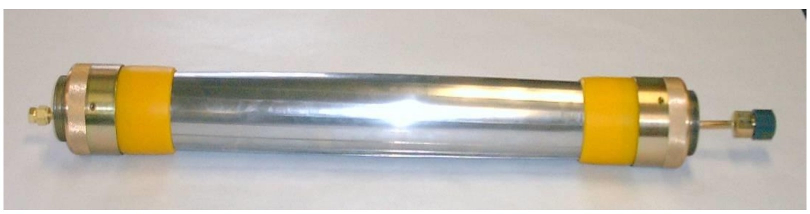
11- Tightly put electrical tape at each end of the sheath in order to squeezing the rubber and metallic strips.
12- Put MOLYKOTE 33 LIGHT grease (Extreme low temperature grease) on the probe's threads, on the electrical tape, on the inner wall of yellow vulcolan rings, and on the flat inner side of the brass knurled nut.

13- Push by hand the yellow ring in place over the probe. Put the brass knurled nut in place and screw it. This will push the yellow ring inward. Proceed until three threads can be seen.
14- Free the probe from the vice and from the vice adaptor, then reinstall it on the vice but on its other end.

15- Make sure that the metallic strips are still straight. Put the yellow ring and knurled nut on this end of the probe.
16- Using a strap wrench, keep on tightening the knurled nut until 5 to 6 threads can be seen.
17- Free the probe from the vice and reinstall it on its other end. Tighten the knurled nut until 5 to 6 threads can be seen.



18- Installation completed.

9 TRANSPORT

1. The instrument can be transported full of water and saturated as long as the piston is in its lowermost position. It is imperative to bleed water when unit will be exposed to freezing temperatures.
2. Unscrew the knurled nut on the screw actuator.
3. Dismount the screw jack and its support columns and disconnect the tubing.
4. Place valve No. 6 on "TEST" and install the control unit cover.

Warning: Always keep the two TEXAM^{e} carrying cases upright. Never tilt them on their side.

10 LIMITATIONS OF USE

10.1 COLD TEMPERATURE

Antifreezes

In order to use the TEXAM^{e} at temperature below 0°C, water must be replaced by an antifreeze solution. Various types of antifreeze can be considered.

Methanol-based antifreezes (regularly used in windshield washer liquid) offer the best protection for pressuremeters at very cold temperature. It must be noted that methanol can be corrosive for the equipment. It is very important to flush the TEXAM^{e} with clean water as often as possible to protect it. Methanol is not considered environment-friendly and is inflammable.

Ethylene-glycol-based antifreeze (regularly used in engine antifreeze liquid) is less corrosive for the equipment. However note that ethylene glycol and low temperatures will significantly increase viscosity of the liquid, which means that time required for inflating and deflating the probe will significantly increase too. A 50-50 solution of water - ethylene glycol by volume will allow using the equipment at about -25°C, a 70-30 solution can be used down to about -10°C. It is very important to flush the unit with clean water as often as possible to protect it and avoid deposits. Ethylene-glycol is not environment-friendly.

Ethanol-based antifreezes are sometime used. It must be noted that ethanol can be corrosive for the equipment, depending on the brand. Internal tests have shown that it will get very viscous at -15 deg C. Ethanol is environment-friendly, but is inflammable.

Propylene-glycol-based antifreeze is normally too viscous for use with pressuremeters.

Valve leakage

When the pressuremeter is used at low temperature, the valve No. 6 may leak. This is caused by the differential thermal contraction of the brass ball valve and its spherical Teflon seat. To stop the leaks, remove the valve handle using a 3/32" Allen wrench and tighten the packing nut using the chrome plated packing nut tool provided with the instrument. Usually 1/8" of a turn will suffice to stop the leak.

10.2 SOFT MATERIAL

The inertia of the TEXAM membrane is very low (40-70 kPa) which allows its use in very soft soils. However, special precautions must be taken not to remould the boreholes while drilling them.

10.3 ROCK

The TEXAM^{e} can be used in rock, but in very soft ones only. And special precautions regarding the volume calibration must then be taken. Two calibrations up to 10,000 kPa must be run just prior from lowering the probe in the borehole. Then, the test itself should be done following the stress controlled method in order to get more points for modulus determination. When these precautions are taken, the user can expect to obtain representative moduli up to about 2 GPa. The repeatability of the system expansion coefficients obtained during calibrations is an indicator of the reliability of the obtained moduli. Size of the borehole will also affect the results. The borehole diameter should be as close as possible to the one of the calibration steel tube.

10.4 DRY BOREHOLE

Past a certain depth (about 5 m), the use of the TEXAM^{e} is possible only if the hole is filled with fluid. The resistance of the membrane being small and due to the effect of the water column inside the equipment, the probe will start to expand quickly if it is lowered in a dry hole.

10.5 DEEP BOREHOLE

The TEXAM^{e} can be used for performing tests at great depth (over 100 m) provided the borehole is filled with fluid.

11 RECOMMENDATIONS

- Do not wait until the last minute to verify and calibrate the equipment
- On site, keep different sizes of drilling bits and two complete probes to speed up testing. On remote sites, bring a bench vise for membrane replacement.
- Check data as test proceeds.
- The shelf life of sheaths is about 2 years. These must be used within this timeframe.
- Keep the equipment dry and clean.

12 MAINTENANCE

12.1 PREVENTING THE EQUIPMENT FROM RUSTING

<u>It is very important not to keep the equipment saturated for extended period of time. Otherwise it will start rusting.</u> When a testing campaign is over, the pressuremeter must be desaturated as per sections 5.1, with the difference that the free end of the saturation tubings must remain out of the water during the entire process. This way, the unit will be ‘saturated with air’. <u>Also, disassemble the probe to keep it dry.</u>

When a testing campaign is over, <u>also make sure no water of humidity has accumulated in the control box.</u> For doing so, unscrew the four screws (f) of the mounting panel. Use two of the four support columns (i) for lifting the panel. **Warning : avoid any shocks between the internal circuit and the box when lifting the panel. For avoiding that, lift the panel slowly and vertically.**

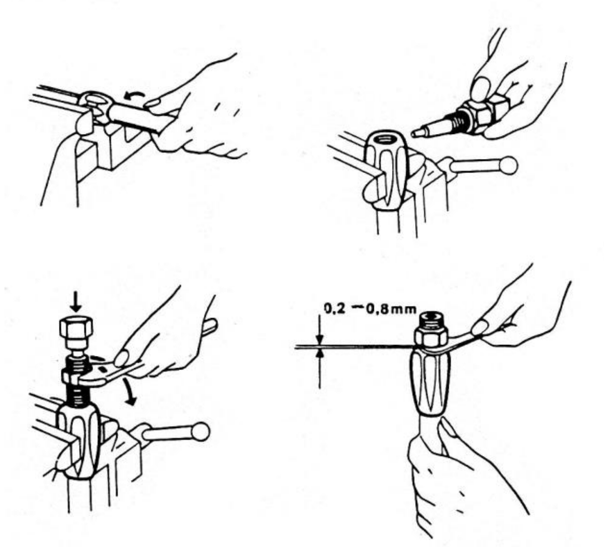
12.2 CLEANING THE FILTER

The filter mounted on the copper line connected to the Port No. 1 must be checked periodically. If it gets plugged, it will be difficult to deflate the probe. To check it, proceed as follows:

- Remove the front panel from the control unit box as indicated above.
- Unscrew the brass nut on the copper tube of port No. 1 with a 9/16" open wrench.
- Unscrew the 2 nuts on both sides of the filter and remove the filter from instrument.
- Check if filter is clean by blowing some air in it.
- If it is plugged, replace it.
- If no spare filter is available, you can clean it as follows: open filter housing with 2-3/4" wrenches and remove filter cartridge. Clean all parts with clean water and re-install filter, following the opposite procedure of the removal.
- Be sure that the arrow on the filter points in the same direction as before.
- After saturating the pressuremeter, put it under pressure up to 10,000 kPa and check for leaks. If the filter leaks, tighten up the nuts or put a new filter assembly.

12.3 SPLICING THE TECALAN TUBING

1. Cut the tubing, at a right angle, cleanly.
2. Install a socket in a vice. Do not overtighten, do not misshape the socket
3. Screw the tubing into the socket thoroughly by rotating counter clockwise. Then, unscrew one quarter of a turn (**very important**)
4. Install the socket-fitted tubing vertically
5. Insert the coupling into the socket by pushing and screwing the coupling. Do not overtighten. Keep a 0.2 to 0.8 mm spacing between the socket and the coupling.



13 USING THE DATA

13.1 DATA REDUCTION

The raw test data are corrected to compensate for membrane resistance, system compressibility and the hydraulic head between the control unit and the probe.

The modulus is determined with the following relation:

$$E_m = 2\,(1+v)\,(Vo + V_m)\,(\Delta P/\Delta V)$$

Where:

E_m = Pressuremeter modulus
v = Poisson's ratio

V_o = Theoretical volume of the measuring portion of the uninflated probe at 0 volume reading at the ground surface
V_m = Corrected volume increase at the center of the ΔV volume increase
ΔP =Corrected pressure increase in the linear zone of the pressure-volume curve between V_1 and V_2
ΔV =Corrected volume increase in the linear zone of the pressure-volume curve between V_1 and V_2

Pressure and volume are corrected as follows:

$P = P_r + P_l - P_c$

Where:

P = Corrected pressure.
P_r = Pressure reading on the control unit.
P_l = Hydrostatic pressure between control unit and the probe.
P_c = Pressure correction for the stiffness of the instrument at corresponding volume; determined with the pressure calibration.

$V = V_r - V_c$

Where:

V = Corrected volume.
V_r = Volume reading on the control unit.
V_c = Volume correction for the volume expansion of the instrument during the test; determined with the volume calibration.

V_c is obtained with a volume correction factor "c" given by the following equation:
$c = a - b$
The correction factor "a" is calculated from the linear part of the curve of the calibration in the steel tube.
The "b" parameter takes into account the expansion of the steel tube during the calibration and is calculated with following equation:
$b = (2V * (r + e * (1 + m))) / E_m * e$

Where:

V = Volume of the probe when in contact with the metallic calibration tube
r = Internal radius of the calibration tube
e = Wall thickness of calibration tube
m = Poisson's ratio of calibration tube material
E_m = Modulus of elasticity of calibration tube material

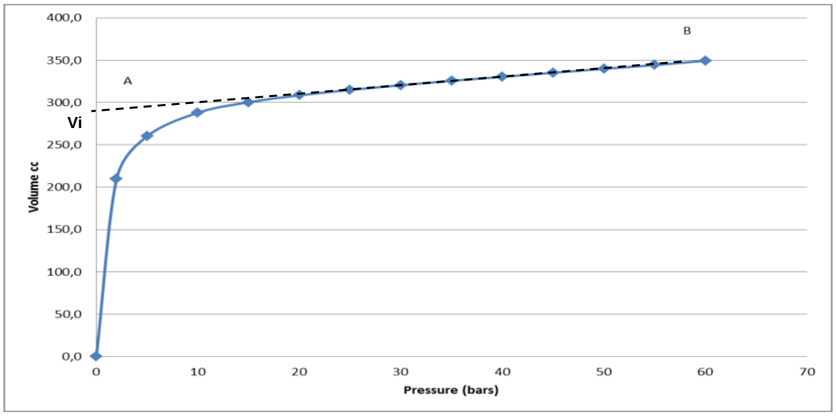
The deflated volume of the probe **Vo** is a value necessary for determining the modulus and the limit pressure. Theoretical values of **Vo** are given below.

PROBE DIAMETER (mm)	**PROBE ASSEMBLY**			
	VULCOLAN RINGS		**METALLIC RINGS**	
	*Distance **L** (cm)*	*Volume **Vo** (cc)*	*Distance **L** (cm)*	*Volume **Vo** (cc)*
44 (A)	54	**820**	58	**880**
70/74 L (N)	46	**1770**	n.a.	**n.a.**

For more representative results, **Vo** must be estimated with the following formula:

$$Vo = (\pi D^2/4) L - Vi$$

Where:
- L is the length of the measuring cell (given in table above)
- D is the inside diameter of the calibration tube
- Vi is the resulting intercept of a straight line extension of the volume calibration curve. Refer to the ASTM D4719 standard for more details.



Vi Determination

The limit pressure P_L corresponds theoretically to the pressure required to double the volume of the initial cavity. The total injected volume is then equal to V_o plus twice the volume injected in order that the probe contacts the walls of the borehole. The recommended procedure to obtain P_L is to estimate it on the manually-extended pressuremeter curve.

<u>Note that Roctest offers a spreadsheet TEXAMCOMPANION for data reduction. You may contact us to get a free copy.</u>

13.2 REFERENCES

Reading interpretation can be done referring to the following documents:

ASTM D4719-20 Standard Test for Pressuremeter Testing in Soils

Briaud, J.-L., (1992), '*The Pressuremeter'*, Balkema,

Briaud, J. L. , (2013), *'Geotechnical Engineering: Unsaturated and saturated Soils'*, John Wiley & sons

Frank R. & al. (2021) *'Design of Shallow and Deep Foundations',* CRC Press, 232 p.

Marcil L. & Sedran G. (2024),'*Comparative tests between Texam and Menard Pressuremeters'* ISC7

Menard L. et al. (1975 rev. 2018), *'D.60 Brochure : The Menard Pressuremeter: Interpretation and application of Pressuremeter test Results to Foundation Design'*, Sols Soils no. 26, Ed. Apageo

NF P94-262 AFNOR, (2012), Eurocode 7

These documents are available on the Internet.

More information is available on the following Web Sites :

https://icp-pressuremeter.com/.
https://insitusoil.com/soil-pressuremeter-test/
https://roctest.com/en/

14 MISCELLANEOUS

Creep test

The creep test kit makes it possible to carry out creep tests by maintaining a constant pressure for a long period of time. To perform creep tests:

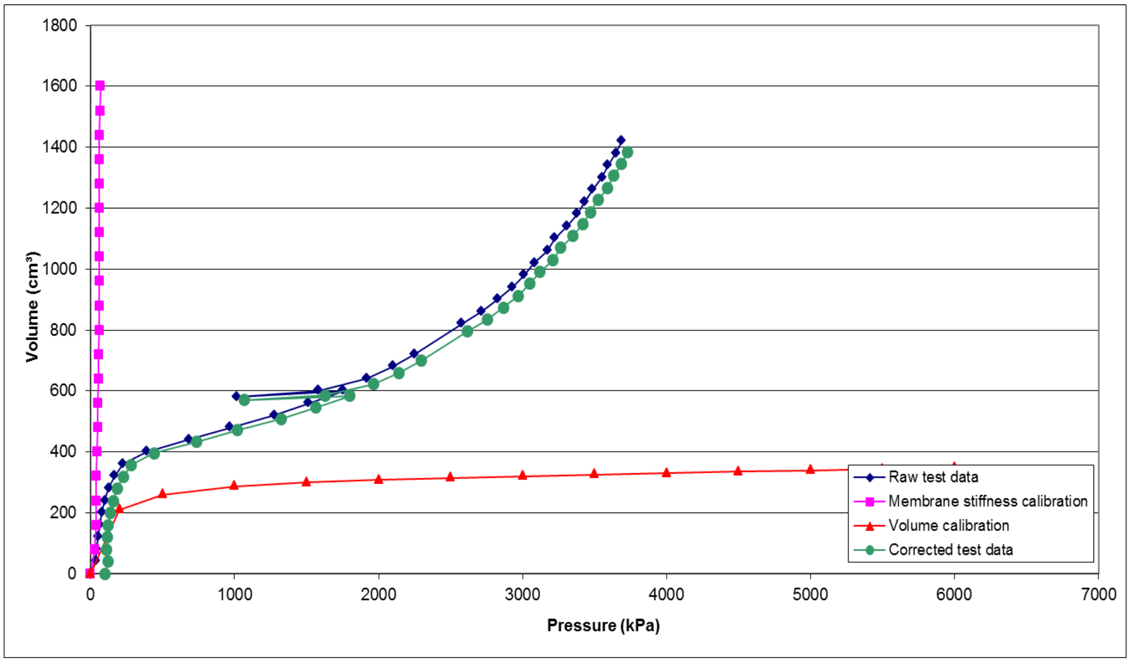
1. Disconnect the actuator screw from the cylinder shaft by unscrewing the knurled nut.
2. Turn the crank clockwise to raise the actuator screw to the uppermost position.
3. Connect one end of the high-pressure tubing to the pressure regulator of the nitrogen cylinder, and one end to the quick port No. 2 of the pressuremeter's front panel.
4. Place valve No. 6 on "TEST".
5. Proceed except as noted below using the same method to carry out stress controlled tests.
6. Instead of advancing the piston with the screw actuator, apply and control pressure using the nitrogen cylinder regulator. The applied pressure will be different from the effective pressure read with the pressuremeter's pressure sensor due to the piston friction and to the difference of area of the two sides of the piston.
7. At each constant pressure step, record the volume readings at regular intervals.
8. To return the piston to its initial position, it is necessary to couple the actuator screw to the piston shaft using the knurled nut.

Volume readings of the electrical sensor vs those of the optional mechanical volume counter

Note: as the pressure in the unit is increased, a slight difference in volume readings between the electrical sensor and the optional mechanical volume counter will appear. This difference is due to the deformation of the pressurized jack which affects only the reading of the mechanical volume counter. This difference will be largely compensated in future calculations when subtracting the equipment deformation value obtained during the volume loss calibration. Consequently, the impact on the corrected values is not significant and should be ignored. Volume readings obtained from the two types of sensors should not be mixed. We suggest to always using by default those from the electrical sensor.

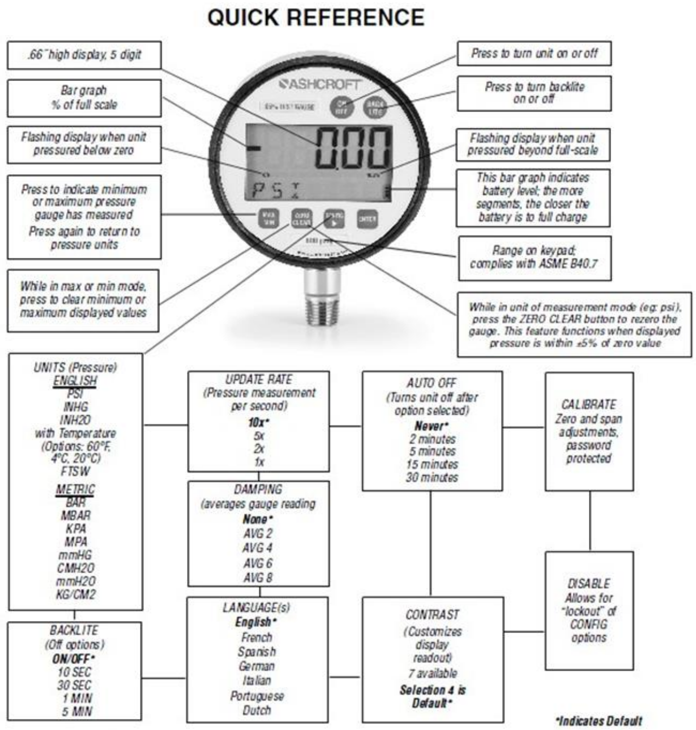
Tecalan Tubing and Connectors	
a	Tecalan Tubing Assembly
b c	Tecalan Connector including a Socket (b) and a Coupling (c)
d	Adaptor from probe to Tecalan (20-1001A02089)
e	Ferrule (05-R17LA1111000)
f	Modified Nut 10 mm (10-1001001149)
g	Male quick connect (05-R01SS1K11)
h	Elbow Connector (optional)
i	Union for splicing the Tecalan
j	Union for connecting a Tecalan to an extension (20-1001002143)
b to f	FR-1001A00100

Probe Components and Accessories			
A	Vulcolan ring extractor	h	Probe's body
B	AWJ box rod to AW pin rod adaptor	i	O-ring
C	AW box rod to BW pin casing slotted adaptor	j	Saturation plug
D	BW box casing to PMT probe adaptor	k	Brass knurled nut
E	Complete PMT probe	l	Vulcolan steel ring
F	Probe shoe	m	Vulcolan collar
G	Probe to bench vice adaptor	n	Metallic sheath



Typical Corrected Test Data

Optional Pressure Gauge Operation :



Battery Installation and Replacement:

The gauge comes standard with a quantity of three AAA alkaline batteries (installed). Use either Duracell MN2400, MX2400 or Energizer E92BP, X92RP AAA alkaline, non-rechargeable batteries.

Batteries have a life of approximately 1000 hours. Battery life is dependent on gauge usage, backlite settings and power off settings. When the display flashes LOW BAT, batteries should be replaced.

To replace the batteries:

1) Remove the single screw on the back of the gauge case.

2) Hold the keypad in the palm of hand.

3) Carefully remove the three batteries from the holder and replace the batteries. Use only AAA alkaline non-rechargeable batteries.

⚠ Pipe to which gauge is attached must be properly grounded.

SPECIFICATIONS

Type	2089 (0.05% accuracy), 2086 (0.10% accuracy), 2084 (0.25% accuracy)
Accuracy	0.05%, 0.10%, 0.25% all Full Scale Terminal Point Total Error Band (TEB) Accuracy Including Hysteresis, Linearity, Repeatablilty & Temperature (–18/65°C) (0/150°F)
Dial Size	3"
Case Material	300 Series SS
Case Finish	Electropolished
Case Enclosure Rating	Weatherproof, IP65
Socket Material	316 SS
Socket Size	¼ NPT Male (others on application)
Connection Location	Lower, 3:00, 9:00
Ranges	Vac thru 7000 psi (see engineering units below for other units of measurement)
Operating Temperature	0/150°F
Storage Temperature	–40/180°F
DISPLAY:	
Type	LCD
Display Digits	5
Character Height	.66"
Backlit	Off By Default
Bar Graph	Yes
Battery Life	1000 Hrs.
Agency Approvals	CE, FM, CSA
KEYPAD FUNCTIONS:	
On/Off	Manually Turns Unit On & Off (auto off options in config menu)
Backlit	Manually Turns Backlit On & Off (auto off options in config menu)
Min/Max	Stores Min & Max Values
Zero/Clear	Zeros Display or Clears Min/Max Values When Displayed

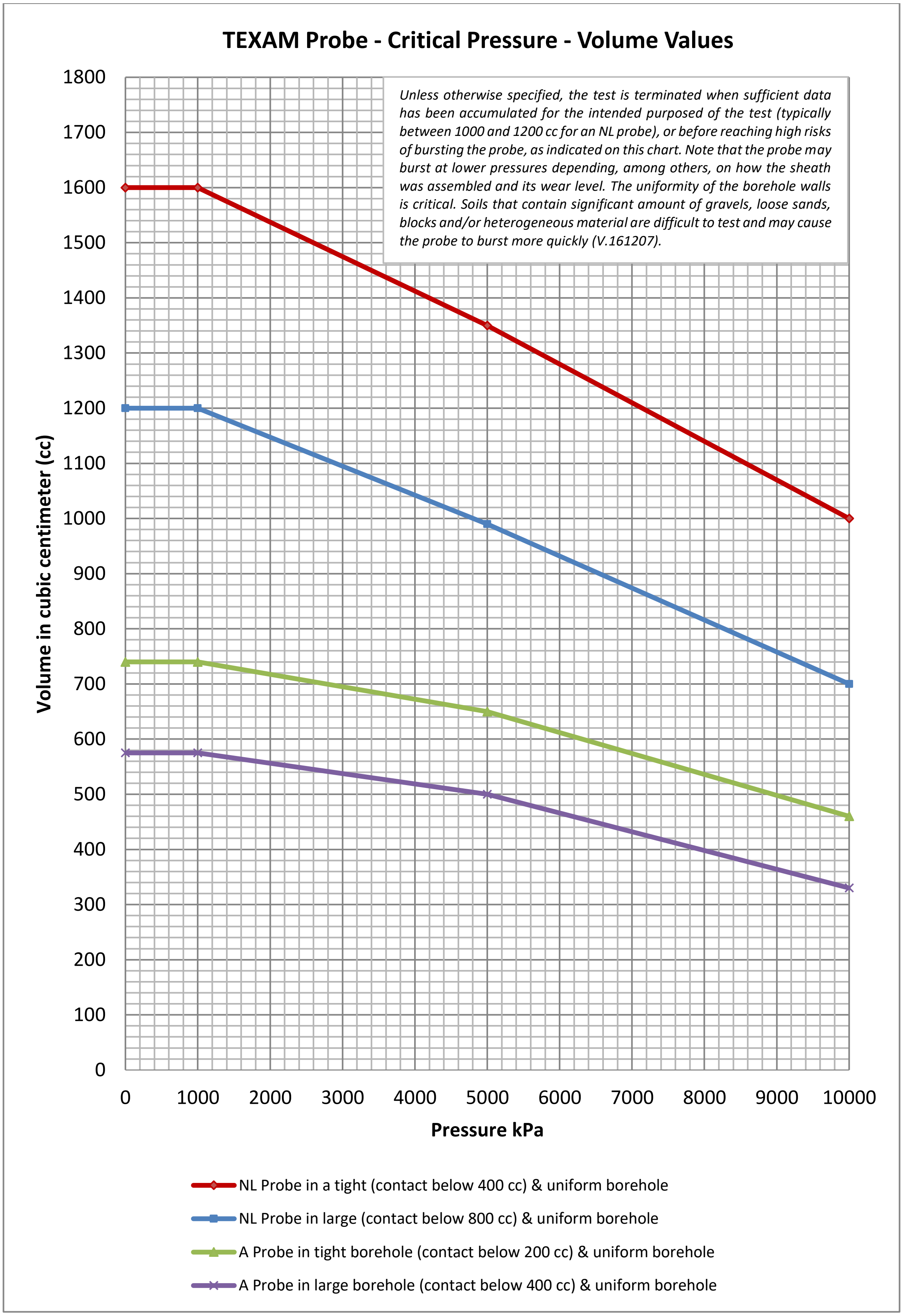
SPECIFICATIONS

Enter	Selects Items In CONFIG Menu
Config Mode	Allows Scrolling Through CONFIG Menus
Engineering Units	Psi, "Hg, "H_2O (with three temperature options, 60°F, 4°C and 20°C), ft.SW, bar, mbar, kPa, mPa, mmHg, cmH_2O, mmH_2O, kg/cm^2
Update Rate	4 Options: 10x/sec, 5x/sec, 2x/sec, 1x/sec
Auto Off	6 Options: Never, 2 Min., 5 Min., 15 Min., 30 Min.,
Dampening	6 Options: None, Average 2, 4, 6, 8 x update rate
Languages	7 Languages: English, Spanish, French, Italian, German, Portuguese, Dutch
Backlite	5 Options: On/Off, 10 Sec., 30 Sec., 5 Min., 15 Min.
Field Recalibration	Zero & Span (password protected)
Contrast	7 Available Options
Disable Config Options	Allows disabling of Config Options (password protected)
Calibration Chart	10 Point Individual NIST Traceable Calibration Chart, Standard
Standard Accessories	300 Series SS Protective Cover Nylon Protective Carrying Pouch

WARNING AND ERROR MESSAGES

Display	Description
Flashing 0% or 100%	Gauge over/underpressured beyond 105% of range
LOW BAT	Low battery, replace
ERROR	Internal error, call customer service (203) 378-8281
RES ERROR	Pressure unit conversion exceeds display resolution or gauge pressured beyond resolution

For more info see www.ashcroft.com


TEXAM Probe - Critical Pressure - Volume Values
Unless otherwise specified, the test is terminated when sufficient data has been accumulated for the intended purposed of the test (typically between 1000 and 1200 cc for an NL probe), or before reaching high risks of bursting the probe, as indicated on this chart. Note that the probe may burst at lower pressures depending, among others, on how the sheath was assembled and its wear level. The uniformity of the borehole walls is critical. Soils that contain significant amount of gravels, loose sands, blocks and/or heterogeneous material are difficult to test and may cause the probe to burst more quickly (V.161207).
Volume in cubic centimeter (cc)
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Pressure kPa
NL Probe in a tight (contact below 400 cc) & uniform borehole
NL Probe in large (contact below 800 cc) & uniform borehole
A Probe in tight borehole (contact below 200 cc) & uniform borehole
A Probe in large borehole (contact below 400 cc) & uniform borehole

Site:				**Site:**		
Date:		**Time:**		**Date:**		**Time:**
Borehole no:		**Depth:**		**Borehole no:**		**Depth:**
Calibration:		**Calibration Ref:**		**Calibration:**		**Calibration Ref:**
Probe ∅ :				**Probe ∅ :**		
Volume cc	**Pressure** Units:	**Variations** Units:		**Volume** cc	**Pressure** Units:	**Variations** Units:

Soil Description: ____**Temperature:** ___________

Pressuremeter Type: ___________________________ **Notes:** _______________________________________

____ **Operator:** ________________

PRESSUREMETER TEST DATA SHEET