C-Tech
Laboratory equipment co..limited

PY SERIES FIELD PRESSUREMETER

PRODUCT MANUAL

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CONTENTS

I. Structure and technical specifications

The PY series field pressuremeter is composed of four parts: a probe, a water tank, a deformation measurement system and a pressure stabilization device (see Figure 1 in the appendix). The main technical specifications are as follows:

Item		Specifications			
		PY-3	PY-4	PY-5	PY-5
Probe	Structure	3-CELL			
	Nominal external diameter	ø60mm			Ø74mm
	Measuring chamber length	250mm			210mm
	Total length of the probe	800mm			850mm
Measuring accuracy	Min. reading of pressure gauge	0.01Mpa			
	Effective measuring range	400mm			
	Error	≤±1%			
Others	Maximum test pressure	2.5Mpa	4.0Mpa	5.5Mpa	
	Cross-sectional area of measuring tube water column	13.58cm^2	13.58cm^2	13.58cm^2	20cm^2
	Measuring tube volume	580cm^3	580cm^3	580cm^3	860cm^3
	Dimensions	830×360×220mm			
	Weight	28kg			
	Application	Cohesive soil, silty soil, etc.	Hard cohesive soil, silty soil, sandy soil, etc.	Cohesive soil, silty soil, sandy soil, strongly weathered rock, soft rock, etc.	

1. Probe: It is the main component of the pressuremeter, which is a three-chamber cylindrical frame with an elastic membrane on the outer jacket. It is divided into three chambers, upper, middle, and lower. The middle chamber is the test chamber; the upper and lower chambers are connected to each other but isolated from the middle chamber, which is a protection chamber. There is a water pipe in the center, which is used to drain the groundwater, so that the probe can

be placed at the test depth smoothly.

2. Water tank: It is mainly used for water injection before the test, and it is not under pressure during the test. In order to avoid bursting, a safety valve is installed.

3. Deformation measurement system:

   a) The function of the measuring tube is to display the volume change of the probe. Two scales, S and V, are set beside the measuring tube.

      S -- engraved with a standard length, the smallest scale is 1 mm, for reading the value (cm) of the liquid level drop of the measuring tube caused by the expansion of the probe.

      V -- The volume increase (cm^3) of the probe after expansion is determined by the position of the liquid level.

   b) The pressure tube is made of imported nylon-11 fiber (high-pressure resistant material), which is a pipeline for transmitting pressure.

II. Working principle

The air pressure added by the pressurizing device is directly transmitted to the water surface of the measuring tube, and the generated water pressure and air pressure are transmitted to the three chambers of the probe (the middle chamber is water pressure, the upper and lower chambers are air pressure). which promotes the expansion of the elastic membrane under pressure, and causes the corresponding deformation of the soil body under pressure. The amount of deformation is measured by the drop value of the water level of the measuring tube, and the pressure value is read by a pressure gauge. According to the measured results, draw the relationship curve between the pressure and the drop value of the water level of the measuring pipe, that is, the pressuremeter curve. According to the curve, the allowable bearing capacity standard of the foundation soil and the calculation of the deformation modulus, compression modulus and other mechanical indexes can be determined. Therefore, the pressuremeter test is essentially a borehole load test.

III. Installation and operation

1. Assembly when the instrument is working: Use a tripod as a support when the instrument is working, and connect it with an M20 knurled copper nut.

2. Connect the high-pressure nitrogen cylinder to the instrument: If using a high-pressure nitrogen source, connect the inlet end of the decompression gauge of the instrument accessory to the nitrogen cylinder, and connect the Φ6×1 nylon tube to the outlet end, that is, connect the other end to the connector marked with "nitrogen source" on the instrument.

IV. Equipment debugging

The instrument should be debugged frequently before working. The purpose of debugging is to check whether the instrument is normal. If there is an abnormality, it must be dealt with to avoid interruption of work.

1. Water seepage inspection of elastic membrane: After the instrument is filled with water, place the probe on the side of the instrument without external force restriction. Slowly pressurize the probe to 0.05Mpa. When the elastic membrane swells, check whether there is any leakage on the membrane. If there is leakage, replace the elastic membrane.

2. Instructions for the use of the quick plug of the pressure tube:

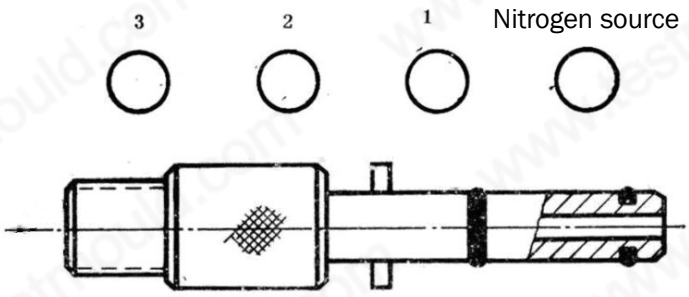


Figure 1 Quick plug and corresponding socket on the host panel

The nut behind the quick plug is numbered 1, 2, and 3, and when connected, it should correspond to 1, 2, 3 on the panel (note: there is no serial number on the nitrogen source plug). In order to prevent the O-ring on the quick plug from damaging and causing leakage, it is necessary to rotate the plug into the socket to lock the protruding part of the plug and the socket groove. If necessary, it can be lubricated with detergent.

V. Drilling

1. In order to obtain ideal test data, there are two necessary conditions: the aperture should meet a specific size; the disturbance of the soil layer and the hole wall by the equipment and method used during drilling should be as small as possible, and the test must be carried out immediately after the hole is formed.

2. Drilling the test hole is the most important step to obtain ideal pressuremeter test data. The degree of dispersion of the test data and the obtained test curve can prove the quality of the hole. Figure 2: Curve 2 is the normal pressuremeter curve, in which: the section AB is the initial section, which represents the compression of the hole wall by the disturbed soil. The BC section is a quasi-elastic section, and the relationship between volume and pressure is approximately linear, and the corresponding pressure P_0 at point B is the critical pressure. The CD section is the plastic section, V and p are in a curve relationship. With the increase of pressure, the volume changes more and more, and finally increases sharply, reaching the failure limit. C corresponds to P_f as the plastic pressure, and D corresponds to the pressure P_t as the ultimate pressure. Curve 1 represents that the hole diameter is too small or there is shrinkage, the probe is forced into the borehole, and the front part of the curve disappears. Curve 3 shows that the hole wall is severely disturbed and a thick disturbance circle is formed. The front part of the curve disappears and the back part is curved upwards, indicating the compression process of the disturbed soil. Curve 4 shows that the pore size is too large, so that a considerable part of the water in the measuring tube is consumed in the gap between the filling membrane and the pore wall.

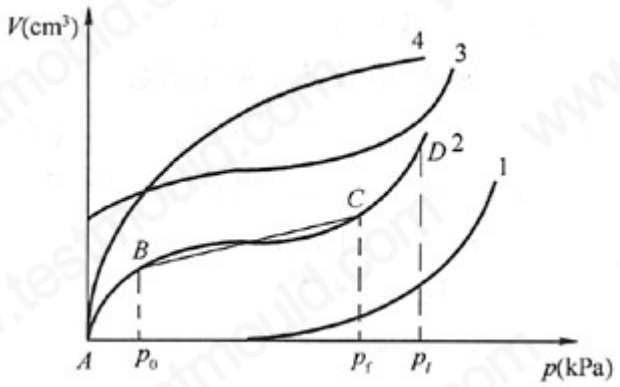


Figure 2 Pressuremeter curves under different pore quality

3. Test hole diameter requirements related to the diameter of the probe.

①. The diameter of the test hole is generally 2~8mm larger than the outer diameter of the

selected probe.

②. Diameter of drilling tool

a) When determining the drilling tool diameter required for drilling, the following three factors need to be considered: (a) Test hole diameter requirements. (b) The hole diameter is enlarged due to the shaking of the drilling tool, or the hole wall is eroded by the mud circulation in the medium to coarse-grained soil, or both. (c) When sinking occurs during the removal of the drilling tool and the placement section of the probe, the use of drilling mud can reduce the sinking of the hole wall.

b) When choosing site test equipment, several drill bits of different specifications should be available to adjust the size of the drill bit according to whether the hole wall is enlarged or indented.

c) The selection of tools should also consider making the test hole wall as smooth as possible, and keeping the hole diameter as constant as possible throughout the depth of the test section. (Note: If the hole diameter in the depth of the test section changes significantly due to the loose and broken stratum, or the borehole is not round, the test quality will be affected.)

4. Tools and methods for completing test holes

①. Any method and tool that can meet the general requirements of 1 to 3 mentioned above can be used.

②. Use the following methods to prepare the test hole

a) Rotary drilling: The following conditions should be met when the rotary bit drills into the soil layer: The vertical pressure of the drilling tool is low (200kpa), the rotation speed is slow (less than 60 rpm), and the flow rate of the drilling fluid is stable (less than 15L/min). The drilling fluid is injected through the shaft bottom leakage to make the impact on the hole wall small. The drilling must have sufficient viscosity to carry the cuttings out at a lower pumping flow rate.

b) Sampling tube sampling: The thin-walled sampling tube used must be long enough to ensure that the depth of the hole to be tested can be obtained after one press-in. (If the sampling tube is blocked or the tube cannot be filled with soil, other hole-forming

methods should be considered.) After taking the soil, the tube should be slowly withdrawn to prevent the hole wall from sinking due to suction. If a thick-walled sampling tube is used, it must have an inwardly inclined cutting edge so that the stress state of the hole wall may be small before the test.

c) Continuous spiral twist drill drilling: A 1.52m long spiral drill bit is installed at the bottom of the drill tool to drill the hole to the depth required by the test. The diameter of the drill bit must be slightly larger than the diameter of the spiral section to avoid damage to the hole wall. The drill must be continuously rotated during the process of raising the drill. The rotation speed and drilling pressure parameters of the continuous spiral twist drill are the same as the requirements of **a)**.

d) Manual scoop drill drilling: A spoon-shaped twist drill is used to drill the hole, some with a hand pump for spraying mud at the bottom, and some without. (Note: The manual scoop drill is only suitable for tests with soft soil and shallow depth, and it is difficult to use when the depth exceeds 6m.)

e) Drive-in or vibration drive-in sampler: Drive the split tube sampler into the soil. Drive-in or vibration drive-in wet sampler can also be used, and the requirements refer to **b)**.

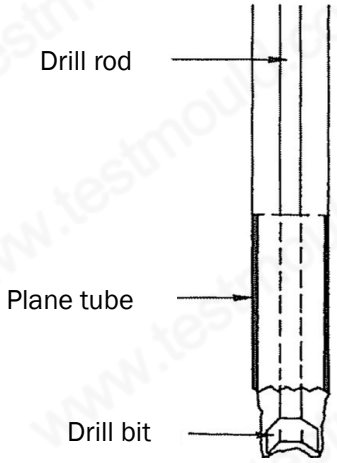
f) Core drilling: When drilling, make circular cutting and grinding on the bottom of the hole. Break the annular part of the rock and soil at the bottom of the hole, and use the circulating fluid to remove the drill cuttings, and retain the cylindrical core in the annular center. Refer to **a)** for the rotation speed and drilling pressure parameters of core drilling.

g) Rotary percussion drilling: Install the impactor on the rotary drill and use hydraulic pressure (wind pressure) to form a comprehensive drilling method with both impact and rotation. Compressed air is used to remove drill cuttings in dry formations, and mud is used in wet formations.

h) Pilot hole drilling and sampling tube sampling: Drill a pilot hole whose diameter is smaller than the diameter of the probe. The sampler can be pushed or driven in to achieve the appropriate aperture. Refer to **b)**.

i) Pilot hole drilling and simultaneous planing: Drill a pilot hole with a diameter smaller than the diameter of the probe. On the drill rod behind the drill bit is a thin-walled tube used to plan the hole (see Figure 3). High-consistency drilling fluid must be used when

advancing the drill bit and the plane tube.



gure 3

Selection of drilling method

Choose the appropriate method from the aforementioned or other acceptable methods. This choice depends on the type of soil layer being tested. The main influencing factors are as follows: (a) particle gradation; (b) plasticity; (c) strength; (d) saturation.

The following table lists the selection of drilling methods for several typical soil layers divided according to the factors mentioned above. The following table does not list all possible drilling methods, only as a reference for the selection.

Soil layer	Clay			Silty soil		Sandy soil			Sand gravel or gravel weathered rock below groundwater level	
Type	Soft	Consolidation–compaction	Compaction–hard	Above groundwater level	Below groundwater level	Loose and above the groundwater level	Loose and below the groundwater level	Medium–dense	Loose	Dense
Rotary drilling	2	1	1	1	1	1	1	1	2	NR
Sampling tube sampling	2	1	2	2	NR	NR	NR	NR	NA	NA
Pilot hole drilling and sampling tube sampling	2	2	1	2	NR	NR	NR	NR	NA	NA
Pilot hole drilling and simultaneous planing	2	2	1	2	2	2	2	2	NA	NA
Continuous spiral twist drill drilling	NR	1	1	1	NR	2	NR	1	NA	NA
Manual scoop drill without mud pump drilling	NR	1	NA	1	NR	2	NR	NA	NA	NA
Manual scoop drill with mud pump drilling	1	1	NA	2	1	1	1	NA	NA	NA
Drive-in or vibration drive-in sampler	NR	NR	NA	2	NR	2	NR	2	NR	NR
Core drilling	NR	NR	1	NR	NR	NA	NA	NR	NA	2
Rotary percussion drilling	NR	NR	2	NR	NR	NR	NR	2	2	2

1 is the first choice, 2 is the second choice, NR is recommended not to be adopted, and NA is not applicable.

Drilling flushing fluid and wall-protecting and plugging materials

Drilling flushing fluid and wall-protecting and plugging materials should be selected according to stratum lithology, task requirements, drilling methods, equipment conditions and environmental protection requirements. Commonly used flushing fluids and wall-protecting and plugging materials should be selected according to the following table.

Water	Dense and stable soil
Mud (no solid phase flushing fluid)	Loose and broken stratum, water-absorbing swelling stratum, leaky stratum with well developed joints and fissures
Clay	Stratum with local hole collapse and leakage, Stratum with cracks in the shallow part of the borehole or overburden, resulting in leakage, water inflow, etc
Cement paste	Stratum with thick fracture zone and serious collapse, fracture stratum with ineffective treatment of special mud and clay and serious leakage, etc
Biological and chemical slurry	Fractured, collapsed and lost formations with well-developed fissures are generally used for local wall protection of short holes to stop leakage.
Vegetable gum	Loose, chipped, fractured stratum or poorly cemented stratum, such as pebble layer, sand layer.
Casing pipe	Severe collapse, shrinkage, leakage, water gushing stratum; larger caves, loose soil layers, sand layers, and other formations where wall protection and leakage stoppage methods are ineffective, holes that need to be closed for hydrogeological experiments, and water-drilling holes in water.

The pressuremeter test is not suitable for the following hole sections:

- Hole section where the original soil sample has been taken or the standard penetration test has been carried out;
- Hole sections including different soil layers.

NOTE

1. The minimum test depth, the interval between continuous test depths, the distance from the original soil drilled hole or other in-situ test holes, and the horizontal distance between the test holes should not be less than 1m.

2. The drilling depth should be 50cm larger than the test depth (the test depth is calculated from the midpoint of the middle chamber of the probe).

VI. Test procedure

1. Fill the water tank with distilled water or clean cold boiled water to keep the pipeline clean and reduce bubbles in the water. The water tank is not subject to high pressure. Therefore, it is best to keep the safety valve of the water tank open during the whole test process to avoid accidental operation mistakes to put the test high-pressure water into the water tank and cause the water tank to burst.

2. Connecting the pipeline: Insert the quick connectors of the No. 1 water injection pipe and the No. 2 and No. 3 pressure pipes of the probe respectively with the sockets on the measuring panel.

3. Inject water into the probe and the deformation measurement system: erect the probe on the ground, close the zero adjustment valve, and open the water injection valve and the measuring tube valve. Screw the test water injection switch valve to the water injection position (at this time, the test water injection switch valve is directly open to the atmosphere), and tighten the water tank cover. Connect the air pump to the pressurized part of the water tank and apply a little pressure (0.01~0.02Mpa) to the water tank, and shake the probe and the nylon tube bundle at the same time to facilitate the exhaust of the air in the probe and the pipeline. When the water level in the pipe to be measured reaches about 15 cm, the water injection speed should be reduced (because the water injection is too fast, the water will easily rush into the pressure regulating valve and the precision pressure gauge to affect the accuracy and service life). If the water is injected very quickly at this time, you can close the measuring tube valve, open the water tank cover to eliminate the pressure, and then open the measuring tube valve. At this time, the water level continues to rise. The water level is required to be at or slightly higher than zero. After the water injection is finished, the water injection valve can be closed.

4. Zero adjustment: Raise the probe vertically until the midpoint of the middle chamber is level with the zero scale of the measuring tube. Open the zero adjustment valve and pay attention to changes in the water level. When the water level drops to zero, immediately close the zero adjustment valve. At this time, the middle chamber of the probe is not subject to hydrostatic pressure, and its elastic membrane is in a non-expanding state. Put down the probe after closing the measuring valve.

5. Lower the probe to the predetermined test depth in the borehole.

6. Open the measuring tube (Note: This valve can only be opened after the probe is lowered to the predetermined test depth. If it is opened in advance, due to the hydrostatic pressure, the water from the measuring tube will be injected into the probe, which will expand the elastic membrane, making it difficult for the probe to be lowered to the predetermined test depth.), and at this time, the hydrostatic pressure is generated in the pressure bypass device. This pressure is the first-stage pressure (this value should be added to the pressure gauge readings at all levels to get the total pressure at all levels), and should be read until it is stable.

7. Pressurization

   ①. Connect the pipe of the nitrogen pressurizing device;

   ②. Screw the test water injection switch valve to the test position;

   ③. Open the low pressure meter valve;

   ④. Screw the pressure reducing valve counterclockwise to the loosest position (it is in the closed state at this time);

   ⑤. Open the nitrogen source valve;

   ⑥. Twist the pressure regulating valve clockwise (that is, one-stage pressurization) to reduce the high-pressure gas source to 0.1~0.2Mpa higher than the required maximum test pressure;

   ⑦. Slowly turn the pressure regulating valve clockwise to adjust to the required test pressure. According to a relatively stable standard, pressurize step by step. (Note: When the loading value reaches about 80% of the range of the low-pressure meter, close the low-pressure meter valve, stop using the low-pressure meter, and use the high-pressure meter to measure the pressure value, and then step by step to load to the required maximum value);

   ⑧. The increment of the test pressure should be 1/5~1/7 of the estimated plastic pressure P_f. If it is not easy to estimate, it can be determined by the following table.

Geotechnical characteristics	Test pressure increment level (kpa)	
	Before critical pressure	After critical pressure
Silt, silty soil, cohesive soil in flow plastic state, loose silt fine sand	≤15	≤30
Cohesive soil in soft plastic state, newly deposited loess, slightly dense saturated silt, slightly dense silty fine sand and slightly dense medium coarse sand	15 ~ 25	30 ~ 50
Plastic to soft plastic cohesive soil, Malan loess, moderately dense to dense saturated silt, moderately dense to dense silty fine sand and moderately dense medium coarse sand	25 ~ 50	50 ~ 100
Hard plastic to hard cohesive soil, dense silt, dense medium coarse sand	50 ~ 100	100 ~ 200
Strong-weathered zone of soft rock	≥100	≥200
Strong-weathered zone of soft rock and hard rock	≥200	≥500

8. Conditions for terminating the test

In any case, when the water level of the measuring tube drops by more than 36 cm (it must not exceed 40 cm), the test should be immediately terminated. At this time, the soil has been damaged. If the test is not stopped, the elastic membrane will burst.

9. Terminate the test

According to the specific situation, one of the following methods can be adopted to make the water in the probe come back up or drained, and the elastic membrane can be restored to its original state, so that the probe can be removed smoothly:

①. When the test depth is less than 2 meters and the test needs to be continued, the water in the probe can be returned to the measuring tube. The method is to screw the pressure regulating valve counterclockwise to the loosest position to make it open to the atmosphere to eliminate pressure, and use the restraining force of the elastic membrane to force the water in the probe to return to the measuring tube. When the water level is close to zero, the tube valve can be closed.

②. When the test depth is greater than 2 meters and the test needs to be continued, the water in the probe can be returned to the water tank. The method is to open the safety cover of the water tank first, and then open the water injection valve, using the high-pressure in the pipeline when the test was aborted to return the water in the probe to the water tank. (Note:

Do not open the water injection valve before opening the water tank cover, otherwise high pressure water will enter the water tank and cause the water tank to burst.) After the water enters the water tank, when you hear the sound of high-pressure air rushing in, you can close the water injection valve.

③. When all the water in the probe needs to be drained, the drain valve can be unscrewed, and the water in the probe can be drained by using the high pressure in the pipeline when the test is stopped. (Note: The valve of the low pressure meter can only be opened when the value displayed on the high pressure meter is close to or equal to the value displayed on the low pressure meter, otherwise the low pressure meter will be damaged.)

VII. Correction of the Instrument

1. Before the test, the instrument should be corrected in two ways: the restraint force correction of the elastic membrane and the comprehensive deformation correction of the instrument. The specific correction items should be determined according to the following conditions:

   ①. When the new pressuremeter is used for the first time, both corrections need to be carried out;

   ②. To replace a new elastic membrane, the binding force of the elastic membrane needs to be corrected;

   ③. The elastic membrane generally needs to be re-corrected after 20 tests. When there is a big change in temperature or it is left unused for a long time, it should be re-corrected;

   ④. When extending or shortening the pressure pipe and the water injection pipe, a comprehensive deformation correction of the instrument is required.

2. Correction of elastic membrane binding force. The correction should be carried out on the ground of the test site, the purpose of which is to determine the pressure consumed by the elastic membrane itself at a certain volume increase. The method is to erect the probe on the ground to allow the elastic membrane to expand freely. Generally, each pressure level is 10kpa (note: each pressure level is 20kpa after the protective outer film is installed), and 8-10 pressure levels are added. The observation time under all levels of pressure is consistent with the formal test time;

3. Correction of comprehensive deformation of the instrument. The correction should be carried out at the test site, and its purpose is to determine the volume loss of the liquid in the measuring tube before it reaches the main chamber of the probe. During the test, put the side pressure device in the calibration cylinder, and then pressurize the probe step by step. The pressure level can be 100kpa, and the test is generally terminated when the pressure is above 800kpa. The observation time under all levels of pressure is consistent with the formal test.

VIII. Maintenance

Main structure and maintenance

1. Ferrule type high pressure ball valve: its structure is shown in Figure 4. Its advantages are: good sealing performance, high pressure resistance, and low failure rate. The valve is composed of a handle, an electric mounting screw, a fixing nut, a lock washer nut, a trunk order, a trunk gasket, a trunk, a ball, a ball washer, a main body, etc.

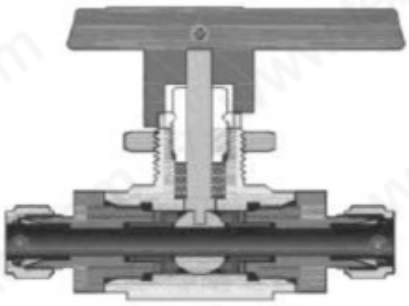
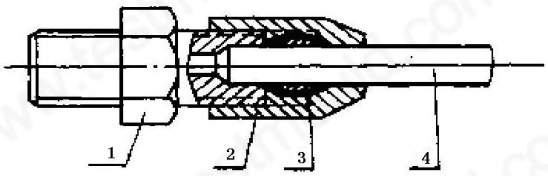


Figure 4

2. Ferrule type pipe joint: the pressuremeter adopts the most advanced pipeline connector at present. The bell type joint has good sealing performance, high pressure resistance, vibration resistance and long service life. The structure is shown in Figure 5.



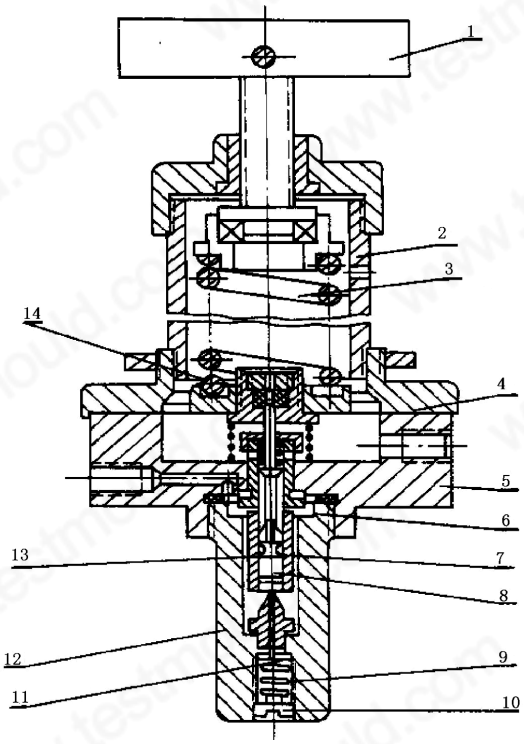
1 – joint body; 2 - compression nut; 3 - sealing ring; 4 - nozzle

Figure 5

The joint is composed of a joint body, a compression nut, a sealing ring and a nozzle.

The joint relies on the compression nut to tightly press the sealing ring, so that it deforms and closely fits the nozzle and the joint body to form a rigid seal. It is not advisable to disassemble after the assembly pressure test. If it needs to be disassembled and repaired, the sealing performance will be significantly reduced. The seal ring must be replaced when it fails to meet its working requirements. The replacement method is as follows: Use a fine-tooth file to file and remove the sealing ring. Take care not to file the nozzle, just replace it with a new sealing ring. After removing the damaged sealing ring, if it is found that the nozzle has been deformed, the nozzle must be replaced at the same time to ensure the quality.

3. Pressure regulating valve: Its structure is shown in Figure 4. The pressure regulating valve is composed of handle, upper cylinder, main spring, balance diaphragm, valve body, ejector rod, air inlet, plug, lower spring, adjusting screw, lower ejector rod, lower air chamber, guide sleeve and overflow port.



1 - handle; 2 - upper cylinder; 3 - main spring; 4 - balance diaphragm; 5 - valve body; 6 - ejector rod; 7 - air inlet; 8 - plug; 9 - lower spring; 10 - adjusting screw; 11 - lower ejector rod; 12 - lower chamber; 13 - guide sleeve; 14 - overflow port

Figure 6

The working principle of the pressure regulating valve balance: turn the pressure regulating handle clockwise, the main spring compresses the balance diaphragm, so that the ejector rod is attached to the overflow port, and the air inlet plug is moved axially to open the air inlet plug to allow the chamber to enter the air. When the air pressure of the working chamber and pipeline rises to a fixed value, the balance diaphragm moves under pressure in the reverse direction, and the ejector rod receives the force of the lower spring and then rises through the lower ejector rod, plug, etc., and the air inlet is closed to stop the air intake. When the air pressure of the working chamber and pipeline exceeds a fixed value, the balance diaphragm is compressed by the working pressure of the working chamber to move the main spring upward, causing the overflow port to open to release residual air, and the pressure drops to the fixed value. When the air pressure of the working chamber and pipeline drops due to volume changes and other reasons, the balance membrane is again acted by the main spring to close the overflow port and push open the air inlet to increase the pressure of the air intake. Repeat this continuously to achieve a voltage stabilizing effect.

The pressure regulating valve is a key component of the instrument. The accuracy of the pressure regulating valve directly affects the accuracy of the test results. When in use, do not turn the pressure regulating handle to perform invalid pressure regulation when the air source is not connected or there is no air pressure. After the work is completed, the handle should be loosened immediately to restore the main spring to its normal state, so as to extend its working life and maintain considerable accuracy.

Common faults and troubleshooting methods of pressure regulating valve:

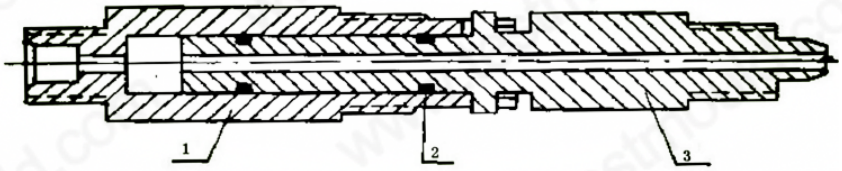
①. The pointer of the pressure gauge crawls after the pressure is adjusted. The reason is that dust accumulated on the surface of the plug due to the air flow medium, so that the air inlet and the plug cannot be closely attached. Secondly, due to long-term use, the surface of the plug has become obvious indentation, which makes the surface uneven and the air inlet cannot be closely attached. Solution: Unscrew the lower air chamber, remove the plug from the guide sleeve, and clean the surface of the plug with alcohol under a magnifying glass to make it free of dust and adhesion. At the same time, wipe the end face of the air inlet with tweezers entrained with alcohol cotton. When cleaning, pay attention to prevent surface bumps and scratches. If there are scratches and bruises under the magnifying glass, the plug or air inlet must be replaced at this time.

②. The overflow port consumes air. That is, when the overflow port does not exceed the rated

working pressure, it starts to vent by itself. Turn the adjusting screw clockwise in the tightening direction until it does not consume air (but considering the sensitivity of the pressure regulator, it should not be too tight). If the air is still consumed, the overflow port must be removed and the contact surface must be ground to make it a uniform contact line with the top rod spherical surface.

③. The lower air chamber is leaking. Generally, it is caused by the aging of the lower ejector rod sealing sleeve, and the sealing rubber sleeve needs to be replaced at this time.

4. Quick connector: It has the characteristics of lightness, durability and pressure resistance, which brings great convenience to the test work. This part is composed of socket, sealing ring and intubation tube. As shown in Figure 7.

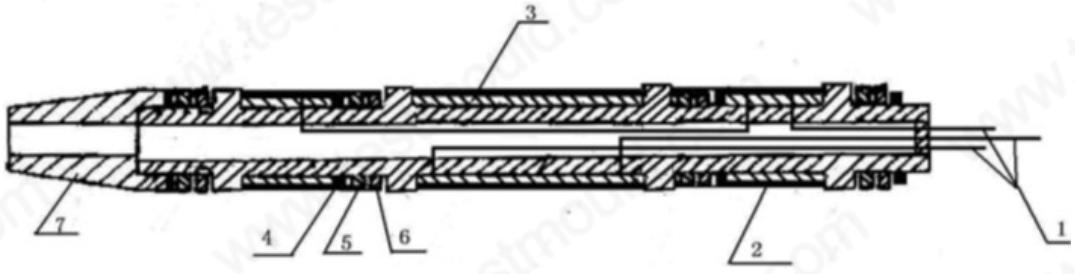


1—Socket; 2—Sealing ring; 3—Intubation tube

Figure 7

Due to frequent use, the sealing ring must be replaced immediately when it is worn out and the sealing performance is affected. After the test is completed, a sheath should be put on after removing the quick connector intubation to prevent the sand from entering the catheter from the intubation port and damaging the instrument.

5. Probe: It is composed of pressure pressure/water pipe, elastic membrane, leakage sleeve, inner compression ring, probe body, fixing cap, and outer compression ring. Its structure is shown in Figure 8.



1—Pressure/water pipe; 2—Elastic membrane; 3—leakage sleeve; 4—Fixing cap; 5—Inner compression ring; 6—Outer compression ring; 7—Probe body

Figure 8 Φ60mm probe

When the elastic membrane of the probe is damaged and needs to be replaced, the operation sequence is as follows:

①. Use a knife to paste the old membrane, remove the probe body, loosen the fixing caps, remove the old membrane, and remove the inner and outer compression rings and caps at the two ends at the same time.

②. Remove the upper and lower auxiliary chamber leakage sleeve to clean.

③. Coat the inner wall of the new membrane with soap solution, insert it from one end of the probe and pass through the outer compression ring of the middle end, and pass through the middle chamber leakage sleeve to make the position of the new membrane exactly equal to the probe skeleton, and put on two middle end outer compression rings.

④. Turn one end of the new membrane outwards (when turning outward, apply soapy liquid between the membrane and the membrane to facilitate lubrication) until the position of the inner compression ring at the middle end is exposed.

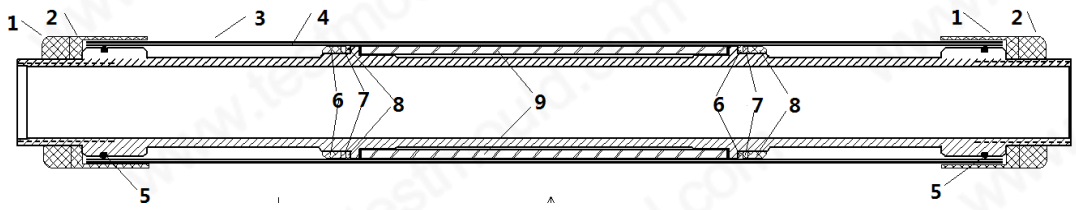
⑤. Put on the inner compression ring and use a spoon wrench to tighten the cap.

⑥. Install the upper leakage sleeve (note the check mark), and turn over the membrane again.

⑦. Put on the outer compression ring, the inner compression ring, and the cap tightly.

⑧. Operate the other end in sequence ④--⑦.

Note: After assembling, each segment of the membrane must be closely fitted to the frame of the probe to prevent slack.



1—fixing nut; 2—shield; 3—outer membrane; 4—elastic membrane; 5—O-ring;
6—Fixing cap; 7—Inner compression ring; 8—Outer compression ring; 9—leakage sleeve

Figure 9 Φ74mm probe

When the elastic membrane of the pressure bypass device is damaged and needs to be replaced,

the operation sequence is as follows

①. Unscrew the knurled fixing nuts at both ends, and remove the guards at both ends. (Note that the shield is tightly installed. You can use cork or hard plastic. Use a hammer to slowly knock it down around the sides. Do not use hard things to avoid damage to the shield)

②. Remove the outer membrane, then use a knife to paste the elastic membrane, loosen the middle fixing cap, and remove the old membrane.

③. Coat the inner wall of the new membrane with soapy liquid, insert it from one end of the probe and pass through the middle end of the outer compression ring, and pass through the middle chamber leakage sleeve, so that the position of the new membrane is exactly equal to the probe skeleton. And put on two middle end outer compression rings. Turn one end of the new membrane outwards (when turning outward, apply soapy liquid between the membrane and the membrane to facilitate lubrication) until the position of the inner compression ring at the middle end is exposed. Do the same on the other end.

④. Then use two spoon wrenches to tighten the caps at the same time. Turn the elastic membrane over again, do the same at the other end, and then fix the elastic membrane with electrical tape at the position of the O-ring.

⑤. Finally put on the outer membrane, and then fix the outer membrane with electrical tape on both ends. You can apply a small amount of silicone grease on the shield and electrical tape. Push the two shields to the probe to expose the threads, then screw on the knurled nut, and tighten at the same time with a hook wrench. After tightening, the screw thread is exposed 14mm, and the middle distance of the shield is 410mm. (Note that the outer membrane of the sheath cannot be protruding or twisted)

6. Replace the visual inspection tube

First open the back cover of the instrument main unit to take out the spare visual inspection tube, and then lay the main unit flat and remove the visual inspection tube cover. Loosen the nuts on both ends of the visual inspection tube, take out the visual inspection tube, and then trim the length of the spare visual inspection tube according to the visual inspection tube on the equipment, and install the it. Reinstall the other parts in the reverse process. Be careful not to overtighten the nuts on both ends.

IX. Factory Inspection standard

The PY series pressuremeters must be inspected before they leave the factory, and the products can be delivered only after they pass the inspection standards. The main inspection items are as follows:

1. Stability: Under various working pressure levels, the allowable passive value is less than or equal to 0.0025Mpa within 1 minute of initial adjustment.

2. Tightness: Under the rated working pressure, cut off the gas source to test the pressure for 4 hours, the pressure drop of the instrument is less than or equal to 0.1Mpa.

3. Pressure regulation value:

NO.	Model	Maximum adjustable pressure value
1	PY-3	Not less than 2.5Mpa
2	PY-4	Not less than 4.0Mpa
3	PY-5	Not less than 5.5Mpa

4. Water injection: When the water injection pressure is less than 0.05Mpa, the working chamber and circuit should be filled within 5 minutes.

5. Water tank cleanliness: There should be no debris in the water tank that will block the pipeline and affect the transparency of the measuring tube.

6. The pressure resistance of the pipe of the quick connector box:

NO.	Model	Pressure resistance of the pipe
1	PY-3	Not less than 2.5Mpa
2	PY-4	Not less than 4.0Mpa
3	PY-5	Not less than 5.5Mpa

X. Cautions

Before use, you must first be familiar with the basic principles of the instrument, the piping diagram and the role of each valve, so as to avoid operating errors.

The test needs to be started immediately after the drilling is completed, and the time interval between them should not be too long. The test section must be on the same soil layer and must not

span two or more soil layers. Otherwise, not only the data is difficult to apply, but also when the softness of the upper and lower layers is very different, it will cause the rupture of the elastic membrane in the test.

When filling water, the water level of the measuring tube cannot cross the highest scale line to prevent water from entering the pressure regulating valve and pressure gauge, which will affect the accuracy of the test.

Impurity water shall not be used for the test water. Distilled water or cold boiled water should be used, otherwise the clarity of the measuring tube will be reduced by dirt deposits on the wall of the measuring tube.

The pressure side device cannot be placed naked, and should be placed in the calibration cylinder when it is not tested to prevent the elastic membrane from being pierced by gravel or other hard sharp objects.

After the quick connector is removed, the protective film should be covered immediately to prevent mud and sand from entering the pipeline and causing damage to the instrument.

The pressure regulating valve shall not be disassembled arbitrarily to prevent the accuracy from decreasing.

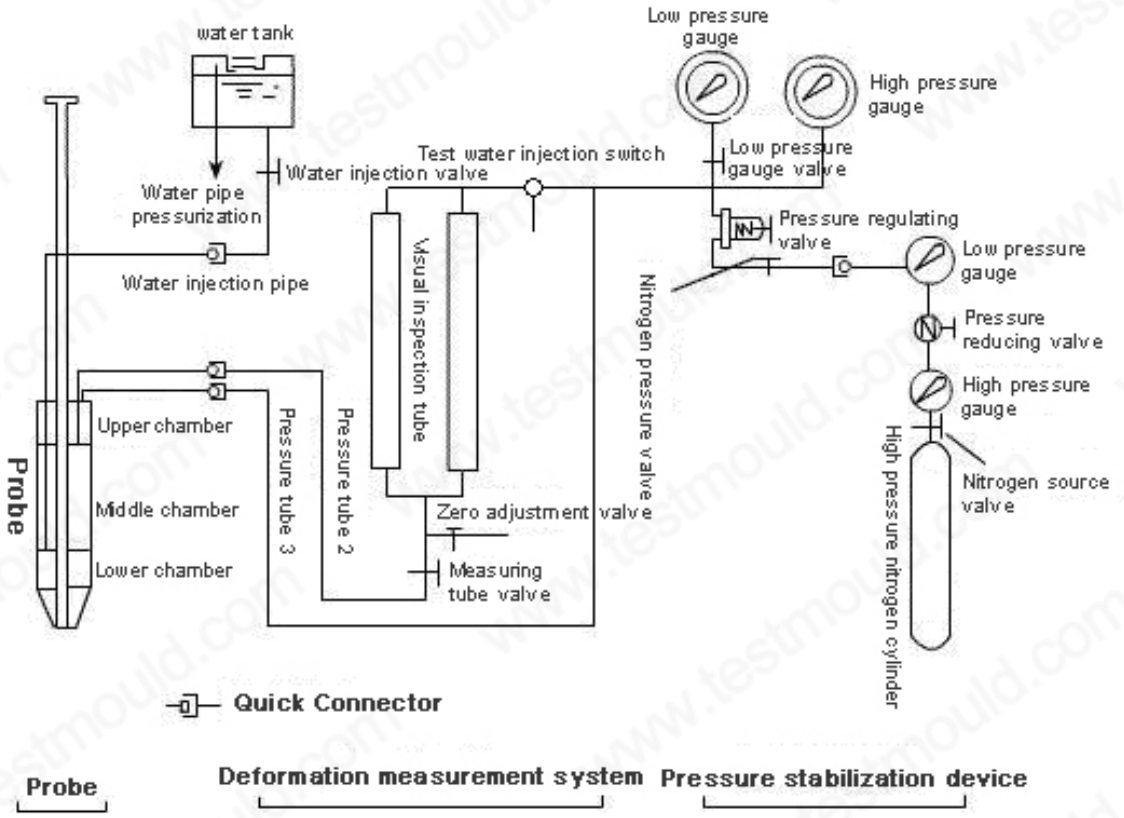
At the end of the test, in order to return the water in the probe to the water tank, the safety valve cover of the water tank must be opened before opening the water injection valve to prevent high-pressure gas from entering the water tank and causing the water tank to burst.

Pay attention to shockproof during transportation to avoid damage to the instrument.

Before the instrument is moved or transported after maintenance, in order to keep the main spring of the pressure regulating valve from shifting and to ensure that the pressure regulating valve works normally, it is advisable to tighten the pressure regulating valve handle slightly to make the spring slightly stressed, and then open it before the next operation.

(Note: The operation method provided in this manual is for reference only, and the user can make other orders or refer to relevant domestic regulations according to their needs)

Appendix 1 Piping Diagram of Pressuremeter



Appendix 2 Main Factors Affecting the Test Accuracy

Borehole quality

The borehole in the test section should be round, vertical and smooth, and the wall of the borehole should not be disturbed. The diameter of the hole should not be too large or too small, and it should be 2~8mm larger than the outside diameter of the probe;

When drilling with large-diameter drilling tools, the hole must be drilled from a position not less than 1m above the test section according to the requirements of the test section, and the test must be carried out immediately after completion;

For the soil with poor stability or the possibility of shrinkage holes, mud wall protection should be adopted. Rotary drilling rigs can be used to drill soft rock and weathered rock;

When carrying out the pressuremeter test, it must be ensured that the three chambers of the probe are in the same soil layer, and must not be carried out at the location where the soil has been sampled or the standard penetration test has been carried out;

For the same hole, a test shall be carried out for each section of drilling, and the tests shall be carried out successively from top to bottom. Because if a hole is formed at one time, practice has proved that the soil structure will be disturbed, which will affect the quality of the test results.

Pressurization method

It can be considered from both the pressure level and the pressure rate.

①. The pressure level is generally determined by the level of 1/8~1/12 of the estimated plastic pressure;

②. The pressurization rate reflects different test conditions, such as drained and undrained. Practice has proved that: different pressurization rates have less impact on the plastic pressure, but have a greater impact on the ultimate pressure.

Structure and specifications of probe

The effective length (L) and diameter (D) ratio of the probe are the key parameters for the design of the probe. When L/D=4~10, the soil deformation is approximately cylindrical;

When the effective aspect ratio of the single-chamber probe is 10, there is not much difference between the results of the deformation modulus obtained by the three-chamber probe. However, the plastic pressure and ultimate pressure of the single-chamber type are relatively small.

The influence of the critical depth of the pressuremeter test

In a homogeneous soil layer, the plastic pressure and ultimate pressure gradually increase from the surface downward, and when they exceed a certain depth, they approach a constant value. A certain depth on the surface of this soil layer is called the critical depth;

It is obvious in sand, and the critical depth increases with the increase of sand density, generally 1~3m;

Within the critical depth, because the ground is an open surface, the soil can produce more obvious vertical deformation. Below the critical depth, the vertical deformation is restricted due to the increased pressure of the overlying soil, and basically only the radial deformation.

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