

# P3100 & P3200 Series

Hydraulic Deadweight Tester

Users Manual

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# Chapter 1

## General Information

### **Introduction**

This manual covers the following pressure instruments:

Oil Operated Instruments: P3111, P3112, P3113, P3114, P3115, P3116, P3123, P3124, and P3125.

Distilled Water Operated Instruments: P3211, P3213, P3214, P3223, and P3224.

### **How to Contact Fluke**

To order accessories, receive operating assistance, or get the location of the nearest Fluke distributor or Service Center, call:

- Technical Support USA: 1-800-99-FLUKE (1-800-993-5853)
- Calibration/Repair USA: 1-888-99-FLUKE (1-888-993-5853)
- Canada: 1-800-36-FLUKE (1-800-363-5853)
- Europe: +31-402-675-200
- China: +86-400-810-3435
- Japan: +81-3-3434-0181
- Singapore: +65-738-5655
- Anywhere in the world: +1-425-446-5500

Or, visit Fluke's website at [www.fluke.com](http://www.fluke.com).

To register your product, visit <http://register.fluke.com>.

To view, print, or download the latest manual supplement, visit <http://us.fluke.com/usen/support/manuals>.

## Safety Information

### Safety Summary

The following are general safety precautions that are not related to any specific procedures and do not appear elsewhere in this publication. These are recommended precautions that personnel must understand and apply during equipment operation and maintenance to ensure safety and health and protection of property.

#### Warning

**If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.**

### Compressed Liquid

Use of compressed liquids can create an environment of propelled foreign matter. Pressure system safety precautions apply to all ranges of pressure. Care must be taken during testing to ensure that all hydraulic connections are properly and tightly made prior to applying pressure. Personnel must wear eye protection to prevent injury.

### Heavy Weights

Lifting and movement of heavy weights can create an environment of strain and impact hazards. Care must be taken during testing to ensure that weight masses are lifted in a manner that avoids over-reaching or twisting, and that the masses are not dropped. Personnel must wear reinforced safety shoes to prevent injury.

### Personal Protective Equipment






Wear eye protection and reinforced safety shoes approved for the materials and tools being used.

## Symbols Used in this Manual

In this manual, a **Warning** identifies conditions and actions that pose a hazard to the user. A **Caution** identifies conditions and actions that may damage the Hydraulic Deadweight Tester

Symbols used on the Hydraulic Deadweight Tester and in this manual are explained in Table 1-1.

Table 1-1. Symbols

Symbol	Description
	AC (Alternating Current)
	Earth Ground
	Important Information: refer to manual
	Shock Hazard
	Do not dispose of this product as unsorted municipal waste. Go to Fluke's website for recycling information.

## Operating Principle

Deadweight Testers are the primary standard for pressure measurement. Utilizing the well-proven Piston-Gauge system, consisting of a vertically mounted, precision lapped Piston and Cylinder assembly, accurately calibrated weight masses (Force) are loaded on the piston (Area), which rises freely within its cylinder. These weights balance the upward force created by the pressure within the system.

$$PRESSURE = \frac{FORCE}{AREA}$$

Each weight is marked with the tester serial number, and the pressure measured when placed on a correctly spinning and floating piston. The total pressure measured is the summation of the weights plus the piston weight carrier assembly.

The schematic diagram below shows the basic hydraulic circuit for a dual-PCU (Piston Cylinder Unit) instrument.

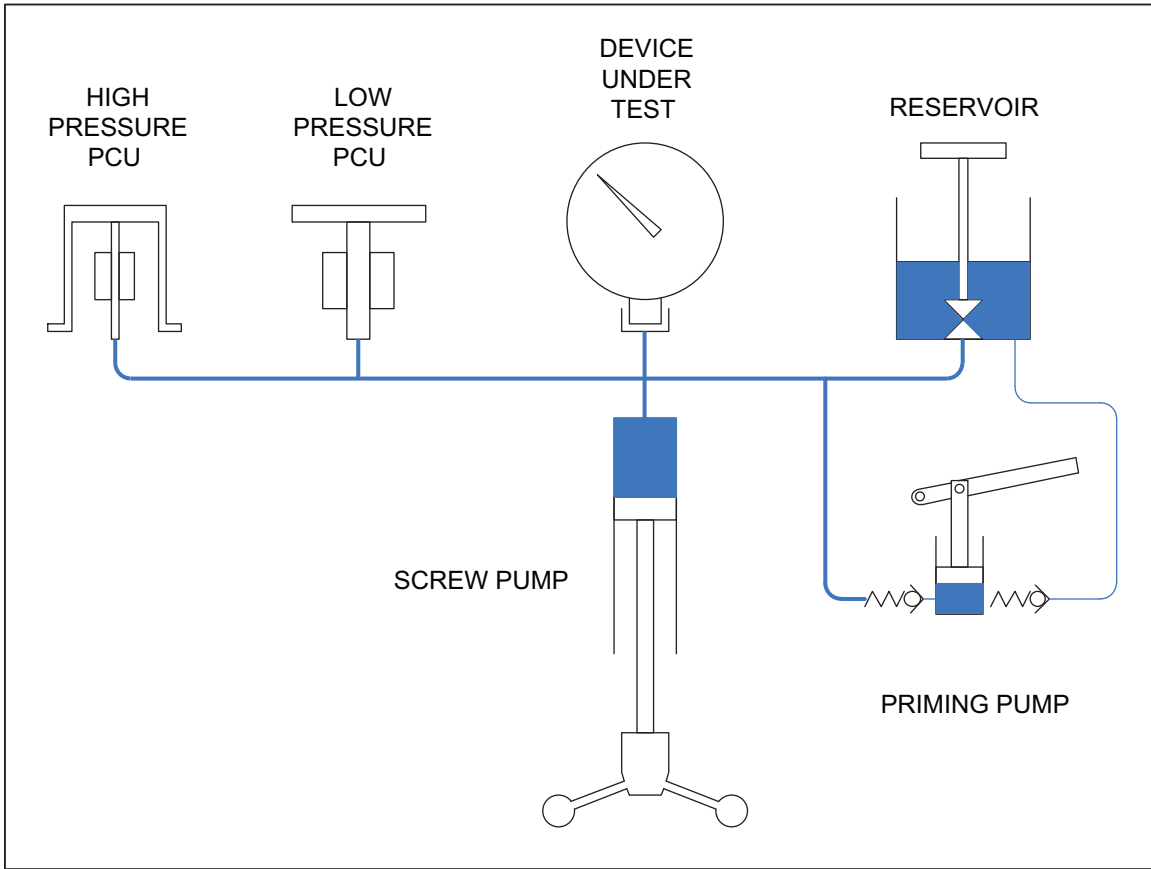
The system is primed with liquid from the Reservoir, and the system pressure is increased by means of the Screw Pump. As liquids are considered incompressible, the displaced liquid causes the pistons to rise within their cylinders to balance the downward force of the weights.

Fluids at the same height in a system are at the same pressure, so when the system is in equilibrium (i.e. the piston and weights are floating freely, rotating and falling at its natural sink-rate), the pressure generated by the combined mass of the piston and weights equals the pressure within the device under test.

The design of a Piston/Cylinder Unit (PCU) fitted to a deadweight tester allows for a very small clearance gap between the piston and cylinder. This is required to allow the working fluid to pass between the components, providing a lubricating film, and preventing metal-to-metal contact.

Therefore, during the normal operation of a deadweight tester, the working fluid in the system will slowly pass through this clearance gap. This is perfectly normal, and there are Sump Rings around the piston bodies to collect the excess fluid.

Although calibration is carried out using one PCU at a time, there is a point during normal operation of a dual-PCU instrument where both PCUs will rise. This is due to the overlap in pressure range of the two PCUs. The PCU that is not in use will seal in the fully extended position to avoid additional fluid loss.



gjn001.eps

**Figure 1-1. Hydraulic Circuit Schematic**

Operating & Storage Specification are as follows:

Temperature and relative humidity ranges for operation and storage of the deadweight tester.

**Table 1-2. Operation and Storage Specifications**

	<b>Operation</b>	<b>Storage</b>
<b>Temperature</b>	18 to 28 °C 64 to 82 °F	10 to 50 °C 50 to 122 °F
<b>Relative Humidity (Non-Condensing)</b>	20 to 75 %	0 to 90 %

## Environmental Corrections

The deadweight tester has been calibrated to the Gravity, Temperature, and Air Density stated on the certificate.

Equations and factors are given on the certificate to adjust for any variations in these environmental conditions.

### Gravity

Gravity varies greatly with geographic location, and so will the deadweight tester reading.

Due to the significant change in gravity throughout the world (0.5%), ensure that the tester has either been manufactured to your local gravity, or that you have applied the correction from the calibrated gravity.

Example:

Deadweight Tester calibrated gravity	980.665 cm/s <sup>2</sup>
(980.665 cm/s <sup>2</sup> is the International Standard Gravity)	
Gravity at site	981.235 cm/s <sup>2</sup>
Indicated Pressure	250 psi

$$TRUE\ PRESSURE = \frac{981.235}{980.665} \times 250$$

$$TRUE\ PRESSURE = 250.1453\ psi$$

The ability to determine the local gravity value will depend on the data available in the country that the instrument is to be used in. Some countries have geographic/geological survey/mapping organizations that have the data readily available. If not, the countries' National Standards Laboratory may be able to recommend a source of suitable information.

### Temperature

Temperature and Air Density variations are less significant than gravity.

Variations should be corrected for when maximum accuracy is required.

Temperature variation example:

Deadweight Tester calibrated temperature	20°C
Operating temperature	24°C
Percentage change per °C	0.002%
Indicated Pressure	250 psi

$$TRUE\ PRESSURE = 250 + (20 - 24) \times \frac{0.002}{100} \times 250$$

$$TRUE\ PRESSURE = 249.98\ psi$$

### **Head of Fluid**

The pressure measured is at the top of the test port seal.

Vertical height difference between this datum point and the connection to the instrument under test should be corrected for. To correct for vertical heights above and below the datum line, either subtract or add respectively, the amount stated on the certificate.

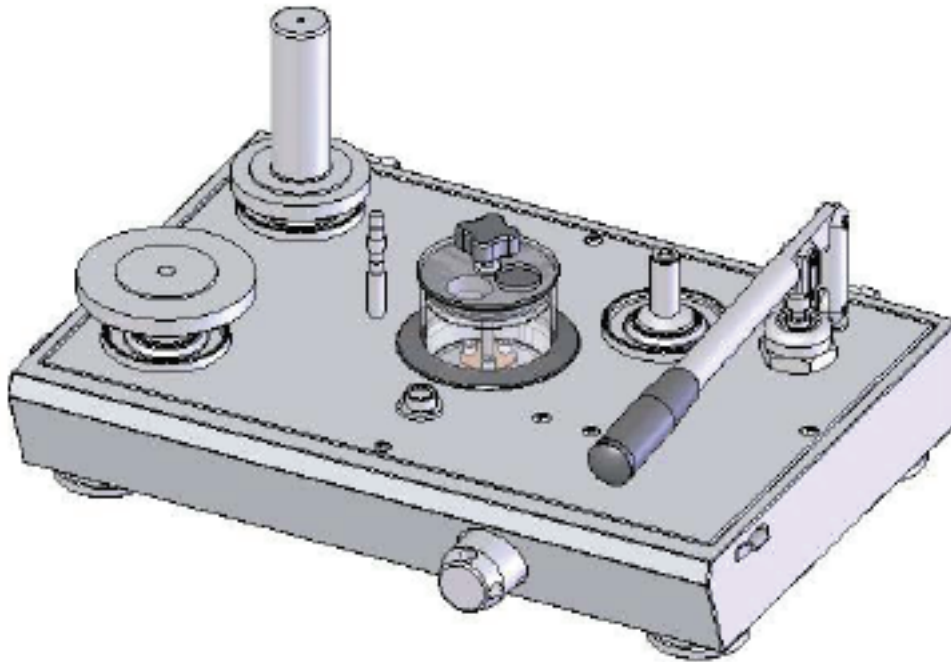
To ensure accuracy is maintained, the piston and weights must be kept clean and undamaged. The tester is accurate when the piston and weights are floating and rotating freely.

### **Model Variations**

This manual covers many pressure ranges and models within the P3100 and P3200 series of instruments.

The following illustrations detail the physical appearance of the three basic models:

Models: 3123, 3124, 3125, 3223 and 3224.

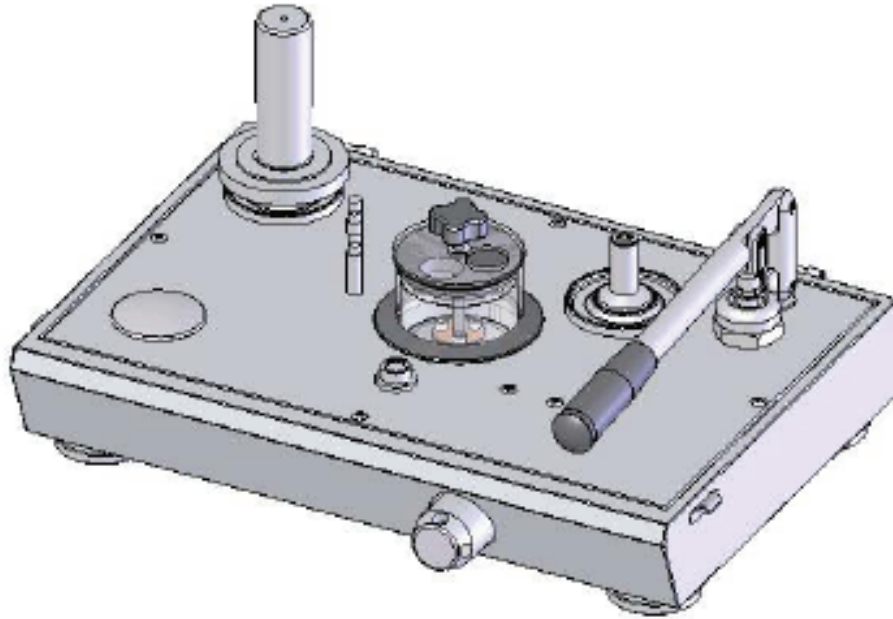


**Figure 1-2. Dual PCU Instrument**

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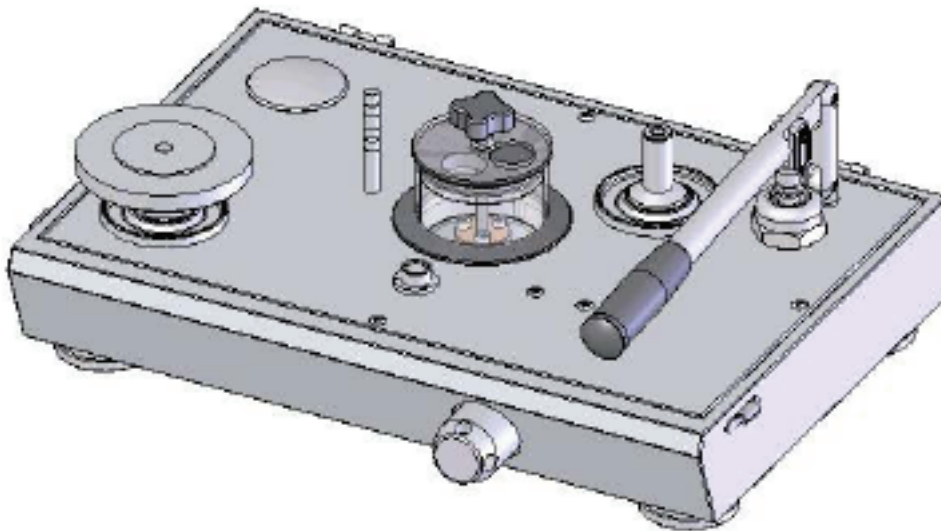
Models: 3112, 3113, 3114, 3115, 3116, 3213, and 3214.



**Figure 1-3. Single High Pressure PCU Instrument**

gjn004.bmp

Models: 3111 and 3211.



**Figure 1-4. Single Low Pressure PCU Instrument**

gjn005.bmp



# Chapter 2

## Preparation

### Introduction

The deadweight tester must be set up on a level, stable workbench or similar surface.

Remove spokes from tool roll and fit to capstan hub.

Level the tester using the four adjustable feet to the bubble level attached to the top plate.

Rotate reservoir dust cover through  $\frac{1}{4}$  turn and fill reservoir approximately  $\frac{3}{4}$  full with the appropriate fluid. Rotate dust cover back to cover hole.

### Operating Fluid

Oil: The instrument is supplied with Shell Spindle Oil 22, our reference 55-655.

Water: Only **Distilled** or **De-ionized Water** should be used in the instrument. Great care must be taken when operating any deadweight tester that uses water as its operating fluid, as any contamination present within the system will result in degradation of performance, and eventual irreparable damage to the PCUs. The impurities found in ordinary water supplies are sufficient to affect the spin and sensitivity of the PCU assemblies, and damage the PCUs.

#### Warning

**The system is designed for use with the fluids described above only; use of other fluids can effect the operation and performance of the instrument, and CAN CAUSE PERMANENT DAMAGE.**

**To avoid damage to the instrument, the operator should check the quality of the operating fluid during use. If the fluid becomes discolored, cloudy or particles appear in the reservoir, the system should be drained and flushed with clean fluid.**

**If the device under test (DUT) is from a system operating on different fluid from that of the deadweight tester, the Liquid Separator, P5521, can be mounted to the test port of the deadweight tester. This will allow the calibration of the DUT in its normal operating fluid, and prevent cross-contamination of the system, (See Chapter 9, Ancillary Equipment, Liquid Separator).**

## Connections

Fit the device under test (DUT) to the test port using the method described below:

### ⚠ Caution

**Ensure that all devices are internally clean and free from contamination before connecting to the tester.**

**Particle contamination can damage the sensitive piston assemblies, valve seats and screw pump.**

**To avoid cross-contamination from other fluids, and protect the system from particulates, we recommend the use of a Liquid-to-Liquid Separator (see Chapter 7, Ancillary Equipment).**

### ⚠ Warning

**DO NOT use Teflon/PTFE tape on these connections, as this will prevent correct sealing. The Gauge Adapter sealing system is designed for hand-tight sealing up to 20,000 psi / 1,400 bar—wrenches or similar tools are not required—over tightening can cause damage to threads or sealing faces.**

**Before connection, ensure that there is an O-ring fitted to the test port.**

**Check that the sealing face of the device to be fitted is clean and undamaged, as scratches or dents can form leak-paths.**

### *Note*

*The thread on the test port, and the lower part of the gauge adapters is LEFT-HANDED. The following procedure details the correct method for mounting devices using these adapters:*

1. Screw the appropriate gauge adapter fully on to the instrument to be tested.

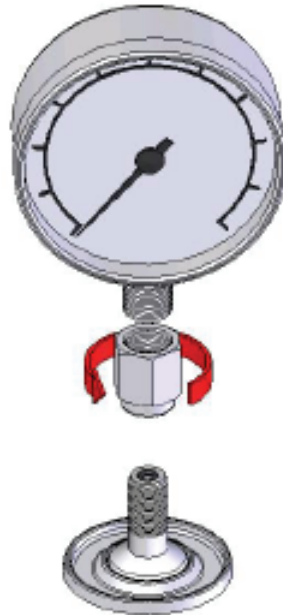


Figure 2-1. Screw on Gauge Adapter

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2. Screw assembly down COUNTER-CLOCKWISE on to test port.

*Note*

*Hand-tight is sufficient; ensure that the bottom face contacts the O-ring on the test port.*



**Figure 2-2. Making Pressure Connections**

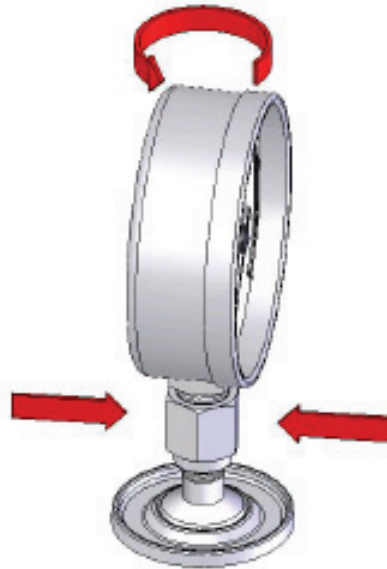
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**Figure 2-3. Adjusting Pressure Connections**

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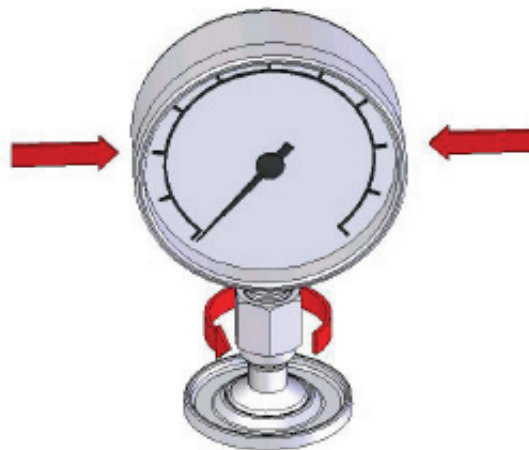
3. To adjust the position to face forward, hold the gauge adapter and turn the instrument COUNTER-CLOCKWISE, so that it faces forward.



**Figure 2-4. Adjust Gauge Position**

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4. Hold the instrument steady, while turning the gauge adapter COUNTER-CLOCKWISE until it pulls down onto the O-ring.



**Figure 2-5. Tighten Gauge**

gjn010.bmp

### **Test Port Insert**

For devices with 1/8 BSP or NPT mounting threads, the diameter of the thread is very close to the effective sealing diameter of the O-ring fitted to the test port.

This can make it difficult to achieve a good seal. When mounting these devices, use the test port insert (stored in the spare seals container) as shown in Figure 2-6.

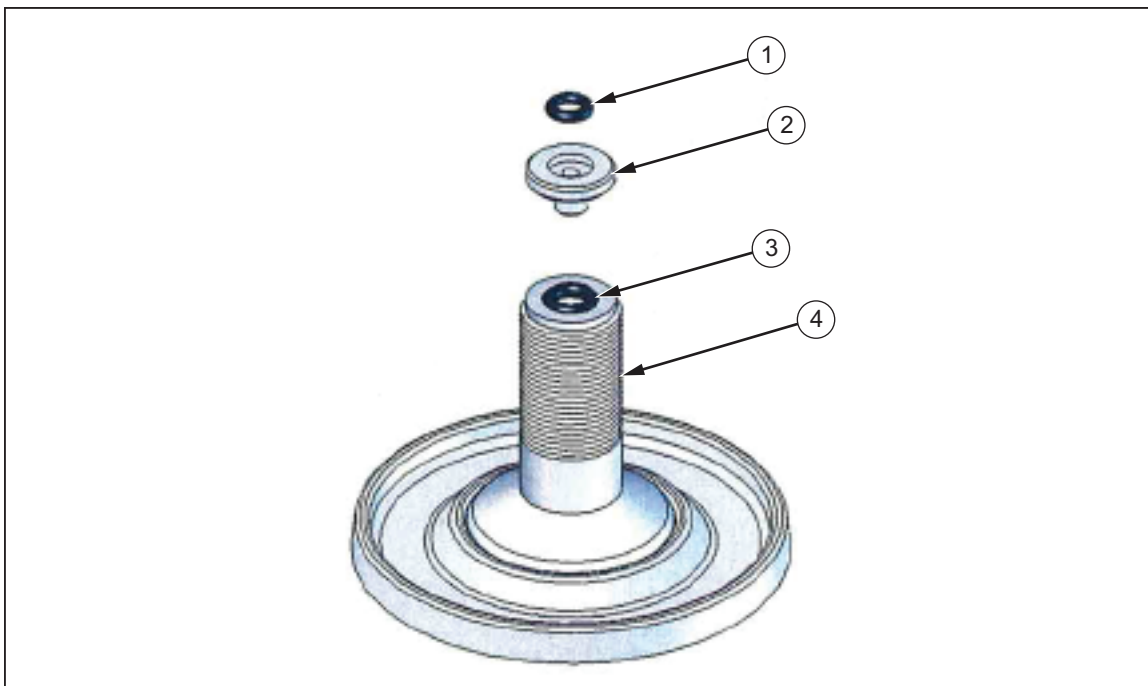


Figure 2-6. Test Port Insert

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Table 2-1. Test Port Insert Parts List

Item	Description	Part
1	O RING	3865142
2	TEST PORT INSERT	3919892
3	O RING	3883397
4	TEST PORT	3921414

To calibrate panel-mounted gauges with pressure connections in the rear, use an Angle Adapter (Refer to Chapter 9, Ancillary Equipment).





## Chapter 3

# Priming

### Priming

1. Open reservoir valve one turn counter-clockwise and turn capstan fully in.
2. Pump the priming pump two times.
3. Close valve and turn capstan fully out.
4. Open valve and turn capstan fully in.

#### *Note*

*During this operation, bubbles may appear in the reservoir, as trapped air is expelled. For large volumes, repeat steps 3 and 4 until no further bubbles appear.*

5. With valve open, turn capstan fully out and close valve. The tester is now ready for use.

#### **⚠ Warning**

**Turning the capstan out with the reservoir valve closed will generate approximately 15 inHg / 0.5 bar vacuum. If the DUT is vacuum sensitive, leave valve open during priming operation.**



# Chapter 4 Operation

## Operation

1. Select the required weights and stack them on the appropriate piston assembly. The pressure measured is the sum of the weights plus the piston/weight carrier.

Dual PCU models: The PCU's are matched in a ratio of effective areas, 20:1 or 10:1, depending upon model, and the weights will be marked accordingly with both high and low pressure values.

### Note

*The priming pump is intended for system priming only, and cannot be used to generate high pressures.*

2. Turn the capstan in (clockwise) to generate pressure. When the piston rises, ensure that the bottom face of the lowest weight is level with the groove, midway in the recessed area on the indicator post.

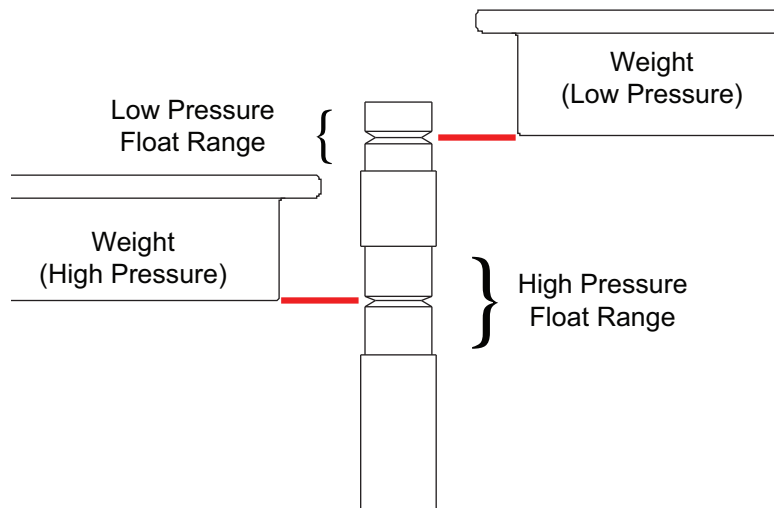


Figure 4-1. Float-Height Indicator Post

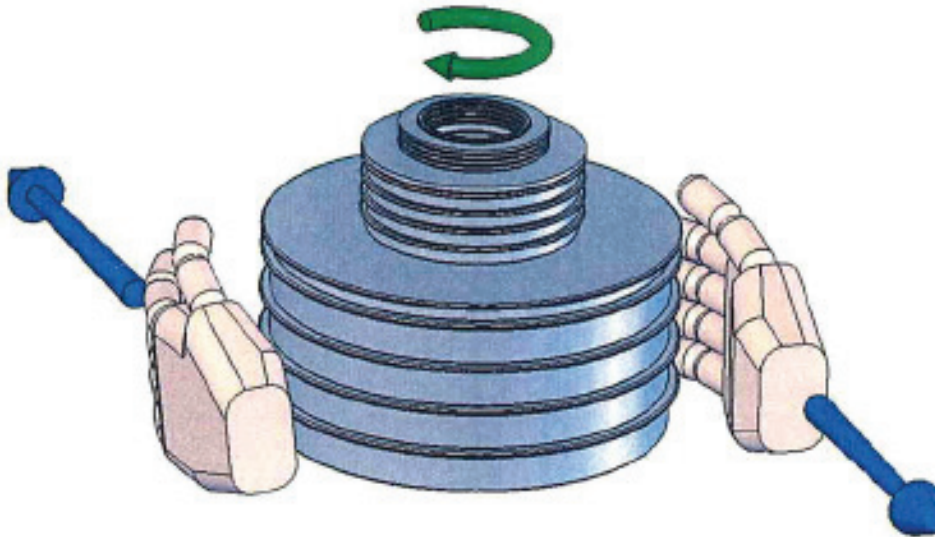
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### Note

*This is the PCU mid-float position, which is the point at which all internal corrections have been made with reference to the pressure datum (at the top of the test port). The recessed area is simply a guide for the operator to indicate the PCU travel limits.*

3. Gently rotate the weight stack clockwise, such that it is turning between approximately 10 and 60 rpm. Avoid side-loads when turning the weights by placing the palms of the hands on either side and “rolling” the stack by pulling in opposite directions, see Figure 4-2.

**DO NOT rotate weights when the piston is against the top or bottom limits of travel.**



**Figure 4-2. Weight Rotation**

gjn013.bmp

4. Allow a few moments for the system to stabilize before taking any readings, especially after large changes in system pressure.

*Note*

*Large, sudden changes in pressure will cause the system temperature to rise or fall, which can cause instrument readings to change as the fluid in the system expands or contracts, thus increasing or decreasing the pressure.*

5. For the next higher calibration point, repeat from step 1 above.
6. To measure reducing pressures, remove the necessary weights, and turn the capstan out so that the weight stack floats at the correct height, then rotate clockwise.
7. Depressurize the system by turning the capstan FULLY OUT.

**⚠ Caution**

**Never release the system pressure without turning the capstan fully out, as sudden depressurization will cause the weight stack to fall quickly, which may damage the piston assembly.**

8. Remove weight stack.

*Note*

*The design of a Piston/Cylinder Unit (PCU) fitted to a deadweight tester allows for a very small clearance gap between the piston and cylinder. This is required to allow the working fluid to pass between the components, providing a lubricating film, and preventing metal-to-metal contact. Therefore, during the normal operation of a deadweight tester, the working fluid in the system will be slowly passed through this clearance gap. This is perfectly normal, and does not mean that the system is leaking. However, over time, it will collect and run down the side of the PCU mounting bodies.*

*The design of this instrument includes Sump Rings around the base of the PCU mounting bodies to collect the excess fluid—these should be wiped clean periodically to avoid overflowing on to the instrument top plate. The sump ring is also fitted at the base of the test station, as it is common for fluid to fall from the DUT when it is disconnected from the instrument after calibration. This should also be kept clean to prevent spills on the top plate.*

Correct Operation of Water-Operated Instruments (3200 Series):

**⚠ Caution**

**To avoid damage to the sensitive PCUs, it is vital to ensure that there is a continuous film of water between piston and cylinder.**

**Due to the very close fit of these components, the water film can break down very quickly after use, due to evaporation, surface tension and capillary action effects.**

Before using the instrument after a period of inactivity:

- Low Pressure: Hold the weight carrier table and gently lift the piston assembly vertically, slowly turning to check for freedom of movement.
- High Pressure: Lift off the weight carrier tube assembly. Hold the piston cap and gently lift the piston assembly vertically, slowly turning to check for freedom of movement.

**⚠ Caution**

**UNDER NO CIRCUMSTANCES should excessive force be used on the piston assembly as this may lead to permanent damage. IT SHOULD NEVER be forced, or pulled, in such a way that a bending movement is applied to it.**

- To aid in piston lubrication and movement, it is sometimes helpful to gently pressurize the system to a maximum of 15 psi/1 bar.
- If any resistance or “grittiness” is felt, the PCU has either dried out too much to use in its current condition or the system has been contaminated. In either case, the PCU must be removed and dismantled for cleaning, see Chapter 6.

If, after cleaning, the PCU’s performance deteriorates quickly, it confirms that the system is contaminated. If this is the case, the instrument must be completely dismantled and cleaned before further operation of the PCU assembly.



# Chapter 5

## ***Calibration in Different Pressure Units***

### ***Calibration in Different Pressure Units***

The deadweight tester can be used to calibrate in different pressure units in either of two methods.

#### ***Conversion Weights***

A set of Conversion Weights can be supplied, marked in the required pressure unit, and adjusted to the correct mass for use with the existing piston(s).

The set includes (where applicable) a replacement low-pressure weight carrier table, and a replacement high-pressure weight carrier ring. These items are simply exchanged for the original items when using the conversion weights. Calibration is carried out as described above, with logical pressure increments throughout the operating range, avoiding the need to perform pressure unit conversion calculations.

#### ***Software***

PressCal software is available for use with deadweight testers, and will allow users to apply all necessary corrections (e.g. local gravity, temperature, pressure head, etc.) to enhance the pressure measurement accuracy of the instrument.

It will allow calibration in any of 12 different pressure units, using the existing weight set.





# Chapter 6

## Maintenance and Servicing

### Maintenance and Servicing

#### Note

*The piston/cylinder assembly is the most critical and sensitive part of the deadweight tester. To maintain accuracy, the piston must always slide freely in the cylinder, and the hydraulic fluid must remain clean.*

The Figures on the following pages detail the components of each assembly, together with the relevant part numbers. Where “Spec” appears as a part number, this indicates that this particular component varies with the specification of the deadweight tester, and is usually associated with other components in an assembly for replacement purposes.

#### PCU Assembly - 10 mm Nominal Diameter

##### Piston Disassembly

1. Hold the weight carrier (1), and lift the piston to its full extent. Tap the carrier sharply down onto the cylinder (2) to release the tapered fit between the piston and carrier. Remove the weight carrier.
2. Unscrew the PCU assembly from the instrument; use the dowel hole if the cylinder is tight.
3. Carefully withdraw the piston from the cylinder.
4. If required, lift support ring (4) from around o-ring (3), the o-ring can now be withdrawn from the piston.

##### Piston Cleaning

5. Use “non-fluffing”, non-abrasive, lint-free tissue or absorbent cloth. Hold the piston by the larger “head” end, and rub the tissue back and forth along its length.
6. To remove all traces of contamination (especially important with Water Operated Testers), the piston can be cleaned in a suitable solvent.

#### **⚠ Caution**

**O-ring seals (where fitted) are Nitrile rubber, and should not be immersed in solvents, as they will become damaged. They should be wiped carefully with a new tissue.**

7. After removal from the solvent, using a NEW tissue, repeat the cleaning procedure in step 5.

8. Place piston carefully on a NEW tissue where it will not be damaged while the cylinder is cleaned.

**⚠ Caution**

**Never touch the working surface of a clean piston with bare fingers—the natural oil in your skin can cause the piston and cylinder to stick.**

9. Wipe excess fluid from the outside surfaces of the cylinder (2).
10. Roll a NEW tissue into a tapered rod of appropriate size. Force the tissue through the cylinder bore while rotating. Ensure that the tissue is a tight fit inside the bore so that dirt and contamination is removed.
11. Repeat step 10 using a NEW tissue but from the opposite end of the cylinder.
12. Immerse the cylinder in a suitable, clean solvent, see note in step 6 above.
13. After removal from the solvent, using a NEW tissue, repeat the cleaning procedure in step 10 and 11.

**Piston Re-Assembly**

14. Replace the clean support ring (4) over the tapered end of the piston, followed by the O-ring (3). Slide the O-ring to the bottom of the piston so that it holds the support ring in place.
15. Holding the piston by the larger “head” end, dip the other end into a container of clean operating fluid, and transfer to the bore in the underside (threaded end) of the cylinder. Allow the fluid to run through the bore. Repeat this 2 or 3 times to ensure a good film of clean operating fluid exists in the cylinder bore.
16. Carefully introduce the piston into the underside of the cylinder, and push gently through (the piston will normally slide freely through due to its own weight).

**⚠ Caution**

**Never force the piston into its cylinder or damage will result.**

If resistance is felt, introduce more fluid. If resistance continues, re-clean piston, cylinder or both. If, after repeated cleaning, the piston still will not slide freely within the cylinder, then permanent damage may have occurred. In which case, the parts should be returned to the factory for evaluation or replacement.

17. Stand assembly upright on a clean, hard, stable surface. Ensure that the O-ring (3) and support ring (4) are both located centrally around the piston. Push the cylinder down so that the O-ring is forced evenly inside the support ring.
18. Ensure that the weight carrier (1) is clean (especially the central mounting hole), and place on the tapered end of the piston. Tap lightly using the palm of the hand to locate on the taper.
19. Carefully screw the assembly into the instrument, ensuring that the seal (6) is clean and undamaged, and correctly re-fitted.

*Replacement PCU Assembly*

**⚠ Caution**

The piston and cylinder assembly is a matched pair, which is calibrated and adjusted to a calculated mass figure. If, for any reason, the piston or cylinder becomes damaged, then the entire assembly must be replaced. The replacement assembly consists of the following components: Item numbers 1 through 5.

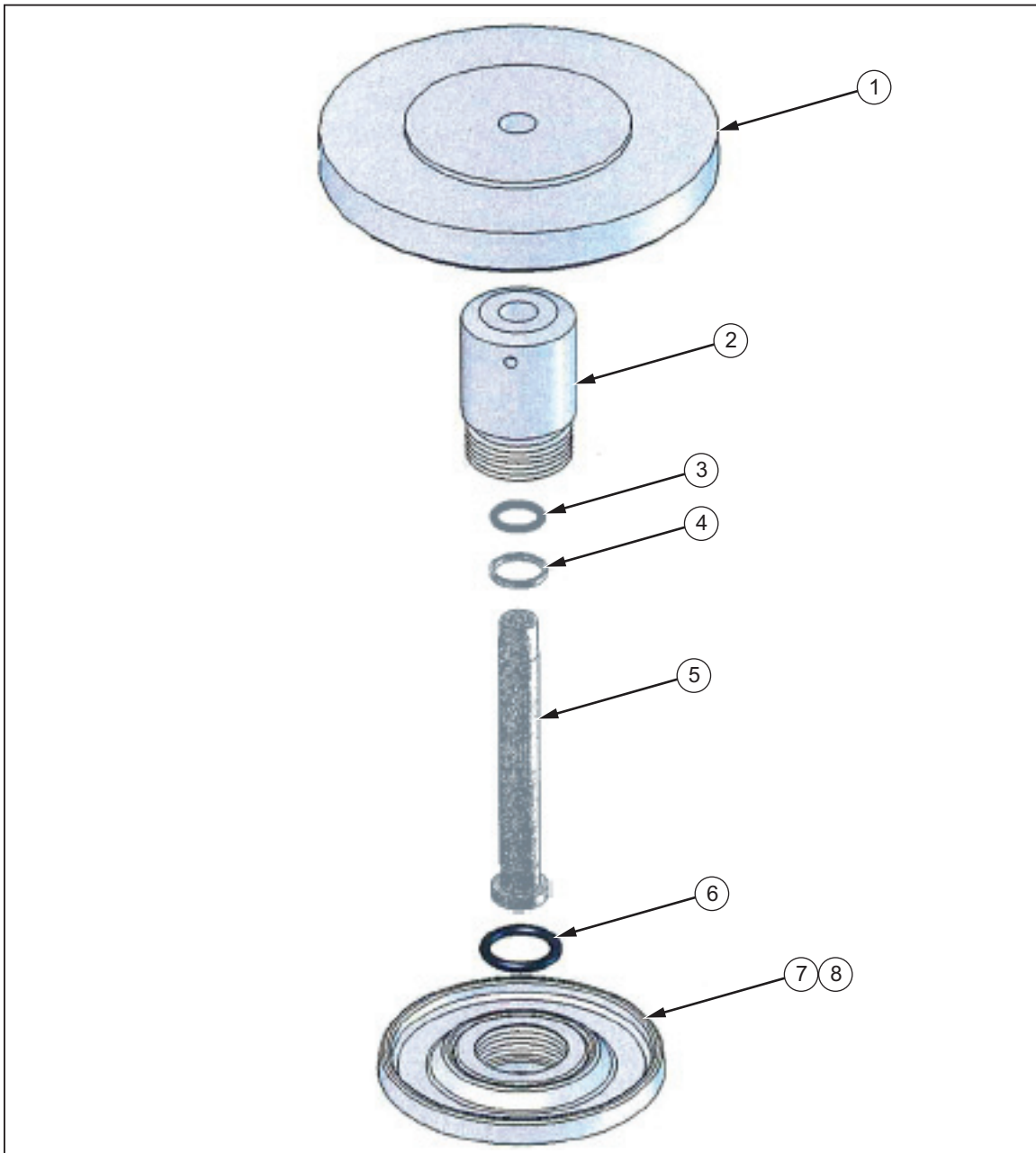


Figure 6-1. PCU Assembly - 10 mm

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**Table 6-1. PCU Assembly - 10 mm Parts List**

Item	Description	Part	Item	Description	Part
1	Weight Carrier	Spec	5	Piston	Spec
2	Cylinder	Spec	6	O Ring	3864802
3	O Ring	3867553	7	LP PCU Body	3921406
4	Support Ring	3918481	8	Sump Ring	3921391

**PCU Assembly - 2 & 3 mm Nominal Diameters**

**Piston Disassembly**

1. Lift off the weight carrier assembly (1 & 2), and unscrew the piston nut (5). Use the dowel hole if the nut is tight. Remove the piston/cylinder assembly.
2. Loosen set screw (3) in piston cap (4), and gently pull the piston cap from the piston. **DO NOT PULL IN SUCH A WAY THAT THE PISTON CAN BEND.** The piston and cylinder assembly (6, 7 & 8) can now be removed from the piston nut.
3. Gently withdraw the piston (8) from the cylinder (6).

**Piston Cleaning**

4. Use “non-fluffing”, non-abrasive, lint-free tissue or absorbent cloth. Hold the piston by the larger “head” end, and rub the tissue back and forth along its length.
5. To remove all traces of contamination (especially important with Water Operated Testers), the piston can be cleaned in a suitable solvent.

**⚠ Caution**

**O-ring seals (where fitted) are Nitrile rubber, and should not be immersed in solvents, as they will become damaged. They should be wiped carefully with a new tissue.**

6. After removal from the solvent, using a NEW tissue, repeat the cleaning procedure in step 2.
7. Place piston carefully on a NEW tissue where it will not be damaged while the cylinder is cleaned.

**⚠ Caution**

**Never touch the working surface of a clean piston with bare fingers—the natural oil in your skin can cause the piston and cylinder to stick.**

8. Wipe excess fluid from the outside surfaces of the cylinder (6).
9. Roll a NEW tissue into a tapered rod of appropriate size. Force the tissue through the cylinder bore whilst rotating. Ensure that the tissue is a tight fit inside the bore so that dirt and contamination is removed.
10. Repeat step 9, using a NEW tissue, but from the opposite end of the cylinder.
11. Immerse the cylinder in a suitable, clean solvent, see note in step 5 above.
12. After removal from the solvent, using a NEW tissue, repeat the cleaning procedure in step 9 and 10.

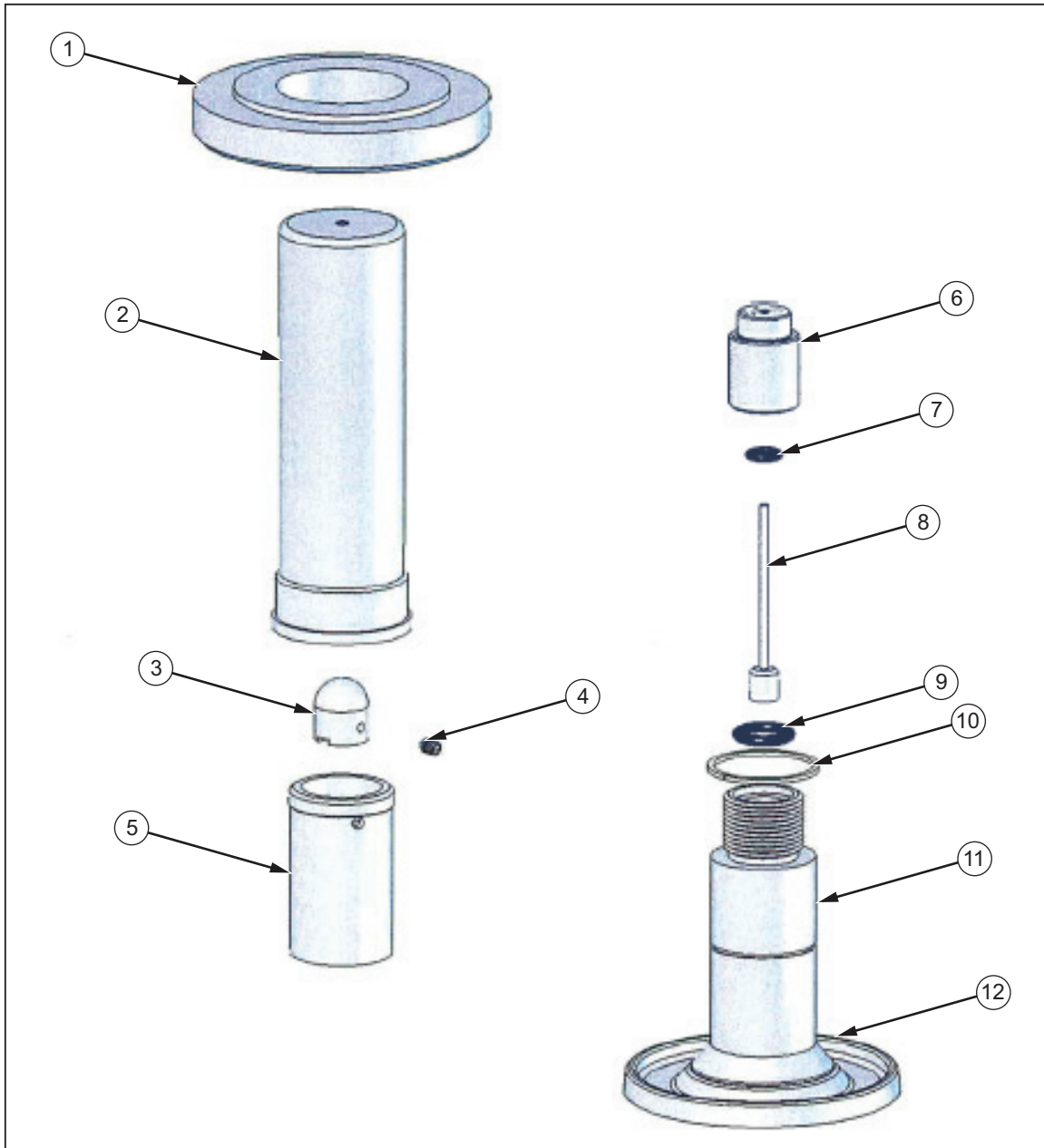
### *Piston Re-Assembly*

13. Replace O-ring (7) in the counter-bore in the underside of the cylinder (F), ensuring that it is located correctly and evenly.
14. Holding the piston by the larger “head” end, dip the other end into a container of clean operating fluid, and transfer to the bore in the underside of the cylinder. Allow the fluid to run through the bore. Repeat this 2 or 3 times to ensure a good film of clean operating fluid exists in the cylinder bore.
15. Carefully introduce the piston into the underside of the cylinder, and push gently through.
16. **NEVER FORCE THE PISTON INTO ITS CYLINDER OR DAMAGE WILL RESULT.** If resistance is felt, introduce more fluid. If resistance continues, re-clean piston, cylinder or both. If, after repeated cleaning, the piston still will not slide freely within the cylinder, then permanent damage may have occurred. In which case, the parts should be returned to the factory for evaluation or replacement.
17. Insert piston/cylinder assembly into piston nut (5) through the threaded end, such that the shoulder on the cylinder is located within the central bore of the nut.
18. Replace piston cap (4), and secure with set screw (3), **DO NOT OVER-TIGHTEN.**
19. Carefully screw the assembly into the instrument, ensuring that the o-ring (10) is clean and undamaged, and correctly fitted to the piston post (11).
20. Replace weight carrier assembly (1 & 2), ensuring that it locates correctly on the piston cap.

### *Replacement PCU Assembly*

#### **⚠ Caution**

**The piston and cylinder assembly is a matched pair, which is calibrated and adjusted to a calculated mass figure. If, for any reason, the piston or cylinder becomes damaged, then the entire assembly must be replaced. The replacement assembly consists of the following components: Item numbers 1 through 8.**



**Figure 6-2. PCU Assembly - 2 and 3 mm**

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**Table 6-2. PCU Assembly - 2 and 3 mm Parts List**

Item	Description	Part	Item	Description	Part
1	Carrier Ring	Spec	7	O Ring	3883397
2	Carrier Tube	Spec	8	Piston	Spec
3	Piston Cap	Spec	9	O Ring	3864782
4	Set Screw	3910313	10	Bearing Ring	3920186
5	Piston Nut	3919915	11	HP PCU Body	3921423
6	Cylinder	Spec	12	Sump Ring	3921391

## PCU Assembly - 5 mm Nominal Diameter

### Piston Disassembly

1. Lift off the weight carrier assembly (1 & 2), and unscrew the piston nut (5). Use the dowel hole if the nut is tight. Remove the piston/cylinder assembly.
2. Loosen set screw (3) in piston cap (4), and gently pull the piston cap from the piston. **DO NOT PULL IN SUCH A WAY THAT THE PISTON CAN BEND.** The piston and cylinder assembly (6 & 7) can now be removed from the piston nut.
3. Gently withdraw the piston (6) from the cylinder (7).

### Piston Cleaning

4. Use “non-fluffing”, non-abrasive, lint-free tissue or absorbent cloth. Hold the piston by the larger “head” end, and rub the tissue back and forth along its length.
5. To remove all traces of contamination (especially important with Water Operated Testers), the piston can be cleaned in a suitable solvent.

#### **⚠ Caution**

**O-ring seals (where fitted) are Nitrile rubber, and should not be immersed in solvents, as they will become damaged. They should be wiped carefully with a new tissue.**

6. After removal from the solvent, using a NEW tissue, repeat the cleaning procedure in step 5.
7. Place piston carefully on a NEW tissue where it will not be damaged while the cylinder is cleaned.

#### **⚠ Caution**

**Never touch the working surface of a clean piston with bare fingers — the natural oil in your skin can cause the piston and cylinder to stick.**

8. Wipe excess fluid from the outside surfaces of the cylinder (6).
9. Roll a NEW tissue into a tapered rod of appropriate size. Force the tissue through the cylinder bore whilst rotating. Ensure that the tissue is a tight fit inside the bore so that dirt and contamination is removed.
10. Repeat step 9, using a NEW tissue, but from the opposite end of the cylinder.
11. Immerse the cylinder in a suitable, clean solvent, see note in step 5 above.
12. After removal from the solvent, using a NEW tissue, repeat the cleaning procedure in steps 9 and 10.

### Piston Re-Assembly

13. Holding the piston by the larger “head” end, dip the other end into a container of clean operating fluid, and transfer to the bore in the underside of the cylinder. Allow the fluid to run through the bore. Repeat this 2 or 3 times to ensure a good film of clean operating fluid exists in the cylinder bore.
14. Carefully introduce the piston into the underside of the cylinder, and push gently through.
15. **NEVER FORCE THE PISTON INTO ITS CYLINDER OR DAMAGE WILL RESULT.** If resistance is felt, introduce more fluid. If resistance continues, re-clean piston, cylinder or both. If, after repeated cleaning, the piston still will not slide freely within the cylinder, then permanent damage may have occurred. In which case, the parts should be returned to the factory for evaluation or replacement.

16. Insert piston/cylinder assembly into piston nut (5) through the threaded end, such that the shoulder on the cylinder is located within the central bore of the nut.
17. Replace piston cap (4), and secure with set screw (3), DO NOT OVER-TIGHTEN.
18. Carefully screw the assembly into the instrument, ensuring that the o-ring (9) is clean and undamaged, and correctly fitted to the piston post (10).
19. Replace weight carrier assembly (1 & 2), ensuring that it locates correctly on the piston cap.

### *Replacement PCU Assembly*

#### **⚠ Caution**

**The piston and cylinder assembly is a matched pair, which is calibrated and adjusted to a calculated mass figure. If, for any reason, the piston or cylinder becomes damaged, then the entire assembly must be replaced. The replacement assembly consists of the following components: Item numbers 1 through 7.**



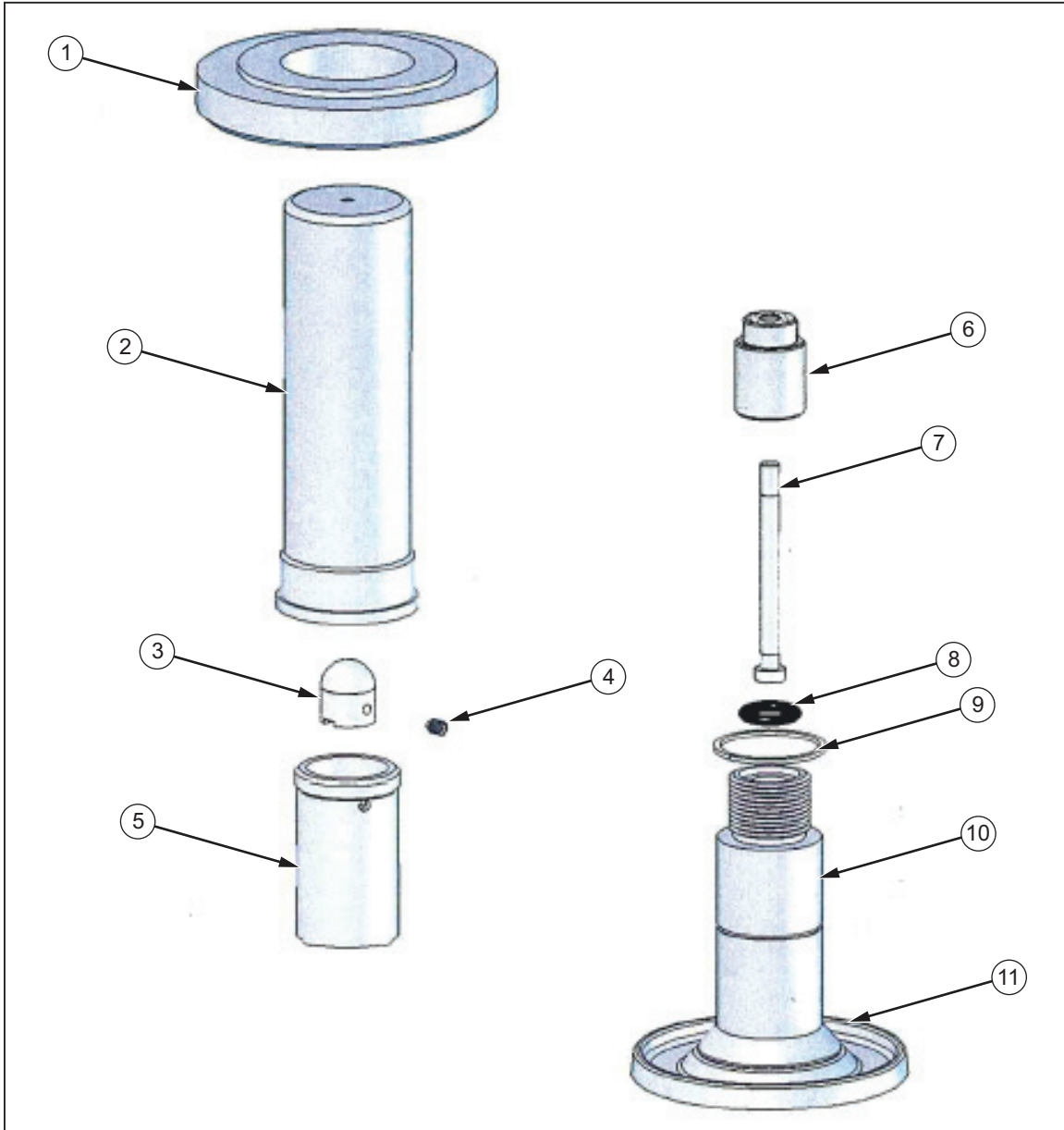


Figure 6-3. PCU Assembly - 5 mm

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Table 6-3. PCU Assembly - 5 mm Parts List

Item	Description	Part	Item	Description	Part
1	Carrier Ring	Spec	7	Piston	Spec
2	Carrier Tube	Spec	8	O Ring	3864782
3	Piston Cap	Spec	9	Bearing Ring	3920186
4	Set Screw	3910313	10	HP PCU Body	3921423
5	Piston Nut	3919915	11	Sump Ring	3921391
6	Cylinder	Spec			

## **Top Plate Removal**

### *Note*

*In order to perform maintenance procedures on the hydraulic system, the Top Plate Assembly must first be removed from the instrument case.*

1. Depressurize the system, open the reservoir valve, and turn the capstan fully in.
2. Disconnect any DUT from the test station, and remove the fluid from the reservoir\*.
3. Remove the spokes from the capstan hub of the screw pump.
4. Remove the 4 screws from the instrument top plate (1 at the mid-point of each edge).
5. Hold the top plate assembly by the test station, and tilt the plate so that the rear edge is lifted, but the front edge remains in contact with the instrument case.
6. Slide the top plate towards the rear until the capstan hub of the screw pump is clear of the front lip of the instrument case.
7. Lift out the top plate assembly.

\*The reservoir is fitted with a drain plug, which can be accessed from the underside of the instrument case (Refer to Chapter 6, Reservoir Assembly).

### **⚠ Caution**

**When handling the top plate assembly, it is good practice to remove the piston assemblies to avoid accidental damage.**

### *Note*

*Replacement is simply the reverse of the above procedure.*

## **Screw Pump Assembly**

1. Unscrew the large union nut (just behind the inner hub) of the screw press assembly.
2. Withdraw the lead screw assembly from the barrel (6), taking care not to drop the rambler assembly (3).
3. The white, anti-extrusion ring (4) is a PTFE spiral and can be removed by “unwinding” it from the rambler.
4. When removing the rambler seal (5), take care not to use any tool that may have a sharp edge that will scratch the surfaces of the rambler, otherwise it may leak when reassembled.
5. The replacement rambler seal can be eased over the front of the rambler, and into the groove.
6. Similarly, the new anti-extrusion ring can be “wound” into the groove in the rambler, behind the rambler seal.
7. If it is necessary to remove the barrel (6), the locknut (7) must be loosened approximately ½ turn. The barrel can then be unscrewed from the test station (9).

### *Note*

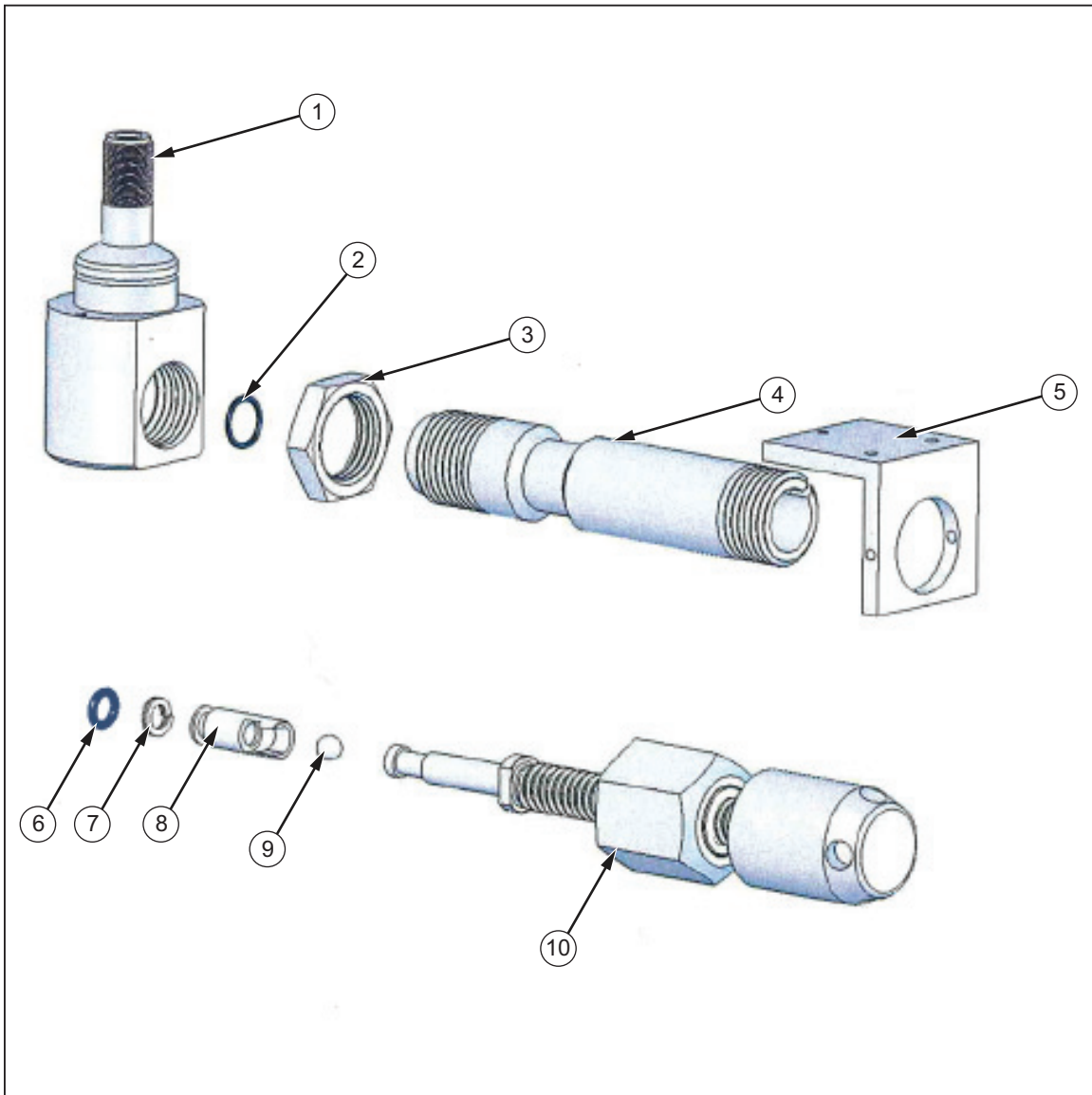
*It is often easier to remove the barrel support bracket (11) to allow greater movement, (remove the 2 screws (12) from the upper side of the top plate).*

8. Before re-fitting the barrel, ensure that the barrel seal (8) is correctly located in the counter-bore in the front of the barrel. Screw the barrel fully in to the test station, and secure with the locknut.
9. Re-align the barrel support bracket (if removed), and secure through the top plate with the 2 screws (12).

10. Ensure that the rambler assembly is correctly located on the end of the lead screw assembly. Carefully introduce the rambler into the open end of the barrel making sure that it does not tilt when entering the barrel.
11. Push the lead screw assembly fully in to the barrel, ensuring that the key in the nut locates correctly in the slot in the barrel.
12. Re-tighten the barrel union nut.

**⚠ Caution**

**If the lead screw assembly shows signs of excessive wear, then it is very likely that the associated components have worn also; therefore, the screw press assembly is available as a spare part. See diagrams for part numbers.**



**Figure 6-4. Screw Pump Assembly**

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**Table 6-4. Screw Pump Assembly Parts List**

Item	Description	Part	Item	Description	Part
1	Test Port	3921414	6	O Ring	3867566
2	O Ring	3864922	7	Back-Up Ring	3919118
3	Barrel Locknut	3921438	8	Rambler	3919129
4	Barrel	3921450	9	Ball	3917855
5	Barrel Support	3921492	10	Lead Screw	3885994

### **Priming Pump Assembly**

#### **Disassembly**

1. On the underside of the top plate, disconnect the hydraulic tubing from the pump block assembly (1).
2. On the upper side of the top plate, unscrew locknut (12) ½ turn, and remove clip pin from clevis (13).
3. The pump arm assembly can be swung out of the way.
4. Remove locknut (12) and clevis (13).
5. Unscrew union nut (11), and withdraw pump assembly from below the top plate.
6. Withdraw pump shaft (9), taking care not to drop shaft bearing (10) or rambler assembly (7).
7. The white, anti-extrusion ring (6) is a PTFE spiral and can be removed by “unwinding” it from the rambler.
8. When removing the rambler seal (5), take care not to use any tool that may have a sharp edge that will scratch the surfaces of the groove in the rambler, otherwise it may leak when reassembled.
9. The replacement rambler seal can be eased over the front of the rambler, and into the groove.
10. Similarly, the new anti-extrusion ring can be “wound” into the groove in the rambler, behind the rambler seal.
11. If it is necessary to remove the barrel (4), the locknut (2) must be loosened approximately ½ turn. The barrel can then be unscrewed from the pump block assembly (1).

#### **Re-Assembly**

1. Before re-fitting the barrel, ensure that the O-ring (3) is correctly located in the counter-bore in the front of the barrel. Screw the barrel fully into the test station, and secure with the locknut.
2. Ensure that the rambler assembly is correctly located on the end of the pump shaft. Carefully introduce the rambler into the open end of the barrel making sure that it does not tilt when entering the barrel.
3. Slide the pump bearing (10) over the shaft, and locate it inside the barrel.
4. Re-introduce the pump assembly from the underside of the top plate, and secure with the union nut (11).

5. Replace locknut (12) and clevis (13), reconnect pump arm assembly, and secure with pin clip.
6. Reconnect hydraulic tubing.

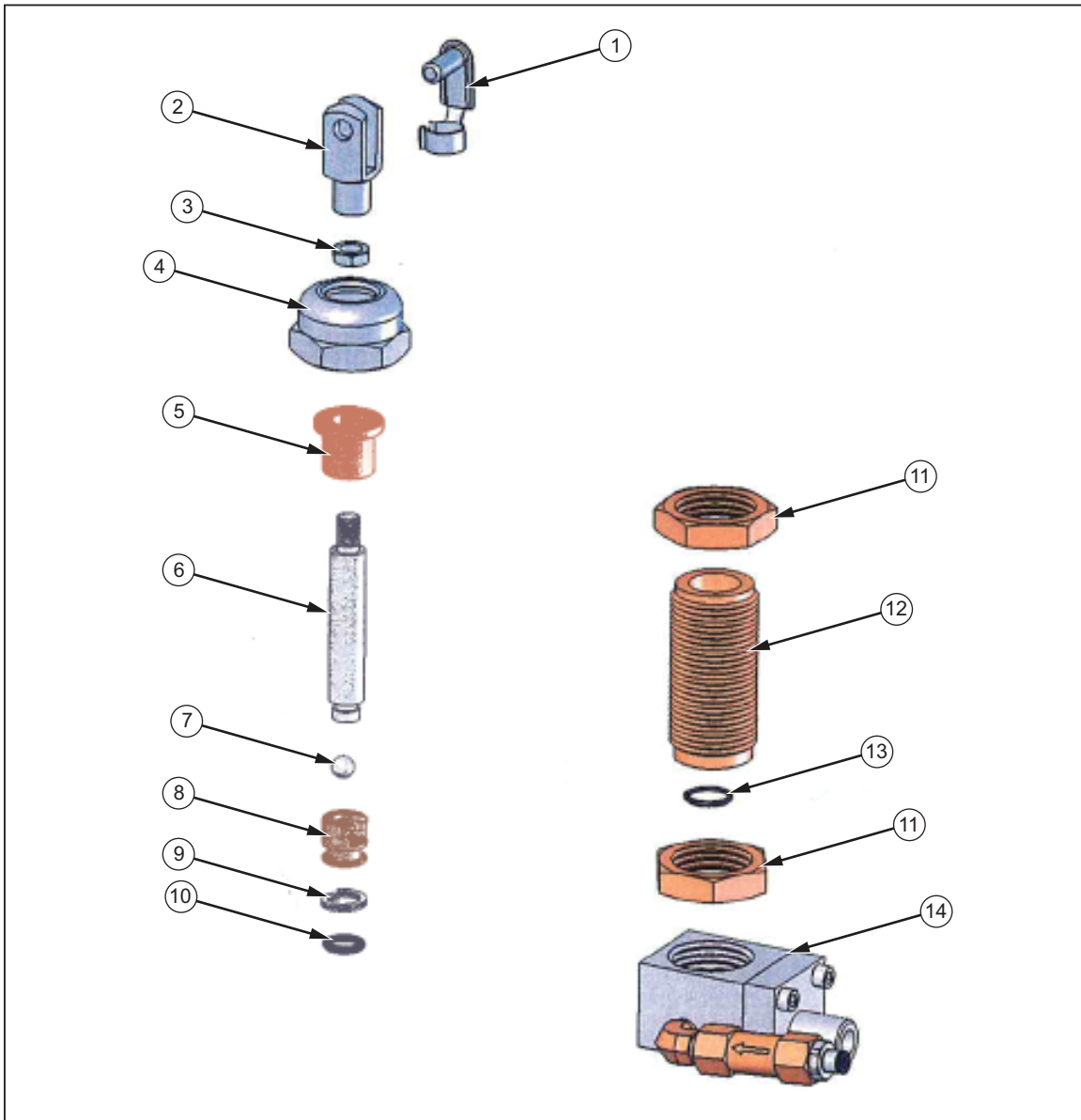


Figure 6-5. Priming Pump Assembly

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**Table 6-5. Priming Pump Assembly - Parts List**

Item	Description	Part	Item	Description	Part
1	Pivot Clip	3920224	8	Rambler	3919165
2	Clevis	3920236	9	Back-Up Ring	3920516
3	Locknut	3918713	10	O Ring	3864782
4	Pump Union Nut	3921527	11	Barrel Locknut	3921438
5	Shaft Bearing	3867744	12	Pump Barrel	3921511
6	Pump Shaft	3921509	13	O Ring	3864711
7	Ball	3917855	14	Pump Block Assembly	

### **Check Valves**

#### **Inlet Check Valve**

The inlet check valve is a bought-in item, and is not readily user-serviceable. To remove:

1. Disconnect nylon tubing from connector (9), by pressing in the collar at the top of the connector, and gently pulling on the tubing.
2. Unscrew and remove connector.
3. Remove check valve assembly (8).
4. When replacing the check valve assembly, take care to remove all traces of PTFE or Teflon sealing tape on the mating threads of elbow (7). New tape (or similar sealing method) must be applied to ensure a pressure-tight joint.
5. Reassembly is the reverse of removal.

#### **Outlet Check Valve**

1. Remove screws (7) and pump check flange (6), taking care not to drop the check valve bullet (3) and spring (4).
2. Inspect the parts for cleanliness and damage—particularly the sealing surfaces.
3. When removing O-rings, take care not to use any tool that may have a sharp edge that will scratch the surfaces of the mating groove, otherwise it may leak when reassembled.
4. Reassembly is the reverse of removal, but care must be taken to ensure that the spring and bullet are seated correctly.

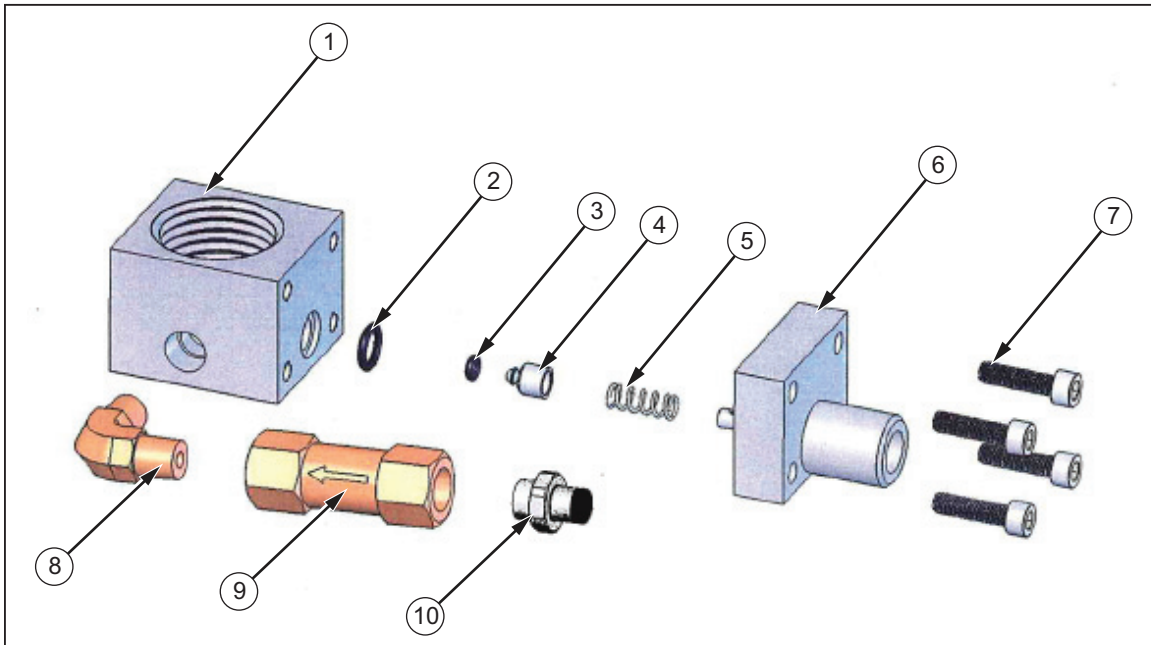


Figure 6-6. Check Valves Assemblies

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Table 6-6. Check Valves Assemblies Parts List

Item	Description	Part	Item	Description	Part
1	Pump Block	3921530	6	Pump Check Flange	3921744
2	O Ring	3864766	7	Screw	3909261
3	O Ring	3865142	8	Elbow	3862616
4	Bullet	3920584	9	Check Valve	3867767
5	Spring	3920600	10	Connector	3923564

### Reservoir Assembly

1. To drain the fluid from the reservoir, first remove any weights, and raise the instrument a few inches by placing suitably sized blocks under the feet.
2. Place a suitable catchment tray or bowl below the reservoir drain (13).
3. Open the valve by turning valve stem (1) counter-clockwise.
4. Remove gland nut and plug (13 & 12), and allow the fluid to drop into the catchment tray.

To completely disassemble the reservoir, the top plate must be removed from the instrument case (Refer to Chapter 6, Top Plate Removal).

5. Disconnect the high-pressure tubing by unscrewing the gland nuts fitted to the reservoir body (11).
6. The low pressure feed to the priming pump is disconnected by pressing down on the black plastic ring at the top of the connector, and gently pulling on the nylon tubing.
7. Remove valve stem completely by turning counter-clockwise, taking care not to lose the spring (2) and nylon washer (3).
8. Lift off reservoir cover (4).

9. Remove three screws from reservoir spacers that hold the assembly to the top plate. The assembly can now be withdrawn from the underside of the top plate.
10. The reservoir body (11) and reservoir cap (5) are a close fit to the reservoir tube (7), and both rely on the O-ring seal (6) to hold them in place. These parts can be separated by gently pulling them apart.
11. The valve vent (9) is disassembled from the reservoir body by removing the three screws (8).
12. Reassembly is the reverse of the above procedure.



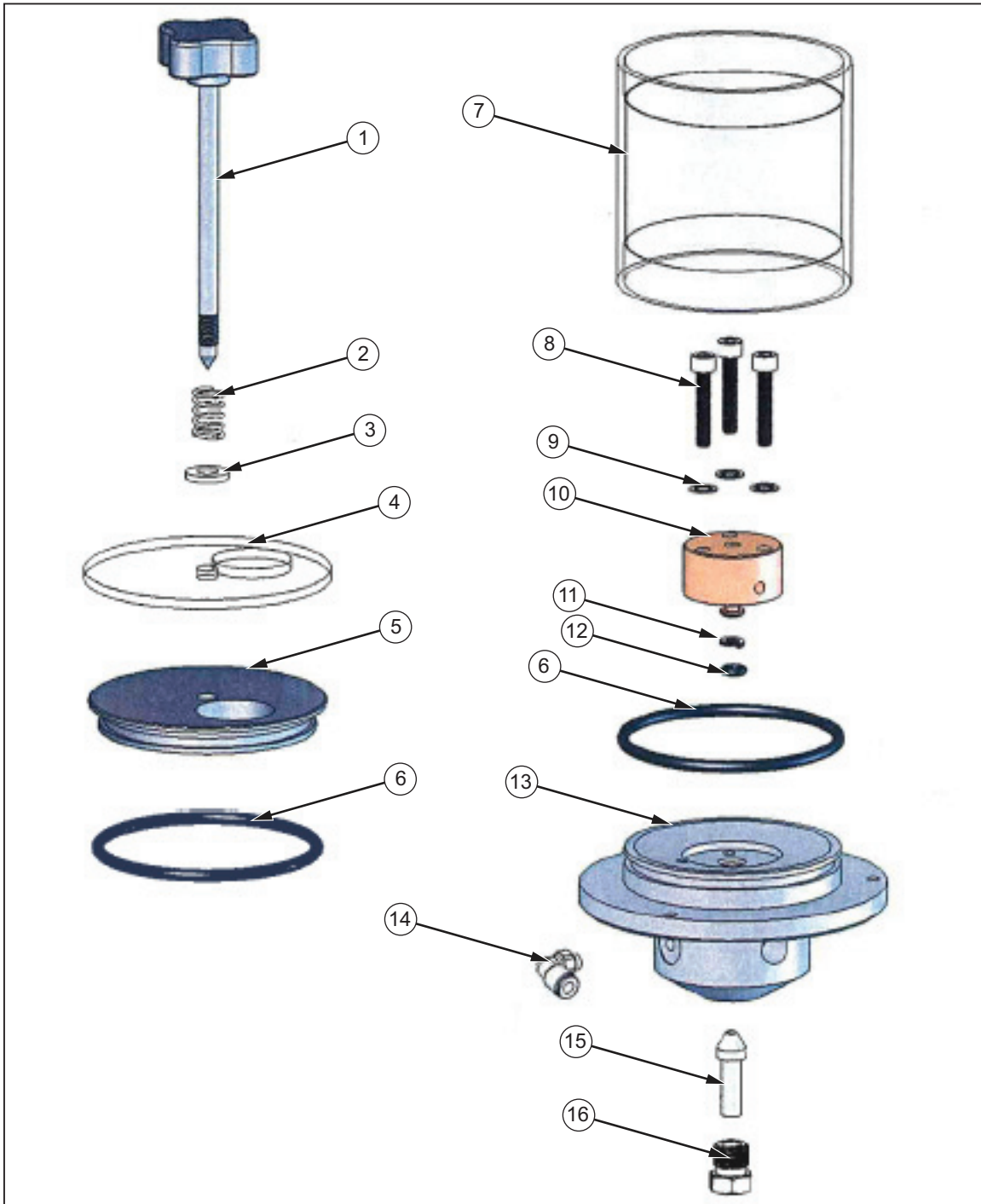


Figure 6-7. Reservoir Assembly

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**Table 6-7. Reservoir Assembly Parts List**

<b>Item</b>	<b>Description</b>	<b>Part</b>	<b>Item</b>	<b>Description</b>	<b>Part</b>
1	Valve Stem	3886430	9	Washer	3205770
2	Spring	3922786	10	Valve Vent	3921582
3	Nylon Washer	3916458	11	Back-Up Ring	3921912
4	Reservoir Cover	3921624	12	O Ring	3865142
5	Reservoir Cap	3921613	13	Reservoir Body	3921575
6	O Ring	3864910	14	Elbow	3926855
7	Reservoir Tube	3921608	15	Plug	3068437
8	Screw	3909292	16	Gland Nut	3903089

# Chapter 7

## Fault Finding

### Poor PCU Spin/Sensitivity

#### General

The weights floating on a clean PCU assembly will rotate freely, slowing down gradually to a complete stop. If the rotation stops quickly, then the PCU may be dirty and require cleaning.

#### **⚠ Caution**

**Do not rotate the piston if it is dirty as permanent damage can occur.**

If the spin/sensitivity of a recently cleaned PCU deteriorates quickly, then it is likely that the hydraulic system has become contaminated.

During the normal operation of a deadweight tester, the working fluid flows slowly through the tiny gap between the piston and its cylinder. If the hydraulic system has become contaminated, any particles will tend to move towards the PCU(s) and thus affect their performance, and possibly damage them.

If this is the case, the system must be completely dismantled, thoroughly cleaned and rebuilt before further calibration is carried out.

#### PCU Assembly - 10 mm

Plug the test station to prevent leakage, and open the reservoir valve. Hold the weight carrier (1) and lift gently up and down, the piston should slide freely within its cylinder. If any resistance greater than fluid drag or a “gritty” sensation is detected, then the PCU must be removed and cleaned. (See Chapter 6, PCU Assembly - 10 mm Nominal Diameter.)

#### PCU Assembly - 2 and 3 mm

Pressurize the system with 1 large weight so that the piston is rotating and floating correctly. Gently push down on the rotating weight carrier (2) and release. This should result in a smooth, “bouncing” oscillation. If the piston does not rotate or “bounce” freely, it must be removed and cleaned. (See Chapter 6, PCU Assembly - 2 and 3 mm Nominal Diameter.)

### **PCU Assembly - 5 mm**

Plug the test station to prevent leakage, and open the reservoir valve. Remove the weight carrier assembly (1 & 2). Hold the piston cap (4), and lift gently up and down, the piston should slide freely within its cylinder. If any resistance greater than fluid drag or a “gritty” sensation is detected, then the PCU must be removed and cleaned. (See Chapter 6, PCU Assembly - 5 mm Nominal Diameter.)

Pressurize the system with 1 large weight so that the piston is rotating and floating correctly. If the piston does not rotate freely, it must be removed and cleaned. (See Chapter 6, PCU Assembly - 5 mm Nominal Diameter.)

### **High PCU Fall-Rate**

The piston will always fall slowly due to a small leak between the piston and cylinder. This fall rate will never be so fast that a stable reading cannot be made.

1. If the system has been pressurized quickly, then sufficient time must be allowed for the instrument to thermally stabilize. Continue re-floating the piston until the fall rate stabilizes; this should take no longer than one minute.
2. If PCU has just been re-fitted after cleaning:

Air pockets can be introduced when re-fitting a PCU. This will cause the piston to fall faster while the air bleeds between the piston and cylinder.

Continue to re-float the piston until the fall rate slows down. If the piston continues to fall quickly, then check for fluid leakage around the base of the PCU assembly. Check for loose/damaged/dirty seal under the PCU, tighten, clean or replace as necessary. (See Chapter 6, PCU Assembly - 10 mm Nominal Diameter, PCU Assembly - 2 and 3 mm Nominal Diameter, and PCU Assembly - 5 mm Nominal Diameter.)

1. Reservoir valve may be leaking. Observe fluid level, it will rise slowly if the valve is leaking. This indicates that the valve seat may be damaged or dirty, or the o-ring below the valve vent may be damaged. It should be disassembled, cleaned and inspected, then retested or replaced as necessary. (See Chapter 6, Reservoir Assembly.)
2. Rambler seal may be leaking. Check lead screw in screw pump for “wetness” when extended, the screw thread should be greased, not running with operating fluid. If lead screw is “wet”, then replace rambler seal and anti-extrusion ring. (See Chapter 6, Screw Pump Assembly.)

### **System Will Not Prime**

1. Check reservoir valve is closed.
2. Check for sufficient fluid in reservoir.
3. Check for damaged/missing/dirty O-ring on test station.
4. Check that the face of the DUT is contacting the O-ring, and that the surface is not scored or dented.

### ***System Will Not Pressurize***

1. Ensure correct valve operation during priming process.
2. Check DUT is not leaking.
3. Clean system externally, check for fluid leak by continually trying to pressurize. Wherever fluid appears, replace the seal—check sealing faces are clean and undamaged before re-assembly.

### ***Priming Pump Malfunction***

1. If pumping does not generate pressure, then the inlet check valve has probably failed, and requires replacement.
2. If the system pressurizes and depressurizes in conjunction with the downward and upward strokes of the pump, then the outlet check valve has failed completely. This should be disassembled and inspected for dirt or damage to valve seat and seal. After inspection, clean all parts carefully, replace as required, and re-assemble correctly.
3. If the pump handle rises during normal system pressurization, then the outlet check valve is leaking. Inspect as above.

**⚠ Caution**

**Do not continue to pressurize if pump handle rises, as this can damage the inlet check valve.**

### ***Cannot Reach Maximum Pressure***

If maximum pressure cannot be reached, even after the screw press has been turned fully in, and the checks above have been made:

1. Ensure that the screw press is FULLY OUT, and the priming pump is used for initial pressurization.
2. If the DUT has a large internal volume or there is air in the system, then re-prime increasing the initial pressurization with the priming pump from 100 psi/7 bar to at least 200 psi/14 bar.



# Chapter 8

## Storage and Transportation

### Storage and Transportation

#### Instrument

1. With the test station plugged, open the reservoir valve and turn capstan fully in, close reservoir valve.
2. Remove spokes from capstan hub, and store in tool-roll.
3. Remove screw-in handle from pump arm, and store in tool-roll.
4. If fluid is to remain in the reservoir, ensure that the tester is kept level at all times to avoid spills. If not, drain the reservoir as described in Chapter 6, Reservoir Assembly.
5. Refit instrument lid, ensuring that the hinges are correctly engaged, and secure with toggle clips at the sides.

#### Weights

1. Starting with the largest increments first, stack all appropriate weights in the wooden weight case.
2. Pass the threaded rod of the weight clamp assembly down through the center of the weight stack, and locate in the base of the weight box.
3. Secure the weights by screwing the clamp assembly in clockwise, ensuring that the stepped rim of the clamping disc locates correctly in the center of the weight stack.
4. Close lid and secure with catches at front.

#### Warning

**The weight set is HEAVY (can be up to 80 lbs/36 kg per individual box) so care must be taken when moving it. Both handles must be used when lifting the set for stability, and we recommend that it be carried between two people.**





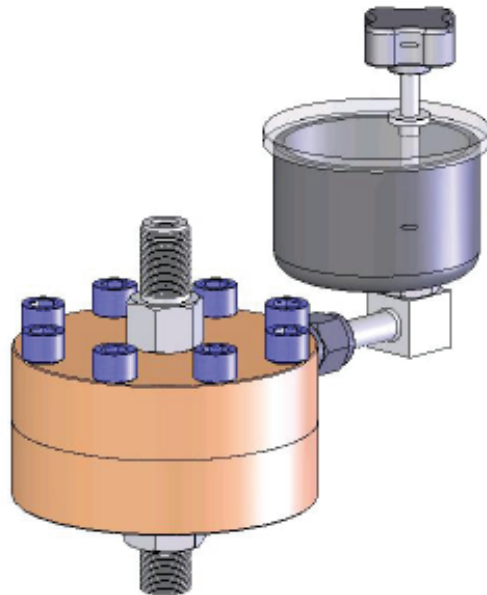
## **Ancillary Equipment**

### **Liquid Separator, P5521 or P5522**

If there is any doubt that the instrument to be tested is not internally clean, then the addition of the P5521 Liquid Separator will protect the deadweight tester from contamination and possible damage. The P5521 is also particularly useful in applications where the instruments under test are used on systems that must not be contaminated by the operating fluid from the deadweight tester. The unit contains a flexible diaphragm that separates the two working fluids, preventing transfer either way.

The P5521 has a Viton diaphragm and seals, and a maximum working pressure range of 10,000 psi / 700 bar.

The P5522 has a PTFE diaphragm and EPDM seals, and a maximum working pressure range of 7,000 psi / 500 bar. This unit is specifically designed for use with brake fluids, Skydrol<sup>®</sup> and similar liquids.

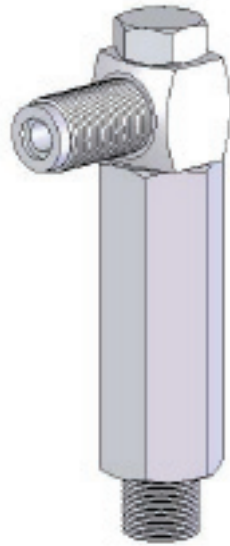


**Figure 9-1. Liquid Separator**

gjn021.bmp

**Angle Adapter, P5543**

To calibrate gauges with the pressure connection on the rear (e.g. panel-mount gauges) in their correct position, an angle adapter should be used. The angle adapter fits directly onto the test station, converting it through 90 degrees, allowing the standard adapters to be used.



**Figure 9-2. Angle Adapter**

gjn022.bmp

**Pointer Remover/Punch, P5551**

To remove and refit the pointer of a pressure gauge, a pointer remover/punch should be used. This tool has a spring-loaded plunger to quickly and consistently refit the pointer.



**Figure 9-3. Pointer/Remover Punch**

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