

PG7607 PISTON GAUGE
Operation and Maintenance Manual
(Use with PG7000 Operation
and Maintenance Manual)



High pressure liquids and gases are potentially hazardous. Energy stored in these liquids and gases can be released unexpectedly and with extreme force. High pressure systems should be assembled and operated only by personnel who have been instructed in proper safety practices.

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ABOUT THIS MANUAL



This manual is designed to be used in conjunction with the PG7000 Piston Gauges Operation and Maintenance Manual, to operate a PG7607 Piston Gauge.

PG7607 is identical in conception and features to a PG7601 piston gauge. PG7607 differs only in the piston-cylinder mounting post and the piston-cylinder module as PG7607 is designed to exploit a unique 50 mm diameter piston-cylinder. This manual covers the aspects of PG7607 that are different from PG7601.

To operate a PG7607, use the PG7000 Piston Gauges Operation and Maintenance Manual and follow the instructions and information applying to PG7601. Refer to this manual for details on the piston-cylinder mounting post and piston-cylinder module.



In PG7607, the CYLINDER rather than the PISTON floats and is rotated. When using the PG7000 Manual to operate PG7607, references to the PISTON of PG7601 apply to the CYLINDER of PG7607.

Manual Conventions



(CAUTION) is used in throughout the manual to identify user warnings and cautions.



(NOTE) is used throughout the manual to identify operating and applications advice and additional explanations.

[] indicates direct function keys (e.g., [RANGE]).
< > indicates PG7000 screen displays (e.g., <1yes>).

NOTES



1. INTRODUCTION

1.1 PRODUCT OVERVIEW

PG7607 is a special model in the PG7000 line of piston gauges. PG7607 is identical to PG7601 except for its piston-cylinder and mounting post.

PG7607 was designed to exploit a unique 50 mm diameter piston-cylinder. With this piston-cylinder, the piston is mounted in a fixed position in the mounting post and the cylinder floats and is rotated. A controlled clearance pressure can be introduced into the mounting post allowing the piston diameter and thus the gap between the piston and cylinder to be varied.

PG7607 is available on a limited basis and, generally, is only offered for use in national measurement institutes or other laboratories performing fundamental research in pressure metrology.



This manual is intended to be used as a supplement to the PG7000 Manual. PG7607 is identical to PG7601 except for its piston-cylinder and mounting post. To operate a PG7607, use a PG7000 Operation and Maintenance Manual and apply the information on PG7601 referring to this manual for piston-cylinder and mounting post information. Also keep in mind that in PG7607, the CYLINDER, rather than the PISTON, floats and is rotated. References to the PG7601 PISTON in the PG7000 Manual apply to the CYLINDER of PG7607.

1.2 SPECIFICATIONS

1.2.1 GENERAL SPECIFICATIONS

Specifications below are specific to PG7607. All other specifications are identical to PG7000 specifications found in the PG7000 Operation and Maintenance Manual (P/N 550099).

Weight	17 kg (29 lb)
<i>Instrument platform with no mass loaded.</i>	
Overall Pressure Ranges	Gauge: 5 to 175 kPa (0.7 to 25.4 psi)
<i>with 35 kg mass set</i>	Absolute: 5 to 175 kPa (0.7 to 25.4 psi)
Operating Medium	Clean, dry, non-corrosive gas
Maximum Mass Load	35 kg (38 kg with AMH automated mass handler)
Pressure Connections	
TEST Port	DH200
Bell Jar Vent Port	DH200
Piston Controlled Clearance Pressure (CCP)	DH200
	NOTE: DH200 is a gland and collar type fittings for 1/4 in. (6 mm) coned and left hand threaded tubes equivalent to AE SF250C, HIP LF4, etc.
Vacuum Reference Ports	KF25 on platform and bell jar (KF40 available on optional AMH automated mass handler)
CE Conformance	Available, must be specified.

1.2.2 PISTON-CYLINDER ASSEMBLY

The piston is mounted in a fixed position on the mounting post. The cylinder floats and is rotated.

Piston Material:	Tungsten carbide
Cylinder Material:	Tungsten carbide
Nominal Diameter:	50 mm
Nominal Area:	2 000 mm ²
Mounting System:	Free deformation with controlled clearance pressure (CCP) available on inside of piston.
Typical Drop Rate:	< 0.1 mm/min
	<i>Full mass load</i>

1.2.3 PRESSURE MEASUREMENTS

The piston is mounted in a fixed position on the mounting post. The cylinder floats and is rotated.

Sensitivity¹:	0.01 Pa + 0.5 ppm
Reproducibility²:	± 2 ppm

1 Sensitivity: The smallest variation in input detectable in output.

2 Reproducibility: Combined long term stability of piston-cylinder effective area and masses.

2. INSTALLATION

2.1 UNPACKING AND INSPECTION

2.1.1 REMOVING FROM PACKAGING

PG7607 is delivered (along with its standard accessories) in a reusable molded transit case with polyurethane inserts to hold it in place.

Remove the PG7607 and its accessories from the shipping container and remove each element from its protective plastic bag.

2.1.1.1 PISTON-CYLINDER ASSEMBLY

The piston-cylinder assembly is shipped in a molded plastic case with custom polyethylene inserts that accommodates 2 Acetal bullet cases. The piston and the cylinder are separate; each is packed in its own bullet case. Do not handle either of these elements with your bare hands. Use the gloves that are in the PG7607 accessory kit or use the lint free wipes.



Never handle the piston or cylinder with bare hands. Oil and acids from bare skin can damage the critical surfaces (polished appearance).

2.1.2 INSPECTING CONTENTS

Check that all items are present and have NO visible damage.

2.1.2.1 PG7607 PLATFORM

Table 1. PG7607 Parts List

	PG7607 #401385 MOTORIZED ROTATION NON-CE	PG7607 #401385-CE MOTORIZED ROTATION CE
Platform	402360	402360-CE
Mass Bell	402135	
Bell Jar W/KF16	401698	
Terminal	401284	
PG Terminal to Platform Cable		
Non-CE (DB25M - DB25F, ≈ 1.8 meters)	102227	
CE (DB25M - DB25F, ≈ 1.5 meters)		102227-CE
Cable, null modem (for flashing)	402114	402114-CE
Power Cable	100770	100770-CE
Accessory Kit	401049	
(2) NIP, SS, DH200, 2.75"	100204	
(2) ADPT, SS, DH200 F X 1/8 in. NPT F	100299	
(2) O-ring, Viton, brown, 2-029	103994	
O-ring, Viton, brown, 2-019	101930	
(2) O-ring, Buna, 2-242	101976	
Cover, storage, 7600 type	102132	
Allen wrench, 2.5 mm	102257	
Allen wrench, 3 mm	102168	
Allen wrench, 5 mm	102262	
Krytox™ GPL205/6 0.5 oz	102496	
Gift kit with gloves	400511	
ADPT, DH200 M X 1/8 in. swage	400518	
Valve, vacuum relief	401050	
Union, SS, 4P	101984	
Valve, toggle, 1/4 in. swage, OGS2	103733	
ADPT, SS, 4P x 1/8 in. NPT F	103734	
Screen, vent, SS, 1/8 in. NPT M	103735	
ADPT, DH200 M x 1/4 in. swage	400528	
Instruction Sht, PG7600 vac relief	560002	
Documentation		
Calibration Report (PG)	550100	
Calibration Report (Mass Bell)	550100	
Technical Data	550101	
Manuals	550099 (PG7000) 550109 (PG7607)	
Documentation CD	102987	

2.1.2.2 PISTON-CYLINDER ASSEMBLY

Table 2. 50 mm Gas Piston-Cylinder Assembly Parts List

	5 KPA/KG PC-7607-TC
Piston-cylinder kit	401463
Piston-cylinder	401566
Piston-cylinder case (w/ 2 bullet cases)	402331
Accessory Kit	401568
(2) O-rings, brown, Viton (2-015)	101928
Documentation	
Calibration report	550100

2.2 INITIAL SETUP

2.2.1 CCP PRESSURE CONNECTION

The pressure connection labeled CCP is for the application of a *controlled clearance pressure* to the inside of the piston (see Section 3.1). In normal operation, the measured pressure is applied to the CCP pressure connection. Use a tee to connect the TEST port and the CCP port together.

2.2.2 INSTALLING AND REMOVING THE PISTON-CYLINDER ASSEMBLY



Unlike other PG7000 models, the PG7607 piston-cylinder and mounting elements are not an integrated module. The piston and cylinder are delivered and installed as separate parts.



Given the large diameter and small annular gap of the PG7607 piston-cylinders, it is very difficult to insert the piston into the cylinder without the aid of the alignment mechanism provided by the PG7607 platform mounting post and piston retaining assembly. There is a risk of cocking the piston in the cylinder. It is not recommended that the piston ever be put into the cylinder when the piston is not installed on the PG7607 mounting post.

To operate the PG7607 platform, a piston-cylinder must be installed on its mounting post. To install a piston-cylinder assembly on the PG7607 platform, follow the sequential procedure below. This procedure may be used on the first and subsequent piston-cylinder installations; it may also be used in reverse order to remove a piston-cylinder. Numerical references in the procedure refer to Figure 1.

- ❶ **Remove the piston retaining assembly (5).** The PG7607 platform is delivered with the piston retaining assembly (5) installed in the mounting post (7). Holding the piston retaining assembly by the knurled surface (14), unscrew it (rotate CCW) fully from the mounting post and remove it. Avoid touching the WHITE cylinder centering ring (15) as it will eventually contact the critical inside surface of the cylinder.

- ② **Check that the lower piston sealing O-ring (10a) is installed.** The PG7607 platform is delivered with the lower and upper piston sealing O-rings (10a, 10b) and O-ring carriers installed loosely in the recess on the mounting post. Remove the upper O-ring and O-ring carrier (10b) and retain. Check that the lower O-ring and O-ring carrier (10a) are present and properly seated. (If needed two spare o-rings are included in the PG7607 platform accessory kit).
- ③ **Remove the piston (6) from its packing.** Using lint free gloves or wipes to avoid direct contact with the piston critical surface (polished appearance) remove the piston (6) from its packing.

 **Never handle the piston or cylinder with bare hands. Oil and acids from bare skin can damage the critical surfaces (polished appearance). The cylinder is part of the mass load and contamination can change its mass.**

- ④ **Install the piston (6) on the mounting post (7).** With the end of the piston etched with “X” and/or the serial number UP (11) so that it will enter the cylinder first, slip the piston over the mounting post and slide it down until it seats on O-ring (10a.) Check that the end of the piston facing UP has “X” and/or the serial number marked on it.
- ⑤ **Install the piston retaining assembly (5).** Place the upper O-ring and carrier (10a) centered on the top surface of the piston. Hold the piston retaining assembly (5) by the knurled ring (14); avoid touching the white cylinder centering ring (15) as it will eventually contact the critical inside surface of the cylinder. Thread the piston retaining assembly into the top of the mounting post (7) and screw it down carefully assuring that upper O-ring carrier (10a) is not pinched. The assembly’s shoulder (13) should meet the top of the piston (11) with no gap between the two surfaces. There will be some resistance from the mounting post O-ring (12), only hand tightening is needed. Do not use tools to install the piston retaining assembly. Tighten lightly by hand until the assembly reaches the end of the engagement threads and surfaces (13) and (11) meet.
- ⑥ **Clean the piston (6) and the cylinder centering ring (15), consider cleaning the cylinder (4).** Using the glass cleaner method described in Section 4.2, clean the piston (6) and the cylinder centering ring (15). If this is the first piston-cylinder installation, also clean the cylinder (4). On subsequent installations consider cleaning the cylinder before installing it.
- ⑦ **Verify that the cylinder cap O-ring (3) is properly installed.** Remove the cylinder (4) from its packing. It is delivered with the cylinder cap O-ring (3) installed. Check that the O-ring is present and properly seated. If not, install one (an extra one is included in the piston-cylinder accessories). Use tweezers or another long narrow tool. DO NOT touch the inside of the cylinder.
- ⑧ **Verify that the cylinder adjustment mass (17) is properly installed.** Check that the cylinder adjusting mass (17) is present and completely threaded onto the cylinder retaining screw (2). This mass is used to adjust the total cylinder mass to the value reported in the calibration report.
- ⑨ **Install the cylinder (4) on the piston (6).** Gently slip the cylinder (4) over the piston (6). The cylinder centering ring (15) aligns the cylinder on the piston facilitating the insertion process. Allow the cylinder to slip all the way down the piston until it reaches end of stroke.

- ⑩ **Tighten the cylinder retaining screw (2).** Using a 5 mm Allen tool (one is supplied in the PG7607 accessories), tighten the cylinder retaining screw (2) into the cylinder stroke limiter (16) of the piston retaining assembly (5). Turn the screw CW to tighten. Since the cylinder stroke limiter (16) is free to move within the piston retaining assembly (5), the retaining screw (2) may rotate with the assembly, failing to tighten. If this is the case, press down a bit or lift up on the screw to help it engage and tighten. Tighten gently until you can feel the cylinder cap O-ring (3) takes its seat in the cylinder stroke limiter.



Be sure the cylinder retaining screw (2) is tightened before applying pressure to the piston-cylinder. The cylinder stroke limiter (16) limits the cylinder's upward movement preventing it from coming off the piston.

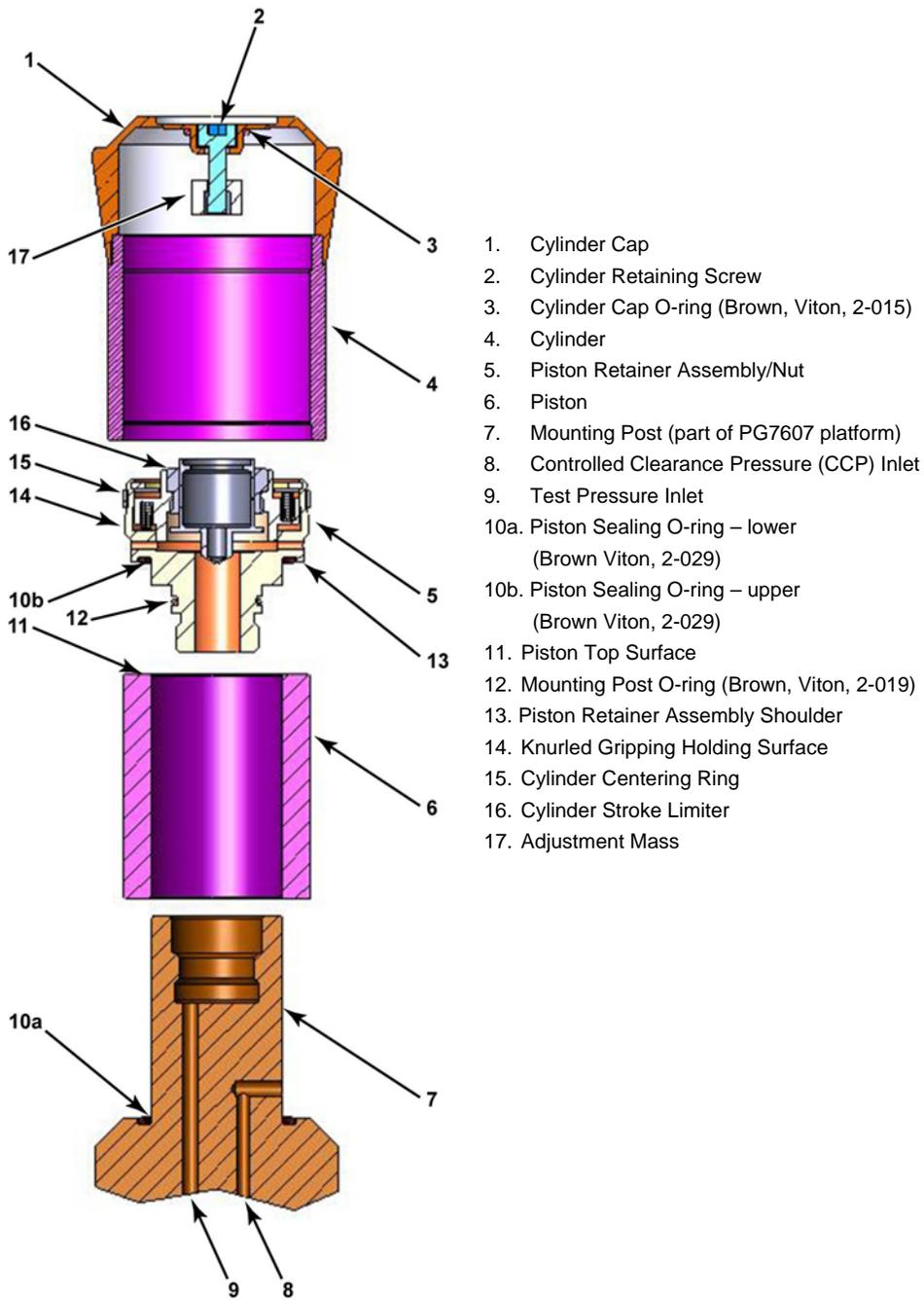


Figure 1. Piston-Cylinder Installation



3. OPERATION

3.1 CONTROLLED CLEARANCE PRESSURE (CCP)



In normal operation, the CCP pressure is the measured pressure. The pressure applied to the TEST port should also be applied to the CCP port.

PG7607 allows an independent pressure to be applied to the inside of the piston. The purpose of this feature is to allow the piston to be artificially expanded, varying the size of the gap between the piston and cylinder. The ability to predictably vary the size of the gap between the piston and the cylinder can be useful in analyzing piston-cylinder behavior.

The controlled clearance pressure is introduced through the CCP port on the back of the PG7607 platform. The pressure is applied through the mounting post to the inside of the piston (see Figure 1, Ref. 8). The pressure is contained by the two piston sealing O-rings (see Figure 1, Refs. 10a, 10b).

The piston sealing O-rings are positioned on the ends of the piston so that the deformation due to pressure along the active zone of the piston is constant and parallel.

The expansion of the piston with pressure can be predicted using thick walled cylinder stress/strain relations and the mechanical properties of the piston material (tungsten carbide). The result is 0.16 micron on the diameter/MPa.

A typical 50 mm piston-cylinder assembly has a radial gap of 0.9 micron so a CCP of 3 MPa will reduce the gap by about 50 %. Around 5 MPa, the CCP may close the gap completely causing mechanical contact between the piston-cylinder and damage to the parts.



A controlled clearance pressure (CCP) of about 5 MPa may close the gap between the piston and cylinder completely causing metal to metal contact between the two parts and possible damage.

3.2 [HEAD]

The natural reference level for the PG7607 piston-cylinder assembly is near the top of the cylinder cap. So that, in practice, the actual reference level is at a conveniently identified location, a reference level offset is applied. The reference level offset places the reference level at the bottom of the piston. This point is defined by the horizontal line where the bottom of the piston meets the mounting post when the piston is mounted.

The reference level offset is included in the piston-cylinder file (see PG7000 Operation and Maintenance Manual).



When using a AMH-3B with the PG7607, the PG7607 reference level is 3 mm below the reference level marked on the AMH vacuum chamber. This is because the AMH-3B is marked for the PG7601.

NOTES

4. MAINTENANCE, ADJUSTMENTS AND CALIBRATION

4.1 PISTON-CYLINDER ASSEMBLY AND DISASSEMBLY

See the piston-cylinder installation and removal description in Section 2.2.2. The only possible further disassembly of the piston cylinder is the removal of the cylinder retaining screw and adjustment mass from the cylinder.

 Given the large diameter and small annular gap of the PG7607 piston-cylinders, it is very difficult to insert the piston into the cylinder without the aid of the alignment mechanism provided by the PG7607 platform mounting post. There is a risk of cocking the piston in the cylinder. It is not recommended that the piston ever be put into the cylinder when the piston is not installed on the PG7607 mounting post.

 Disassembly of the piston-cylinder assembly exposes the piston-cylinder to possible damage. The main risk is damage to the exposed critical working surfaces. Only qualified personnel should undertake piston-cylinder disassembly and reassembly and the instructions and recommendations contained in this manual should be followed carefully throughout the operation.

 NEVER touch the lapped surfaces (polished appearance) of the piston or cylinder with your bare hands. Body oils and acids can permanently etch the surfaces.

 The cylinder assembly (cylinder + cylinder cap + adjusting mass + cap retaining screw + cylinder retainer) is part of the PG7607 mass load. Its mass has been measured and is reported in the calibration report. When handling these parts, take care not to change their mass by swapping parts, contaminating them or leaving parts out in reassembly.

4.2 CLEANING PISTON-CYLINDERS

The piston-cylinder cleaning methods described in the PG7000 Operation and Maintenance Manual should be used with the following exceptions/comments:

- **Water/detergent method:** Due to the piston-cylinder's large diameter and very small annular gap, it is very difficult to insert the piston into the cylinder when the piston is not installed on the PG7607 mounting post. Without the alignment mechanism provided by the mounting post arrangement (see Figure 1) there is a substantial risk of cocking the cylinder on the piston. When using the water/detergent method to clean a PG7607 piston-cylinder, wash the cylinder and the piston separately and do not attempt to put the piston into the cylinder until the piston is installed on the PG7607 platform mounting post.
- **Quick method:** As it is difficult to hold the piston without making contact with its critical working surface, install the piston onto the PG7607 platform mounting post to clean it (see Section 2.2.2).

4.3 PISTON-CYLINDER RECALIBRATION

4.3.1 MASS OF THE CYLINDER

The floating assembly of the PG7607 cylinder includes (see Figure 1):

- The cylinder and cap (4, 1).
- The cylinder cap screw (2).
- The adjustment mass (17).
- The cylinder cap O-ring (3).
- The cylinder stroke limiter (16).

To determine the mass of the floating cylinder assembly, the mass of all these parts must be determined. The cylinder stroke limiter (16) is captivated in the piston retaining assembly (5) and the retaining assembly must be disassembled to remove it. See Section 4.4 for disassembly instructions for the piston retaining assembly.

4.4 DISASSEMBLY OF PISTON RETAINING ASSEMBLY

The piston retaining assembly (see Figure 2) does not need to be disassembled as part of routine maintenance. However, the piston retaining assembly captivates the cylinder stroke limiter that is part of the of cylinder assembly whose mass must be determined when recalibrating the cylinder.

4.4.1 DISASSEMBLY PROCEDURE

To remove the cylinder stroke limiter from the piston retaining assembly follow the procedure below. To reassemble, follow the reassembly procedure in Section 4.4.2. Numerical references in this procedure refer to Figure 2.

- ❶ (See Section 4.1, Figure 1 for this step.) With the piston NOT installed, install the piston retaining assembly (5) onto the mounting post (7).
- ❷ Using circlip pliers, remove the spring retaining circlip (1) from the top of the assembly. As the circlip is removed, the spring washer (2) will lift slightly as the springs (3, 5) decompress.
- ❸ Lift off spring washer (2).
- ❹ Gently lift out the spring carrier (4) along with the four high stop springs (3) it carries. This leaves behind, in the piston retaining nut (7), the cylinder stroke limiter (6) and the four low stop springs (5). Take care that the springs do not drop down into the measured pressure opening in the center of the mounting post.
- ❺ Using tweezers, carefully remove the four low stop springs (5). Then lift out the cylinder stroke limiter (6).

 *The cylinder stroke limiter (6) floats with the cylinder and is thus part of the cylinder assembly mass. Take care not to contaminate this part when handling it. It is preferable to avoid contacting this part with bare hands.*

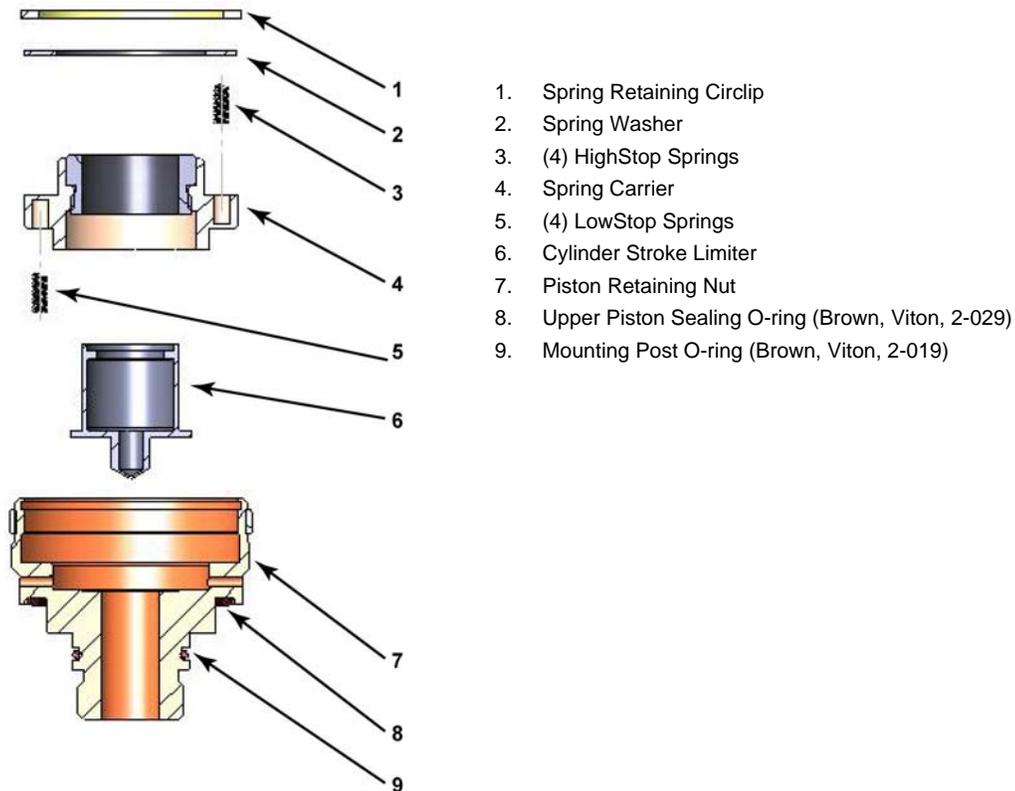


Figure 2. Piston Retainer Assembly

4.4.2 REASSEMBLY PROCEDURE

To reassemble the cylinder stroke limiter into the piston retaining assembly, follow the procedure below. Numerical references in this procedure refer to Figure 2.

- ❶ Remove the piston retaining nut (7) from the mounting post and set aside.
- ❷ Flip over the spring carrier (4) and place the four low stop springs (5) into the four holes on the bottom of the spring carrier (4) (the bottom of the spring carrier is the side WITHOUT the white plastic ring).
- ❸ Place the cylinder stroke limiter (6) into the center section of the spring carrier (4). Be sure to orient the cylinder stroke limiter correctly: pointed end facing out in the direction of the springs.

 *The cylinder stroke limiter floats with the cylinder and is thus part of the cylinder assembly mass. Take care not to contaminate this part when handling it. It is preferable to avoid contacting this part with bare hands.*

4. MAINTENANCE, ADJUSTMENTS AND CALIBRATION

- ④ Carefully slip the piston retaining nut (7) over the spring carrier (4), low stop springs (5) and piston stroke limiter (6). Take care so that the springs do not come out of the holes and so the piston retaining nut (7) does not cock on the spring carrier (4).
- ⑤ Verify that no springs have fallen out of place by pressing the spring carrier (4) into the piston retaining nut (7) and compressing the springs. There should be about 3 to 4 mm of movement. If there is less, one or several of the springs is probably sideways in the space and the process should be repeated from Step ② above.
- ⑥ Place the four high stop springs (3) into the holes on the spring carrier (4).
- ⑦ Place the spring washer (2) on top of the high stop springs (3).
- ⑧ Install the spring retaining circlip (1). The spring washer (2) needs to be pressed down compressing the springs slightly to allow the circlip (1) to engage in its seat in the retaining nut (7).

NOTES



5. TROUBLESHOOTING

5.1 OVERVIEW

Identify the symptom or unexpected behavior you are observing from the **SYMPTOM** list below. A **PROBABLE CAUSE** is provided and a **SOLUTION** is proposed including references to manual sections that provide information that may be of assistance. Table 3 concerns troubleshooting issues for the PG7607 only. See the PG7000 Operation and Maintenance Manual for the complete PG7000 troubleshooting table.

Table 3. PG7607 Troubleshooting Checklist

SYMPTOM	PROBABLE CAUSE	SOLUTION
There is internal leak in the PG7607 that cannot be located.	Cylinder cap O-ring is incorrectly installed, damaged or missing.	Check cylinder cap O-ring (see Section 2.2.2).

NOTES