OPG1-30000-AF™

Oil Pressure Generator/Controller
Operation and Maintenance Manual

NSN 6685-01-470-8667
(1 of 2)

1 August 2000

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 provides the user with the information necessary to operate an OPG1-30000-AF Hydraulic Pressure Generator/Controller. It also includes a great deal of additional information provided to help you optimize OPG1-30000-AF use and take full advantage of its many features and functions.

FOR THOSE OF YOU WHO "DON'T READ MANUALS", GO DIRECTLY TO SECTION 2.3 TO SET UP YOUR OPG1-30000-AF. READ SECTION 2.4.4 AND GO TO SECTION 3.3. THIS WILL GET YOU UP AND RUNNING QUICKLY WITH MINIMAL RISK OF CAUSING DAMAGE TO YOURSELF OR YOUR OPG1. THEN… WHEN YOU HAVE QUESTIONS OR START TO WONDER ABOUT ALL THE GREAT FEATURES YOU MIGHT BE MISSING, GET INTO THE MANUAL!

Manual Conventions

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

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

1. INTRODUCTION

1.1 PRODUCT OVERVIEW

The OPG1-30000-AF Hydraulic Pressure Generator/Controller is a stand alone, pressure generating and controlling component intended to be used as the pressure source and means of pressure adjustment in hydraulic calibration and test systems. It is capable of both generating and precisely adjusting pressure from atmosphere to 200 MPa (30 000 psi).

OPG1-30000-AF combines the versatility, speed and reliability of direct operator control with the convenience and effort-free operation of automation. It is the standard pressure generating and control component in an HGC-30000-AF Hydraulic Gauge Calibration system as well as in a PG7302 piston gauge system.

OPG1-30000-AF includes an on-board hydropneumatic pump to fill the system under test and generate pressures up to 200 MPa (30 000 psi). Two progressive needle valves control the inlet of pressure from the pump to increase pressure and outlet back to the reservoir to decrease pressure. Very fine pressure adjustment and generation of small pressure excursions is accomplished using a Pneumatically Driven Variable Volume (PDVV) with push button control. Pneumatic power (drive air) of up to 850 kPa (120 psi) is needed to drive the hydropneumatic pump and PDVV.

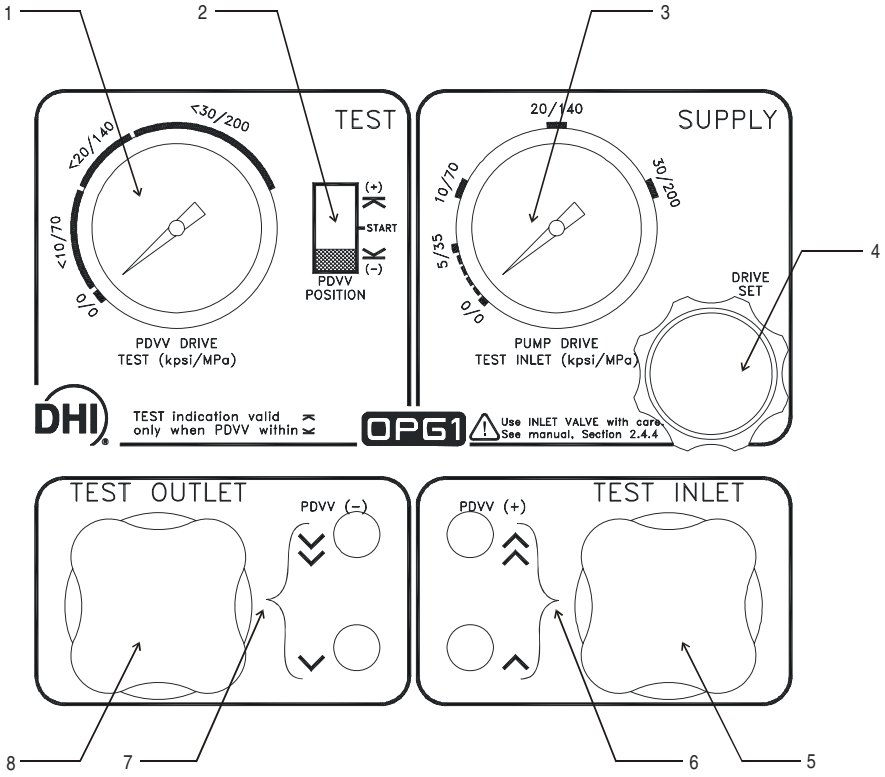
1.2 SPECIFICATIONS

Electrical Power Requirements	None
Pneumatic Power Requirements	Clean, dry, compressed air @ 50 slm (1.8 scfm) flow. Maximum pressure needed depends on maximum oil pressure desired: - 70 MPa (10 000 psi): 550 kPa (80 psi) - 140 MPa (20 000 psi): 700 kPa (100 psi) - 200 MPa (30 000 psi): 850 kPa (120 psi)
Operating Temperature Range	10 to 45 °C
Weight	27 kg (60 lb)
Dimensions	30 cm H x 30 cm W x 53.5 cm D (11.75 in. x 11.75 in. x 21.0 in.) (Height: Top of tank which is 8.5 cm (3.3 in.) above the top instrument surface)
Pressure Range	0 to 200 MPa (30 000 psi) *Maximum output pressure depends on pneumatic power supply (see above)*
Operating Medium	Di-2-Ethyl Hexyl Sebacate (same as PG7302 piston gauge) and other non-corrosive oils
Pneumatic Power Connection(s)	1/4 in. NPT F (can be configured into two independent connections, one for pump drive and one for variable volume drive)
Hydraulic Test Connections	(3) DH500 F test connections (one at back of either side and one on top of reservoir) ***NOTE:*** *DH500 is a gland and collar type fitting for 1/4 in. (6.35 mm) coned and left hand threaded tube. DH500 is equivalent to AE F250C, HIP HF4, etc.*
Reservoir Capacity	200 cc (12 in^3)
Pneumatically Actuated Variable Volume (PDVV) Displacement	1 cc (0.06 in^3)
Typical Pressure Generation Time (0 to 200 MPa/30 000 psi) *into air purged 50 cc volume*	Less than 12 seconds

1.3 INSTRUMENT LAYOUT

1.3.1 FRONT PANEL

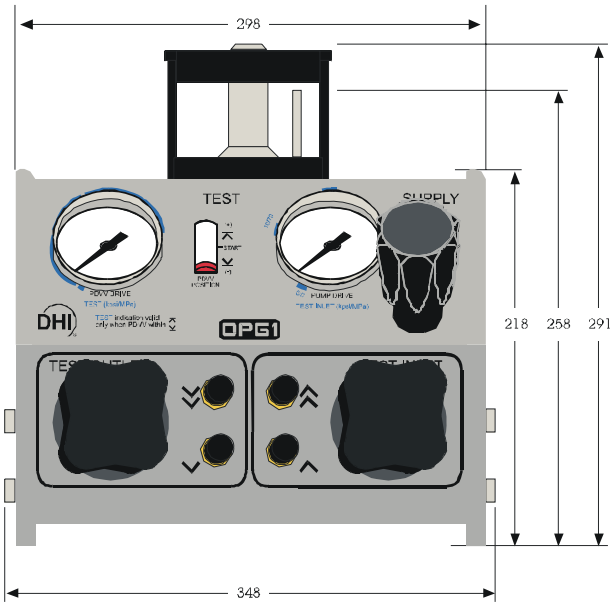
The front panel provides all of the controls and indications needed to set and adjust pressure.



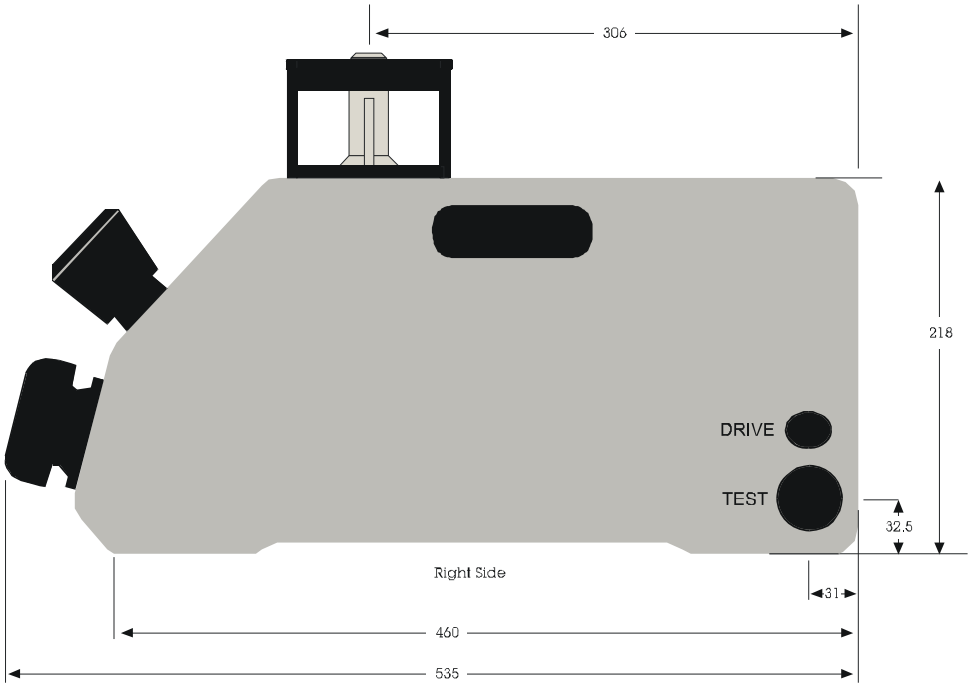
1. PDVV Drive Air/Test Oil Pressure Gauge
2. PDVV Piston Position Indicator
3. Pump Drive Air/Inlet Oil Pressure Gauge
4. Pump Drive Air Set Regulator
5. Test Inlet Valve Knob
6. PDVV Increase Fast and Slow Buttons
7. PDVV Decrease Fast and Slow Buttons
8. Test Outlet Valve Knob

Figure 1. Front Panel

1.3.2 OVERALL DIMENSIONS



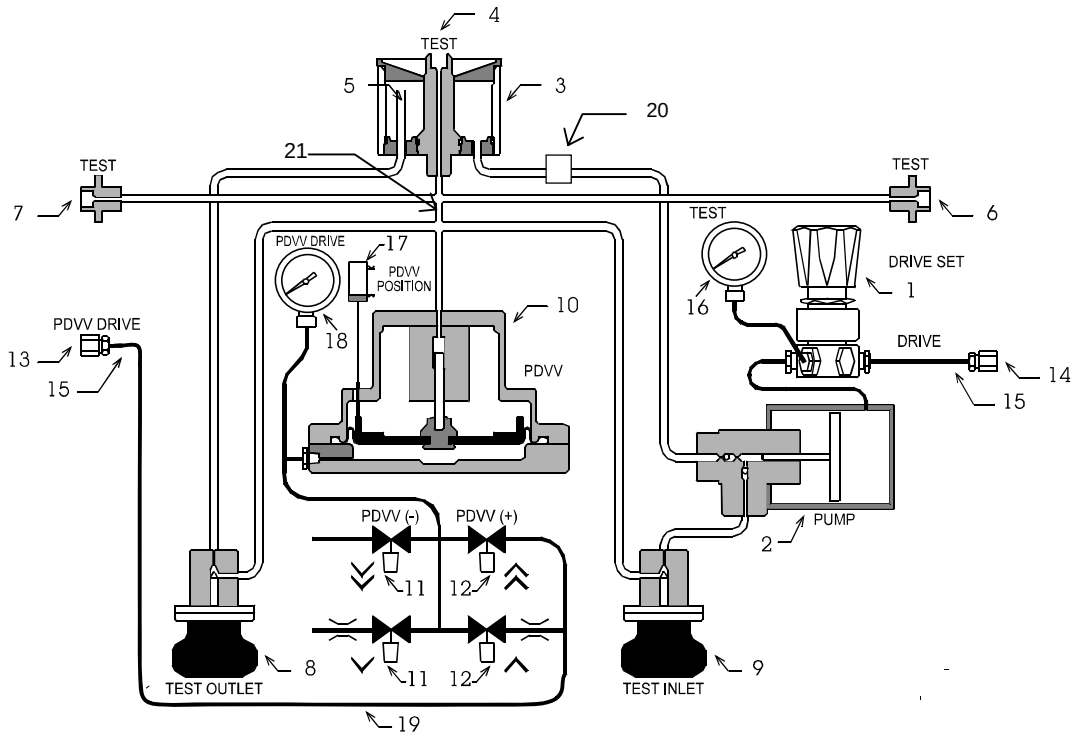
All dimensions shown are mm.



Left Side identical except DRIVE replaced by PDVV DRIVE.

Figure 2. Front and Side Views with Dimensions

1.3.3 SYSTEM SCHEMATIC



1. Pump Drive Air Set Regulator
2. Hydropneumatic Pump
3. Tank
4. Top TEST Connection
5. Oil Return Overflow Tube
6. Right Side TEST Connection
7. Left Side TEST Connection
8. Test Outlet Valve
9. Test Inlet Valve
10. Pneumatically Drive Variable Volume (PDVV)
11. Fast and Slow PDVV Decrease Valves
12. Fast and Slow PDVV Increase Valves
13. PDVV DRIVE Air Connection
14. Common DRIVE Air Connection
15. DRIVE Air Filters
16. PUMP DRIVE Pressure Gauge
17. PDVV Plunger Position Indicator
18. PDVV DRIVE Pressure Gauge
19. PDVV DRIVE to PDVV Connection
20. Oil Filter

Figure 3. System Schematic

NOTES

2. INSTALLATION

2.1 UNPACKING AND INSPECTION

2.1.1 REMOVING FROM PACKAGING

OPG1-30000-AF is delivered, along with its standard accessories in a corrugated container with corrugated and polyurethane inserts to hold it in place.

Remove the OPG1 and its accessories from the shipping container and remove each element from its protective plastic bag.

Retain the packaging in case of future OPG1 shipments.

2.1.2 INSPECTING CONTENTS

Check that all items are present and have **NO** visible damage. Verify the items received against the parts list in Table 1.

Table 1. OPG1-30000-AF Parts List

DESCRIPTION	PART NO.
OPG1-30000-AF Instrument	401602
Operation and Maintenance Manual	550114
Accessories:	401580
Mat, Top Surface Protection	122998
Sebacate (synthetic oil), 1 qt.	400503
Syringe, 10 cc	102817
O-ring, Brown Viton, 2-104	102758
Interconnections Kit:	401603
1 ea. Nipple, 2.75 in., DH500	100207
1 ea. Nipple, 6 in., DH500	100208
1 ea. Nipple, 24 in., DH500	100270
1 ea. Elbow, 24 in., DH500	123136
1 ea. Adaptor, DH500 F x 1/4 in. NPT M	102889
1 ea. Adaptor, DH500 F x 1/4 in. NPT F	102820
1 ea. Adaptor, DH500 F x 37 degree (AN4) Mi	102888
2 ea. Gland, DH500	100271
5 ea. Collar, DH500	100201

2.2 SITE REQUIREMENTS

The OPG1-30000-AF is typically delivered as part of an HGC-30000-AF hydraulic gauge calibrator that includes an RPM3/HPMS-A30000/A6000-AF that has its own Operation and Maintenance Manual.

When selecting and preparing a site to set up the OPG1-30000-AF and HGC-30000-AF system, the following should be considered:

- **Bench Stability:** The OPG1 weighs about 27 kg (60 lb). The RPM3/HPMS-A30000/A6000-AF weighs about 10 kg (22 lbs). Consider the combined weight and that of other components, including possible items to be tested, when selecting a bench.

- **Footprint:** The HGC-30000-AF system requires a minimum bench space approximately 84 cm (33 in.) wide and 60 cm (24 in.) deep.

- **Location of Other Components:** Plan the space required and a convenient layout for the complete system in which OPG1 is the pressure generation/control component.

  If the OPG1 is to be used with an RPM3/HPMS, the OPG1 accessories include the hardware necessary for setting up in a standard configuration (see Sections 2.1.2, 2.3.1.3). These allow the RPM3/HPMS to be placed to the right or the left of the OPG1, as desired.

  The interconnecting tubing and fittings provided with the OPG1 accessories can also be used to connect to other systems. If interconnections other than the OPG1 accessories are used, select tubing and fittings rated to handle the maximum pressures that will be generated. OPG1 hydraulic fittings are all DH500 (equivalent to AE F250C, HIP HF4, etc.). The female DH500 fittings are delivered with gland nuts and plugs installed. Collars are included in the accessory kit.

  If you do not plan to use OPG1's top TEST port, consider where a device or system under test (DUT) will be connected.

- **Pressure Supply:** Plan the pneumatic power to OPG1. This requires two separate sources: a) 850 kPa (120 psi) from an N2 or Air bottle connected to the rear left of the OPG1; b) 620 kPa (90 psi) non-lubricated compressed air connected to the rear right of the OPG1 (see Section 2.3.1.2). The connections are 1/4 in. NPT female.

- **System Interconnections:** Plan the interconnections between OPG1 and other components in the system. Minimizing the volume and maximizing the mass of all interconnecting elements will reduce pressure generation and stabilization time. An extra nipple is provided in the OPG1 interconnection accessories for possible connection to an existing oil/air separator (see Section 2.3.1.3).


ALWAYS use external tubing and fittings rated for pressures equal to or greater than the maximum pressure OPG1 will be used to generate.

2.3 INITIAL SETUP

2.3.1 PREPARING FOR OPERATION

Before setting up the OPG1, see Section 2.2 for general information on site requirements.

To prepare an OPG1 for check out and operation:

❶ Set up the OPG1 (see Section 2.3.1.1).

❷ Connect pneumatic power (see Section 2.3.1.2).

❸ Make the system hydraulic pressure interconnections (see Section 2.3.1.3).

2.3.1.1 SET UP THE OPG1-30000-AF

To set up the OPG1, proceed as follows:

❶ Place the OPG1 platform on the site table in the proper orientation with the front panel controls conveniently accessible.

❷ Fill tank with oil if necessary. Back off the tank cover until a gap for oil passage can be seen between the DUT connection shaft and the cover. Pour in oil to just under the overflow tube (see Section 4.2).

❸ Leave tank cover open to allow oil to drain from the DUT connection and air to escape when venting oil back to tank.

❹ Install the mat delivered with accessories on top front of OPG1 around oil tank.

2.3.1.2 CONNECT PNEUMATIC POWER (DRIVE AIR)

OPG1 requires pneumatic power to drive two different components: the hydropneumatic pump and the pneumatically driven variable volume (PDVV) (see Section 3.1, Figure 6).

The drive air supply to the two components requires two independent connections (see Section 3.1, Figure 6). The requirements for the two different components are summarized in Table 2.

Make the two drive air connections as follows (but do not supply the air before reading Section 2.4.3.2):

❶ **"DRIVE" connection (right side, rear):** Connect a regulated air supply meeting the requirements of Table 2 to the 1/4 in. NPT F "DRIVE" connection. This is usually a shop air supply.

⚠ The maximum output pressure of the hydropneumatic pump is the drive air pressure x 400. To avoid accidentally generating greater pressure than desired, do not supply more pressure than necessary to the "DRIVE" connection.

❷ **"PDVV DRIVE" connection (left side, read):** Connect a regulated air supply meeting the requirements of Table 2 to the 1/4 in. NPT F "PDVV DRIVE" connection. This is usually supplied from an N2 or Air "K" bottle.

⚠ The OPG1 "PDVV DRIVE" connection must be supplied with NON-LUBRICATED drive air. The internal components are permanently lubricated. The oil in lubricated air can contaminate the small diameter tubing inside OPG1 and lead to erratic behavior requiring difficult and costly cleaning. Install a filter/dryer on the drive air line if necessary.

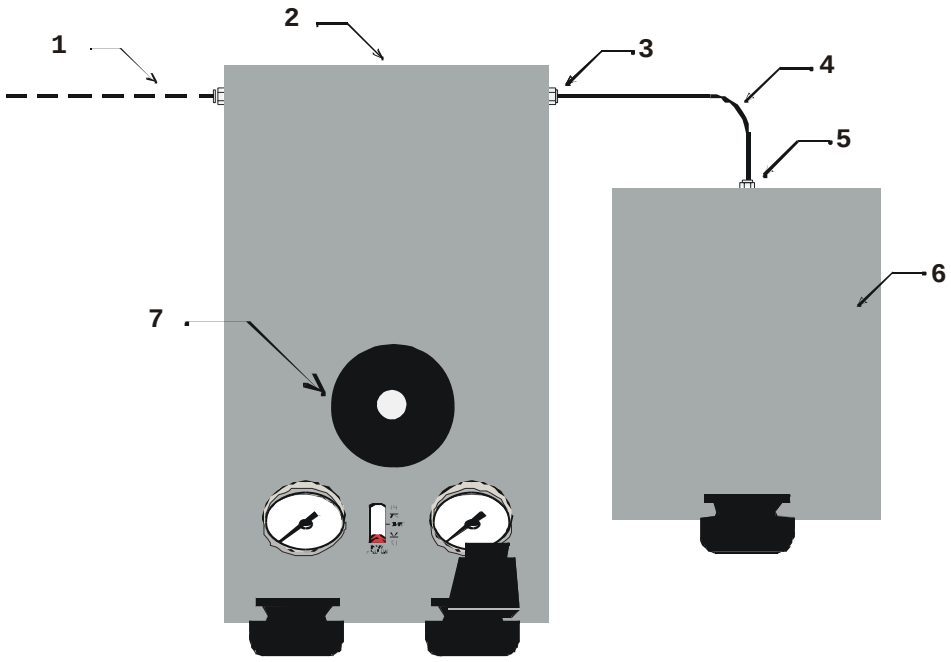
Table 2. Pneumatic Power (Drive Air) Requirements

CONNECTION	FITTING	INTERNAL COMPONENT SUPPLIED	DRIVE AIR PRESSURE NEEDED	MINIMUM FLOW	LUBRICATED	CLEANLINESS CRITICAL
DRIVE (right side, rear)	1/4 in. NPT F	Hydropneumatic Pump	620 kPa (90 psig)	50 slm (1.8 scfm) *This is fairly high flow.*	No	No
PDVV DRIVE (left side, rear)	1/4 in. NPT F	PDVV	For 70 MPa (10 000 psi) oil pressure: 550 kPa (80 psi) For 140 Mpa (20 000 psi) oil pressure: 700 kPa (100 psi) For 200 Mpa (30 000 psi) oil pressure: 850 kPa (120 psi)	200 sccm (< 0.01 scfm) *This is very low flow.*	No (must be dry)	Yes

2.3.1.3 MAKE HYDRAULIC PRESSURE INTERCONNECTIONS

CONNECTING TO THE RPM3/HPMS-A30000/A6000-AF

OPG1-30000-AF is delivered with a fittings accessory kit (see Section 2.1.2, Table 1). This kit includes the high pressure hardware necessary to connect OPG1-30000-AF to the RPM3/HPMS-A30000/A6000-AF. See Figure 4 for the recommended layout and to identify the parts used from the interconnection kit. Figure 4 shows the RPM3/HPMS installed to the right of the OPG1. It may be installed on either side using either one of OPG1's rear side test connections.



1. Optional connection to an existing oil/air interface or other device (use 24 in. DH500 nipple P/N 100270)
2. OPG1-30000-AF
3. OPG1 TEST connection (DH500)
4. OPG1 to RPM3/HPMS connection (use 24 in. DH500 elbow P/N 123136)
5. RPM3/HPMS TEST connection (DH500)
6. RPM3/HPMS-A30000/A6000-AF
7. OPG1 connection for device under test

Figure 4. Connecting OPG1-30000-AF to an RPM3/HPMS

Always use external tubings and fittings rated for pressure equal to or greater than the maximum pressure the OPG1 will be used to generate.

When planning system interconnections, consider that the time required to generate and stabilize a pressure is a direct function of the test volume and the mechanical stability of the test tubing and vessels. Always minimize volume to the extent possible and use thick walled, high pressure tubing and vessels.

When planning a DUT or other fitting make and break point external to OPG1, consider that if the point is lower than the OPG1 oil tank, oil will run out of the tank through the open point when OPG1's OUTLET valve is open.

The fluid head reference level of OPG1 when vented (OUTLET valve open), is the top of the tank's oil return overflow tube (see Section 3.2.6).

2.3.1.4 CONNECTING TO A DEVICE UNDER TEST

In an HGC-30000-AF system, the device under test (DUT) is intended to be connected on the top of the OPG1 at the center of the oil tank (see Figures 6 and 10).

The top TEST connection is a DH500 F (DH500 is a gland and collar type fitting for 1/4 in. (6.35 mm) coned and left hand threaded tube. DH500 is equivalent to AE F250C, HIP HF4, etc.

The OPG1-30000-AF fittings accessory kit includes adaptors to convert the DH500 F TEST connection to other commonly used fittings. The adaptors are made by combining a DH500 F adaptor with a 2.75 in. or 6 in. DH500 nipple. The nipple/adaptor assembly is then installed on the DUT. Finally, the nipple/adaptor/DUT assembly is installed on the OPG1's DH500 F test connection. Note that the gland nut on the adaptor/nipple assembly can be tightened into the DH500 F connection without rotating the nipple or DUT. Adaptors available are:

- 1/4 in. NPT F
- 1/4 in. NPT M
- 37 degree flare M (AN4 M)

The test connection is a DH500.

The DH500 test connection can be converted to 1/8 in. NPT M or 1/4 in. NPT M using the 2.75 in. (7 mm) tube and DH500 F x 1/8 in. NPT M or DH500 F x 1/4 in. NPT M adaptor supplied in the OPG1 accessories. Install the tube into the adaptor.

Any device connected to the OPG1 and/or HGC-30000-AF system should be purged of air to the extent possible prior to being connected to the system (see Section 3.2.5).

OPG1 covers a very wide range of pressures all the way up to 200 MPa (30 000 psi). It is the user's responsibility to assure that fittings and devices connected to OPG1 are rated for the pressures at which they will be used.

If the DUT connection is lower than the OPG1 oil tank, when the OUTLET valve is open and the DUT connection is open, oil will run out of the tank through the DUT connection.

2.4 POWER UP AND VERIFICATION

2.4.1 APPLY PNEUMATIC POWER (DRIVE AIR)

Proceed as follows (numerical references refer to Section 3.2, Figure 7):

❶ Fully back off the **DRIVE SET regulator** (4).

❷ Close the **TEST INLET valve** (5).

❸ Open the **TEST OUTLET valve** (8).

❹ Connect the drive air supplies to the DRIVE and PDVV DRIVE ports, if you haven't already done so (see Section 2.3.1.2).

❺ Adjust the **external** drive air regulator(s) to apply the appropriate level of pressure to the **DRIVE** and **PDVV DRIVE ports** (see Section 2.3.1.2, Table 2).

2.4.2 ADJUST HYDROPNEUMATIC PUMP DRIVE AIR PRESSURE

This section assumes that the OPG1-30000-AF system has already been set up, including pressure interconnection (see Section 2.3).

OGP1 hydraulic output pressure is directly proportional to pump DRIVE pressure. When the OPG1 INLET valve is opened, the full pump pressure may be applied to the test system very rapidly. ALWAYS adjust the pump pneumatic drive pressure low enough so that the maximum pump output does not exceed the maximum pressure rating of the devices to which OPG1 is connected.

Turn the **DRIVE SET Regulator** CW and observe the **PUMP DRIVE Gauge** to set the drive air pressure to the desired level (the BLUE indication on outside of gauge gives the **approximate** maximum oil pressure that will be generated).

2.4.3 CHECK PROPER OPERATION OF HYDROPNEUMATIC PUMP AND LEAK CHECK

Checking the proper operation of the hydropneumatic pump and leak checking has two steps. The first step is purging air from the pump hydraulic circuit. The second step is generating high pressures.

2.4.3.1 STEP ONE: PURGING AIR FROM THE HYDRAULIC PUMP CIRCUIT

Proceed as follows (numerical references refer to Section 3.1, Figure 6):

❶ Verify that there is oil in the tank and verify that all test connections are plugged or dead ended.

❷ Open the **OUTLET valve** (8) fully.

❸ Open the **INLET valve** (9) fully.

❹ If drive pressure has been properly connected and set (see Section 2.4.2), pump should begin cycling.

❺ Observe tank oil return overflow tube (5). Continue allowing pump to cycle until bubble free oil flows regularly from the tube. If no oil appears, or bubbles continue to appear, a cavitated pump priming procedure must be used (see Section 4.4).

If hydropneumatic pump is filled with air (cavitated), closing inlet valve will not stop pump from operating. To stop pump, turn AIR DRIVE regulator (1) fully CCW to stop air flow. See Section 4.4 for information on priming the pump if it is cavitated.

❻ After a successful purge, close the **INLET valve** (8), then the **OUTLET valve** (9) and proceed to Step ❷ (see Section 2.4.3.2) of hydropneumatic pump operation checkout.

2.4.3.2 STEP TWO: GENERATING A PRESSURE

Before applying pressure to the OPG1 and/or the system connected to it, be sure that all pressure vessels and connections are rated for the pressure levels that will be applied and that all connections have been properly tightened.

OGP1 hydraulic output pressure is directly proportional to pump DRIVE pressure. When the OPG1 INLET valve is opened, the full pump pressure may be applied to the test system very rapidly. ALWAYS adjust pump drive air pressure low enough so that the maximum pump output does not exceed the maximum pressure rating of the devices to which OPG1 is connected (see Sections 2.4.2 and 3.2.1).

Proceed as follows (numerical references refer to Section 3.1, Figure 6):

❶ Verify that there is oil in the tank.

❷ Connect a high pressure indicating device to one of the OPG1 **TEST** ports (4, 6, 7). Plug all other **TEST** ports (4, 6, 7).

There are three TEST ports on OPG1: One on each lower, rear side and one on the top in the middle of the tank.

❸ Fully close the **OUTLET valve** (8).

❹ Slowly open **INLET valve** (9).

❺ The pump should begin to cycle and the pressure indicated on the high pressure device should increase. If the pump does not cycle, the drive pressure is set too low or the pump is not operating correctly. If the pump cycles but the pressure does not increase:

- The pump is not properly primed (see Section 2.4.3.1).
- There is a leak in the system to which the OPG1 is connected or in the OPG1 itself.
- Air flow to the pump is too low.
- The pump is not operating properly.

❻ Keep **INLET valve** (9) open until the desired oil pressure is set.

❼ Fully close **INLET valve** (9).

❽ **Leak Check:** The pressure indicated by the high pressure device connected to the **TEST port** should stabilize and hold. If it does not, there is a leak in the system to which OPG1 is connected or in OPG1 itself.

> ⚠ *The time required for pressure to stabilize after the pressure has been changed is directly proportional to the volume connected to OPG1 and the mechanical stability of the volume's connections and vessels. To reduce stabilization time, go beyond the pressure set point and return. Be sure the pressure has had time to stabilize before concluding there is a leak in the system.*

❾ When leak checking is complete, slowly open the **OUTLET valve** (8) to remove pressure and vent to atmosphere.

2.4.4 PRECAUTIONS TO TAKE BEFORE GENERATING PRESSURE/SAFETY CONSIDERATIONS

Before using the OPG1 to generate and adjust pressure, consider the following:

- Check that all connections, vessels and DUTs connected to OPG1 are rated for the pressure to be generated and that all fittings are properly tightened.
- If the OPG1 is being used with an RPM3/HPMS, be sure that the HPMS valve is set to shut off the low RPT of the RPM3 if pressure greater than 400 MPa (6 000 psi) will be generated.

- Opening the **INLET valve** opens the test system to the output of the hydropneumatic pump. As long as the **INLET valve** is open, the pump will cycle until it stalls. To avoid accidental overpressure of the items to which OPG1 is connected, always adjust the **DRIVE SET regulator** so that the hydropneumatic pump output will be lower than the maximum desired pressure BEFORE opening the **INLET valve** (see Sections 2.4.2 and 3.2.1).

> ⚠ *Always adjust the DRIVE SET regulator so that the hydropneumatic pump output is not higher than the maximum desired pressure BEFORE opening the INLET valve. Failure to adjust the DRIVE SET regulator increases the chances of accidental overpressure of the system connected to OGP1.*

- When using INLET valve, pressure rate of rise may increase very rapidly after system is primed. Exercise extra caution when setting the first pressure coming off zero. When test is < 400 MPa (6 000 psi), consider using INLET valve to prime only (only until pressure starts rising), then use PDVV for all pressure control.

- The ^ and ^^ push button valves can increase pressure very quickly. Observe pressure evolution carefully when operating these valves (see Section 3.2.3).

- Check oil tank level before operating and regularly during operation. Operating with an empty oil tank will cause the hydropneumatic pump to draw air and require priming it (see Section 4.4).

- Put the PDVV in the **START** position when starting a calibration or test sequence (see Section 3.2.3).

- Systems and DUTs connected to OPG1 should be purged of air before they are pressurized (see Section 3.2.5).

- If there is an open point in the system to which OPG1 is connected that is lower than the OPG1 tank, oil will run out of the OPG1 tank through this point when the **OUTLET valve** is open. Close the **OUTLET valve** when a point lower than the tank is open.

- The fluid head reference level of OPG1 when the **OUTLET valve** is open is the top of the tank return overflow tube. Consider the difference between this reference level and the reference measuring device reference level to avoid zero gauge points that are inconsistent with other pressure points (see Section 3.2.6).

2.5 SHORT TERM SHUT-DOWN

When leaving OPG1 at rest but still set up for operation:

❶ Fully close the **INLET valve**.

❷ Release hydraulic pressure by fully opening the **OUTLET valve**.

❸ Plug any open point in the hydraulic test system connected to OPG1 that is lower than the OPG1 tank or the oil will run out of the tank through the open point.

❹ Release pump drive pressure by fully backing off the **DRIVE SET regulator**.

2.6 LONG TERM STORAGE AND SHIPPING

To prepare OPG1 for long term storage or shipping:

❶ Release hydraulic pressure by fully opening the **OUTLET valve**.

❷ Release pump drive pressure by fully backing off **DRIVE SET regulator**.

❸ Release pneumatic drive pressure and disconnect the **DRIVE** and **PDVV DRIVE** pressure connection(s). Cap both ports with plastic caps if available.

❹ Close the **OUTLET valve** and **INLET valve**.

❺ Disconnect all hydraulic pressure connections and plug the connections using DH500 plugs held by gland nuts (DH500 plugs were delivered with OPG1-30000-AF). There are three hydraulic connections: one on either side labeled **TEST** and one on top at the center of the tank cover.

❻ Screw the tank cover firmly shut. Oil may be left in the tank.

When shipping OPG1, use the original shipping materials, if possible. When using alternate materials (If the original shipping materials are not available) take care to assure that: a) the front panel controls and indicators are protected; b) the top mounted oil reservoir is not subjected to shock or load; c) the tubing and components exposed through OPG1's open bottom are protected. OPG1 must carry its weight on its four feet - NOT on its internal components.

3. GENERAL OPERATION

3.1 OPERATING PRINCIPLE

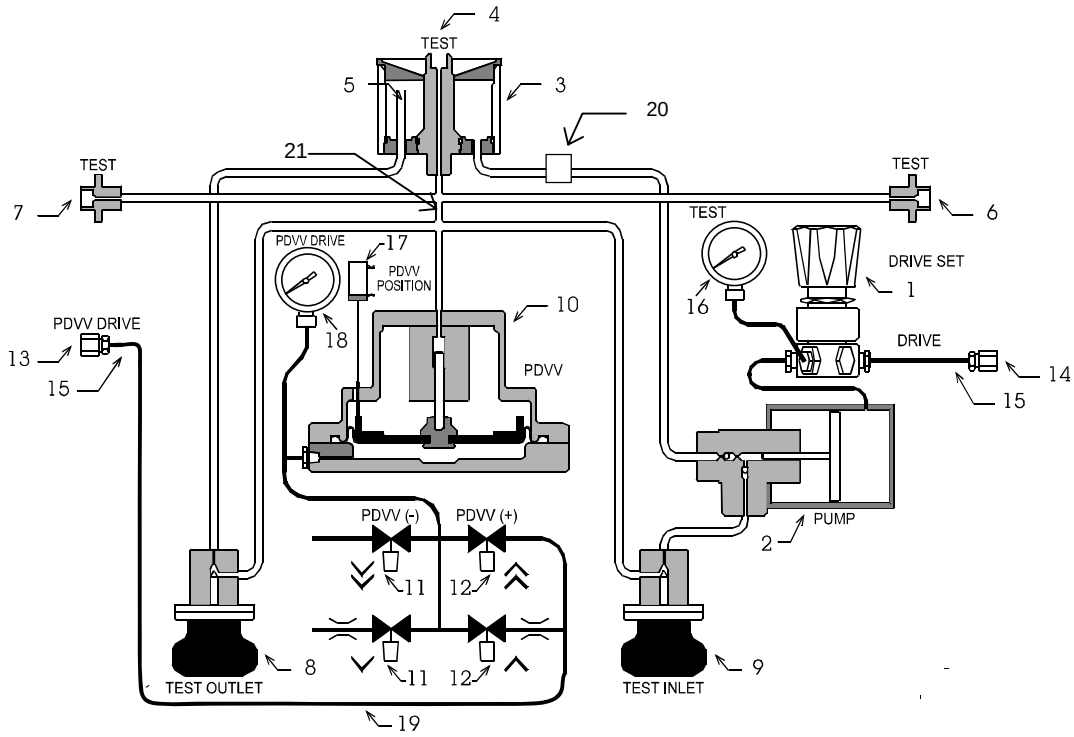
Numerical references in this section refer to Section 3.1, Figure 5.

OPG1-30000-AF is a self-contained system designed to generate and adjust pressure from atmosphere (zero gauge) to 200 MPa (30 000 psi) in and HGC-30000-AF Hydraulic Gauge Calibrator System. OPG1 combines the capability to fill the system with oil and execute large pressure changes very rapidly with very fine pressure adjustment around a point.

OPG1 uses two different techniques to generate and adjust pressure.

The first means of generating and adjusting pressure is the hydropneumatic pump (2) combined with the oil tank (3), **DRIVE SET regulator** (1), **INLET valve** (9) and **OUTLET valve** (8). **This combination is used for filling the system under test, large pressure changes and rough pressure control.** The valves are Belleville spring loaded, highly progressive, half-turn needle valves. The pump is a pneumatically powered, gate valve controlled, piston pump similar to a double-acting pneumatic cylinder. There is a ratio of 400:1 between the pneumatic piston and hydraulic plunger. The pump will operate continuously until the pneumatic drive pressure on the pneumatic piston is in equilibrium with the oil pressure on the oil plunger. For example, if the pneumatic drive pressure is 500 kPa (75 psi), the pump will cycle until the oil pressure reaches 200 MPa (30 000 psi). The pump draws oil from the oil tank on top of OPG1. The **DRIVE SET regulator** (1) is used to set the pneumatic drive pressure to the pump and thus the oil output pressure. The pump oil output is connected to the **INLET valve** (9). Opening the **INLET valve** connects the pump output to the test system causing the pump (2) to cycle, drawing oil from the tank as needed and pressurizing the system. Opening the **OUTLET valve** (8) returns oil to the tank (3), depressurizing the system.

The second means of generating and adjusting pressure is the Pneumatically Controlled Variable Volume (PDVV) (10) combined with the **PDVV (+) valves** (12) and **PDVV (-) valves** (11). **This combination is used for smaller pressure changes and fine pressure control.** The PDVV is a pneumatically actuated variable volume. A piston or plunger in a cylinder is exposed to the oil pressure. The other end of the plunger is connected to a dome loaded pneumatic actuator. Changing the pneumatic pressure on the dome loaded actuator causes the plunger to move, increasing or decreasing oil pressure. A spring returns the plunger to its minimum stroke position when there is no pressure on it. A mechanical system tracks movement of the plunger and an indicator (17) displays the plunger position on the front panel. The **PDVV (+) valves** (12) and **PDVV (-) valves** (11) are momentary, poppet valves that open when pressed. The **(+) valves** (12) admit drive air pressure to the PDVV actuator causing the PDVV piston to move forward compressing the oil and increasing the pressure. The **(-) valves** (11) have the opposite effect causing pressure to decrease.

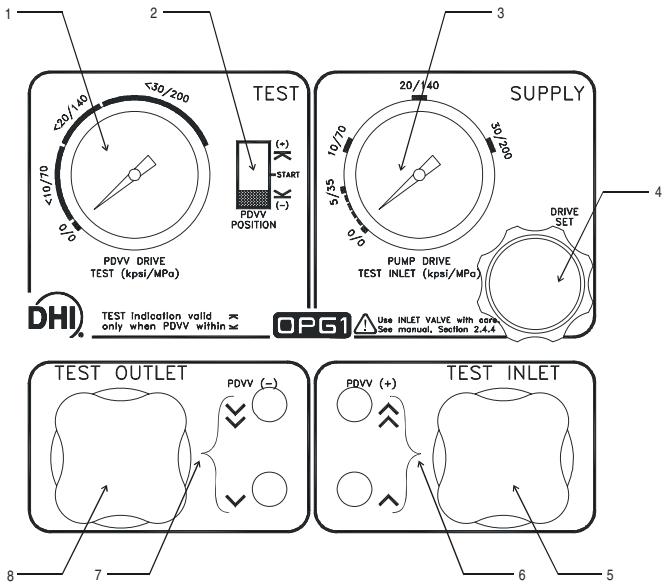


1. Pump Drive Air Set Regulator
2. Hydropneumatic Pump
3. Tank
4. Top TEST Connection
5. Oil Return Overflow Tube
6. Right Side TEST Connection
7. Left Side TEST Connection
8. Test Outlet Valve
9. Test Inlet Valve
10. Pneumatically Drive Variable Volume (PDVV)
11. Fast and Slow PDVV Decrease Valves
12. Fast and Slow PDVV Increase Valves
13. PDVV DRIVE Air Connection
14. Common DRIVE Air Connection
15. DRIVE Air Filters
16. PUMP DRIVE Pressure Gauge
17. PDVV Plunger Position Indicator
18. PDVV DRIVE Pressure Gauge
19. PDVV DRIVE to PDVV Connection
20. Oil Filter

Figure 5. System Schematic

3.2 OPERATIONAL FUNCTIONS

All OPG1 operational functions are accessed from the instrument front panel. Sections 3.2.1 to 3.2.6 detail the various functions.



1. PDVV Drive Air/Test Oil Pressure Gauge
2. PDVV Piston Position Indicator
3. Pump Drive Air/Inlet Oil Pressure Gauge
4. Pump Drive Air Set Regulator
5. Test Inlet Valve Knob
6. PDVV Increase Fast and Slow Buttons
7. PDVV Decrease Fast and Slow Buttons
8. Test Outlet Valve Knob

Figure 6. Front Panel

3.2.1 SETTING INLET PRESSURE, DRIVE SET REGULATOR ADJUSTMENT

Numerical references in this section refer to Section 3.2, Figure 6.

The **DRIVE SET regulator** (4) is a self venting regulator that sets the pneumatic drive pressure to the hydropneumatic pump. This determines the oil pressure that the pump will generate before stalling and that is available **on demand** when the **INLET valve** (5) is opened.

The **PUMP DRIVE gauge** (3) indicates the pump drive pressure on its inner dial and the corresponding pump output oil pressure on its outer dial (BLUE numbers). Use the outer BLUE indication to predict the maximum pressure that will be generated when the inlet valve is opened.

With the **INLET valve** (5) closed, use the **DRIVE SET regulator** (4) and the **PUMP DRIVE gauge** (3) indication to set the desired maximum pump output pressure. This is generally done at the beginning of a test or calibration based on the maximum pressure of the calibration. It is good practice to set the pump output pressure below the maximum pressure desired to avoid accidental overpressure. The PDVV can then be used for the final pressure adjustment at the maximum pressure (see Section 3.2.3).

⚠ *The DRIVE SET regulator sets the oil pressure output of the hydropneumatic pump. When the INLET valve is opened, this pressure can be generated very rapidly in the system connected to OPG1. Use caution in setting the pump drive pressure and always check the setting and adjust if necessary before using the INLET valve (see Sections 2.4.2 and 3.2.1).*

3.2.2 ROUGH PRESSURE GENERATION/CONTROL, INLET AND OUTLET VALVE OPERATION

Numerical references in this section refer to Section 3.2, Figure 6.

The **INLET valve** (5) and **OUTLET valve** (8) are high pressure needle valves. Their operation is highly progressive over a half-turn with mechanical stops at each end so they cannot be overtightened. The valve is turned CW to close and CCW to open. A WHITE dot on the handle body indicates its current open/close position.

The **INLET valve** (5) controls the flow of oil from the hydropneumatic pump into the test system. When the **INLET valve** is closed, the pump is shut off from the test system and dead ended. When the **INLET valve** is open, the pump output is connected to the test system and can fill and generate pressure into the system.

The **OUTLET valve** (8) controls the flow of oil from the test system back to the tank. When it is closed, the test system is shut off from the tank. When the **OUTLET valve** is open, the system returns oil to the tank and is opened to atmospheric pressure.

The **INLET valve** (5) and **OUTLET valve** (8) are used to execute large pressure changes in the test system and for rough pressure control. The **INLET valve** is used to connect to the pump to purge and prime the test system at the beginning of a test or calibration. The **OUTLET valve**, when fully opened, is the means of opening the test to atmosphere and **setting zero** pressure. The **INLET valve** and **OUTLET valve** are not generally used for ON/OFF action but progressively to roughly set the desired pressure. Exercise caution when operating the valves to not open them too quickly which may cause pressure in the system to change much more rapidly than desired.

⚠ *The INLET valve connects the output of the hydropneumatic pump to the test system. When the INLET valve is opened, high pressure can be generated very rapidly in the system connected to OPG1. Use caution in opening the INLET valve and always check the PUMP DRIVE gauge before doing so (see Sections 2.4.2 and 3.2.1).*

3.2.3 FINE PRESSURE ADJUSTMENT, PDVV (+) AND (-) VALVE OPERATION

Numerical references in this section refer to Section 3.2, Figure 6 except where specified otherwise.

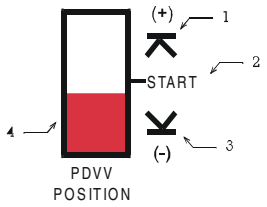
The **PDVV (+) valves** (6) and **PDVV (-) valves** (7) are push button, poppet valves that control the supply and exhaust of drive air pressure to the PDVV actuator (see Section 3.1). When the push button is pressed, the valve opens. When the push button is released the valve closes.

The valves labeled ⌄ and ⌄⌄ release gas from the PDVV actuator causing the PDVV plunger to back off and oil pressure to decrease. The valves labeled ⌃ and ⌃⌃ admit gas to the PDVV actuator causing the PDVV plunger to move forward and oil pressure to increase. The ⌄⌄ and ⌃⌃ valves are for high speed PDVV operation. The ⌄ and ⌃ valves are for slow speed PDVV operation.

The **PDVV (+) valves** (6) and **PDVV (-) valves** (7) are used to make small pressure changes and for fine pressure control. Brief momentary action on the ⌄ and ⌃ valves is used to **bump** or **jog** pressure in very small amounts around a pressure point.

The actual rate of pressure change caused by the **PDVV (+) valves** and **PDVV (-) valves** is dependent on the test volume that is connected to OPG1. Increasing the test volume lowers the rates and pressure step size. The maximum pressure that can be generated by the **PDVV (+) valves** is dependent on the drive air supply (see Section 2.3.1.2, Table 2).

The position of the PDVV plunger is indicated by the PDVV POSITION indicator (2). The RED index (Figure 7, Ref 4) on the indicator tracks the movement of the PDVV plunger. Minimum and maximum end of stroke positions (Figure 7, Refs 3 and 1) as well as a recommended start position (Figure 7, Ref 2) are indicated. The full stroke displacement of the PDVV plunger from maximum to minimum end of stroke is 1 cc (0.06 in.).



1. PDVV Plunger Maximum End of Stroke
2. PDVV Plunger Recommended Start Position
3. PDVV Plunger Minimum End of Stroke
4. PDVV Plunger Current Position (red/white line)

Figure 7. PDDV Position Indicator

The current air drive pressure on the PDVV actuator and approximate corresponding oil test pressure are indicated by the PDVV DRIVE gauge (1). The oil test pressure indication is highly approximate and only valid when the PDVV plunger is NOT at an end of stroke position.

For the PDVV (+) valves (6) and PDVV (-) valves (7) to have an effect, the PDVV plunger must have stroke available. If the PDVV is at its end of stroke (Figure 7, Ref 1 or 3), the plunger cannot move to change pressure. The recommended PDVV START position (Figure 8, Ref 2) puts the plunger at the middle of its stroke so 50 % of PDVV displacement is available in either direction. The PDVV plunger can be positioned without affecting oil pressure using the ⩔ and ⩓ valves when the OUTLET valve is open (oil pressure vented). The plunger is returned to minimum end of stroke position by a spring. The PDVV plunger is usually set to the desired position at the start of a calibration or test.

If the PDVV plunger reaches end of stroke during a calibration or test, used the INLET valve and/or OUTLET valve to increase or decrease the pressure, as needed.

The PDVV (+) valves (6), ***generate pressure indefinitely when opened.*** *Use caution not to generate more pressure than desired when using these valves.*

3.2.4 CONNECTING A DEVICE UNDER TEST (DUT)

See Section 2.3.1.4.

OPG1 covers a very wide range of pressures all the way up to 200 MPa (30 000 psi). It is the user's responsibility to assure that fittings and devices connected to OPG1 are rated for the pressures at which they will be used.

If the DUT connection is lower than the OPG1 oil tank, when the OUTLET valve is open and the DUT connection is open, oil will run out of the tank through the DUT connection.

3.2.5 PURGING AIR FROM THE DUT/SYSTEM UNDER TEST

Air is highly compressible. Oil is not. To the extent possible, air should be purged from the system and devices that are connected to OPG1 prior to applying pressure to them. Leaving air in the DUT reduces OPG1 efficiency, increases the time required to generate pressures, increases the dangers associated with high pressure operation and makes it more difficult to set a valid zero point.

The system and/or DUTs that are connected to OPG1 can be filled with oil prior to connecting them or they can be purged using OPG1. To purge air using OPG1, open the system or DUT at the highest point possible. Close the OPG1 **OUTLET valve**. Then carefully open the **INLET valve** causing oil to be drawn from the tank and pumped into the system. Observe the oil level at the purge point. Close the **INLET valve** when oil is present at the purge point.

While purging, watch the tank oil level carefully to be sure it is filled. Do not run the hydropneumatic pump without oil in the reservoir.

3.2.6 MEASUREMENT REFERENCE LEVEL WHEN VENTED

Generally, the test or calibration system is opened to atmosphere (zero gauge pressure) by opening the OPG1 **OUTLET valve**.

The fluid head reference level when the **OUTLET valve** is open is the top of the tank return overflow tube. This point is 258 mm (10.15 in.) above the surface on which OPG1 is sitting (see Figure 8).

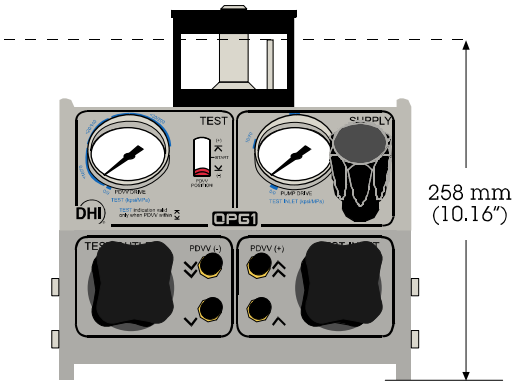


Figure 8. Fluid Head Level When Vented, **INLET Valve** Open

When the **OUTLET valve** is closed, the fluid head reference level is at the device being used as the measurement reference. Consider the possible difference in fluid head between the two conditions or incorrect fluid head corrections will be applied and the zero point will be inconsistent with other measurements.

See the RPM3/HPMS-A30000/A6000-AF Operation and Maintenance Manual for recommendations on setting zero and handling fluid heads when using OPG1 in an HGC-30000-AF system.

OPG1 is designed so that the top of the oil tank return overflow tube aligns with the measurement reference level of a PG7302 oil operated piston gauge. This assures that, when using a PG7302 piston gauge, the nominal reference level is the same at zero with the OPG1 vented and when pressures are defined by the piston gauge.

When the OPG1 OUTLET valve is open, the test system is connected to the OPG1 oil tank. If there is an open point in the test system below the oil level in the oil tank, oil will run from the tank and out of the open point in the test system.

3.3 TYPICAL OPERATING SEQUENCE FOR A COMPLETE CALIBRATION OR TEST

OPG1-A30000-AF is most often used to generate and adjust pressures to a reference measuring device and a DUT when performing a test or calibration. In an HGC-30000-AF the reference measuring device is an RPM3/HPMS-A30000/A6000-AF.

The typical operational sequence for a complete calibration or test when using the OPG1-A30000-AF in an HGC-30000-AF system is as follows (numerical references refer to Section 3.2, Figure 6):

❶ **Connect the DUT** to the OPG1 TEST port on the top of the OPG1 tank (see Section 2.3.1.4).

❷ **Position the PDVV plunger:** Open the **OUTLET valve** (8). Use the **PDVV (+) valves** (6) and **PDVV (-) valves** (7) and the **PDVV POSITION indicator** (2) to position the PDVV plunger at the **START** position or at another desired position (for example near the minimum end of stroke if the PDVV is to be used extensively for pressure generation).

❸ **Set the pump drive pressure:** Adjust the **DRIVE SET regulator** (4) and observe the pressure on the **PUMP DRIVE gauge** (3). Set the pressure so that the pump oil pressure output will be just under the maximum pressure to be reached in the test.

❹ **Take the starting zero reading on the DUT:** With the **OUTLET valve** (8) open, the pressure in the test system is zero gauge and the fluid head reference level is the top of the oil tank return overflow tube. Loosen the TEST connection fitting if desired to be sure no back pressure is applied to the DUT when checking the DUT zero point.

❺ **Initialize the test on the RPM3/HPMS-A30000/A6000-AF (see the RPM3/HPMS Operation and Maintenance Manual):** Press **[ENTER]** on the keypad of the RPM3 and initialize the test.

❻ **Set ascending test pressures:** Carefully open the **INLET valve** (5) and control the oil input from the pump to set the pressure in the test system just under the desired test point. Then use the **PDVV (+) valves** (6) and **PDVV (-) valves** (7) to adjust the pressure to the pressure desired as indicated by the DUT. Repeat this process for all of the ascending increments. If the increments are small enough for the PDVV displacement to generate the pressure, only the **PDVV (+) valves** may be needed to generate the next pressure. If the PDVV runs out of stroke, use the **INLET valve** to generate pressure.

❼ **Set descending test pressures:** Very carefully open the **OUTLET valve** (8) and control the oil return to the tank to set the pressure in the test system just over the desired test point. Then use the **PDVV (+) valves** (6) and **PDVV (-) valves** (7) to adjust the pressure to the exact test pressure desired as indicated by the DUT. Repeat this process for all of the descending increments. If the increments are small enough for the PDVV displacement to generate the pressure, only the **PDVV (-) valves** may be needed to generate the next pressure. If the PDVV runs out of stroke, use the **OUTLET valve** to reduce pressure.

❽ **Vent the system and disconnect the DUT:** Open the **OUTLET valve** (8) fully. Disconnect the DUT. If the test port is lower than the oil level in the oil tank, be sure to close the **OUTLET valve** so that oil does not run out of the tank through the test port.

4. MAINTENANCE ADJUSTMENTS AND CALIBRATION

4.1 OVERVIEW

OPG1 was designed for maintenance free operation. The hydropneumatic pump and PDVV are permanently lubricated. No maintenance is required other than:

- **Maintain oil level in tank:** Replace lost oil to never allow the tank to empty which would cause the pump to run without oil (see Section 4.2).
- **Replace oil and purge hydraulic system when oil becomes dirty:** Over time, contamination from the system to which OPG1 is connected may cause the oil to become contaminated. It should then be replaced and the OPG1 hydraulic system purged (see Section 4.3).
- **Prime hydropneumatic pump if it becomes cavitated:** If the hydropneumatic pump is run without oil in the tank, it may fill with air and become cavitated. If this occurs, the pump will no longer draw oil and generate pressure. To correct the situation, the pump must be primed (see Section 4.4).
- **Clean/replace filter elements on PDVV and hydropneumatic pump drive air filters:** The filters may become contaminated and restrict the free flow of drive air pressure. They should then be cleaned or replaced (see Section 4.5).

Maintenance and repair services for OPG1 are offered by authorized DHI Authorized Service Providers (see Section 6.1, Table 4).

OPG1 is a sophisticated pressure generation and adjusting instrument with advanced features and functions. Before assuming that unexpected behavior is caused by a system defect or breakdown, use this manual and other training facilities to become thoroughly familiar with OPG1 operation. For rapid troubleshooting assistance in specific situations, see Section 5.

Standard, commercial OPG1s are covered by a limited 1 year warranty (see Section 6.1). OPG1-30000-AFs delivered under F33660-99-C7003 are covered by a limited, 5 year worldwide warranty. The warranty start and finished dates are marked on each unit. Unauthorized service or repair during the warranty period is undertaken at the owner's risk and may cause damage that is NOT covered under the product warranty and/or may void the product warranty.

4.2 FILLING THE TANK

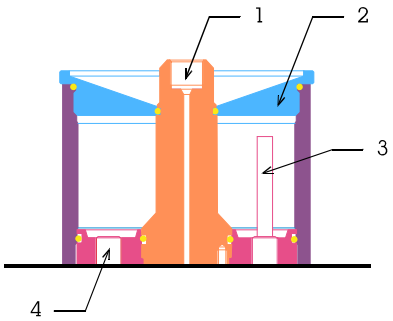
The oil level in the OPG1 tank should be maintained at all times. Opening the **INLET valve** and operating the hydropneumatic pump when the tank is empty will cause the pump to draw air and lose its prime.

To fill the oil tank, proceed as follows (numerical references refer to Figure 9):

❶ Unscrew the tank cover/oil fill funnel (2) until a gap for oil passage can be seen between the TEST port shaft (1) and the cover.

❷ Using the tank cover as a funnel, pour oil into the tank to just under the top of the overflow tube (3). DO NOT bring the oil level in the tank above the top of the overflow tube.

❸ Leave the tank cover open to allow oil to drain from the cover into the tank when swapping DUTs and to allow air to escape from the tank when venting oil back into the tank.



1. TEST Port
2. Tank Cover/Oil Fill Funnel (screws off)
3. Oil Return Overflow Tube (oil return)
4. Pump Draw (oil outlet)

Figure 9. Oil Tank

4.3 REPLACING OIL AND PURGING CONTAMINATED OIL

If OPG1 is used to generate and adjust pressure into test systems and DUTs that are not clean, the oil returned to OPG1 will become contaminated.

Observe the oil in the OPG1 tank. If its color is significantly different from the color of clean oil or if any particulate contamination can be observed, replace the oil in the oil tank and purge the OPG1 oil system.

To replace the oil in the oil tank proceed as follows:

❶ Fully remove the oil tank cover by unscrewing it (rotating CCW) and removing it completely.

❷ Remove the oil from the tank with a suction bulb or similar device.

❸ Clean out the tank with paper towels or rags. Remove all particulates that may be present.

❹ Refill the tank with fresh oil to just under the overflow tube.

To purge OPG1 of dirty oil proceed as follows:

❶ Fill the oil tank with clean oil (see Section 4.2).

❷ Open one of the side **TEST** ports and put a cup under the port.

❸ Close the **OUTLET valve**. Open the **INLET valve** causing the pump to cycle and oil to be drawn from the tank and expelled from the open **TEST** port. Observe the oil coming out of the test port until it runs clean. TAKE CARE to not allow the oil level in the tank to run out or the pump will draw air and lose its prime, requiring it to be primed (see Section 4.4). When the oil coming out the **TEST** port is running clean, close the **INLET valve**.

❹ Repeat from Step ❶, if necessary, until the oil running out the **TEST port** runs clean and the oil in the tank is clean.

4.4 PRIMING THE HYDROPNEUMATIC PUMP

If hydropneumatic pump is filled with air (cavitated), if will pump continuously when drive air is applied without drawing oil from the tank or generating oil pressure. If you believe the pump may be cavitated, first attempt to purge it following the procedure described in Section 2.4.3.1. If the pump cannot be purged, use the priming by syringe injection procedure described in Section 4.4.1. If the syringe injection procedure is not successful, consider using the internal priming procedure described in Section 4.4.2.

4.4.1 PRIMING THE HYDROPNEUMATIC PUMP BY SYRINGE INJECTION

The hydropneumatic pump injection priming procedure is only required if the regular purge procedure fails (see Section 2.4.3.1).

Numerical references in this section refer to Section 4.2, Figure 9.

To prime the pump with the syringe proceed as follows:

❶ Back off the OPG1 **DRIVE SET regulator** to zero by turning it fully CCW.

❷ Open **INLET valve** and **OUTLET valve**.

❸ Remove oil tank cover (2).

❹ Install 2-104 O-ring on tip of 10 cc syringe (both supplied in OPG1 accessory kit, see Section 2.1.2).

❺ Fill syringe with oil from the tank.

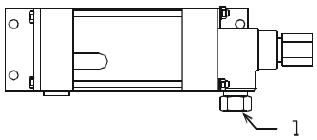
❻ Insert the tip of the syringe into the tank pump draw port (4) and press so that the O-ring seals against bottom of tank.

❼ Increase pump drive air pressure by rotating **DRIVE SET regulator** CW until the pump begins to cycle. When pump begins to cycle, press syringe plunger, injecting oil into pump. Continue until oil returning through the tank oil return overflow tube (3) is free of air bubbles. Note that in some cases, air free oil will return before trapped gas is expelled from the pump.

4.4.2 INTERNAL PURGE OF HYDROPNEUMATIC PUMP

The hydropneumatic pump internal purge procedure is only required if the regular purge procedure fails (see Section 2.4.3.1) and a syringe is not available to perform the injection priming procedure (see Section 4.4.1).

To purge the hydropneumatic pump internally, proceed as follows (see Figure 10):



1. Hydraulic Output Pressure Connection

Figure 10. Hydropneumatic Pump

❶ Verify that there is oil in the tank.

❷ Back off **DRIVE SET regulator** to zero.

❸ Position the OPG1 so that you can access the hydraulic output pressure connection (1) of the hydropneumatic pump while keeping the OPG1 in its normal, horizontal operating position. This is accomplished by placing either end on separate tables and accessing the pump from beneath OPG1 or by slightly lifting the front of the OPG1.

❹ Open the **INLET valve** fully.

❺ Use a wrench to turn the hydraulic output pressure connection gland (1) 1/8 turn CCW. This cracks the connection so that output oil from the pump can escape through the safety weep hole.

❻ Slightly adjust **DRIVE SET regulator** CW until the pump starts cycling.

❼ Allow the pump to cycle until clear, bubble free oil flows regularly from the weep hole. If this does not occur, the pump may require service. Contact your **DHI** Authorized Service Provider (see Section 6.1).

❽ Retighten the hydraulic output pressure connection (1) by turning the gland nut approximately 1/8 turn CW.

❾ Go to Section 2.4.3.1 and proceed with the normal purge procedure.

4.5 CLEANING/REPLACING DRIVE AIR FILTER ELEMENTS

There are filters on the OPG1 drive air inlet ports, one on the **PDVV DRIVE port** and the other on the **DRIVE port**. If the drive air supplied is excessively dirty, the filters may become contaminated and restrict air flow to the PDVV and/or hydropneumatic pump (see Section 3.1, Figure 6).

The drive air filters are filter bodies with scintered elements. To clean or replace the drive air filters, the filter body must be removed from OPG1.

To remove and reinstall the drive air filters, proceed as follows:

❶ Close the OPG1 tank cover fully and plug all hydraulic ports. Ensure that tank is filled to just under oil return tube.

❷ Place the OPG1 back down on the bench, so that the front panel is up with the open bottom towards you.

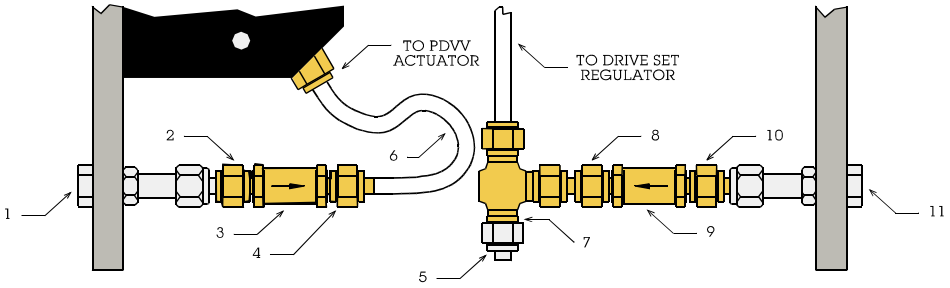
❸ Disconnect the filter connection fittings (2, 4) for the **PDVV DRIVE** filter (3) and (8, 10) for **DRIVE** filter (9). Remove the filter (3) and/or (9).

❹ To reinstall the filter, make the filter connections (2) and (4) or (8) and (10). Take care to insure that the filter is oriented in the correct direction (determined by the arrow on the filter body). The two filters are identical.

❺ Connect recommended pressures (see Section 2.3.1.2, Table 2) to the **PDVV DRIVE** port and **DRIVE** port. Check new connections for leaks using a liquid leak detector. Correct leaks, if present.

The filters may be replaced completely, cleaned by back flushing or disassembled and the filter element cleaned or replaced.

To disassemble the filter body, open the body by unscrewing the filter body cap CCW. Once the filter body cap is removed, the scintered filter element can be removed.



1. PDVV DRIVE Port
2. PDVV DRIVE Filter Upstream Connection
3. PDVV DRIVE Filter
4. PDVV DRIVE Filter Downstream Connection
5. Cap
6. PFA PDVV Supply Tube
7. DRIVE Tee PDVV Connection
8. DRIVE Filter Downstream Connection
9. DRIVE Filter
10. DRIVE Filter Upstream Connection
11. DRIVE Port

Figure 11. Drive Air Filters

5. TROUBLESHOOTING

PG1 is a sophisticated pressuring generating and adjusting instrument with advanced features and functions. Before assuming that unexpected behavior is caused by a system defect or breakdown, the operator should use this manual and other training facilities to become thoroughly familiar with OPG1 operation. This troubleshooting guide is intended as an aid in identifying the cause of unexpected OPG1 behavior and determining whether the behavior is due to normal operation or an internal or external problem.

Identify the symptom or unexpected behavior you are observing from the **Symptoms** listed in Table 3. 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. OPG1 Troubleshooting Checklist

SYMPTOM	PROBABLE CAUSE	SOLUTION
Test pressure continuously increases even with all valves closed.	Leak in **INLET valve** or leak in **PDVV (+) valve(s)**.	Isolate leak to **INLET valve** or **PDVV (+) valve(s)** by checking whether pressure continues to increase when **PDVV (-) valves** are opened or PDVV is at end of stoke. Replace or repair valve(s) if qualified to do so. Contact **DHI** Authorized Service Provider. (6.1)
Test pressure continuously decreases even with all valves closed.	Leak in **OUTLET valve**, leak in **PDVV (-) valve(s)** or pneumatic circuit, leak in OPG1 hydraulic circuit or leak in test volume to which OPG1 is connected.	Identify and correct leak in test volume if present. Isolate leak to **OUTLET valve** or **PDVV (-) valve(s)** by checking if pressure continues to decrease when PDVV is in minimum end of stroke position. Replace or repair valve(s) if qualified to do so. Contact **DHI** Authorized Service Provider. (6.1)
Test pressure takes too long to stabilize or will never stabilize.	You are observing normal evolution of pressure in an uncontrolled static volume, excess gas in hydraulic circuit.	Reduce test volume. Increase stability of test tubings and vessels. Wait longer for stability. Overshoot test point and return to reduce stabilization time. Reduce reference reading resolution to appropriate level.

Table 3. OPG1 Troubleshooting Checklist (Continued)

SYMPTOM	PROBABLE CAUSE	SOLUTION
PDVV will not increase pressure.	PDVV is at maximum end of stroke position, PDVV supply pressure is not high enough, or PDVV supply plugged.	Verify PDVV piston position and readjust if necessary. Use **INLET valve** to increase pressure. Increase pneumatic supply pressure. Clean filter. (3.2.3, 4.5)
PDVV will not decrease pressure.	PDVV is at minimum end of stroke position.	Verify PDVV piston position and readjust if necessary. Use **OUTLET valve** to decrease pressure. (3.2.3)
Opening **INLET valve** does not increase pressure.	Pump drive pressure too low.	Adjust pump drive pressure, increase pneumatic supply pressure if necessary. (3.2.1, 2.3.1.2, Table 2)
Pump cycles continuously without generating pressure.	The pump has lost its prime, oil tank empty.	Purge and prime pump. (4.4)
Pump cycles continuously without generating pressure.	**OUTLET valve** is open.	Close **OUTLET valve.** (3.2.2)
Pump cycles continuously without generating pressure.	There is a large leak in the test system to which OPG1 is connected.	Identify and correct leak in test system.
Pump cycles excessively before beginning to generate pressure.	The test volume to which OPG1 is connected has not been purged of air and pump is filling test volume and compressing air.	Purge air from test system before generating pressure. (3.2.5)
Oil is leaking out of an open point in the test system.	The open point in the test system is below the OPG1 tank and the **OUTLET valve** is open so oil is running out from the tank .	Operation is normal. Be sure to keep the **OUTLET valve** closed when any point at a lower height than the OPG1 tank is open. (2.3.1.4)
Pressure is not returning to zero when the **OUTLET valve** is opened.	There is air in the OPG1 and/or system under test.	Purge air from the OPG1 and/or system under test. Disconnect the DUT at the test port to zero the DUT. (3.2.5)

6. APPENDIX

6.1 WARRANTY STATEMENT

Except to the extent limited or otherwise provided herein, **DH Instruments, Inc.** warrants for one year from purchase (five years for OPG1-A30000-AF units purchased under AFMETCAL Contract F33660-99-C7003, as labeled on the instrument rear panel), each new product sold by it or one of its authorized distributors, only against defects in workmanship and/or materials under normal service and use. Products which have been changed or altered in any manner from their original design, or which are improperly or defectively installed, serviced or used are NOT covered by this warranty.

DH Instruments, Inc. and any of its authorized service providers' obligations with respect to this warranty are limited to the repair or replacement of defective products after their inspection and verification of such defects. All products to be considered for repair or replacement are to be returned to **DH Instruments** or its authorized service provider after receiving authorization from **DH Instruments** or its authorized service provider. The buyer assumes all liability vis-à-vis third parties in respect of its acts or omissions involving use of the products. In NO event shall **DH Instruments** be liable to purchaser for any unforeseeable or indirect damage, it being expressly stated that, for the purpose of this warranty, such indirect damage includes, but is NOT limited to, loss of production, profits, revenue, or goodwill, even if **DH Instruments** has been advised of the possibility thereof, and regardless of whether such products are used individually or as components in other products.

The provisions of this warranty and limitation may NOT be modified in any respect except in writing signed by a duly authorized officer of **DH Instruments, Inc.**

The above warranty and the obligations and liability of **DH Instruments, Inc.** and its authorized service providers exclude any other warranties or liabilities of any kind.

The 5 year warranty provided on purchases made under AFMETCAL Contract F33660-99-C7003 extends the 1 year commercial warranty defined above. This warranty provides for remedy of defects in material, workmanship, manufacturing and design only. It is NOT an extended service contract. Units returned for service not covered under the warranty terms are subject to normal service charges including charges for evaluation and/or analysis of warranty claims when no defect is found.

Table 4. DHI Authorized Service Providers

DH INSTRUMENTS, INC. AUTHORIZED SERVICE PROVIDERS 2000 JAN			
COMPANY	**ADDRESS**	**TELEPHONE, FAX EMAIL**	**NORMAL SUPPORT REGION**
DH Instruments, Inc.	4765 East Beautiful Lane Phoenix AZ 85044-5318 USA	Tel 602.431.9100 Fax 602.431.9559 jbaines@dhinstruments.com	Worldwide
Minerva I.P.&M. B.V.	Handelsweg 13 Postbus 76-1270 AB Huizen NETHERLANDS	Tel 31/35.52.54.887 Fax 31/35.52.64.560 minervaipm@compuserve.com	European Union
Nippon CalService, Inc.	2-9-1 Sengen, Tsukuba-Shi Ibaraki Prefecture 305 JAPAN	Tel 0298-55-8778 Fax 0298-55-8700 aohte@ohtegiken.co.jp	Japan/Asia

GLOSSARY

⩔, ⌄	Fast ⩔ and slow ⌄, **PDVV (-) valves**. Used to decrease pressure and for fine pressure adjustment.
⩓, ⌃	Fast ⩓ and slow ⌃, **PDVV (+) valves**. Used to increase pressure and for fine pressure adjustment.
CW	Clockwise
CCW	Counter-clockwise
Collar	The DH500 fitting element that is threaded onto the tube and provides a surface for the gland to push against.
DH500	High pressure, gland and collar type fitting for 1/4 in. (6mm) coned and left hand threaded, stainless steel, tubes. DH500 is equivalent to AE F250C, HIP HF4, etc.
DRIVE SET Regulator	Self venting regulator used to regulate the drive air (pneumatic power) to the hydropneumatic pump. Sets maximum inlet pressure.
DUT	Device or System Under Test. The device that is connected to OPG1 to be tested or calibrated.
Gland	The “jam nut” in a DH500 fitting that pushes the collar on the tube into the seat.
Hydropneumatic Pump	Pneumatically operated, gate valve controlled, piston pump used to supply high pressure oil to the **INLET valve**.
INLET Valve	Progressive, half-turn, needle valve used to admit oil from the hydropneumatic pump into the test system. Used to generate pressure and for rough pressure adjustment.
OUTLET Valve	Progressive, half-turn, needle valve used to return oil from the test system to the oil tank. Used to release pressure and for rough pressure adjustment.
PDVV (Pneumatically Driven Variable Volume)	A pneumatically actuated plunger in a cylinder used to increase and decrease the volume of the oil test system and provide fine adjustment of the test pressure.

PDVV (+) Valves	Momentary, push button actuated, poppet valves that admit air drive pressure to the PDVV actuator causing the PDVV plunger to move forward, compressing oil and increasing the test pressure. Used to increase pressure and for fine pressure adjustment.
PDVV (-) Valves	Momentary, push button actuated, poppet valves that release air drive pressure from the PDVV actuator causing the PDVV plunger to move back, decompressing oil and decreasing the test pressure. Used to decrease pressure and for fine pressure adjustment.
PDVV DRIVE Gauge	Analog gauge that indicates the PDVV actuator air pressure and the approximate corresponding oil test pressure.
PUMP DRIVE Gauge	Analog gauge that indicates the pump drive air pressure and the approximate corresponding pump oil output pressure.
Test Pressure	The oil pressure in the OPG1 PDVV, at its TEST connections and in the system to which the OPG1 is connected.