GPC1-10000-AF™

Gas Pressure Controller

Operation and Maintenance Manual

NSN 6685-01-529-6990 RN
(1 of 3)

This equipment described in this manual is designed and manufactured for the intended purpose of generating high pressure gas. Certain precautions need to be followed during installation and operation of this device. Reading and understanding this material is essential to the safe and correct operation of the unit.

Pressurized equipment is potentially dangerous. The equipment described in this manual generates and controls very high gas pressures. It should not be operated by anyone who has not become thoroughly familiar with this manual. Additional training in general and pressure specific safety procedures will help assure protection from harm or damage to personnel or property. Responsibility for the proper and safe operation of this instrument rests with the user.

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.

This instrument is not to be operated in any other manner than that specified by the manufacturer.

Document No. 550135a
050726
Printed in the USA

TABLE OF CONTENTS

TABLES

FIGURES

NOTES

ABOUT THIS MANUAL

This manual provides the user with the information necessary to operate a GPC1-10000-AF Gas Pressure Controller. It also includes a great deal of additional information provided to help you optimize GPC1 use and take full advantage of its many features and functions.

FOR THOSE OF YOU WHO "DON'T READ MANUALS", GO DIRECTLY TO SECTION 2.4 TO SET UP YOUR GPC1. THEN GO TO SECTIONS 2.5.5 and 3.3. THIS WILL GET YOU RUNNING QUICKLY WITH MINIMAL RISK OF CAUSING DAMAGE TO YOURSELF OR YOUR GPC1. THEN… WHEN YOU HAVE QUESTIONS OR START TO WONDER ABOUT ALL THE GREAT FEATURES YOU MIGHT BE MISSING, GET INTO THE MANUAL!

GPC1-1000-AF is usually delivered as part of an PGC-10000-AF system which also includes an RPM4/HPMS A70M/A20M-AF reference pressure monitor and and a GB-152-AF gas booster. The RPM4/HPMS and the GB-152 have their own Operation and Maintenance Manuals.

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.

NOTES

1. INTRODUCTION

1.1 PRODUCT OVERVIEW

The GPC1-10000-AF Gas Pressure Controller is a stand alone, pressure setting and adjusting component intended to be used as the means of pressure control in pneumatic calibration and test systems. GPC1-10000-AF covers the range from atmosphere to 10 000 psi (70 MPa).

GPC1 combines the versatility, speed and reliability of direct operator control with the convenience and effort-free operation of automation. It is the standard pressure control component in a PGC-10000-AF Pneumatic Gauge Calibrator as well as in a PG7202 piston gauge system.

The GPC1-10000-AF is typically delivered as part of a PGC-10000-AF Pneumatic Gauge Calibrator. The PGC-10000-AF system includes a GB-152-AF gas booster and an RPM4/HPMS A70M/A20M that have their own Operation and Maintenance Manuals.

1.2 SPECIFICATIONS

Electrical Power Requirements: None

Pneumatic Power Requirements: Clean, dry, low flow, compressed gas. Max flow 200 sccm (<0.01 scfm):

Working P	Drive Air P
- 750 psi (5 MPa):	45 psi (300 kPa)
- 7 500 psi (50 MPa):	87 psi (600 kPa)
- 10 000 psi (70 MPa)	100 psi (700 kPa)

High Pressure Supply: Not to exceed 10 000 psi (10 MPa)

Operating Temperature Range: 10 to 35 °C

Weight: 24 kg (53 lb)

Dimensions: 21.5 cm H x 30 cm W x 53.5 cm D (8.5 in. x 11.8 in. x 21.1 in.)

Pressure Range: 0 to 10 000 psi (70 MPa)

Operating Medium: Any non-corrosive gas

Pneumatic Power Connection: 1/4 in. NPT F

Test Connections: (3) DH500 F test connections ((1) left, rear side and (2) on top)

DH500™ is a gland and collar type fitting for ¼ in. (6 mm) coned and left hand threaded tube. DH500 is equivalent to AE F250C, HIP HF4, etc.

Pneumatically Actuated Variable Volume (PDVV) Displacement: 2 cc (0.12 in^3)

PGC-10000-AF SYSTEM

Temperature: Operating: 18 to 28 °C

Storage: -20 to 70 °C

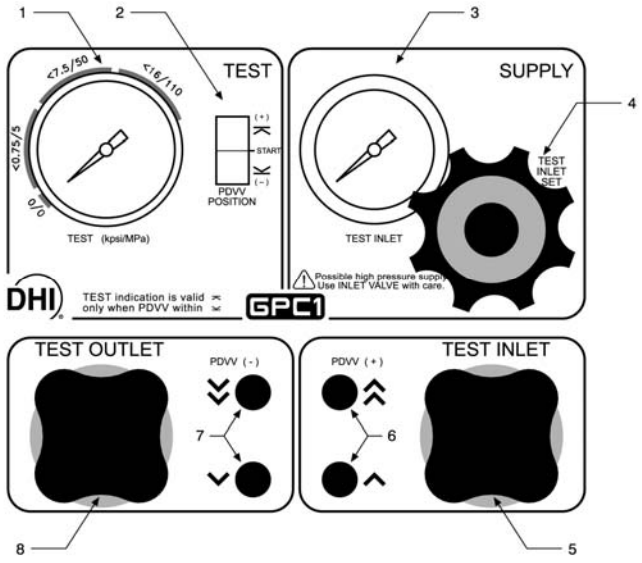
Relative Humidity: Operating: 15 to 70%RH (non-condensing)

Storage: 10 to 90%RH (non-condensing)

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 gas pressure gauge
2. PDVV plunger position indicator
3. Test inlet pressure gauge
4. Test inlet pressure 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 view

1.3.2 OVERALL DIMENSIONS

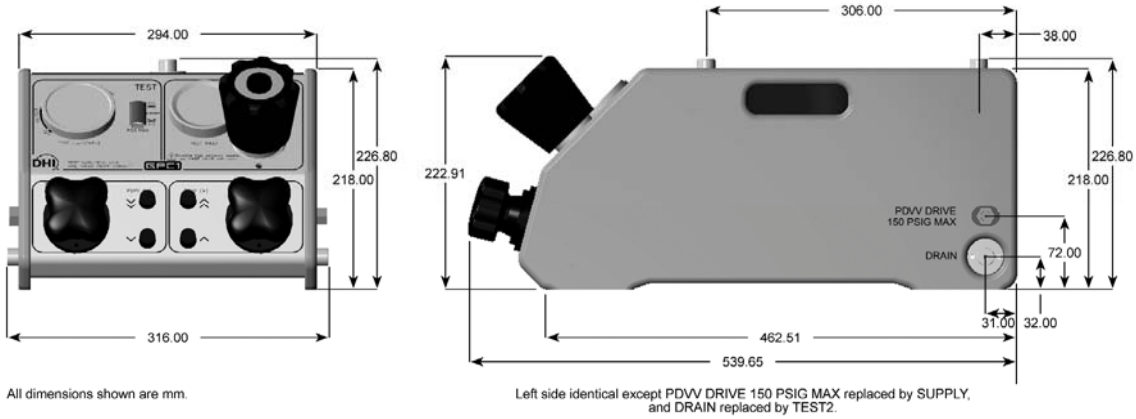
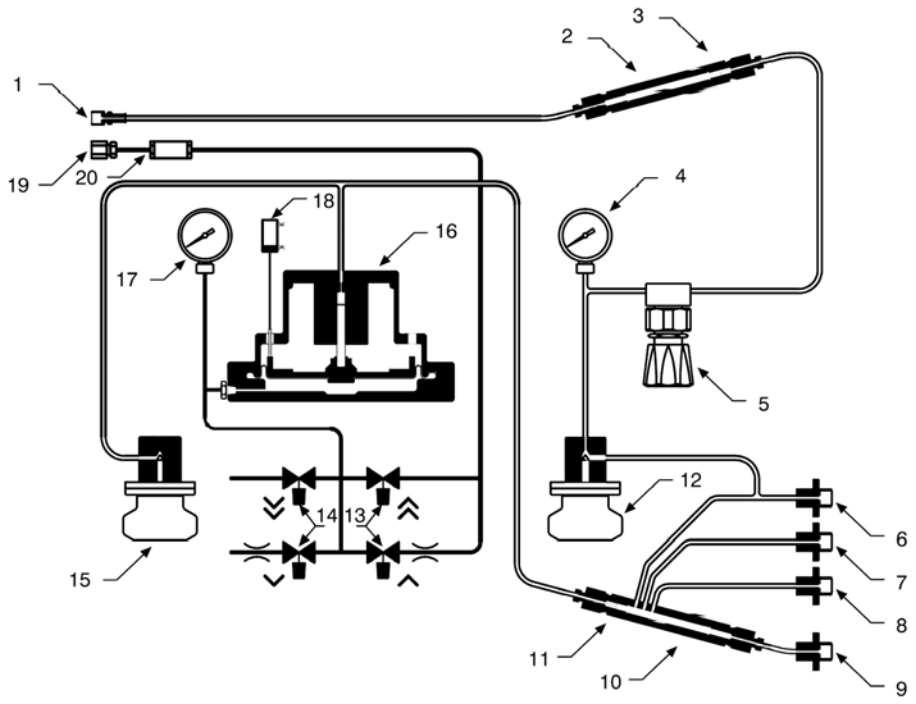


Figure 2. Front and side views with dimensions

1.3.3 SYSTEM SCHEMATIC



1. High pressure gas SUPPLY connection (left lateral)
2. Supply accumulator
3. Supply filter (not shown)
4. TEST INLET gauge
5. TEST INLET SET regulator
6. TEST1 port (rear top)
7. TEST2 port (left lateral)
8. TEST3 port (front top)
9. DRAIN port (right lateral)
10. Test liquid collection sump
11. Sump filter (not shown)
12. TEST INLET valve
13. Fast and slow PDVV increase valves
14. Fast and slow PDVV decrease valves
15. TEST OUTLET valve
16. Pneumatically driven variable volume (PDVV)
17. PDVV drive pressure gauge
18. PDVV plunger position indicator
19. PDVV DRIVE air connection (right lateral)
20. DRIVE air filter

Figure 3. System schematic

2. INSTALLATION

2.1 UNPACKING AND INSPECTION

2.1.1 REMOVING FROM PACKAGING

GPC1 is delivered, along with its standard accessories, in a corrugated container with corrugated and polyurethane inserts to hold it in place.

Remove GPC1 and its accessories from the shipping container and remove each item from its protective plastic bag.

Retain the specialized packing and shipping materials in case the GPC1 needs to be shipped.

2.1.2 INSPECTING CONTENTS

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

Verify the items received against the parts list in Table 1.

Table 1. GPC1-10000-AF Parts List

DESCRIPTION		PART #
GPC1-10000-AF instrument		402190
ACCESSORIES:		
1	Mat, Top Surface Protection	123481
1 ea.	PGC-10000-AF Documentation Disk including: • RPM4/HPMS A70M/A20M-AF Operation and Maintenance Manual, p/n 550136 • **GPC1-10000-AF Operation and Maintenance Manual, p/n 550135** • GB-152-AF Operation and Maintenance Manual, p/n 550137	402189 **(Shipped with RPM4/HPMS accessories in transport case)**
1	Wrench, Open End, 5/8 in.	103044
INTERCONNECTIONS KIT:		**402165**
2 ea.	Nipple, 2.75 in. (70 mm), DH500	100207
1 ea.	Nipple, 6 in. (152.4 mm), DH500	100208
1 ea.	Nipple, 12 in. (30.5 mm), DH500	100209
1 ea.	Elbow, 12 in. (30.5 mm), DH500	123136
1 ea.	Adaptor, DH500 F x 1/8 in. NPT M	102819
1 ea.	Adaptor, DH500 F x 1/4 in. NPT F	102820
1 ea	Adaptor, DH500 F x 1/4 in. NPT M	102889
1 ea	Adaptor, DH500 F x AN4 M	102888
3 ea.	Plug, DH500	100285
3 ea.	Collar, DH500	101201

2.2 PGC-10000-AF SYSTEM

GPC1-10000-AF is usually delivered as the pressure generation and control component of a PGC-10000-AF Pneumatic Gauge Calibration System (see Figure 4). The PGC-10000-AF system includes:

- RPM4/HPMS A70M/A20M-AF: Reference pressure monitor and high pressure mounting system used as the pressure measuring reference of the calibration system.
- GPC1-10000-AF: Gas pressure controller used to set and adjust high pressure gas in the calibration system.
- GB-152-AF: Gas booster package used to supply gas pressure up to 10 000 psi (70 MPa) to the GPC1-10000-AF pressure controller.

Each of the three components of the PGC-10000-AF system has its own Operation and Maintenance Manual and individual setup and start up instructions. Figure 4 shows the typical setup configuration of the complete PGC-10000-AF system.

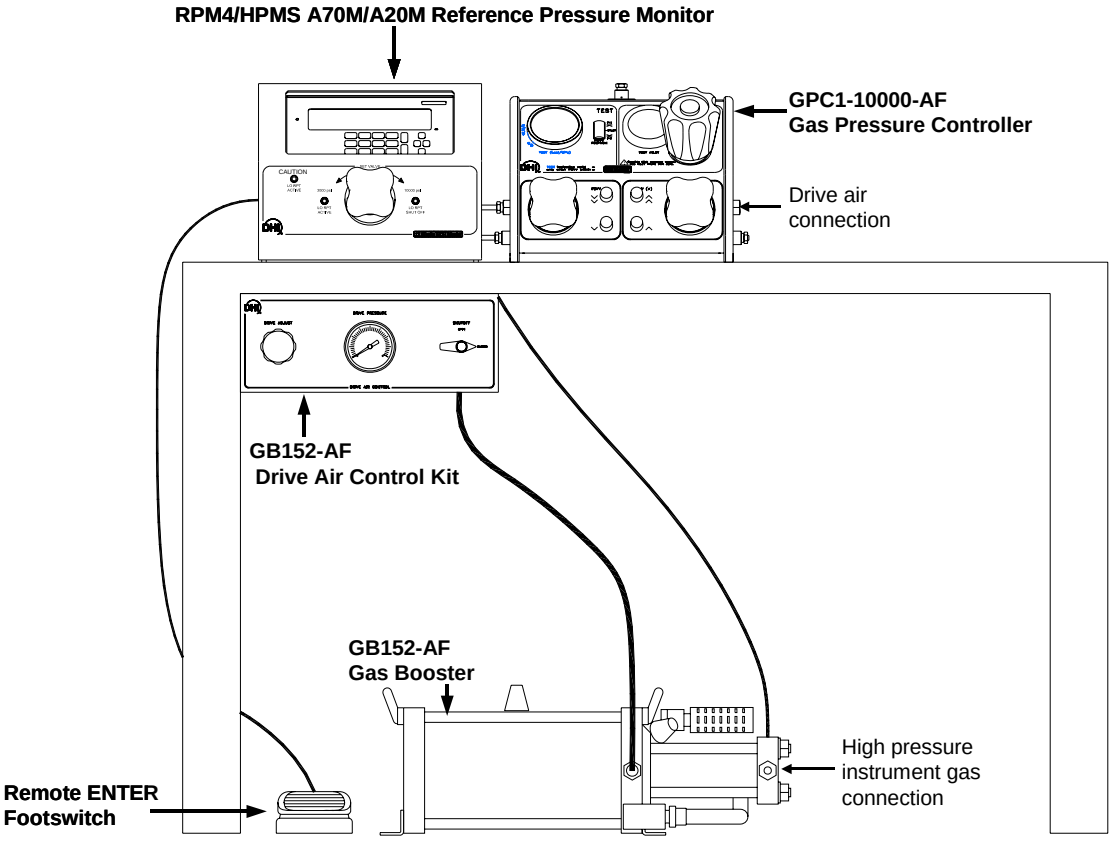


Figure 4. Typical PGC-10000-AF system installation

2.3 SITE REQUIREMENTS

The GPC1-10000-AF is typically delivered as part of a PGC-10000-AF Pneumatic Gauge Calibrator (see Section 2.2). The PGC-10000-AF system also includes a GB-152-AF gas booster and an RPM4/HPMS A70M/A20M that have their own Operation and Maintenance Manuals.

When selecting and preparing a site to setup a GPC1 system, the following should be considered:

- **Bench stability:** GPC1 weighs about 24 kg (53 lb). The RPM4/HPMS A70M/A20M-AF weighs about 12 kg (26 lbs). Consider the combined weight of all components, including possible items to be tested, when selecting a bench.
- **Footprint:** The PGC-10000-AF system requires a minimum bench space approximately 33 in. (84 cm) wide and 24 in. (60 cm) deep.
- **Location of other components:** Plan the space required and a convenient layout for the complete system in which GPC1 is the pressure control component.
- If the GPC1 is to be used with an RPM4/HPMS, the GPC1 accessories include the hardware necessary for setting up in a standard configuration (see Sections 2.2, 2.4.3, 2.4.4). The RPM4/HPMS is normally placed to the left of the GPC1 and connected to the **TEST2** port.
- **DRAIN port:** Provide access to the **DRAIN** port on the right, rear side of the GPC1. This port needs to be accessed regularly to purge contaminants from GPC1.
- **High pressure supply:** Plan the connection from the high pressure gas supply to GPC1. If the high pressure is being supplied by a GB-152-AF gas booster (included in GPC-10000-AF Pneumatic Gauge Calibrator), interconnecting hardware to connect the booster output to the GPC1 **SUPPLY** port is included with the booster (see the GB-152-AF Operation and Maintenance Manual).
- **Drive air supply:** Plan the PDVV drive air supply. The maximum drive air supply required is 100 psi (700 kPa) but may be lower depending on the maximum test pressure to be adjusted (see Section 2.4.2, Table 2). The drive air **PDVV DRIVE AIR** port is on the right, rear side of GPC1. The connection is 1/4 in. NPT female. This is usually supplied from an N2 or Air "K" bottle.
- **System interconnections:** Plan the interconnections between GPC1 and any other components in the system. Minimizing the volume and maximizing the mass of all interconnecting elements will reduce pressure generation and stabilization time (see Section 2.2).

ALWAYS use external tubing and fittings rated for pressures equal to or greater than the maximum pressure which GPC1 will be used to control.

DH500 F fittings are delivered with disposable, orange, plastic dummy plugs installed. These are NOT intended to hold high pressure. They should be removed and replaced with appropriate fittings or stainless steel plugs before high pressure operation. Each dummy plug carries a DH500 collar. Remove and retain the collar for use in connecting to the fitting.

2.4 INITIAL SETUP

Before setting up GPC1, see Section 2.3 for general information on site requirements.

To prepare a GPC1 for check out and operation:

❶ Set up GPC1 (see Section 2.4.1).

❷ Connect drive air (see Section 2.4.2).

❸ Connect the high pressure supply (GB-152-AF) (see Section 2.4.3).

❹ Make test pressure interconnections, including connecting the reference pressure measuring device (RPM4/HPMS A70M/A20M-AF) (see Section 2.4.4).

2.4.1 SET UP GPC1

To set up GPC1 proceed as follows:

❶ Place GPC1 on the site table in the proper orientation with the front panel controls conveniently accessible.

❷ Install the mat delivered with the GPC1 accessories on the top, front surface of the GPC1.

2.4.2 CONNECT PNEUMATIC POWER (DRIVE AIR)

GPC1 requires pneumatic power to drive its pneumatically driven variable volume (PDVV).

The drive air requirements are summarized in Table 2. Since the flow requirements are very low and cleanliness of the gas is important, the supply is usually regulated Nitrogen or instrument grade air from a “K” bottle.

Connect the pneumatic pressure source to the 1/4 in. NPT F connection labeled **PDVV DRIVE** on the right side of GPC1 housing. Use Teflon™ tape or another thread sealant to minimize leakage.

GPC1 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 GPC1 and lead to erratic behavior requiring difficult and costly cleaning.

Table 2. Pneumatic power (drive air) requirements

INTERNAL COMPONENT	DRIVE AIR PRESSURE NEEDED	MINIMUM FLOW	LUBRICATION REQUIRED	CLEANLINESS CRITICAL
PDVV	For 750 psi (5 MPa): Supply 45 psi (300 kPa) For 7 500 psi (50 MPa): Supply 87 psi (600 kPa) For 10 000 psi (70 MPa): Supply 100 psi (700 kPa)	< 0.01 scfm (200 sccm) ** This is very low flow.*	No	Yes

2.4.3 CONNECT HIGH PRESSURE GAS SUPPLY (GB-152-AF)

GPC1 requires a high pressure gas supply of 10 000 psi (70 MPa) or lower. If the GPC1 is part of a PGC-10000-AF Pneumatic Gauge Calibrator, the high gas pressure supply is provided by a GB-152-AF gas booster. Hardware to connect the booster output to the GPC1 **SUPPLY** port is supplied with the booster. See the GB-152-AF Operation and Maintenance Manual for instructions on making the connection using the GB-152-AF interconnections kit.

The high pressure gas supply is connected to the GPC1 **SUPPLY** port. The **SUPPLY** port is a DH500 female (DH500 is equivalent to AE F250C, HIP HF4, etc.).

Do not connect pressure greater than 10 000 psi (70 MPa) to the GPC1 SUPPLY port.

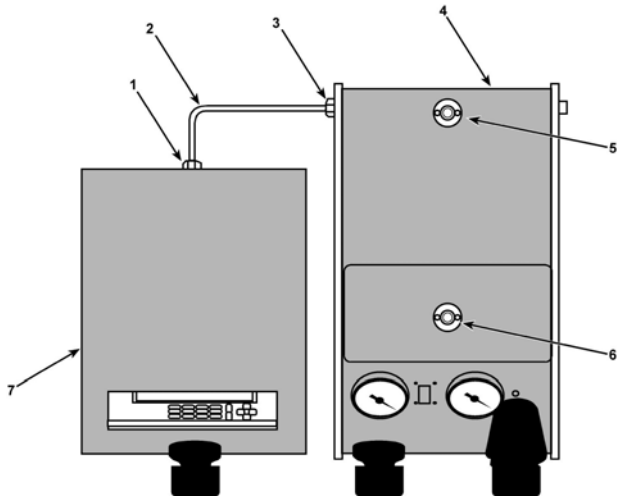
Highly pressurized gas can be extremely hazardous. Before applying pressure to GPC1 and/or the system connected to it, be sure that all pressure vessels and connections are rated for the pressure levels that will be applied and that all connections have been properly tightened (see Section 2.5.5). Ensure that the GPC1 TEST INLET SET regulator is fully backed off and its INLET valve is closed (see Section 2.5.1).

DH500 F fittings are delivered with disposable, orange, plastic dummy plugs installed. These are NOT intended to hold high pressure. They should be removed and replaced with appropriate fittings or stainless steel plugs before high pressure operation. Each dummy plug carries a DH500 collar. Remove and retain the collar for use in connecting to the fitting.

2.4.4 MAKE TEST PRESSURE INTERCONNECTIONS

2.4.4.1 CONNECT THE SYSTEM REFERENCE PRESSURE MEASURING DEVICE (RPM4/HPMS A70M/A20M-AF)

GPC1-10000-AF is delivered with an interconnections kit (see Section 2.1.2, Table 1). This kit includes a 12 in. (305 mm) DH500 elbow intended to connect GPC1 to an RPM4/HPMS A70M/A20M-AF reference pressure monitor which is included in the PGC-10000-AF Pneumatic Gauge Calibrator. See Figure 5 for the recommended layout. The setup assumes that one of the **TEST** ports on the top of GPC1 or an open leg of the interconnecting tee will be used to connect to the device or system under test.



1. RPM4/HPMS **TEST** port
2. 12 in. DH500 elbow (in GPC1 interconnections kit)
3. GPC1 **TEST2** port
4. GCP1-10000-AF
5. GPC1 **TEST1** port
6. GPC1 **TEST3** port
7. RPM4 A70M/A20M-AF

Figure 5. Connecting GPC1-10000-AF to RPM4/HPMS A70M/A20M-AF

2.4.4.2 CONNECTING TO A DEVICE UNDER TEST

In a PGC-10000-AF system, the device under test (DUT) is intended to be connected to one of the **TEST** connections on the top surface of the GPC1. See Section 2.4.4.3 concerning cleanliness considerations before connecting a DUT.

The **TEST** connections on the top of the GPC1 are DH500 F (DH500 is a gland and collar type fitting for 1/4 in. (6 mm) coned and left hand threaded tube. DH500 is equivalent to AE F250C, HIP HF4, etc.).

The PGC-10000-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., 6 in. or 12 in. DH500 nipple. The nipple/adaptor assembly is then installed on the DUT. Finally, the nipple/adaptor/DUT assembly is installed on the GPC1's DH500 F **TEST** connection. Note that the gland nut on the DH500 nipple assembly can be tightened into the DH500 F connection without rotating the nipple or DUT. Adaptors included in the GPC1 accessory kit are:

- 1/4 in. NPT F
- 1/4 in. NPT M
- 1/8 in. NPT M
- 37 degree flare M (AN4 M)

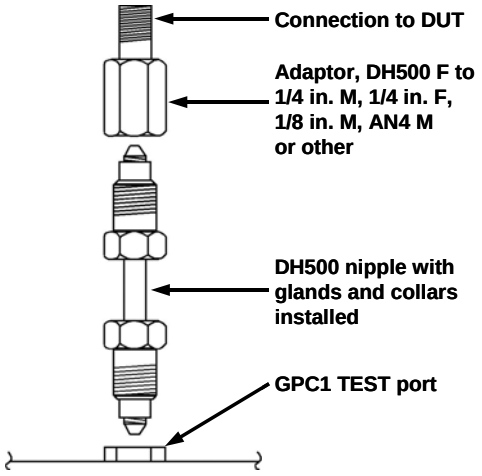


Figure 6. Adapting TEST port to connect a device under test

Highly pressurized gas can be extremely hazardous. Before applying pressure to GPC1 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 (see Section 2.5.5).

2.4.4.3 CLEANLINESS CONSIDERATIONS WHEN CONNECTING DUTS

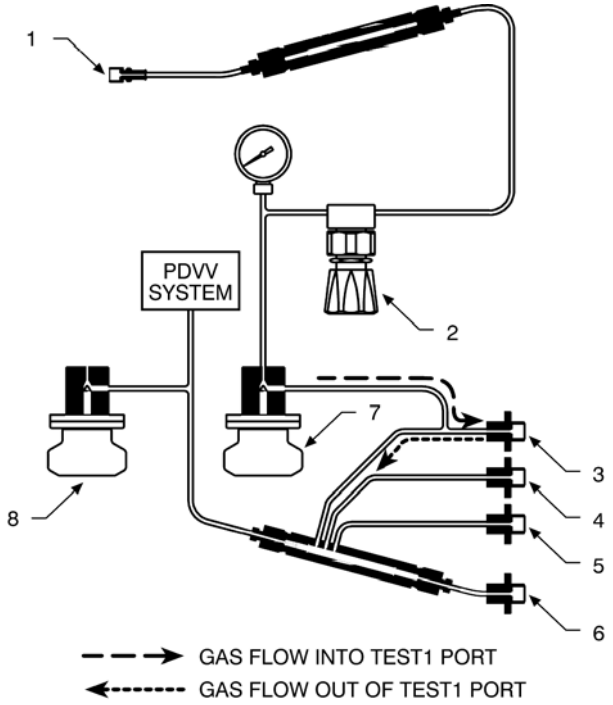
Special design features are included in GPC1 to avoid excessive contamination of GPC1 if liquids should return from a DUT to which it is connected. For this purpose, GPC1 is equipped with an inclined manifold that serves as a liquid sump (see Figure 77). A **DRAIN** port is provided at the low point so that the sump can be easily purged. The **TEST** ports all go directly through the sump so that any liquids returning from the system under test will collect there rather than being carried throughout GPC1. The top, rear **TEST1** port is supplied directly from the **SUPPLY** port so that it is always filled with clean gas from the supply. Even if liquids are present in the sump, they will not enter the **TEST1** port as gas that may have been exposed to liquids never flows into the port from GPC1
(see Figure 77).

Below are recommendations for use of the three (3) GPC1 **TEST** ports. If there is no risk of return of liquids from the devices that will be connected to GPC1, it is not necessary to discriminate **TEST** port usage.

- **TEST1** port (top, rear): This port is supplied directly with clean gas from the **SUPPLY** port and should be reserved for connecting devices that are known to be liquid free and must be protected from any risk of liquid contamination. If no such devices will be connected to GPC1, then this port may be used as any **TEST** port would.

- **TEST2** port (left lateral): Normally, the system reference pressure measurement device is connected here. In a PGC-10000-AF Pneumatic Gauge Calibrator, this is an RPM4/HPMS A70M/A20M-AF.
- **TEST3** port (top, front): This port is connected to the lowest point on the GPC1 sump and should be used for connecting test devices that may contain liquids.

By design, the TEST1 port is always filled directly with clean gas from the SUPPLY port and exhausted away from the port. Do not break the TEST1 port connection under pressure. If unclean gas is present in GPC1, flowing out the TEST1 port will contaminate the port.



1. High pressure gas SUPPLY connection
2. TEST INLET SET regulator
3. TEST1 port (top, rear)
4. TEST2 port (left lateral)
5. TEST3 port (top, front)
6. DRAIN port
7. TEST INLET valve
8. TEST OUTLET valve

Figure 7. Clean TEST1 port, sump and drain port

2.5 POWER UP AND VERIFICATION

2.5.1 APPLY THE HIGH PRESSURE SUPPLY

This section assumes that the GPC1 system has already been set up, including pressure interconnection (see Section 2.4.1).

Highly pressurized gas can be extremely hazardous. Before applying pressure to GPC1 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 (see Section 2.5.5). Ensure that the GPC1 TEST INLET SET regulator is fully backed off and the INLET valve is closed (see Section 2.4, 2.5.1).

Do not connect pressure greater than 10 000 psi (70 MPa) to the GPC1 SUPPLY port.

Proceed as follows (numerical references refer to Section 3.1, Figure 88):

❶ Fully back off the **TEST INLET SET** regulator (5).

❷ Close the **TEST INLET** valve (12).

❸ Open the **TEST OUTLET** valve (15).

❹ Apply the high pressure supply to the **SUPPLY** port (1).

2.5.2 ADJUST THE INLET PRESSURE

This section assumes that the GPC1 system has already been set up, including pressure interconnection (see Section 2.4.1).

Be sure the INLET valve is CLOSED before adjusting the TEST INLET SET regulator. If the INLET valve is open, the supply pressure will be admitted to GPC1 components and TEST ports.

Turn the **TEST INLET SET** regulator clockwise while observing the **TEST INLET** gauge. Set the pressure as indicated by the **TEST INLET** gauge to the desired maximum test pressure. The pressure set by the **TEST INLET SET** regulator is applied to the inlet of the **INLET** valve.

2.5.3 APPLY PDVV DRIVE PRESSURE

This section assumes that the GPC1 system has already been set up, including pressure interconnections (see Section 2.4.1).

Apply drive pressure to the **PDVV DRIVE** port. See Table 2 to determine the necessary PDVV drive pressure value.

2.5.4 CHECK OPERATION OF COMPONENTS

Highly pressurized gas can be extremely hazardous. Before applying pressure to the GPC1 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 (see Section 2.4, 2.5.5).

When the GPC1 INLET valve is opened, the SUPPLY pressure may be applied to the test system rapidly. Before operating the INLET valve, ALWAYS adjust the TEST INLET SET regulator pressure low enough so that the SUPPLY pressure does not exceed the maximum pressure rating of the devices or system to which GPC1 is connected (see Sections 2.5.2 and 3.2.1).

Proceed as follows:

❶ If an RPM4 A70M/A20M-AF is not already connected, connect a high pressure indicating device to one of GPC1's **TEST** ports (see Section 3.2.4). Plug all other **TEST** ports using DH500 plugs.

There are three TEST ports: One on the left, rear side and two on the top (see Section 2.4.4.2).

❷ Fully close the **OUTLET** valve.

❸ Slowly open the **INLET** valve.

❹ The pressure indicated by the reference and/or device under test should begin to increase. If the pressure does not increase, possible explanations are:

- The **TEST INLET SET** regulator has not been properly adjusted (see Section 2.4.2).
- There is no high pressure supply (see Section 2.4.3).
- There is a large leak in the system to which GPC1 is connected or in GPC1 itself.

❺ Keep the **INLET** valve open until the desired gas pressure is set.

❻ Fully close the **INLET** valve.

❼ **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 GPC1 is connected or in GPC1 itself.

The time required for pressure to stabilize after the pressure has been changed is directly proportional to the volume connected to GPC1, to the magnitude of the pressure change and to the mechanical stability of the volume's connections and vessels. It may take up to 10 minutes to stabilize pressure well enough to perform a valid leak test. To reduce stabilization time, go beyond the pressure set point and return. If in doubt as to the validity of a leak test, consider running the leak test overnight to observe the change in pressure over a very long time period. If the GPC1 is part of a PGC-10000-AF Pneumatic Gauge Calibrator, the RPM4/HPMS A70M/A20M-AF leak test function can be used (see the RPM4/HPMS Operation and Maintenance Manual).

❽ When leak checking is complete, slowly open the **OUTLET** valve to reduce pressure and vent to atmosphere.

2.5.5 PRECAUTIONS TO TAKE BEFORE WORKING WITH HIGH PRESSURE GAS / SAFETY CONSIDERATIONS

Highly pressurized gas can be extremely hazardous if proper procedures are not followed or incorrect hardware is used. Before using GPC1 to set and adjust pressure, consider the following:

- Double check that all connections, vessels and DUTs connected to GPC1 are rated for the pressure to be set and that all fittings are properly tightened.
- Opening the **INLET** valve opens to the high pressure gas supply. To avoid accidental overpressure of the any item connected to the GPC1, BEFORE opening the **INLET** valve, ALWAYS adjust the **TEST INLET SET** regulator so that the supply to the **INLET** valve is lower than the maximum pressure that is intended to be set with the GPC1 (see Section 2.4.2).
- At high pressure, the ^ and ^^ push button PDVV valves increase pressure much more quickly than at low pressure. Observe pressure evolution carefully when operating these valves (see Section 3.2.3).
- Drain/purge the GPC1 sump regularly to remove any contaminants that may have entered the system from the supply gas or devices connected to GPC1 (see Section 4.2).
- Put the PDVV plunger in the **START** position when starting a calibration or test sequence (see Section 3.2.3).
- Systems and DUTs connected to GPC1 should be emptied of liquids before they are pressurized (see Section 3.2.5, 4.2).

2.6 STORAGE AND SHIPPING

When leaving GPC1 at rest but still setup for operation:

❶ Fully close the **INLET** valve.

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

❸ Open the **DRAIN** port.

❹ Release the high pressure supply and fully back off the **TEST INLET SET** regulator.

To prepare GPC1 for long term storage or shipping:

❶ Disconnect all pneumatic pressure connections and plug the DH500 connections using DH500 plugs or orange dummy plugs held by gland nuts. Plug the 1/4 in. NPT port with a plastic plug.

When shipping GPC1, use the original shipping materials, if possible. If it is necessary to use alternate materials, use caution and ensure that: a) the front panel controls and indicators are protected; and, b) the tubing and components exposed through GPC1's open bottom are protected. GPC1 must ride on its four (4) feet - NOT on its internal components.

3. OPERATION

3.1 OPERATING PRINCIPLE

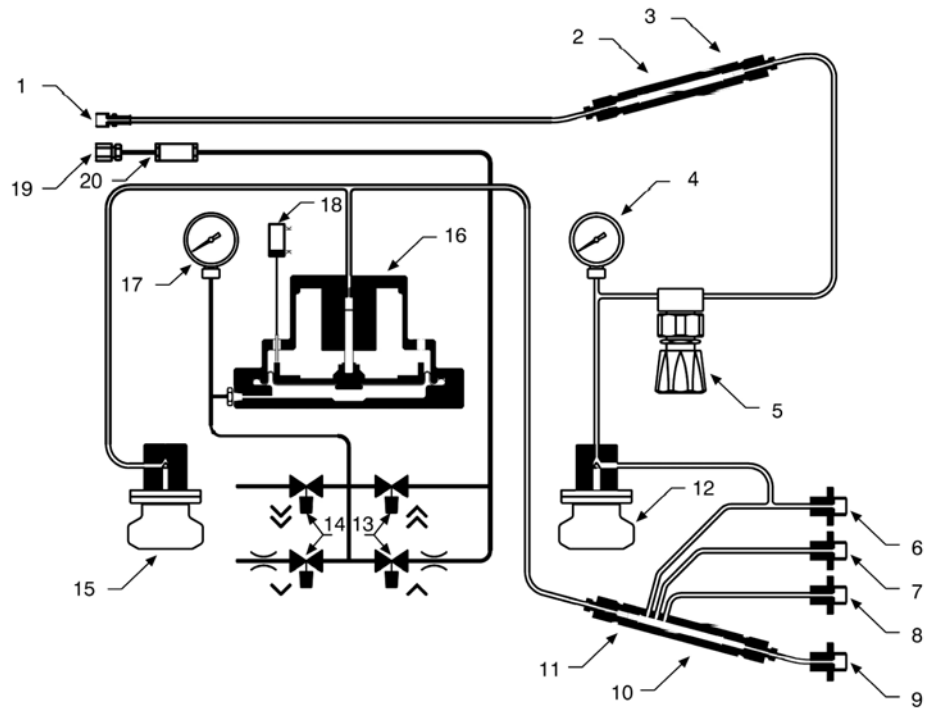
Numerical references in this section refer to Section 3.1, Figure 88.

GPC1 is a self-contained system designed to set and adjust gas pressure in static pressure test and calibration systems. GPC1-10000-AF operates to 10 000 psi (70 MPa). GPC1 combines the capability to execute large pressure changes very quickly with very fine pressure adjustment.

GPC1 uses two different techniques to set and adjust pressure. These are rough pressure control using the **TEST INLET** and **TEST OUTLET** valves (12, 15) and fine pressure control using the **PDVV (+)** and **(-)** valves (13, 14).

The first means of setting and adjusting pressure uses the external gas pressure supply (1) with the **TEST INLET SET** regulator (5), **TEST INLET** valve (12) and **TEST OUTLET** valve (15). This combination is used for filling the system under test, making large pressure changes and for rough pressure control. The valves are Belleville spring loaded, half-turn needle valves. Their operation is highly progressive over a half-turn with mechanical stops at each end so they cannot be over tightened. The regulator is self venting and its output is indicated by the **TEST INLET** gauge (4). The valve is turned clockwise (CW) to close and counter-clockwise (CCW) to open. A WHITE dot on the handle body indicates the valve's current open/close position. The **TEST INLET SET** regulator (5) and **TEST INLET** gauge (4) are used to set the supply pressure to the **TEST INLET** valve (12). Opening the **INLET** valve (12) allows the supply pressure to enter GPC1 and reach the **TEST** ports (6,7,8). Opening the **OUTLET** valve (15) exhausts gas, reducing pressure in the system.

The second means of generating and adjusting pressure is the Pneumatically Driven Variable Volume (PDVV) (16) combined with the **PDVV (+)** and **(-)** valves (13, 14). 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 high pressure gas to be adjusted. 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 the high gas pressure. A spring returns the plunger to its minimum stroke position when there is no pressure on the dome or on the plunger. A mechanical system tracks movement of the plunger and an indicator (18) displays the plunger position on the front panel. The **PDVV (+)** and **(-)** valves (13, 14) are momentary, poppet valves that open when pressed. The **(+)** valves (13) admit drive air pressure to the PDVV actuator causing the PDVV piston to move forward, compressing the high pressure gas and increasing the pressure. The **(-)** valves (14) have the opposite effect, causing pressure to decrease when they are operated.

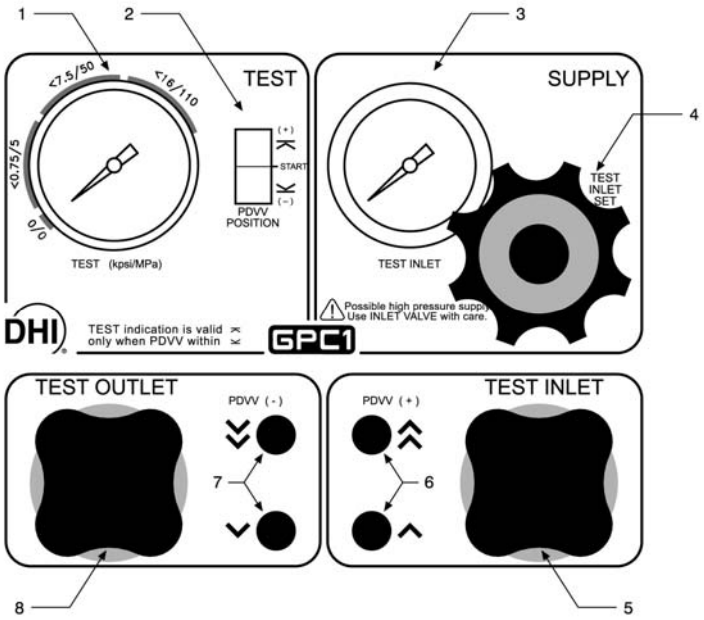


1. High pressure gas SUPPLY connection (left lateral)
2. Supply accumulator
3. Supply filter (not shown)
4. TEST INLET gauge
5. TEST INLET SET regulator
6. TEST1 port (rear top)
7. TEST2 port (left lateral)
8. TEST3 port (front top)
9. DRAIN port (right lateral)
10. Test liquid collection sump
11. Sump filter (not shown)
12. TEST INLET valve
13. Fast and slow PDVV increase (plus) valves
14. Fast and slow PDVV decrease (minus) valves
15. TEST OUTLET valve
16. Pneumatically driven variable volume (PDVV)
17. PDVV drive pressure gauge
18. PDVV plunger position indicator
19. PDVV DRIVE air connection (right lateral)
20. DRIVE air filter

Figure 8. System schematic

3.2 OPERATIONAL FUNCTIONS

All GPC1 operational functions are accessed from the instrument front panel. Sections 3.2.1 to 3.2.5 detail the various functions.



1. PDVV drive air/test gas pressure gauge
2. PDVV piston position indicator
3. Test inlet pressure gauge
4. Test inlet pressure 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 9. Front panel view

3.2.1 SETTING INLET SUPPLY PRESSURE, TEST INLET SET REGULATOR ADJUSTMENT

Numerical references in this section refer to Section 3.2, Figure 99. For information on the GPC1 operating principle, see Section 3.1.

Setting inlet supply pressure is generally done at the beginning of a test or calibration based on the maximum pressure of the calibration. To avoid accidental overpressure, it is good practice to set the inlet pressure just below the maximum pressure desired. The PDVV can then be used for the final pressure adjustment at the maximum pressure (see Section 3.2.3).

With the **INLET** valve (5) closed, use the **INLET SET** regulator (4) and the **INLET** gauge (3) indication to set the maximum desired test pressure.

The TEST INLET SET regulator sets the pressure to the TEST INLET valve. When the TEST INLET valve is opened, this pressure can be generated rapidly in the system connected to GPC1. Use caution in setting the TEST INLET regulator pressure and always check the setting and adjust if necessary before using the TEST INLET valve (see Section 2.4.2).

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

Numerical references in this section refer to Section 3.2, Figure 99. For information on the GPC1 operating principle, see Section 3.1.

The **INLET** and **OUTLET** valves (5, 8) are used to execute large pressure changes in the test system and for rough pressure control. The **INLET** valve is used to increase pressure and the

OUTLET valve decreases pressure and vents the system to atmosphere, setting zero gauge pressure. If finer pressure control is needed, use the **PDVV** valves (see Section 3.2.3).

To increase pressure in the GPC1 system, open the **INLET** valve (5) slowly. Use the progressive nature of the valve to control the rate of pressure increase. Close the valve when the desired pressure has been reached. When a gas booster is used to supply high pressure, the booster may not be able to keep up with the flow rate needed to set the desired pressure. In this case, with the **INLET** valve open, wait for the booster to reach the desired pressure.

To decrease pressure in the GPC1 system, open **OUTLET** valve (8) slowly. Open the valve fully to vent the system to atmosphere (set zero gauge).

The TEST INLET valve connects the pressure supply to the test system. When the TEST INLET valve is opened, high pressure can be generated rapidly in the system connected to GPC1. Use caution when opening the TEST INLET valve and always check the TEST INLET pressure gauge to know the supply pressure before doing so (see Section 2.4.2).

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

Numerical references in this section refer to Section 3.2, Figure 99 except where specified otherwise. For information on the GPC1 operating principle, see Section 3.1.

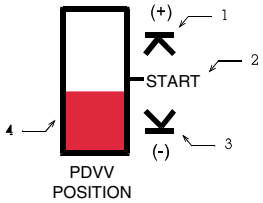
Use the valves labeled ⌄ and ⌄⌄ to release gas from the PDVV actuator, causing the PDVV plunger to back off and pressure to decrease. Use the valves labeled ⌃ are ⌃⌃ to admit gas to the PDVV actuator, causing the PDVV plunger to move forward and pressure to increase. The ⌄⌄ and ⌃⌃ valves are for high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

The **PDVV (+)** and **(-)** valves (6, 7) are utilized 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.

If the PDVV plunger reaches end of stroke during a calibration or test, use the **INLET** valve and/or **OUTLET** valve (5, 8) to increase or decrease the pressure, as needed (see Section 3.2.2).

The actual rate of pressure change caused by the **PDVV (+)** and **(-)** valves is dependent on the test volume that is connected to GPC1 and the current pressure value. Increasing the test volume lowers the pressure rate of change and pressure step size. Increasing the volume increases the rate and the pressure step size. The maximum pressure that can be generated by the **PDVV (+)** valves is dependent on the PDVV drive air supply (see Section 2.4.2, Table 2).

The position of the PDVV plunger is indicated by the **PDVV POSITION** indicator (2). The RED index (Figure 10, Ref 4) on the indicator tracks the movement of the PDVV plunger. Minimum and maximum end of stroke positions (Figure 10, Refs 3 and 1) as well as a recommended start position (Figure 10, Ref 2) are indicated. The full stroke displacement of the GPC1 PDVV plunger from maximum to minimum end of stroke is 2 cc (0.12 in.^{3}).



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

Figure 10. PDVV plunger position indicator

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

For the **PDVV (+)** and **(-)** valves (6, 7) to have an effect, the PDVV plunger must have stroke available. If the PDVV is at its end of stroke position (Figure 10, Refs 1 and 3), the plunger cannot move to change pressure. The recommended PDVV **START** position (Figure 10, 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 test pressure using the ⩛ and ⩓ valves when the **OUTLET** valve (8) is open (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.

The PDVV (+) valves ***generate pressure indefinitely when opened****. Particularly when operating at very high pressure, use caution when operating these valves so that they do not generate more pressure than is desired.*

3.2.4 CONNECTING A DEVICE UNDER TEST

The device to be tested or calibrated should be connected either to a **TEST** port configured on the interconnections external to GPC1 or to one of GPC1's top **TEST** ports (see Section 2.4.4.2). The test connection is a DH500 F (DH500 is a gland and collar type fitting for 1/4 in. (6 mm) coned and left hand threaded tube. DH500 is equivalent to AE F250C, HIP HF4, etc.).

The DH500 test connection can be converted to 1/8 in. NPT M, 1/4 in. NPT F, 1/4 in. NPTM or AN4 M using the 2.75 in. (70 mm) tube and DH500 F X 1/8 in. NPT M or DH500 F x 1/4 in. NPT F adaptor supplied with GPC1 accessories. Install the tube into the adaptor. Then install that adaptor/tube assembly onto the DH500 F **TEST** port (see Section 2.4.4.2)**.**

GPC1 covers a very wide range of pressure up to 10 000 psi (70 MPa). It is the user's responsibility to ensure that fittings and devices connected to GPC1 are rated for the pressures at which they will be used.

By design, TEST1 port is always filled directly with clean gas from the SUPPLY port and exhausted away from the port. Do not break the TEST1 port connection under pressure as, if unclean gas is present in GPC1, this could cause it to flow to the TEST1 port.

3.2.5 PURGING LIQUIDS FROM THE DUT/SYSTEM UNDER TEST

For information on the GPC1 operating principle, see Section 3.1.

GPC1 includes a sump to collect liquids that may return from the device or system under test to which it is connected. However, the amount of liquid that the sump can collect without liquids entering other GPC1 internal circuitry is limited. Excessive fluids in GPC1 and test connections can cause erratic pressure control and introduce unexpected uncertainty in measurements. DUTs and the system under test should be cleaned of liquids to the extent reasonably possible before being connected to GPC1. Also, see Section 2.4.4.3 for information about the appropriate GPC1 **TEST** port connection to use.

The procedure to purge the GPC1 sump and/or a DUT connected to GPC1 is:

❶ Use GPC1 to pressurize the system, including the DUT, to approximately 500 psi (3.5 MPa) (or maximum pressure of the DUT if less than 500 psi).

❷ Open **DRAIN** port. Use the 5/8 in. open end wrench supplied in the GPC1 accessories to slowly and then more fully open the **DRAIN** port allowing gas to exhaust as quickly as is safe and practical.

❸ Observe whether the gas coming out of the **DRAIN** port contains liquid or liquid vapor.

❹ Repeat steps ❶ through ❸ until there is no evidence of liquid in the gas escaping from the **DRAIN** port.

3.3 TYPICAL OPERATING SEQUENCE FOR A COMPLETE CALIBRATION OR TEST

GPC1 is most often used to set and adjust pressure to a reference measuring device and a DUT when performing a test or calibration. If the GPC1 is part of a PGC-10000-AF Pneumatic Gauge Calibrator, the reference measurement device is an RPM4/HPMS A70M/A20M. The typical operational sequence is as follows:

❶ **Connect the DUT** to the appropriate GPC1 **TEST** port or to a test port on the external system to which GPC1 is connected (see Sections 3.2.4, 2.4.4.2).

❷ **Set the TEST INLET SET regulator** (see Section 3.2.1)

❸ **Position the PDVV plunger** (see Section 3.2.3).

❹ **Purge the DUT (if necessary)** (see Section 3.2 5).

❺ **Take the starting zero reading on the DUT:** With the **OUTLET** valve open, and the **INLET** valve closed, the pressure in the test system is zero gauge.

❻ **Set ascending test pressures:** Carefully open the **INLET** valve and control the gas input to set the pressure in the test system just under the desired test point (see Section 3.2.2). Pause a moment. Then use the **PDVV (+)**and/or **(-)** valves to adjust the pressure to the exact test pressure desired or, if the reference is a piston gauge, to float the piston gauge piston (see Section 3.2.3). 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 reach the next pressure. If the PDVV runs out of stroke, use the **INLET** valve to generate pressure and reposition the PDVV plunger.

❼ **Set descending test pressures:** Very carefully open the **OUTLET** valve and control the gas exhaust to set pressure in the test system just over the desired test point (see Section 3.2.2). Then use the **PDVV (+)** and/or **(-)** valves to adjust the pressure to the exact test pressure desired or, if the reference is a piston gauge, to float the piston gauge piston (see Section 3.2.3). 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 fully and check that the DUT reads near zero. Disconnect the DUT.

4. MAINTENANCE AND ADJUSTMENTS

4.1 OVERVIEW

GPC1 was designed for maintenance free operation. The PDVV is permanently lubricated. No maintenance is required other than:

- **Purge the sump** very regularly (see Section 4.2).
- **Clean/replace the PDVV drive air filter element** when needed: The drive air filter may become contaminated and restrict the free flow of pressure. It should then be cleaned or replaced (see Section 4.3).

Maintenance and repair services for GPC1 are offered by DHI Authorized Service Providers (see Section 6.2, Table 4).

GPC1 is a sophisticated pressure setting 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 and troubleshooting facilities to become thoroughly familiar with GPC1 operation. For rapid troubleshooting assistance in specific situations, see Section 0.

GPC1 is covered by a limited 1 year warranty (see Section 6.2). Unauthorized service or repair during the warranty period is undertaken at the owner's risk and may cause damage that is NOT covered under product warranty and/or may void the product warranty.

4.2 PURGING THE SUMP (DRAIN)

The GPC1 sump (see Section 2.4.4.3, Figure 7) is designed to collect liquids that may be returned from the pressure supply or system/device under test so that they do not contaminate the rest of the system. The sump has a limited volume so it should be drained regularly as part of normal operation. The purge process below should also be used when a DUT is connected that is known to contain liquids (see Section 3.2.5). The procedure to purge the GPC1 sump and/or a DUT connected to GPC1 is:

❶ Use the GPC1 to pressurize the system, including the DUT, to approximately 500 psi (3.5 MPa) (do not exceed the pressure rating of the system or the DUT connected to GPC1).

❷ Open the **DRAIN** port (see Figure 111). Use the 5/8 in. open end wrench supplied in the GPC1 accessories to slowly and then more fully open the **DRAIN** port allowing gas to exhaust as quickly as is safe and practical.

❸ Observe whether the gas coming out of the **DRAIN** port contains liquid or liquid vapor.

❹ Repeat steps ❶ through ❸ until there is no evidence of liquid in the gas that vents through the **DRAIN** port.

Figure 11. Drain port location

4.3 CLEANING/REPLACING PDVV DRIVE AIR FILTER ELEMENT

There is a filter on the **PDVV DRIVE** port. If the drive air supplied is excessively dirty, this filter may become excessively dirty and restrict air flow to the PDVV actuator (see Section 3.1, Figure 88).

The drive air filter is a filter body with a sintered element. To clean or replace the filter the filter body must be removed from GPC1.

To remove and reinstall the drive air filter, proceed as follows (numerical references in this section refer to Figure 122):

❶ Place GPC1 on the bench, so that its front panel is up with its open bottom is facing you.

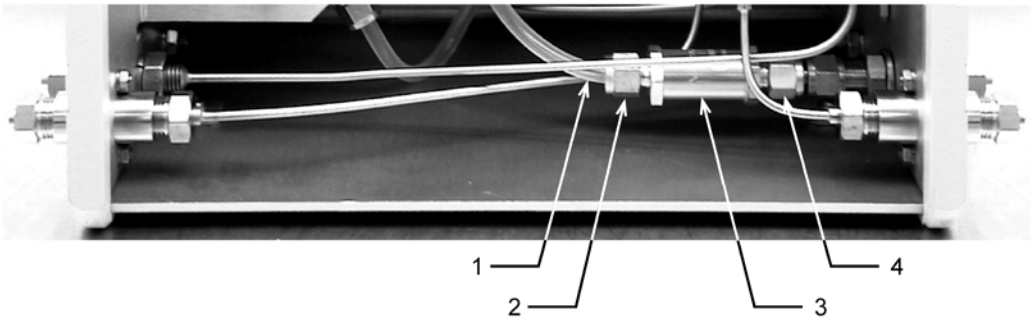
❷ Disconnect the downstream filter connection fitting (2) and move the 1/4 in. PFA flexible tubing (1) away from the filter body (3). Then disconnect the upstream filter connection (4) and remove the filter body (3).

❸ To reinstall the filter, make the upstream filter connection (4). Then make the downstream filter connection (2). Use caution to ensure that the filter body (3) is oriented in the correct direction (the arrow on the filter body should be pointing in the direction of flow in from the **PDVV DRIVE** port).

❹ Connect recommended drive pressure (see Section 2.4.2, Table 2) to the **PDVV DRIVE** port. Check the new connections for leaks using a liquid leak detector. Correct leaks, if present.

The filter 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 sintered filter element can be removed.



1. 1/4 in. (6 mm) PFA tube
2. PDVV DRIVE filter downstream connection
3. Filter body
4. PDVV DRIVE filter upstream connection

Figure 12. PDVV drive air filter

NOTES

5. TROUBLESHOOTING

GPC1 is a sophisticated pressuring setting 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 GPC1 operation. This troubleshooting guide is intended as an aid in identifying the cause of unexpected GPC1 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. GPC1 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 is at maximum end of stoke. Replace or repair valve(s) if qualified to do so. 3.1, 3.2.2, 3.2.3.
Test pressure continuously decreases even with all valves closed.	Leak in **OUTLET** valve, leak in **PDVV (-)** valve(s), leak in test system connected to GPC1 or internal leak in GPC1 high pressure gas system.	Identify and correct leak in test system if present. Disconnect from test system and plug GPC1 **TEST** ports to test GPC1 alone. 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. 3.1, 3.2.2, 3.2.3
Test pressure takes too long to stabilize or will never stabilize.	You are observing normal evolution of pressure in an uncontrolled static volume.	Reduce resolution of pressure reading to appropriate level. Reduce test volume. Increase stability of test tubing and vessels. Wait longer for stability. Overshoot test point and return to reduce stabilization time.
Test pressure takes too long to stabilize or will never stabilize.	Leak in GPC1 or test system connected to GPC1.	See troubleshooting tips “Test pressure continuously increases…” and “Test pressure continuously decreases…” above.
Test pressure takes too long to stabilize or will never stabilize.	GPC1 and/or test system tubing is contaminated with liquids that are “plugging” tubes.	Thoroughly purge complete system. 3.2.5, 4.2
PDVV will not increase pressure.	PDVV is at maximum end of stroke position, PDVV drive air supply pressure is not high enough, or PDVV drive air supply is plugged.	Verify PDVV piston position and readjust if necessary. Use **INLET** valve to increase pressure. Increase PDVV drive air supply pressure. Clean filter. 3.2.3, 2.4.2, 4.3
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, 3.2.2
Opening **INLET** valve does not increase pressure.	**TEST INLET SET** regulator is set too low and/or external pressure supply to low.	Check value of supply pressure on **TEST INLET** gauge. Adjust **INLET** regulator, increase supply pressure if necessary. 3.2.1, 2.4.3

NOTES

6. APPENDICES

6.1 GPC1 TERMS, LABELS, AND SYMBOLS (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.
collar	The DH500 fitting element that is threaded onto the tube and provides a surface for the gland to push against.
CCW	Counter-clockwise
CW	Clockwise
DH500	High pressure, gland and collar type fitting for 1/4 in. (6 mm) coned and left hand threaded, stainless steel tubes. DH500 is equivalent to AE F250C, HIP HF4, etc.
DUT	Device or System Under Test. The device that is connected to GPC1 to be tested or calibrated.
gland	The "jam nut" in a DH500 fitting that pushes the collar on the tube into the seat.
PDVV (Pneumatically Driven Variable Volume)	A pneumatically actuated plunger in a cylinder used to increase and decrease the volume of the high pressure gas test system and provide fine adjustment of the test pressure.
PDVV (+) valves	Momentary, push button actuated, poppet valves that admit drive air drive pressure to the PDVV actuator causing the PDVV plunger to move forward, compressing the high pressure gas 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 the high pressure gas 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 gas test pressure.
TEST INLET gauge	Analog gauge that indicates the pressure set by the TEST INLET SET regulator and applied to the TEST INLET valve.
TEST INLET valve	Progressive, half-turn, needle valve used to admit high pressure gas into the test system. Used for rough pressure adjustment.
TEST INLET SET regulator	Self venting regulator used to regulate the external high pressure gas supply. Sets maximum TEST INLET valve pressure.
TEST OUTLET valve	Progressive, half-turn, needle valve used to return exhaust gas from the test system. Used to release pressure and for rough pressure adjustment.
Test pressure	The high gas pressure in GPC1 PDVV, at its TEST connections and in the system to which GPC1 is connected.

6.2 WARRANTY STATEMENT

Except to the extent limited or otherwise provided herein, **DH Instruments, Inc.** (**DHI**) warrants for one year from purchase, 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.

DHI 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 **DHI**, or its authorized service provider, freight prepaid, after receiving authorization from **DHI** or its authorized service provider. The buyer assumes all liability vis-à-vis third parties in respect to its acts or omissions involving use of the products. In no event shall **DHI** be liable to purchaser or any party 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 **DHI** has been advised of the possibility thereof, and regardless of whether such products are used individually or as components in other products.

Items returned to **DHI** under warranty claim but determined to not have a defect covered under warranty or to not have a defect at all are subject to an evaluation charge as well as applicable repair and/or calibration costs.

The provisions of this warranty and limitation may not be modified in any respect except in writing signed by a duly authorized officer of **DHI**.

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

Table 4. DHI Authorized Service Providers

DH INSTRUMENTS, INC. AUTHORIZED SERVICE PROVIDERS			
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 cal.repair@dhinstruments.com	Worldwide
Minerva I.P.&M. B.V.	Handelsweg 13 Postbus 76-1270 AB Huizen NETHERLANDS	Tel 31/35.52.54.997 Fax 31/35.52.64.560 info@minervaipm.com	European Union
Ohte Giken, Inc. Technology Center	258-1, Nakadai Kasumigaura-machi, Niihari-Gun, Ibaraki 300-0133	Tel 81/29.840.9111 Fax 81/29.840.9100 tech@ohtegiken.co.jp	Japan/Asia