



# **RUSKA MODEL 7010 DIGITAL PRESSURE CONTROLLER USER'S MANUAL**

# **DIGITAL PRESSURE CONTROLLER**

## **MODEL 7010**

### **USER'S MANUAL**

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Release: 7010-1D01  
Revision: F  
Date: 01/02/02



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RELEASE NUMBER	REV	DATE OF RELEASE	DESCRIPTION
7010-1D01	A	11/10/93	Original release
7010-1D01	B	9/16/94	Text changes, ECO-19492
7010-1D01	C	4/20/95	Text & drawing changes, ECO-19578
7010-1D01	D	6/16/97	Text & drawing changes, ECO-17791
7010-1D01	E	07/29/99	Text changes per ECO-17805.
7010-1D01	F	01/02/02	Equation change per DC/RO-22102

## **REVISION HISTORY**

**RELEASE 7010-1D01**

.Original release.

**Revision A (11/10/93)**

**RELEASE 7010-1D01**

Text changes, ECO 19492.

**Revision B (9/16/94)**

**RELEASE 7010-1D01**

Text & drawing changes, ECO 19578.

**Revision C (4/20/95)**

**RELEASE 7010-1D01**

Text & drawing changes, ECO 17791.

**Revision D (6/16/97)**

**RELEASE 7010-1D01**

Text changes per ECO-17805.

**Revision E (07/29/99)**

**RELEASE 7010-1D01**

Equation change per DC/RO-23192

**Revision F (01/02/02)**

## **SAFETY SUMMARY**

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

### **KEEP AWAY FROM LIVE CIRCUITS**

Operating personnel must at all times observe safety regulations. Do not replace components or make adjustments inside the equipment with the voltage supply connected. Under certain conditions, dangerous potentials may exist when the power control is in the off position due to charges retained by capacitors. To avoid injuries, always remove power from, discharge, and ground a circuit before touching it.

### **DO NOT SERVICE OR ADJUST ALONE**

Do not attempt internal service or adjustment unless another person capable of rendering aid and resuscitation is present.

### **RESUSCITATION**

Personnel working with or near dangerous voltages shall be familiar with modern methods of resuscitation. Such information may be obtained from your local American Medical Association.

## **ELECTROSTATIC DISCHARGE SENSITIVE PARTS**

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**CAUTION:** Electrostatic discharge sensitive (ESDS) is applied to low power, solid-state parts which could be damaged or destroyed when exposed to discharges of static electricity. Maintenance personnel are often not aware that an ESDS part has been damaged or destroyed because electrostatic discharges at levels less than 4,000 volts cannot be seen, felt, or heard.

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When the ESDS symbol appears between a paragraph number and paragraph title, the entire paragraph and all subparagraphs shall be considered ESD sensitive. When the ESDS symbol appears between a step number and the step test, the step shall be considered ESD sensitive.

### **COMPRESSED GAS**

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

### **PERSONAL PROTECTIVE EQUIPMENT**

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

### **INERT GASES**

Operation of pressure equipment may be accompanied by the discharge of inert gases to the atmosphere. The result is a reduction of oxygen concentration. Therefore, it is strongly suggested that exhaust gases not be trapped in the work area.

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# SECTION 1.0 GENERAL INFORMATION

## 1.1 INTRODUCTION

This manual contains operation and routine and preventive maintenance instructions for the Model 7010 Digital Pressure Controller (DPC) manufactured by Ruska Instrument Corporation, Houston, Texas. This section of the manual provides general information about the DPC and presents its features and options.

## 1.2 GENERAL INFORMATION

The Ruska Model 7010 DPC uses force-balanced, fused-quartz Bourdon tube technology to provide the precise measurement of pressure. During normal operation, the DPC performs in either Measure mode or Control mode.

In Control mode, the DPC simultaneously measures and controls pressure. Control mode is commonly used in the calibration and testing of pressure gauges, transducers, pressure switches, and production pressure instruments.

In Measure mode, the DPC measures pressure. Typically, Measure mode applications are found in research laboratories, wind tunnel testing, power plant testing, and bubbler tank volume accountancy systems. It is also used to monitor barometric pressures, vacuum systems, and differential pressure devices.

## 1.3 FEATURES

The following features are standard on all Model 7010 DPCs.

**Fused-Quartz Bourdon Tube Technology:** Ruska's force-balanced, fused-quartz Bourdon tube sensor makes use of the stability, high elasticity, low hysteresis, and excellent fatigue strength of fused quartz. This time-proven technology eliminates the need for gear trains, bearings, shafts, and other moving parts that can wear out or introduce hysteresis or deadband into the process.

**Mercury-Free:** All components in the DPC are mercury-free. This includes the temperature controller for the quartz Bourdon tube, which is totally electronic.

**NIST Traceability:** All DPCs are calibrated per ANSI/NCSL Z-540-1-1994 using Ruska deadweight gauges that are directly traceable to the National Institute of Standards and Technology (NIST).

**Universal Power Supply:** The DPC's universal power supply accepts AC voltages between 90 and 260 volts, and DC voltages between 100 and 370 volts. To "reconfigure" the DPC for use in another country, the user simply changes the power cord.



DPCs with ranges from 501 to 2500 psi can be either 115 or 230 VAC.  
Please refer to section 3.4.

**Measure While Control:** The DPC simultaneously displays the commanded pressure, the actual pressure, and the difference between the two. A bar graph indicates how close the actual pressure is to the commanded pressure, as well as how close the commanded pressure is to the DPC's full scale pressure.

**Friendly Display:** The DPC's vacuum fluorescent display combines a bright, low-glare readout with a wide viewing angle. During normal operation, the measured pressure is easily visible from a distance of 10 feet (3 meters).

**Adjustable Pressure Display:** The pressure display may be adjusted to show one decimal greater than or less than the default resolution.

**Ease of Operation:** An intuitive, menu-driven interface makes the DPC easy to use. Frequently used selections such as the units of measure are restored to memory each time the DPC powers up.

**Easily Programmable:** The DPC's powerful microprocessor provides the basis for smart electronics. With a few simple keystrokes, the user can set limits on the system pressure, create unique units of measure, program a test sequence, and more.

**Modular Design:** The sensing element, pneumatics, electronics, and user interface are separated into modules, making maintenance faster and easier.

**Attractive Desktop Packaging:** A sturdy aluminum case houses all of the DPC's pneumatics, electronics, and user controls. With the optional rack mount kit, this standard 19" EIA chassis fits easily into a rack mount system.

**Power On Self Test:** Upon power-up, the DPC quickly tests its hardware and software. After the DPC completes this test, the user can select more extensive self-tests for the pneumatics and electronics.

**Ease of Calibration:** A three-point calibration may be performed either remotely or entirely from the front panel. No disassembly is required, and there are no potentiometers to tune.

**Automatic Zero Adjust:** At the user's request, the DPC's software automatically performs the zero adjustment, with no potentiometers to tune.

**Automatic Head Correction:** The DPC automatically corrects for head pressure between the DPC and the device under test (DUT), taking into account the density of the test gas; e.g., air or nitrogen.

**Choice of Medium:** Although the DPC is not sensitive to the type of gas used within the system, the user can select either instrumentation air or nitrogen, allowing the DPC to automatically make pressure head corrections.

**Choice of Display Units:** Standard units include inHg at 0 °C and 60 °F, kiloPascals, bars, pounds per square inch, inH<sub>2</sub>O at 4 °C, 20 °C, and 25 °C, kilograms per square centimeter, mmHg, cmHg at 0 °C, and cmH<sub>2</sub>O at 4 °C. Altitude and airspeed units include feet, meters, knots, and kilometers per hour. In addition to these predefined units, four user-defined units are programmable.

**Communications Interface:** The DPC includes standard RS-232 serial and IEEE-488 interfaces. The user's computer communicates with the DPC through the Standard Commands for Programmable Instruments (SCPI) protocol. *The DPC can also be configured to accept existing software written for the Ruska Series 6000 Digital Pressure Gauge/Controller.*

## 1.4 STANDARD EQUIPMENT & OPTIONS

A standard DPC includes this manual, a power cord, and a small tools kit. Although the standard DPC is fully functional with just these items and the appropriate pressure and vacuum supplies, the following options are also available.

**Rack Mount Kit:** This 6.969" kit meets ANSI/EIA requirements for a 4U, 19" rack mount kit.

**Memory Card:** The DPC accepts a credit-card sized memory card through the front panel. This allows the user to move test sequences from machine to machine and to easily upgrade software.

**Additional Power Cords:** Additional power cords are available for most countries.

All options are summarized in Table 1-1. To order these items, please contact Ruska Instrument Sales in the U.S. at (713) 975-0547.

**TABLE 1-1  
OPTIONS LIST FOR THE MODEL 7010 DPC**

Option	Ruska Part Number (RIC #)
Opto 22 Kit	Based on application
LabView Driver (National Instruments)	7000-LABDRV
Rack Mount Kit - Cabinets 18-24 inches deep	7000-903
Rack Mount Kit - Cabinets 24-30 inches deep	7000-904
Memory Card	35-403
Vacuum Pump - 139 L/min	
115 VAC 50/60 Hz	99876-900
230 VAC 50/60 Hz	99876-960
Vacuum Pump - 69 L/min	
115 VAC 50/60 Hz	99875-900
230 VAC 50/60 Hz	99875-960
Power Cord - USA, Canada, Central Europe	16-81, 16-81, 16-86
Power Cord - India, Japan, Israel	16-96, 16-93, 16-97
Power Cord - Australia/New Zealand	16-95
Battery, Processor, Spare	4-720
Battery, Memory Card	4-715
Test Port Isolation Kit, 110 VAC	7000-810 <sup>1</sup>
Test Port Isolation Kit, 220 VAC	7000-820 <sup>1</sup>

<sup>1</sup>Test port isolation kits are only required for DPCs from 501-2500 psi.

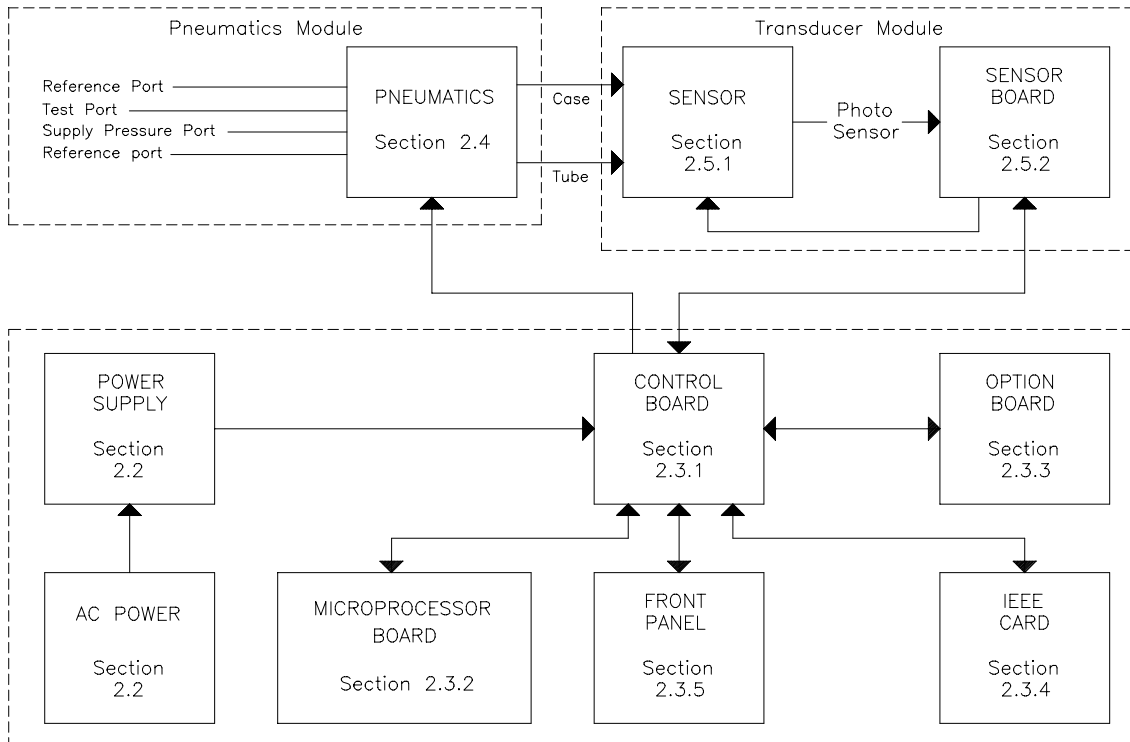
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## SECTION 2.0 THEORY OF OPERATION

### 2.1 INTRODUCTION

The DPC's power supply, electronics, pneumatics, and sensor combine to form a complete, stand-alone, measure and control instrument. This section of the manual describes the DPC's component modules (Figure 2-1) and provides a general discussion of each.


**FIGURE 2-1**



**DPC BLOCK DIAGRAM**

### 2.2 POWER SUPPLY

The DPC's universal power supply accepts AC voltages from 90 to 260 volts at 47-63 Hz. And DC voltages from 100 to 370 volts. This triple-output supply produces +5VDC, +12VDC, and -12VDC, which are distributed to the Control Board.



DPC's with ranges from 501 to 2500 psi are either 115 or 230 VAC. See Section 3.4.



## **2.3 ELECTRONICS MODULE**

### **2.3.1 CONTROL BOARD**

The Control Board monitors every major component of the Electronics Module. The Microprocessor Board, the Option Board, the IEEE-488 Interface, and the optional memory cards all plug into the Control Board. The Sensor Board and Front Panel both communicate with the Control Board via ribbon cables.

The three voltages produced by the Power Supply are distributed to the Control Board where they are conditioned to produce four additional voltages of +5VDC, -5VDC, +15VDC, and -15VDC for analog use. The resulting seven DC voltages are then used either directly or indirectly throughout the entire DPC.

Data that is subject to change after the DPC leaves the factory are held in electrically erasable, programmable, read-only memory (EEPROM) on the Control Board. This includes the current units of measure, the coefficients from the zeroing process, the current pressure medium, calibration coefficients, and the conversion factors for the four user-defined units of measure. These values are used by the Microprocessor Board as described below.

The Control Board also holds the OPTO 22 connector, which communicates with the user's OPTO 22 modules through a cable that connects to the back panel.

### **2.3.2 MICROPROCESSOR BOARD**

All of the DPC's software resides in nonvolatile, programmable, read-only memory (Flash EPROM) on the Microprocessor Board, which plugs directly into the Control Board. This software contains all of the instructions that operate the DPC, as well as the conversion factors that the DPC uses to translate the detected pressure into the units selected by the user. These factors are given in Table 2-1.

When the DPC powers up, its software is loaded into random access memory (RAM), also on the Microprocessor Board. At the same time, the values stored in EEPROM on the Control Board are restored to memory.

Another important component on the Microprocessor Board is the lithium battery. The battery continuously updates the DPC's date and time, even when the unit is powered down.

The Microprocessor Board also supports the RS-232 serial interface that allows the user's computer to communicate with the DPC.

**TABLE 2-1  
CONVERSION FACTORS**

Unless specified otherwise, conversion factors are based on ANSI 268-1982.

<b>Symbol</b>	<b>Description</b>	<b>Conversion Factor</b>
inHg	inches of mercury (0 °C)	= kPa x 0.2952998
inHg	inches of mercury (60 °F)	= kPa x 0.296134
kPa	kiloPascals	= kPa x 1.0
bar	bars	= kPa x 0.01
psi	pounds per square inch	= kPa x 0.1450377
cmH <sub>2</sub> O	centimeters of water (4 °C)	= kPa x 10.19744
inH <sub>2</sub> O	inches of water (4 °C)	= kPa x 4.014742
kg/cm <sup>2</sup>	kilograms per square centimeter	= kPa x 0.0101972
mmHg	millimeters of mercury (0 °C)	= kPa x 7.500605
cmHg	centimeters of mercury (0 °C)	= kPa x 0.7500605
knots	indicated airspeed	per NASA TN D-822
km/hr	kilometers per hour	= knots x 1.852
feet	feet of altitude	per MIL-STD-859A
meters	meters of altitude	per MIL-STD-859A
user1	user defined	= kPa x user defined
user2	user defined	= kPa x user defined
Pa	user defined (Pascals)	= kPa x 1000.0
hPa	user defined (hectoPascals)	= kPa x 10.0
%FS	percent of full scale	

### 2.3.3 OPTION BOARD

Future models of the DPC may include an Option Board that plugs directly into the Control Board. In the future, this board could be used to provide nonstandard options.

### 2.3.4 IEEE-488 INTERFACE

The DPC's IEEE-488 (GPIB) interface card, which plugs directly into the Control Board, provides the DPC with an IEEE-488 interface. This interface allows the user to automate the measurement and control processes.

### 2.3.5 FRONT PANEL

The Microprocessor Board and Control Board work together to interpret all input from the Front Panel. The Front Panel contains the vacuum fluorescent display and rubberized keys used to operate the DPC.

The DPC also accepts an optional memory card that slides through a slot in the Front Panel and plugs directly into the Control Board.


## 2.4 PNEUMATICS MODULE

The DPC's Pneumatics Module varies depending on whether the DPC is a Gauge mode, Differential mode, or an Absolute mode instrument. Differential mode DPCs reference their measurements to pressures between vacuum and 15 psi inclusive, whereas Absolute mode DPC measurements are made with respect to vacuum. Thus, a Differential mode DPC can operate as an Absolute mode instrument if the user selects vacuum as the reference pressure. Similarly, a Differential mode DPC can operate as a gauge instrument if ambient is used as the reference pressure.

For the user, the only difference between the Differential mode and Absolute mode instruments occurs on the DPC's back panel. On Differential mode instruments, there is a functioning reference port, whereas on Absolute mode DPCs, no connection is made to this port.

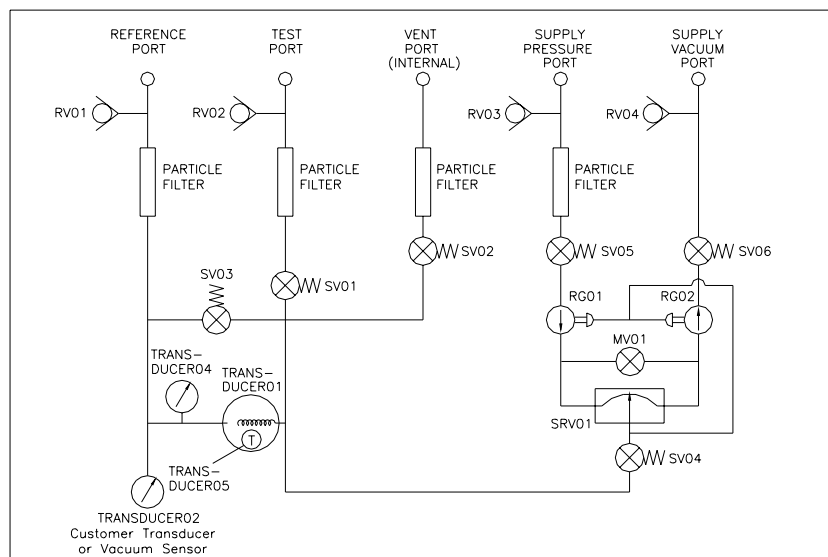
The valves, filters, transducers, and regulators that make-up the pneumatics module of a Differential mode PC are shown in Figure 2-2A. The schematic for the Absolute mode DPC is shown in Figure 2-2B. The schematic for high pressure DPCs is shown in Figure 2-2C.

In the sections that follow, components SV01 through SV06 are all 12-volt, DC solenoid valves that are either open or closed depending on the DPC's operational mode. Their behavior is summarized in Table 2-2.

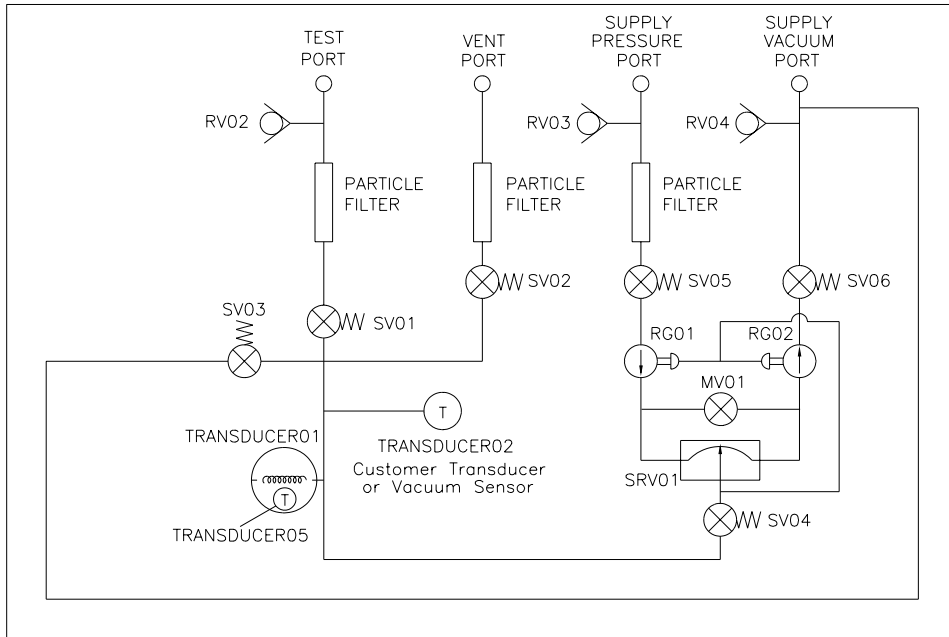


DPCs with ranges from 501 to 2500 psi have solenoids that operate on 115 or 230 VAC.

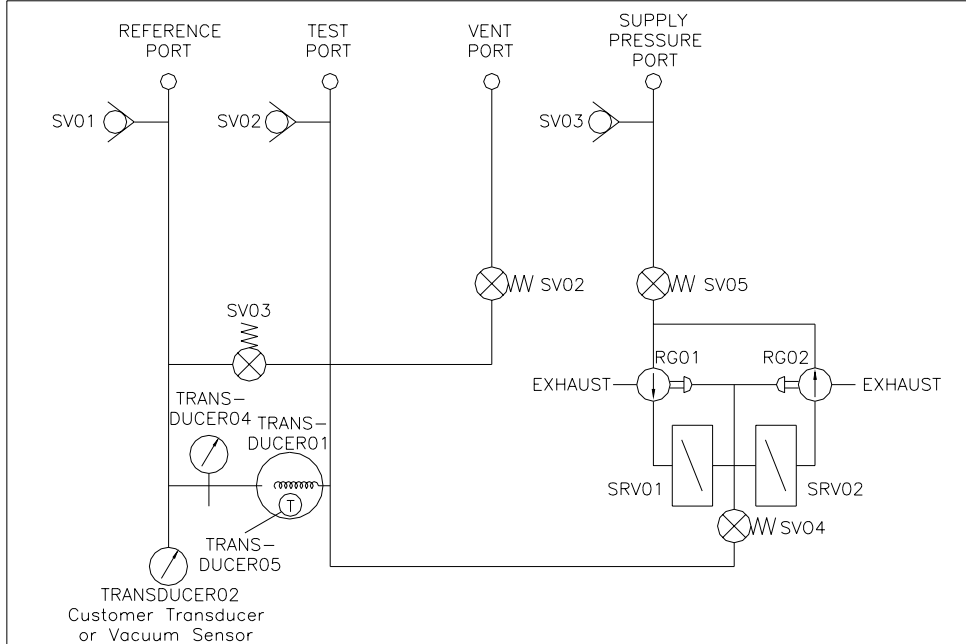
Components RG01 and RG02 are low pressure regulators. Component SRV01 is a three-port, DC servo valve, with one supply port, one exhaust port, and one output port. RV01 through RV04 are relief valves. See Figures 2-2A and 2-2C.



**FIGURE 2-2A**  
**MODEL 7010 DPC DIFFERENTIAL PNEUMATICS DIAGRAM**



**FIGURE 2-2B**  
**MODEL 7010 DPC ABSOLUTE PNEUMATICS DIAGRAM**



**FIGURE 2-2C**  
**MODEL 7010 DPC HIGH PRESSURE PNEUMATICS DIAGRAM**

**TABLE 2-2  
SOLENOID VALVES STATES**

<b>Valve</b>	<b>Measure Mode</b>	<b>Vent</b>	<b>Control Mode</b>	<b>Zeroing</b>
SV01	open	Open	open	closed
SV02	closed	Open	closed	closed
SV03	closed	Closed	closed	open
SV04	closed	Closed	open	closed
SV05	closed	Closed	open	closed
SV06	closed	Closed	open	closed
SV07				
SV08				

**2.4.1 MEASURE MODE PNEUMATICS**

The left half of Figure 2-2A through 2-2C summarizes the Measure Mode Pneumatics. This block, which is associated with measurement, is described in Sections 2.4.1.1 through 2.4.1.3 of this manual.

**2.4.1.1 REFERENCE PORT**

For gauge measurements, the Reference Port is left open to atmosphere. For other differential measurements, reference pressures from 0 to 15 psia inclusive may be applied to this port.

The medium from the Reference Port first passes through a particle filter before it enters the Reference Port of the transducer module. In addition, the Reference Port is isolated from the Test Port and Vent Port by a solenoid valve (SV03) that is closed during the DPC's Measure, Vent, and Control modes. When the user commands the DPC to perform the zeroing process, SV03 automatically opens, and the pressure on the Reference Port and Test Port become equal.

The Reference Port is protected by a relief valve (RV01), and a pressure sensor (TRANSDUCER02), used for measurements that are not referenced to atmosphere. Additionally, a temperature sensor (TRANSDUCER05) helps keep the quartz Bourdon tube sensor at 50°C.

**2.4.1.1.1 SPECIAL CONSIDERATIONS FOR 1 PSI 7010**

The 1-4.99 psi version of the DPC requires special handling to assure the full performance of the instrument. The instrument is only available in a Gauge mode. Thus, it is sensitive to atmospheric changes. To realize how sensitive it is, consider that a change in the least significant digit at 1 psi full scale corresponds to approximately 2 microns of pressure change. The reference side must be carefully controlled or changes due to air handler operation, doors being opened and closed, etc. will cause significant variations. The DPC tracks these changes but it may not track in the same way as the tst instrument.

To control these changes, it is recommended that the references of all relevant devices be tied to the reference of the DPC. This in turn should be connected to a tank with a volume of 200 in<sup>3</sup> or more. The tank should be vented to the atmosphere through a bleeder valve at the other end of the tank. The entire reference assembly should be shielded from rapid fluctuations in air temperature and flow. The vent valve should be set experimentally. In an environment with no

temperature changes, the valve would be closed. In an environment with no pressure fluctuations the valve would be wide open. Thus, the appropriate setting varies, but a good compromise can be found.

To observe the variations, connect the reference as discussed and open the test port to the atmosphere. In Measure mode, the DPC will indicate the variations. A good filter may be used in place of the valve if it provides approximately the correct restriction of air flow.



On Absolute Models there is no reference port.

#### 2.4.1.2 TEST PORT

The Test Port connects the DUT to the Pneumatics Module. The Test Port includes a particle filter, and a solenoid valve (SV01) that is open during the DPC's Measure, Vent, and Control modes and closed during the zeroing process. On Differential mode DPCs (see Section 2.4), the pressure at the DUT also appears at the tube of the quartz Bourdon tube sensor (TRANSDUCER01), where it is compared to the pressure from the Reference Port and measured/



On High Pressure Models (501–2500 psi), SV01 is not present. An externally mounted valve is available as an option.



On Absolute Models, the Bourdon tube is permanently evacuated and sealed at the factory, and the Test Port connects to the case of the sensor. Thus, the test pressure is always relative to vacuum.

The Test Port is isolated from the Vent Port by a solenoid valve (SV02) that is closed when the DPC is in Measure mode, Control mode, or performing the zeroing process. When the user commands the DPC to enter Vent mode, SV02 automatically opens, and the pressure on the Test Port is vented to ambient.

The Test Port is additionally protected by a relief valve (RV02).

#### 2.4.1.3 VENT PORT

The Vent Port allows the DPC to be rapidly returned to atmosphere. Referring to Figures 2-2A through 2-2C, note that low pressure Gauge and Differential mode DPCs (1-500 psi) are vented internally, and Absolute and High Pressure DPCs are vented externally via the Vent Port. A solenoid valve (SV02) is connected to the internal pressure measurement and control manifold. The other side is open to atmosphere. Vent mode opens SV02. If the autovent value set by the user is exceeded, SV-2 automatically opens.

## 2.4.2 CONTROL MODE PNEUMATICS

### 2.4.2.1 PRESSURE SUPPLY PORT

The Pressure Supply Port connects the user's regulated gas supply (see Section 3.5.1) to the Pneumatics Module, which is protected by a relief valve (RV03).

### 2.4.2.2 VACUUM SUPPLY (EXHAUST) PORT

For many applications, a vacuum pump is not necessary.

The Vacuum Supply Port includes a solenoid valve (SV06) that is open only when the DPC is in Control mode. The port also includes a relief valve (RV04).

In Gauge mode, if the DPC will not be used to control pressures at or near 0 psig, then the Vacuum Supply Port should simply be left open to atmosphere (be sure to remove any plastic shipping plugs). Likewise, in Absolute mode, if the DPC will not be used to control pressures at or below atmospheric pressure, the same rule would apply. However, if the DPC will be required to control 0 psig in Gauge mode or subatmospheric pressures in Absolute mode, then a vacuum pump must be connected to this port. Typically, a vacuum pump with a 50 liter per minute (L/m) capacity is sufficient. Ruska can supply a high quality vacuum pump (part number 99875-900, 115VAC, or 99875-960, 230VAC) that has a capacity of 69 L/m and includes an auto-vent valve, backstream filter and muffler. Also, when the DPC is used in Absolute mode, connecting a vacuum pump to this port will allow the user to perform autozeroing.



On High Pressure Models (501–2500 psi) there is no Vacuum Supply Port. Exhaust is internal to the DPC. This is due to the extremely large gas flows when controlling from higher to lower pressures and the low control limit specification of high pressure DPCs.



On Absolute Models, connecting a vacuum pump to the Vacuum Supply Port will allow control of subatmospheric pressures as well as autozeroing.

### 2.4.2.3 PRESSURE CONTROL

Two regulators supply a fixed differential pressure to a servo valve system. This system provides closed-loop control, based on feedback from the quartz Bourdon tube. A metering valve (MV01) located between RG01 and RG02 allows sufficient flow for the two regulators to operate efficiently. The output of SRV01 connects to a solenoid valve SV04 that is open only when the DPC is in Control mode.

## 2.4.3 CONTROL STRATEGY

The pressure controller is a PID controller executed every 100 milliseconds (10 times per second). The pressure is controlled to an exponential decay curve.

$$V = p*(S - A) + i*\int (S - A)dt + d*\frac{d}{dt}(S - A)$$

S = Setpoint

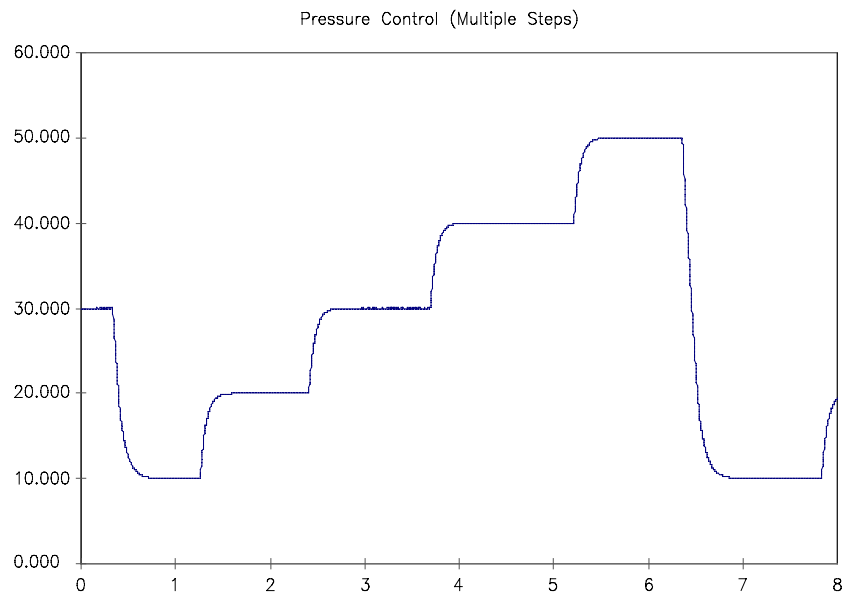
A = Actual

V = Control Output

p,i,d = Control Coefficients

The gain required by the controller is affected by many factors such as volume, absolute pressure, pressure supply, vacuum supply, and hardware variability. To compensate for these factors, the gain is continually updated by the control software. The gain is updated based on the comparison between the pressure and the ideal exponential decay curve. The gain update requires some time to occur if one or more of the following system parameters change quickly: Test Port volume change, external release/increase of pressure, changing of reference pressure, or change in pressure or vacuum supply.

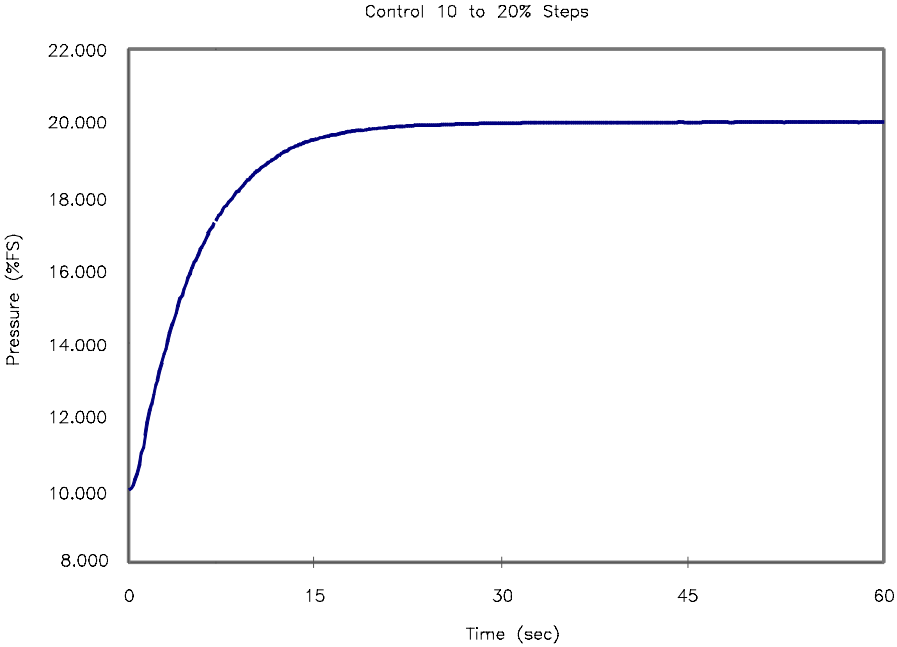
Figure 2-3 shows typical Control mode operation. Pressure in percent full scale is plotted versus time to show the smooth monotonic change in pressure as the instrument steps from one control point to the next.



**FIGURE 2-3  
PRESSURE CONTROL (MULTIPLE STEPS)**



Figure 2-4 shows an expanded view of a step from 10% to 20% of full scale.



**FIGURE 2-4  
PRESSURE CONTROL (10% to 20% STEP)**

## 2.5 TRANSDUCER MODULE

### 2.5.1 QUARTZ BOURDON TUBE SENSOR (TRANSDUCER01)

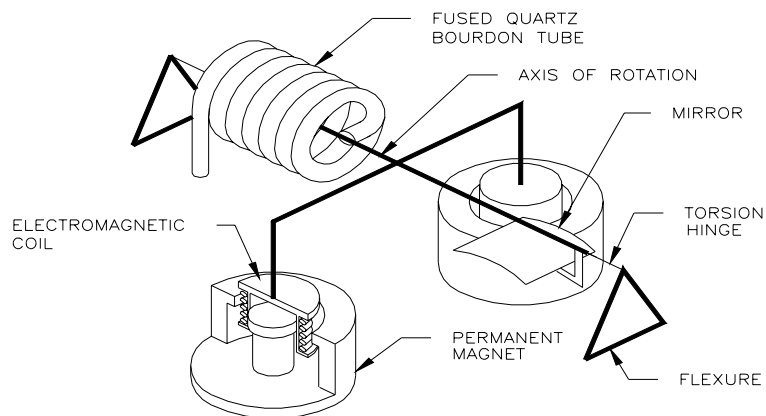
The quartz Bourdon tube sensor (TRANSDUCER01 in Figure 2-2A thru 2-2C) is mounted in a machined aluminum/steel housing. The sensor consists of a helical quartz tube with a mirror fixed to one end, as shown in Figure 2-5.

A rigid beam is attached transverse to the axis of the helical tube. Attached to both ends of this beam are electromagnetic coils. Mounted beneath the coils are permanent magnets. A lamp assembly directs light through a sapphire window onto the mirror affixed to the helical tube, as shown in Figure 2-6. The mirror reflects the light back through the window and strikes two identical photodiodes. When there is zero pressure differential across the helical tube, the photodiode assembly is mechanically adjusted so that the light spot is centered between each photocell. In this "aero position", the outputs of the two photodiodes provide energy used to maintain the quartz assembly in its zero position, thus; a force balance is created.

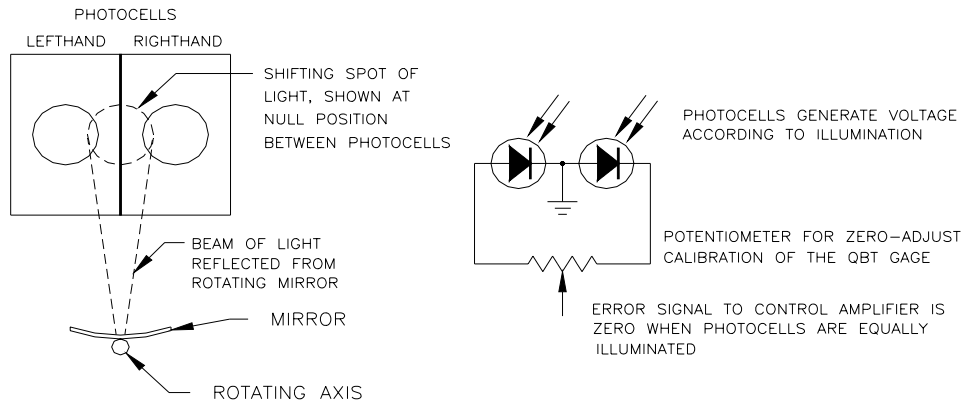
As pressure is applied in the helical tube, the entire apparatus attempts to rotate. This causes the mirror to move the reflected light spot to shine more on one photodiode than the other. The Sensor Board (see Section 2.5.2) then responds by changing the current to the electromagnetic coils that, through interaction with the permanent magnets, force the helical tube to return to its zero position. The amount of current required to do this is proportional to the pressure applied across the helical tube. Thus, the pressure is determined by the amount of current required to return the helical tube to its zero position.



On Absolute Models, the process is similar, except that the Bourdon tube is permanently evacuated and sealed at the factory, and the test pressure is applied to the sensor case. With this configuration, all test pressures are measured with respect to vacuum.



**FIGURE 2-5  
SHAFT/MAGNET SECTION**



**FIGURE 2-6  
PHOTOCELL/LIGHT SPOT**

### 2.5.2 SENSOR BOARD

A temperature sensor and the quartz Bourdon tube pressure sensor are monitored by the Sensor Board, which works with the Control Board to interpret pressure and temperature signals from these sensors and maintain the sensor housing at 50 °C.

### 2.5.3 LINEARIZATION TERM

As described in the previous section, the relationship between the pressure being measured and the current required to keep the quartz Bourdon tube in its zero position is the main principle behind the operation of the DPC's sensing element.

Ideally this pressure-current relationship would be a linear equation of the form

$$I = kP,$$

where I is current, k is a constant of proportionality, and P is pressure.

However, due to certain mechanical characteristics of the helical tube and its supporting structure, this pressure-current relationship is slightly nonlinear. The nonlinear portion of this pressure-current relationship closely follows the form of a second order polynomial, or

$$aP^2 + bP + c,$$

where again P is pressure and a, b, and c are coefficients generated during the calibration procedure as discussed below.

When the user performs a three-point calibration, the DPC's software creates the three coefficients based on the user's zero, mid-point, and full-scale adjustments. From then on, the nonlinear term given above is subtracted from the total pressure-current curve to achieve the desired linear pressure-current relationship.

## 2.5.4 AUXILIARY SENSORS

Auxiliary sensors are the case reference pressure sensor, and the oven temperature sensor. These are reference sensors aligned at the factory and are utilized by the firmware which do not require calibration.

### 2.5.4.1 CASE REFERENCE VACUUM SENSOR

The case reference vacuum sensor is a user installed option. See Section 3.5.5. The user needs this sensor to zero the DPC and to monitor the case reference in Differential instruments in Absolute mode. It is the users discretion to calibrate this sensor.

## 2.6 SOFTWARE

The DPC is a digital, software-based instrument. The controlling software uses a PID algorithm and allows for user-definable units and onboard programming.

### 2.6.1 SOFTWARE SAFETY CONTROLS

#### 2.6.1.1 PREVENTING OPERATOR ERRORS

The operator is required to verify a change to Control mode or Vent mode by pressing the **[Enter]** key. Additionally, the control setpoint is set to zero upon power-up or when any of the limit errors occur.

#### 2.6.1.2 PNEUMATIC ERRORS

The DPC continually monitors the pressure for low, high and slew (rate of change) limits. When these limits are exceeded, the DPC is returned to Measure mode, shutting off the pressure and vacuum supplies, and an error message is generated. Additionally a vent limit may be set. The DPC will go to Vent mode when the pressure exceeds this limit.

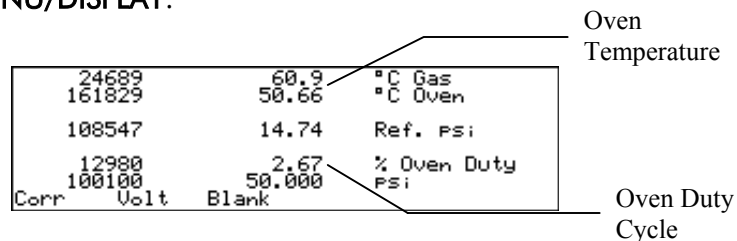
#### 2.6.1.3 SHUTOFFS

Measure mode can be entered from the main screen with no acknowledgement required. The DPC will turn off the control or vent operation immediately.

#### 2.6.1.4 OVEN CONTROL

The oven temperature is controlled via a pulse-width modulated signal running at 300 hertz. The time the heater is on can be varied from 0 to 100%. The pulse-width at startup is initialized to the previous value which was stored in battery-backed CMOS RAM.

The oven control is a PID controller updated approximately every 7 seconds. Figure 2-7 is accessed by pressing **MENU/DISPLAY**.



**FIGURE 2-7**  
**AUXILIARY SENSOR DISPLAY**

#### 2.6.1.5 PRESSURE READING AND CORRECTION

The sensor's analog output is processed by an analog-to-digital circuit that results in an output referred to as **counts**. This output has to be corrected for the applied effects listed below.

The counts are linearized and the resulting pressure value is corrected for the variations in head pressure, vacuum, case effect, and oven temperature effects.

The following equations are used by the control algorithm to adjust and correct the pressure signal.

### Gain and Offset Corrected Counts

$$A = (R + C_0 - Z_O + Z_C) * C_3 * S_O$$

### Linearized Counts

$$L = A - C_1 * A^2 - C_2 * A + Z_V$$

### Head Corrected Pressure

$$P = L * K_K + HeadPressure(L * K_K)$$

$C_0, C_1, C_2, C_3$  Calibration coefficients

$HeadPressure$  Head pressure

$R$  A/D Reading

### Counts to Pressure Conversion Factor

$$K_K = \frac{FullScale}{200,000}$$

### Vacuum Correction

$$Z_V = \frac{Vacuum}{K_K}$$

### Oven Temperature Offset

$$Z_O = K_O * (OvenSetpoint - OvenTemp)$$

### Oven Temperature Slope

$$S_O = 1.0 - K_S * (OvenSetpoint - OvenTemp)$$

### Case Pressure Offset

$$Z_C = \frac{K_C * CasePressure}{K_K}$$

$FullScale$

Full scale pressure of the 7010

$Vacuum$

Vacuum level for absolute measurements

$OvenSetpoint$

Oven temperature setpoint (50.0 °C)

$OvenTemp$

Current oven temperature reading

$K_O$

Oven temperature offset factor

$K_S$

Oven temperature slope facto.

$K_C$

Case pressure effect factor

The setup and configuration of the DPC is stored in nonvolatile memory (EEPROM) on the system board. The data is stored in sections each with a CRC (Cyclic Redundancy Check) checksum. If

the CRC checksum is not correct on power-up, the system displays an error message and uses default values (100 psi Differential, Linear calibration, etc.).

The following information is stored in EEPROM and is available to the processor on reboot of the controller.

- Manufacturing Data
  - Sensor Type (Absolute/Differential) and Full Scale
  - Oven Temperature and Case Effect Corrections
  - Serial Number
- Data Acquisition
  - Calibration Coefficients
  - Calibration Date/Time
  - Oven Control Parameters
- Mux
  - Secondary Sensor Coefficients
- Global Data
  - Units
  - Head Correction
  - Reading Type (Absolute/Differential/Gauge)
- Local
  - Step Size and Bar Graph Maximum
- Control
  - Pressure Limits
- Remote
  - Protocol, Setup
- Programs

An abort key is available on the front panel. When this key is pressed, the DPC will immediately close all valves, show a message on the front display, and reset the system software.

## 2.7 USING OPTO 22™ MODULES

Opto 22 I/O modules may be used to control vacuum pumps, external solenoids, and other user-defined devices. Modules may be controlled via the DPC front panel or remote communications. Valid Opto 22 mounting racks include the PB8, PB16A, PB16C, PB16H, PB16HC, PB16HQ, PB24, and PB24Q. If used, the Opto 22 modules should be configured according to Table 2-3.

The user's Opto 22 mounting rack connects to a 50-pin connector on the DPC's back panel. The DPC's Input/Output (I/O) screen then allows the user to observe the various modules and turn them on or off.

1. Connect the desired Opto 22 mounting rack to the 50-pin connector on the DPC's back panel. Connect the desired external devices to the modules according to Table 2-3, and provide power to the mounting rack.
2. To control the board from the DPC's front panel, select **MENU/SETUP/SYSTEM/I/O**. The I/O screen will appear.
3. To turn the desired module on or off, use the arrow keys to move the cursor bar to the module, then select on or off.
4. To exit the I/O and calibration screens, press the **[PREV.]** key twice.

**TABLE 2-3  
OPTO 22 MODULES**

<b>Module Number and Type</b>	<b>Device/Function</b>
0 (reserved)	Vacuum supply (exhaust) pump. The pump is turned on whenever vacuum is required at the vacuum supply port
1 (reserved)	Supply pressure pump. The pump is turned on whenever pressure is required at the test port.
2 (reserved)	Reference vacuum pump. The pump is turned on whenever vacuum is required at the reference port.
3 (reserved)	External solenoid valve #1 (test port shutoff for 501–2500 psi DPCs).
4 (reserved)	Remote operation continue. When remote operation (Section 5.0 of this manual) is used to run a programmed test sequence (Section 3.0), input from this module executes the next instruction in the test sequence.
5	Pressure supply ok. When this input turns off, a pressure supply alarm sounds.
6–7 (user–defined)	Intended for input. Responses may be observed through the DPC front panel.
8–23 (user–defined)	Intended for output. Responses may be controlled through the DPC front panel.

## **SECTION 3.0 INSTALLATION**

### **3.1 INTRODUCTION**

This section of the manual discusses initial installation for the Model 7010 DPC. Installing the DPC involves connecting the supply and test pressure tubing, powering up the unit, and configuring the system through the front panel

### **3.2 UNPACKING THE DPC**

Carefully unpack all components, checking for obvious signs of damage. In addition to any optional items ordered with the DPC, the shipment contains the following items:

- a Model 7010 DPC,
- a power cord,
- a user's manual,
- a calibration report, and
- a small tools kit.

If necessary, report any shipping damage to the freight agency. Remove all shipping and packing materials (including the shipping plugs) from all components. If possible, save the packing materials for future use.

Finally, install the DPC in a location that meets the requirements listed in Table 3-1.

**NOTE:** The DPC should not be subjected to mechanical shocks or vibration during installation or use. It should be mounted on a rigid bench or in a sturdy 19" rack. Although the zeroing process will compensate for a slightly unlevel mounting, the DPC should be mounted to within 5° of level.

**TABLE 3-1  
GENERAL SPECIFICATIONS: GENERAL PARAMETERS**

<b>PARAMETER</b>	<b>VALUE</b>	<b>MODEL</b>
Operating Humidity	5-95% RH, noncondensing	all
Storage humidity	none*	all
Operating Temperature	18 - 36°C	all
Storage Temperature	-20 to 70°C	all
Electrical Power	90 - 260 VAC	refer to Section 3.4
Power Consumption	150 W	all
Warmup Period	≤3 hrs	all

\*If there is any condensation when storing the DPC, it must be thoroughly dried before power is applied.'

### **3.3 CAUTIONS**

The following cautions should be heeded at all times to ensure safe operation of the DPC.



1. Never operate the DPC with the cover removed. The power supply has internal voltages near 400 volts.
2. Never apply more than 120% of the DPC's full scale as a pressure supply. Pressure supply must be regulated and meet will criteria as stated in Appendix A of this manual.
3. Never apply more than 110% of the DPC's full scale to the test port. Never try to control while a pressure source is connected to the test port.
4. Do not expose the instrument to thermal and mechanical shock, or vibration. This may affect performance and require rezeroing.
5. See the safety summary in the introduction.

### 3.4 POWERING UP THE DPC

First, plug the power cord supplied with the DPC into the power connector on the DPC's back panel.

**NOTE:** Grounding for the DPC is provided through the power cord.

Next, plug the power cord into a receptacle rated for any AC voltage between 90 and 260 volts. If a different power cord is necessary for your receptacle, consult Table 1-1 for available power cords.



The High Pressure DPC (501-2500 psi) uses either 115V or 230 VAC solenoids. Therefore, there are both 115V and 230V models available for these units. Unlike other DPC models, High Pressures DPCs do not allow for a wide range of power line voltages and must be ordered for the proper use.

Finally, turn on the DPC by flipping the power switch on the back panel. The MEASURE screen will appear on the vacuum fluorescent display, and the front panel will be fully operational.

#### 3.4.1 OBSERVING THE DPC'S FULL SCALE RATING

To observe the DPC's full scale rating;

1. Press [PREV.] until the main menu appears.
2. Select **MENU/CAL.** The DPC's full scale pressure rating (FS) will appear on the screen (in the currently selected units of measure).
3. To return to the main menu, press [PREV.].

### 3.5 PNEUMATIC CONNECTIONS

Pneumatic connection to the DPC is straightforward. The following sections discuss each port. All ports are 1/4" NPT pipe fittings. See Figure 3-1A through 3-1C.

#### 3.5.1 PRESSURE SUPPLY PORT

The pressure supply port must be connected to a regulated source of clean, dry nitrogen or air. Shop air should not be used. Refer to Appendix A for supply port gas purity and pressure regulation requirements.

Tubing must be of at least 1/8-inch (3-mm) inside diameter and of a sufficient wall thickness for the pressure. Either stainless steel or copper tubing is acceptable.

### 3.5.2 SUPPLY VACUUM

The supply vacuum lines must have minimum restrictions. Tubing should have a minimum I.D. of 1/4 inches. A vacuum pump is required in Absolute mode for controlling pressure below atmospheric pressure, and will allow lower pressure control in Gauge mode (i.e. to control to 0 psig).



This is the vent port on >500 psi DPC's. DO NOT attach a vacuum pump to this port.

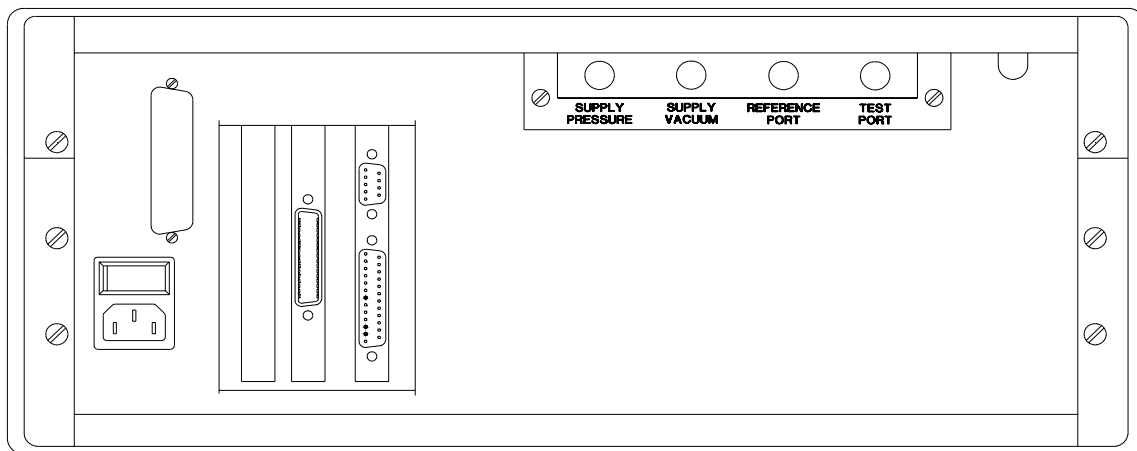
### 3.5.3 TEST PORT

The device(s) under test is connected to the test port. The DPC controller is designed to operate within its specification limits into load volumes from 5 to 60 in<sup>3</sup> (80 to 1000 cc). Excessive leaks in the test volume will cause measurement errors in the device under test and possible control stability. Tubing connect from the test port to the load volume should have an internal diameter greater than 0.125 inches (3 mm). Tubing should be shorter than 15 feet when minimum diameter tubing is used.

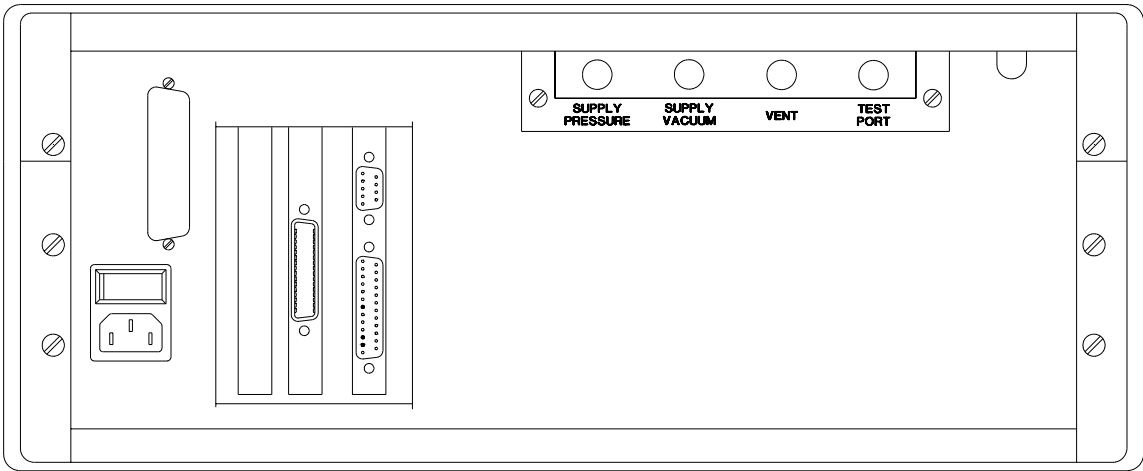
### 3.5.4 REFERENCE PORT

The reference port is open to atmosphere for gauge measurements. In Absolute mode, a vacuum pump capable of producing a vacuum level of 200 mTorr or less at the sensor reference port is required. See Appendix A for vacuum pump requirements.

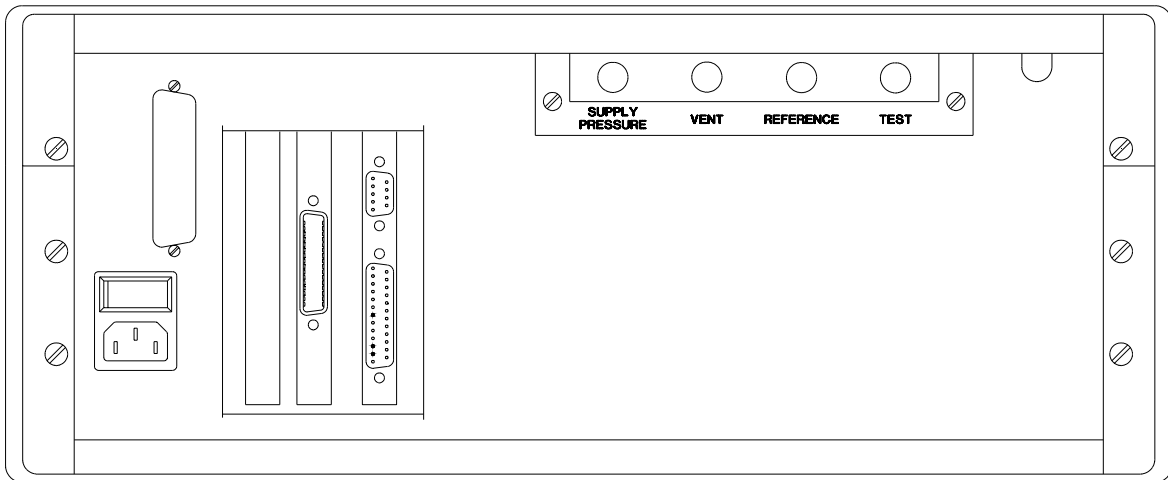
The vacuum tubing from the pump to the reference port should be a recommended 1/4-inch inner diameter or larger with a minimum length. If tubing with smaller than recommended inner diameters or long tubing lengths is used, longer pull down times may result.



**FIGURE 3-1A  
MODEL 7010 BACK PANEL**



**FIGURE 3-1B**  
**MODEL 7010 ABSOLUTE BACK PANEL**



**FIGURE 3-1C**  
**MODEL 7010 HIGH PRESSURE BACK PANEL**



**CAUTION:** For DPCs with ranges from 1 to 4.99 psig, the reference port must be left open to atmosphere. Do not apply a positive pressure or a vacuum to the reference port on these units. Refer to Figures 2-2A through 2-2C for plumbing information.

### 3.5.5 VACUUM TRANSDUCER INSTALLATION

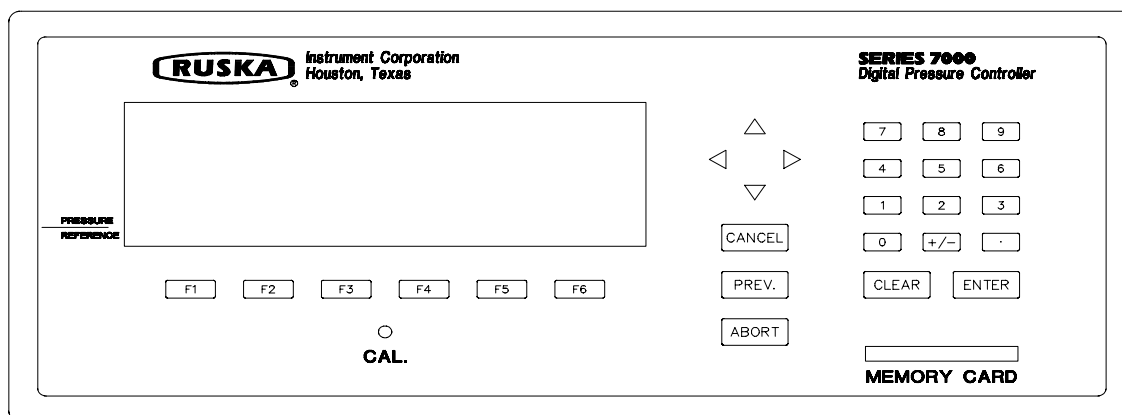
A vacuum port is provided inside the DPC to monitor vacuum levels and is required in the autozeroing process. The following steps describe vacuum transducer installation.

1. Relieve all pressure from the DPC by venting the instrument.
2. Turn the power off and unplug the power cord from the DPC.
3. Remove the cover.
4. Looking from the back of the DPC, locate the fittings on the right side of the black box. The configuration of these fittings will vary depending on the DPC model.
5. Locate and remove the 1/8-inch NPT stainless steel pipe plug using a 3/16-inch Allen wrench. (The plug is located on the reference port for Gauge and Differential DPCs, and the test port for Absolute models.)
6. Make two wraps of Teflon tape on the 1/8-inch NPT fitting threads of the vacuum transducer. Apply a small amount of vacuum grease to the tape.
7. Install the vacuum transducer in the fitting in the DPC.
8. Plug the cable from the vacuum gauge into the vacuum transducer.
9. Route the cable over the pneumatics and into the u-shaped slot on the right side of the back panel.
10. Replace the DPC's cover, plug the power cord back into the DPC, and turn the power on.

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## SECTION 4.0 LOCAL OPERATION

This section of the manual describes operation of the DPC using the front panel. The local interface (front panel) consists of a vacuum fluorescent display and a set of keys. The display shows the system status and menu options. The keys are grouped according to function.



**FIGURE 4-1  
MODEL 7010 FRONT PANEL**

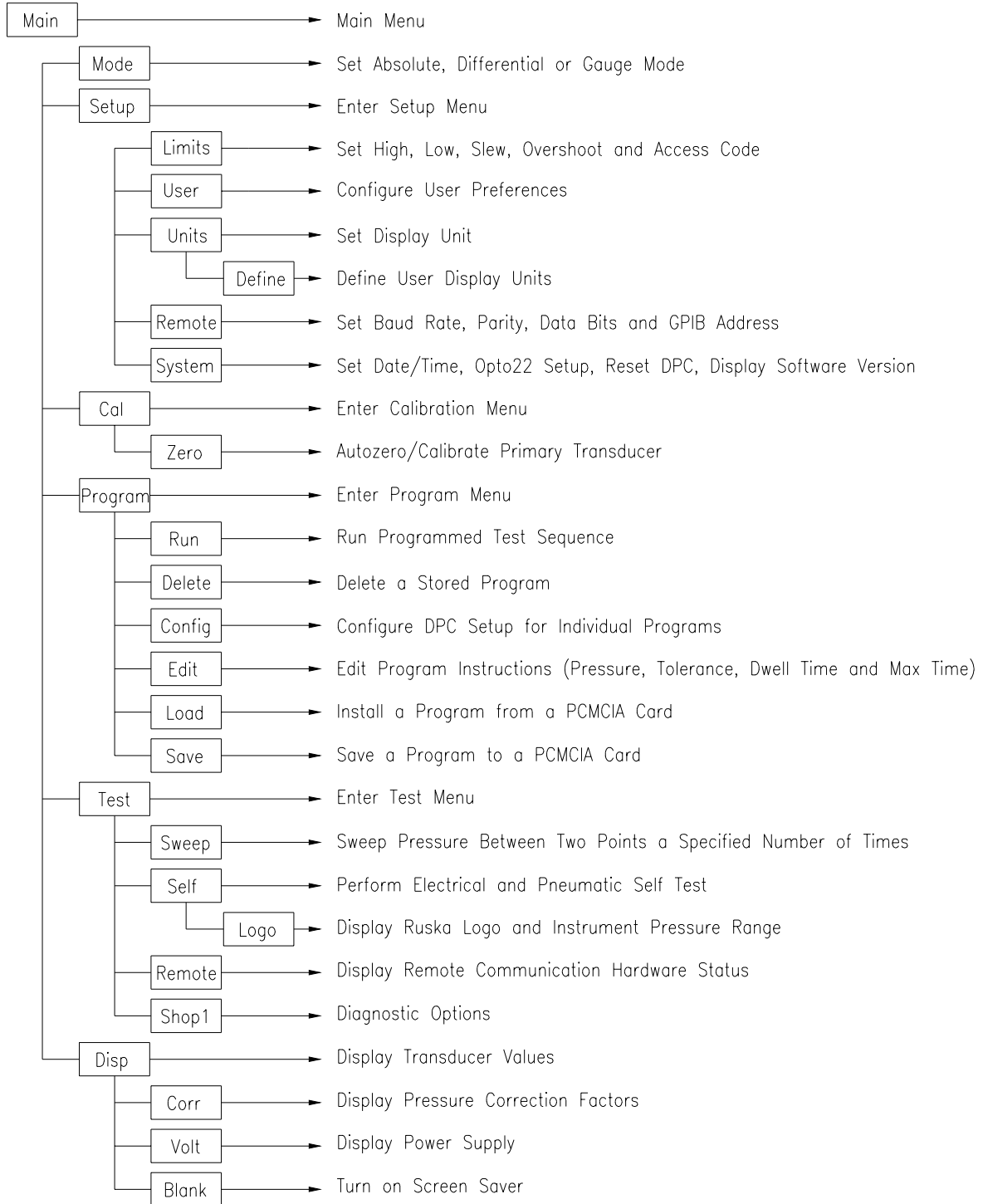
**Numeric Keypad:** This includes the number keys, the decimal point [.] , and the change sign key [+/-]. The [CLEAR] key will clear the numeric entry field. The [ENTER] key accepts the entered number or confirms a command.

**Function Keys:** The [F1] through [F6] keys are used to navigate the menus and perform predefined functions. The name of the function is displayed above the key on the bottom line of the display.

**Arrow Keys:** The up and down arrows select a field for editing and are used for small pressure changes (pressure jog) at the main menu. The left and right arrows select between multiple choice options for the selected field.

**CANCEL, PREV., ABORT:** These keys are used to stop, undo, or exit the current operation. The [CANCEL] key returns all edited fields on the current entry screen to their original values. It also stops the current program sequence or calibration process. The [PREV.] key exits the current menu and returns to the previous menu. The [ABORT] key causes an immediate shutdown and restart of the system.

Figure 4-2 is a menu tree showing the relationship between all the menus in the system. Refer to it to for selections available under the menu. To move to a lower menu, press the function key with the correct label. To move towards the main menu, press the [PREV.] key. In the Main Menu screen, the [F1] key places the unit in Measure mode. The [F2] key places the unit in Control mode. [ENTER] must be pressed to actually enter the Control mode. The [F3] key places the unit in Vent mode. This opens the test port to atmosphere and rapidly reduces the pressure. [ENTER] is required to confirm the operation. The [F4] and [F5] keys step the control setpoint by the correct step amount. To go to one of the menus, press the [F6] key.



**FIGURE 4-2  
MENU TREE**

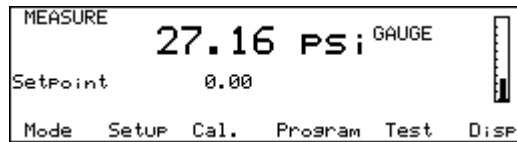
## 4.1 TUTORIAL

To begin the tutorial, first verify that the DPC is powered-up and that the pneumatic connections have been completed. The DPC should display a screen similar to the one shown below. (The bottom line of the display should show the options.) If an error message is displayed, press **[F6]**, then press **[PREV.]**.

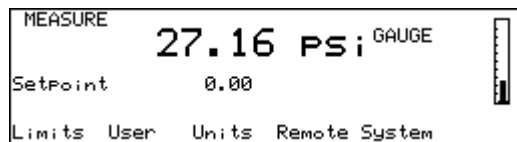


This is the Main Menu. It is at the top level of the menu tree (see figure 4.2) and all descriptions in this manual start from this point. The top center of the display shows the current pressure (27.16 psi gauge). The upper left corner shows the current mode of the DPC (MEASURE or CONTROL). The right side of the screen shows a bar graph displaying the current pressure relative to a user-configurable full-scale value. Below the pressure is the pressure control setpoint with a numeric scratchpad for entering a new setpoint value. The highlighted label on the bottom line of the screen displays the current assignments of the function keys **[F1]** through **[F6]** that are located below the display.

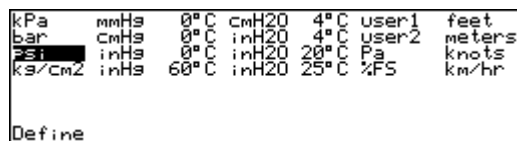
Step 1. Change the pressure units. The units are changed from the screen MENU/SETUP/UNITS. From the Main Menu shown above, first press **Menu** (the **[F6]** key). This will display the **MENU** screen.



Step 2. Now press **Setup** (the **[F2]** key). This will display the **MENU/SETUP** screen, shown below.



Step 3. Now press **Units** (the **[F3]** key). This will display the **MENU/SETUP/UNITS** screen. The list of available units will be displayed with the current units highlighted.



Step 4. Use the arrow keys located to the right of the display to move the highlight bar.



Step 5. When the unit desired is highlighted, press the **[ENTER]** key on the far right side of the front panel, under the numeric keypad. The display will return to the **MENU/SETUP** screen with the current units.

Step 6. Press **[PREV.]** to return to the **MENU** screen.

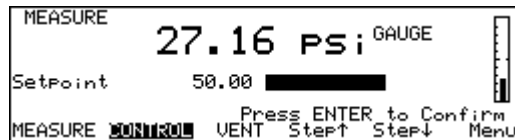
Step 7. Press **[PREV.]** again to return to the **Main Menu**.

The second part of this tutorial uses the DPC to generate pressure. The pressure supply must be connected and the test port must be connected to a closed volume, in accordance with Section 3.5 of this manual.

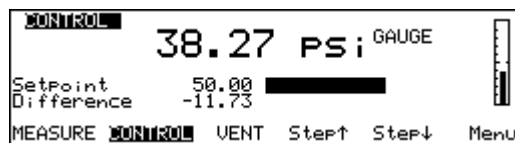
Step 8. From the Main Menu, use the numeric keypad to enter the starting pressure. The pressure is entered in the units set in the previous exercise. As the pressure is entered, each digit will be displayed in the numeric scratchpad (the highlighted box in the middle of the display). If a mistake is made, press the **[CLEAR]** key (under the numeric keypad), and the numeric scratchpad will be cleared.

Step 9. When the entry is correct, press the **[ENTER]** key. The scratchpad will be cleared and the value will appear to the left of the scratchpad.

Step 10. Now that the starting pressure is entered, enter Control mode. Press **Control** (the **[F2]** key). The highlight will move from MEASURE to CONTROL, and the message "Press Enter to Confirm" will appear above the function key definitions. Notice that the upper left corner still shows MEASURE. The DPC stays in Measure mode until the change is confirmed.



Step 11. Press **[ENTER]** to confirm the mode change. The upper left corner will change to **CONTROL**, and the pressure will start moving towards the setpoint.



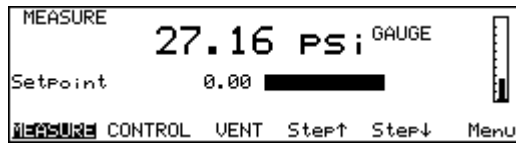
Step 12. After the pressure is stabilized, press the **[Step ↑]** or **[Step ↓]** key. The scratchpad will be updated with a new setpoint. The step size defaults to 10% of full scale.

Step 13. Press **[ENTER]** to accept the new setpoint. The DPC will move to the new setpoint.

Step 14. Press **Measure** (the **[F1]** key). The DPC will change to Measure mode. No confirmation is necessary to leave Control mode.

## 4.2 MEASURING PRESSURE

The Main Menu displays the measured pressure in double-size numbers. To the right of the pressure is the current unit and type (Gauge, Differential or Absolute). The Main Menu can always be reached by repeatedly pressing **[PREV.]**.



## 4.2.1 SELECTING MODE OF OPERATION

The DPC is offered as gauge only, absolute only or differential type instruments.

### 4.2.1.1 Gauge Only Instruments

The mode of operation is selected from the Mode Menu. From the Main Menu (press **[Prev.]** until the Main Menu appears), press **Menu [F6]**, **Mode [F1]**. Select Absolute, Gauge or Differential mode of operation.

**NOTE:** On Gauge only instruments, although gauge, differential and absolute modes are selectable from the Mode Menu, the instrument will have only been tested in the gauge mode.

### 4.2.1.2 Absolute Only Instruments

The only mode of operation available for this instrument will be the Absolute mode.

### 4.2.1.3 Differential Instruments

A differential 7010 is capable of operating in Gauge, Absolute and differential modes. Additionally, on some differential units, a negative gauge (or vacuum) option is available which allows the unit to measure and control both positive and negative pressures about the reference pressure.

The mode of operation is selected from the Mode Menu. From the Main Menu (press **[Prev.]** until the Main Menu appears), press **Menu [F6]**, **Mode [F1]**. Select Absolute, Gauge or Differential mode of operation.

#### 4.2.1.3.1 Absolute Mode

The differential instruments are capable of operating in Absolute mode when the case reference is pulled down with a vacuum pump.

While zeroing a differential unit in the Absolute mode, the user is prompted to enter the vacuum level of the reference pressure port. The displayed pressure value is then corrected for the vacuum pressure offset in the reference port. See Section 6.4.4.2.2.

**NOTE:** When operating a differential instrument with the case reference pulled down to a vacuum, the operator must select the Absolute mode of operation in order for the instrument to correct the displayed pressure for the vacuum pressure offset.

#### 4.2.1.3.2 Gauge Mode

The differential instruments are capable of operating in the Gauge mode when the case reference is opened to atmosphere.

While zeroing a differential unit in Gauge mode, if the internal reference pressure transducer measures the reference pressure outside of a 57.2 to 1-6.8 kPa range, "Out Of Range" will be

displayed in the ref. Psi section of the zero screen. The unit will not automatically zero if the case reference pressure is "Out Of Range". See Section 6.4.4 and 6.4.4.2.1.

#### 4.2.1.3.3 Differential Mode

The differential instruments are capable of operating in a Differential mode when the case reference is set anywhere from vacuum to 10 psig.

In the Differential mode, no software limits exist on the case reference while the instrument is being zeroed. See Section 6.4.4 and 6.4.4.2.1.

### 4.2.2 SELECTING PRESSURE UNITS

1. The pressure units are selected from the **Units Menu**. From the **Main Menu** (press [PREV.] until the Main Menu appears), press **Menu [F6]**, **Setup [F2]**, and then **Units [F3]**. The current units will be highlighted.
2. Use the arrow keys to highlight the desired pressure unit.
3. Press [ENTER] to accept the change. Press [PREV.] to exit without changing the units.

The DPC uses the conversion factors listed in Table 2-1 to translate the pressure from kiloPascals to one of the DPC's units of measure.

In addition to the predefined units offered in the **Units** menu, there are four user-defined units available.

### 4.2.3 DEFINING A NEW PRESSURE UNIT

In addition to the standard units of measure provided by the DPC, four user-defined units are available. To create one of these units, the user enters a *name* that is one to ten characters long and a *conversion factor* that is a multiple of kiloPascals (kPa).

For example, using the information from Table 2-1, the conversion factor for millitorr or one micron of mercury at 0°C is calculated as follows.

$$mTorr = kPa \times \frac{1000 \text{ mTorr}}{1 \text{ Torr}} \times \frac{1 \text{ Torr}}{1 \text{ mmHg} 0^\circ C} \times \frac{1 \text{ mmHg} 0^\circ C}{0.0193368 \text{ psi}} \times \frac{0.1450377 \text{ psi}}{1 \text{ kPa}}$$

thus the conversion factor simplifies to

$$mTorr = kPa \times 7500.6051$$

1. The pressure units are defined from the **Units Define Menu**. From the **Main Menu** (press [PREV.] until the Main Menu appears) press **Menu [F6]**, then **Setup [F2]**, then **Units [F3]**, and then **Define [F1]**.
2. Press **Next [F2]** until the desired user-defined unit is highlighted.
3. The following sequence is used to change the name of the selected unit.
  - a. Use the arrow keys to highlight the desired character in the matrix.
  - b. Press **Add [F3]** to add the character to the name entry box.
  - c. Repeat a and b until the desired name is entered. Press **Clear [F4]** to start over.
  - d. Press **Enter [F5]** to accept the name.
4. Use the numeric keypad to enter the conversion factor and press [ENTER] to accept.
5. Press [PREV .] to return to the **Units Menu**. The new unit definition may be selected.

#### 4.2.4 CHANGING THE NUMBER OF DECIMALS

Each unit has a default number of decimal places used for pressure display. This may be adjusted up or down by one decimal place.

1. The decimal digits are set from the **Setup User Menu**. From the **Main Menu** (press [PREV.] until the Main Menu appears), press **Menu [F6]**, then **Setup [F2]**, and then **User [F2]**.
2. Press the down arrow key until the label "Display digits" is highlighted.
3. Use the left and right arrow keys to change the number of decimal digits.
4. Press [PREV.] to exit the menu. Press [CANCEL] to return all edited fields to their original values.

#### 4.2.5 SETTING THE ALARM LIMITS

The DPC continually checks the measured pressure against high, low, and slew rate limits. If the measured pressure exceeds the high limit, falls below the low limit, or changes faster than the slew rate limit, an alarm is generated.

1. The alarm limits are set from the **Setup Limits Menu**. From the **Main Menu** (press [PREV.] until the Main Menu appears), press **Menu [F6]**, then **Setup [F2]**, and then **Limits [F1]**.
2. Press the up and down arrow keys to highlight the desired limit.
3. Use the numeric keypad to enter the new value.
4. Press [ENTER] to accept the new value.
5. **Default [F1]**, **Max [F2]**, and **Min [F3]** place standard values for the field into the numeric scratchpad.
6. Press [PREV.] to exit the menu. Press [CANCEL] to return all edited fields to their original values.

#### 4.2.6 USING HEAD PRESSURE CORRECTION

The term *head height* refers to the vertical distance between the sensing element in the device under test and the DPC's sensor. Once the user inputs the head height and selects air or nitrogen, the DPC automatically corrects for head pressure.

1. Locate the Pressure Reference Line on the DPC's front panel. This line provides the *reference plane* against which the Device Under Test (DUT) pressure is measured.
2. Determine the vertical distance between the Pressure Reference Line and the sensing element in the device under test.
3. The head height is set from the **Setup User Menu**. From the **Main Menu** (press [PREV.] until the Main Menu appears), press **Menu [F6]**, then **Setup [F2]**, and then **User [F2]**.
4. Press **Length [F1]** to select either inches (in) or millimeters (mm) for the head height entry. The selected units will appear on the Gas Head line to the right of the number.
5. Highlight "Air" or "Nitrogen."
6. Use the up or down arrows to highlight the label "Head Height."
7. Use the numeric keypad to enter the height. Use a positive value if the device under test is below the DPC, and a negative value if the device under test is above the DPC.
8. Press [ENTER] to accept the entry.

#### 4.2.7 ZEROING

Ruska recommends that the DPC be zeroed once a day to maintain optimal performance. Zero drift is a separate specification from precision and stability. The zero drift specification is defined in Appendix A under General Specifications. Refer to section 6.4.4 in this manual for the zeroing procedure.

### 4.3 CONTROLLING PRESSURE

#### 4.3.1 SETTING THE PRESSURE SETPOINT

The pressure setpoint is the destination of the pressure control algorithm. It should be set before entering Control mode. The pressure setpoint is set to zero at power-up and whenever a pressure error occurs.

1. The pressure setpoint is set from the **Main Menu**. (Press **[PREV.]** until the Main Menu appears.)
2. Use the numeric keypad to enter the new pressure setpoint in the current pressure units.
3. Press **[ENTER]** to accept the entry or press **[CLEAR]** to clear the numeric scratchpad.

#### 4.3.2 ENTERING/EXITING CONTROL MODE

1. The Control mode is set from the **Main Menu**. (Press **[PREV.]** until the Main Menu appears.)
2. Press **CONTROL [F2]** to enter Control mode. **[ENTER]** must be pressed to confirm entry into Control mode. Note that any entry in the numeric scratchpad will also be taken as the new pressure setpoint. The DPC controls its internal pressure to the test port pressure before opening SV01 and entering the Control mode. During this period, the Control mode indicator flashes.
3. Press **MEASURE [F1]** to exit Control mode. No confirmation is necessary. Entering Measure mode is nearly instantaneous. SV04 is closed to isolate the control pneumatics.

#### 4.3.3 SETTING SLEW RATE

The DPC control algorithm tries to limit the rate of pressure change to the slew rate. If the slew rate value is too high, then the DPC will control at maximum speed. The DPC does not control to the slew limit (for the slew limit refer to section 4.2.4).

1. The slew rate is set from the **Setup Limits Menu**. From the **Main Menu** (press **[PREV.]** until the Main Menu appears), press **Menu [F6]**, then **Setup [F2]**, and then **Limits [F1]**.
2. Press the down arrow key until the label "Slew Rate" is highlighted.
3. Use the numeric keypad to enter a new value for slew rate. Press **[ENTER]** to confirm. Entering values larger than the DPC can maintain results in the DPC running at its maximum slew rate.
4. Press **[PREV.]** to exit the menu. Press **[CANCEL]** to return all edited fields to their original values.

#### 4.3.4 STEPPING AND JOGGING

In addition to entering a new value, the pressure setpoint **may** also be changed by user-definable steps and by jogging small amounts. From the **Main Menu** (press **[PREV.]** until the Main Menu appears), press **Step<sup>↑</sup> - [F4]** to add the step amount to the current setpoint. Press **[ENTER]** to confirm the setpoint change. In the same way, use **Step<sup>↓</sup> - [F5]** to subtract the step amount from the current setpoint. The up and down arrow keys may be used to jog the pressure. Each key press increments or decrements the pressure in the least significant digit. If the up or down arrow

key is held down, the pressure will continue to change until the key is released. The jog increment is fixed, but the step amount may be changed.

1. The step amount is set from the **Setup User Menu**. From the **Main Menu** (press [PREV.] until the Main Menu appears), press **Menu [F6]**, then **Setup [F2]**, and then **User [F1]**.
2. Press the up or down arrows to highlight the Step Size parameter.
3. Use the numeric keypad to enter a new value. Press [ENTER] to confirm.
4. Press [PREV.] to exit the menu. Press [CANCEL] to return all edited fields to their original values.

## 4.4 PROGRAMMING SEQUENCES

### 4.4.1 STORING A SEQUENCE IN MEMORY

Consider an exercise that requires the DPC to start at 30 psi, increase to 50 psi, then return to 20 psi. Test sequences like this may be stored in the DPC's memory as a *program*.

One benefit of storing a sequence in memory is that the user does not have to command each pressure separately every time a multipoint test or calibration routine is performed. Another benefit is that the user can specify a tolerance for each setpoint pressure. Once a tolerance is set, the dwell timer will start counting down instead of waiting until the pressure is at the exact setpoint to start the dwell timer. This gives the user a time advantage compared to manual mode operation and provides a degree of automation without the use of a computer.

*The DPC can store up to 1,000 program steps that may be unevenly divided among a maximum of 20 named programs. Additional programs can be stored on memory cards (see Section 4.6).*

### 4.4.2 PREPARING TO PROGRAM

Before entering a test sequence, consider the items discussed below.

**Program Name:** Valid program names range from one to eight characters in length and can include numbers, upper case letters, and the /, %, and # symbols. For example, **Exer#14** and **%FStest** are both valid names.

**Configuration:** Since a program will depend on the current setup of the DPC (the current configuration is stored with the program) the user should set the units, limits, control parameters, etc., to the desired values before creating a program.

**Number of Setpoints:** Before entering the sequence, the user should determine the number of upscale **and** downscale setpoints required to complete the exercise.

**Setpoint Pressure and Tolerance:** Each setpoint in the program requires both a **pressure** and a **tolerance**, in the current units of measure. For example, one setpoint might require a tolerance as low as 0.05 psi, whereas another setpoint in the same program could be satisfied with a tolerance as high as 5 psi.

**Dwell Time:** Once the pressure is within the specified tolerance, the DPC starts a timer that runs for a user-defined number of seconds. This is referred to as **dwell time**. As long as this timer is running, the DPC will not continue to the next setpoint unless the **max time** (see below) elapses. When the **dwell time** expires, the DPC will proceed to the next step. Typically the **dwell time** should be set to a value less than the **max time**.

Usually **dwell time** has a value of a few seconds, but a value of 0 can be used to create a **pause** in the program. When the **dwell time** is set to zero, the DPC switches to manual control once it is within the tolerance value of the setpoint pressure. The user must then press a key on the front

panel to continue the program (refer to paragraph 5 of section 4.4.8; function key [F4] is CONTInue).

**MaxTime:** The *max time* is the maximum time in seconds, including the *dwel time*, that the DPC can spend on one step of the program. After the *max time* elapses, the DPC will automatically proceed to the next setpoint in the program, even if the current setpoint has not been achieved. Thus, the *max time* selection limits the amount of time that the DPC can spend on any one setpoint. Typically the *max time* should be set to a value greater than the *dwel time*. If the *max time* is set to zero, the DPC will attempt to achieve the setpoint indefinitely (e.g. the *max time* function is disabled).

**Mode of Entry:** If the upscale portion of the sequence *and* the downscale portion of the sequence both have the same highest and lowest setpoints *and* consist of evenly spaced steps, the <Auto> option can be used to automatically generate the program. However, if any part of the sequence includes unevenly spaced steps, or the starting and ending setpoints are not the same, each step must be programmed individually. In the example given at the beginning of Section 4.4.3, each step must be programmed individually since the starting setpoint is 30 psi and the ending setpoint is 20 psi.

Detailed instructions for entering these items are given in the sections that follow.

#### 4.4.3 ENTERING A NEW PROGRAM

To program the DPC, use the keys on the front panel to change values on the DPC's program editing screen. Instructions for entering each step of a new program are included below.

1. Ensure that the units, limits, and control parameters have been set to the desired values.
2. The program is entered from the **Program Menu**. From the **Main Menu** (press [PREV.] until the Main Menu appears), press **Menu [F6]**, then **Program [F4]**.
3. Use the arrow keys to highlight "new."
4. Press **Edit [F4]**. Since "new" was highlighted, the DPC will create a new program and give a default name of NAMEnn, where nn is a two digit number. The program editing screen will appear, displaying the first step.
5. Using the numeric keypad, enter the values for **Pressure**, **Tolerance**, **Dwell time**, and **Max time**, pressing [ENTER] after each value. The up and down arrow keys may be used to skip fields.
6. Press **Next [F1]** to move to the next step.
7. Repeat steps 5 and 6 until the test sequence is complete. The **Tolerance**, **Dwell time** and **Max time** will default to the value programmed in the first program step, and only need to be changed if a different value is desired for a particular step.
8. When all steps have been entered, press [PREV.] to return to the **Named programs** screen. See Section 4.4.5 for creating a user-defined program name.

#### 4.4.4 AUTOMATICALLY GENERATING A PROGRAM

For the DPC to automatically generate a program, the user must input the first setpoint pressure, the last setpoint pressure, and the number of steps in between, as well as the dwell time, max time and tolerance common to all setpoints.

1. Ensure that the units, limits, and control parameters are set to their desired values.
2. The program is entered from the **Program Menu**. From the **Main Menu** (press [PREV.] until the Main Menu appears), press **Menu [F6]**, then **Program [F4]**.
3. Use the arrow keys to highlight "new." If these steps are used on an existing program, all program steps will be deleted and replaced with the automatically generated program.

4. Press **Edit [F4]**. Since “new” was highlighted, the DPC will create a new program and give a default name of NAMEnn where nn is a two digit number. The program editing screen will appear, displaying the first step.
5. Press **Auto [F3]**.
6. Using the numeric keypad, enter the values for **Start, Stop, Tolerance, Dwell time, Max time, Points up,** and **Points down,** pressing **[ENTER]** after each value. The up and down arrow keys may be used to skip fields.
7. Press **Program [F1]**. The program will be generated and the display will show the first step.
8. Press **[PREV.]** to return to the **Named programs** screen. See Section 4.4.5 for creating a user-defined program name.

#### 4.4.5 CHANGING THE NAME OF A PROGRAM

1. The name of an existing program is changed from the **Program Menu**. From the **Main Menu** (press **[PREV.]** until the Main Menu appears), press **Menu [F6]**, then **Program [F4]**. At this point, a new program may be initiated by selecting “new” and performing the same steps as outlined to change the name of a program.
2. Use the arrow keys to highlight the current name. (For a new program name, select “new.”)
3. Press **Edit [F4]**. The program editing screen will appear, displaying the first step.
4. Press **Name [F6]**.
5. Use the arrow keys to highlight a character from the character set.
6. Press **Add [F3]** to add the character to the scratchpad.
7. To correct a mistake, press **Clear [F4]** and return to step 5.
8. Repeat steps 5 and 6 until the name is complete.
9. Press **Enter [F5]** to store the contents of the scratchpad as the new name of the program.
10. Press **[PREV.]** twice to return to the **Named programs** screen.

#### 4.4.6 CHANGING AN EXISTING PROGRAM

Instructions for changing an existing sequence are given below. Both manually and automatically generated programs may be edited.

1. Programs are changed from the **Program Menu**. From the **Main Menu** (press **[PREV.]** until the Main Menu appears), press **Menu [F6]**, then **Program [F4]**.
2. Use the arrow keys to highlight the name of the program.
3. Press **Edit [F4]**. The program editing screen will appear, displaying the first step.
4. The **Next [F1]** and **Prev [F2]** keys may be used to move through the program. To go directly to a specific step, use the arrow keys to highlight “go to step” at the bottom of the program step list. Then use the numeric keypad to enter the step number and press **[ENTER]**.





**NOTE:** **Next [F1]** will actually display one step past the end of the program (step 6 of 5). This is to allow adding a step to the end of a program. The step does not actually exist until **[ENTER]** is pressed.

5. To add a step to the program, first move to the step *after* the new step. For example, to insert a step between steps 3 and 4, move to step 4. Press **Insert [F4]**.
6. To delete a step in the program, first move to the step to be deleted, then press **Delete [F5]**.
7. To change a step in the program, move to the desired step. Use the up and down arrow keys to highlight the field to be changed. Use the numeric keypad to enter the new value. Press **[ENTER]** to save the value.
8. When all changes have been made, press **[PREV.]** to return to the **Named programs** screen.

#### 4.4.7 CHANGING THE CONFIGURATION STORED WITH A PROGRAM

1. Programs are configured from the **Program Menu**. From the **Main Menu** (press **[PREV.]** until the Main Menu appears), press **Menu [F6]**, then **Program [F4]**.
2. Use the arrow keys to highlight the name of the program.
3. Press **Config [F3]**. The configuration screen will appear.
4. Press **Recall [F2]**. The DPC will be set to the configuration stored with the program.
5. Press **[PREV.]** until the Main Menu appears.
6. Press **Setup [F2]**, then **Limits [F1]**. Change the desired parameters using the normal procedures. (Refer to section 4.2.4.)
7. Return to the Main Menu by pressing **[PREV.]** three times.
8. Press **Menu [F6]**, then **Program [F4]**.
9. Use the arrow keys to highlight the name of the program.
10. Press **Config [F3]**, then **Save [F1]**. The configuration of the DPC will be changed to the current settings and stored in the program's configuration.

#### 4.4.8 RUNNING A PROGRAM

1. Programs are run from the **Program Menu**. From the **Main Menu** (press **[PREV.]** until the Main Menu appears), press **Menu [F6]**, then **Program [F4]**.
2. Use the arrow keys to highlight the name of the program.
3. Press **Run [F1]**. The program run screen will appear. "Stop" will be highlighted, showing that the program is not currently running.
4. Press **Run [F2]**. The configuration of the DPC stored with the program is restored, the pressure setpoint is set to the pressure value in the first step, and the DPC is placed in Control mode. "Run" will now be highlighted and the program will proceed through its steps.
5. To pause the program, press **Pause [F3]**. "Pause" will now be highlighted and the DPC will continue controlling to the current setpoint. The DPC will maintain control of the current setpoint until further instructions from the operator. Press **Cont [F4]** to resume the program.
6. To stop the program, press **Stop [F5]**. The program will stop running but the DPC will continue controlling to the current setpoint.

#### 4.4.9 SWEEP TEST

The sweep function can be utilized to automatically exercise the elastic sensing element of the device under test prior to performing a calibration. For the DPC to perform the sweep test, the user must input the first and last setpoint pressure, the pressure control tolerance, the dwell time at setpoint, and the number of cycles to perform.

1. Ensure that the units, limits, and control parameters are set to their desired values.
2. The sweep test is entered from the Sweep Test Menu. From the Main Menu, (press **[PREV.]** until the Main Menu appears), press **Menu [F6]**, then **Test [F5]**, and then **Sweep [F5]**.
3. Enter the first and second pressure points, the control tolerance, dwell time, and the number of cycles.
4. Press **Run [F2]** to initiate the test.
5. To pause the program, press **Pause [F3]**. Pause will now be highlighted and the DPC will continue controlling to the current setpoint. The DPC will maintain control of the current setpoint until further instructions from the operator. Press **Cont [F4]** to resume the program.
6. To stop the program, press **Stop [F5]**. The program will stop running but the DPC will continue controlling to the current setpoint.

### 4.5 CONFIGURATION

#### 4.5.1 CALIBRATION PASSWORD

The calibration password allows the operator to protect access to DPC calibration constants and the calibration procedure. If the calibration password is set to any number other than zero, it is *required* before the user is allowed to calibrate the DPC or manually change the calibration constants.

**IMPORTANT:** Document the calibration password, as it is not retrievable from the DPC.

1. The calibration password is set from the **Calibration Menu**. From the **Main Menu** (press **[PREV.]** until the Main Menu appears), press **Menu [F6]**, then **Cal. [F3]**.
2. Press the recessed **CAL.** button on the front panel.
3. Use the up and down arrow keys to highlight "Access."
4. Use the numeric keypad to enter the new calibration password. Setting the calibration password to zero allows free access to DPC calibration and constants. Press **[ENTER]**.
5. Press **Yes [F4]** to acknowledge changing the calibration password. Press **No [F5]** to reject changing the calibration password.

#### 4.5.2 TEST ACCESS PASSWORD

The test access password allows the operator to protect access to DPC configuration and programs. If the test access password is set to any number other than zero (factory default), it is *required* before the user is allowed to change the limits, control parameters or programs.

**IMPORTANT:** Document the test access password, as it is not retrievable from the DPC.

1. The test access password is set from the **Limits Menu**. From the **Main Menu** (press [PREV.] until the Main Menu appears), press **Menu [F6]**, then **Setup [F2]**, and then **Limits [F1]**.
2. Use the up and down arrow keys to highlight "Access."
3. Use the numeric keypad to enter the new access password. Setting the test access password to zero (factory default) allows free access to DPC configuration and programs. Press [ENTER].
4. Press **Yes [F4]** to acknowledge changing the access password. Press **No [F5]** to reject changing the access password.

#### 4.5.3 BAR GRAPH MAXIMUM

The bar graph on the Main Menu screen can be scaled to match the device under test by setting the full scale value of the bar graph.

1. The bar graph maximum is set from the **Setup User Menu**. From the **Main Menu** (press [PREV.] until the Main Menu appears), press **Menu [F6]**, then **Setup [F2]**, and then **User [F2]**.
2. Use the up and down arrow keys to highlight "Bargraph Max."
3. Use the numeric keypad to enter the bar graph maximum value in the current pressure units.
4. Press [ENTER].

#### 4.5.4 KEY CLICK

The DPC can be configured to click each time a key is pressed.

1. The key click is set from the Setup User Menu. From the Main Menu (press [PREV.] until the Main Menu appears), press **Menu [F6]**, then **Setup [F2]**, and then **User [F2]**.
2. Use the up and down arrow keys to highlight "Key click."
3. Use the left and right arrow keys to select **on** or **off**.

#### 4.5.5 DATE/TIME

The DPC's system clock is continuously updated, even through power off and on.

1. The date and time are set from the **Setup System Menu**. From the **Main Menu** (press [PREV.] until the Main Menu appears), press **Menu [F6]**, then **Setup [F2]**, and then **System [F5]**.
2. To set the system date, press **Date [F1]**. Use the numeric keypad to enter the current month, date, and four-digit year (*mmdyyy*). All digits must be entered. Press [ENTER] to accept.
3. To set the system time, press **Time [F2]**. Use the numeric keypad to enter the current hour, minute, and second (*hhmmss*). All digits must be entered. Press [ENTER] to accept.

#### 4.5.6 FAN OPERATION

The 7010 was designed to operate without a fan. However, in some applications where multiple systems are housed in consoles without adequate ventilation, the system may generate Oven Control Failure Error codes. If this occurs, the internal fan can be turned on by the operator. Once the operator has commanded the instrument to turn on the fan, it will remain on even if the system is rebooted until it is commanded to turn off.

To turn the fan on or off, press **Menu [F6]** from the **Main Menu**, then **Test [F5]**, then **Shop1 [F5]**.

In the upper right portion of the display the numbers 1-9 are listed, each representing a solenoid driver. Under each number the solenoid status is displayed, "C" for closed and "O" for open.

Press the right arrow key until the number "9" is highlighted. This is the fan solenoid driver. Press **Open [F5]** to turn the fan on, the **Close [F6]** to turn the fan off.

## 4.6 MEMORY CARD

The DPC supports the use of a PCMCIA memory card to store setup, calibration, and program information. This provides the ability to save the current setup of the system for later restoration or loading into another DPC. The calibration information is specific to the device and can only be loaded into the DPC from which it was saved. The memory card also allows for future software/firmware upgrades in the field.

### 4.6.1 CARD SUPPORT

The DPC supports static RAM cards conforming to PCMCIA Type I specification.

### 4.6.2 SAVING/RESTORING SETUP INFORMATION

To save the setup information to the memory card, follow the procedure given below.

1. Setup information is stored from the **Setup Systems Menu**. From the **Main Menu** (press **[PREV.]** until the Main Menu appears), press **Menu [F6]** then **Setup [F5]** and then **System [F2]**.
2. Press **Save [F6]**. The saved information includes the parameter entries from **MENU/SETUP/LIMITS**, **MENU/SETUP/USER**, **MENU/SETUP/UNITS**, and **MENU/SETUP/REMOTE**.
3. To restore information from the memory card, press **Menu [F6]**, then **Setup [F5]**, then **System [F2]**, and finally **Load [F5]**.

### 4.6.3 SAVING/RESTORING CALIBRATION INFORMATION

Saving and restoring calibration information requires entry into Calibration mode.

1. Enter the Calibration mode by first pressing **MENU [F6]** and then **Cal [F5]**.
2. Press the recessed **CAL.** button on the front panel. Pressing the **CAL.** button enables the additional keys. If the calibration access code is enabled, enter it at the prompt.
3. Press **Save [F6]** to save the calibration data or **Load [F5]** to restore the calibration data. Calibration data may only be restored to the same DPC that saved it.

### 4.6.4 SAVING/RESTORING PROGRAMS FROM PCMCIA MEMORY CARD

Programs are saved and restored (loaded) individually by name.

Programs are saved from the **Menu/Program** screen.

1. From the **Main Menu** (press **[PREV.]** until the Main Menu appears), press **Menu [F6]**, then **Program [F4]**. Use the arrow keys to highlight the program to be saved.
2. Press **Save [F6]** to write the program to the memory card. Repeat for all programs desired. If a program with the same name already exists on the memory card, it is overwritten.

Programs from the memory card are loaded from the **Menu/Program/Load** screen.

1. From the **Main Menu** (press **[PREV.]** until the Main Menu appears), press **Menu [F6]**, then **Program [F4]**, and then **Load [F5]**. The screen will display all programs on the memory card.
2. Use the arrow keys to highlight the program to be loaded and press **[F1]**. The program will be copied from the memory card into the DPC. If a program with the same name already exists in the DPC, it is overwritten.

3. To erase a program from the card, use the arrow keys to highlight the program to be deleted and press **Delete [F2]**.

## **SECTION 5.0 REMOTE OPERATION**

The DPC can be operated remotely by a computer. Three interfaces are supported: IEEE-488, RS-232, RS-485. All three interfaces support SCPI (Standard Commands for Programmable Instruments). The IEEE-488 interface additionally supports emulation of a Ruska Single Channel Interface Panel (Models 6005-701 and 6005-761). The IEEE-488 interface conforms to the following standards.

ANSI/IEEE Std 488.1-1987	IEEE Standard Digital Interface for Programmable Instrumentation
ANSI/IEEE Std 488.2-1987	IEEE Standard Codes, Formats, Protocols, and Common Commands
SCPI 1991.0	Standard Commands for Programmable Instruments

### **5.1 CAPABILITIES**

#### **5.1.1 IEEE-488**

The following identification codes define the interface capabilities of the DPC. Their meaning is described in the IEEE-488 standard.

SH1	Source Handshake, Complete Capability
AH1	Acceptor Handshake, Complete Capability
T5	Talker
L3	Listener
SR1	Service Request, Complete Capability
RL1	Remote-Local, Complete Capability
PP0	Parallel Poll, No Capability
DC1	Device Clear, Complete Capability
DT0	Device Trigger, No Capability
C0	Controller, No Capability

The optional IEEE-488 interface is installed next to the processor board. The interface is identified by the IEEE-488 standard connector on the back panel of the unit.

**NOTE:** Do not change any jumpers or switch settings on the IEEE-488 interface board. The IEEE-488 address is set by the MENU/SETUP/REMOTE screen.

#### **5.1.2 RS-232**

The RS-232 interface supports standard serial operation from a computer to a single DPC. RS-232 supports the IEEE-488.2 and SCPI commands. The DPC allows the following port setups:

Baud Rate:	1200, 2400, 9600, or 19200
Data Bits:	7 or 8
Parity:	Even, Odd, or None
Stop Bits	1 or 2
Handshaking	XON/XOFF

The RS-232 connection is a DB-9P connector found on the back panel of the DPC. It is located on the processor board directly above the DB-25S connector. The following pins are used; all other pins are reserved.

Pin #	Direction	Signal	
2	In	RXD	Receive Data
3	Out	TXD	Transmit Data
5	--	GND	Ground
7	Out	RTS	Request to Send

## 5.2 REMOTE/LOCAL OPERATION

In Local mode, the DPC is operated manually through the front panel. Section 4.0 covers local operation. The DPC always powers up in the Local mode. In Remote mode, the DPC is operated by a computer connected to an interface. Most functions that can be performed in Local mode can also be performed remotely.

Remote mode does not automatically disable local operation. The remote interface may be active while local operations are being done. In cases where full remote control is required, the following methods may be used.

1. Issue a Local Lockout (LLO) interface message via the IEEE-488 interface. The DPC will disable the local keyboard until the Go TO Local (GTL) interface message is received or the REN (Remote Enable) line is unasserted. This method cannot be used on the serial interface.
2. Issue the SCPI command "SYSTEM:KLOCK ON" to lock the local keyboard. The DPC will disable the local keyboard until the command "SYSTEM:KLOCK OFF" is received.
3. Issue the SCPI command "DISPLAY:ENABLE OFF" or "DISPLAY:TEXT <string>." These commands will disable the local display in addition to locking the keyboard. The command "DISPLAY:ENABLE ON" will restore the local display and keyboard operation.

Local operation may also be restored by powering the DPC off and back on.

## 5.3 CONFIGURATION

The remote interface must be configured before it is connected. The remote interface is configured using the local interface. The parameters needed vary with the interface used.

IEEE-488	Address, Protocol
RS-232	Baud Rate, Data Bits, Parity, Stop Bits
RS-485	Address, Baud Rate, Data Bits, Parity, Stop Bits

To configure the remote interface follow these steps:

1. The remote interface is configured from the **Setup Remote Menu**. From the **Main Menu** (press **[PREV.]** until the Main Menu appears) press **Menu [F6]**, then **Setup [F2]**, and then **Remote [F4]**.
2. Use the up and down arrows to highlight the desired parameter.
3. Use the numeric keypad to enter the address, use the left and right arrows to change the other parameters. The **[ENTER]** key must be pressed after entering the address.
4. Repeat steps 2 and 3 to set all parameters needed.

## 5.4 DEVICE MESSAGES

### 5.4.1 SCPI COMMAND FORMAT

SCPI mnemonics have two forms: long and short. The short form is all in capital letters. The long form is the entire mnemonic. Commands may use either the short form or the entire long form. No other forms are accepted. SCPI ignores case: uppercase and lowercase are equivalent.

A SCPI command is made by following the command tree as presented in the command summary. Each level adds a mnemonic to the command separated by colons (:). Mnemonics enclosed in square brackets are optional and may be omitted.

Some mnemonics are followed by an optional numeric suffix. If omitted the suffix defaults to 1.

Multiple commands may be placed in a single message separated by semicolons (;). Each command starts at the same level of tree where the last command stopped, unless the command starts with a colon. The first command in a message and any commands starting with a colon start at the root of the command tree. IEEE 488.2 commands may occur between SCPI commands without affecting the tree level.

Command parameters are separated from the command name by one or more spaces. Multiple parameters are separated by commas (.). SCPI accepts numeric parameters with optional sign, decimal point, and exponent. OFF is equivalent to zero and ON is equivalent to one. Floating point numbers are rounded to the nearest integer for commands accepting integer values only.

A message is terminated by a Line Feed (hexadecimal 0A). Carriage returns, tabs, and other control characters are ignored.

### 5.4.2 SCPI RESPONSE FORMAT

Only commands ending in a question mark (?) have responses. Multiple values from a single command are separated by commas. Responses from different commands in the same message are separated by semicolons (;). The response message is terminated by a line feed (hexadecimal 0A).

Integer responses are returned as one or more digits. Boolean values (ON and OFF values) are always returned as numbers, with zero for OFF and one for ON. Floating point values are returned in the format "+d.ddddddddE+dd".

### 5.4.3. ANSI/IEEE 488.2-1987 COMMAND SUMMARY

*CLS		Clear Status
*ESE?		Event Status Enable Query
*ESE	<number>	Event Status Enable
*ESR?		Event Status Register
*IDN?		Identification
*OPC?		Operation Complete Query (Returns 1)
*OPC		Operation Complete
*RST		Reset
*SRE?		Service Request Enable Query
*SRE	<number>	Service Request Enable
*STB?		Status Byte Query
*TST?		Self-Test Query
*WAI		Wait (No operation)



#### 5.4.4. SCPI COMMAND SUMMARY

The current value associated with a SCPI command may be read by appending a question mark to the command. For example CALC:LIM:UPP? will return the current upper pressure limit.

MEASure	
[:PRESsure]?	Returns Current Pressure Reading
:TEMPerature2?	Returns Oven Temperature
:PRESsure2?	Return Case Pressure
:TEMPerature?	Returns Gas Temperature
:VOLTage?	Returns -15V (volts)
:VOLTage2?	Returns +15V (volts)
:VOLTage3?	Returns +5V (volts)
:SLEW?	Returns Pressure Slew Rate (units/min)
CALCulate	
:LIMit	
:LOWer <number>	Get/Set Low Pressure Limit
:SLEW <number>	Get/Set Slew Rate Limit
:UPPer <number>	Get/Set High Pressure Limit
:VENT <number>	Get/Set Auto-Vent Limit
CALibration	
[:PRESsure]	
:DATA <n,n,n,n>	Sets C0, C1, C2, C3 for Pressure
:DATA?	Reads Coefficients
:DATA2 ,n,n,n>	Sets C4, C5, C6 for Vacuum Gauge
:DATA2? Reads Coefficients	
:VALue1 <number>	Perform Mid-Point Calibration
:VALue2 <number>	Perform Full Scale Calibration
:VALue3 <number>	Perform Vacuum Gauge Mid-Point Calibration
:VALue4 <number>	Perform Vacuum Gauge Full-Scale Calibration
:ZERO	
:VALUE <number>	Performs Zero Calibration
:INITiate	Sets Vacuum Value
:INITiate?	Enter Zero Calibration Mode
	Status for Cal, Pressure, Temp., Reference
	Cal: 0=Not Zeroing,
	1=Local Zero,
	2=Remote Zero
	Pressure, Temperature, Reference:
	-1=Out of Range
	0=Stable
	>0=Time until stable
:RUN	Start Zero Calibration
:STOP	Abort Zero Calibration
:TEMPerature	
:DATA <number>,<number>	Sets C0, C1 for Gas Temperature
:VALue <number>	Calibrates to Value
:PRESsure2	
:DATA <number>,<number>	Sets C0, C1 for Case Pressure
:VALue <number>	Sets First Calibration Point

:VALue2 <number>	Sets Second Calibration Point
:TEMPerature2	
:DATA <number>, <number>	Sets C0, C1 for Oven Temperature
:DATA?	Reads C0, C1
:VALue <number>	Calibrates to Value
:MODE?	Calibration Edit Enabled?
:MODE ON OFF 1 0	Enable Calibration Edit (Cal. Button Required)
DISP	
:ENABle ON OFF 1 0	Turns Front Panel Display On/Off
:TEXT <string>	Displays Message on Front Panel
:BGRaph <number>	Sets Bar Graph Maximum
OUTPut	
:STATe ON OFF 1 0	Off=MEASure, on=CONTRol
:STATe?	Returns 0=Measure or 1=Control
:MODE MEASure CONTRol VENT	Sets Mode
:MODE?	Returns Mode String
:SState<n> ON OFF 1 0	Set Opto-22 Module
PROGram	
:CATalog?	Returns List of Defined Programs
[SElected]	
:DEFine <program block>	Define Program Press1, Toler1, Dwell1, Max1, Press2, Toler2, ...
:DEFine?	Read Program Definition
:DELeTe	
[:SElected]	Deletes Current Program
:ALL	Deletes All Programs
:NAME <program name>	Select Current Program
:STATe RUN PAUSE STOP CONTInue	Set Program State
:STATe?	Read Program State
:CONFigure	
:RECall	Restore Saved Configuration
:SAVE	Save Current Configuration
SENSE	
[:PRESSure]	
[:RESolution] <number>	Set Pressure Display Resolution
:AUTO <boolean> ONCE	Return to Default Resolution
:MODE ABSolute DIFFerential GAGE	
:RANGE	
[:UPPer]	Returns DPC Full Scale Value in Units
:LOWer	Returns Lowest Calibrated Value
:REFerence	
[:HEIGHt] <number>	Set Gas Head Height
:MEDIum N2 AIR	Set Gas Medium
[SOURCE]	
[:PRESSure]	
[:LEVel]	
[:IMMediate]	

[:AMPLitude] <number>	Sets Pressure Setpoint
[:AMPLitude]?	Read Pressure Setpoint
:MODE FIXEd LIST	Set Source Parameter Set
:TOLerance <number>	Specifies Output Tolerance
:SLEW <number>	Set Slew Rate
:LIST	
:PRESSure <number> [,<number>]	Set List of Pressure Values
:POINTs?	Returns Number of Points Defined
:DWELL <number> [,<number>]	Specifies Dwell Times
:POINTs?	Returns Number of Dwell Times
:TOLerance <number> [,<number>]	Specifies Tolerances
:POINTs?	Returns Number of Tolerances
:DIRection UP DOWN	Direction To Go Through List
:COUNT <number>	Number of Times To Go Through List
:STATus	
:OPERation	
[:EVENT]?	Read/Clear Operation Event Register
:CONDition?	Read Operation Condition Register
:ENABle <number>	Set Operation Enable Mask
:QUESTionable	
[:EVENT]?	Read/Clear Questionable Event Register
:CONDition?	Read Questionable Condition Register
:ENABle <number>	Set Questionable Enable Mask
:PRESet	Reset Condition Flags
SYSTem	
:DATE <year>,<month>,<day>	Set System Date
:ERRor?	Returns <error#,"descr;info"> Or 0,"No Error"
:KLOCK ON OFF 1 0	Lock Keyboard
:TIME <hour>,<minute>,<second>	Set System Time
:VERSion?	Returns 1991.0
:LANGUage "6000" "SCPI"	Set Interface Protocol to 6000 or SCPI
:PRESet	Reset System
:TEST	
:ELECTronic?	Perform Electronic Self-Test
:PNEumatic	Start Pneumatic Self-Test
:PNEumatic?	Return Status of Pneumatic Self-Test
:LEAK                   Start Leak Test	
:LEAK?	Get Leak Rate
:VOLume	Start Volume Test
:VOLume?	Get Volume
:STOP	Abort Pneu, Volume, or Leak
:UNIT	
:DEFine<n> <name>,<number>	Define a Unit
:LENGth MM IN	Set Length Units for Head Height
[:PRESSure] <unit name>	Set Pressure Units
:TEMPerature C CEL F FAR K	Set Temperature Units

#### 5.4.5. EXAMPLE SCPI COMMANDS

To request the current pressure reading all of the following commands are equivalent:

```
:MEASURE:PRESSURE?  
:measure:pressure?  
:MeAsUrE:pReSsUrE?  
:meas:pres?  
:measure?  
:meas?  
MEAS?
```

To set the control pressure setpoint to 50 all of the following commands are equivalent:

```
SOURCE:PRESSURE:LEVEL:IMMEDIATE:AMPLITUDE 50  
SOUR:PRES:LEV:IMM:AMPL 50.0  
PRESSURE +50  
PRES 50
```

To zero the unit via the remote interface use the following sequence:

```
CAL:ZERO:INIT           Enter Zero Mode  
CAL:ZERO:INIT?         Read Status (Mode, Pressure, Temperature, Reference)  
                        and Wait Until Stable.  
CAL:ZERO:RUN           Start Zero Adjust Sequence  
STAT:OPER:COND?       Wait Until Complete (Bit 0 = 0)
```

#### 5.4.6. SCPI STATUS REGISTERS

Status Byte Register (STB), Service Request Enable Register (SRE)

Bit 7 Operation status summary. Set when an event enabled in OPER:ENABLE occurs  
Bit 6 Service request. SEt when an event enabled in SRE occurs. (This bit is not used in SRE.)  
Bit 5 EBS - Event status bit. Set when an event enabled in ESE occurs.  
Bit 4 MAV - Message available. Set when a response is ready to be sent.  
Bit 3 Questionable status summary. Set when an event enabled in QUES:ENABLE occurs.  
Bit 2 Error/event queue not empty.  
Bit 1 Reserved. 0.  
Bit 0 Reserved. 0.

Standard Event Status Register (ESR), Standard Event Status Enable Register (ESE)

Bit 7 Power-on. Set at power-up.  
Bit 6 Reserved. 0.  
Bit 5 Command error. Error in command syntax.  
Bit 4 Execution error. Error in command execution.  
Bit 3 Device dependent error. Device error independent of commands.  
Bit 2 Query error. Output queue empty when request received.  
Bit 1 Reserved. 0.  
Bit 0 Operation complete. Set for \*OPC command.

Operation Status (OPER:EVENT, OPER:CONDITION, OPER:ENABLE)

Bit 0 Calibrating. Currently performing a calibration.  
Bit 1 Settling. Control setpoint has not been reached.  
Bit 2 Reserved. 0.  
Bit 3 Reserved. 0.

- Bit 4 Measuring. The instrument is actively measuring.
- Bit 5 Reserved. 0.
- Bit 7 Reserved. 0.
- Bit 8 Self-test in progress.
- Bit 9 Volume/leak tst in progress.
- Bit 10 Reserved. 0.
- Bit 11 Reserved. 0.
- Bit 12 Reserved. 0.
- Bit 13 Reserved. 0.
- Bit 14 Program running.
- Bit 15 Reserved. 0.

Questionable Status (QUES:EVENT, QUES:CONDITION, QUES:ENABLE)

- Bit 0 Voltage Is Questionable. Set when supply voltages are not within 5%.
- Bit 1 Reserved. 0.
- Bit 2 Time Is Questionable. Set when the clock has not been set.
- Bit 3 Temperature is questionable. Set when the oven temperature is not within range.
- Bit 4 Reserved. 0.
- Bit 5 Reserved. 0.
- Bit 6 Reserved. 0.
- Bit 7 Calibration is questionable. Set when the unit has not been calibrated.
- Bit 8 pressure is questionable. Set when the pressure is overranged.
- Bit 9 Reserved. 0.
- Bit 10 Reserved. 0.
- Bit 11 Reserved. 0.
- Bit 12 Reserved. 0.
- Bit 13 Reserved. 0.
- Bit 14 Command warning. Set whenever a command ignores a parameter.
- Bit 15 Reserved. 0.

## 5.5 INTERFACE PANEL EMULATION

The DPC may be configured to emulate the IEEE-488 command set of the Ruska Single Channel Interface Panel (Models 6005-701 and 6005-761). See the Interface Panel User's Manual for a description of the protocol. The DPC emulation has the following differences:

1. The DPG is always in Remote mode (Byte 1, Bit 1).
2. All TI strip outputs must be written as OFF.
3. No special functions are implemented.
4. Any message written to the DPC that starts with a colon as the first character is interpreted as a SCPI command.

To change from SCPI to Interface Panel Emulation via the retmote interface, send the following message: :SYSTem:LANGUage "6000".

To change from Interface Panel Emulation to SCPI via the remote interface send the following message: :SYSTem:LANGUage "SCPI".

## 5.6 SERIAL OPERATION

The RS-232 port accepts the same SCPI commands as the IEEE-488 port. The commands can be terminated by a carriage return (hexadecimal 0D) or a line feed (hexadecimal 0A). The responses are always terminated by a carriage return followed by a line feed.

The serial port also supports XON/XOFF. When the XOFF (hexadecimal 13) command is received, the DPC will stop transmitting. Transmission is restarted when the XON (hexadecimal 11) command is received.

When only one unit is attached, the Control-C (hexadecimal 03) command will clear the transmit and receive buffers and disable addressing. When addressing is disabled, the unit will respond to commands without being addressed.

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# SECTION 6.0 MAINTENANCE

## 6.1 INTRODUCTION

Very little maintenance is normally required for the DPC. This section of the manual discusses suggested procedures.

## 6.2 OBSERVING THE SOFTWARE VERSION NUMBER

Follow the steps below to observe the DPC's software version number.

1. If necessary, press [PREV.] several times to return the display to the **Main Menu**.
2. Select **MENU/SETUP/SYSTEM**. The software version number will appear on the screen.
3. Press [PREV.] to return to the previous screen.

## 6.3 PREVENTIVE MAINTENANCE

Although the DPC is designed to be nearly maintenance free, occasional preventive maintenance is required to keep the DPC's performance optimal.

### 6.3.1 INITIATING THE DPC'S SELF TEST

To test the DPC's hardware, software, and pneumatics, follow the steps below.

1. If necessary, press [PREV.] several times to return the display to the **Main Menu**.
2. Select **MENU/TEST/SELF**. The electronics self test will run and display the results.
3. Press **Pneu [F2]** to run the pneumatic test.

**NOTE:** To run the pneumatic test, supply pressure and a closed test port volume must be connected to the DPC.



High pressure versions of the 7010 without the optional test isolation solenoid must have a closed volume of 5 to 15 cubic inches attached to the test port for proper operation of the pneumatic self test.

4. Press [PREV.] to return to the previous screen.

The electronics test runs eight sets of tests on various parts of the electronic modules. Table 6-1 describes these test and the possible actions needed if a test fails. The pneumatics test runs nine tests on the pneumatics module. Table 6-2 describes these tests and the possible actions needed if a test fails.



**TABLE 6-1  
ELECTRONICS SELF TEST**

<b>TEST</b>	<b>DESCRIPTION</b>	<b>ACTION ON FAILURE</b>	<b>RIC PART #</b>
Coprocessor	Tests the 80-287 math coprocessor chip	Replace chip. Replace processor board.	13-932 7000-286-16
Clock	Tests the real time clock	Replace processor board.	7000-286-16
Timer	Tests the 10 ms interval timer	Replace.	7000-PCA-001
EEPROM	Tests the nonvolatile memory	Replace.	7000-PCA-001
Oven	Tests operation of the sensor oven	Replace. Replace sensor assy. Allow oven to warm up.	7000-PCA-001
-15	Tests negative power supply <sup>1</sup>	Replace.	7000-PCA-001
+15	Tests positive power supply <sup>1</sup>	Replace.	7000-PCA-01
+5	Tests main logic power <sup>1</sup>	Replace power supply.	62-288

<sup>1</sup>See Figure 4-2 for viewing voltages.

**TABLE 6-2  
PNEUMATICS SELF TEST**

<b>TEST</b>	<b>DESCRIPTION</b>	<b>ACTION ON FAILURE</b>
Mode	Saves current state and changes to Measure mode.	No failure.
SV05	Open SV04, SV05 and SV06. Set servo valve to increase pressure. Verify that pressure increases.	1. Check for adequate supply pressure. 2. Ensure that a closed volume is connected to the test port. 3. Ensure that the servo valve connector is fully seated. 4. Replace pneumatics module.
SV06	Set servo valve to decrease pressure. Verify that pressure decreases.	1. Check that the vacuum supply is free from obstructions and is connected to a vacuum pump. 2. Ensure that the servo valve connector is fully seated. 3. Replace pneumatics module.
SV02	Close SV04, SV05, SV06. Open SV02. Verify that pressure moves toward atmospheric pressure.	1. Check that the vent port is free from obstructions. 2. Ensure that the DPC is in the correct mode: Absolute, Differential, or Gauge for the pressure on the reference port. 3. Replace pneumatics module.
SV03	Close SV02. Open SV03. Verify that pressure moves toward zero.	Replace pneumatics module.
Oven Temp	Verify that oven temperature is within 5% of setpoint.	1. Verify that the DPC has been powered up for at least three hours. 2. Verify that the ambient temperature is within the operating range. 3. Call factory.

### 6.3.2 REMOVING THE DPC'S COVER

The DPC should be kept clean and completely assembled at all times. Operating the DPC without its cover affects the DPC's thermal gradients and therefore reduces precision. If it becomes necessary to remove the DPC's cover, follow the instructions below.

**CAUTION:** The DPC should only be opened by qualified electrical/mechanical service technicians. Lethal voltages are present and exposed in the power supply and display.

1. Turn off the DPC and disconnect the power cord from the DPC.
2. Locate and unscrew the two screws that secure the cover to the back panel.
3. Place your hands near the middle of the cover and slide the cover towards the DPC's back panel.
4. Lift up on the cover. With the cover removed, use typical electronic cleaning tools to remove any accumulated dust from inside the instrument.
5. Replace the cover before resuming operation.

### 6.3.3 MOISTURE FILTER

The Bourdon tube sensor is hygroscopic. An external desiccant filter prevents introduction of moisture and is strongly recommended for high humidity areas. RIC #24-631 is suggested. The filter should be replaced annually. The moisture filter is used with the reference port only.

### 6.3.4 PARTICLE FILTERS

The DPC's pneumatics module (Section 2.0) contains a particle filter. Proper use is essential. Refer to Appendix A for air supply quality requirements. During normal operation, the DPC transfers gas both into and out of the device under test (DUT). When necessary, the user is expected to use and maintain an inline disposable particle filter to protect the DPC's pneumatics from any contamination that may exist in the DUT.

### 6.3.5 VACUUM PUMPS

Periodic checks of the user's vacuum pumps for oil levels and the correct operation of power-down vacuum venting valves are recommended to ensure minimal chances of external oil contamination from the vacuum sources. Periodic changing of vacuum pump oil as recommended by the vacuum pump manufacturer should also be done.

### 6.3.6 PROCESSOR BATTERY

The processor board uses a lithium battery to maintain time and date information. This battery has a varying life. If the instrument is left on 24 hours a day, it may last 5 to 10 years. If the instrument is stored, it may only last one year. Annual replacement is recommended. To replace the battery:

1. Turn off power and remove the instrument cover. (See Section 6.3.2).
2. Remove the processor card by removing one screw and gently rocking the card upward.
3. Holding the processor card, remove the battery (the round silver object), by carefully pulling on the battery.
4. Plug in a new battery (RIC #4-720).
5. Reinstall the processor card and the screw. Replace the instrument cover.
6. The time and date may have to be re-entered. See Section 4.5.6.

## 6.4 CALIBRATION

To keep the DPC operating within its specified precision, the calibration procedure described below should be performed every 180 days. After gaining history for specific DPCs, they may be calibrated once a year. If a higher level of overall performance is desired, the user can calibrate more frequently.

**NOTE:** The calibration procedure automatically generates coefficients that are stored in memory on the DPC's Control Board (Section 2.3.1). If these constants are "lost" for any reason, the calibration procedure must be performed, regardless of the last calibration date. If the calibration coefficients have been recorded, they may be restored to the DPC at any time by "editing the coefficients" (Section 6.4.3).

### 6.4.1 CALIBRATION INSTRUCTIONS

To calibrate the DPC, the user connects a calibration standard such as the Ruska Instrument Model 2465 Gas Piston Gauge to the DPC's test port, then follows the three-step calibration procedure on the DPC's display. This procedure requires the user to control the calibration standard to 50% and 100% of the DPC's full scale rating (Section 3.4.1). The standard DPC requires a positive pressure calibration. A vacuum gauge option is available and requires special calibration per Section 6.4.2. No disassembly is required and there are no potentiometers to tune.

**NOTE:** The uncertainty of the final calibration must include the uncertainty of the pressure standard being used.

#### 6.4.1.1 PREPARATION

1. Verify that the DPC's Reference Port is open to atmosphere for gauge calibrations.
2. Verify that the calibration standard is connected to the Test Port.
3. Verify that the DPC has been at stable environmental temperature and that the oven temperature (**MENU/DISPLAY**) has been stable for *at least* two hours.
4. Verify that the DPC is in Measure mode (Section 4.0).
5. If desired, change the DPC's units of measure (Section 4.0) to match those of the calibration standard.
6. To go to the calibration screen, select **MENU/CAL**.
7. To begin the calibration process, press the recessed calibration button beneath the vacuum fluorescent display. If the calibration access code is enabled, enter it at the prompt. The first calibration screen will appear.

**NOTE:** To exit the calibration procedure before the calibration coefficients have been changed, press [CANCEL] any time during the procedure. Canceling restores all previous calibration values.

#### Step 1

- 1.1 To begin step 1 of the calibration process, select **Zero [F1]**. The zero procedure will start when the reading is in-range and stable or when **OK [F6]** is pressed. Press **OK [F6]** only if the zeroing conditions are stable. The zero calibration will not be accurate if **OK [F6]** is pressed when conditions are unstable.

- 1.2 Wait until the zero procedure finishes. This may take several minutes. When the DPC completes step 1, the calibration screen will appear.



On High Pressure Models, pressure must be removed from the test port. If zeroing in Absolute mode, then the Test Port must be isolated.

#### Step 2

- 2.1 To begin step 2, use the calibration standard to apply the 50% full scale +/- 5% of full scale pressure requested by the DPC. As pressure is admitted into the Test Port, the measured pressure on the DPC's screen will change accordingly.
- 2.2 When the measured pressure stabilizes, use the DPC's numeric keypad to enter the actual pressure applied by the calibration standard and then press **OK[F6]**. *Do not enter the measured pressure reported by the DPC.* If necessary, use the **[CLEAR]** key to correct a mistake in the edit field. If the *actual pressure applied* is within the indicated tolerance, the third calibration screen will appear.

**NOTE:** If the actual pressure is outside of the tolerance for the requested mid-point pressure, *Error --222 Data out of range* will occur. Acknowledge this error by selecting **OK [F6]**, then re-enter the **actual pressure**, repeating Step 2.1 if necessary.

#### Step 3

- 3.1 To begin step 3, use the calibration standard to apply the 100% full scale +/- 5% of full scale pressure requested by the DPC. As pressure is admitted into the Test Port, the measured pressure on the DPC's screen will change accordingly.
- 3.2 When the measured pressure stabilizes, use the DPC's numeric keypad and **OK [F6]** to enter the *actual pressure* reported by the calibration standard. *Do not enter the measured pressure reported by the DPC.* If necessary, use the **[CLEAR]** key to correct a mistake in the edit field. If the *actual pressure applied* is within the indicated tolerance, the calibration complete screen will appear.

**NOTE:** If the **actual pressure applied** is outside of the tolerance for the requested highpoint pressure, *Error --222 Data out of range* will occur. Acknowledge this error by selecting **OK [F6]**, then re-enter the actual pressure, repeating Step 3.1 if necessary.

#### 6.4.1.2 STORING THE COEFFICIENTS

**NOTE:** In addition to saving the calibration coefficients to the DPC's memory, the user is advised to separately record the calibration coefficients and store this "backup" in a safe place.

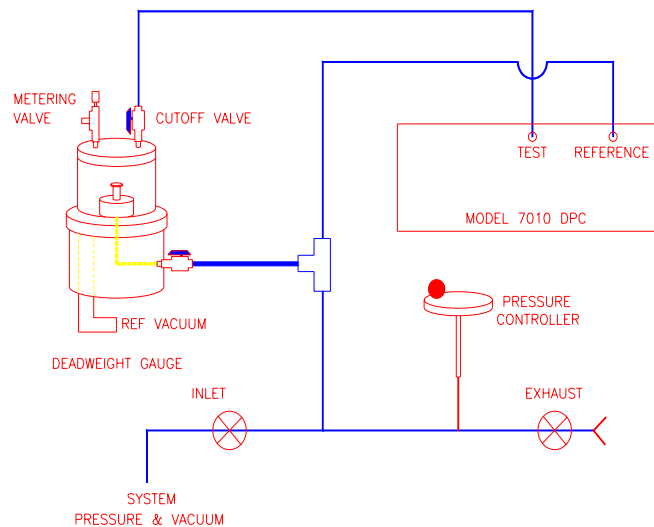
Step 4 Calibration is complete. To exist the calibration procedure without storing the calibration coefficients in memory, press [CANCEL]. To store the calibration coefficients in memory, select OK [F6].

Step 5 Press [PREV.] to return to the Main Menu.

Once the calibration procedure is complete, the user should verify several pressure readings against the pressure standard. If there are variances beyond the stated precision, then an error was probably made in generating one of the calibration pressures, and the calibration procedure should be repeated.

#### 6.4.2 VACUUM (NEGATIVE GAUGE) CALIBRATIONS

Vacuum mode is an available option. The following configuration should be used when calibrating in the Vacuum mode.



**FIGURE 6-4  
VACUUM CALIBRATION**

To calibrate in Vacuum mode with the configuration shown in Figure 6.4, the following actions should be taken. The system pressure and vacuum inlet valve should remain closed. The bottom side of the piston must be open to atmosphere and connected to the reference port of the DUT. The test port of the DUT must be connected to the bell jar with a cutoff valve in line to isolate the Bourdon tube from the bell jar vacuum when drawing a hard vacuum to seal the bell jar and float the masses. Once the masses have risen in response to evacuation of the bell jar, close the reference vacuum cutoff valve and use the metering valve on the bell jar to adjust the atmosphere until the masses begin to sink. When the masses are floating, open the bell jar cutoff valve to the

test port, close the exhaust valve, and use the pressure controller handwheel to adjust float position.

### 6.4.3 EDITING THE CALIBRATION COEFFICIENTS

If the DPC's memory is erased but the calibration coefficients are known, the user can restore the coefficients to the DPC by following the directions below.

**CAUTION:** Never randomly adjust the calibration coefficients. Only qualified personnel with valid backup data should be allowed to edit the coefficients. If the backup coefficients are questionable, perform the calibration procedure in its entirety.

1. Verify that the DPC is in Measure mode (Section 4.0).
2. Enter the calibration screen by selecting **MENU/CAL**.
3. To edit the calibration coefficients, press the recessed **CAL** button beneath the vacuum fluorescent display. If the calibration access code is enabled, enter it at the prompt. The first calibration screen will appear.

**NOTE:** To exit the calibration procedure before the calibration coefficients have been changed, press **[CANCEL]** any time during the procedure. Canceling restores all previous calibration values.

4. Use the up and down arrow keys to highlight **C0:**, **C1:**, **C2:**, or **C3:**. The terms are coefficients of a linear regression analysis.
5. Use the numeric keypad and the **[ENTER]** key to enter a new value. To correct a mistake in the edit field, use the **[CLEAR]** key.
6. Repeat steps 4 and 5 until all four coefficients are correct.

**NOTE:** In addition to saving the calibration coefficients to the DPC's memory, separately record the calibration coefficients and store this "backup" in a safe place.

7. To exit the editing procedure without storing the calibration coefficients in memory, press **[CANCEL]**. To store the calibration coefficients in memory, select **OK [F6]**.
8. Press **[PREV.]** to return to the Main Menu.

Once the calibration coefficients are input, the user should record several pressure readings. If there are any variances beyond the stated precision at these points, then the calibration procedure should be performed.

### 6.4.4 ZEROING

The zeroing procedure is performed to correct for system zero shift and does not require a full calibration. The most important requirement for performing a valid zeroing procedure is to guarantee that there is not a pressure differential between the sensor's test port and case reference.

If during the zeroing procedure, the message "Mechanical Zeroing Needed" appears, the sensor photocell may need to be zeroed. See Section 6.5 for more information.

The zeroing screen presents several pieces of information

**Counts:** One count equals 0.0005%FS

**°C Oven:** Oven temperature

**Ref. psi:** Case reference pressure (excluded in Absolute mode DPCs).

**Delay Time:** Total time delayed while in zero display.

If any of the above are unstable, then the system will delay until stability is achieved. Pressing **OK [F6]** will bypass this wait period.

**NOTE:** Bypassing this wait period can have a negative effect on the zeroing procedure.

#### 6.4.4.1 GAUGE ONLY INSTRUMENTS

1. Verify that the Reference Port is open to atmosphere.
2. Enter the **Calibration Screen** by selecting **MENU/CAL**.
3. Select **Zero [F1]**. Do not press the recessed **CAL.** button.
4. Do not disturb the instrument while zeroing is in process.
5. Wait for the zeroing procedure to finish

#### 6.4.4.2 DIFFERENTIAL INSTRUMENTS

##### 6.4.4.2.1 GAUGE MODE

A differential instrument in Gauge mode is zeroed with the same procedure as a gauge only instrument. See Section 6.4.4.1.



For DPCs with ranges from 501 to 2500 psi, a test port isolation valve is not standard. For systems without this valve, it is important to vent the DPC and verify that there is not a pressure source supplying gas into the DPC test port before proceeding with the procedure outlined in Section 6.4.4.1.

##### 6.4.4.2.2 ABSOLUTE MODE

A vacuum gauge should be installed for measuring the case reference pressure. This gauge should be installed as close to the sensor as possible. There is an 1/8-inch NPT fitting available for this installation near the DPC sensor.

1. From the Main Menu, verify that the unit is in the absolute mode of operation. See Section 4.2.1.2.
2. Enter the **Calibration Screen** by selecting **MENU/CAL**.
3. Select **Zero [F1]**. Do not press the recessed **CAL.** button.
4. Apply vacuum to the case reference port. Wait for the vacuum level to stabilize.
5. Select the desired pressure units using the **[F4]** key.
6. Enter the vacuum level of the reference port and press **OK [F6]**.
7. Do not disturb the instrument while zeroing is in process.
8. Wait for the zeroing procedure to finish.



For DPCs with ranges from 501 to 2500 psi, a test port isolation valve is not standard. For systems without this valve, it is important to vent the DPC and verify that there is not a pressure source supplying gas into the DPC test port before proceeding with the procedure outlined in Section 6.4.4.1.

#### 6.4.4.3 ABSOLUTE INSTRUMENTS

The DPC uses the supply vacuum to evacuate the test port. Thus, a vacuum pump must be connected to the vacuum supply port.

A vacuum gauge should be installed for measuring the case reference pressure. This gauge should be installed as close to the sensor as possible. There is an 1/8-inch NPT fitting available for this installation near the sensor.

1. Enter the **Calibration Screen** by selecting **MENU/CAL**.
2. Select **Zero [F1]**. Do not press the recessed **CAL** button.
3. Wait for the vacuum level on the test port to stabilize.
4. Enter the vacuum level of the test port and press **OK [F6]**.
5. Select the desired pressure units using the **[F4]** key.
6. Do not disturb the instrument while zeroing is in process.
7. Wait for the zeroing procedure to finish.

#### 6.5 SENSOR PHOTOCCELL ZEROING

If the error message "Mechanical Zeroing Needed" is displayed, the sensor photocell must be zeroed. The following steps describe this process.

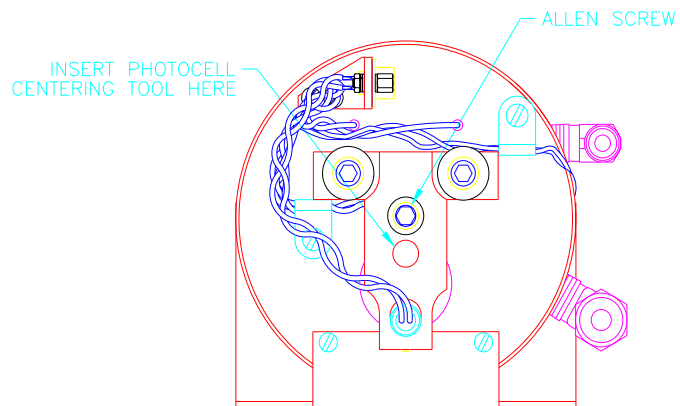
**CAUTION:** The DPC should only be opened by qualified electrical/mechanical service technicians. Lethal voltages are present and exposed in the power supply and display.

**NOTE:** The sensor **MUST** have zero differential between the Test port and Reference port. For Differential DPCs, apply atmospheric pressure to both the Test and Reference port. For Absolute DPCs, apply a vacuum to the Test port (<200  $\mu$ Hg.)

1. Remove the DPC's top cover and sensor housing covers.
2. Enter the **Display Screen** by selecting **MENU/DISP**.
3. Referring to Figure 6-5, slightly loosen the Allen screw on the back of the sensor bracket, making sure to maintain a snug fit on the screw. Using the T-shaped Photocell Centering Tool (RIC #6000-88), adjust the photocells by placing the tool in the hole in the back of the sensor and turning the tool slightly. Adjust for a pressure counts reading of 0 +/-100 (the reading is found in the left hand column, next to the Test Port Pressure reading on the display). **DO NOT** attempt to set the pressure value (bottom center of display) to zero.
4. Tighten the Allen screw.
5. Tap on the bracket with a screwdriver handle to relieve mechanical stress. Continue to tap on the bracket until the counts stop changing.
6. Repeat this procedure as necessary.
7. Reinstall sensor housing and instrument covers.



8. Perform a normal instrument zeroing procedure. After the unit has become thermally stabilized. Refer to Section 6.4.4.



**FIGURE 6-5  
PHOTOCELL LOCATION**

## **SECTION 7.0**

### **PREPARATION FOR STORAGE & SHIPMENT**

**NOTE:** The procedures given in Sections 7.1 through 7.3 must be strictly adhered to in order to prevent damage to the instrument. Failure to follow these procedures will likely result in damage to the DPC during shipment. This damage is not covered by the carrier's insurance.

#### **7.1 DISCONNECTING THE DPC**

1. Relieve all pneumatic pressure from the DPC.
2. Turn the DPC power switch to the off position.
3. Disconnect the power cable from the DPC power receptacle.
4. Disconnect all pneumatic lines from the DPC's back panel.
5. Plug all ports.

#### **7.2 PACKING INSTRUCTIONS**

To prevent shipping and handling damage to the instrument, adhere to and strictly follow the instructions below.

The governing discipline in ensuring a damage-free shipment is to ensure that the possibility of handling shocks to the DPC is minimized and/or prevented during transit. Ruska accomplishes this task by cradling the DPC within two foam cradles that are encapsulated within a double-walled, corrugated box. The DPC is restrained and supported, but still has resilience. The materials used in the packaging operation are foams that have a minimum impact rating of not less than **N-95**.

*Styrofoam, poured "foam in place" mixtures, and other rigid foams are **not recommended**.*

If polyfoam or rubber foam other than that used in the original packaging is to be used, cut it into strips so that it will not present a large rigid surface to the DPC.

Ruska has found that corrugated cardboard boxes provide the best packaging exterior. The box must have an impact rating of **275 lb** and be of **double-walled** construction. This type of box will sustain most types of damages incurred during the shipping and handling process, but ensures that the contents remain intact and damage-free. The foam cradle ensures that a minimum of 3 inches of foam separates the inner surface of the box and any portion of the DPC. **Wood or metal boxes do not absorb shock when dropped and therefore are not recommended.**

If the original packaging and shipping materials have been retained, use them for packing the DPC. If the DPC is being packed for long-term storage (more than 30 days), place a desiccant bag inside the box.

The DPC must be prepared for shipment in the following manner:

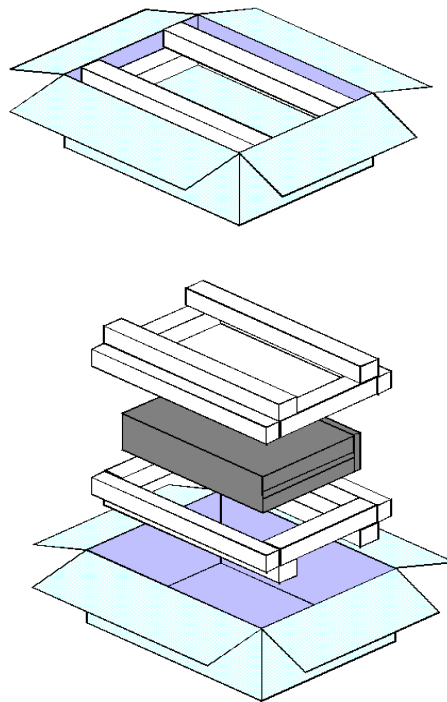
1. Ruska Instrument has an RMA procedure in place. Please contact the Customer Service Center to obtain an RMA number prior to returning any equipment to Ruska. Have the following information available when contacting Ruska:
  - a. The part number,
  - b. the serial number,
  - c. the purchase order number,
  - d. the billing and ship-to address, and
  - e. the buyer's name and telephone number.

This information plus the RMA number must be attached to the unit when it is shipped to Ruska Instrument. There will be a minimal charge for inspection and/or evaluation of returned goods.

2. Enclose the DPC in plastic or any good water barrier material. Antistatic material is recommended.
3. If the original shipping carton is not usable or available, use a double-walled corrugated carton with a 275-b rating. The recommended carton size is 25-1/2 x 19-1/2 x 12-3/8 inches.
4. Insert one form cradle from the original shipment onto the floor of the box. (The original foam cradles are of the same type of construction and are completely interchangeable.) If the foam cradles are not available, cover the bottom and sides with no less than 3 inches of N-95 foam strips. Arrange the strips in the configuration illustrated in Figure 7-1.
5. Before sealing the carton, include the following:
  - a. Statement of the problem or service needed. Be specific. Include the name and telephone number of a knowledgeable technician for consultation.
  - b. The part number, serial number, return address, and purchase order number.
6. Seal the carton using gummed tape.
7. Address the carton to:

**RUSKA INSTRUMENT CORPORTION  
10311 WESTPARK DRIVE  
HOUSTON, TEXAS 77042**

8. Label the carton with the following labels: THIS SIDE UP, HANDLE WITH CARE, DO NOT DROP, and FRAGILE. (If the original Ruska shipping carton is utilized for this shipment, the above markings are preprinted on the carton.)



**FIGURE 7-1  
PACKING THE DPC**

### **7.3 SHIPPING INSTRUCTIONS**

Ruska recommends using air freight for transportation. Surface transportation subjects the shipment to more frequent handling and much more intense shock. In most cases, if surface transportation is the mode of transport employed, handling damage is likely.

Again, it is essential that the procedures mentioned in Sections 7.1 through 7.3 be strictly adhered to in order to prevent any shipping and handling damage to the instrument.

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# **APPENDIX A**

## **SUMMARY OF SPECIFICATIONS**

### **A.1 ACCURACY**

Specifications of pressure transducer instrumentation can be divided into three categories: Input Specifications, General Specifications, and Performance Specifications. Each of these categories in turn consists of parameters that are usually specified by minimum and/or maximum numeric limits. Almost all of these parameters can have an effect on what is generally referred to as the instrument's "accuracy". Therefore, the accuracy of pressure instrumentation can be varied either beneficially or detrimentally by controlling the Input Specifications, operating within the General Specifications, or knowing the actual Performance Specifications.

For example, if Input Specifications have not been met for the line voltage, the DPC may not have a catastrophic failure, but errors may be present in the transducer measurement. As another example, if the requirement for the pressure source Flow capacity has not been met, the DPC may not be able to achieve a final steady state controlled pressure within the settling time specification. Finally, if the DPC is commanded to a pressure outside of the applicable control pressure range, the non-linearity in the pressure output may be greater than that specified.

Performance Specifications give the user the most flexibility and control over "accuracy claims". The term accuracy is defined by ISA-S37.1 as either the ratio of the error to the full-scale output (%FS) or the ratio of the error to the reading (%RDG). Note that the definition of accuracy is not the summation of some or even all of the possible error source maximum limits.

The true accuracy of an instrument is relative to the actual error introduced by the calibration transfer standard plus the actual error not eliminated from the instrument's indicated output. Therefore, an instrument's accuracy can be influenced by introducing more or less actual error through the choice of a calibration standard; or its accuracy can be varied by the elimination of actual errors inherent in the instrument. For example, if an instrument has a known error due to being used in an attitude, or tilt, the %FS zero shift error can be eliminated by re-zeroing the instrument in the tilted position. Even %RDG sensitivity shifts can be eliminated mathematically or by controlling the attitude of the instrument during its calibration.

The key to eliminating an error is knowing its source and type along with its polarity and magnitude. Generally, the source is simple to detect and is represented by the specific parameter. The type is usually a function of the instrument's design and manufacturing process. Within a given instrument, an error can be either random or systematic as well as random or systematic within the instrument's population. The user is free to consult Ruska for recommended methods of minimizing error source contributions.

In summation, total error can and should be managed by the control of the three general error sources: Input Specifications, which includes the user's chosen calibration standards; General Specifications, which includes the user's chosen processes; and Performance Specifications, which includes the user's chosen applications for the instrumentation. The parameters and value limits listed in the following specifications indicate the product line's general acceptance limits and are not a report of any unit's specific error contribution. Any parameter exceeding the specified limits should be considered in need of maintenance.

## A.2 SPECIFICATIONS

### GENERAL SPECIFICATIONS

Pressure Range:	1-2500 psi, 0.07-172 bar
Display:	Graphical vacuum florescent
Electrical Power:	90-260 VAC, 50-400 Hz, 150 W
>500 psi	102-120VAC, 60Hz or 102-110VAC, 50 Hz 204-240VAC, 60Hz or 204-220VAC, 50 Hz
Operating Temperature:	18-36°C
Storage Temperature:	-20-70°C
Humidity:	5-95% relative humidity, noncondensing
Nominal Control Volume:	5-60 in <sup>3</sup>
Dimensions:	7"H x 17"W x 16"D (17.8 cm x 43.2 cm x 40.6 cm)
Zero Drift:	<0.004%FS in 24 hours

### PERFORMANCE

Display Resolution:	User-selectable up to 1:1,000,000
Hysteresis:	Negligible
Pressure Medium:	Nitrogen* or Air
Pneumatic Ports:	1/4-inch NPT female
Overpressure Protection:	Internal relief valves, auto vent feature
Standard Pressure Units:	inHg at 0 and 60°C, kPa, bar, psi, inH <sub>2</sub> O at 4, 20, and 25°C, kg/cm <sup>2</sup> , mmHg at 0°C, cmHg at 0°C, and cmH <sub>2</sub> O at 4°C

### GAS SPECIFICATIONS

Pressure Source Medium:	Nitrogen* or Air
Pressure Source Particle Size Contamination:	≤50 microns
Pressure Source Max. Moisture Content:	-50°C dew point
Pressure Source Max. Hydrocarbon Content:	30 ppm

### VACUUM REQUIREMENTS

Supply Vacuum:	50 liters per minute (minimum)
Reference Vacuum:	100 liters per minute (minimum)

\*Industrial grade nitrogen, 99.5% pure.

**TABLE A-1  
PERFORMANCE SPECIFICATIONS**

Pressure Range	1-4.9 psi (0.07-0.33 bar)	5-100 psi (0.34-6.9 bar)	101-500 psi <sup>6</sup> (7-34.4 bar)	501-2500 psi <sup>6</sup> (34.5-172 bar)	15-120 psi (1-8.3 bar)
Mode	Gauge	G, A, V <sup>1</sup>	G, A, V <sup>1</sup>	G, A	Absolute
Precision <sup>2</sup>	0.004% FS	0.003% FS	0.003% FS	0.003% FS	0.003% FS
Stability Over 6 Months	0.005% RDG	0.005% RDG	0.005% RDG	0.005% RDG	0.005% RDG
Control Stability	0.004% FS	0.001% FS	0.001% FS	0.004% FS	0.001% FS
Control Low Limits					
Gauge Mode	0 psig <sup>3</sup>	0 psig <sup>3</sup>	0 psig <sup>3</sup>	10% FS	N/A
Absolute Mode	N/A	0.15 psia of 1% FS <sup>3</sup>	1% FS	10% FS	N/A
Vacuum Mode	N/A	95% of Barometric	95% of Barometric	N/A	N/A
Electrical Power	115/240 VAC	115/240 VAC	115/240 VAC	115 or 240 VAC	115/240 VAC
Gas Consumption (Steady State)	<8 SCFH	,8 SCFH	<20 SCFH	<10 SCFH	<8 SCFH
Slew Rate <sup>5</sup>	30 Seconds	30 Seconds	45 Seconds	60 Seconds	30 Seconds
Test Port Isolation	Standard	Standard	Standard	Optional	Standard
Weight	35 lb/15.9 kg	35 lb/15.9 kg	35 lb/15.9 kg	45 lb/20.4 kg	35 lb/15.9 kg

G = gauge, A = absolute, V = vacuum

<sup>1</sup> Optional

<sup>2</sup> Defined as the combined effect of linearity, repeatability, and hysteresis throughout the operating temperature range.

<sup>3</sup> Requires vacuum pump to control 0 psig, or use of vent mode.

<sup>4</sup> Whichever is greater.

<sup>5</sup> Defined as 10% FS increments into a 15 cubic inch volume.

<sup>6</sup> Supply vacuum is not applicable for instruments ranging from 501-2500 psi.



**TABLE A-2  
RELIEF VALVE SETTINGS**

<b>MODEL NUMBER</b>	<b>TEST PORT</b>	<b>SUPPLY PRESSURE</b>	<b>SUPPLY VACUUM</b>	<b>REFERENCE PORT</b>
7010-701	5 psig	F.S. +15 psig	10 psig	5 psig <sup>1</sup>
7010-702	5 psig	F.S. +15 psig	10 psig	10 psig
7010-703	6 psig	F.S. +15 psig	10 psig	10 psig
7010-704	11 psig	F.S. +15 psig	10 psig	10 psig
7010-705	22 psig	F.S. +15 psig	10 psig	10 psig
7010-706	41 psig	F.S. +15 psig	10 psig	10 psig
7010-707	55 psig	F.S. +15 psig	10 psig	10 psig
7010-708	112 psig	F.S. +15 psig	10 psig	10 psig
7010-709	165 psig	F.S. +75 psig	10 psig	10 psig
7010-710	330 psig	F.S. +75 psig	10 psig	10 psig
7010-711	550 psig	F.S. +75 psig	10 psig	10 psig
7010-712	990 psig	F.S. +15 psig	N/A	10 psig
7010-713	1650 psig	F.S. +15 psig	N/A	10 psig
7010-714	2200 psig	F.S. +15 psig	N/A	10 psig
7010-715	2750 psig	F.S. +15 psig	N/A	10 psig
7010-716	17 psig	F.S. +15 psig	10 psig	N/A
7010-717	50 psig	F.S. +15 psig	10 psig	N/A
7010-718	116 psig	F.S. +15 psig	10 psig	N/A

<sup>1</sup> Relief valve is reversed to prevent sub-atmospheric references (i.e., gauge only instruments).

## **APPENDIX B**

### **SUMMARY OF ERROR MESSAGES**

Negative error numbers are from the Standard Commands for Programmable Instruments (Version 1991.0).

<b>Value</b>	<b>Description and Corrective Action</b>
0	No Error.
-103	Invalid Separator. Check punctuation in the SCPI command.
-104	Data Type. The type of parameter data is incorrect.
-109	Missing Parameter. No valid parameter was found for the SCPI command.
-110	Command Header. The Command name is not valid.
-113	Command Unknown. The command specified does not exist.
-114	Header Suffix. The numeric suffix for the command name is out of range.
-221	Settings Conflict. The command could not be executed due to the current state of the DPC. Some commands cannot be executed while a program, self-test, or calibration is in progress.
-222	Out of Range. The value is not within the valid range. For pressures check high and low limits.
-281	Cannot create program. Program memory is full.
-282	Illegal Program Name. The name specified is not valid or does not exist.
-284	Program Currently Running. The command cannot be executed while a program is running.
-285	Program Syntax Error. The syntax of the program definition is not correct.
-286	Program Runtime Error. An error occurred while running the program. Usually the set-point is out of range.
-313	Calibration Data Lost. The calibration data has been lost and the unit must be recalibrated.
-315	Configuration Data Lost. The configuration data has been lost. Check all parameters to be sure they are correct.
-330	Self-Test Failed. Check the display for the test that failed.
-350	Queue Overflow. The error queue was full and messages were lost.
-400	Query Error. A read request was received when there was nothing to read.
500	Controller Malfunction. Internal control failure.
501	High Limit Exceeded. The pressure was greater than the high limit.
502	Low Limit Exceeded. The pressure was less than the low limit.
503	Slew limit Exceeded. The pressure changed faster than the slew limit allowed.
521	Pressure Overrange. The pressure reading is outside the rang of the DPC.
530	Gas Temp Overrange. The temperature on the gas on the test line (Section 2.0) indicates a bad connection of a faulty gas temperature sensor. To observe the gas temperature, select OK, then select MENU/DISP. Check for broken wires or a faulty sensor, requesting service (Section 7.0) if necessary.

<b>Value</b>	<b>Description and Corrective Action</b>
531	Oven Temp Overrange. Either the transistor that drives the heater for the quartz Bourdon tube sensor (Section 2.0) or the oven temperature sensor itself is malfunctioning. To observe the oven temperature, select OK then select MENU/DISP. Check the transistor and sensor for malfunction, requesting service (Section 7.0) if necessary.
532	Vacuum Sensor Overrange. Select OK, then if absolute measurements are desired, verify that the pressure applied to the case reference port is low enough to be considered vacuum (Section 4.0).
533	Case Pressure Overrange. Select OK, then reduce the pressure at the case reference port to 30 psia or lower.
534	Voltage Sensor Overrange. The -15 voltage provided by the control board (Section 2.0) is incorrect. To observe the voltage, select OK, then select MENU/DISP. Factory service (Section 7.0) is usually required for this problem.
535	Voltage Sensor Overrange. The +15 voltage provided by the control board (Section 2.0) is incorrect. To observe the voltage, select OK, then select MENU/DISP. Factory service (Section 7.0) is usually required for this problem.
536	Voltage Sensor Overrange. The +5 voltage provided by the control board (Section 2.0) is incorrect. To observe the voltage, select OK, then select MENU/DISP. Factory service (Section 7.0) is usually required for this problem.
538	Automatic Vent. The pressure has exceeded the limit specified in MENU/SETUP/LIMITS and the DPC vented the pressure.
540	Mechanical Zeroing Needed. The zero point of the quartz Bourdon sensor is beyond the range of the compensation circuit. The zero is adjusted by the software but should be manually adjusted for complete accuracy.
542	Oven Control Failure. The temperature controller is unable to keep the sensor at the proper temperature.
543	Supply Pressure Low. Low supply pressure signaled from Opto-22 input.
544	Gas Temp Not Installed. The requested function requires the optional gas temperature sensor.
600	Factory Data Lost. Internal factory constants have been lost. Contact Ruska for more information.
601	Calibration Mode. The CAL. button must be pressed before SCPI calibration commands can be executed.
610	Memory Card Not Inserted. A memory card must be inserted.
611	Error Reading Memory Card. The requested data was not found on the memory card.
612	Error Writing Memory Card. Unable to save information on card.
613	Memory Card Write Protected. Unable to save information on card.
614	Data Not From This Unit. The calibration data from another unit cannot be loaded.