RUSKA MODEL 7000
DIGITAL PRESSURE INDICATOR
USER'S MANUAL

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MODEL 7000

USER'S MANUAL

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REVISION NOTICE

RELEASE NUMBER	REVISION	DATE OF RELEASE	DESCRIPTION
7000-1D01	A	02/11/99	Original release.
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RELEASE 7000-1D01	Revision A (02/11/99)
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Changes in Section 7.2.	

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.

RESUSCITAITON

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

ELECTROSTATIC DISCHARGE SENSITIVE PARTS

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.

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 are.

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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 7000 Digital Pressure Controller (DPI) manufactured by Ruska Instrument Corporation, Houston, Texas. This section of the manual provides general information about the DPI and presents its features and options.

1.2 GENERAL INFORMATION

The Ruska Model 7000 DPI uses force-balanced, fused-quartz Bourdon tube technology to provide the precise measurement of pressure. During normal operation, the DPI performs in Measure mode only.

In Measure mode, the DPI 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 7000 DPI's.

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 DPI are mercury-free. This includes the temperature controller for the quartz Bourdon tube, which is totally electronic.

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

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

HIGH PRESSURE

DPI's with ranges from 501 to 2500 psi can be either 115 or 230 VAC. Please refer to Section 3.4.

Friendly Display: The DPI'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 grater than or less than the default resolution.

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

Easily Programmable: The DPI'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 DPI's 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 DPI quickly tests its hardware and software. After the DPI 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 DPI's software automatically performs the zero adjustment, with no potentiometers to tune.

Automatic Head Correction: The DPI automatically corrects for head pressure between the DPI 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 DPI is not sensitive to the type of gas used within the system, the user can select either instrumentation air or nitrogen, allowing the DPI 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_2O at 4°C, 20°C, and 25°C, kilograms per square centimeter, mmHg, cmHg at 0°C, and cmH_2O 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 DPI includes standard RS-232 serial and IEEE-488 interfaces. The user's computer communicates with the DPI through the Standard Commands for Programmable Instructions (SCPI) protocol. *The DPI can also be configured to accept existing software written for the Ruska Series 6000 Digital Pressure Gauge/Indicator*.

1.4 STANDARD EQUIPMENT & OPTIONS

A standard DPI includes this manual, a power cord, and a small tools kit. Although the standard DPI 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 DPI 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 7000 DPI

OPTION	RUSKA INSTRUMENT CORP. 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 230 VAC 50/60 Hz Vacuum Pump - 69 L/min 115 VAC 50/60 Hz 230 VAC 50/60 Hz	 99876-900 99876-960 99875-900 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[1]
Test Port Isolation Kit, 220 VAC	7000-820[1]

[1] Test port isolation kits are only required for DPI's from 501-2500 psi.

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SECTION 2.0
THEORY OF OPERATION

2.1 INTRODUCTION

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

Figure 2-1
DPI Block Diagram

2.2 POWER SUPPLY

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

DPI'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 +5 VDC, -5 VDC, +15 VDC, and -15 VDC for analog use. The resulting seven DC voltages are then used either directly or indirectly throughout the entire DPI.

Data that is subject to change after the DPI 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 DPI'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 DPI, as well as the conversion factors that the DPI uses to translate the detected pressure into the units selected by the user. These factors are given in Table 2-1.

When the DPI powers up, its software is loaded into random access memory (RAM0, 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 DPI'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 DPI.

Table 2-1
Conversion Factors

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

Symbol	Description	Conversion Factor
inHg	inches of mercury (0^oC)	= kPa x 0.2952998
inHg	inches of mercury (60^oF)	= 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_2O	centimeters of water (4^oC)	= kPa x 10.19744
inH_2O	inches of water (4^oC)	= kPa x 4.014742
kg/cm^2	kilograms per square centimeter	= kPa x 0.0101972
mmHg	millimeters of mercury (0^oC)	= kPa x 7.500605
cmHg	centimeters of mercury (0^oC)	= 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 DPI 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 DPI's IEEE-488 (GPIB) interface card, which plugs directly into the Control Board, provides the DPI 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 DPI.

The DPI also accepts an optional memory card that slides thorough a slot int he Front Panel and plugs directly into the Control Board.

2.4 ELECTRONICS MODULE

2.4.1 MEASURE MODE PNEUMATICS

Figure 2-2A
Model 7000 DPI Differential Pneumatics Diagram

The left half of Figure 2-2A summarizes the Measure Mode Pneumatics. This block, which is associated with measurement, is described in Sections 2.1.4.1.1 through 2.4.1.3 of this manual.

<u>2.4.1.1 Reference Port</u>
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 DPI's Measure mode. When the user commands the DPI 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.

ABSOLUTE MODEL

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 DPI's Measure mode and closed during the zeroing process. On Differential mode DPIs (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.

HIGH PRESSURE

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

ABSOLUTE MODEL

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 DPI is in Measure mode or performing the zeroing process. When the user commands the DPI 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).

2.5 TRANSDUCER MODULE

2.5.1 QUARTZ BOURDON TUBE SENSOR (TRANSDUCER01)

The quartz Bourdon tube sensor (TRANSDUCER01 in Figure 2-2A) is mounted in a machined aluminum 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 "zero 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.

ABSOLUTE MODEL

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 DPI'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 DPI'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. The user needs this sensor to zero the DPI 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 DPI is a digital, software-based instrument. The software 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.

2.6.1.2 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 MAIN/DISPLAY.

Figure 2-7
Auxiliary sensor display

2.6.1.3 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 presure
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 7000
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 factor
K_c	Case pressure effect factor

The setup and configuration of the DPI 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
- Date 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 DPI will immediately close all valves, show a message on the front display, and reset the system software.

SECTION 3.0
INSTALLATION

3.1 INTRODUCTION

This section of the manual discusses initial installation for the Model 7000 DPI. Installing the DPI involves connecting the test pressure tubing, powering up the unit, and configuring the system through the front panel.

3.2 UNPACKING THE DPI

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

- a Model 7000 Digital Pressure Indicator,
- 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 DPI in a location that meets the requirements listed in Table 3-1.

> **NOTE:** The DPI 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 DPI should be mounted to within 5° of level.

TABLE 3-1
GENERAL SPECIFICATIONS: GENERAL PARAMETERS

Parameter	Value	Model
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	$\leq$3 hrs	all

*If there is any condensation when storing the DPI, 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 DPI.

1. Never operate the DPI with the cover removed. The power supply has internal voltages near 400 volts.
2. Never apply more than 110% of the DPI's full scale to the test port.
3. Do not expose the instrument to thermal and mechanical shock, or vibration, This may affect performance and require rezeroing.
4. See the safety summary in the introduction.

3.4 POWERING UP THE DPI

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

NOTE: Grounding for the DPI 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.

HIGH PRESSURE

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

Finally, turn on the DPI 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 DPI'S FULL SCALE RATING

To observe the DPI's full scale rating.

1. Press **[PREV.]** until the main menu appears.
2. Select MAIN/CAL. The DPI'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

3.5.1 TEST PORT

The device(s) under test is connected to the test port. Excessive leaks in the test volume will cause measurement errors in the device under test. Tubing connect from the test port to the load volume should have an internal diameter grater than 0.125 inches (3 mm). Tubing should be shorter than 15 feet when minimum diameter tubing is used.

3.5.2 REFERENCE PORT

The reference port is open to atmosphere for gauge measurements.

Figure 3-1A
Model 7000 Back Panel

Figure 3-1B
Model 7000 Absolute Back Panel

Figure 3-1C
Model 7000 High Pressure Back Panel

LOW PRESSURE

CAUTION: For DPIs 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.

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SECTION 4.0
LOCAL OPERATION

This section of the manual describes operation of the DPI 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 7000 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 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.

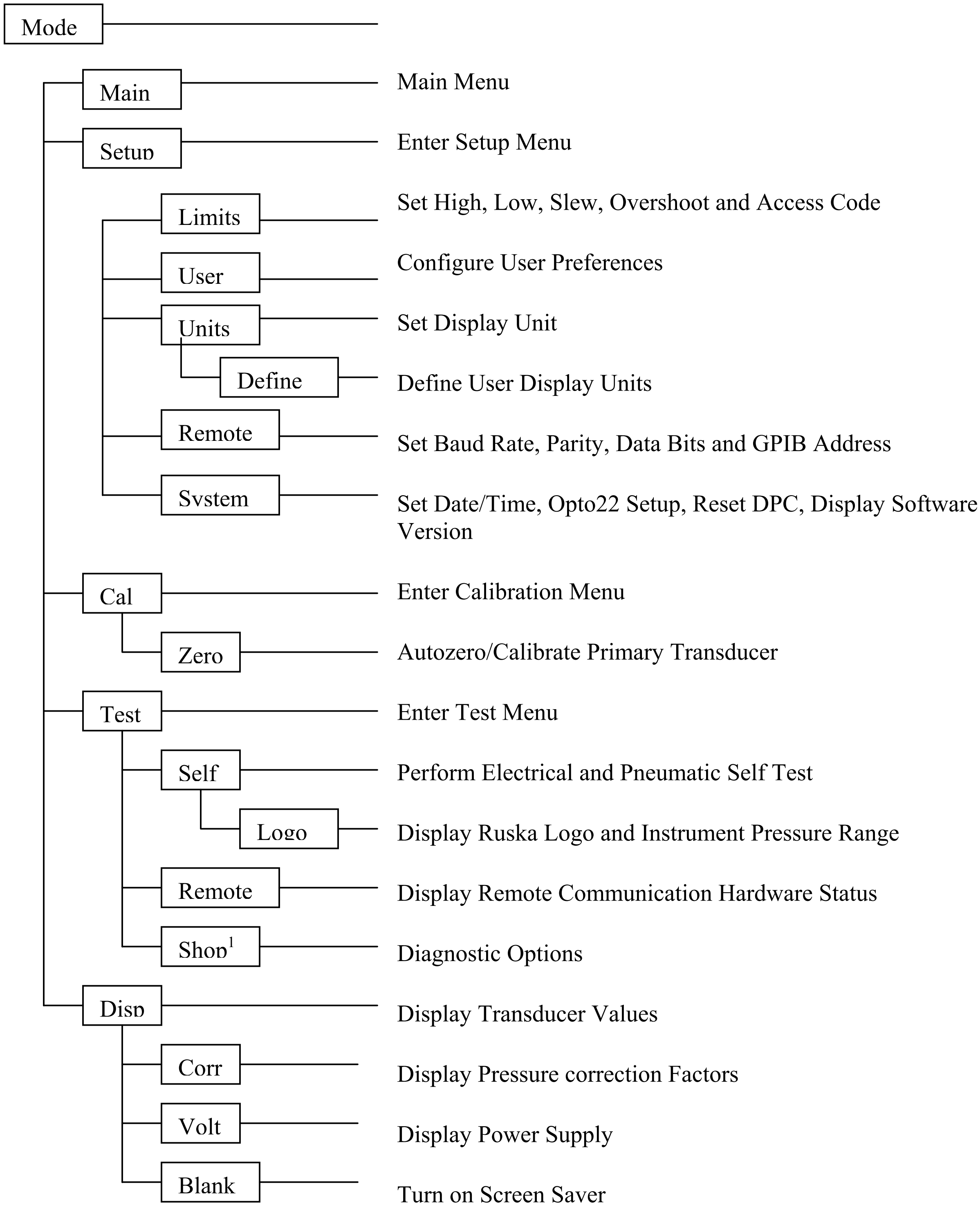

Figure 4-2
Menu Tree

4.1 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.].

4.1.1 SELECTING MODE OF OPERATION

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

4.1.1.1 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.

4.1.1.2 Absolute Only Instruments

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

4.1.1.3 Differential Instruments

A differential 7000 is capable of operating in Gauge, Absolute and Differential modes.

The mode of operation is selected from the Main Menu. From the Main Menu, select Absolute, Gauge or Differential mode of operation.

4.1.1.3.1 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 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.

4.1.1.3.2 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 106.8 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.

4.1.1.3.3 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.

4.1.2 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 Main [F6], then 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 DPI uses the conversion factors listed in Table 2-1 to translate the pressure from kiloPascals to one of the DPI's units of measure.

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

4.1.3 DEFINING A NEW PRESSURE UNIT

In addition to the standard units of measure provided by the DPI, 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

$$mTorr = kPa x \frac{1000 mTorr}{1 Torr} x \frac{1 Torr}{1 mmHg 0^o C} x \frac{1 mmHg 0^o C}{0.0193368 psi} x \frac{0.1450377 psi}{1 kPa}$$

thus the conversion factor simplifies to

mTorr = kPa x 7.5006051

1. The presure units are defined from the Units Define Menu. From the Main Menu (press [PREV.] until the Main Menu appears) press Main [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.

4.1.4 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 Main [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.

4.1.5 SETTING THE ALARM LIMITS

The DPI continually checks the measured pressure against high and low limits. If the measured pressure exceeds the high limit or falls below the low 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 Main [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 filed into the numeric scratchpad.
6. Press [PREV.] to exit the menu. Press [CANCEL] to return all edited fields to their original values.

4.1.6 USING HEAD PRESSURE CORRECTION

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

1. Locate the Pressure Reference Line on the DPI'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 Main [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 DPI, and a negative value if the device under test is above the DPI.
8. Press [ENTER] to accept the entry.

4.1.7 ZEROING

Ruska recommends that the DPI 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.

4.2 CONFIGURATION

4.2.1 CALIBRATION PASSWORD

The calibration password allows the operator to protect access to DPI 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 DPI or manually change the calibration constants.

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

1. The calibration password is set from the Calibration Menu. From the Main Menu (press [PREV.] until the Main Menu appears), press Main [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 DPI calibration and constants. Press [ENTER].
5. Press Yes [F4] to acknowledge changing the calibration password. Press No [F5] to reject changing the calibration password.

4.2.2 TEST ACCESS PASSWORD

The test access password allows the operator to protect access to DPI 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.

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

1. The test access password is set from the **Limits Menu**. From the **Main Menu** (press [**PREV**.] until the Main Menu appears), press **Main [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 DPI configuration and programs. Press [**ENTER**].
4. Press **Yes [F4]** to acknowledge changing the access password. Press **No [F5]** to reject changing the access password.

4.2.3 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 **Main [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**].

4.2.4 KEY CLICK

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

1. The key click is set from the Setup User Menu. Form the Main Menu (press [**PREV**.] until the Main Menu appears), press **Main [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**.

4.2.5 ENABLE ERROR

The enable error selection enables the out-of-range errors on the secondary transducers. Normally the only secondary transducer installed is the temperature transducer.

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

4.2.6 DATE/TIME

The DPI'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 Main [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 (mmddyyyy). 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.

4.3 MEMORY CARD

The DPI supports the user 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 DPI. The calibration information is specific to the device and can only be loaded into the DPI from which it was saved. The memory card also allows for future software/firmware upgrades in the field.

4.3.1 CARD SUPPORT

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

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

4.3.3 SAVING/RESTORING CALIBRATION INFORMATION

Saving and restoring calibration information requires entry into Calibration mode.

1. Enter the calibration mode by first pressing MAIN [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 DPI that saved it.

SECTION 5.0
REMOTE OPERATION

5.1 CAPABILITIES

The DPI can be operated remotely by a computer. Two interfaces are supported: IEEE-488 and RS-232. Both 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

5.1.1 IEEE-488

The following identification codes define the interface capabilities of the DPI. Identification codes are 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 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 MAIN/SETUP/REMOTE screen.

5.1.2 RS-232

The RS-232 interface supports standard serial operation from a computer to a single DPI. RS-232 supports the IEEE-488.2 and SCPI commands. The DPI 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 DPI. 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 DPI is operated manually through the front panel. Section 4 covers local operation. The DPI always powers up in the Local mode. In Remote mode, the DPI 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 DPI 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 DPI 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 turning the DPI 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

To configure the remote interface:

1. The remote interface is configured from the Setup Remote Menu. From the Main Menu (press [PREV.] until the Main Menu appears), press Main [F6], then Setup [F2], and finally 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 0A0. 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 formal "+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}	
:DATE<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                      Performs Zero Calibration
            :VALUE<number>         Sets Vacuum Value
            :INITiate              Enter Zero Calibration Mode
            :INITiate?             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
        :DATE<number>,<number>     Sets C0, C1 for Gas Temperature
        :VALue<number>             Calibrates to Value
    :PRESsure2
        :DATE<number>,<number>     Sets C0, C1 for Case Pressure
        :VALue<number>             Sets First Calibration Point
        :VALue2<number>            Sets Second Calibration Point
    :TEMPerature2
        :DATE<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 DPI 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
        :DWEL1<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	
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	State 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><noame>,<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 pressures 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 test 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 6005 INTERFACE PANEL EMULATION

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

1. The DPI 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 tot he EPI 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 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 XOFF (hexadecimal 13) command is received, the DPI 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 DPI. This section of the manual discusses suggested procedures.

6.2 OBSERVING THE SOFTWARE VERSION NUMBER

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

1. If necessary, press [PREV.] several times to return the display to the Main Menu.
2. Select MAIN/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 DPI is designed to be nearly maintenance free, occasional preventive maintenance is required to keep the DPI's performance optimal.

6.3.1 INITIATING THE DPI'S SELF TEST

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

1. If necessary, press [PREV.] several times to return the display to the Main Menu.
2. Select MAIN/TEST/SELF. The electronics self test will run and display the results.
3. 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 tests and the possible actions needed if a test fails.

Table 6-1
Electronics Self Test

Test	Description	Action on Failure	RIC Part #
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.	700-PCA-001
Oven	Tests operation of the sensor oven	Replace. Replace sensor assy.	7000-PCA-001
-15	Tests negative power supply[1]	Replace.	7000-PCA-001
+15	Tests positive power supply[1]	Replace.	7000-PCA-001
+5	Tests main logic power[1]	Replace power supply.	62-288

[1] See figure 4-2 for viewing voltages.

6.3.2 REMOVING THE DPI'S COVER

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

CAUTION: The DPI 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 DPI and disconnect the power cord from the DPI.
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 DPI'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 hydroscopic. 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 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 changes 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.

6.3.5 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.

6.3.6 MEMORY CARD BATTERY

Some versions of the optional memory card require a replaceable battery (RIC #4-715). This battery should be replaced at least once a year. The "Centennial Recharge Card" uses a rechargeable battery. This card should be plugged into a powered-on instrument at least once every four to five months for ten hours. This will keep the battery charged.

6.4 CALIBRATION

To keep the DPI operating within its specified precision, the calibration procedures described below should be performed every 180 days. After gaining history for specific DPIs, 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 DPI'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 DPI at any time by "editing the coefficients" (Section 6.4.3).

6.4.1 CALIBRATION INSTRUCTIONS

To calibrate the DPI, the user connects a calibration standard such as the Ruska Instrument Model 2465 Gas Piston Gauge to the DPI's test port, then follows the three-=step calibration procedure on the DPI's display. This procedure requires the user to control the calibration standard to 50% and 100% of the DPI's full scale rating (Section 3.4.1). The standard DPI 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 DPI'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 DPI has been at stable environmental temperature and that the oven temperature (MAIN/DISPLAY) has been stable for *at least* two hours.
4. Verify that the DPI is in Measure mode (Section 4.0).
5. If desired, change the DPI's units of measure (Section 4.0) to match those of the calibration standard.
6. To go to the calibration screen, select MAIN/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 DPI completes step 1, the calibration screen will appear.

HIGH PRESSURE

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 DPI. As pressure is admitted into the Test Port, the measured pressure on the DPI's screen will change accordingly.

2.2 When the measured pressure stabilizes, use the DPI'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 DPI.* 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 DPI. As pressure is admitted into the Test Port, the measured pressure on the DPI's screen will change accordingly.

3.2 When the measured pressure stabilizes, use the DPI'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 DPI*. 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 DPI'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 exit 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.

If the DPI's memory 6.4.3 EDITING THE CALIBRATION COEFFICIENTS
is erased but the calibration coefficients are known, the user can restore the coefficients to the DPI 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. Enter the calibration screen by selecting MAIN/CAL.
2. 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.

3. Use the up and down arrow keys to highlight C0:, C1:, C2:, or C3:. The terms are coefficients of a linear regression analysis.
4. 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.
5. Repeat steps 4 and 5 until all four coefficients are correct.

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

6. To exit the editing procedure without storing the calibration coefficients in memory, press [CANCEL]. To store the calibration coefficients in memory, select OK [F6].
7. 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 DPIs)

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 MAIN/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 DPIs 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 DPI and verify that there is not a pressure source supplying gas into the DPI 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 e 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 DPI 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 be selecting MAIN/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 DPIs 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 DPI and verify that there is not a pressure source supplying gas into the DPI test port before proceeding with the procedure outlined in Section 6.4.4.1.

6.4.4.3 Absolute Instruments

A vacuum gauge should be installed for measuring the test port 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 MAIN/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 PHOTOCELL ZEROING

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

CAUTION: The DPI 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 DPIs, apply atmospheric pressure to both the Test and Reference port. For Absolute DPIs, apply a vacuum to the Test port (<200 µHg.)

1. Remove the DPI's top cover and sensor housing covers.
2. Enter the Display screen by selecting MAIN/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 #600-88), adjust the photocells by placing the tool in the hole in the bcvk 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 DPI during shipment. This damage is not covered by the carrier's insurance.

7.1 DISCONNECTING THE DPI

1. Relieve all pneumatic pressure from the DPI.
2. Turn the DPI power switch to the off position.
3. Disconnect the power cable from the DPI power receptacle.
4. Disconnect all pneumatic lines from the DPI'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 DPI is minimized and/or prevented during transit. Ruska accomplishes this task by cradling the DPI within two foam cradles that are encapsulated within a double-walled, corrugated box. The DPI 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.

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 DPI.

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 DPI. *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 DPI. If the DPI is being packed for long-term storage (more than 30 days), place a desiccant bag inside the box.

The DPI 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 DPI 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-lb 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 CORPORATION
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 DPI

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 DPI 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 DPI may not be able to achieve a final steady state controlled pressure within the settling time specification. Finally, if the DPI is commanded to a pressure outside of the applicable control pressure range, the nonlinearity in the pressure output may be greater than that specified.

Performance Specifications give the user the most fl4xibility 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 rezeroing 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
	102-120VAC, 60Hz or 102-110VAC, 50Hz
	204-240VAC, 60Hz or 204-220VAC, 50Hz
Operating Temperature:	18-36°C
Storage Temperature:	-20 - 70°C
Humidity:	5-95% relative humidity, noncondensing
Nominal Control Volume:	5-60 in^3
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_2O at 4, 20, and 25°C, kg/cm^2, mmHg at 0°C, cmHg at 0°C, and cmH_2O 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 (7-34.4 bar)	501-2500 psi[6] (34.5-172 bar)	15-120 psi (1-8.3 bar)
Mode	Gauge	G, A, V[1]	G, A, V[1]	G, A	Absolute
Precision[2]	0.007% 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
Electrical Power	115/240 VAC	115/240 VAC	115/240 VAC	115 or 240 VAC	115/240 VAC
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

[1] Optional

[2] Defined as the combined effect of linearity, repeatability, and hysteresis throughout the operating temperature range.

[4] Whichever is greater

[5] Defined as 10% FS increments into a 15 cubic inch volume

[6] Supply vacuum is not applicable for instruments ranging from 501-2500 psi.

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APPENDIX B
SUMMARY OF ERROR MESSAGES

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

Value	Description and Corrective Action
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 DPI. 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 setpoint 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 range of the DPI.
530	Gas Temp Overrange. The temperature on the gas on the test line (Section 2) 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) if necessary.

531	Oven Temp Overrange. Either the transistor that drives the heater for the quartz Bourdon tube sensor (Section 2) 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) 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).
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) is incorrect. To observe the voltage, select OK, then select MENU/DISP. Factory service (Section 7) is usually required for this problem.
535	Voltage SEnsor Overrange. The +15 voltage provided by the control board (Section 2) is incorrect. To observe the voltage, select OK, then select MENU/DISP. Factory service (Section 7) is usually required for this problem.
536	Voltage Sensor Overragne. The +5 voltages provided by the control board (Section 2) is incorrect. To observe the voltage, select OK, then select MENU/DISP. Factory service (Section 7) is usually required for this problem.
538	Automatic Vent. The pressure has exceeded the limit specified in MENU/SETUP/LIMITS and the DPI 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.