

Series 332

Series 332 Ionization Gauge Controller



Instruction Manual

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Series 332

Series 332 Ionization Gauge Controller

This Instruction Manual is for use with all Series 332 Ionization Gauge Controllers.



Customer Service / Technical Support:

MKS Global Headquarters

2 Tech Drive, Suite 201

Andover MA, 01810 USA

Phone: +1-833-986-1686

Email: insidesales@mksinst.com

Visit our website at www.mksinst.com

Instruction Manual

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Introduction & Safety Notices

Receiving Inspection

On receipt of your equipment, inspect all material for damage. Confirm that the shipment includes all items ordered. If items are missing or damaged, submit a claim as stated below for a domestic or international shipment, whichever is applicable.

If materials are missing or damaged, the carrier that made the delivery must be notified within 15 days of delivery, or in accordance with Interstate Commerce regulations for the filing of a claim. Any damaged material, including all containers and packaging, should be held for carrier inspection. If the shipment is not correct for reasons other than shipping damage, contact the MKS Customer Service Department, Phone: +1-833-986-1686, or email: insidesales@mksinst.com.

International Shipment

Inspect all materials received for shipping damage and confirm that the shipment includes all items ordered. If items are missing or damaged, the airfreight forwarder or airline making delivery to the customs broker must be notified within 15 days of delivery. The following illustrates to whom the claim is to be directed.

If an airfreight forwarder handles the shipment and their agent delivers the shipment to customs, the claim must be filed with the airfreight forwarder.

If an airfreight forwarder delivers the shipment to a specific airline and the airline delivers the shipment to customs, the claim must be filed with the airline.

Any damaged material, including all containers and packaging, should be held for carrier inspection. If your shipment is not correct for reasons other than shipping damage, contact MKS.

Limited Warranty

This product is warranted against defects in materials and workmanship for 1 year from the date of shipment provided the installation, operating and preventive maintenance procedures specified in this instruction manual have been followed. MKS will, at its option, repair, replace, or refund the selling price of the product if it proves to be defective in materials or workmanship during the warranty period, provided the item is returned to MKS together with a written statement of the problem.

Defects resulting from or repairs necessitated by misuse or alteration of the product or any cause other than defective materials or workmanship are not covered by this warranty.

MKS INSTRUMENTS, INC. EXPRESSLY DISCLAIMS ANY OTHER WARRANTY, WHETHER EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. UNDER NO CIRCUMSTANCES SHALL MKS INSTRUMENTS, INC. BE LIABLE FOR CONSEQUENTIAL OR OTHER DAMAGES RESULTING FROM A BREACH OF THIS LIMITED WARRANTY OR OTHERWISE.

WARNING

Read this instruction manual before installing, using, or servicing this equipment. If you have any doubts about how to use this equipment safely, contact MKS.

DANGER, HIGH VOLTAGE

180 VDC is present in the 332 Controller, the gauge cable, and the ion gauge when the gauge is turned ON.

Explosive Gases

Do not use Series 332 instruments to measure the pressure of explosive or combustible gases or gas mixtures. Ionization gauge filaments operate at high temperatures.

Implosion / Explosion

Glass ionization gauges, if roughly handled, may implode under vacuum causing flying glass which may injure personnel. If pressurized above atmospheric pressure, glass tubes may explode. A substantial shield should be placed around vacuum glassware to prevent injury to personnel.

Danger of injury to personnel and damage to equipment exists on all vacuum systems that incorporate gas sources or involve processes capable of pressuring the system above the limits it can safely withstand.

For example, danger of explosion in a vacuum system exists during backfilling from pressurized gas cylinders because many vacuum devices such as ionization gauge tubes, glass windows, glass belljars, etc., are not designed to be pressurized.

Install suitable devices that will limit the pressure from external gas sources to the level that the vacuum system can safely withstand. In addition, install suitable pressure relief valves or rupture disks that will release pressure at a level considerably below that pressure which the system can safely withstand.

Suppliers of pressure relief valves and pressure relief disks are listed in Thomas Register under "Valves, Relief", and "Discs, Rupture".

Confirm that these safety devices are properly installed before installing the 332 Ionization Gauge Controller (IGC). In addition, check that (1) the proper gas cylinders are installed, (2) gas cylinder valve positions are correct on manual systems, and (3) the automation is correct on automated systems.

Safety/Warning Notices

WARNING

Operation of the 332 Ionization Gauge Controller with line voltage other than that selected by the power supply line voltage selector can cause damage to the instrument and injury to personnel.

WARNING

It is the installer's responsibility to ensure that the automatic signals provided by the process control module are always used in a safe manner.

Carefully check manual operation of the system and the setpoint programming before switching to automatic operation. Where an equipment malfunction could cause a hazardous situation, always provide for fail-safe operation.

WARNING

Do not attach cables to glass gauge pins while the gauge is under vacuum. Accidental bending of the pins may cause the glass to break and implode. Cables, once installed, should be secured to the system to provide strain relief for the gauge tube pins.

WARNING

Safe operation of vacuum equipment, including the 332 Ionization Gauge Controller, requires grounding of all exposed conductors of the gauges and the Controller and the vacuum system. **LETHAL VOLTAGES** may be established under some operating conditions unless correct grounding is provided.

Ion producing equipment, such as ionization gauges, mass spectrometers, sputtering systems, etc., from many manufacturers may, under some conditions, provide sufficient electrical conduction via a plasma to couple a high voltage electrode potential to the vacuum chamber. If exposed conductive parts of the gauge, controller, and chamber are not grounded, they may attain a potential near that of the high voltage electrode during this coupling. Potential fatal electrical shock could then occur because of the high voltage between these exposed conductors and ground.

During routine pressure measurement, using ionization gauge controllers from any manufacturer, about 160V may become present on ungrounded conductors at pressures near 10^{-3} Torr. All isolated or insulated conductive parts of the controller, the gauge, and the vacuum system must be grounded to prevent these voltages from occurring.

Grounding

Grounding, though simple, is very important! Be certain that the ground circuits are correctly used on all ion gauge power supplies, gauges, and vacuum chambers, regardless of their manufacturer, for this phenomenon is not peculiar to MKS equipment. Refer to all Safety Instructions and Section 1.2, Installation, for additional information. If you have questions, or wish additional labels or literature, please contact one of our technical personnel.

Chapter 1

Series 332 Vacuum Gauge Controller

1.1 General Description

The 332 Vacuum Gauge Controller (VGC) measures pressure from less than 1×10^{-9} Torr (1.3×10^{-9} mbar or 1.3×10^{-7} Pa) to 1×10^{-3} Torr, air equivalent, using a standard Bayard-Alpert ionization gauge. Pressure readout is via a logarithmic analog voltage on the I/O connector.

The 332 VGC is a modular instrument intended for computer control only with no external controls or adjustments. Line voltage is fixed at 105-125 VAC, 50-60 Hz unless otherwise indicated on the front panel.

Available Options

Convectron Gauge Option

The 332 VGC can be ordered with a factory installed Convectron Gauge option which allows pressure reading in the range of 1×10^{-4} Torr to 1000 Torr.

1.2 Installation

Mounting Configurations

The 338 VGC should be mounted in a location with free air flow and ambient temperature less than 40 °C. When mounting, allow a 1" minimum air gap between units for cooling.

The 332 VGC can be mounted to a surface using the four 10-32 threaded inserts located on the end opposite the cables. See Figure 1-1. It may also be secured using "L" brackets attached under the screws to the cover. Up to three modules may be mounted on a 3-1/2" high by 19" long standard rack panel.

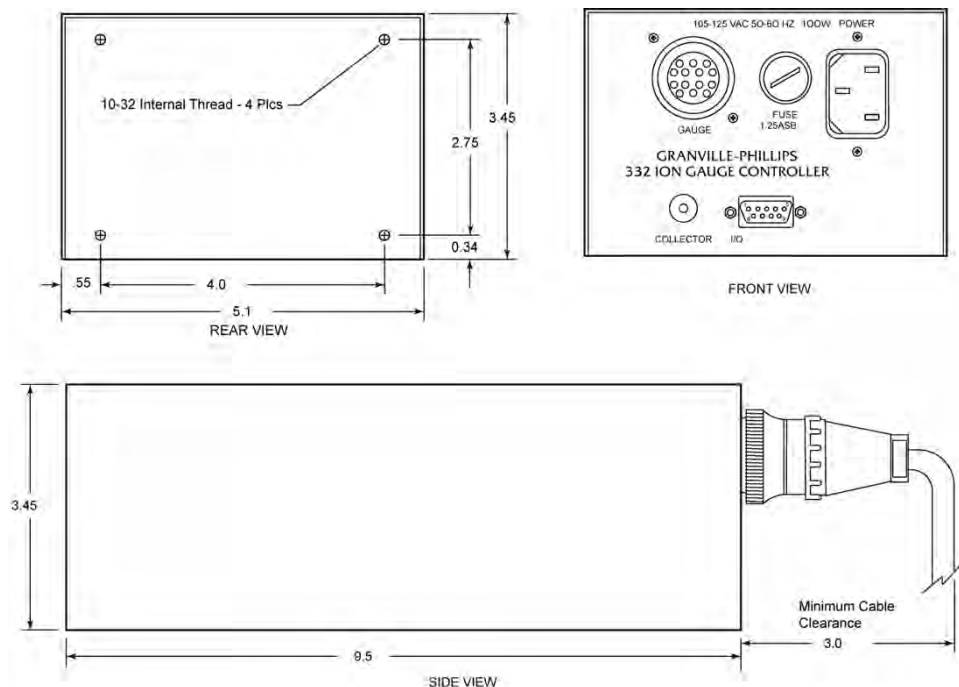


Figure 1-1 332 VGC Dimensions

Ionization Gauge Types and Installation

WARNING

Do not attach cables to glass gauge pins while the gauge is under vacuum. Accidental bending of the pins may cause the glass to break and implode. Cables, once installed, should be secured to the system to provide strain relief for the gauge tube pin.

The 332 VGC operates a Bayard-Alpert type or equivalent ionization gauge. Coated Iridium filament type gauges are recommended since at higher pressures they provide longer operating life and greater burnout resistance. When installing an ion gauge, note that if placed near the pump, the pressure in the gauge may be considerably lower than in the rest of the system. If placed near a gas inlet or source of contamination, the pressure in the gauge may be higher.

If an unshielded gauge is placed near an electron beam evaporation source or used in a sputtering system, spurious electrons or ions may disturb the measurement. Screens or other shielding should be placed between the gauge and the system if spurious charged particles or severe electromagnetic interference is present. Consideration should also be given to electrostatic shielding of glass tubulated gauges when measuring pressures near their x-ray limits.

MKS offers 2 cable types for use with the 332 VGC. One has a standard connector for the Series 274 tubulated gauge tubes. One has individual pin sockets for use with non-standard pin configurations as well as with MKS "nude" tubes. To use the second filament of a dual filament gauge, the cable connector at the gauge is removed and rotated 180°, then reinstalled.

Figure 1-2 shows typical tube base configurations used with the standard connector cables.

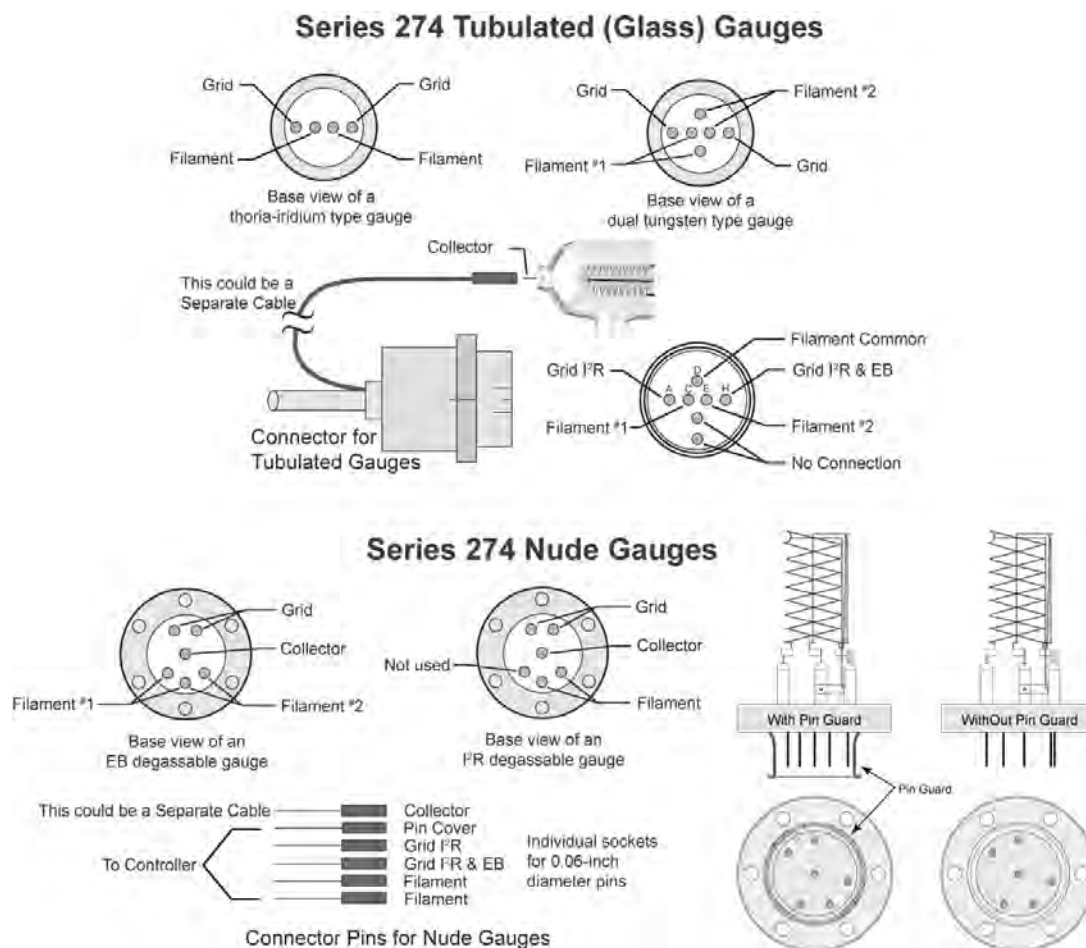


Figure 1-2 Standard B-A Gauge Configurations

Ion Gauge Cable Connections

The 9-pin “D” I/O connector is used to operate the Bayard-Alpert ionization gauge and output the analog voltage corresponding to pressure. See Table 1-1.

Pin	Function
1	Ion Gauge ON/OFF. A momentary ground (100 milliseconds minimum) will cause the filament circuit to change state. This can be either from an unpowered switch (or relay closure) or from a powered circuit which uses a pull up voltage of less than 50 Vdc.
2	Ground
3	Analog output
4	+12 Vdc (for test purposes only)
5	Degas Status. Open collector transistor (grounded emitter) rated at 40 V max VCE, 100 mA max. Transistor OFF = gauge OFF. Transistor ON = gauge ON.
6	Degas ON/OFF. Same operation as pin 1.
7	Ground
8	Emission current sense. Voltage proportional to emission current a Vdc = 1 mAdc, 110 ohms impedance. (Note: Grounding this pin will increase the emission current a factor of 10).
9	Ion Gauge Status. Same as degas status.

System Ground Test Procedure

Procedure: Physically examine the grounding of both the 338 VGC and the vacuum chamber. Is there an intentional heavy duty ground connection to all exposed conductors on the vacuum chamber? There should be. Note that a horizontal "O" ring or "L" ring gasket, without metal clamps, can leave the chamber above it electrically isolated. Power can be delivered to mechanical and diffusion pumps without any ground connections to the system frame or chamber. Water line grounds can be lost by a plastic or rubber tube interconnection. What was once a carefully grounded vacuum system can, by innocent failure to reconnect all ground connections, become a very dangerous device. Use the following procedure to test each of your vacuum systems which incorporate an ionization gauge.

This procedure uses a conventional volt-ohm meter (VOM) and resistor (10 ohm, 10 watt).

1. With the gauge controller turned off, test for both dc and ac voltages between the metal parts of the vacuum chamber and the power supply chassis.
2. If no voltages exist, measure resistance. The resistance should not exceed 2 ohms. Two ohms, or less, implies commonality of these grounds that should prevent the plasma from creating a dangerous voltage between them. This test does not prove that either connection is earth ground, only that they are the same. If more than 2 ohms is indicated, check with your electrician.

3. If ac or dc voltages exist and are less than 10 volts, shunt the meter with a 10 ohm, 10 watt resistor. Repeat the voltage measurement. With the shunt in place across the meter, if the voltage remains at 83% or more of the unshunted value, commonality of the grounds is implied. Repeat the measurements several times to be sure that the voltage ratio is not changing with time. If,

$$\frac{\text{Voltage}(\text{shunted})}{\text{Voltage}(\text{unshunted})} = .83 \text{ more,}$$

this should prevent the plasma from creating a dangerous voltage between these grounds. If more than 10 volts exists between grounds, check with your electrician.

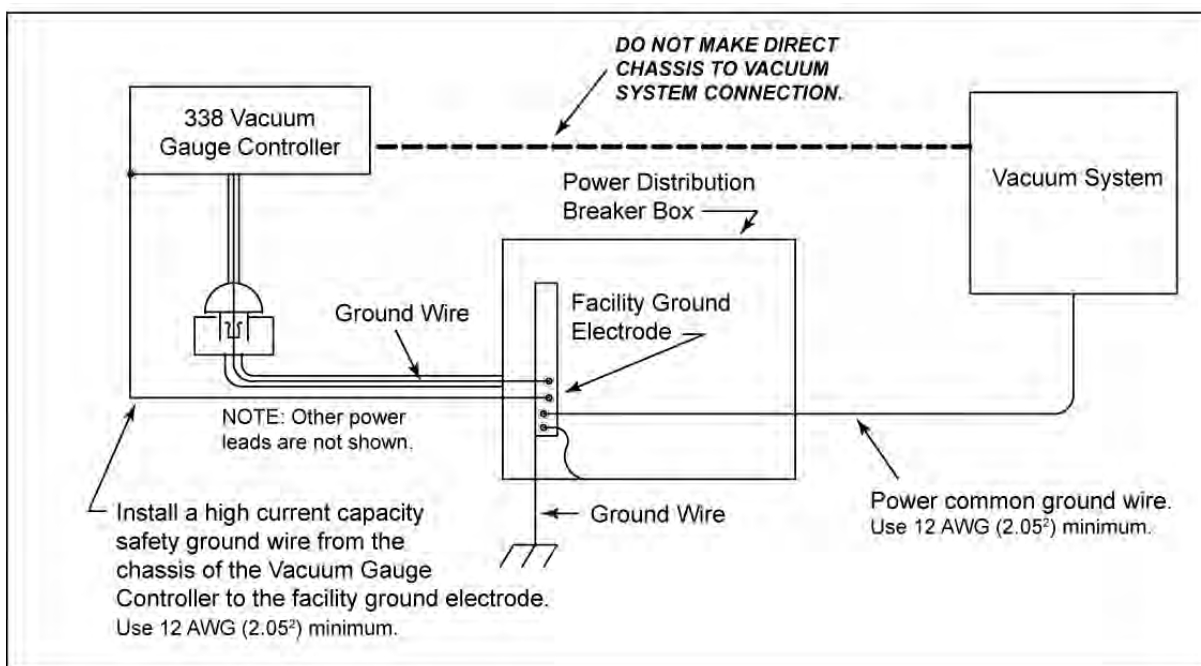


Figure 1-3 Correct System Grounding

4. If the voltage change in Step 3 is greater than 17%, due to the placement of the shunt, it complicates the measurement. The commonality of the grounds may be satisfactory and the coupling poor, or the commonality could be poor! Your electrician should be asked to check the electrical continuity between these two ground systems. The placement of a second ground wire, (dashed line in Figure 1.5), between the vacuum chamber and the VGC chassis is not a safe answer for large currents could flow through it. Professional help is recommended.

1.3 Operation

Ion Gauge Theory of Operation

The functional parts of a typical ionization gauge are the filament (cathode), grid (anode) and ion collector, which are shown schematically in Figure 1-9. These electrodes are maintained by the gauge controller at +30, +180, and 0 volts, relative to ground, respectively.

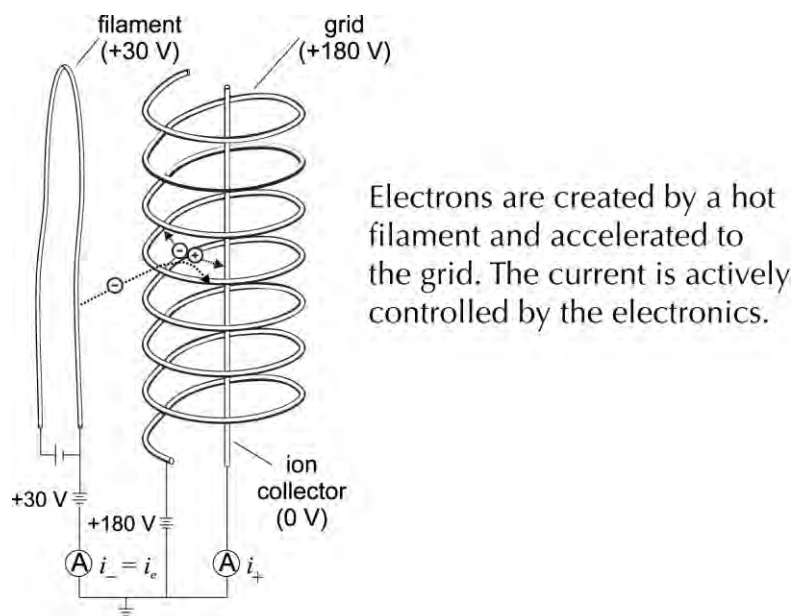


Figure 1-4 Ion Gauge Schematic

The filament is heated to such a temperature that electrons are emitted and accelerated toward the grid by the potential difference between the grid and filament. Most of the electrons eventually collide with the grid, but many first traverse the region inside the grid one or more times.

When an energetic electron collides with a gas molecule an electron may be dislodged from the molecule leaving it with a positive charge. Most ions are then accelerated to the collector. The rate at which electron collisions with molecules occur is proportional to the density of gas molecules, and hence the ion current is proportional to the gas density (or pressure, at constant temperature).

The amount of ion current for a given emission current and pressure depends on the ion gauge design. This gives rise to the definition of ion gauge "sensitivity", frequently denoted by "K".

$$K = \text{ion current} / (\text{emission current} \times \text{pressure})$$

Bayard-Alpert type gauges typically have sensitivities of 10/Torr when used with nitrogen or atmosphere. Sensitivities for other gases are given in Section 2-3.

The ion gauge controller varies the heating current to the filament to maintain a constant

electron emission and measures the ion current to the collector. The pressure is then calculated from these data.

Ion gauge degas is accomplished by resistance heating (I²R). During I²R degas a large current is passed through the grid structure raising its temperature and driving off contaminants. Some ion gauge tube designs do not allow I²R degas.

Emission Current Adjustment

The IGC has been factory calibrated at 1 mAdc emission current making it direct reading for N₂ using a gauge tube with a sensitivity of 10/Torr. The IGC also gives the same indication for air as for N₂ within the accuracy of the instrument. To make the IGC direct reading for other gauge tubes or for gases other than N₂ and air, use Eq. (1) to determine the correct emission current setting.

$$\text{Eq. 1} \quad i_e = \frac{.01}{(r)(\text{GaugeTubeSensitivityforN}_2)}$$

where r is given in Table 1-1.

Table 1-1

Gas	N ₂	He	Ne	Ar	Kr	Xe	H ₂
r	1	0.15	0.24	1.19	1.86	2.73	0.46

Ion gauge sensitivity ratios, r, derived from data obtained by S. Dushman and A. H. Young, Phys, Rev. 68 278 (1945).

Example 1

If your tube has a sensitivity of 25/Torr for N₂, then the emission current to make the controller direct reading for N is

$$i_e = \frac{.01}{1 \times 25} = .4mA$$

Example 2

If your tube has a sensitivity of 15/Torr for N₂ and you wish to measure argon pressure, the emission setting to make the controller direct reading for argon is

$$i_e = \frac{.01}{1.19 \times 15} = .56mA$$

Example 3

Assume you have a tube with a gauge sensitivity of 10/Torr for N₂ and wish to make the controller direct reading for helium. Here Eq. 1 is not applicable for it calls for an emission current beyond the capability of the controller.

In such a situation one possibility is to set the emission current at 1/10 of the emission called for by Eq. 1, i.e., .67 mA for the assumed case, and remember to increase the indicated reading by a factor of 10. Under these assumptions a reading of 5×10^{-6} Torr for helium corresponds to a pressure of helium of 5×10^{-5} Torr.

$$i_e = \frac{.01}{0.15 \times 10} = 6.67 \text{ mA}$$

Once the emission current requirement has been established it may be adjusted as follows:

1. Remove the cover from the 332 VGC and locate the I_e potentiometer.
2. Monitor the DC voltage at pin 8 of the I/O connector with respect to ground using a digital voltmeter.
3. The voltage at pin 8 is related to emission current by a factor of 1.0 Vdc being equal to 1.0 mAdc. Adjust the I_e pot for the desired voltage. The I_e range is from less than 0.1 mA to 1.2 mA.
4. For operation at low pressures, the emission current can be increased a factor of 10 by applying a ground (pin 2 or 7) to pin 8 of the connector. Since this will result in 10 times more collector current the analog output will increase 1.00 Vdc for a given pressure. This must be corrected for in the program. Note that the voltage at pin 8 can no longer be monitored as an indicator of emission current.

Analog Output

This signal is proportional to the logarithm of the pressure with 0 volts at 1×10^{-11} Torr at 1 mA emission or 1×10^{-12} Torr at 10 mA emission. When the ion gauge is turned OFF, the output will switch to slightly over +10 Vdc. See Figures 1-5 and 1-6.

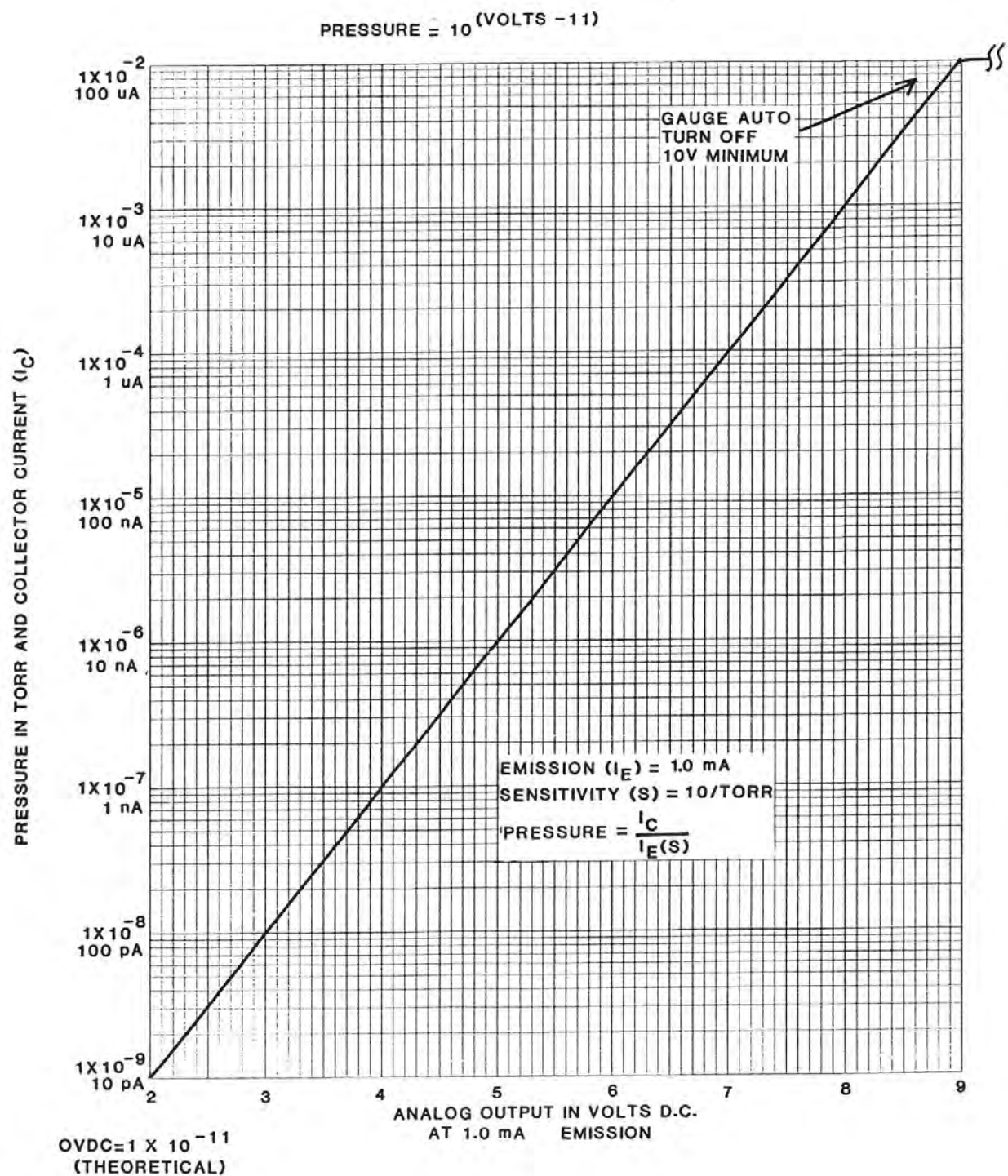


Figure 1-5 Analog Output in Vdc at 1.0 mA Emission

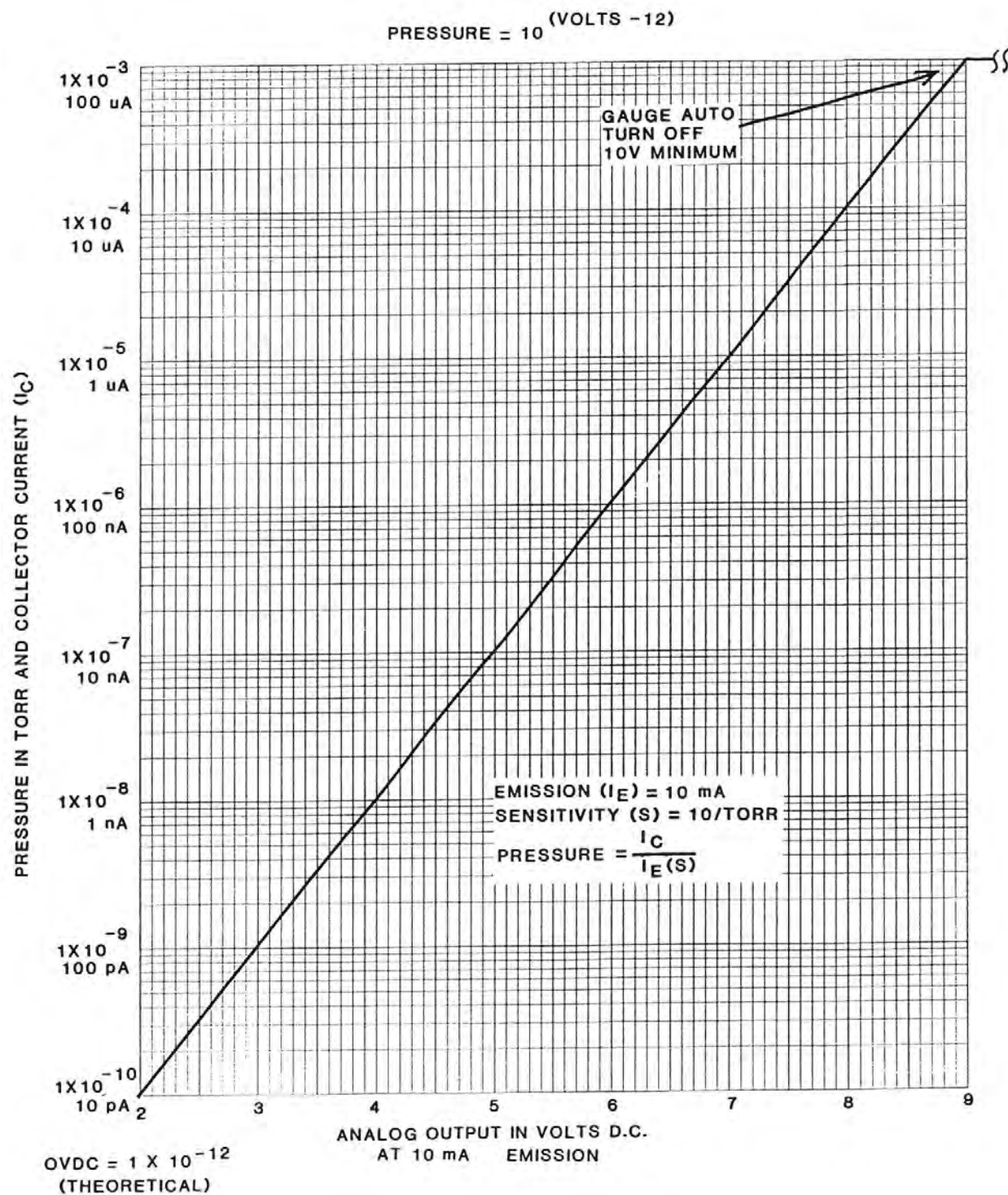


Figure 1-6 Analog Output in Vdc at 10 mA Emission

Overpressure Shutdown

The 332 VGC is preset by fixed component values to shut down the ion gauge should pressure rise above 1×10^{-2} Torr at 1 mA emission or 1×10^{-3} Torr at 10 mA emission.

Degas

Degassing of the ion gauge is accomplished by I^2R heating of the grid utilizing a separate winding of the transformer. Pressure reading during degas is allowable. To activate the degas circuit, the IG ON circuit must be first activated. This assures there is a vacuum in the system prior to degas. The degas circuit will turn OFF if the IG ON circuit is turned OFF.

When and how long to degas is a matter of user preference. In our experience, degas, when working with pressures higher than the 10^{-6} Torr range, is of little or no value. As pressure decreases from this point it becomes more necessary to read a true value of pressure. Generally, degassing for 5 minutes or less is satisfactory although it can be left on indefinitely without harm to the gauge tube or controller.

1.4 Calibration

Electrometer Zero

There is an internal zero adjust potentiometer which rarely, if ever, will require adjustment. Since this is a log type of circuit, which does not zero in a conventional manner, we recommend checking by disconnecting the collector cable input while the gauge is on and monitoring the analog output voltage. If it is below +2 Vdc, this indicates that the zero is below 1×10^{-9} Torr. Readings in the 10^{-9} Torr range could be effected a maximum of 10% of F. S., reading in the 10^{-8} Torr range 1% and so on. For further information refer to Step 3 of the following procedure.

Electrometer Log Amplifier

To calibrate the electrometer circuit you need a DVM with at least 4 digits resolution and a picoamp source such as the Keithley 220 programmable current source.

1. Electrometer offset adjustment

This adjustment creates an offset voltage which is the same for any input current. With an input current of 1×10^{-8} A, the offset adjustment can be done without effects from the zero or scale adjustments. Adjust the offset potentiometer, R33, for 5.00 V output.

2. Electrometer scale adjustment

The scale or gain adjustment sets the slope of the curve. Set the current source for 1×10^{-5} A and adjust the scale potentiometer, R33, for 8.00 V output.

3. Electrometer zero adjustment

The zero adjustment compensates for the current offset. It is difficult to get a true zero with this circuit because as the electrometer reading gets lower, the response time increases. The circuit also becomes more sensitive to changes in the zero adjustment as the output

approaches zero. For an accurate reading at very low pressures, set the current source for 1×10^{-11} A. Adjust the zero potentiometer, R19, for 2.00 V output. For a 10/Torr gauge, this will yield accurate results at 1×10^{-9} Torr with 1 mA emission. This adjustment can be made without a current source. With no input current, adjust the zero potentiometer, R19, for an output voltage at least 1 V lower than the lowest expected reading. This will yield less than +10% error in the lowest decade and decrease by a factor of 10 for each successive higher decade.

Summary

Input (A)	Adjustment	Output (Vdc)
1×10^{-8}	Offset (R33)	5.00
1×10^{-5}	Scale (R39)	8.00
1×10^{-11}	Zero (R19)	2.00

1.5 Specifications

Physical	
Width	5.1 inches
Height	3.5 inches
Depth	9.5 inches (allow 3 inches for cable connectors)
Weight	8.0 pounds
Electrical	
Voltage	105 to 125 VAC
Frequency	50 to 60 Hz
Power	100 watts max.
Fuse Ratings	Line fuse: 1.25A (90-130V), .60A (200-260V)
Mounting	Four threaded 10-32 holes on the bottom of the Controller. Can also use 4 (L) brackets same as furnished with a 307 power supply.
Environmental Temperature	0 °C to 40 °C
Pressure Range	Less than 1×10^{-8} Torr to 5×10^{-3} Torr with 1 mA emission and gauge sensitivity of 10/Torr. (Less than 1×10^{-9} Torr to 5×10^{-4} Torr at 10 mA emission.)
Emission Range	Normally set for 1 mA. Adjustable from .1 to 1.2 mA to correct for tubes with sensitivities between 8 and 100/Torr. External ground will switch set current one decade higher.
Pressure Analog Output	Logarithmic: 1 Vdc/decade. 0 volts = 1×10^{-11} Torr (theoretical) at 1 mA.
Filament & Degas Control	Momentary ground to input/output connector pins will cause the circuit to change state.
Degas	I ² R approximately 7 VAC, 8 A (56 watts). Pressure reading available during degas. Degas inoperative unless the gauge is

	on.
Ion Gauge & Degas Status	Open collector transistor rated at 40 V max. VCE, 100mA max., referenced to ground. Gauge OFF = transistor OFF. Gauge ON = transistor ON.
Ion Gauge	
Type	Bayard-Alpert
Collector Potential	0 V
Grid Potential	+180 Vdc
Filament Potential	+30 Vdc
Degas	I ² R: 8 Vac, 10 A maximum.
Maximum Cable Length	50 ft. with reduced degas power (16 AWG cable).
Convectron Gauge	
Gauge Type	MKS Series 275 ONLY
Pressure Range	1 x 10 ⁻⁴ Torr to 1000 Torr, N ₂ equivalent
Gas Type	Direct reading for N ₂ and Air
Log Output Resolution	2 significant digits, except for 1 significant digit in the 10 ⁻⁴ decade
Log Output Update Time	0.5 sec typical
Analog Output Loading	10 mA maximum current

Notes

Chapter 2

Convectron® Gauge Module

2.1 General Description

The Convectron Gauge Module provides pressure measurement from 1.0×10^{-3} Torr (1.3×10^{-3} mbar or 1.3×10^{-1} Pa) to 1000 Torr, and one meaningful digit pressure indication down to 1×10^{-4} Torr, air equivalent.

Analog output is also provided. The Convectron Gauge can also be used to automatically turn ON or OFF the ion gauge and the process control relays.

2.2 Safety Instructions

Explosive Gases

Do not use the gauge tube when there is danger of explosion from ignition of combustible gas mixtures. The sensing element normally operates at only 125 °C but it is possible that momentary transients or controller malfunction can raise the sensor above the ignition temperature of combustible mixtures, which may then explode, causing damage to equipment and injury to personnel.

Limitation of Use of Compression Mounts

Do not use a compression mount (quick connect) for attaching the Convectron Gauge to the system in applications resulting in positive pressures in the gauge. Positive pressures might blow the gauge out of a compression fitting and damage equipment and injure personnel. The Convectron Gauge should not be used above 1000 Torr (1333 mbar or 1.33×10^5 Pa).

Convectron Gauge Mounting Position

If the Convectron Gauge will be used to measure pressures greater than 1 Torr or 1 mbar, the gauge must be mounted with its axis horizontal. Although the gauge will read correctly below 1 Torr when mounted in any position, erroneous readings will result at pressures above 1 Torr if the gauge axis is not horizontal. Erroneous readings can result in over or under pressure conditions which may damage equipment and cause injury to personnel.

Overpressure Conditions

Convectron Gauges should not be used above 1000 Torr true pressure. Series 338 Vacuum Gauge Controllers are furnished calibrated for N₂. They also measure the pressure of air correctly within the accuracy of the instrument. Do not attempt to use a Convectron Gauge calibrated for N₂ to measure or control the pressure of other gases such as argon or CO₂, unless accurate conversion data for N₂ to the other gas is properly used. If accurate conversion data is not used or improperly used, a potential overpressure explosion hazard can be created under certain conditions.

For example, at 760 Torr of argon gas pressure, the indicated pressure on a Convectron Gauge calibrated for N₂ is 24 Torr. At an indicated pressure of 50 Torr, the true pressure of

argon is considerably above atmospheric pressure. Thus, if the indicated pressure is not accurately converted to true pressure, it is possible to over-pressure the vacuum system. Over-pressure may cause glassware such as ionization gauges to shatter dangerously, and if high enough may cause metal parts to rupture, thus damaging the system and possibly injuring personnel. See Section 3.3 for proper use of conversion data.

A pressure relief valve should be installed in the system should the possibility of exceeding 1000 Torr exist.

High Indicated Pressure

For some gases, be aware the indicated pressure will be higher than the true pressure. For example, at a true pressure of 9 Torr for helium, the indicated pressure on a Convectron Gauge calibrated for N₂ is 760 Torr. The safe way to operate the gauge is to properly use accurate conversion data. See Section 3.3 for proper use of conversion data.

Chemicals

Cleaning solvents, such as trichloroethylene, perchloroethylene, toluene and acetone, produce fumes that are toxic and/or flammable. Use them only in areas well ventilated to the outdoors and away from electronic equipment, open flames, or other potential ignition sources.

Sensor Failure

If the Convectron Gauge becomes disconnected from the 338 Controller or if the sensor wire in the gauge fails, the Controller will indicate 9.9+9. If the gauge is unplugged from a powered Controller, there may be an instantaneous (0 to 0.2 seconds) drop in the pressure indication and the process control relay could activate for this brief time, depending on the order in which the gauge pins break contact.

Tube Contamination

The calibration of the gauge will be seriously affected by any gas which will attack the gold-plated sensor and could result in over pressurizing the system. Two primary gases in this category are mercury vapor and fluorine.

2-3 Convectron Gauge Theory of Operation

The Convectron transducer is represented in Figure 1-10 as R1, R2, R3, and R4. These four resistances form the legs of a bridge circuit, with R1 designating the sensor wire of the transducer. R2 is a resistive network in the tube which compensates for changes in the ambient temperature. At bridge null, $R1=R2 \times R3/R4$. If there are no changes in ambient temperature, the value of R1 is a constant and the bridge is balanced.

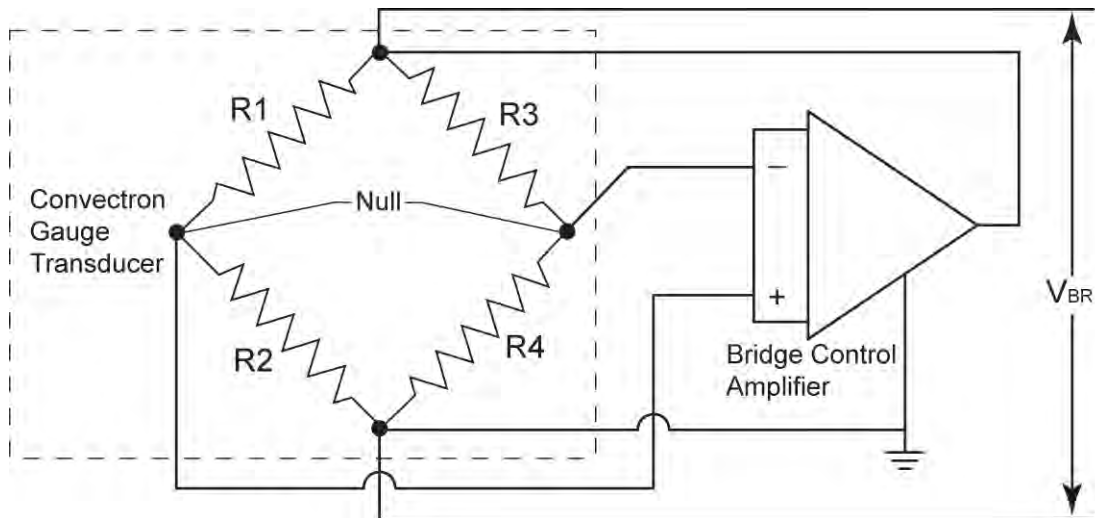


Figure 2-1 Simplified Schematic Convectron Gauge Module

As the vacuum system pressure is decreased, there are fewer molecules in the system to conduct the heat away from the sensor wire causing the temperature and resistance of R1 to increase. The increased resistance of R1 causes the bridge to unbalance and a voltage is developed across the null terminals. The bridge control circuit senses the null voltage and decreases the voltage across the bridge until the null voltage is again zero. When the bridge voltage is decreased, the power dissipated in the sensor wire is decreased causing the resistance of R1 to decrease to its previous value. The opposite events happen for a pressure increase. The bridge voltage is a non-linear function of pressure.

All materials have been chosen for ultra high vacuum service, corrosion resistance and bakeability to 150 °C. The gauge tube envelope is type 304 stainless steel. All metallic joints in the envelope are TIG welded. No solder is used within the envelope. The following materials are exposed to the vacuum. Type 304 stainless steel, Carpenter Alloy 52, Kovar®, Kapton®, gold plated tungsten, borosilicate glass and Dow-Corning 9015 glass. The blue trim cover is molded of Ultem® polyetherimide resin suitable for service above 150 °C.

2.4 Convectron Gauge Installation

Important Precautions for Gauge Installation

The following precautions for installation and use of the Convectron Gauge must be followed:

1. Observe the precautions at the front of this chapter regarding the gauge mounting position and high pressure operation.
2. It is recommended that the gauge be installed with the port oriented vertically downward to ensure that no system condensates or other liquids collect in the gauge. It is not necessary, however, from a performance standpoint.
3. Keep the gauge clean; **Do not** remove the mounting port cover until you are ready to

- install the gauge.
4. **Do not** mount the gauge in a manner such that deposition of process vapors upon the internal surfaces of the gauge may occur through line-of-sight access to the interior of the gauge.
 5. **Do not** install the gauge where high amplitudes of vibration are present. Excessive vibration will cause forced convection at high pressure giving erroneous readings.
 6. **Do not** bake the gauge to temperatures above 150 °C.
 7. **Do not** install the gauges where they will be exposed to corrosive gases such as mercury vapor, chlorine, or fluorine, which will attack the gold-plated sensor.
 8. For greatest accuracy and repeatability the gauge should be located in a stable room temperature environment.

Convectron Gauge Orientation

It is important to consider the orientation of the gauge tube if accurate readings above 1 Torr are desired.

Below 1 Torr: The gauge tube will operate and accurately read pressures below 1 Torr when mounted in any orientation.

Above 1 Torr: The gauge tube will accurately read pressures above 1 Torr only when mounted with its axis horizontal, preferably with the port pointing vertically downward, as shown in Figure 3-2. Mounting the gauge with the port downward facilitates the removal of condensation and other contaminants.

Furthermore, the gauge is factory calibrated with the port pointing vertically downward. Installation of the gauge with the port in other orientations may affect the accuracy of the indicated pressure.

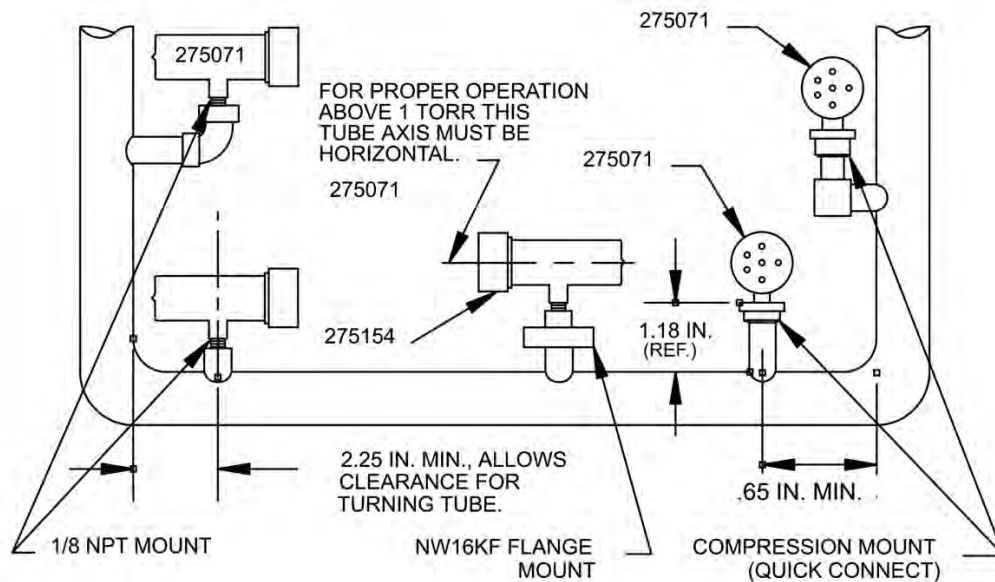


Figure 2-2 Convectron Gauge Mounting

Compression Mount (Quick Connect)

- Do not use for positive pressure applications.
- The gauge port is designed to fit a standard 1/2 in. compression (quick connect) mount such as the Cajon® Ultra-Torr® fittings.
- Remove the caplug from the gauge port, insert the gauge port into the compression fitting and finger tighten the press ring. If a seal is not achieved it may be due to extreme cleanliness of the O-ring. A light film of vacuum grease will ensure sealing and is normally preferable to the use of pliers or pipe wrench to further tighten the press ring. You may point the electrical pins of the gauge tube anywhere you wish in a 360 degree horizontal circle for optimum routing of the gauge interconnect cable.

1/8 NPT Mount

- The threads on the gauge port will fit a standard 1/8 NPT female fitting. Wrap the threads of the gauge tube port with thread sealant tape and screw these threads into the system fitting hand tight. Do not use any wrench or tool. The gauge body functions adequately as its own wrench. Tighten only sufficiently to achieve a seal. After this, one-half turn additional tightening is all that can be gained without over-stressing the gauge port.

NW10, 16, 25 and 40KF Flange Mount

- The KF mounting system requires an O-ring and centering ring to be placed between the mating flanges. The flanges are then held together with the aluminum flange clamp by tightening the wing nut. Maximum pressure for this style mounting system is 1000 Torr absolute.

Gauge Cable Connections

The 332 Convector gauge is designed to operate using standard Convector cables from MKS Series 316 product line. These are available in standard lengths of 10, 15 and 50 ft. and as a variable length with a maximum of 500 feet. This cable provides the connections to power the gauge tube. In addition, it will be necessary to provide the analog output cable for your application.

Pin No.	Function
1	Analog output (logarithmic)
2	Ground (shield)
14	Analog output (nonlinear)
9 & 15	Ground (signal)

For short lengths in a low noise environment a two-lead cable is satisfactory. For long runs and/or a noisy environment this cable should be shielded.

2.5 Operation

Special Considerations for Use Below 10^{-3} Torr

During a fast pumpdown from atmosphere, thermal effects will prevent the Convectoron Gauge from tracking pressure rapidly below 10^{-3} Torr. After about 15 minutes readings in the 10^{-4} range will be valid and response will be rapid. Calibration at vacuum may be performed at this time, or sooner if readings in the 10^{-4} range are not needed.

The 10^{-4} Torr range is accurate to about 0.1 milliTorr provided the instrument has been carefully zeroed at vacuum. See Section 3.4 for vacuum and atmosphere calibration procedures. For accurate use in the 10^{-4} Torr range, zeroing should be repeated frequently. Pressure readings in the 10^{-4} Torr range may differ from those found from ion gauges, since ion gauges usually lose sensitivity near their upper pressure limits.

Use with Gases other than N_2 and Air

Before using the Convectoron Gauge to measure the pressure of other gases make certain the ATM adjustment is correctly set for air. See Section 3.4.

It is important to understand that the indicated pressure on a Convectoron Gauge depends on the type of gas in the gauge, and on the orientation of the gauge axis as well as on the gas pressure in the gauge. Convectoron Gauges are supplied calibrated for N_2 within the accuracy of the instrument. With certain safety precautions, the Convectoron Gauge may be used to measure pressure of other gases.

Convectoron Gauges are thermal conductivity gauges of the Pirani type. These gauges transduce gas pressure by measuring the heat loss from a heated sensor wire maintained at constant temperature. For gases other than N_2 and air the heat loss is different at any given true pressure and thus the indicated reading will be different.

Indicated vs. True Pressure Curves

Figures 2-3, 2-4, and 2-5 show the true pressure vs. indicated pressure on Series 332 Controllers for eleven commonly used gases. The following list will help to locate the proper graph for a specific application:

Figure	Range and Units	Gases
2-3	1 to 100 mTorr	All
2-4	0.1 to 1000 Torr	Ar, CO ₂ , CH ₄ , Freon 12, He
2-5	0.1 to 1000 Torr	D ₂ , Freon 22, Kr, Ne, O ₂

A useful interpretation of these curves is, for example, that at a true pressure of 2×10^{-2} Torr of CH₄, the heat loss from the sensor is the same as at a pressure of 3×10^{-2} Torr of N_2 (see Figure 2-3). The curves at higher pressure vary widely from gas to gas because the thermal losses at higher pressures are greatly different for different gases.

The Convectoron Gauge uses convection cooling to provide resolution superior to any other thermal conductivity gauge near atmospheric pressure of N_2 and air. Because convection effects are geometry dependent, the true pressure vs. indicated pressure curves for the Convectoron Gauge are likely to be much different from curves for heat loss tubes made by

others. Therefore, *it is not safe to attempt to use calibration curves supplied by other manufacturers for their gauges with a Convectron Gauge; nor is it safe to use curves for the Convectron Gauge with gauges supplied by other manufacturers.*

If you must measure the pressure of gases other than N₂ or air, use Figures 2-3 through 2-5 to determine the maximum safe indicated pressure for the other gas as explained below.

Example 1 Maximum Safe Indicated Pressure.

- Assume a certain system will withstand an internal pressure of 2000 Torr or 38.7 psia. For safety you wish to limit the maximum internal pressure to 760 Torr during backfilling. Assume you wish to measure the pressure of argon. On Figure 2-4 locate 760 Torr on the left hand scale, travel to the right to the intersection with the argon (Ar) curve and then down to an indicated pressure of 24 Torr (N₂ equivalent). Thus, in this hypothetical situation the maximum safe indicated pressure for argon is 24 Torr.
- For safety, it is prudent to place a warning label on the instrument face which, under the assumed conditions, would read *"DO NOT EXCEED 24 TORR FOR ARGON."*

Example 2 Indicated to true pressure conversion.

- Assume you wish to determine the true pressure of argon in a system when the Convectron Gauge is indicating 10 Torr. On Figure 2-4, read up from 10 Torr (N₂ equivalent) indicated pressure to the argon curve and then horizontally to the left to a true pressure of 250 Torr. Thus 250 Torr argon pressure produces an indication of 10 Torr, (N₂ equivalent).

Example 3 True to indicated pressure conversion.

- Assume you wish to set a process control set point at a true pressure of 20 Torr of CO₂. On Figure 2-4, locate 20 Torr on the true pressure scale, travel horizontally to the right to the CO₂ curve and then down to an indicated pressure of 6 Torr (N₂ equivalent). Thus, the correct process control setting for 20 Torr of CO₂ is 6 Torr (N₂ equivalent).

Example 4 True to indicated pressure conversion.

- Assume you wish to obtain a helium pressure of 100 Torr in the system. On Figure 2-4, locate 100 Torr on the left hand scale, travel horizontally to the right to attempt to intersect the He curve. Because the intersection is off scale it is apparent that this true pressure measurement requirement for helium exceeds the capability of the instrument.

For gases other than those listed, the user must provide accurate conversion data for safe operation. *The Convectron Gauge is not intended for use above 1000 Torr true pressure.*

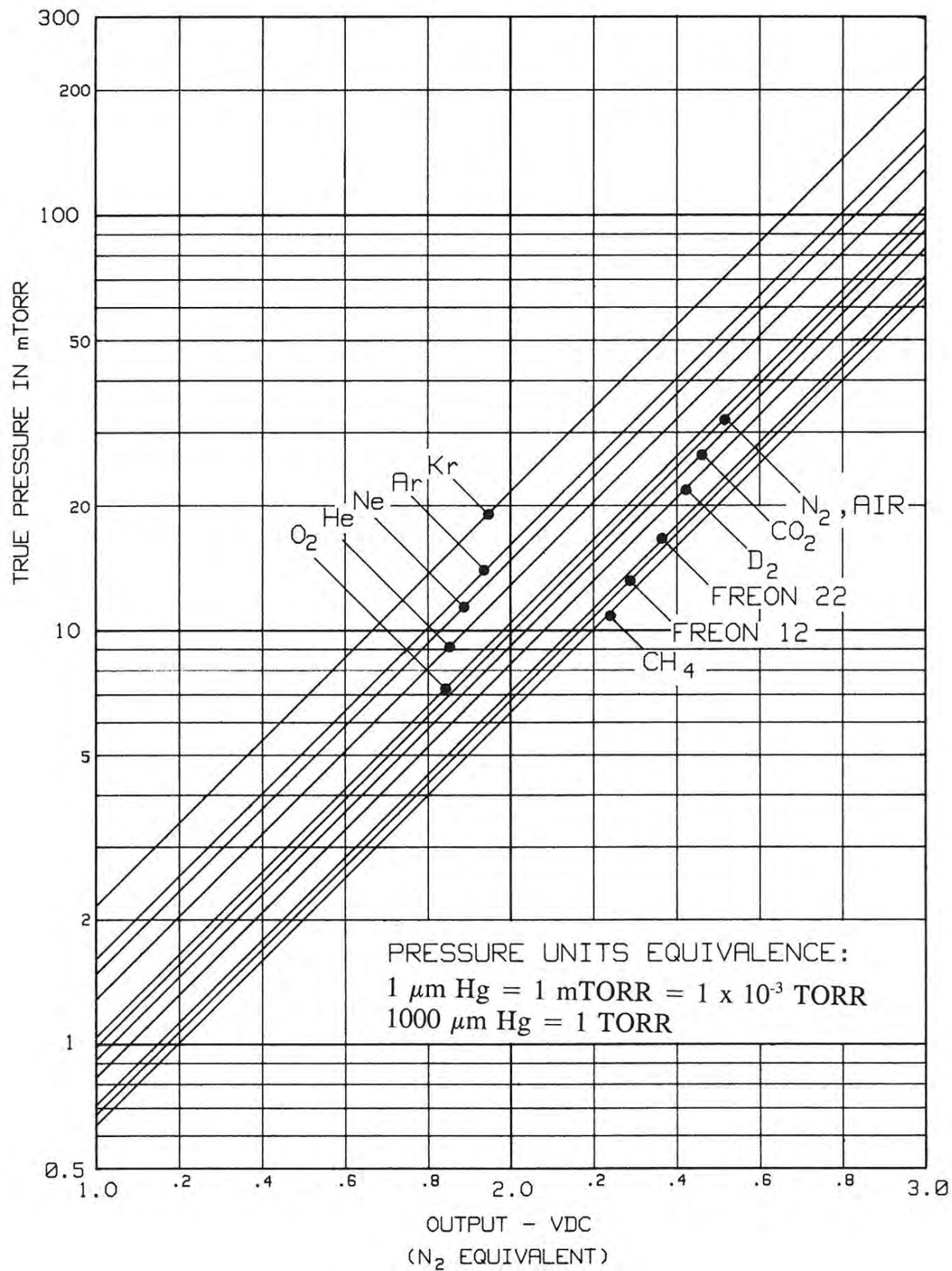


Figure 2-3 True Pressure vs. Indicated Pressure for Commonly used Gases: 10^{-4} to 10^{-1} Torr

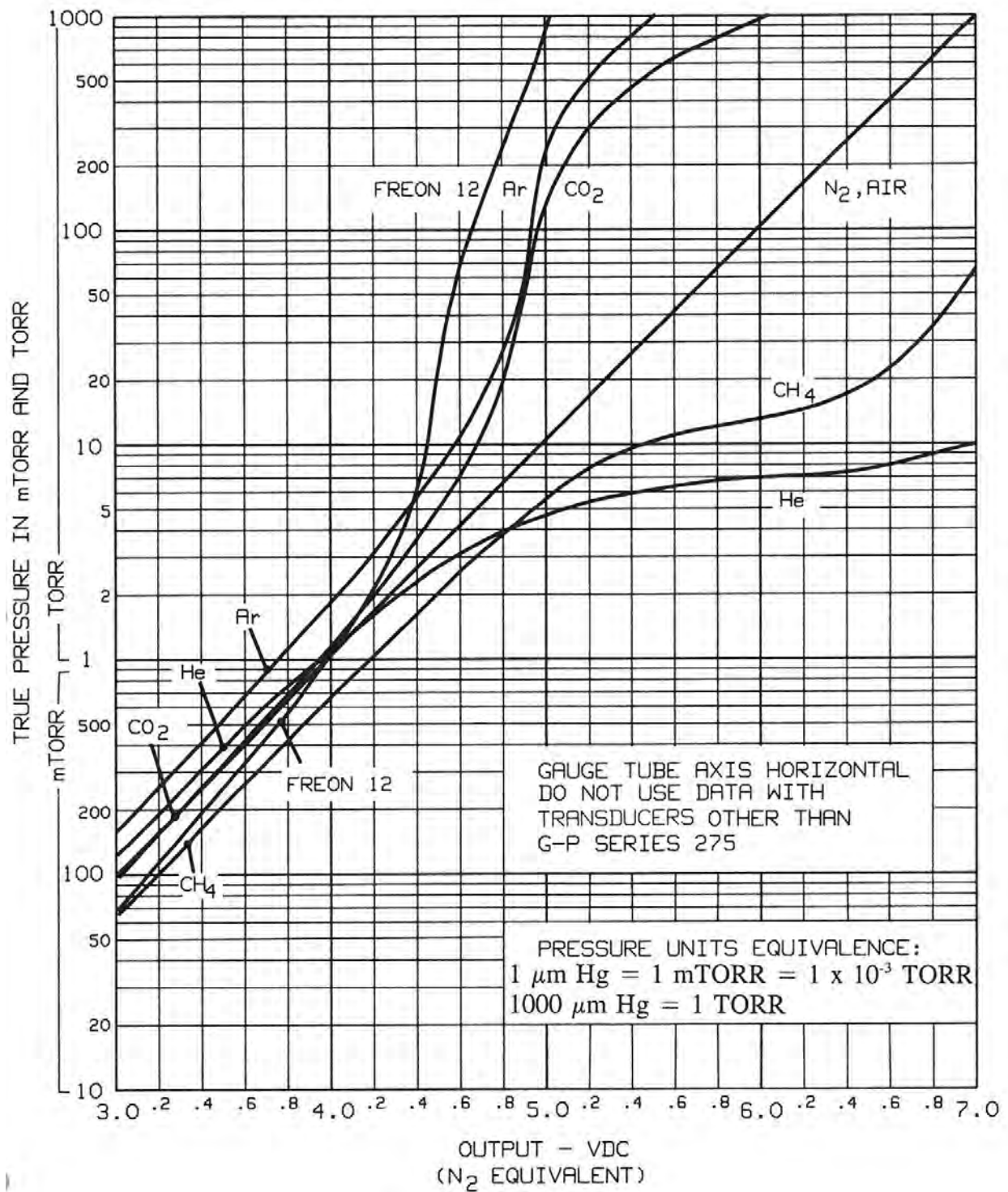


Figure 2-4 True Pressure vs. Indicated Pressure for Commonly used Gases: 10^{-1} to 1000 Torr

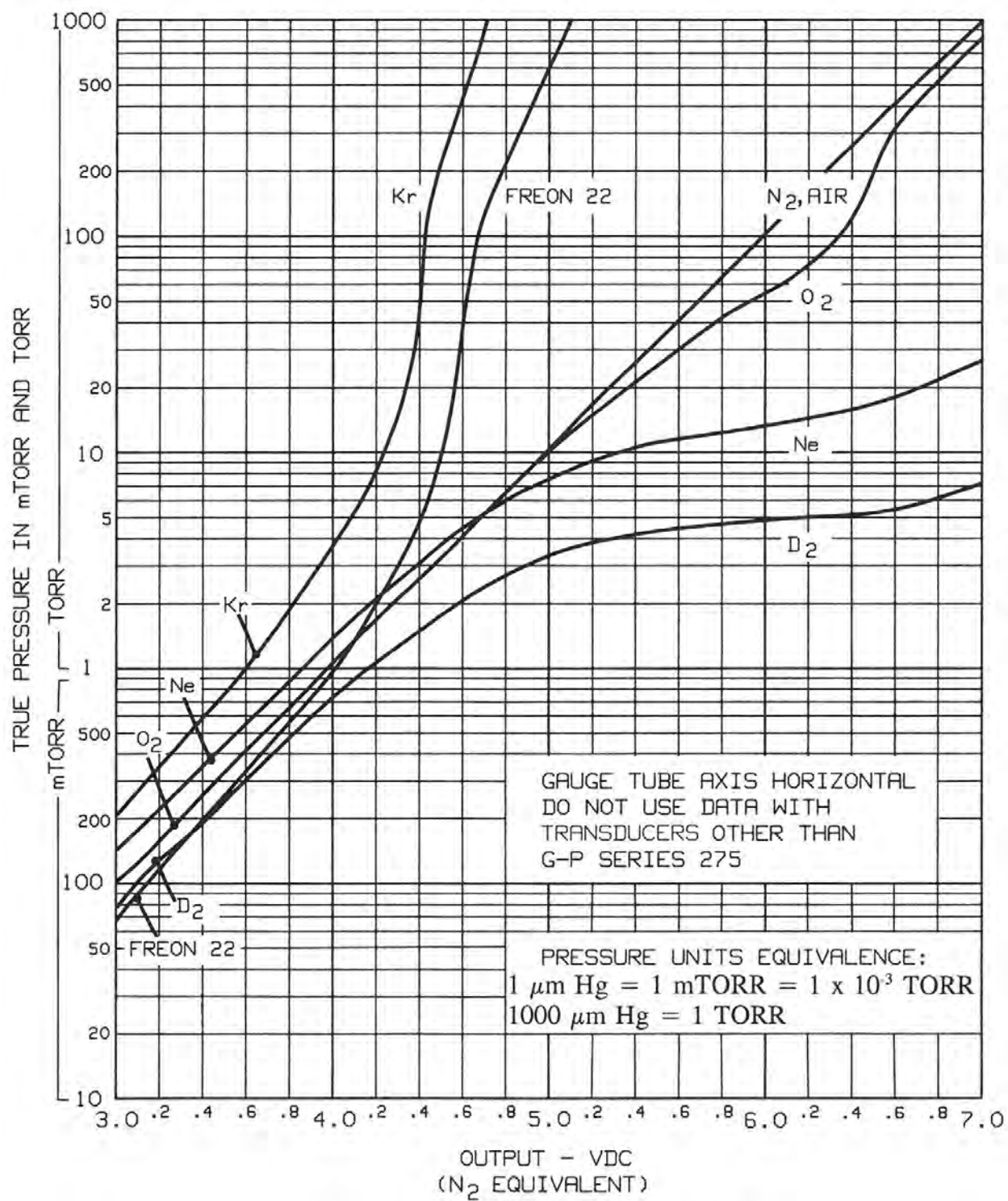


Figure 2-5 True Pressure vs. Indicated Pressure for Commonly used Gases: 10^{-1} to 1000 Torr

Analog Output (Logarithmic)

An analog output jack is provided on the rear panel. This is a DC voltage proportional to the logarithm of the pressure, scaled to 1 volt per decade: 0 volts = 1×10^{-4} or less, Torr or mbar, 1 volt = 1×10^{-3} , etc.

Internal offset adjustments are provided which allow a shift in the analog output at 10^{-4} Torr away from 0 volts to anywhere in the range -7 to +1V. This adjustment does not affect the slope of the analog output vs pressure curve.

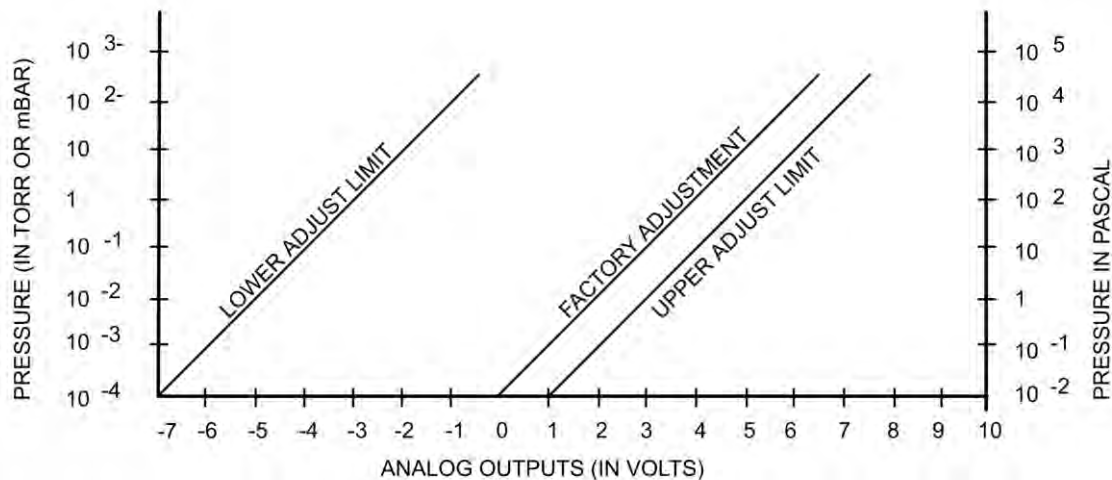


Figure 2-6 Convectron Gauge Pressure Logarithmic Output

The analog output is from a D/A converter and is not truly continuous but is a series of discrete steps which follow the equation of $V = 4 + \log_{10} \text{Pressure}$, or, $\text{Pressure} = 10^{(V-4)}$, assuming 1×10^{-4} Torr is set at 0 Vdc.

Since the resolution in the 10^{-4} Torr range is single digit, the increments will be the greatest. All other decades have two-digit resolution resulting in smaller steps.

Analog Output (Non linear)

The nonlinear analog output signal is the output of the bridge which is normally .375 Vdc to 5.659 Vdc, conditioned to produce 0.00 Vdc to 2.00 Vdc. This output cannot be precisely set since the same external adjustment potentiometer which affects this output is also used to calibrate the A/D converter. See Figure 2-7.

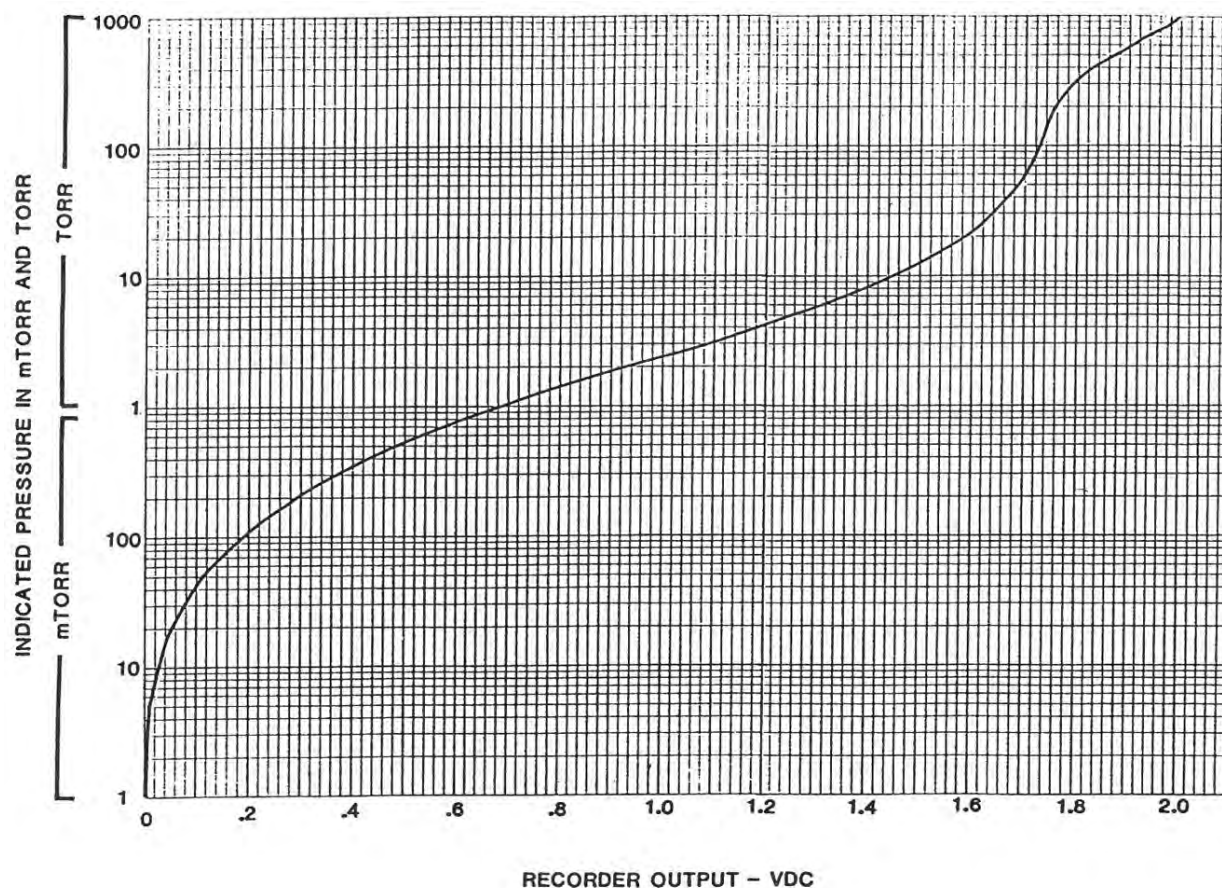


Figure 2-7 Convectron Gauge Pressure Nonlinear Output

2.6 Calibration

Each Convectron Gauge is individually calibrated for N_2 and air prior to shipment from the factory. The Convectron Gauge itself has a temperature compensated design. Each 332 Controller is also individually calibrated to provide accurate readout of N_2 and air pressure with any calibrated Convectron Gauge. Therefore, initial calibration should not be necessary. See Section 2.5 for use with gases other than N_2 or air.

Calibration should be performed if (1) accurate readings in the 10^{-4} Torr range are desired, (2) the Convectron Gauge becomes contaminated, (3) the Convectron Gauge does not read correctly, or (4) to readjust for use with long cables. The Gauge and Controller can be calibrated as a system by performing the following steps:

Zero Adjustment

1. Evacuate the system to a pressure less than 1×10^{-4} Torr.
2. With the Convectron Gauge operating, adjust the VAC potentiometer clockwise until the log output reads greater than 0.0 Vdc. Then rotate the pot counter-clockwise until the log output reading does not change as the pot is rotated. Do not rotate the pot past this point.

Atmosphere Adjustment

1. Allow the system pressure to rise to atmospheric pressure of N₂ or air.
2. Adjust the ATM potentiometer until the log output voltage agrees with the absolute pressure as read on an accurate barometer. Use absolute pressure, not corrected to sea level.

NOTE:

1 atmosphere normal at sea level = 7.6×10^2 Torr = 6.88 Vdc,
assuming 1×10^{-4} Torr = 0.0 Vdc.

Full Scale Adjustment (Internal)

Slight adjustment calibrates the span of the analog output voltage to the factory setting of 1.0 volt per decade. This adjustment is rarely ever required.

Zero Adjustment (Internal)

The zero adjustment potentiometer provide an adjustable offset voltage to the analog output. The range of this adjustment allows setting the analog output vacuum ($P = 1 \times 10^{-4}$ Torr) anywhere in the range of -7 to +1 volt.

The factory calibration of the internal zero and full scale potentiometers is established by adjusting the zero pot to yield 0.0 volt output when the gauge is at a pressure of 1×10^{-4} Torr, then adjusting the full scale pot to increase 1 volt for each decade the pressure increase.

Chapter 3

Service/Maintenance

3.1 General Description

It is recommended that only qualified technical personnel attempt repairs.

If difficulties are encountered with the Convectron Gauge, the following list of symptoms and possible causes which can assist in quickly getting back into operation.

If the prescribed remedies do not correct the troubles, or if additional assistance or special parts are required, contact the MKS Technical Service Department, Phone: +1-833-986-1686, or email: insidesales@mksinst.com.


This following list of symptoms and possible causes is not complete but should be sufficient to solve most problems. *All possible causes of failure should be thoroughly explored before attempting any repair.*

Repairs properly made with equivalent electronic parts and rosin core solder, which do not damage other portions of the unit, do not represent a violation of the warranty.

- Use a grounded, conductive work surface.
- Use static dissipative envelopes to store or ship printed circuit boards.
- *Do not* handle the printed circuit board more than absolutely necessary, and only when wearing a ground strap.
- *Do not* use an ohmmeter for troubleshooting the electronics. Rely on voltage measurements.
- Use grounded-type soldering irons only.

3.2 Troubleshooting

General Symptoms/Possible Causes

Symptom	Possible Causes
No power indication	No input power. Check to be sure the Convectron Gauge interconnect cable is properly attached to the gauge and the controller, and that the cable is not damaged.
Bridge analog output voltage reads less than +0.22 Vdc or greater than +10 Vdc	<p>Gauge tube failure. Test for gauge tube failure. Measure the resistance between the following terminals with the gauge at atmospheric pressure and an ohmmeter which cannot apply more than 10 mA.</p>  <p> Pins 1 to 2: 18 to 23 ohms Pins 2 to 3: 50 to 60 ohms Pins 1 to 5: 180 to 185 ohms If the resistance from pins 1 to 2 reads about 800 ohms, the sensor wire in the gauge is broken. Replace the gauge tube. <i>Note: If the resistance values shown here are correct, but you still think the gauge is not reading correctly, the gold plating on the sensor wire may be eroded and the gauge will have to be replaced.</i> </p>
Readout indicating a pressure in the system is vastly different than that being observed by supporting gauges.	<p>Gas composition on system is not what the user believes it to be. This can be caused by selective gas pumping, process in use, outgassing of product, etc. Determine the gas composition and calibrate accordingly.</p> <p>If the gauge is contaminated with material from the vacuum system, clean or replace the gauge.</p>

Convectron Gauge Bakeout Procedure

The Convectron Gauge can be baked to 150 °C. Measure the temperature at the mounting flange of the Convectron Gauge.

After the system has cooled down, reassemble the electronics and connect the cable(s).

Cleaning a Convectron Gauge

When the small sensor wire is contaminated with oil or other films, its emissivity or its diameter may be appreciably altered and a change of calibration will result. Cleaning with trichloroethylene, perchloroethylene, toluene, or acetone is possible but it must be done very carefully to avoid damaging the sensor.

WARNING

The fumes from solvents such as trichloroethylene, perchloroethylene, toluene, and acetone can be dangerous to health if inhaled. Only use these solvents in well ventilated areas exhausted to the outdoors. Acetone and toluene are highly flammable and should not be used near an open flame or energized electrical equipment.

Hold the gauge with the main body horizontal and the port projecting upward at a 45° angle.

Slowly fill the port with solvent using a standard wash bottle with the spout inserted in the port to the point where it touches the screen. Let the solvent stand in the gauge for at least ten minutes. *Do not shake the gauge.* Shaking the gauge with liquid inside can damage the sensor wire.

To drain the gauge, position it horizontally with the port facing downward.

Allow the gauge to dry overnight with the port vertically downward and uncapped. Before re-installing the gauge on the system, be certain no solvent odor remains.

If the gold plating on the sensor has been attacked by a gas such as fluorine or mercury vapor, changing its emissivity and/or resistance, replace the gauge tube. Cleaning cannot solve this problem.

Technical Support and Service

Some minor problems are readily corrected on site. If the product requires service, contact the MKS Technical Support Department: Phone: +1-833-986-1686, or email: insidesales@mksinst.com.

If the product must be returned to the factory for service, request a Return Material Authorization (RMA) from MKS. Do not return products without first obtaining an RMA. In some cases, a hazardous materials disclosure form may be required. The MKS Customer Service Representative will advise you if the hazardous materials document is required.

When returning products to MKS, be sure to package the products to prevent shipping damage. Shipping damage on returned products as a result of inadequate packaging is the Buyer's responsibility.

For Customer Service / Technical Support:

MKS Corporate Headquarters

MKS Instruments, Inc.
2 Tech Drive, Suite 201
Andover, MA 01810 USA
Phone: +1-833-986-1686
Email: insidesales@mksinst.com

Series 332

Series 332 Ionization Gauge Controller

This Instruction Manual is for use with all 332 Ionization Gauge Controllers.



Customer Service / Technical Support:

MKS Global Headquarters

2 Tech Drive, Suite 201

Andover MA, 01810 USA

Phone: +1-833-986-1686

Email: insidesales@mksinst.com

Visit our website at www.mksinst.com

Instruction Manual

Instruction manual part number 332004

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