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Series 352

Granville-Phillips® Series 352
Vacuum Gauge Controller with DeviceNet™



Instruction Manual

Instruction manual part number 352004
Revision A - January 2015


SETPOINT ADJUST
SETPOINT
MODULE STATUS
ZERO
NETWORK STATUS
MAC ID
DATA RATE
125 Kb
250 Kb
500 Kb
PGM
MSD
LSD
DeviceNet
POWER
GRANVILLE-PHILLIPS
352 GAUGE CONTROLLER
CG1
CG2
CG3
ION GAUGE

Series 352

Granville-Phillips® Series 352 Vacuum Gauge Controller with DeviceNet™

This Instruction Manual is for use with Granville-Phillips Series 352 Vacuum Gauge Controllers with DeviceNet. A list of applicable catalog numbers is provided on the following page.

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Instruction Manual

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Granville-Phillips® Series 352 Controller with DeviceNet™

Catalog numbers for Series 352 Controllers with DeviceNet

This Instruction Manual is for use with the following catalog numbers:

352001	Controller calibrated for use with an Ultra High Vacuum Stabil-Ion Gauge
20352007	Controller calibrated for use with an Extended Range Stabil-Ion Gauge
352016	Controller calibrated for use with an Ultra High Vacuum Stabil-Ion Gauge (discontinued)
352017	Controller calibrated for use with an Ultra High Vacuum Stabil-Ion Gauge
352018	Controller calibrated for use with an Ultra High Vacuum Stabil-Ion Gauge
352019	Controller calibrated for use with an Ultra High Vacuum Stabil-Ion Gauge with 352020 attached

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1.1 Safety Introduction

BEGIN BY READING THESE IMPORTANT SAFETY INSTRUCTIONS AND NOTES collected here for your convenience and repeated with additional information at appropriate points in these instructions.

Throughout this instruction manual, the word "product" refers to the Series 352 Module, the Stabil-Ion Gauge, or the Convectron Gauge(s).

NOTE: This product is designed and tested to offer reasonably safe service provided it is installed, operated, and serviced in strict accordance with these safety instructions.

NOTE: These instructions do not and cannot provide for every contingency that may arise in connection with the installation, operation, or maintenance of this product. If you require further assistance, contact MKS, Granville–Phillips Division at the address on the title page of this manual.



These safety alert symbols in this manual or on the Product rear panel, mean caution – personal safety, property damage or danger from electric shock. Read these instructions carefully.



Failure to comply with these instructions may result in serious personal injury, including death, or property damage.



The service and repair information in this manual is for the use of Qualified Service Personnel. To avoid shock, do not perform any procedures in this manual or perform any servicing on this product unless you are qualified to do so.

These safety precautions must be observed during all phases of operation, installation, and service of the products covered in this instruction manual. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. MKS Instruments, Inc. disclaims all liability for the customer's failure to comply with these requirements.

- *Read Instructions* – Read all of the safety and operating instructions before installing and operating the Series 352 Module, the Stabil-Ion Gauge, and the Convectron Gauge(s).
- *Retain Instructions* – Retain the Safety and Operating Instructions for future reference.
- *Heed Warnings* – Adhere to all warnings and cautions throughout this instruction manual.
- *Follow Instructions* – Follow all operating and maintenance instructions.
- *Accessories – Do not* use accessories not recommended in this manual as they may be hazardous.



To reduce the risk of fire or electric shock, do not expose this product to rain or moisture.



Objects and Liquid Entry – Never push objects of any kind into this product through openings as they may touch dangerous voltage points or short out parts that could result in a fire or electric shock. Be careful not to spill liquid of any kind onto the products.



Do not substitute parts or modify the product.

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the product. Return the product to a service facility designated by Granville–Phillips for service and repair to ensure that safety features are maintained. Do not use this product if it has unauthorized modifications.

1.2 Equipment Grounding



Proper Grounding:

All components of a vacuum system used with this or any similar high voltage product must be maintained at Earth ground for safe operation. The power cord of this product shall be connected only to a properly grounded outlet. Be aware, however, that grounding this product does not guarantee that other components of the vacuum system are maintained at Earth ground.

Complying with the usual warning to connect the power cable only to a properly grounded outlet is necessary but not sufficient for safe operation of a vacuum system with this or any similar high voltage producing product.

Verify that the vacuum port to which the Stabil–Ion Gauge or Convectron Gauge is mounted is electrically grounded. It is essential for personnel safety as well as proper operation that the envelope of the gauge be connected to a facility ground. Use a ground lug on a flange bolt if necessary.

1.3 Implosion / Explosion



Install suitable devices that will limit the pressure 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 the pressure that the system can safely withstand.

It is the installer's responsibility to ensure that the automatic signals provided by the product are always used in a safe manner. Carefully check manual operation of the system and the set point programming before switching to automatic operation.

Where an equipment malfunction could cause a hazardous situation, always provide for fail-safe operation. As an example, in an automatic backfill operation where a malfunction might cause high internal pressures, provide an appropriate pressure relief device.

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 pressurizing 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 glass ionization gauges, glass windows, glass bell jars, etc., are not designed to be pressurized. Also, vacuum gauges with compression fittings may be forcefully ejected if the vacuum system is 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.

Search for suppliers of pressure relief valves and pressure relief disks via an on-line search, or in the *Thomas Register* under "Valves, Relief" and "Discs, Rupture."

Confirm that these safety devices are properly installed before installing the product. In addition, check to be sure that:

a. The proper gas cylinders are installed,

b. Gas cylinder valve positions are correct on manual systems, and

c. The automation is correct on automated gas delivery systems.



Series 275 Vacuum Gauges should not be used above 1000 Torr true pressure.

Series 275 Convectron vacuum gauges are furnished calibrated for Air/N_2, and measure pressure correctly within the accuracy of the instrument. Do not attempt to use a Series 275 gauge calibrated for Air/N_2 to measure or control the pressure of other gases such as argon or CO_2 unless accurate conversion data for the other gas is properly used. See Section 4.4.6 and Section 4.4.7.



If accurate conversion data is not used, or is improperly used, a potential overpressure explosion hazard can be created under certain conditions.



Do not attempt to use a Series 275 gauge calibrated for N_2 to measure or control the pressure of other gases such as argon or CO_2 unless accurate conversion data for N_2 to the other gas is properly used. See Section 4.4.6 and Section 4.4.7.



If used improperly, Convectron gauges can supply misleading pressure indications that can result in dangerous overpressure conditions within the system.



Do not operate vacuum gauges in an explosive atmosphere or in the presence of flammable gases or fumes.

Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

Do not use the product to measure the pressure of explosive or combustible gases or gas mixtures. The sensor wire of the Convectron Gauge normally operates at only 125 °C, but it is possible that a controller malfunction can raise the sensor temperature above the ignition temperature of combustible mixtures.

Danger of an explosion or inadvertent venting to atmosphere exists on all vacuum systems which incorporate gas sources or involve processes capable of pressurizing the system above safe limits.



The fumes from solvents such as trichloroethylene, perchloroethylene, toluene, and acetone can be dangerous to health if inhaled. Use only 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.

1.4 Damage Requiring Service

Disconnect the product from all power sources and refer servicing to Qualified Service Personnel under the following conditions:

a. When any cable or plug is damaged.

b. If any liquid has been spilled onto, or objects have fallen into, the product.

c. If the product has been exposed to rain or water.

d. If the product does not operate normally even if you follow the operating instructions. Adjust only those controls that are covered by the operation instructions. Improper adjustment of other controls may result in damage and will often require extensive work by a qualified technician to restore the product to its normal operation.

e. If the product has been dropped or the enclosure has been damaged.

f. When the product exhibits a distinct change in performance. This indicates a need for service.



Replacement Parts – When replacement parts are required, be certain to use the replacement parts that are specified by Granville–Phillips or that have the same characteristics as the original parts. Unauthorized substitutions may result in fire, electric shock or other hazards.



Safety Check – Upon completion of any service or repairs to this product, ask the Qualified Service Person to perform safety checks to determine that the product is in safe operating order.



Finite Lifetime – After ten years of normal use or even non–use, the electrical insulation in this product may become less effective at preventing electrical shock. Under certain environmental conditions which are beyond the manufacturer's control, some insulation material may deteriorate sooner. Therefore, periodically inspect all electrical insulation for cracks, crazing, or other signs of deterioration. Do not use if the electrical insulation has become unsafe.



Be aware that when high voltage is present in any vacuum system, a life threatening electrical shock hazard may exist unless all exposed conductors are maintained at earth ground.

This hazard is not peculiar to this product.



Be aware that an electrical discharge through a gas may couple dangerous high voltage directly to an ungrounded conductor almost as effectively as would a copper wire connection. A person can be seriously injured or even killed by merely touching an exposed ungrounded conductor at high potential.

This hazard is not unique to this product.



Install suitable devices that will limit the pressure 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 the pressure that the system can safely withstand.

1.5 Service Guidelines

Some minor problems are readily corrected on site. If the product requires service, contact the MKS, Granville-Phillips Division Customer Service Department at +1-800-227-8766 or +1-303-652-4691 for troubleshooting help over the phone.

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

When returning a products to Granville-Phillips, be sure to package the products to prevent shipping damage. Circuit boards and modules separated from the gauge assembly must be handled using proper anti-static protection methods and must be packaged in anti-static packaging. Granville-Phillips will supply return packaging materials at no charge upon request. Shipping damage on returned products as a result of inadequate packaging is the Buyer's responsibility.

For Customer Service or Technical Support 24 hours per day, 7 days per week, every day of the year including holidays:
Phone: +1-800-227-8766 or +1-303-652-4691
Email: gp-csr@mksinst.com

MKS, Granville-Phillips Division
6450 Dry Creek Parkway
Longmont, CO 80503 USA
Phone: 1-303-652-4691 or 1-800-776-6543
FAX: 1-303-652-2844

1.6 Warranty Information

MKS Instruments, Inc. provides an eighteen (18) month warranty from the date of shipment for new Granville-Phillips Products. The MKS General Terms and Conditions of Sale provides the complete and exclusive warranty for Granville-Phillips products. This document can be located on our web site at *www.mksinst.com*, or can be obtained by contacting a Granville-Phillips Customer Service Representative.

1.7 FCC Verification

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with this instruction manual, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense. If this equipment does

cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio or television technician for help.

1.8 Canadian users

This Class B digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

2.1 The Series 352 Vacuum Gauge Controller

The Series 352 Vacuum Gauge Controller can operate one Stabil-Ion Gauge and up to three Convectron Gauges simultaneously. Pressure readout is via the DeviceNet interface.

Within this manual:

- The term "Module" refers to the Series 352 Module. See Figure 2-1.
- The term "Gauge" refers to either the replaceable Stabil-Ion Gauge or the Convectron Gauge(s) connected to the Controller. See Figure 2-3 and Figure 2-4.



Figure 2-1 *Series 352 Controller with DeviceNet Interface*

Table 2-1 *Series 352 Controllers - Catalog Numbers*

Catalog Number	Description
352001	Controller calibrated for use with an Ultra High Vacuum Stabil-Ion Gauge.
20352007	Controller calibrated for use with an Extended Range Stabil-Ion Gauge
352016	Controller calibrated for use with an Ultra High Vacuum Stabil-Ion Gauge (discontinued).
352017	Controller calibrated for use with an Ultra High Vacuum Stabil-Ion Gauge.
352018	Controller calibrated for use with an Ultra High Vacuum Stabil-Ion Gauge.
352019	Controller calibrated for use with an Ultra High Vacuum Stabil-Ion Gauge with 352020 attached.

2.2 Specifications

Table 2-2 *Series 352 Controller Specifications*

Function	Description
Power required for module	11 Vdc to 26.5 Vdc at 0.3 A 5.5 W maximum Protected against reversals, transients, and over-voltages
Power required for Stabil-Ion Gauge	+24 Vdc at 0.8 A to 3.0 A, depending on the status of the Stabil-Ion Gauge
Digital interface	DeviceNet
Baud rate	125K, 250K, or 500K, switch selectable
Setpoint	Single pole, double throw relay, silver alloy - gold clad contacts UL rating: 1 A at 30 Vdc, AC non-inductive Responds to variation in pressure from Convectron Gauge 1.
Connectors	5-pin DeviceNet Micro 7-pin IEC female for Stabil-ion Gauge 9-pin D female for Convectron Gauges 9-pin D female for setpoints
Ambient operating temperature range	0 °C to +50 °C (non-condensing)
Non-operating temperature range	-40 °C to +70 °C
Package	Aluminum extrusion design with aluminum end plates 5.25″ long x 4.37″ wide x 4.25″ high
Weight	1 Kg
Mounting holes	4 holes @ 0.140" ±0.010" dia.

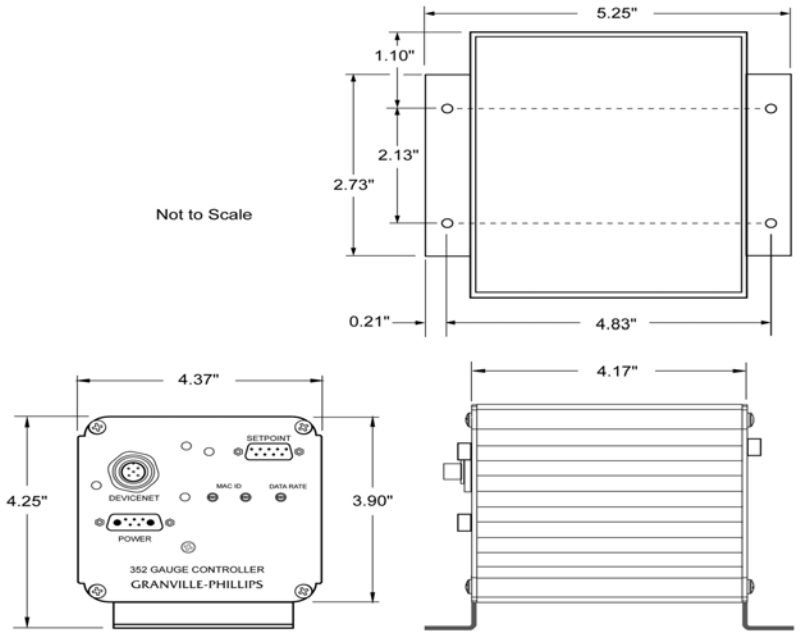


Figure 2-2 *Dimensions of the Series 352 Controller*

Table 2-3 *Series 370 Stabil-Ion Gauge Specifications*

Function	Description
Measuring range for Air or N_2 (1) UHV Gauge (1.0 mA emission) Extended Range Gauge	 2 X 10^{-11} to 2 X 10^{-2} Torr; 3 X 10^{-11} to 3 X 10^{-2} mbar; 3 X 10^{-9} to 3pascal 2 X 10^{-10} to 2 X 10^{-2} Torr; 3 X 10^{-10} to 3 X 10^{-2} mbar; 3 X 10^{-8} to 3 pascal
Accuracy for N_2 (2)	±25% of reading from 1 X10^{-8} to 1 X 10^{-4} Torr
Repeatability (3)	±3% of reading from 1 X10^{-8} to 1 X 10^{-4} Torr
Emission currents	0.1 mA and 1.0 mA
X-ray limit (4) UHV Stabil-Ion Gauge Extended Range Stabil-Ion Gauge	 2 X 10^{-11} Torr; 3 X 10^{-11} mbar; 3 X 10^{-9} pascal 2 X 10^{-10} Torr; 3 X 10^{-10} mbar; 3 X 10^{-8} pascal
Degas	Electron Bombardment, 20 W with 2-minute timer
Filament material	Tungsten or Yttria-coated iridium
Gauge operating temperature	0 °C to 50 °C ambient, non-condensing
Gauge bakeout temperature	450 °C maximum, non-operating, cable removed
Materials exposed to gas	All vacuum fired, UHV compatible
Internal volume	70.3 cm^3, (4.45 $inch^3$) to the port screen
1. Stabil-Ion Gauges are not intended for use with flammable or explosive gases. 2. The difference between the gauge reading and a calibrated reference standard is determined statistically and includes the combined performance of the gauge and electronics. 3. Repeatability refers to the ability of the same module to read the same pressure at different times. 4. The X-ray limit is the absolute lowest indication of the gauge. It is not practical to make repeatable measurements near the X-ray limit.	

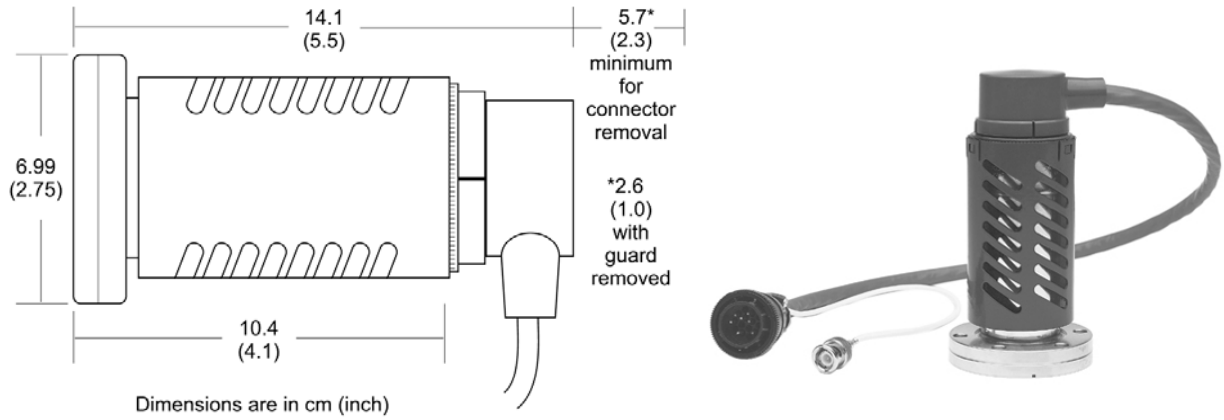


Figure 2-3 *Dimensions of the Stabil-Ion Gauge*

Table 2-4 *Series 275 Convectron Gauge Specifications*

Function	Description
Measuring range for Air or N_2 (See Section 4.4.6 and Section 4.4.7 of this instruction manual for correction curves for other gases.)	1 x 10^{-4} to 1000 Torr Operation in the range of 1x10^{-4} to 1x10^{-3} Torr will require periodic verification of the zero by reducing system pressure to below 1 x 10^{-5} Torr; 1 x 10^{-4} to 1300 mbar; 1 x 10^{-2} to 130 Kpa
Resolution	1 x 10^{-3} Torr; 1 x 10^{-3} mbar; 1 x 10^{-1} pascal
Mounting position	Horizontal preferred
Gauge tube temperature compensation range	+15 to +50 °C
Ambient operating temperature range	0 °C to +50 °C (non-condensing)
Non-operating temperature range	-40 °C to +70 °C
Bakeout temperature range (non-operating)	150 °C max.
Gauge tube internal volume	40 cc (2.5 cu in.)
Sensor wire	Gold-plated tungsten

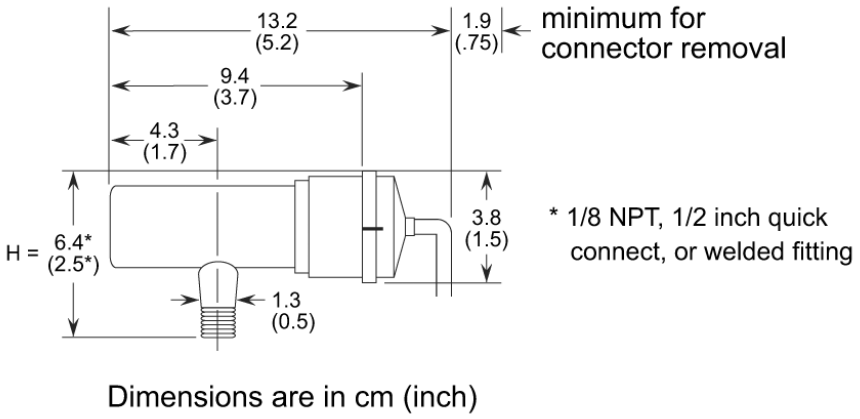


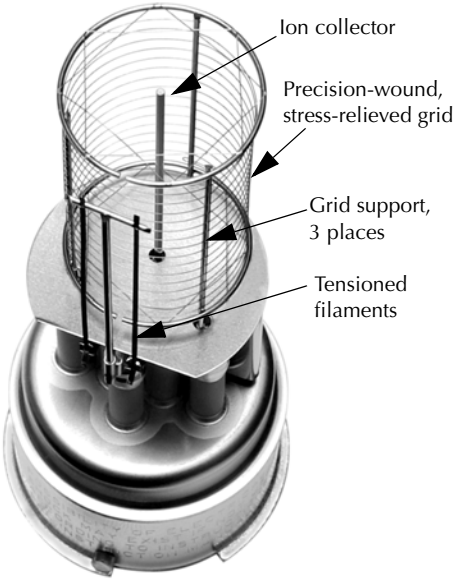
Figure 2-4 *Dimensions of the Convectron Gauge*

2.3 Theory of Operation

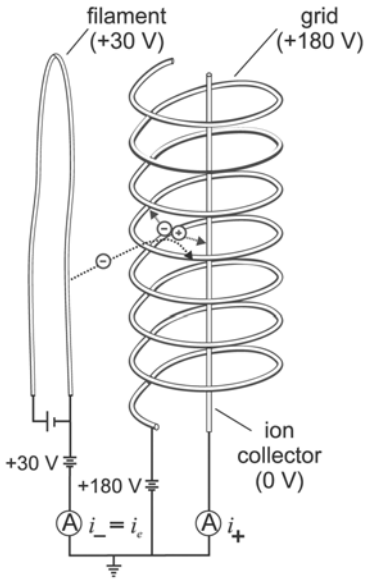
2.3.1 Stabil-Ion Gauge Theory of Operation



Stabil-Ion Gauge illustration shown with part of the stainless steel cover and heat shield removed.



Stabil-Ion Gauge shown with the stainless steel cover removed for clarity.



Principle of Operation: Electrons are created by a hot filament and accelerated to the grid. The current is actively controlled by the electronics.

Figure 2-5 *Stabil-Ion Gauge Illustrations and Principle of Operation*

A Bayard-Alpert (B-A) gauge is a hot-filament style ionization gauge. It is called such because a heated filament (cathode) is used to emit electrons toward a grid (anode).

The pressure indication of a B-A vacuum gauge is based on the ionization of the gas molecules by a constant flow of electrons. The negative electrons are emitted at a well-controlled, selectable rate from a heated filament (cathode) and are accelerated toward a positively-charged wire grid (anode). Electrons pass into the space enclosed by the grid. In this space the electrons collide with the gas molecules that are in the vacuum system, and produce positive ions. The positive ions are then collected by the ion collector that is located along the axis of the cylindrical grid. The ion collector is at nearly ground potential, which is negative with respect to the grid. At a constant filament-to-grid voltage and electron emission current, the rate that positive ions are formed is directly proportional to the density of molecules (pressure) in the gauge for pressures below approximately 1 x 10^{-3} Torr. The strength of the ion current is then indicated on an electrometer that is calibrated in units of pressure.

Because the pressure indication is linear, the hot cathode B-A gauge is generally considered to be the most accurate continuous indicator for pressures below 1 x 10^{-3} Torr.

The development of the Stabil-Ion Gauge brought the accuracy of B-A technology to the 4% to 6% range. Although prior B-A style vacuum gauges were usually inaccurate as much as 20% to 50%, they were still the best, commonly available vacuum gauge in the 1 x 10^{-3} to 2 x 10^{-11} Torr range.

2.3.2 X Ray Limit of Bayard-Alpert Gauges

The low end of the operating range of a B-A gauge is determined by the x ray limit of this type of gauge. The x ray limit varies with different gauge designs. X rays are produced when the electrons emitted by the cathode impact the grid (anode). Because of the geometry of the B-A gauge, only a small fraction of the x rays emitted from the grid are intercepted by the ion collector. When the x rays strike the collector they cause electrons to be photoelectrically ejected from the collector. This photo-electron current from the ion collector is detected the same as positive ions arriving at the ion collector and consequently adds to the ion current. This x ray current limits the pressures that can be measured, and is equivalent to a pressure reading in the 10^{-10} to 10^{-11} Torr ranges. The x ray limit refers to the lowest pressure indication that may be obtained in a gauge when all the output current is due to x ray induced photoemission and there is an absence of gas.

The x ray limit of an Extended Range Stabil-Ion Gauge is approximately 2x10^{-10} Torr. To measure below this limit, an ultrahigh vacuum (UHV) Stabil-Ion gauge can be used. The UHV Stabil-Ion gauge has an x ray limit of approximately 2x10^{-11} Torr. This lower x ray limit is achieved by modifying two elements of the standard B-A gauge design. First, the diameter of the collector is reduced. The smaller cross-sectional area reduces the probability that the x rays created at the grid will strike the collector. Second, the helical grid structure is replaced with a fine-wire mesh grid structure, and there is also a fine-wire structure across both ends of the grid. The fine grid wires provide a more transparent grid for longer electron path lengths, and the grid ends confine the positive ions for better ion collection. Together, these two modifications cause a higher gauge sensitivity for ions from the gas phase which causes the x ray current to be converted into a smaller pressure indication (i.e., a lower x ray limit).

Some processes can result in deposits on the electrodes. These deposits can lead to an increase in x ray limit since more electrons are released under x ray bombardment. Process deposits can generally be removed by degassing the electrodes. See Degassing on the next page.

2.3.3 Filaments (Cathodes) used in Bayard-Alpert Gauges

There are two types of materials commonly used for filaments: tungsten and iridium. And, there are two types of coatings used on the filaments: thoria and yttria.

Generally, filaments are yttria-coated iridium, thoria-coated iridium, or uncoated tungsten. The most common style is coated iridium because they operate at a lower temperature than tungsten, therefore less reactive. Coated iridium filaments are also more burnout resistant when exposed to atmospheric pressure while power is on. Tungsten filaments will burn out immediately if exposed to pressures of 1 x 10^{-2} Torr or higher while they're on. However, tungsten filaments are the best type to use when the chemistry (such as halogen compounds) of the vacuum process causes premature failure of coated iridium filaments.

The amount of emission current that a B-A gauge requires for proper operation depends on many factors such as: the size or style of the gauge, the process in which the gauge is used, the pressure range of operation, and the desired accuracy of the indicated pressure. Emission currents are typically in the range of 25 µA to 10 mA.

2.3.4 Degassing Bayard-Alpert Gauges

The deposition of elements or compounds on exposed gauge surfaces can result from some processes, such as sputtering or coating operations. Water vapor is another compound that can collect inside the gauge when a vacuum chamber is exposed to atmosphere. During normal operation these materials will slowly come off the gauge surfaces, increasing the local pressure in the gauge. To more rapidly get the pressure in the gauge in equilibrium with the pressure in the chamber, "degassing" can be used to drive the molecules on the inner walls and surfaces from the gauge back into the chamber where they can be pumped out of the system. Degassing can be done as required or as part of a regular pumpdown sequence. Regular degassing helps prevent process deposits from collecting and allows the gauge to provide lower and more repeatable pressure indications by bringing the pressure in the gauge closer to equilibrium with the chamber.

Electron Bombardment (EB) degassing is accomplished by increasing the anode voltage and the emission current to bombard the gauge with electrons of sufficient quantity and energy to displace deposited molecules.

Cleaning a gauge with solvents is not recommended. However, if a gauge has been exposed to silicone-based pump oil, solvent may be needed to remove the oil. If solvent is used, the gauge must be thoroughly dried before installing it back on the system and operating or degassing it.

2.3.5 Convectron Gauge Theory of Operation

The Convectron transducer is represented in Figure 2-6 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 x R3/R4. If there are no changes in ambient temperature, the value of R1 is a constant and the bridge is balanced.

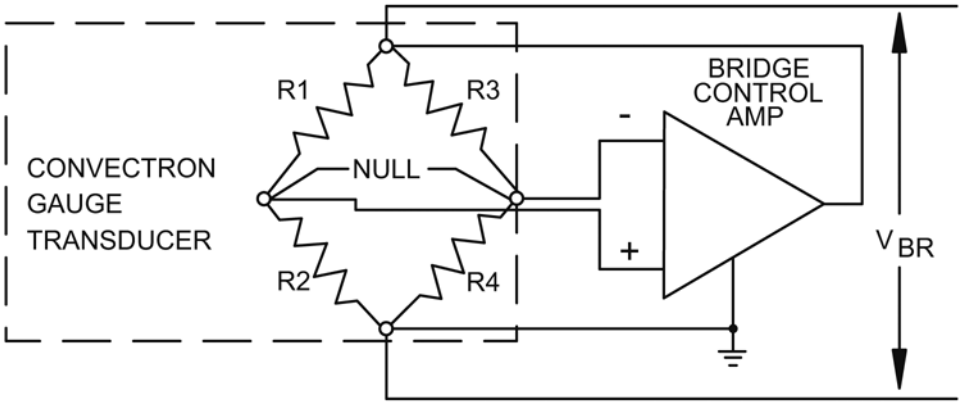


Figure 2-6 *Convectron Gauge Schematic*

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.

2.3.5.1 Convectron Gauge Construction

All materials have been chosen for ultra high vacuum service, corrosion resistance and bakeability to 150 ºC. 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
- Dow-Corning 9015 glass

The blue trim cover is molded of polysulfone thermoplastic suitable for service to 150 ºC.

3.1 Receiving Inspection

Inspect all material received for shipping damage. Confirm that your shipment includes all of the products and options you ordered. If materials are missing or damaged, the carrier that made the delivery must be notified within 15 days of delivery in accordance with Interstate Commerce regulations in order to file a valid claim with the carrier. Any damaged material including all containers and packing should be held for carrier inspection. Contact our Customer Service Department, 6450 Dry Creek Parkway, Longmont, Colorado 80503, 303-652-4400 if your shipment is not correct for reasons other than shipping damage.

3.1.1 International Shipments

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, *not* the freight forwarder.

3.2 Vacuum Gauge Controller Installation

The Series 352 Vacuum Gauge Controller can be mechanically mounted anywhere on a system with free airflow and ambient temperature between 0 °C and 50 °C, and is protected from physical damage. Dimensions for the Controller are given in Figure 2-2.

1. Mount the Controller in the desired location, making sure that the necessary cables can be routed to, and connected to the Controller.
2. Connect the Convectron Gauge cable(s) to the Controller.
3. Connect the Stabil-Ion Gauge cable to the Controller.
4. Connect the Setpoint cable to the Setpoint connector on the Controller.
5. Connect the DeviceNet cable to the DeviceNet connector on the Controller. Power requirements are listed in Table 3-1, below. The connector is illustrated in Figure3-1.
6. Connect the power cable to the power connector on the Controller. Power requirements are listed in Table 2-1. The connector is illustrated in Figure 3-1.

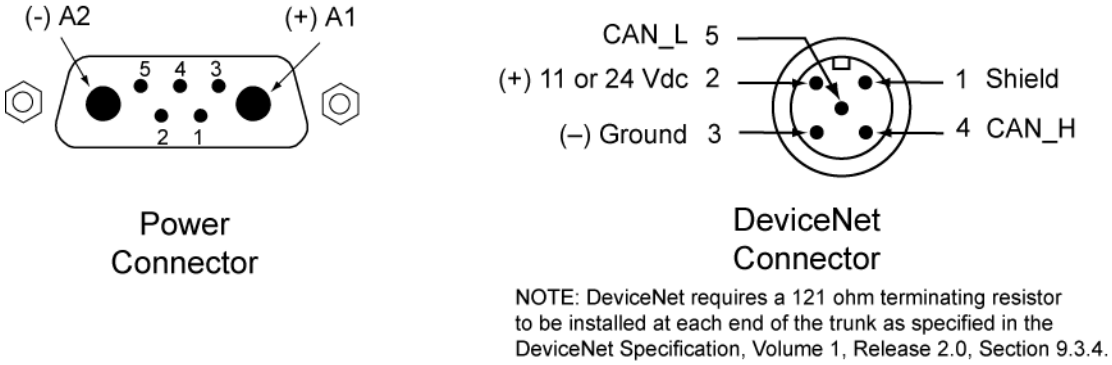


Figure 3-1 *Power and DeviceNet Connectors*

Table 3-1 *Controller and DeviceNet Power Requirements*

Connector	Surge Current	Operating Current	Input Voltage	Pin Connection
Power		0.8 A @ Low	24 Vdc	+V : A1, 1, 3 -V : A2, 2, 5
Power		1.0 A @ High	24 Vdc	+V : A1, 1, 3 -V : A2, 2, 5
Power		3.0 A @ Degas	24 Vdc	+V : A1, 1, 3 -V : A2, 2, 5
DeviceNet	2.0 A 200 ms	0.3 A	24 Vdc	+V : 2 -V : 3
DeviceNet	2.0 A 200 ms	0.8 A	11 Vdc	+V : 2 -V : 3

3.2.1 DeviceNet Cables

The maximum length for DeviceNet cables is 500 meters at 125K baud; or 250 meters at 250K baud; or 100 meters at 500K baud. The maximum number of devices is 64. See the DeviceNet Specification, Volume 1, Section 9.4 for cable requirements.

3.2.2 Grounding the Controller

Two separate, isolated grounds are required: a DeviceNet ground and a Controller Chassis ground. Typical isolation between these grounds is 1 mOhm up to +/-26 Vdc, assuming the DeviceNet drain is grounded. Above 30V the isolation approaches zero ohms. The Module generates +180 Vdc during normal operation and 530 Vdc during degas. For safety and proper operation, the outer housing of the Controller MUST be grounded to the vacuum chamber. More details regarding grounding requirements are provided in Section 3.5 on page 28.

3.3 Stabil-Ion Gauge Installation

3.3.1 Gauge Installation Tips



It is the installer's responsibility to ensure that the automatic signals provided by the product are always used in a safe manner. Carefully check the system programming before switching to automatic operation.



Where an equipment malfunction could cause a hazardous situation, always provide for fail–safe operation. As an example, in an automatic backfill operation where a malfunction might cause high internal pressures, provide an appropriate pressure relief device.

For best results locate pressure gauges close to the point where pressure is to be measured. Gas sources, long tubulation or other constrictions can cause large errors in indication. 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 much higher.

To minimize temperature effects, locate pressure gauges away from internal and external heat sources in a region where the ambient temperature is reasonably constant.

Parts of the gauge can get hot during degassing, especially if there is poor ventilation. This will not damage the gauge. However, care should be taken to prevent low temperature rated materials such as plastic wire insulation from touching hot parts of the gauge.

3.3.1.1 EMC Compliance

To comply with the standards for immunity as called for by the EMC Directive, careful consideration to grounding and shielding of instrumentation cables is required. User-supplied cables must have the drain shield of the cable connected to chassis ground. Immunity to radiated and conducted RF energy in industrial environments will depend on cable construction and routing.

3.3.1.2 Cable Installation

It is intended that all wiring either to or from the Stabil-Ion Gauge Controller unit, whether supplied by Granville-Phillips or not, be installed in accordance with the safety requirements of NEC/NFPA 70. Cables provided by Granville-Phillips for connection to sensors or transducers is, at a minimum, designed for use as Appliance Wiring Material (UL category AVLV2), and is constructed of appropriate material and dimensions for the voltages and currents provided by the Stabil-Ion Gauge Controller unit. It is the user's responsibility to install cables to/from the Series 352 Stabil-Ion Gauge Controller unit, whether provided by Granville-Phillips or not, in accordance with the applicable local, state, and national safety requirements. Raceway or conduit may be needed for certain installations.

3.3.2 Install the Stabil-Ion Gauge



Verify that the vacuum port to which the Stabil–Ion Gauge is mounted is electrically grounded. It is essential for personnel safety as well as proper operation that the envelope of the gauge be connected to a facility ground. Use a ground lug on a flange bolt if necessary.

The Stabil-Ion Gauge is double packaged at the factory for cleanroom compatibility. Handle the gauge carefully to avoid damage to the vacuum port screen after the hard plastic packaging is removed. To reduce the chance of contamination, do not remove a Stabil-Ion Gauge from its inner bag until moments before it is to be connected to the vacuum system.

Follow good vacuum practice. Avoid contaminating the Stabil-Ion Gauge. Do not touch the port. Do not talk directly at an open vacuum port.

Any mounting orientation may be used. However, to minimize the possibility of excessive temperature at the electrical connector when degassing, do not install the Stabil-Ion Gauge with the electrical connector above the gauge. If it is necessary to install the gauge with the connector on top, degas time must be limited to 10 minutes/hour. When mounted horizontally, the ventilation slots in the Guard will be oriented for best cooling if the gauge is installed with the locating key in the pin guard on the bottom. See Figure 3-2. Note that the cable will exit in the direction the locating key is oriented.

For best results, locate the Stabil-Ion Gauge close to the point where the pressure is to be measured. Gas sources, long tubulation or other constrictions can cause large errors in indication. If the gauge is placed near the pump, the displayed pressure may be considerably lower than the rest of the system. If the gauge is placed near a gas inlet or source of contamination, the displayed pressure may be much higher.

To minimize temperature effects, locate the Stabil-Ion Gauge away from internal and external heat sources in a region where the ambient temperature is reasonably constant. Avoid mounting the gauge near strong magnetic fields.

To minimize the possibility of leaks with Conflat flanges, use high strength stainless steel bolts and a new, clean OFHC copper gasket. Avoid scratching the seal surfaces. Do not use nonmetal gaskets.

After finger tightening all bolts, continue tightening about 1/8 turn in crisscross order, e.g., 1, 4, 2, 5, 3, 6, 4, 1, 5, 2, 6, 3, 1 until the flanges are in contact. After contact, further tighten each bolt about 1/16 turn.

Connect the cable to the Stabil-Ion Gauge and the Controller. Refer to Figure 3-1 and 2-2.

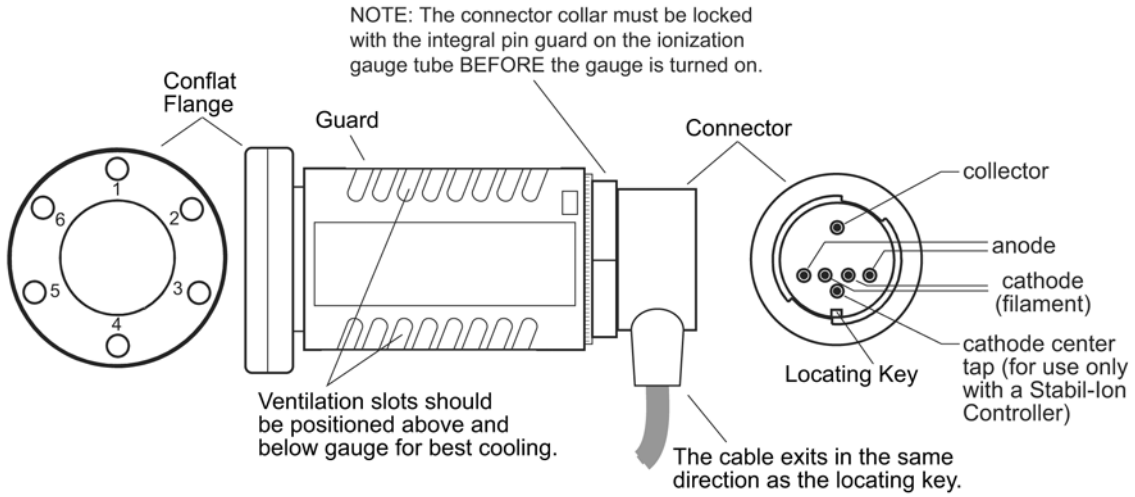


Figure 3-2 *Stabil-Ion Gauge*

3.4 Convectron Gauge Installation

Cleanliness pays. Keep the port cover in place until moments before installation.

For proper operation above about 1 Torr, install Convectron gauges with the gauge axis horizontal. See Section 3.4.1 and Figure 3-3. 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.

Vibration causes convection cooling of the sensor and will result in high pressure readings. Mount Convectron gauges where they will not vibrate excessively.

Orient the gauge to prevent condensation of process vapors on the internal surfaces through line-of-sight access to its interior. If vapor condensation is likely, orient the port downward to drain liquids out of the gauge.

3.4.1 Important Precautions for Convectron Gauge Installation

NOTE: The following precautions must be observed in the use and operation of Convectron Gauges.

- It is recommended that Convectron gauges be installed with the port oriented vertically downward to ensure that system condensates or other liquids do not collect in the gauge tube. The gauge tube axis must be horizontal if it is to be used at pressures above 1 Torr. Although the gauge tube will read correctly below 1 Torr when mounted in any position, erroneous readings will result at pressures above 1 Torr if the gauge tube axis is not horizontal.
- Do not use a compression mount (quick connect) to attach Convectron gauges to a system in applications resulting in positive pressures in the gauge tube. Positive pressures might blow the gauge tube out of a compression fitting and damage equipment and injure personnel. Pipe thread or flange mounting systems should be used for positive pressure applications. In any case, the absolute pressure in the gauge tube should not exceed 1000 Torr.
- Do not perform electrical continuity tests on a Convectron gauge tube with instruments applying voltages in excess of 1 volt when the gauge tube is at vacuum, or 5 volts when at atmospheric pressure. Exceeding these voltages will damage the sensing element.
- Keep the gauge tube clean. Do not remove the mounting port cover until you are ready to install the gauge tube.
- Do not mount a Convectron gauge in a manner such that deposition of process vapors, upon the internal surfaces of the gauge tube, may occur through line-of-sight access to the interior of the gauge tube.
- Do not install the Convectron gauge where high amplitudes of vibration are present. Excessive vibration will cause forced convection at high pressure giving erroneous readings.
- Do not bake the Convectron gauge at temperatures exceeding 85 °C.
- Do not install the Convectron gauge where it will be subject to corrosive gases such as mercury vapor or fluorine which will attack the gold plated sensor.
- For greatest accuracy and repeatability the Convectron gauge should be located in a stable room temperature environment.
- All connections to the unit are to be made with shielded cable or cables. The shield or shields are to be connected to the connector shell.

3.4.2 Convectron Gauge Mounting Locations

Where you mount the gauge is critical to obtaining reliable pressure measurements. To minimize temperature effects, locate pressure gauges away from internal and external heat sources in an area where the ambient temperature is reasonably constant.

Long tubing or other constrictions can cause large errors in pressure readings. If you mount the gauge near the pump, the pressure in the gauge may be considerably lower than in the rest of the system. If you place the gauge near a gas inlet or other source of contamination, the pressure in the gauge may be much higher than in the rest of the system.

Use Figure 3-3 as a guideline to install Convectron Gauges on your vacuum system. Dimensions of the Convectron Gauge are given in Figure 3-4. Dimensions of the Convectron Gauge flange fittings are given in Table 3-2.

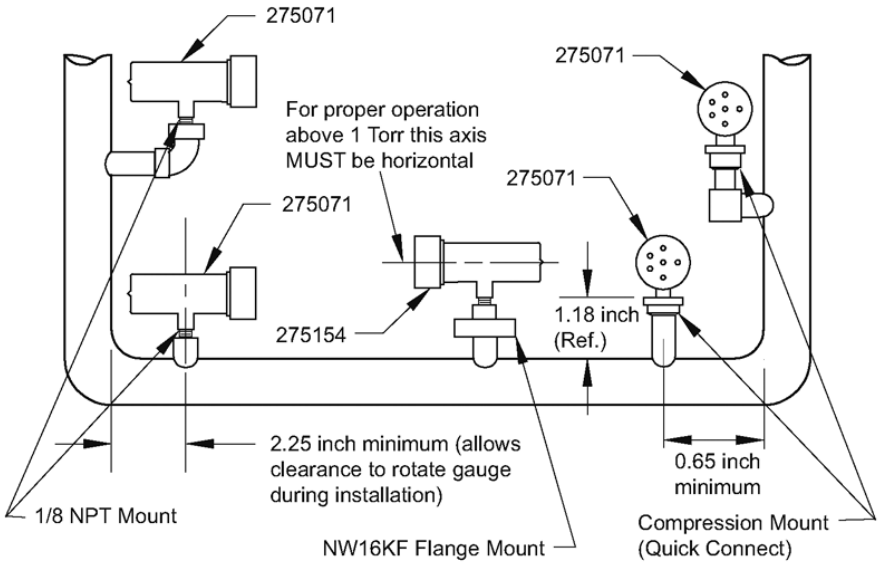


Figure 3-3 *Recommended Convectron Gauge Installation*

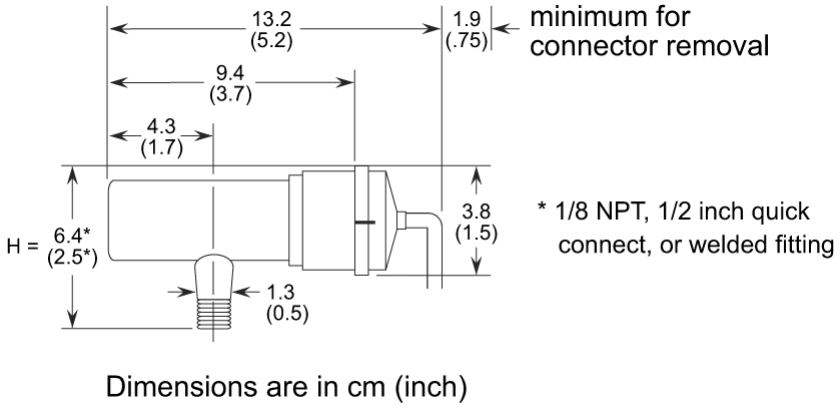


Figure 3-4 *Convectron Gauge Dimensions*

Table 3-2 *Convectron Gauge Fittings*

Fitting		Description	Dimension H
	1/8 NPT pipe thread 1/2 inch compression fitting	1/8 NPT pipe thread 1/2 inch quick connect/weld	2.5 cm (1.0 in.)
	VCR-type female fitting	1/4 inch VCR-type female fitting 1/2 inch VCR-type female fitting	3.0 cm (1.2 in.) 3.9 cm (1.4 in.)
	ConFlat-type flange	1.33 inch (NW16CF) ConFlat-type 2.75 inch (NW35CF) ConFlat-type	3.8 cm (1.5 in.) 3.8 cm (1.5 in.)
	KF flange	NW16KF flange NW25KF flange NW40KF flange	3.1 cm (1.2 in.) 3.1 cm (1.2 in.) 3.1 cm (1.2 in.)

3.4.3 Gauge Mounts

3.4.3.1 Compression Mount/Quick Connect

Do not use this type of fitting for positive pressure applications. The gauge may be forcefully ejected. The gauge port is designed to fit a standard 1/2 in. compression/quick connect mounting such as an Ultra-Torr® fitting. Insert the gauge tube port into the compression fitting and finger-tighten the press ring. A light film of vacuum grease, such as Apiezon®, will ensure sealing.

3.4.3.2 1/8 NPT Mount

Fits standard 1/8 NPT female fitting. Wrap the threads of the gauge port with Teflon® tape and hand tighten. Do not use a wrench or tool. Tighten only enough to achieve a seal.

3.4.3.3 NW or Flange Mount

The KF mounting system requires O-rings and centering rings between mating flanges. Tightening the wing nut will hold the flanges and the aluminum flange clamp together. Maximum pressure for this style of mounting system is 1000 Torr absolute.

3.4.3.4 ConFlat Flange

To minimize the possibility of leaks with ConFlat® flanges, use high strength stainless steel bolts and a new, clean OFHC copper gasket. Avoid scratching the seal surfaces. To avoid contamination, do not use nonmetal gaskets.

Finger tighten all bolts. Use a wrench to continue tightening $^{1}/_{8}$ turn at a time in crisscross order, e.g., 1, 4, 2, 5, 3, 6 until all flanges are in contact. After contact, further tighten each bolt about $^{1}/_{16}$ turn.

3.4.4 Convectron Gauge Cable Interconnect

Connect the cable to the Convectron Gauge and the Controller.

3.5 System Grounding

When high voltage is present, all exposed conductors of a vacuum system must be maintained at earth ground.

Under certain conditions, dangerously high voltage can be conducted through a gas directly to an ungrounded conductor almost as effectively as through a copper wire. The ability of an electric current to flow through a gas under certain circumstances poses a serious risk. Do not touch the exposed pins on any gauge installed on a vacuum system when high voltage is present.

3.5.1 System Grounding Procedure

Improper grounding can cause product damage or personal injury.

Follow ground network requirements for the facility.

Maintain all exposed conductors at earth ground.

Connect the power cord to a properly grounded outlet.

Make sure the vacuum port to which the gauge is mounted is properly grounded.

Connect the gauge envelope to a facility ground. If necessary, use a ground lug on the flange bolt or a hose clamp connected to the gauge/component.

High voltage can couple through a gas to the internal electrodes of a gauge. Do not touch the exposed pins on any gauge installed on a vacuum system where high voltage is present.

Touching the pins on the gauge in a high−voltage environment can cause an electrical discharge through a gas or plasma, resulting in property damage or personal injury due to electrical shock.

Vent the vacuum chamber to atmospheric pressure and shut OFF power to the controller before you touch the pins on the gauge.

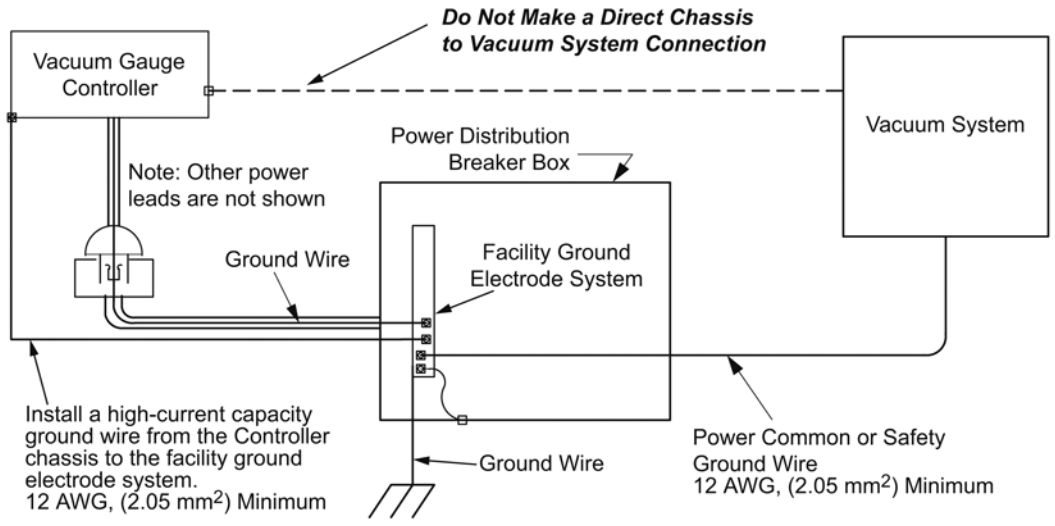


Figure 3-5 *System Grounding Diagram*

WARNING – The placement of a second ground wire (dashed line in Figure 3–5) between the vacuum chamber and the 330 Vacuum Gauge Controller chassis is NOT safe – large currents could flow through it.

WARNING – After each maintenance/service procedure and before operating the controller and vacuum system, make sure that your vacuum system and controller are grounded as shown in Figure 3–5. FAILURE TO DO SO COULD BE FATAL.

When high voltages are used within the vacuum system and the gauge envelope is not reliably grounded through its vacuum connection, either a separate ground wire must be added, or the envelope must be shielded to positively prevent human contact. The gauge envelope may be grounded by using a metal hose clamp on the gauge connected by a #12 AWG copper wire to the grounded vacuum chamber. See Figure 3-6.



Figure 3-6 *Grounding a Convectron Gauge*

1. Connect a heavy duty ground wire #12 AWG or larger from the ground lug on the back of the Controller to your facility grounding electrode system. This will provide an earth ground for the Controller in the event the interconnect cables are not in place. Do not connect the ground lug to the vacuum system or other component. Connect it directly to the facility grounding system such as a grounded outlet box or a grounded copper water supply pipe. Do not rely on small metal water lines to ground a component. Later on someone may replace the metal tubing with plastic tubing thus unwittingly causing a potentially dangerous situation.
2. Provide a connection to ground for other instruments with electrodes in the vacuum system possibly exposed to high voltage electrical discharges.
3. Provide a connection to ground for each ungrounded metal component in, on or around the vacuum system, including the gauge envelopes, which personnel may touch and which can potentially be exposed to high voltage electrical discharges within the vacuum system. For example, a metal bell jar resting on an organic O-ring must be connected to ground if a Convectron gauge is to be used or if other high voltage sources are present in the vacuum system.

3.5.2 System Ground Test Procedure

Use the following procedure to test each of your vacuum systems which incorporates an ionization gauge.

NOTE: This procedure uses a conventional multi meter (DMM) and a 10 Ω, 10 W resistor.

1. Examine the grounding of both the 352 Vacuum Gauge Controller and the vacuum chamber. Make sure there is a heavy duty ground connection to all exposed conductors on the chamber and to all exposed conductors on the vacuum chamber.
2. With the 352 VGC turned OFF, test for both DC and AC voltages between the metal parts of the vacuum chamber and the power supply chassis.
3. If no voltages exist, measure the 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.
4. 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 un-shunted value, commonality of the grounds is implied. Repeat the measurements several times to be sure that the voltage ratio is not changing with time. This should prevent the plasma from creating a dangerous voltage between these grounds. Make sure that no more than 10 volts exists between grounds.

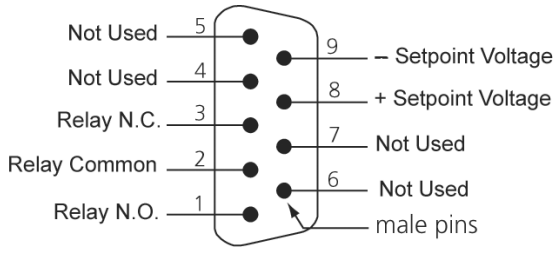
$$\frac{\text{VOLTAGE (SHUNTED)}}{\text{VOLTAGE (UNSHUNTED)}} = 0.83 \text{ OR MORE}$$

5. 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. Be sure to check the electrical continuity between these two ground systems.

The placement of a second ground wire (dashed line in Figure 3–5) between the vacuum chamber and the 352 Vacuum Gauge Controller chassis is NOT safe – large currents could flow through it.

After each maintenance/service procedure and before operating the controller and vacuum system make sure that your vacuum system and controller are grounded as shown in the following schematic diagram.
FAILURE TO DO SO COULD BE FATAL.

3.6 Setpoint Connector Wiring



The Normally Open relay is Closed when the Convectron 1 pressure is Low.

The Normally Closed relay is Closed when the Convectron 1 pressure is High or Power is OFF.

Figure 3-7 *Setpoint Connector*



Figure 4-1 *Series 352 Controller with DeviceNet Interface*

4.1 Module Status LEDs

Two LEDs – Module Status and Network Status – on the front panel of the Controller indicate the current status of the Controller.

4.1.1 Module Status LED

Table 4-1 *Module Status LED*

LED	Status
OFF	No power to the Series 352 Controller.
Green	The Controller is on-line with connections in the established state.
Amber	The Controller has an unrecoverable fault and may need to be replaced.
Flashing Amber/Green	The Controller is in self-test mode. Refer to the Identity Object in Volume II of the DeviceNet specification.

4.1.2 Network Status LED

Table 4-2 *Network Status LED*

LED	Status
OFF	No power to the Controller. The Controller is not online. The Controller has not yet completed the Dup_MAC_ID test.
Green	The Controller is on-line with connections in the established state. The Controller is allocated to a Master.
Flashing Green	The Controller is on-line with no connections in the established state. The Controller has passed the Dup_MAC_ID test, is on-line, but has not established connections to other nodes. The Controller is not allocated to master.
Flashing Amber	One or more I/O connections are in the Timed-Out state. The module has detected an error that has rendered it incapable of communicating on the network (Duplicate MAC ID or Bus-Off).
Amber	The module has detected an error that has rendered it incapable of communicating on the network (Duplicate MAC ID or Bus-Off).

4.2 Control Switches/Settings

4.2.1 MAC ID Address Switches

Use the address switches to set the media access control identifier (MAC ID), which the network master uses to address the Controller. When the device powers up or is reset by the network, the device firmware will read the address switch settings.

Specific address values range from 0 to 63.

- Set the switch labeled “MSD,” to a value of 0 to 6 for the most significant (first) digit.
- Set the switch labeled “LSD,” to a value of 0 to 9 for the least significant (second) digit.

If a valid address between 0 and 63 is set, and it differs from the current address stored in non-volatile RAM (NVRAM), the new address will be saved in memory.

Upon connection to the DeviceNet network, the module requests a duplicate address check.

- If another device on the network has the same address as the module, the module will not join the network.
- If the address is unique, the module will join the network and the net status indicator will blink green until a connection to the master node is established.

4.2.2 Data Rate (Baud Rate) Switches

The Baud Rate switch must be set according to the length of the cable between the DeviceNet controller and the 352 Controller. See Table 4-3.

The maximum number of devices on a network is 64.

Table 4-3 *Baud Rate Switch Settings*

Maximum Cable Length	Baud Rate Setting
500 meters	125 K
250 meters	250 K
100 meters	500 K

4.2.3 Setpoint Adjust Potentiometer

Adjusts the pressure setpoint value from Zero to Atmosphere for Convectron Gauge 1 (CG1). See Section 4.4.3 for adjustment procedures.

4.3 Stabil-Ion Gauge Operation

Ion gauge pressure in Torr can be calculated from the A/D output. The formula is: $P = 10^{\wedge}\left(\frac{-COUNTS}{410}\right)$ where emission current = 1 mA.

If a different emission current is used, the pressure formula is scaled accordingly. I.e., for an emission current of 0.1 mA the formula pressure becomes: $P = 10^{\wedge}\left(\left(\frac{-COUNTS}{410}\right)+1\right)$

4.3.1 Ion Gauge Control Logic

Refer to the object model specification Assembly #2. The IG bit must be reset to 0 after power is applied to enable ion gauge operation. When a master sets the IG bit to 1, the ion gauge will turn ON. The IGS bit in byte 9 of Assembly #1 will not respond immediately. The delay is typically 1/2 second. The ion gauge will first attempt to run both filaments. If emission is not established within 5 seconds, only filament 1 will be tried. If emission is still not established, only filament 2 will be tried. If emission is still not established, the ion gauge will return to the OFF status. The Master will then have to reset the IG bit back to 0, then back to 1 to attempt another ion gauge startup. The FIL1S and FIL2S bits in byte 9 of Assembly #1 can be used to indicate filament quality. If the ion gauge is always operating with 1 filament, the gauge may be near the end of its life.

To operate the ion gauge at 1 mA emission current, set the 1 mA bit in Assembly #2. If the bit is 0, emission will be 100 µA.

4.3.2 Gas Sensitivity Correction

The Series 352 Controller is calibrated to read pressure for nitrogen or air. If used with gases other than this, it is required that the analog output voltage to pressure reading be corrected for the gas in use. Table 4-4 gives some typical sensitivity ratios. To correct the analog output to pressure curve reading, divide the indicated pressure reading by the sensitivity ratio.

Ion gauge sensitivity ratios, r, derived from data obtained by NASA Technical Note TND5285, “Ionization Gauge Sensitivities as Reported in the Literature,” by Robert L. Summers, Lewis Research Center, National Aeronautics and Space Administration are shown in Table 4-4.

Table 4-4 *Stabil-Ion Gauge Sensitivity Ratios (r)*

Gas	He	Ne	D_2	H_2	N_2	Air	O_2	CO
r	0.18	0.30	0.35	0.46	1.00	1.00	1.01	1.05
Gas	H_2O	NO	Ar	CO_2	Kr	SF_6	Xe	Hg
r	1.12	1.16	1.29	1.42	1.94	2.50	2.87	3.64

4.3.3 Example

Pressure measurement for air or nitrogen indicates a pressure of 5×10^{-5} Torr. If the gas type in the system is known to be neon, then

$$\frac{5 \times 10^{-5} \text{ Torr}}{0.30} = 1.67 \times 10^{-4} \text{ Torr of neon.}$$

4.3.4 Overpressure Shutdown

The 352 Controller is preset to shut down the Stabil-Ion Gauge if the pressure rises above 1×10^{-2} Torr of nitrogen. Use parameter object instance 9 to change the overpressure shutdown value.

4.3.5 Stabil-Ion Gauge Degas

Danger, high voltage – 180V is present in the Power Supply, on the cable, and at the ion gauge when the gauge is turned on. Voltages as high as 850V peak are present during degas.

Be aware that an electrical discharge through a gas may couple dangerous high voltage directly to an ungrounded conductor almost as effectively as would a copper wire connection. A person may be seriously injured or even killed by merely touching an exposed ungrounded conductor at high potential.

This hazard is not unique to this product.

Be aware that when high voltage is present in any vacuum system, a life threatening electrical shock hazard may exist unless all exposed conductors are maintained at earth ground.

This hazard is not peculiar to this product.

All conductors in, on, or around the vacuum system that are exposed to potential high voltage electrical discharges must either be shielded at all times to protect personnel or must be connected to earth ground at all times.

Compliance with the usual warning to connect the power cable only to a properly grounded outlet is necessary but not sufficient for safe operation of a vacuum system with this or any similar high voltage producing product. Grounding this product does not and cannot guarantee that other components of the vacuum system are all maintained at earth ground.

Do not touch the Stabil–Ion Gauge during degas operation –serious burns can occur.

The Series 352 Vacuum Gauge Controller employs electron bombardment (EB) degassing of gauge electrodes, which is the most direct and efficient means to remove contaminants. High energy electrons strike the anode, and heat the anode to remove any foreign materials while the increased filament power effectively cleans the filament surface. It is necessary to pump the contaminants from the gauge during degas. A system pressure below 10^{-5} Torr is required to accomplish this effectively. Measurements below about 10^{-8} Torr require degassing in the 10^{-6} Torr range, and again as the system approaches the ultimate pressure.

Degas cannot be activated unless the Stabil-Ion Gauge pressure indication is below 5×10^{-5} Torr (6.6×10^{-5} mbar, or 6.6×10^{-3} pascal). Degassing above this pressure is of little value and may cause pressure bursts that can cause an electrical gas discharge which can couple high voltage to the vacuum system hardware, shut down the Stabil-Ion Gauge, and in some cases cause damage or create a shock hazard unless the system is properly grounded.

Degas the Stabil-Ion Gauge by setting the Degas ON/OFF bit in Assembly #2 to 1. Degas will operate at 20 Watts for 10 minutes then return to normal emission. The Degas ON/OFF bit must be reset to 0, then back to 1 to start another degas cycle.

4.3.5.1 Pressure Indication During Degas

An approximate indication of pressure within the Stabil-Ion Gauge is provided during degas. Observing this pressure indication rise, peak out and then fall is an excellent means of determining the optimum time of degas. The indication may eventually be unrealistically low due to a reverse x-ray current effect or temporary gauge pumping. Degassing purposely changes surface conditions in the gauge. After degassing, permit sufficient time for steady state conditions to be established before attempting to make measurements.

4.3.6 Gauge Bakeout

Applying an external heat source to the vacuum system and to the gauge envelope can speed the removal of contamination from the interior surfaces. Bakeout temperatures between 150 °C and 300 °C are typically adequate. Do not exceed 450 °C at the Stabil-Ion Gauge envelope. Do not exceed 150 °C at the cable and connector.

4.4 Convectron Gauge Operation

4.4.1 Preparing for Pressure Measurement

The steps in this chapter assume:

- The 275 Convectron Gauge was properly set up and installed per the instructions in Chapter 3.
- The gas in your vacuum system is Air or N_2. If you are using other gases you **must** follow the instructions in Section 4.4.7.
- You are reasonably familiar with the general theory of operation of thermal conductivity gauges.

It is recommended that you consult a good textbook if you are unfamiliar with vacuum technology or if you require more information on the general theory behind operating a thermal conductivity gauge. The following books are useful reference volumes.

- Dushman, S., Lafferty, J. M., *Scientific Foundations Of Vacuum Technique,* John Wiley & Sons, Inc., Second Edition, New York, 1962.
- Redhead, P. A., et al., *Ultrahigh Vacuum,* Chapman and Hall, London, 1968.
- O'Hanlon, J. F., *A User's Guide To Vacuum Technology,* John Wiley & Sons, New York, 1980.

4.4.2 Gas Type

The Convectron Gauge is calibrated for Air/N_2 unless otherwise labeled for custom applications.



If used improperly, Convectron Gauges can supply misleading pressure indications that can result in dangerous overpressure conditions within the system. For use with gases other than air or N_2, consult the gas type correction charts in Section 4.4.7.

4.4.3 Process Control Relay Settings

Use either of the two methods below to set the process control relay to the desired pressure trip point. The first method sets the trip point by adjusting the setpoint potentiometer to a certain voltage as listed in Table 4-5. The second method sets the trip point by adjusting the setpoint potentiometer while the vacuum system operating.

NOTE: The pressure settings and voltages listed in Table 4–5 are for use with Air or N_2 ONLY.

4.4.3.1 Setting the Process Control Relay with a Digital Voltmeter:

1. On Table 4-5, determine the analog output voltage corresponding to the pressure at which you want the setpoint relay to trip.
2. Measure the setpoint voltage across pins 8 and 9 of the 9-pin D connector on the Controller. See Figure 4-2.
3. Adjust the Setpoint potentiometer on the front panel of the 352 Controller (See Figure 4-1) to the desired trip-point voltage.

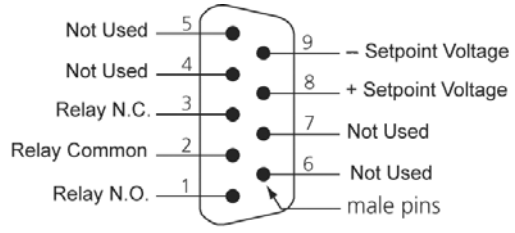
4.4.3.2 Setting the Process Control Relay by Setting the Pressure, Rather than the Voltage:

1. Set the Setpoint potentiometer on the front panel of the 352 Controller (See Figure 4-1) to the full counterclockwise position (relay de-energized).
2. With the vacuum system operating, establish the desired setpoint (trip point) pressure.

3. Slowly adjust the Setpoint potentiometer on the front panel of the 352 Controller clockwise until the relay energizes. You can see when the relay trips by monitoring the voltage across pins 8 and 9 of the 9-pin D connector on the Controller, or by noticing when the setpoint signal goes to the device being controlled by the setpoint relay. See Figure 4-2.

Table 4-5 *Pressure (Torr) vs. Setpoint Voltage*

Pressure (Torr)	Setpoint Volts		Pressure (Torr)	Setpoint Volts
0	0.375		10	4.205
0.001	0.384		20	4.576
0.002	0.392		50	4.8436
0.005	0.417		100	4.944
0.01	0.455		200	5.019
0.02	0.522		300	5.111
0.05	0.681		400	5.223
0.1	0.878		500	5.329
0.2	1.1554		600	5.419
0.5	1.683		700	5.494
1	2.216		760	5.534
2	2.8412		800	5.558
5	3.6750		900	5.614
			1000	5.659



The Normally Open relay is Closed when the Convectron 1 pressure is Low.

The Normally Closed relay is Closed when the Convectron 1 pressure is High or Power is OFF.

Figure 4-2 *Convectron Setpoint 9-pin Connector*

4.4.4 Reading Pressure

Pressure for the Convectron gauges is read only from the DeviceNet interface. A network POLL returns data as A/D counts. See Chapter 5 for the protocol. The response from the Convectron Gauge can be converted to pressure as indicated in Table 4-6. The count value is equivalent to 410 counts/volt on a scale of 0 to 9 Volts.



If used without proper calibration or without reference to proper calibration tables, Convectron gauges can supply misleading pressure indications. This may result in dangerous overpressure conditions within the system. As supplied from the factory, the controller is designed to read pressure for nitrogen. For use with any other gases, consult the gas type correction charts found later in this chapter.

Table 4-6 *Polled Data to Pressure Conversion*

Pressure (Torr)	A/D Counts	Hex Counts
0.0	0	0000
0.0001	4	0004
0.0002	8	0008
0.0005	20	0014
0.001	39	0027
0.002	78	004E
0.005	187	00BB
0.01	356	0164
0.0193	625	0271
0.02	629	0275
0.05	723	0203
0.1	840	0348
0.2	1003	03EB
0.5	1315	0523
1	1630	065E
2	1999	07CF
5	2491	09BB
10	2805	0AF5
20	3024	0BD0
50	3183	0C6F
100	3241	0CA9
200	3285	0CD5
300	3340	0D0C
400	3406	0D4E
500	3468	0D8C
600	3522	0DC2
700	3566	0DEE
760	3589	0E0D
800	3604	0E14
900	3637	0E35
1000	3663	0E4F

4.4.5 Special Considerations For Use Below 10^{-3} Torr

During a fast pumpdown from atmosphere, thermal effects will prevent the Convectron 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 4.5 on page 47 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 measured by ion gauges, since ion gauges usually lose sensitivity near their upper pressure limits.

4.4.6 Use With Gases Other Than N_2 and Air

Before using the Convectron gauge to measure the pressure of other gases make certain the ATM adjustment is correctly set for air. Refer to Section 4.5 on page 47.

It is important to understand that the indicated pressure on a Convectron 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. Convectron gauges are supplied calibrated for N_2 within the accuracy of the instrument. With certain safety precautions, the Convectron gauge may be used to measure pressure of other gases.

Convectron 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.

4.4.7 Indicated vs. True Pressure Curves

Figures 4-3 to 4-8 show the true pressure vs. indicated pressure of a Convectron gauge for eleven commonly used gases. The following list will help to locate the proper graph for a specific application:

Table 4-7 *Polled Data to Pressure Conversion*

Figure	Range and Units	Gases
4-3	1 to 100 mTorr	All
4-4	0.1 to 1000 Torr	Ar, $C0_2$, CH_4, Freon 12, He
4-5	0.1 to 1000 Torr	D_2, Freon 22, Kr, Ne, 02
4-6	10^{-3} to 10-1 mbar	All
4-7	0.1 to 1000 mbar	Ar, $C0_2$, CH_4, Freon 12, He
4-8	0.1 to 1000 mbar	D_2, Freon 22, Kr, Ne, 02

NOTE: 1 mbar = 100 pascal, so the mbar charts may be used for pascal units by multiplying the values on the axes by 100.

A useful interpretation of these curves is: at a true pressure of 2 x 10^{-2} Torr of CH_4 the heat loss from the sensor is the same as at a pressure of 3 x 10^{-2} Torr of N_2 (refer to Figure 4-4). 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 Convectron 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 Convectron gauge are likely to be much different from curves for heat loss tubes made by others. ***It is not safe to attempt to use calibration curves supplied by other manufacturers for their gauges with the Convectron, 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 N_2 or Air, use Figures 4-3 through 4-8 to determine the maximum safe indicated pressure for the other gas as explained below.



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 999 Torr true pressure.

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 want to limit the maximum internal pressure to 760 Torr during backfilling. Assume you want to measure the pressure of argon. On Figure 4-4, 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 (N_2 equivalent). Thus in this hypothetical situation the maximum safe indicated pressure for argon is 24 Torr.

Example 2: Indicated to True Pressure Conversion

Assume you want to determine the true pressure of argon in a system when the Convectron is indicating 10 Torr. On Figure 4-4, read up from 10 Torr (N_2 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 (N_2 equivalent).

Example 3: True to Indicated Pressure Conversion

Assume you want to set a process control setpoint at a true pressure of 20 Torr of CO_2. On Figure 4-4, locate 20 Torr on the true pressure scale, travel horizontally to the right to the CO_2 curve and then down to an indicated pressure of 6.5 Torr (N_2 equivalent). Thus the correct process control setting for 20 Torr of $C0_2$ is 6.5 Torr (N_2 equivalent).

Example 4: True to Indicated Pressure Conversion

Assume you want to obtain a helium pressure of 100 Torr in the system. On Figure 4-4, 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.

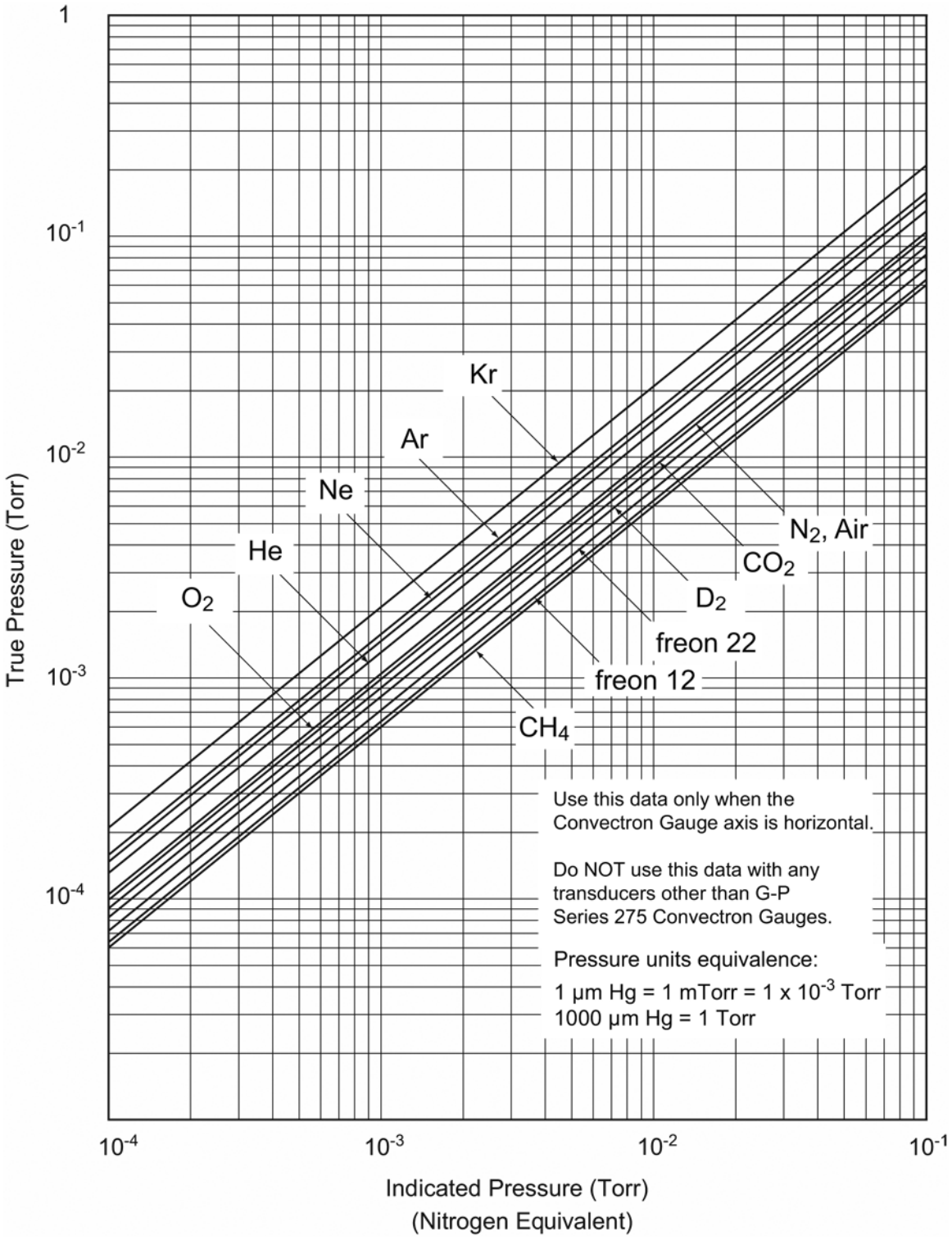


Figure 4-3 *Convectron Gauge Indicated vs. True Pressure Curve; 0.1 to 100 mTorr*

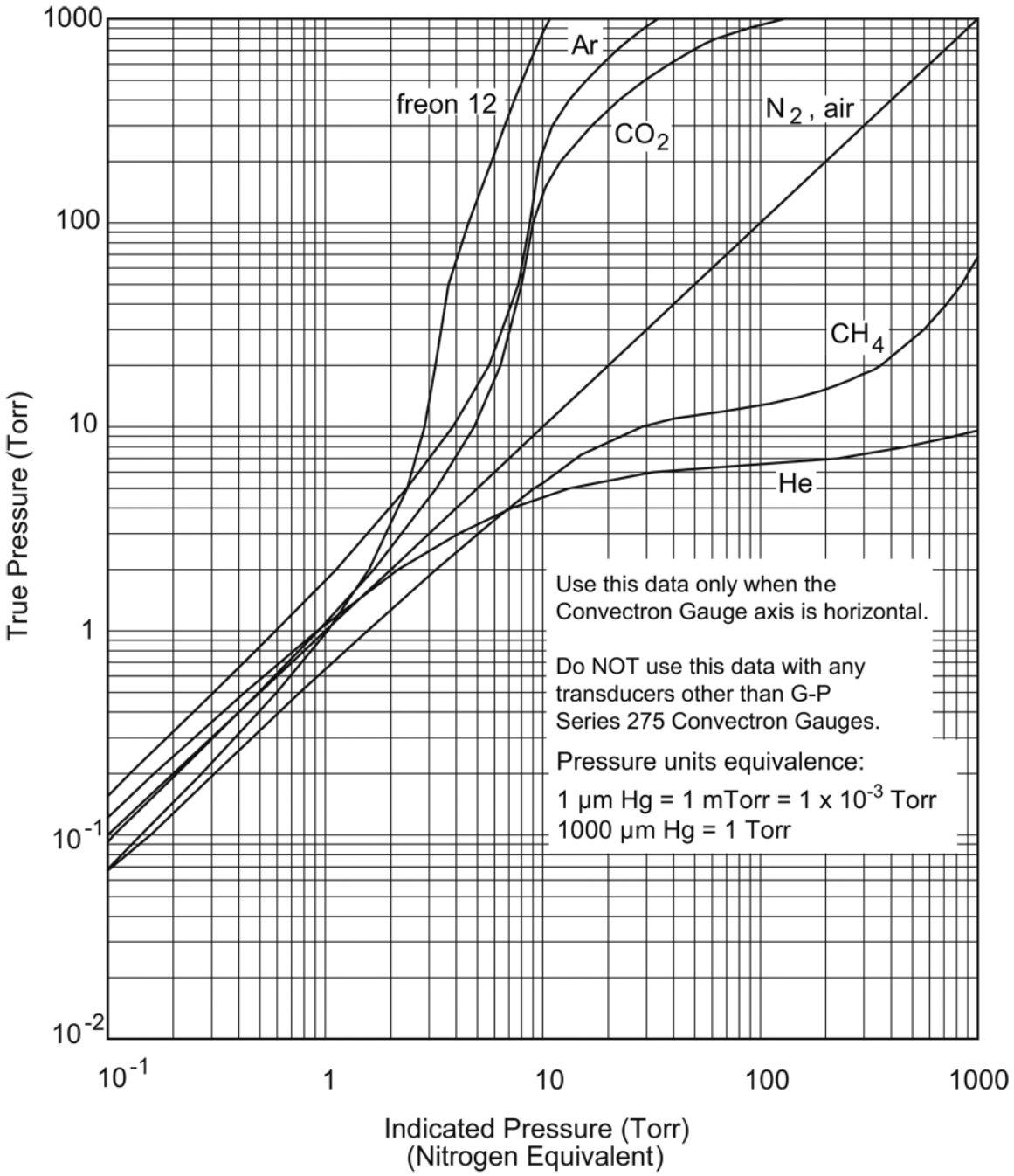


Figure 4-4 *Convectron Gauge Indicated vs. True Pressure Curve; 0.1 to 1000 Torr*

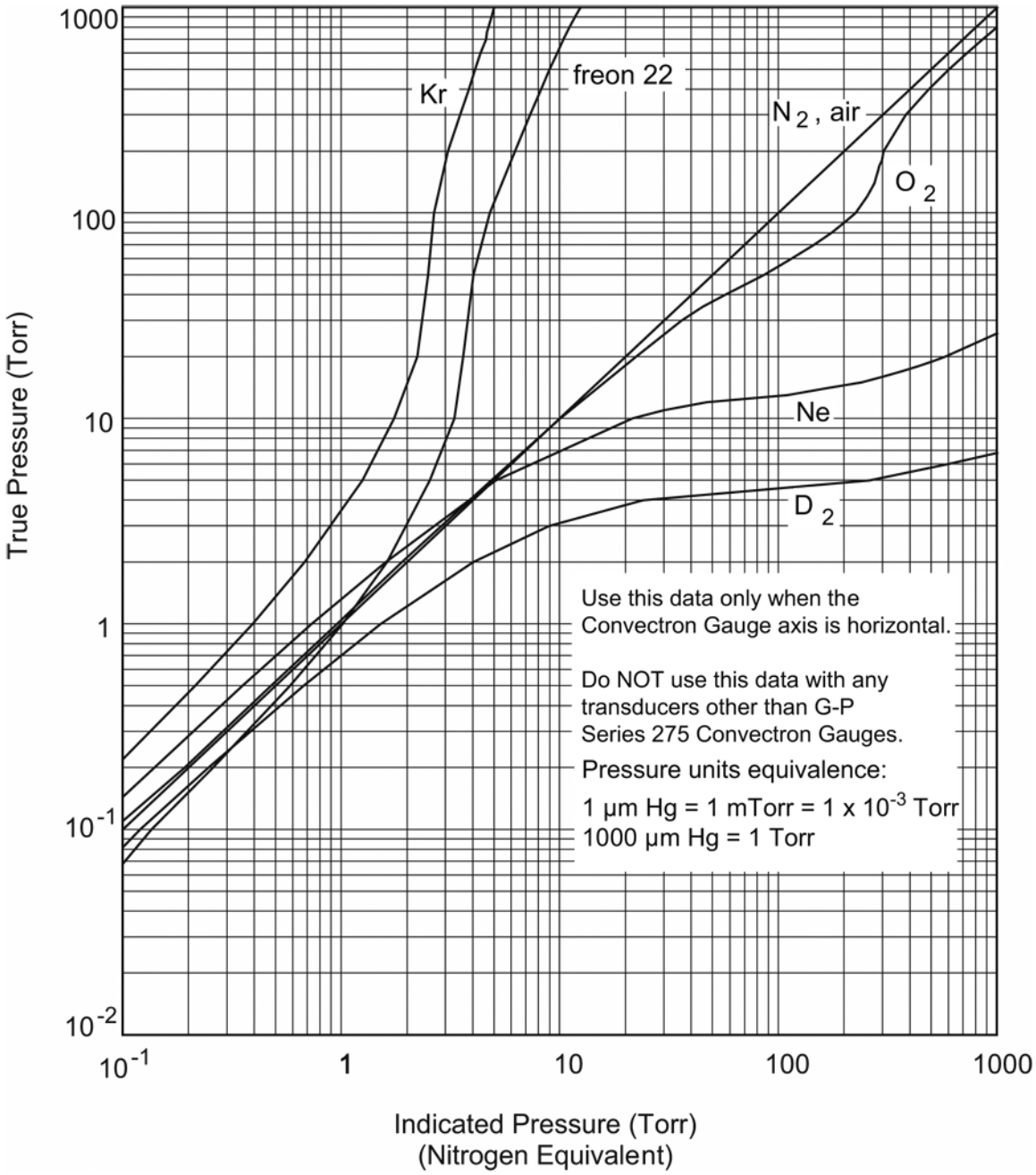


Figure 4-5 *Convectron Gauge Indicated vs. True Pressure Curve; 0.1 to 1000 Torr*

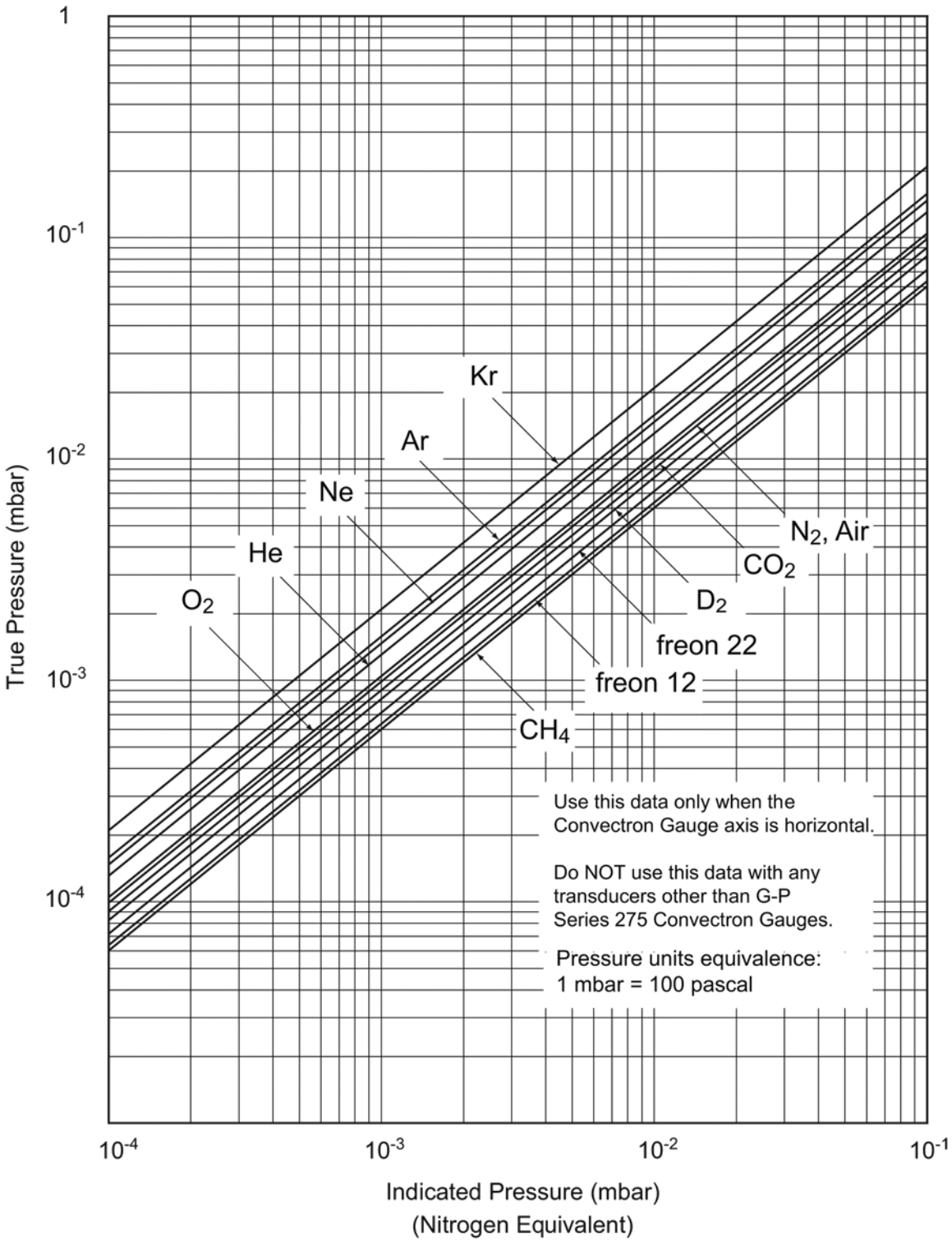


Figure 4-6 *Convectron Gauge Indicated vs. True Pressure Curve; 10^{-4} to 0.1 mbar*

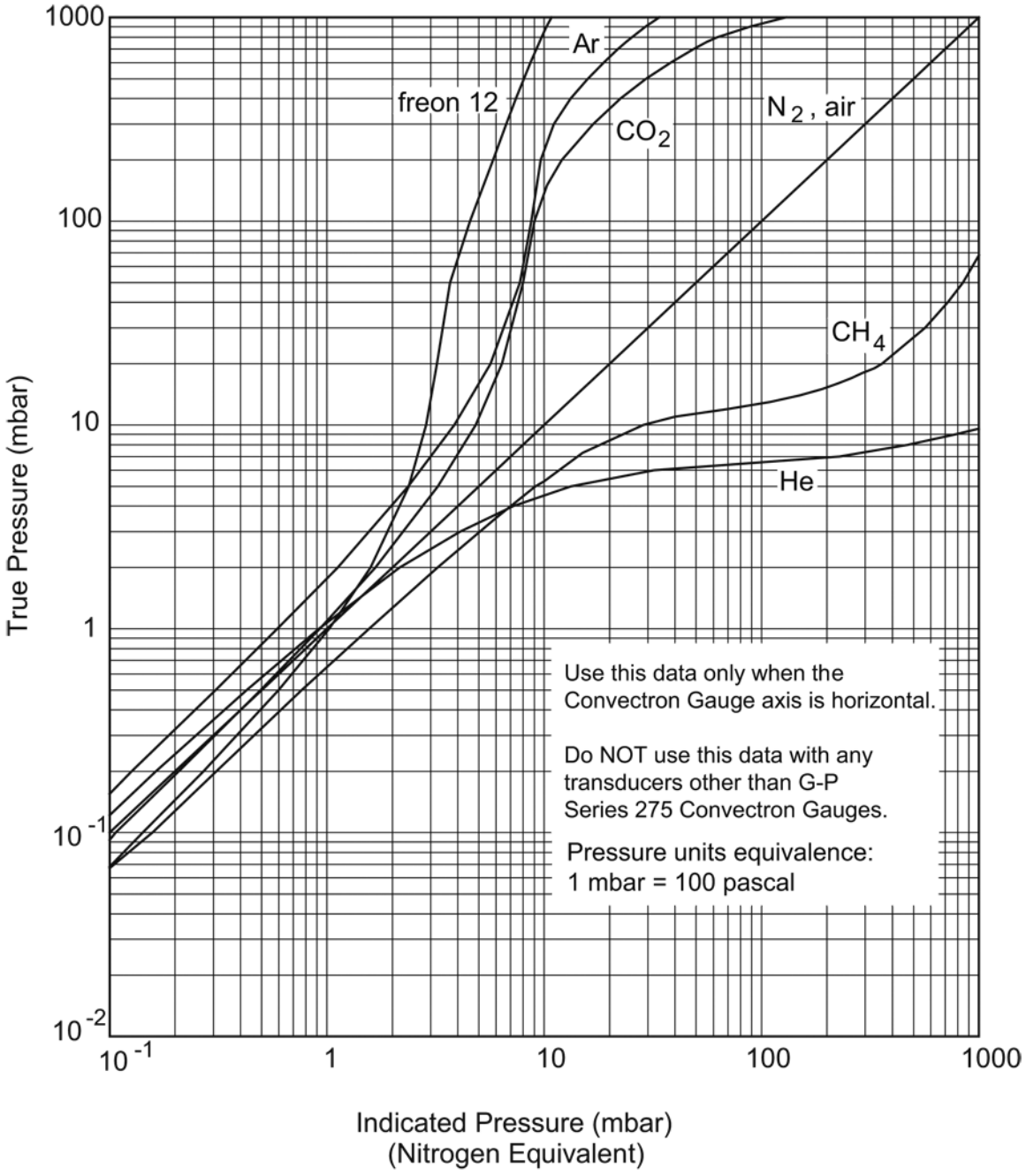


Figure 4-7 *Convectron Gauge Indicated vs. True Pressure Curve; 0.1 to 1000 mTorr*

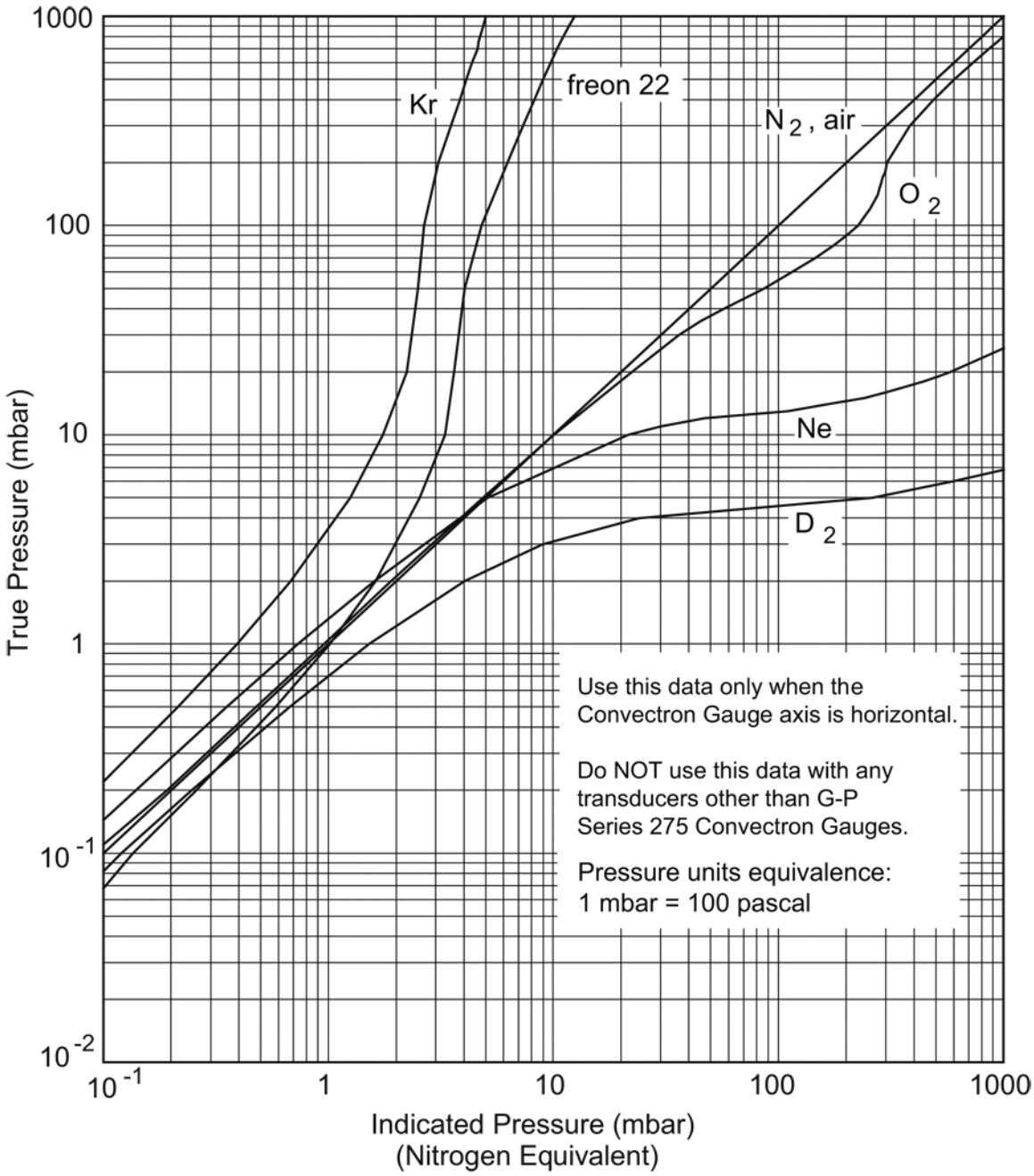


Figure 4-8 *Convectron Gauge Indicated vs. True Pressure Curve; 0.1 to 1000 mbar*

4.5 Adjustment of Convectron Gauge Zero and Atmospheric Pressure Indications



Using the N_2 calibration to pressurize a vacuum system above about 1 Torr with certain other gases can cause dangerously high pressures which may cause explosion of the system. See Section 4.4.6 on page 39 and Section 4.4.7 on page 39 before using with other gases.

Each Convectron Gauge has a stable, temperature compensated design and is individually computer calibrated for N_2. Zero adjustment of the gauge should not be necessary unless readout accuracy is required below 1 x 10^{-3} Torr or the gauge has been contaminated. Adjustment of the atmospheric indication should not be necessary unless compensating for long cables, variations in mounting orientation, or contamination.

For accurate readout, the vacuum and atmosphere adjustments must be made in the following order. Atmosphere adjustment will not effect the vacuum setting, but vacuum adjustment will effect the atmosphere setting. The subscript data is an unassigned 16 bit integer.

4.5.1 Calibrate the Vacuum Reading for Convectron Gauge #1

1. Evacuate the Convectron Gauge to a pressure known to be less than 1 x 10^{-4} Torr of N_2.

2. With power ON and pressure less than 1 x 10^{-4} Torr for at least 15 minutes, send Parameter Object 0F, Instance 3, Attribute 1, Data 00 $00_{hex,}$ to zero the Convectron Gauge. If the base pressure is between 1 x 10^{-4} to 1 x 10^{-1} Torr, use another gauge or pump specs to set zero. For example: If your pump will go down to 1 x 10^{-2} Torr, send 1640_{hex} for data. (Multiply the counts listed in Table 4-6 times 16 to find other values.)

3. Use Instance 5 for Convectron Gauge #2, and Instance 7 for Convectron Gauge #3.

NOTE: The 352 Controller circuit and firmware do not prevent incorrect calibration. Double check the calibration value and the system pressure before proceeding. The Convectron Gauge will not function properly if incorrectly calibrated.

4.5.2 Calibrate the Atmosphere Reading for Convectron Gauge #1

1. Allow the system pressure to increase to atmospheric pressure.

2. Read the local atmospheric pressure on an accurate barometer or use the data in Table 4-8 to set the Decimal Count value or Hex Count Value for your system.

3. With the power on, set the Decimal Count value or Hex Count Value for your system. For example: at sea level, send Parameter Object 0F, Instance 4, Attribute 1, Data E0 60. (Multiply the counts listed in Table 4-6 times 16 to find other values.)

NOTE: The 352 Controller circuit and firmware do not prevent incorrect calibration. Double check the calibration value and the system pressure before proceeding. The Convectron Gauge will not function properly if incorrectly calibrated.

4. Use Instance 6 for Convectron 2, and Instance 8 for Convectron 3.

Table 4-8 *Data Values for Atmosphere Calibration*

Altitude in Feet - Above Sea Level	Pressure in Torr for N2 or Air	Decimal Count Value	Hex Count Value
0	760	57440	E060
1000	773	57272	DFB8
2000	707	57110	DF15
3000	681	56932	DE63
4000	656	56755	DDB2
5000	632	56585	DD09
6000	609	56423	DC66
7000	586	56239	DBAE
8000	564	56049	DAF1
9000	543	55869	DA3C
10000	523	55696	D990

5.1 DeviceNet Protocol for the Series 352 Controller

The Series 352 Vacuum Gauge Controller is based on the Open DeviceNet Vendors Association (ODVA) standard. The command set includes public and vendor-specific classes, services, and attributes.

DeviceNet communication requires identifier fields for the data. The use of identifier fields provides the means for multiple priority levels, efficient transfer of I/O data, and multiple consumers. As a node in the network, the Controller produces data on the network with a unique address. All devices on the network that need the data listen for messages. When other devices on the network recognize the Controller's unique address, they use the data.

Table 5-1 *Input Polled I/O Messaging Summary (9 Bytes)*

Instance	Master data	Device data	Data type: STRUCT	Description	Type
1	None	00 00	Bytes 0 - 1	IG (Ion Gauge) Pressure	Vendor Specific
		00 00	Bytes 2 - 3	CG1 (Convectron Gauge) Pressure	Vendor Specific
		00 00	Bytes 4 - 5	CG2 Pressure	Vendor Specific
		00 00	Bytes 6 - 7	CG3 Pressure	Vendor Specific
		00	Byte 8	Status Bit 7: 1_maS (one milliamp status) / 1 = ON, 0 = OFF Bit 6: IGS (ion gauge status) / 1 = ON, 0 = OFF Bit 5: CG3S / Always 1 Bit 4: CG3S / Always 1 Bit 3: CG1S / Always 1 Bit 2: FIL2S (filament 2 status) / 1 = ON, 0 = OFF Bit 1: FIL1S (filament 1 status) / 1 = ON, 0 = OFF Bit 0: DGS (degas) / 1 = ON, 0 = OFF	Vendor Specific

NOTE: Unsigned binary is used to represent the positive analog voltage.

Table 5-2 *Output Polled I/O Messaging Summary (1 Byte)*

Instance	Master data	Device data: NONE	Data type: STRUCT	Description
1	Bit 7	NONE	STRUCT	High Emission 1mA / 1 = 1 mA / 0 = 0.1 mA
	Bit 6			Ion Gauge Control: / 1 = ON / 0 = OFF
	Bit 5 - 1			Not Used
	Bit 0			Degas Control: / 1= ON / 0 = OFF

5.1.1 Standard Objects

There is a single instance of the Identity Object for the Series 352 Controller. No class attributes are supported. All of the instance attributes are contained in ROM or EEPROM.

5.1.1.1 Indentity Object

Table 5-3 *Explicit Message Summary - Indentity Object*

Service	Class	Instance	Attribute	Master data	Device data	Data type	Description	Type
$0E_{hex}$	1	1	1	None	00 $5C_{hex}$	UINT	Vendor identification	Open
$0E_{hex}$	1	1	2	None	00 00_{hex}	UINT	Product type	Open
$0E_{hex}$	1	1	3	None	01 00	UINT	352 product ID	Open
$0E_{hex}$	1	1	4	None	01 01	STRUCT	Firmware revision	Open
$0E_{hex}$	1	1	5	None	00 00	WORD	Status and fault information	Open
$0E_{hex}$	1	1	6	None	00 00 00 00	UDINT	Serial number	Open
$0E_{hex}$	1	1	7	None	"GP352"	S_STRING	Identification	Open

05_{hex}	1	1	None	None	None		Reset module to power-up state	Open

5.1.1.2 DeviceNet Object

There is a single instance of the DeviceNet Object for the Mini-Convectron Module. No class attributes are supported.

Table 5-4 *Explicit Message Summary - DeviceNet Object*

Service	Class	Instance	Attribute	Master data	Device data	Data type	Description	Type
$0E_{hex}$	3	1	1	None	0	USINT	Get node address, range 0–63	Open
$0E_{hex}$	3	1	2	None	0	USINT	Get baud rate, range 0–2	Open
$0E_{hex}$	3	1	3	None	0	BOOL	Get bus-off interrupt, range 0–1	Open
$0E_{hex}$	3	1	4	None	0	USINT	Get bus-off counter, range 0–255	Open
10_{hex}	3	1	4	0	Success		Set bus-off counter	Open
$0E_{hex}$	3	1	5	None	00 00	STRUCT	Get allocation choice, range 0–3 Get master ID, range 0–63	Open
$4B_{hex}$	3	1	None	03 00	Success	STRUCT	Set allocation choice, range 0–3 Set master ID, range 0–63	Open
$4C_{hex}$	3	1	None	3	Success	BYTE	Release allocation, range 0–3	Open

5.1.1.3 Assembly Object

There are 2 instances of the Assembly Object. Instance 1 is engaged to get pressure data from the device; Instance 2 is assigned to set the ion gauge state of the device.

Table 5-5 *Explicit Message Summary - Assembly Object*

Service	Class	Instance	Attribute	Master data	Device data	Data type	Description	Type
$0E_{hex}$	4	1	3	None	00 00	STRUCT	Get USINT IG pressure	Open
					00 00	STRUCT	Get USINT CG1 pressure	
					00 00	STRUCT	Get USINT CG2 pressure	
					00 00	STRUCT	Get USINT CG3 pressure	
					00	BYTE	Status Bit 7: 1_maS (one milliamp status) / 1 = ON, 0 = OFF Bit 6: IGS (ion gauge status) / 1 = ON, 0 = OFF Bit 5: CG3S / Always 1 Bit 4: CG3S / Always 1 Bit 3: CG1S / Always 1 Bit 2: FIL2S (filament 2 status) / 1 = ON, 0 = OFF Bit 1: FIL1S (filament 1 status) / 1 = ON, 0 = OFF Bit 0: DGS (degas) / 1 = ON, 0 = OFF	
10_{hex}	4	2	3	00	Success	BYTE	Bit 7: 1mA emission / 1 = 1 mA / 0 = 0.1 mA	
							Bit 6: Ion gauge ON/OFF / 1 = ON / 0 = OFF	
							Bit 5: 1 Ignored	
							Bit 0: Degas ON/OFF / 1 = ON / 0 = OFF	

5.1.1.4 Connection Object

There are two instances of the Connection Object for the Convectron Gauge. Instance #1 is assigned to the Explicit Message Connection. Instance #2 is assigned to the Polled I/O Connection. Table 5-6 and Table 5-7 show the attributes and the predefined values of each.

Table 5-6 *Explicit Message Summary - DeviceNet Object*

Service	Class	Instance	Attribute	Master data	Device data	Data type	Description	Type
$0E_{hex}$	5	1	1	None	3_{hex}	USINT	Get state of the object, range 0–5	Open
$0E_{hex}$	5	1	2	None	0_{hex}	USINT	Get instance type, explicit	Open
$0E_{hex}$	5	1	3	None	83_{hex}	BYTE	Get transport class trigger	Open
$0E_{hex}$	5	1	4	None	FB 05_{hex}	UINT	Get produced connection ID	Open
$0E_{hex}$	5	1	5	None	FC 05_{hex}	UINT	Get consumed connection ID	Open
$0E_{hex}$	5	1	6	None	21_{hex}	BYTE	Get initial communication character	Open
$0E_{hex}$	5	1	7	None	16 00_{hex}	UINT	Get produced connection size	Open
$0E_{hex}$	5	1	8	None	07 00_{hex}	UINT	Get consumed connection size	Open
0Ehex	5	1	9	None	C4 09_{hex}	UINT	Get expected packet rate, range 0–65535	Open
10_{hex}	5	1	9	C3 01_{hex}	Success	UINT	Set expected packet rate	Open
$0E_{hex}$	5	1	$0C_{hex}$	None	1	USINT	Get watchdog timeout action, 1 or 3	Open
$0E_{hex}$	5	1	$0D_{hex}$	None	00 00_{hex}	UINT	Get produced connection path length	Open
$0E_{hex}$	5	1	$0E_{hex}$	None	4	EPATH	Get produced connection path	Open
$0E_{hex}$	5	1	$0F_{hex}$	None	00 00_{hex}	UINT	Get consumed connection path length	Open
$0E_{hex}$	5	1	10_{hex}	None	00	EPATH	Get consumed connection path	Open

Table 5-7 *Connection Object - Polled I/O Connection*

Service	Class	Instance	Attribute	Master data	Device data	Data type	Description	Type
$0E_{hex}$	5	2	1	None	3_{hex}	USINT	Get state of the object, range 0–5	Open
$0E_{hex}$	5	2	2	None	1_{hex}	USINT	Get instance type, I/O	Open
$0E_{hex}$	5	2	3	None	82_{hex}	BYTE	Get transport class trigger	Open
$0E_{hex}$	5	2	4	None	FF 03_{hex}	UINT	Get produced connection ID	Open
$0E_{hex}$	5	2	5	None	FD 05_{hex}	UINT	Get consumed connection ID	Open
$0E_{hex}$	5	2	6	None	01_{hex}	BYTE	Get initial communication character	Open
$0E_{hex}$	5	2	7	None	05 00_{hex}	UINT	Get produced connection size	Open
$0E_{hex}$	5	2	8	None	01 00_{hex}	UINT	Get consumed connection size	Open
$0E_{hex}$	5	2	9	None	00 00_{hex}	UINT	Get expected packet rate, range 0–65535	Open
10_{hex}	5	2	9	$00\ 00_{hex}$	Success	UINT	Set expected packet rate	Open
$0E_{hex}$	5	2	$0C_{hex}$	None	0_{hex}	USINT	Get watchdog timeout action	Open
$0E_{hex}$	5	2	$0D_{hex}$	None	06 00_{hex}	UINT	Get produced connection path length	Open
$0E_{hex}$	5	2	$0E_{hex}$	None	01	EPATH	Get produced connection path (1,2,4,5)	Open
$0E_{hex}$	5	2	$0F_{hex}$	None	06 00_{hex}	UINT	Get consumed connection path length	Open
$0E_{hex}$	5	2	10_{hex}	None	00	EPATH	Get consumed connection path(0,1)	Open

5.1.1.5 Parameter Object

There are nine instances of the Parameter Object. Instance #1 manages the IG offset calibration. This two-byte value represents the desired output. Performing the Get_Attribute_Single service initiates the calibration sequence. Instance #2 manages the IG gain calibration. This two-byte value represents the desired output. Performing the Get_Attribute_Single service initiates the calibration sequence. The IG calibration should not be done by the user, as it requires special tools to calibrate.

Table 5-8 *Explicit Message Summary - Parameter Object*

Service	Class	Instance	Attribute	Master data	Device data	Data type	Description	Type
$0E_{hex}$	0F	1	1	None	00 00_{hex}	UINT	Indicate data used with last "set"	Vendor specific
10_{hex}	0F	1	1	00 00_{hex}	None	UINT	Ion gauge offset calibration	Vendor specific
$0E_{hex}$	0F	2	1	None	60 E0 $_{hex}$	UINT	Indicate data used with last "set"	Vendor specific
10_{hex}	0F	2	1	60 $E0_{hex}$	None	UINT	Ion gauge gain calibration	Vendor specific
$0E_{hex}$	0F	3	1	None	00 00_{hex}	UINT	Indicate data used with last "set" (CG1)	Vendor specific
10_{hex}	0F	3	1	00 00_{hex}	None	UINT	Set vacuum reading to Zero - transducer must be measuring vacuum (CG1)	Vendor specific
$0E_{hex}$	0F	4	1	None	60 E0 $_{hex}$	UINT	Indicate data used with last "set" (CG1)	Vendor specific
10_{hex}	0F	4	1	60 $E0_{hex}$	None	UINT	Set Atmosphere (ATM) reading to 760 Torr - transducer must be measuring ATM (CG1)	Vendor specific
$0E_{hex}$	0F	5	1	None	00 00_{hex}	UINT	Indicate data used with last "set" (CG2)	Vendor specific
10_{hex}	0F	5	1	00 00_{hex}	None	UINT	Set vacuum reading to Zero - transducer must be measuring vacuum (CG2)	Vendor specific
$0E_{hex}$	0F	6	1	None	60 E0 $_{hex}$	UINT	Indicate data used with last "set" (CG2)	Vendor specific
10_{hex}	0F	6	1	60 $E0_{hex}$	None	UINT	Set Atmosphere (ATM) reading to 760 Torr - transducer must be measuring ATM (CG2)	Vendor specific
$0E_{hex}$	0F	7	1	None	00 00_{hex}	UINT	Indicate data used with last "set" (CG3)	Vendor specific
10_{hex}	0F	7	1	00 00_{hex}	None	UINT	Set vacuum reading to Zero - transducer must be measuring vacuum (CG3)	Vendor specific
$0E_{hex}$	0F	8	1	None	60 E0 $_{hex}$	UINT	Indicate data used with last "set" (CG3)	Vendor specific
10_{hex}	0F	8	1	60 $E0_{hex}$	None	UINT	Set Atmosphere (ATM) reading to 760 Torr - transducer must be measuring ATM (CG3)	Vendor specific
$0E_{hex}$	0F	9	1	None	4033_{hex}	UINT	Indicate setpoint value with last set	Vendor specific
10_{hex}	0F	9	1	4033_{hex}	None	UINT	Set IG overpressure shutdown value OVP = 6560 x (-Log Pressure)	Vendor specific
$0E_{hex}$	0F	10	1	None	7C 15_{hex}	UINT	Get IG overpressure timer value	Vendor specific

5.1.1.6 Polled Data

A network POLL will return Convectron data as A/D counts. This response can be converted to pressure as indicated in Table 5-9. The maximum value is 0FFF or 2^12 counts.

Table 5-9 *Polled Data to Pressure Conversion*

Pressure (Torr)	A/D Counts	Hex Counts
0.0	0	0000
0.0001	4	0004
0.0002	8	0008
0.0005	20	0014
0.001	39	0027
0.002	78	004E
0.005	187	00BB
0.01	356	0164
0.0193	625	0271
0.02	629	0275
0.05	723	0203
0.1	840	0348
0.2	1003	03EB
0.5	1315	0523
1	1630	065E
2	1999	07CF
5	2491	09BB
10	2805	0AF5
20	3024	0BD0
50	3183	0C6F
100	3241	0CA9
200	3285	0CD5
300	3340	0D0C
400	3406	0D4E
500	3468	0D8C
600	3522	0DC2
700	3566	0DEE
760	3589	0E0D
800	3604	0E14
900	3637	0E35
1000	3663	0E4F
ERROR	4095	0FFF

Ion Gauge pressure in Torr can be calculated from the A/D output. For an emission current of 1 mA the formula for pressure is: $P = 10^{\wedge}\left(\frac{-COUNTS}{410}\right)$

For an emission current of 0.1 mA the formula for pressure is: $P = 10^{\wedge}\left(\left(\frac{-COUNTS}{410}\right)+1\right)$

Counts Value = $0FFF_{hex}$ or 4095 when the Ion gauge is OFF.

Notes

Chapter 6

Service and Maintenance

6.1 Service Guidelines

If a Qualified Service Person makes repairs at the component level, repairs properly made with equivalent electronic parts and rosin core solder do not void the warranty.

The Series 352 Vacuum Gauge Controller contains static-sensitive electronic parts. The following precautions must be followed when troubleshooting:

- Use a grounded, conductive work surface. Wear a high impedance ground strap for personal protection.
- Use conductive or static dissipative envelopes to store or ship static sensitive devices or printed circuit boards.
- Do not operate the product with static sensitive devices or other components removed from the product.
- Do not handle static sensitive devices more than absolutely necessary, and only when wearing a ground strap.
- Do not use an ohmmeter for troubleshooting MOS circuits. Rely on voltage measurements.
- Use a grounded, electrostatic discharge safe soldering iron.

NOTE: This product was designed and tested to offer reasonably safe service provided it is installed, operated, and serviced in strict accordance with these safety instructions.



The service and repair information in this manual is for the use of Qualified Service Personnel. To avoid shock, do not perform any procedures in this manual or perform any servicing on this product unless you are qualified to do so.



Do not substitute parts or modify the product.

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the product. Return the product to a service facility designated by Granville–Phillips for service and repair to ensure that safety features are maintained. Do not use this product if it has unauthorized modifications.



Safety Check – Upon completion of any service or repairs to this product, ask the Qualified Service Person to perform safety checks to determine that the product is in safe operating order.

6.2 Damage Requiring Service

Disconnect this product from the power source and refer servicing to Qualified Service Personnel if any the following conditions exist:

- The gauge cable, power-supply cord, or plug is damaged.
- Liquid has been spilled onto, or objects have fallen into, the product.
- The product does not operate normally even if you have followed the Operation Instructions. Adjust only those controls that are covered in the instruction manual.
- The product has been dropped or the enclosure has been damaged.

6.3 Returning a Module for Service

Some minor problems are readily corrected on site. If the product requires service, contact the MKS, Granville-Phillips Division Customer Service Department at +1-800-227-8766 or +1-303-652-4691 for troubleshooting help over the phone.

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

When returning a products to Granville-Phillips, be sure to package the products to prevent shipping damage. Circuit boards and modules separated from the gauge assembly must be handled using proper anti-static protection methods and must be packaged in anti-static packaging. Granville-Phillips will supply return packaging materials at no charge upon request. Shipping damage on returned products as a result of inadequate packaging is the Buyer's responsibility.

For Customer Service or Technical Support 24 hours per day, 7 days per week, every day of the year including holidays:
Phone: +1-800-227-8766 or +1-303-652-4691
Email: gp-csr@mksinst.com

MKS, Granville-Phillips Division
6450 Dry Creek Parkway
Longmont, CO 80503 USA
Phone: 1-303-652-4691 or 1-800-776-6543
FAX: 1-303-652-2844

6.4 Troubleshooting

6.4.1 Stabil-Ion Module Troubleshooting Procedures

Table 6-1 presents problems along with possible causes and corrective actions.

Table 6-1 *General Symptoms/Possible Causes*

Problem	Possible Cause	Corrective Action
Unit will not power-up:	No power supplied to the module.	Check for +11 Vdc to +24 Vdc power across pins 2 and 3 of the DeviceNet connector. See Section 3.2 in the Installation chapter.
Unit does not respond to DeviceNet communication from a Master but the Module Status LED is solid green:	1. Address rotary switches set to incorrect address positions. 2. Incorrect baud rate programmed. 3. Incorrect data format programmed.	1. Set the address rotary switches to the correct address positions. 2. Set the baud rate switch to the correct position. 3. Set the Polled Input & Output I/O Data Format as described in Chapter 5.
Module Status LED does not illuminate:	1. DeviceNet power supply disconnected, off, or inadequate for load.	A switching supply may shut down from the current surge upon power up. If a switching power supply is used, size the current limit to two times the working load. Refer to Section 3-1 for power requirements.
Inaccurate pressure reading:	1. Organic seals. If the Gauge connection to the vacuum system is sealed with an organic O-ring, the gauge will not read accurately below 1 x 10^{-7} Torr. 2. Mechanical damage. If the unit is dropped or excessive force is applied to the vacuum connection during installation, gauge elements may be damaged or pin leaks may occur. 3. Contamination. Pump oil and other organic compounds or metal coating from a sputtering process can cause electrical current leakage between Gauge elements.	1. Replace the O-ring with a metal seal. 2. Replace the gauge. 3. Degas the Stabil-Ion Gauge by setting the DEGAS state = 1. Refer to Section 4.3.5 and Table 5-5. Several degas cycles may be required to decontaminate the Gauge. If this does not work, the Gauge may be heated externally. See Section 4.3.6.
Process control Trip Point does not function as expected:	1. The Trip Point connector may be wired incorrectly. 2. Wrong Trip Point adjustment. **NOTE: T**he process control Trip Point will always have the COMMON contact connected to the N.C. contact when the Module is OFF or when the unit is not powered.	1. Refer to the Trip Point Cable Connections in Figure 3-7. 2. Read the Trip Point voltage. If Trip Point voltage is incorrect, set it to the proper voltage. See Section 4.4.3.

Problem	Possible Cause	Corrective Action
The Stabil-Ion Gauge shuts OFF during degas:	1. The pressure has increased above 5 x 10^{-5} Torr. 2. The DeviceNet Current requirement is over 3.0 Amps.	1. Repeat degas procedure until the pressure remains below 5 x 10^{-5} Torr for the entire cycle. 2. Replace the +24 V, 4 A dc power supply.

6.4.2 Convectron Gauge Test Procedure

The small diameter sensor wire can be damaged by even small voltages. Do not perform electrical continuity tests with instruments applying in excess of 0.1 volt when the gauge is at vacuum, or 2 volts when at atmospheric pressure.

The Convectron Gauge should show the resistances listed in Figure 6-1. Pin numbers are embossed on the gauge base. Measure the resistance across the pins with the gauge at atmospheric pressure, using an ohmmeter that will not apply more than 10 mA.



- Pins 1 to 2: 19 to 22 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.

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.

Figure 6-1 *Convectron Gauge Connector and Resistance in Ohms*

6.4.3 Cleaning Contaminated Convectron Gauges

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.

The Convectron Gauge may be baked to 150 °C, nonoperating, while under vacuum with the cable disconnected from the gauge.

All materials were chosen for ultra high vacuum service, corrosion resistance, and bakeability. The envelope is type 304 stainless steel. All metallic joints in the envelope are 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 rated at 150 °C.

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 prevent damaging the sensor.

Hold the gauge with the main body horizontal and the port projecting upward at an angle of 45 degrees. Slowly fill it 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. Slightly warming the gauge will help dry the gauge. 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.

6.4.4 Convectron Gauge Symptoms and Possible Causes

Table 6-2 *General Symptoms/Possible Causes*

SYMPTOM	POSSIBLE CAUSE
Pressure readout cannot be calibrated using the specified calibration commands.	The gauge tube is contaminated with material from the vacuum chamber. Clean the gauge tube (See Section 6.4.3) or replace the gauge tube. If the gold plating on the sensor wire has been attacked by a gas such as fluorine or mercury vapor, which has changed the emissivity or resistance, cleaning the gauge tube will not solve the problem - the gauge tube must be replaced.
The pressure readout from a Convectron Gauge is vastly different from that which is observed by supporting gauges on the vacuum system.	The gas composition in the vacuum chamber may not be what the user believes it to be. Determine the actual type of gas in the chamber, and calibrate the Convectron Gauge accordingly. See Section 4.4.6 and Section 4.4.7. Unexpected gas sources can also be caused by the process within the chamber or outgassing of the product in the process chamber. Gauge not mounted horizontally. See Section 3.4.2. Sensor damaged (e.g., by reactive gas) or dirty. See Section 6.4.2 and Section 6.4.3. Extremes of temperature or mechanical vibration.

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Series 352

Granville-Phillips® Series 352 Vacuum Gauge Controller with DeviceNet™



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