GRANVILLE-PHILLIPS
HELIX TECHNOLOGY CORPORATION

Series 316 Vacuum Gauge Controller Installation and Operation Instructions

316059
Rev. 4 (8/2001)

HELIX TECHNOLOGY CORPORATION
http://www.helixtechnology.com

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For assistance in using or servicing this instrument contact:

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Product Part Numbers

This manual is for use only with the following product part numbers:

Product Part Numbers
20316046
316035

Receiving Inspection

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

If materials are missing or damaged, the carrier that made the delivery must be notified within 15 days of delivery, or in accordance with Interstate Commerce regulations for the filing of a claim. Any damaged material including all containers and packaging should be held for carrier inspection. Refer to **Appendix A - Customer Support** and call the local Customer Support Center for assistance if your shipment is not correct for reasons other than shipping damage.

International Shipment

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

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

Any damaged material including all containers and packaging should be held for carrier inspection. Refer to **Appendix A - Customer Support** and call the local Customer Support Center for assistance if your shipment is not correct for reasons other than shipping damage.

Warranty

HELIX TECHNOLOGY CORPORATION CONDITIONS OF SALE ARE INCORPORATED BY REFERENCE HEREIN.

Certification

Helix Technology Corporation certifies that this product met its published specifications at the time of shipment from the factory. Helix Technology Corporation further certifies that its calibration measurements are traceable to the National Institute of Standards and Technology to the extent allowed by the Institute's calibration facility. See also CE Declaration of Conformity inside envelope for CE tests performed.

Service Guidelines

Some minor problems are readily corrected on site. If the product requires service, please contact our Customer Service Department at 1-303-652-4400 for troubleshooting help over the phone. If the product must be returned for service, request a Return Authorization (RA) from Helix Technology Corporation. See the Service Form at the end of Chapter 6. Do not return products without first obtaining an RA.

Shipping damage on returned products as a result of inadequate packaging is the Buyer's responsibility.

When returning equipment to Helix Technology Corporation, please use the original packing material whenever possible. Otherwise, contact your shipper or Helix Technology Corporation for safe packaging guidelines. Circuit boards and modules separated from the controller chassis must be handled using proper anti-static protection methods and must be packaged in anti-static packaging. Helix Technology Corporation will supply return packaging materials at no charge upon request.

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.

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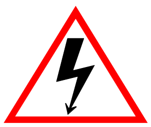
Safety

WARNING

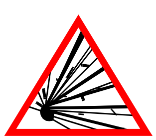
Read this instruction manual before installation, using, or servicing this equipment. If you have any doubts about how to use this equipment safely, refer to **Appendix A - Customer Support** and call the local Customer Support Center for assistance.



This symbol is associated with high voltage hazards. Follow all local and state codes when working with high voltage equipment.

This symbol is associated with handling of combustible materials. Follow all local and state codes when working with flammable materials and liquids.

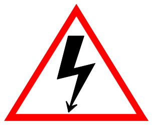

These symbols are associated with the handling of poisons and acids. Follow all local and state codes when working with caustic materials and liquids.



These symbols are associated with situations that may cause equipment to burst violently due to excessive pressures. Make sure systems are de-pressurized before attempting to work on them.

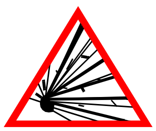
This symbol is associated with situations where there is a risk of being burned. Make sure the heat shield is properly installed to shield the gauge from any human contact.

WARNING



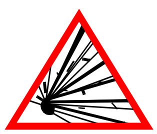
Voltages (up to 530 VDC) capable of causing injury or death are present in the Module. Avoid touching the connector sockets, tube pins, and other high voltage conductors. Servicing should be performed by qualified personnel only.

WARNING



Do not turn on the ionization gauge when there is danger of explosion from explosive or combustible gases, or gas mixtures. Ionization gauge filaments operate at temperatures sufficiently high to cause ignition.

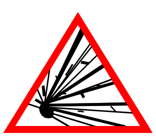
WARNING



A substantial shield should be placed around vacuum glassware to prevent injure to personnel. 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.

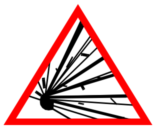
WARNING

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 ionization gauge tubes, glass windows, glass bell jars, etc., are not designed to be pressurized.

WARNING

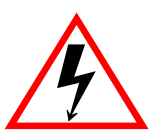


Install suitable devices that will limit the pressure from external gas sources to the level that the vacuum system can safely withstand. In addition, install suitable pressure relief valves or rupture discs that will release pressure at a level considerably below that pressure which the system can safely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

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

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

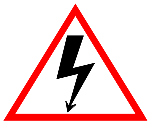
WARNING



Safe operation of ion producing equipment, including the Micro-Ion Gauge, requires grounding of both its power supply and the vacuum chamber. **LETHAL VOLTAGES** may be established under some operating conditions unless correct grounding is provided.

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

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



WARNING

Grounding, though simple, is very important! Please be certain that the ground circuits are correctly utilized, both on your ion gauge power supplies and on your vacuum chambers, regardless of their manufacturer, for this phenomenon is not peculiar to Granville-Phillips equipment. Refer to **Section 2 - Installation**, for additional information. If you have questions, or wish additional labels or literature, please contact one of our service personnel.

WARNING

To reduce the risk of being burned, make sure the heat shield is properly installed to shield the gauge from any human contact. Temperatures around 100º C have been observed during degas of Stabil-Ion gauges.

Section 1 - The 316 Vacuum Gauge Controller

1.1 Introduction

The 316 Vacuum Gauge Controller (VGC) measures pressures from 1×10^{-4} Torr (1×10^{-4} mbar or 1×10^{-2} Pa) to atmosphere, depending on modules and transducers used.

Modules are available to operate Convectron, capacitance manometer, and thermocouple gauges with three pressures displayed simultaneously.

Pressure readout is via 3 front panel displays, analog output, and available computer interface.

The 316 VGC is a modular instrument which can be easily customized to fit most user's exact needs. Infrequently used controls are housed behind a hinged front panel, reducing front panel clutter and allowing the control unit to reside in a half-rack space.

1.2 Available Configurations

1.2.1 Convectron Gauge (CG) Module

Permits pressure measurements from 1×10^{-4} to 999 Torr of N_2 from up to three Granville-Phillips Series 275 Convectron Gauges simultaneously. Provides analog output of each indicated pressure.

1.3 Installation

1.3.1 Line Voltage Selection

Line voltages of 90-110 or 105-125 or 220-240 volts are user selectable via jumpers on the power supply PC board within the controller. The factory preset line voltage and fuse rating are marked on the rear panel. Compare your unit to Figure 1-1 to determine if it is configured for your requirements. Do not apply power until the correct configuration is achieved.

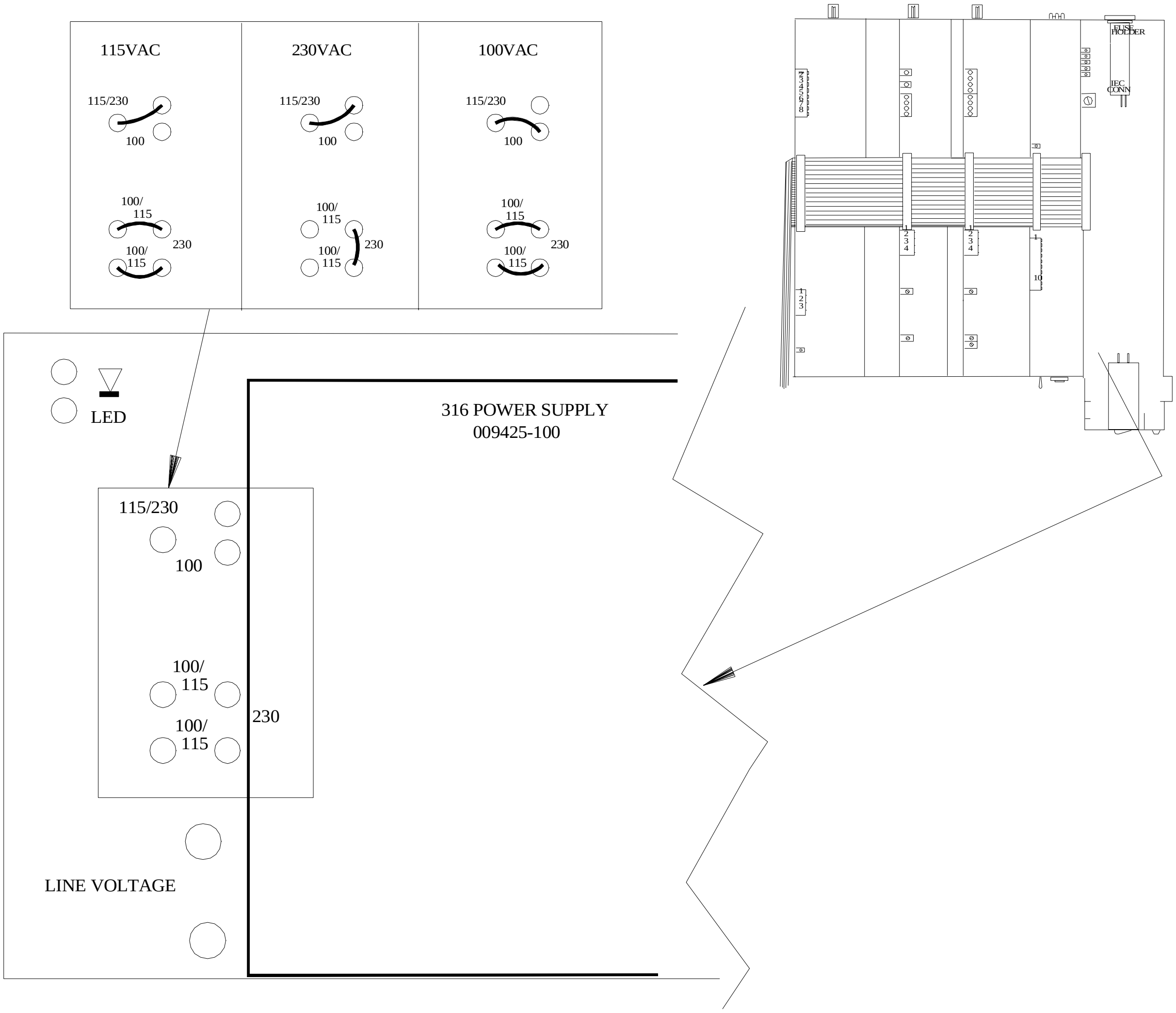


Figure 1-1: Line Voltage Select Jumpers, Power Supply PC Board

1.3.2 Mounting Configurations

NOTE: *The 316 controller should be mounted in a location with free air flow and ambient temperature less then 40 ^{o}C.*

NOTE: *Figure 1-2 illustrates the various configurations available for mounting the 316 control unit and power supply.*

NOTE: *When installing a mounting ear 8 into the left side of the control unit, the door should be open.*

The bracket (Figure 1-2, item 9) used to connect two control units for side by side rack mounting is not symmetrical. Install as shown.

The rear support bracket assembly consists of a U-shaped bracket (Figure 1-2, item 7) and two spring clamps (Figure 1-2, item 6) which grip into grooves in the side of the control unit.

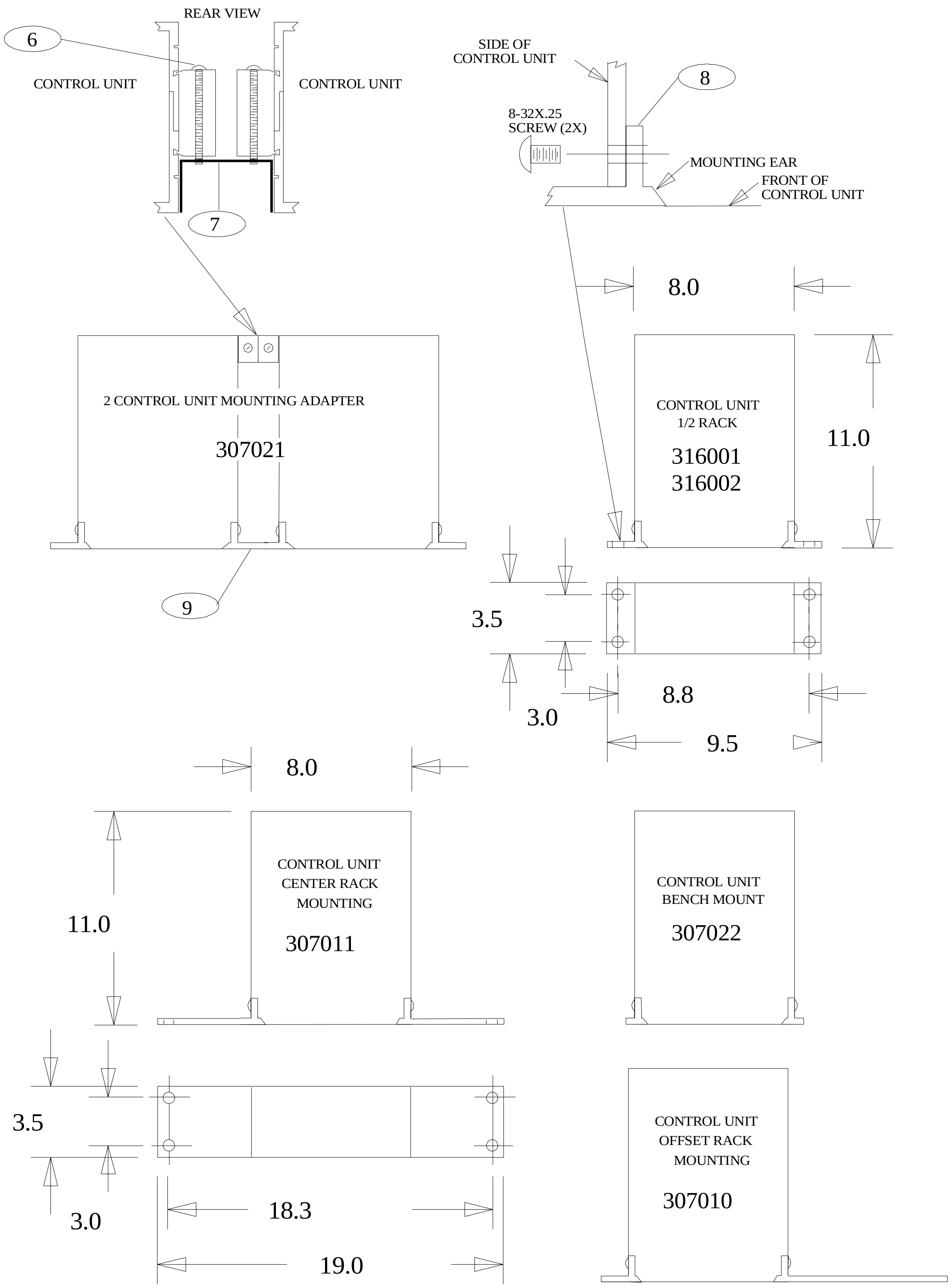


Figure 1-2: Mounting Configurations

1.3.3 Cable Connections

To avoid confusion in cable connections, a set of labels is provided with the cable. The labels are easily attached to the gauge connector with the adhesive backing. The rear panels of the Convectron and thermocouple modules are labeled with their respective display designations, A, B and C. See Figure 1-3 for cable connections. Tighten screws to secure connectors.

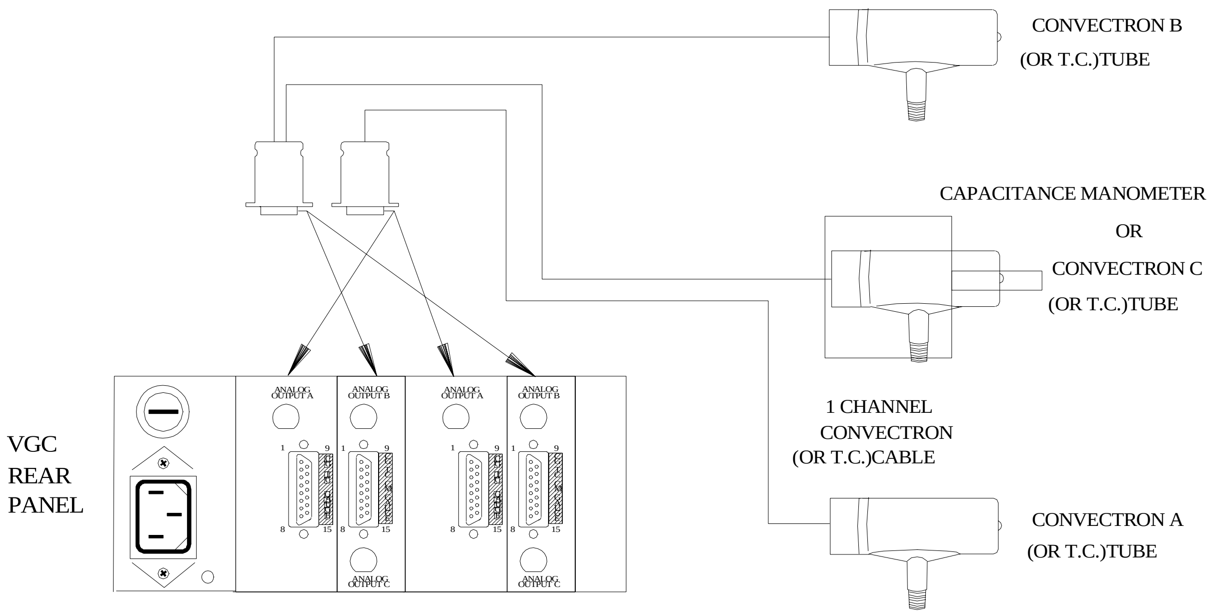


Figure 1-3: 316 VGC Cable Connections

1.3.3 Instrument Grounding

For safe operation, the VGC controller must be connected to an AC power source which includes a ground wire. This power ground is generally a sufficient safety precaution. A grounding stud is provided on the rear panel of the power supply module should the user require a separate earth ground. We recommend that you ground all metal parts of your vacuum system separately to power or earth ground. Do not ground the system via a wire to the 316 chassis. Refer to Figure 1-4.

NOTE: *The metal case of the gauge tube does not connect to the controller ground. Electrical connection of the gauge tube envelope to the system does not cause a ground connection between the system and the controller.*

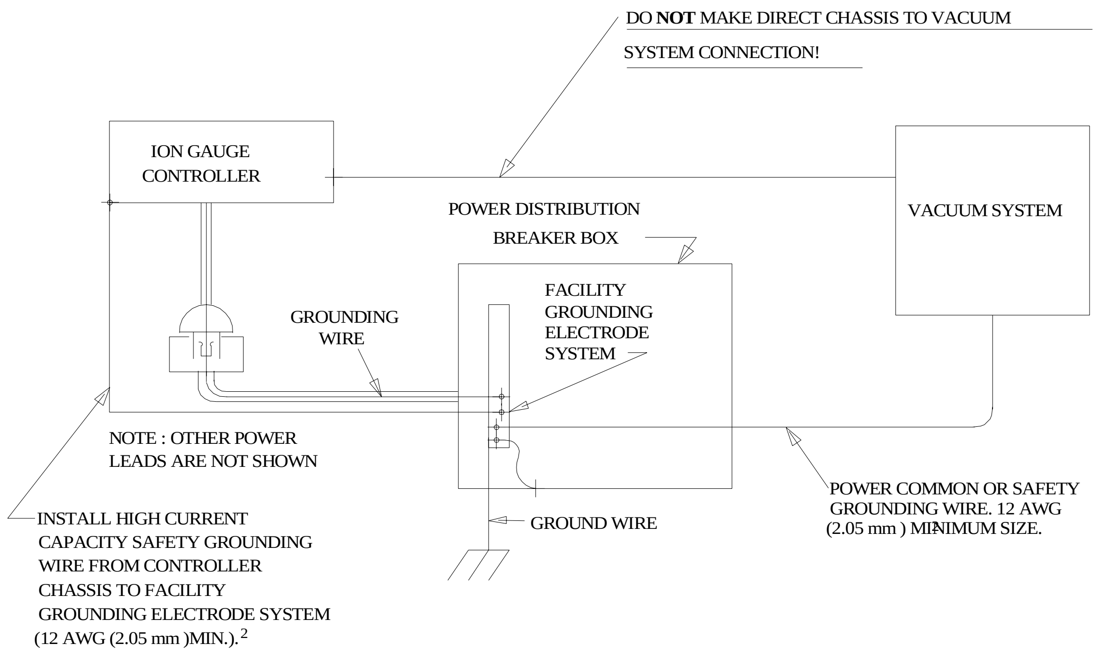


Figure 1-4: Correct System Grounding

1.4 Summary of Controls and Indicators

A description of the controls and indicators found on a basic 316 VGC is given in this section.

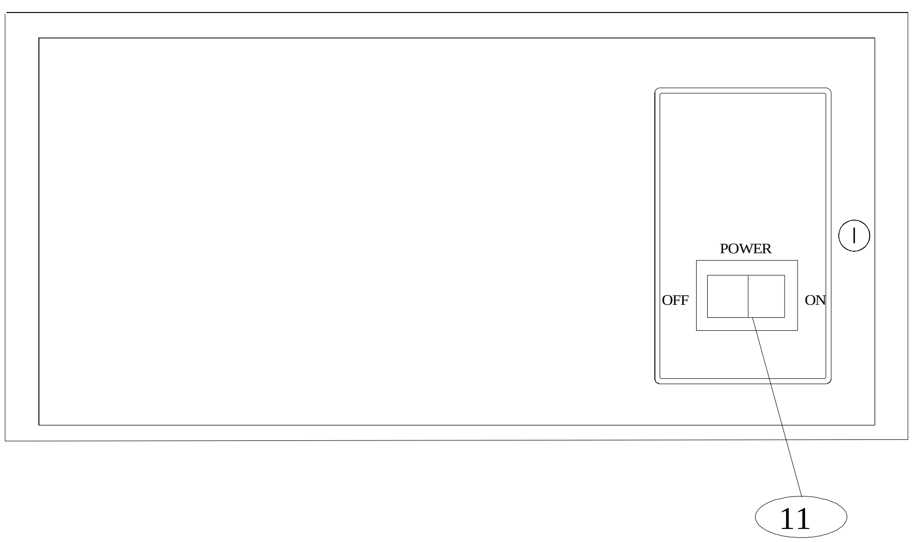


Figure 1-5: 316 VGC Control Unit Front Panel

1.5 Theory Of Operation

1.5.1 Microcontrollers and Bus Structure

Each module in the 316 has a dedicated microcontroller with internal ROM, RAM, timing, and interrupt management functions. This architecture provides high-performance at low cost with greater reliability and noise immunity than more complicated microprocessor systems using external buses and memory.

Each microcontroller is equipped with a watchdog timer, which automatically generates a reset if the processor fails to fulfill timing "checkpoints" within its code.

Inter-processor communication is accomplished via the display bus. These lines carry BCD-format pressure data which is used to generate the 316 display. The bus is updated once per millisecond. Out of every sixteen cycles, fifteen cycles are used for display data, and one is reserved for inter-processor communication. Modules that require pressure data, such as process control and computer interface, take it directly from the display update cycles.

1.5.2 Gauge Theory

The Convectron gauge is a heat loss transducer. This causes the response of the gauges to be gas type dependent and non-linear. The Convectron gauge uses feedback amplifier circuitry to maintain the sensor at a constant temperature thus providing greater resolution over a wider pressure range. More detailed explanations of the theory of operation of the Convectron gauge can be found in section 2.5.

1.6 Calibration

Calibration instructions for each gauge module are contained in the chapter for that module. Convectron gauge calibration is in section 2.5.

1.7 Basic 316 VGC Troubleshooting

1.7.1 Guidelines

Further troubleshooting information is located in the chapters for specific modules. The 316 VGC has been designed for easy repair by replacement of modules. If the user elects to perform repairs at the component level, repairs properly made with equivalent electronic parts and rosin core solder do not represent a violation of the warranty.

Some minor difficulties are user correctable, and the built-in diagnostic aids described here may be helpful.

Each module has status LEDs which will aid in localizing failures. These are described in the troubleshooting section of the chapters for each module. Shown in Figure 1-6 are those LEDs found on the 316 VGC power supply board. This is the PC board on the right side (when viewed from the front) of the 316 control unit.

Since the 316 VGC contains static-sensitive electronic parts, the following precautions must be followed when troubleshooting:

a. Use a grounded, conductive work surface.

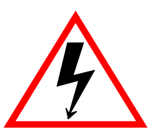
b. Use conductive envelopes to store or ship MOS devices or printed circuit boards.

c. Do not operate the 316 VGC with MOS devices removed from the unit.

d. Do not handle MOS devices more than absolutely necessary, and only when wearing a ground strap.

e. Do not use an ohmmeter for troubleshooting. Rely on voltage measurements.

f. Use grounded-type soldering iron only.



WARNING

High voltages are present within the controller capable of causing injury or death. do not touch cable connections or circuitry of the power supply module when power is applied.

Table 1-1: 316 VGC Troubleshooting

Symptom	Possible Cause
Unit won't power-up, no response to power switch.	Power fuse 17 blown.*
Power fuse 17 blows repeatedly.*	1. Wrong line voltage selection, see Figure 1-1. 2. Wrong fuse rating. 3. Wrong line voltage selection, see Figure 1-1.
LED 12 out on control board.*	+15 volt supply faulty (power to capacitance manometer).
LED 13 out.*	+12 volt supply faulty (power to analog circuitry and RS232).
LED 14 out.*	+5 volt supply faulty (power to logic and display).
LED 15 out.*	-12 volt power faulty (power to analog circuitry and RS232).
LED 16 out.*	-15 volt supply faulty (power to capacitance manometer).

** Refer to Figure 1-6 for component location.*

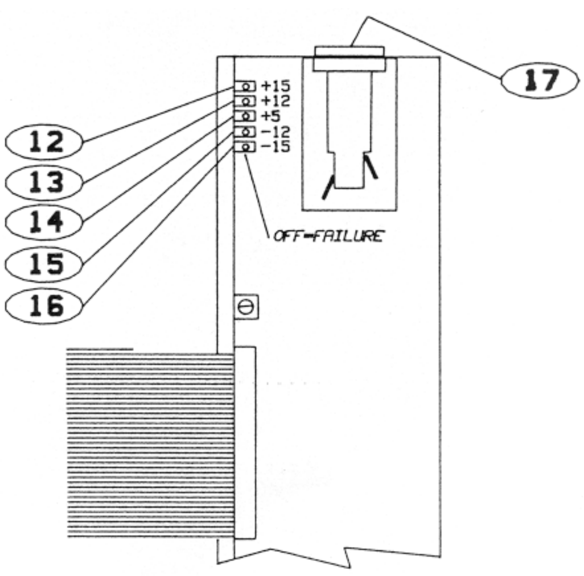


Figure 1-6: Power Supply Board Top View

1.8 Repair Ordering

Please telephone Granville-Phillips to obtain a return authorization prior to returning your unit for repairs.

A repair order should accompany returned equipment even when the equipment is being returned for a warranty repair at no charge. This should include a detailed description of the problem in addition to your name, telephone number and address where we may contact you. Equipment returned for repair should be carefully and strongly packaged to withstand shipping abuse. Components or printed circuit boards to be returned separately should be protected against static damage by wrapping them in static proof containers or in aluminum foil prior to packaging them for shipment. Address replacement/repair orders and correspondence to the address given on the title page of this manual.

If a replacement module is desired, it is important that you give our Service Department the complete catalog number of the module. This will help ensure that you receive the correct replacement.

NOTE: *Under no circumstances will Granville-Phillips be liable for shipping damages due to rough handling, improper packaging, or other circumstances beyond its control.*

All return shipments must be freight prepaid.

1.9 Specifications

See the chapters for each module for additional specifications relating to that module.

Table 1-2: 316 VGC Physical Specifications

Parameter	Value
Width	241 mm (9.5 in.) with 1/2 rack mounting ears.
Height	89 mm (3.5 in.)
Depth	356 mm (14 in.) includes 76 mm (3 in.) for connectors and cables.
Weight	3 kg (6.5 lb.)
Environmental Operating Temperature	0 ^oC to 40 ^oC

Table 1-3: 316 VGC Electrical Specifications

Parameter	Value
Voltage	90-110 VAC or 105-125 VAC
Frequency	50 or 60 Hz
Power	100 watts max.
Fuse Ratings	0.5 A (90-125 VAC), 3AG normal blow 0.25 A (220-240 VAC), 3AG normal blow

Section 2 - The Convectron Gauge Module

2.1 Safety

CAUTION

Safety pays. Read this instruction manual before installing, using, or servicing this equipment. If you have any doubts about how to use this equipment safely, contact the Granville-Phillips customer service at the address listed on this manual.

2.1.2 Explosive Gases

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

2.1.3 Limitation on Use of Compression Mounts

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

2.1.4 Tube Mounting Position

If the gauge tube will be used to measure pressures greater than 1 Torr or 1 mbar, the tube must be mounted with its axis horizontal. 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 tube axis is not horizontal. Erroneous readings can result in over or under pressure conditions which may damage equipment and injure personnel.

2.1.5 Overpressure

Convectron gauges should not be used above 1000 Torr true pressure. Do not use above 1000 Torr true pressure. Series 307 instruments are furnished calibrated for N_2. They also measure the pressure of air correctly within the accuracy of the instrument. Do not attempt to use a Convectron 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. If accurate conversion data is not used or improperly used, a potential overpressure explosion hazard can be created under certain conditions.

For example, at 760 Torr of argon gas pressure, the indicated pressure on a Convectron gauge calibrated for N_2 is 24 Torr. At an indicated pressure of 50 Torr, the true pressure of argon is considerably above atmospheric pressure. Thus if the indicated pressure is not accurately converted to true pressure, it is possible to overpressure your system. Overpressure may cause glassware such as ionization gauges to shatter dangerously, and if high enough may cause metal parts to rupture thus damaging the system and possibly injuring personnel. See Section 2.3 for proper use of conversion data.

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

2.1.6 High Indicated Pressure

For some gases, be aware the indicated pressure will be higher than the true pressure. For example, at a true pressure of 9 Torr for helium the indicated pressure on a Convectron gauge calibrated for N_2 is 760 Torr. The safe way to operate the gauge is to properly use accurate conversion data. See Section 2.3 for proper use of conversion data.

2.1.7 Chemical

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

2.1.8 Sensor Failure

If the gauge tube becomes disconnected from the controller or if the sensor wire in the gauge tube fails, the controller will indicate 9.99E+9. If the tube is unplugged from a powered controller, there may be an instantaneous (0 to 0.2 seconds) drop in the pressure indication and the process control relays could activate for this brief time, depending on the order in which the tube pins break contact.

2.1.9 Tube Contamination

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

2.2 Convectron Module Introduction

The Convectron Gauge (CG) Module provides pressure measurement from 1.0 x 10^{-3} Torr (1.0 x 10^{-3} mbar or 1.0 x 10^{-1} Pa) to 999 Torr, and one meaningful digit pressure indication down to 1 x 10^{-4} Torr, air equivalent. The basic 316 VGC displays pressure from one Convectron gauge in display "A" via the single channel, "A", Convectron module. Two additional pressures from Convectron gauges may be displayed in displays "B" and "C" via the dual channel "B" and "C" module. These gauges, modules, and displays are designated "CGA", "CGB", and "CGC" in this manual.

Analog output (logarithmic in pressure, 1 volt per decade) is also provided through the phone jack(s) on the rear panel. When used with the Process Control Module, CGA controls setpoints 1 and 2, CGB controls setpoints 3 and 4, and CGC controls setpoints 5 and 6.

2.2.1 Convectron Installation

2.2.2 Convectron Gauge Tube Installation

NOTE: *The following precautions in the use and installation of the* Convectron *gauge tube must be observed.*

WARNING

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

Under certain conditions, dangerous high voltage can be coupled directly to an ungrounded conductor through a gas almost as effectively as through a copper wire connection. This hazard, which is not peculiar to this product, is a consequence of the ability of an electric current to flow through a gas under certain circumstances. A person may be seriously injured, or even killed by merely touching an exposed ungrounded conductor at high potential.

WARNING

When high voltages are used within the vacuum system and the Convectron 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

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.

NOTE: *Observe the precautions regarding tube mounting position and high pressure operation.*

1. The gauge tube should be installed with the port oriented vertically downward to ensure that no system condensates or other liquids collect in the gauge tube.
2. Keep the tube clean. Do not remove the mounting port cover until you are ready to install the tube.
3. **Do not** mount the gauge tube in a manner such that deposition of process vapors upon the internal surfaces of the tube may occur through line-of-sight access to the interior of the gauge tube.
4. **Do not** install the tube where high amplitudes of vibration are present. Excessive vibration will cause forced convection at high pressure giving erroneous readings.
5. **Do not** bake the tube to temperatures above 150 ^{o}C.
6. **Do not** install the gauge tubes where they will be exposed to corrosive gases such as mercury vapor, chlorine, or fluorine, which will attack the gold plated sensor.
7. For greatest accuracy and repeatability the gauge tube should be located in a stable room temperature environment.

2.2.3 Gauge Tube Orientation

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

2.2.3.1 Below 1 Torr

The gauge tube will operate and accurately measure pressure below 1 Torr when mounted in any orientation.

2.2.3.2 Above 1 Torr

The gauge tube will accurately measure pressures above 1 Torr only when mounted with its axis horizontal, preferably with the port pointing vertically downward, as shown in Figure 2-1. It is valuable to point the port downward to facilitate the removal of condensation and other contaminants.

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

Mounting clearance dimensions are shown in Figure 2-1.

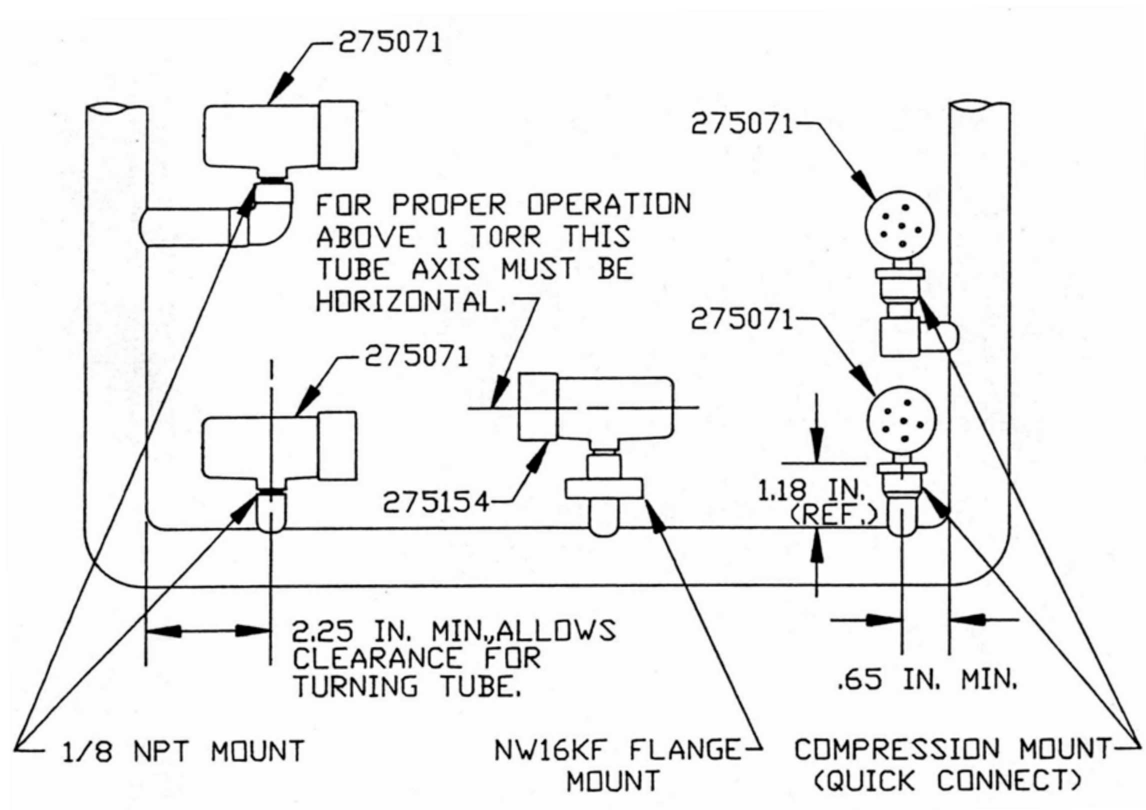


Figure 2-1: Convectron Gauge Mounting

2.2.4 Compression Mount (Quick Connect)

CAUTION

Do not use for positive pressure applications.

The gauge tube port is designed to fit a standard 1/2 in. compression (quick connect) mount such as the Cajon Co.® Ultra-Torr® fittings.

Remove the cap plug from the gauge tube port, insert the gauge tube port into the compression fitting and finger tighten the press ring. If a seal is not achieved it may be due to extreme cleanliness of the O-ring. A light film of vacuum grease will insure sealing and is normally preferable to the use of pliers or pipe wrench to further tighten the press ring. You may point the electrical pins of the gauge tube anywhere you wish in a 360 degree horizontal circle for optimum routing of the gauge tube cable.

2.2.5 1/8 NPT Mount

The threads on the gauge tube port will fit a standard 1/8 NPT female fitting. Wrap the threads of the gauge tube port with Teflon® tape and screw these threads into the system fitting hand tight. Do not use any wrench or tool. The gauge tube body functions adequately as its own wrench. Tighten only sufficiently to achieve a seal. When the threads have been tightened to the point where a seal is just achieved, about one-half turn additional tightening is all that can be gained without overstressing the tube port.

2.2.6 NW16KF Flange Mount

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

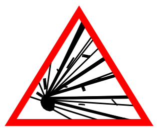
2.2.7 Other Mounting Options

The Convectron gauge is also available in several other mounting systems. These include Cajon® SS-4-VCR®-1, SS-4-VCR-3, and SS-6-VCO®-1 fittings, 2-3/4 inch rotatable and non-rotatable CuSeal flanges, 1-5/16 inch non-rotatable CuSeal flange, and welded NW16 and NW25 SST flanges.

2.3 Convectron Operation

2.3.1 Reading Pressure

WARNING



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.

Convectron gauge pressures are indicated in the 316 display with two or three significant digits of resolution above one millitorr and one significant digit in the 10^{-4} Torr decade. (Refer to specifications section of this chapter for details.) The pressure is displayed in torr/millitorr (mbar/mbar x 10^{-3} or pascal/pascal x 10^{-3}) notation. That is, at pressures below one Torr, the display shows a 10^{-3} exponent indicating millitorr while higher pressures display no exponent, indicating torr.

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

During a fast pump down 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 2.5 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.

2.3.3 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. See Section 2.5.

It is important to understand that the indicated pressure on a Convectron gauge depends on the type of gas in the tube, and on the orientation of the tube axis as well as on the gas pressure in the tube. 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 gauge tubes 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.

2.3.4 Indicated vs. True Pressure Curves

Figures 2-2 - 2-7 show the true pressure vs. indicated pressure of Convectron gauge for eleven commonly used gases. Table 2-1 will help to locate the proper graph for a specific application:

Table 2-1: True Pressure vs. Indicated Pressure Figures

Figure	Range and Units	Gases
2-2	1 to 100 mTorr	All
2-3	0.1 to 1000 Torr	Ar, $C0_2$, CH_4, Freon 12, He
2-4	0.1 to 1000 Torr	D_2, Freon 22, Kr, Ne, 0_2
2-5	10^{-3} to 10^{-1} mbar	All
2-6	0.1 to 1000 mbar	Ar, $C0_2$, CH_4, Freon 12, He
2-7	0.1 to 1000 mbar	D_2, Freon 22, Kr, Ne, 0_2

Note that 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, for example, that 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 (see Figure 2-2). 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 tube utilizes 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 tube are likely to be much different from curves for heat loss tubes made by others. Therefore, it is not safe to attempt to use calibration curves supplied by other manufacturers for their gauges with 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 2-2 through 2-7 to determine the maximum safe indicated pressure for the other gas as explained below.

2.3.5 Example 1 - Maximum Safe Indicated Pressure

Assume a certain system will withstand an internal pressure of 2000 Torr or 38.7 psia. For safety you wish to limit the maximum internal pressure to 760 Torr during backfilling. Assume you wish to measure the pressure of argon. On Figure 2-3, 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.

For safety, it is prudent to place a warning label on the instrument face which under the assumed conditions would read "DO NOT EXCEED 24 TORR FOR ARGON."

2.3.6 Example 2 - Indicated to True Pressure Conversion

Assume you wish to determine the true pressure of argon in a system when the Convectron is indicating 10 Torr. On Fig. 2.4, 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).

2.3.7 Example 3 - True to Indicated Pressure Conversion

Assume you wish to set a process control setpoint at a true pressure of 20 Torr of CO_2. On Figure 2-3, 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).

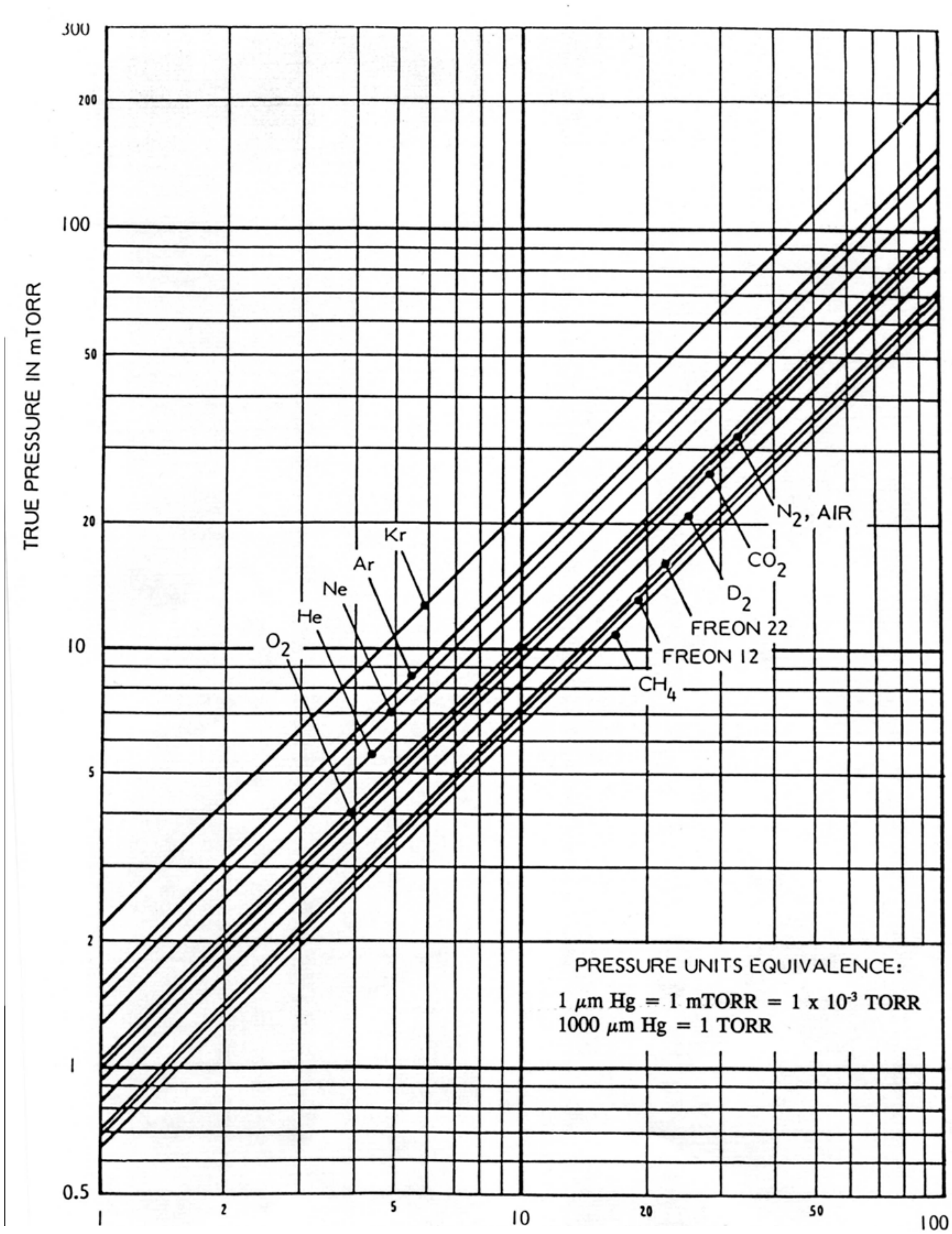


Figure 2-2: Indicated Pressure of a Convectron Gauge (1 to 100 mTorr)

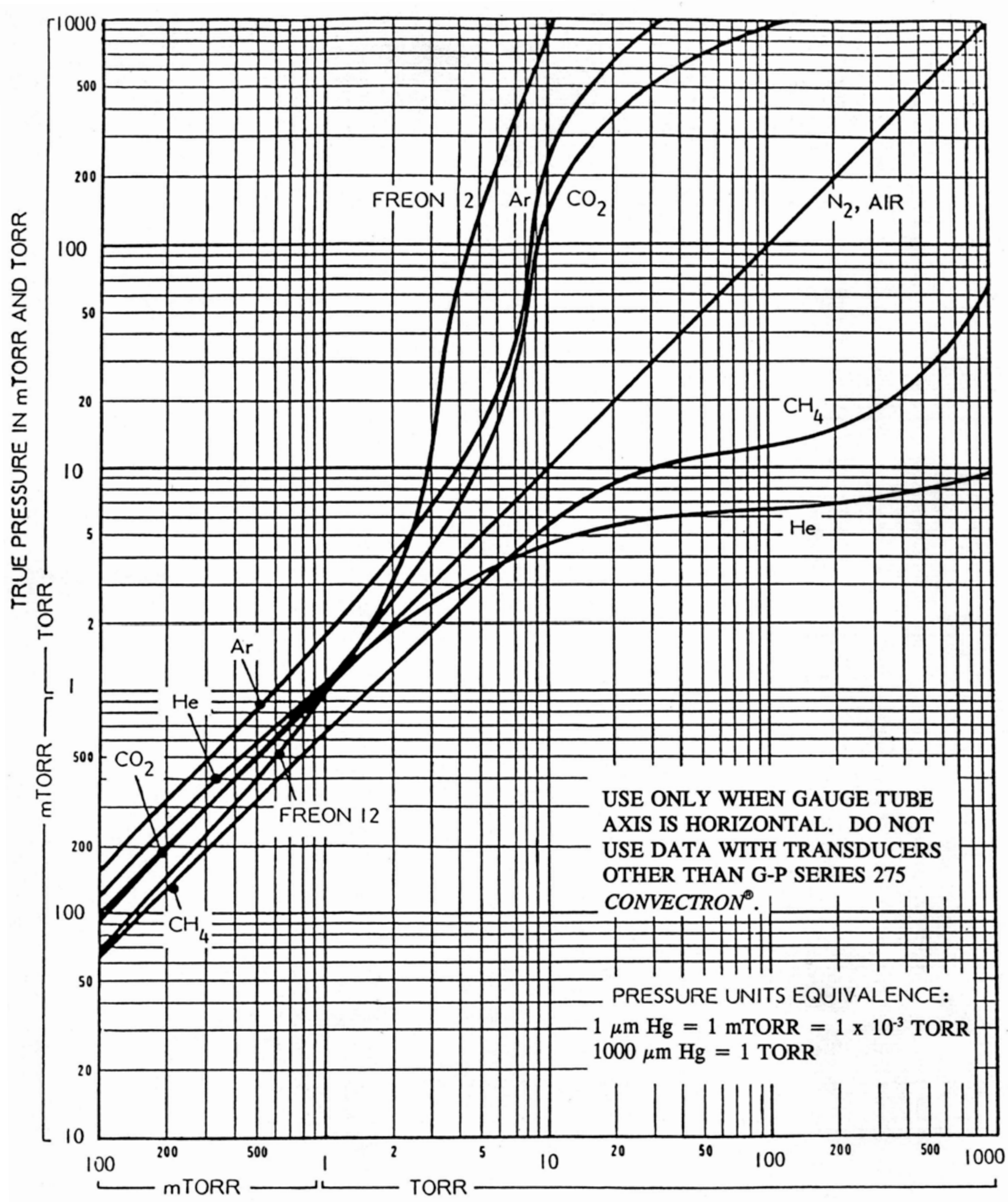


Figure 2-3: Indicated Pressure of a Convectron Gauge (0.1 to 1000 Torr)

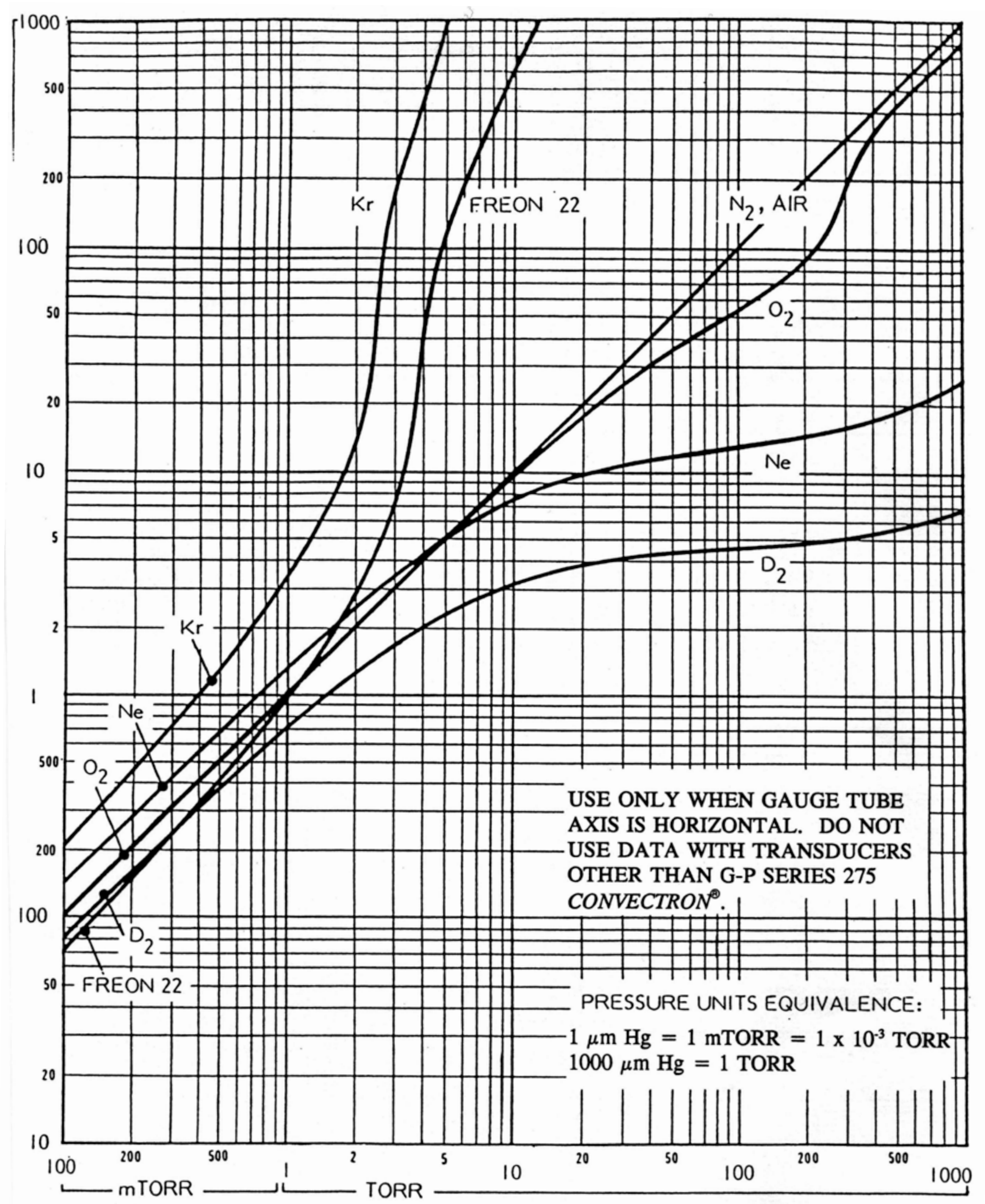


Figure 2-4: Indicated Pressure of a Convectron Gauge (0.1 to 1000 Torr)

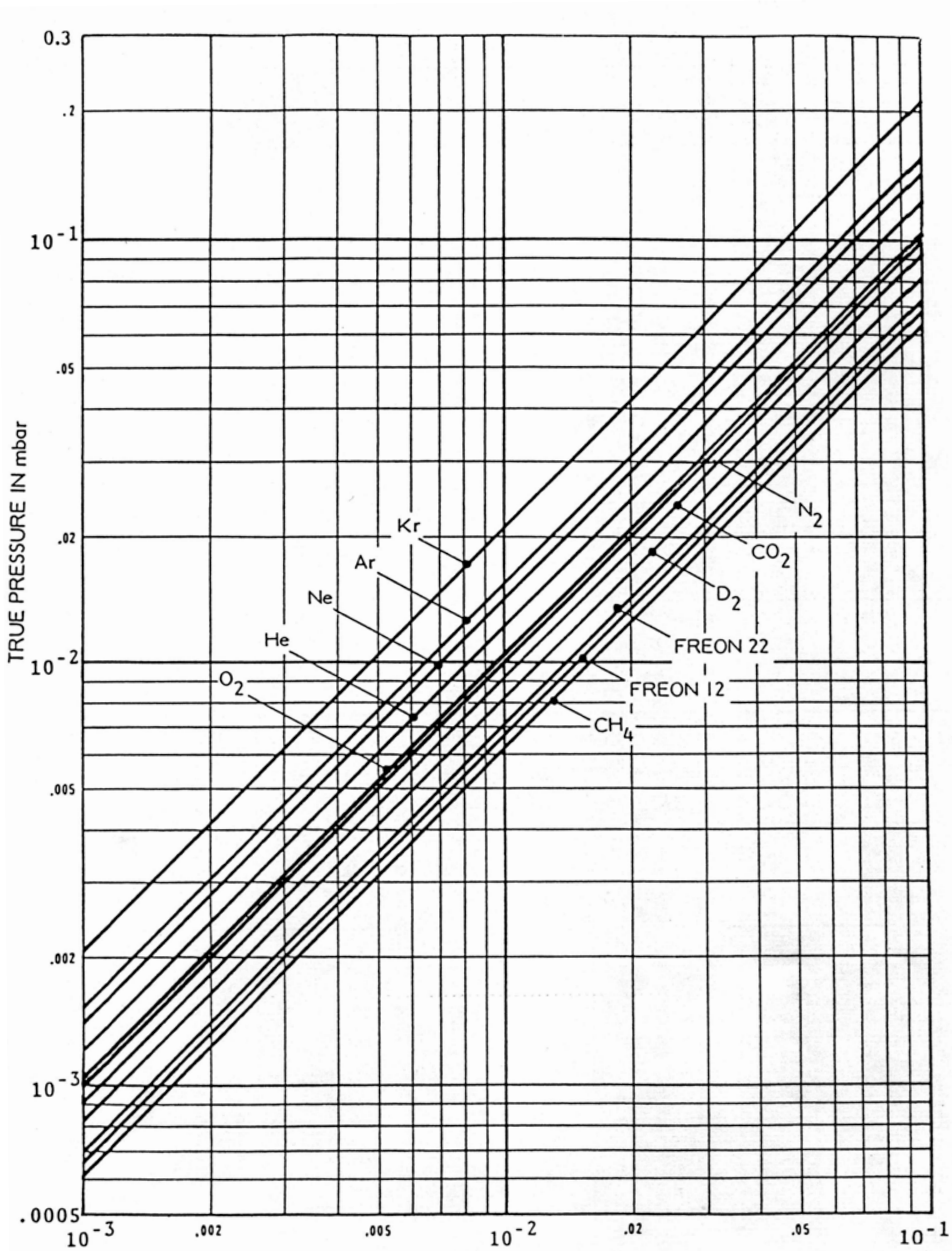


Figure 2-5: Indicated Pressure of a Convectron Gauge (10^{-3} to 10^{-1} mbar)

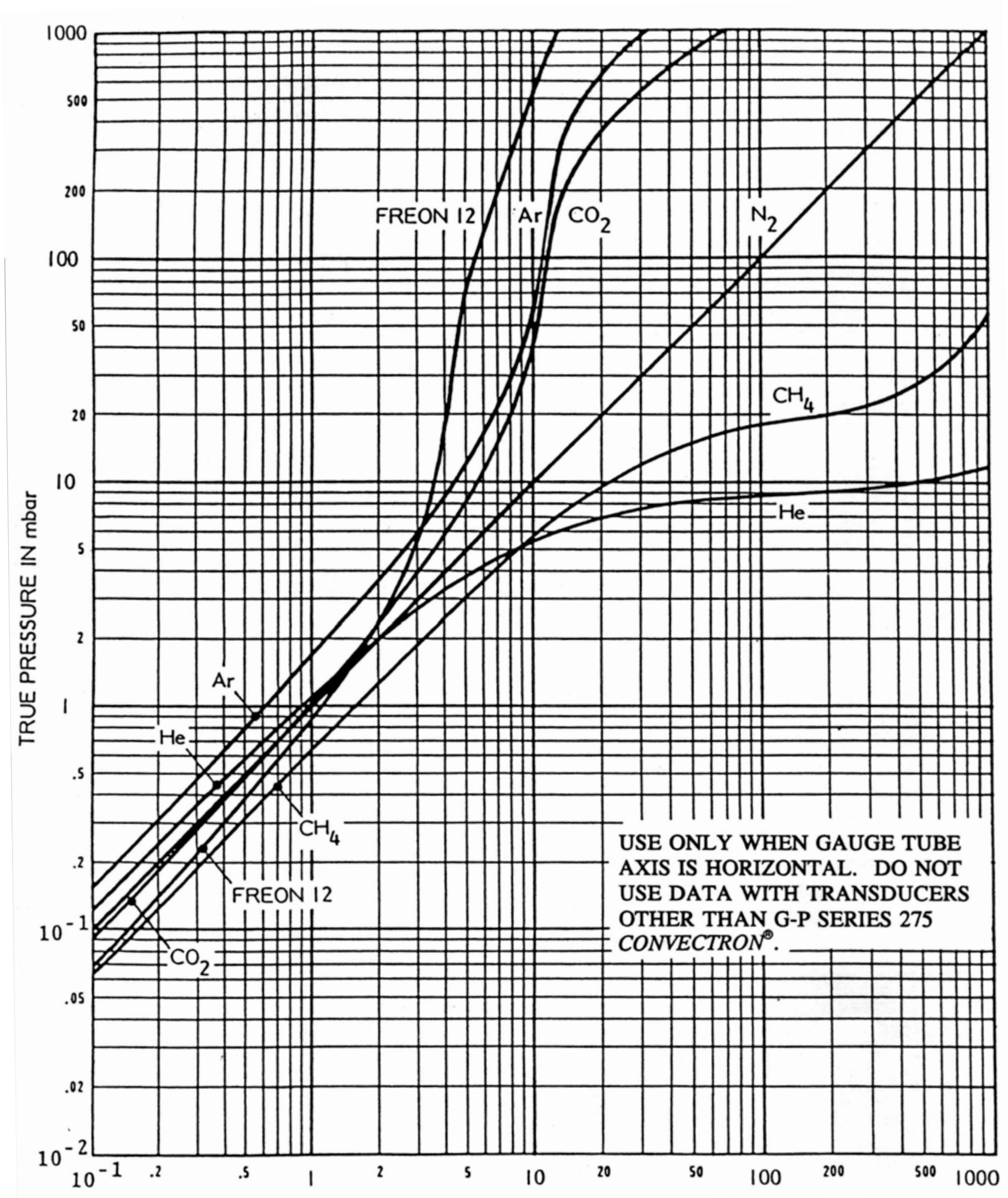


Figure 2-6: Indicated Pressure of a Convectron Gauge (0.1 to 1000mbar)

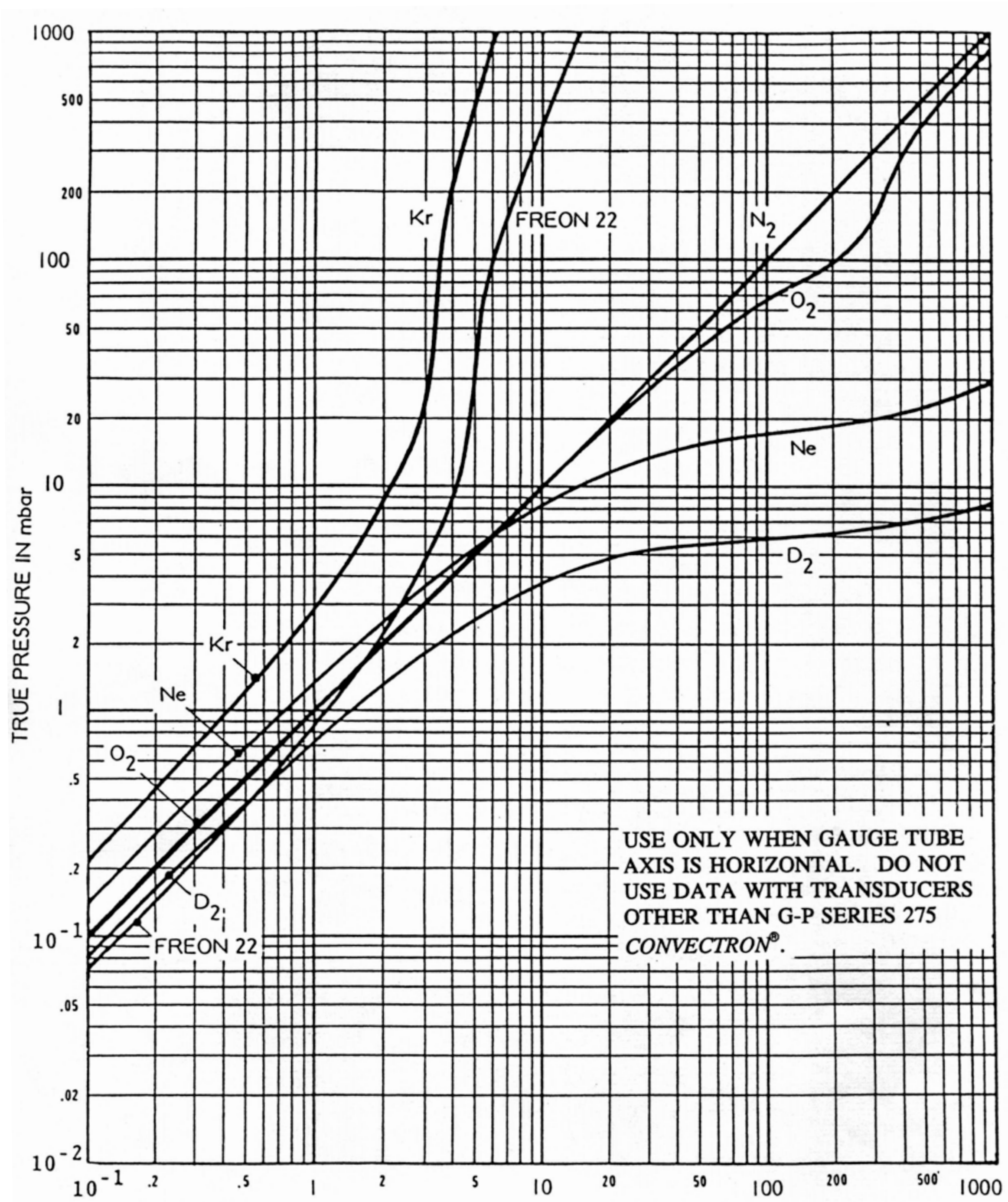


Figure 2-7: Indicated Pressure of a Convectron Gauge (0.1 to 1000 mbar)

2.3.8 Example 4 - True to Indicated Pressure Conversion

Assume you wish to obtain a helium pressure of 100 Torr in the system. On Figure 2-3, locate 100 Torr on the left hand scale, travel horizontally to the right to attempt to intersect the He curve. Because the intersection is off scale it is apparent that this true pressure measurement requirement for helium exceeds the capability of the instrument.

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

2.4 Analog Output

On the rear panel is provided an analog output for each gauge, see Figure 2-8, items 22 and 23. These are DC voltages proportional to the logarithm of the pressure, scaled to 1 volt per decade: 0 volts = 1×10^{-4} or less, Torr or mbar, 1 volt = 1×10^{-3}, etc.

For pascal units, the analog output will be scaled to 0 volts = 1×10^{-2} Pa.

Internal offset adjustments are provided which allow a shift in the analog output at 10^{-4} Torr away from 0 volts to anywhere in the range -7 to +1 V. This adjustment does not affect the slope of the analog output vs. pressure curve. See Section 2.5 for adjustment.

Standard BNC connectors are provided for the analog output.

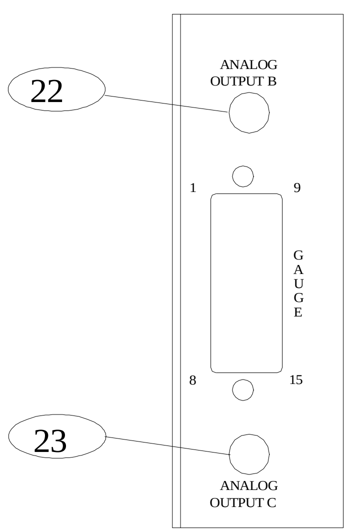


Figure 2-8: Convectron Module Rear Panel

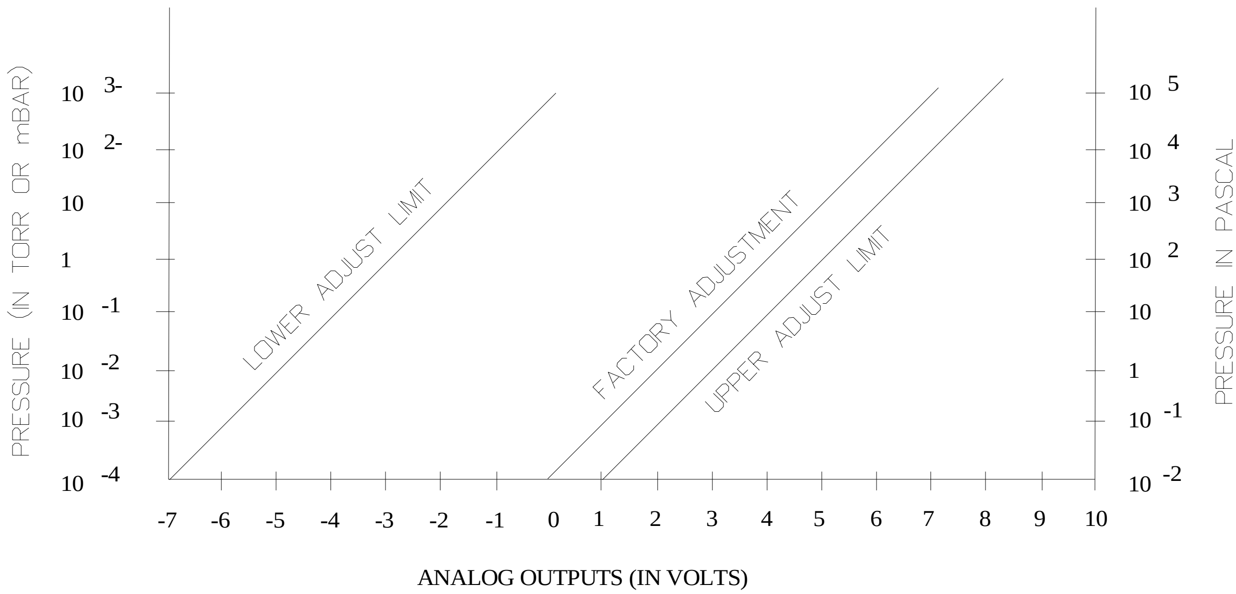


Figure 2-9: Convectron Gauge Pressure Analog Output

2.5 Convectron Calibration and Maintenance

Each gauge tube is individually calibrated for N_2 and air prior to leaving the factory. The Convectron gauge tube itself has a temperature compensated design. Each controller is also individually calibrated to provide accurate readout of N_2 or air pressure with any calibrated tube. Therefore, initial calibration should not be necessary. See section 2.3.3 for use with gases other than N_2 or air.

Calibration should be performed if accurate readings in the 10^{-4} Torr range are desired, if the tube becomes contaminated, does not read correctly, or to readjust for use with long cables. Since there is some interaction of adjustments, perform the zero adjustment first for most precise calibration throughout the pressure range. For accurate calibration, the VAC and ATM adjustments must be made in the following order.

The gauge and controller can be calibrated as a system by performing the following steps:

2.5.1 Zero Adjustment

1. Evacuate the system to a pressure less than 1 x 10^{-4} Torr.
2. With the gauge tube operating, adjust the VAC pot until 0.0 0 shows in the display.

NOTE: *If the adjustment is turned too far below zero, a minus sign will appear before the exponent (0.0 -0). Thus proper zero calibration is achieved when only 0.0 0 appears.*

2.5.2 Atmosphere Adjustment

1. Allow the system pressure to rise to atmospheric pressure of N_2 or air.
2. Adjust the ATM pot until the pressure displayed agrees with the absolute pressure as read on an accurate barometer. Use absolute pressure, not corrected to sea level.

NOTE: *1 atm. normal at sea level = 760 Torr = 1013 mbar = 1.01 x 10^5 Pa.*

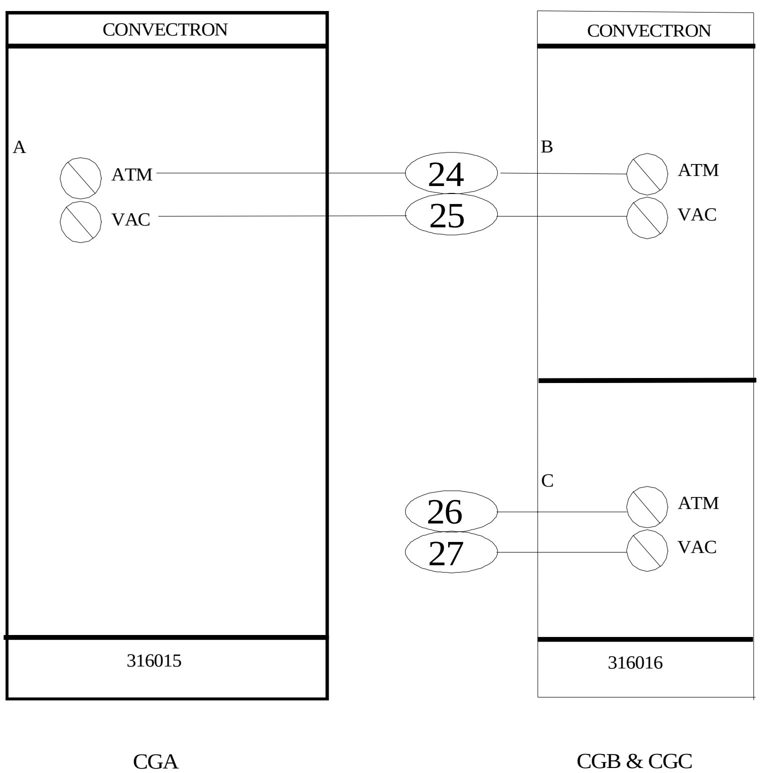


Figure 2-10: Convectron Modules Front Panel

2.5.3 Analog Output Full Scale Adjustment

This potentiometer may be adjusted to calibrate the span of the analog output voltage to the factory setting of 1 volt per decade. This adjustment is common to both outputs.

2.5.4 Analog Output Offset

These potentiometers provide adjustable offset voltages to each analog output. The range of this adjustment allows setting the analog output at vacuum (P = 1 x 10^{-4} Torr) anywhere in the range -7 to +1 V.

The factory calibration is established by adjusting potentiometers 29 and 30 in Figure 2-11 to yield 0-volt outputs when the gauge is at vacuum (pressure less than 1 x 10^{-4} Torr), then adjusting potentiometer 28 in Figure 2-11 to increase 1 volt for each decade the pressure increases.

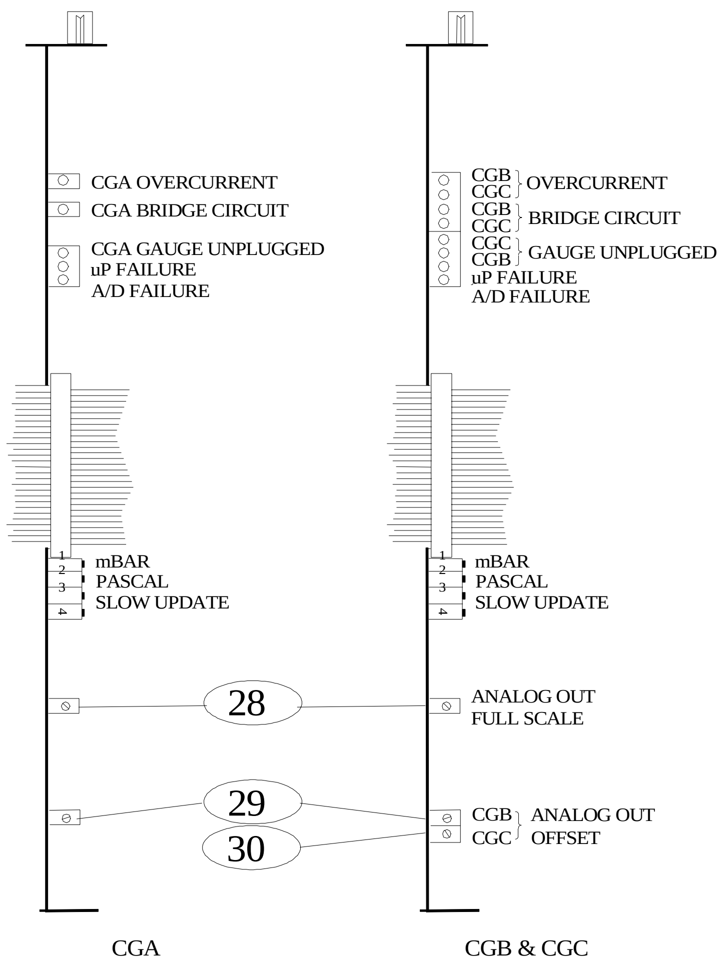


Figure 2-11: Convectron Modules Top View

2.6 Cleaning the Gauge Tube

The Convectron gauge may be baked to 150 ^{o}C. See Section 2.5 for a list of materials exposed to vacuum.

When the fine sensor wire is so contaminated with oil or other films that its emissivity or diameter is appreciably altered, a change of calibration will result. Cleaning with trichloroethylene, perchloroethylene, toluene, or acetone is possible but it must be done carefully so as not to damage the sensor.

WARNING

The fumes from any of these solvents can be dangerous to your health if inhaled. They should be used in well ventilated areas exhausted to the outdoors. Acetone and toluene are highly flammable and should be used away from open flame or electrical equipment.

Hold the gauge tube with the main body horizontal and the port projecting upward at an angle of 45^{o} and slowly fill it with solvent. As it becomes nearly full, turn the port to the vertical and fill completely. Let the solvent stand in the tube for at least ten minutes.

CAUTION

Do not shake the tube. Shaking the tube with liquid inside can damage the sensor wire.

Carefully pour out the solvent so that air may enter smoothly during pouring. Rotate the tube slowly and tip end to end so that all of the solvent drains out. Flush the tube one or more times, allow the tube to dry overnight with port vertically downward and uncapped. Be certain no solvent odor remains before reinstalling gauge tube on system.

2.7 Theory of Operation

The Convectron transducer is represented in Figure 2-12 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.

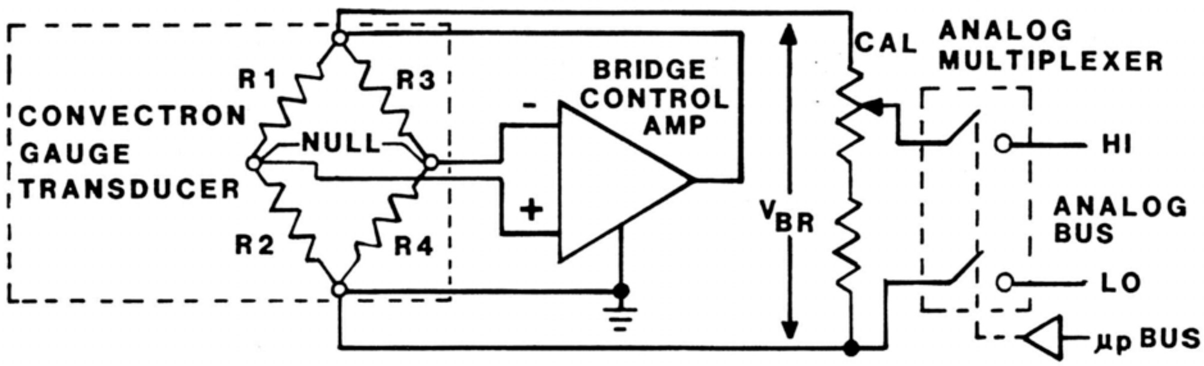


Figure 2-12: Simplified Schematic Convectron Gauge Module

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

All materials have been chosen for ultra high vacuum service, corrosion resistance and bakeability to 150 ^{o}C. The gauge tube envelope is type 304 stainless steel. All metallic joints on 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, and borosilicate glass and Dow-Corning 9015 glass. The blue trim cover is molded of polysulfone thermoplastic suitable for service to 150 ^{o}C.

2.8 Convectron Troubleshooting

2.8.1 Transducer Test Procedure

Do not perform electrical continuity tests with instruments applying in excess of 1 volt when the tube is at vacuum, or 5 volts when at atmospheric pressure.

The 275 transducer should show the following resistances (pin numbers are embossed on the transducer cap).

Table 2-2: 275 Transducer Pin Resistance

Pins	Resistance (ohms)
1 to 2	18 to 23 ohms
2 to 3	50 to 60 ohms
1 to 5	175 to 190 ohms
Any pin to envelope	open circuit

NOTE: *If the resistance from pin 1 to 2 is about 800 ohms, the sensor wire is broken.*

Table 2-3: Convectron Troubleshooting Guide

Symptom	Possible Cause
Overcurrent indicator 31 lit.**	Cable short, pins 1-3 on CGB (CGA)*.
Overcurrent indicator 32 lit.**	Cable short, pins 1-3 on CGC.
Indicators 33 or 4 lit.**	Bridge amplifier circuit failure.
Indicator 35 lit.**	CGC unplugged; broken sensor wire.
Indicator 36 lit.**	CGB (CGA)* unplugged; broken sensor wire.
Microprocessor reset LED 37 lit or flashing.**	Microprocessor failure.
*Gauge without parentheses refers to CGB and CGC module; with parentheses to CGA module. ** Refer to Figure 2-13 for component locations.	

Table 2-3: Convectron Troubleshooting Guide

Symptom	Possible Cause
Indicator 38 lit or flashing.**	A/D integration failure.
Display reads 9.99 +9.	Broken sensor wire.
Display reads -.	Tube or cable at controller unplugged.
Pressure reading very inaccurate.	Controller out of calibration, unknown gas type, tube mounted in the wrong orientation, sensor damaged (e.g., by reactive gas), tube very dirty, extremes of temperature or mechanical vibration.

*Gauge without parentheses refers to CGB and CGC module; with parentheses to CGA module.
** Refer to Figure 2-13 for component locations.

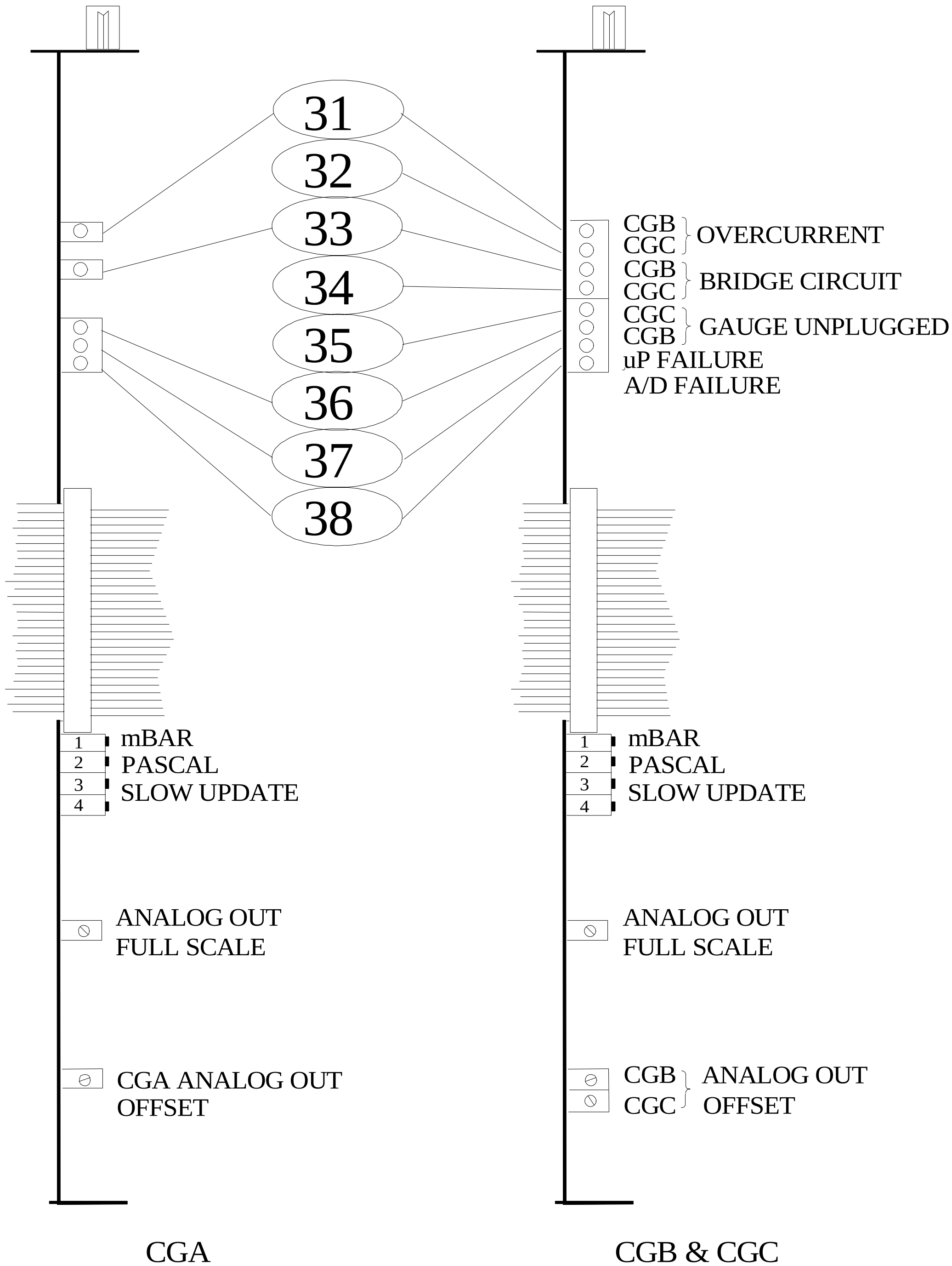


Figure 2-13: Convectron Module, Top view

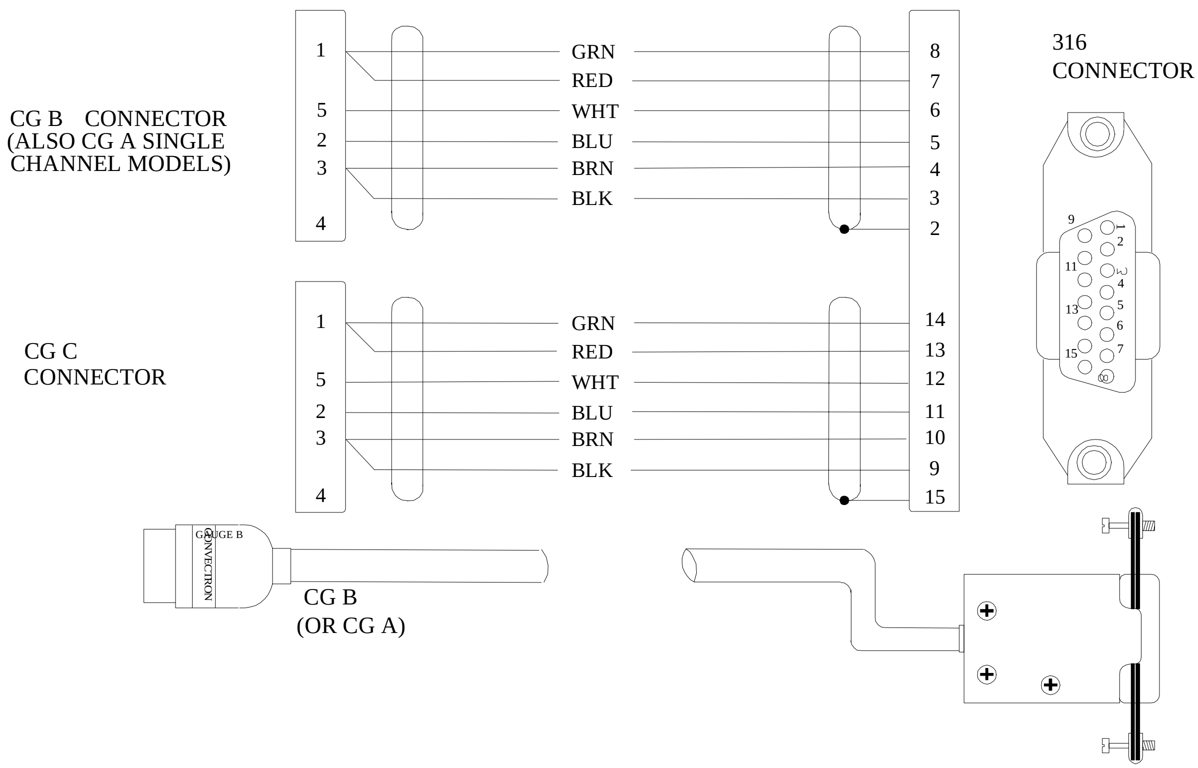


Figure 2-14: Convectron Cable Wiring (Single Filament)

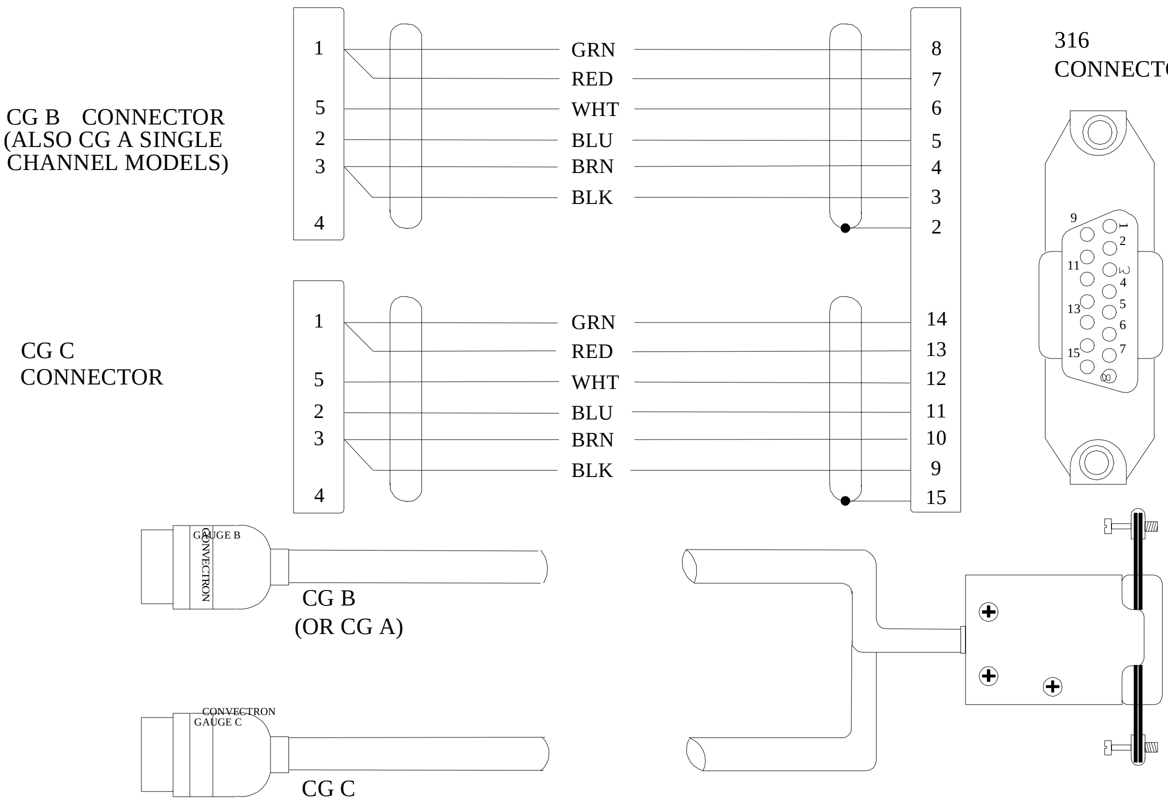


Figure 2-15: Convectron Cable Wiring (Dual Filament)

3.0 Convectron Specifications

Table 2-4: Convectron Specifications

Parameter	Specification
Gauge Type	GP Series 275
Pressure Range	1 x 10^{-4} Torr to 990 Torr, N_2 equivalent.
Gas Type	N_2, Air
Analog Output	Logarithmic, 1V/decade, Factory set to 0-7 V. Adjustable offset +1 V to -7 V. 5 mA maximum current.
Maximum Gauge Temperature	+150 ^{o}C.
Gauge Operating Temperature	+150 ^{o}C to +50 ^{o}C