Varian, Inc.
Vacuum Technologies

Vacuum Measurement

Varian's broad line of vacuum gauge controllers and gauge tubes are the most reliable, accurate, and economical means of measuring, monitoring, and controlling pressures in a variety of ranges. The vacuum gauge controllers and tubes are specifically designed for industrial use where simplicity in operation and rugged design for challenging environments are important. In addition, their accuracy and efficiency meet the demanding requirements for research applications.

Selecting a Vacuum Measurement System

Vacuum gauges can be grouped by pressure range. Useful ranges are:

- *Rough Vacuum* – Atmosphere down to 1mTorr (1mbar)
- *High Vacuum* – 1mTorr and lower

Within the high vacuum range:

- *Ultra High Vacuum (UHV)* – pressures below 1×10^{-9} Torr (mbar)
- *Extreme High Vacuum (XHV)* – pressures below 1×10^{-12} Torr (mbar)

Varian supplies products for all but the XHV range.

Roughing Gauges

There are many applications for rough gauges, from the simple monitoring of the high vacuum pump foreline and determination of high vacuum crossover points, to the control of the pump down and vent sequences of a load lock system.

Thermal roughing gauges, of which Varian supplies several types, are the most cost effective choice when absolute accuracy and gas species independence are not required. A thermal type gauge, since it measures heat loss to the surrounding gas and not the actual force exerted by it, is dependent on several properties of the gas, such as the specific heat and thermal conductivity.

Since the properties of gases vary, the calibration of a thermal rough gauge is different in nitrogen versus argon for example. In practice, this gas sensitivity is not a practical problem, as calibration curves can be determined for any gas of interest. Compared to a typical capacitance manometer, a thermal gauge is smaller and can cost 1/10th as much and still provide excellent performance in a real system.

The traditional thermocouple (TC) type gauge is a very low cost solution for monitoring forelines, chamber evacuation, and crossover to high vacuum pumps. TC's are characterized by response times of several seconds and operate over the range of 1mTorr to 2 Torr (0.001mbar to 2mbar). However, in large chambers where pump down is inherently slow and a need for good measurement at high pressures exists, or when monitoring foreline pressures, TC's (such as the 531 or 536) are a sound, cost-effective choice.

A convection-enhanced thermal gauge maintains the sensing element at a constant temperature.

This provides two benefits:

- Excellent response and sensitivity over the entire roughing range up to atmosphere.
- Fast response time (typically 0.2 seconds).

Varian's Convectorr, operated by convector controller, is such a gauge. It provides excellent performance from atmosphere all the way down to 1 or 0.1mTorr (0.001 to 0.0001mbar) depending on the controller. In addition to its superior performance, it features a modern locking bayonet type connector rather than the old industry standard octal type which relies on friction of the electrical contacts to stay on.

In load lock applications where sensitivity, repeatability, and fast response are requirements, a convector gauge can replace a much more expensive capacitance manometer at a fraction of the cost. The gauge can be used to control a two-stage pump down in which initial pumping from atmosphere is done slowly to minimize particulate circulation, and then when the pressure reaches a predetermined level a valve is opened to allow full pumping speed. The same gauge can then be used to signal the time to open the door to the main chamber. Upon venting, the gauge is used to signal back to atmosphere condition.

In large systems, the excellent sensitivity to pressure changes near atmosphere can be used to indicate potential leaks or other pumping problems by measuring the pressure at specific points in time.

High and Ultra-High Vacuum Gauges

These gauges comprise hot cathode and cold cathode types and measure pressure by ionization of the gas. Hot cathode type gauges employ a filament for the electron source, while the cold cathode types rely on field emission of electrons under a high electric field. There are advantages and disadvantages of each type.

- *Hot cathode gauges* of the Bayard-Alpert (B-A) design, the only ones Varian supplies, are preferred over cold cathode gauges for their better accuracy and repeatability over time. They are offered in glass, metal, and nude versions. Because of low initial cost, a glass B-A gauge can be the most cost effective gauge for measuring high vacuum. However, the danger of glass breakage may make a totally metal encased version, such as the MBA series, a better choice.

  The filament provides a ready source of electrons and therefore operation is assured over the entire high vacuum range. However, the filament is hot, and though more rugged than that of a light bulb, it is subject to degradation over time and can be damaged by shock and vibration. The filament is also a source of gas and excess electrons. These electrons generate x-rays when they hit the chamber walls and other surfaces causing an offset current, called the x-ray limit, that effectively limits the lower range of the gauge.

  Hot filament gauges are available with either tungsten or thoriated-iridium filaments. Tungsten is the material of choice for low cost and stable operation or when operating with hydrogen or halogen gases. However, it runs very hot and oxidizes readily if accidentally exposed to air. Thoriated-iridium filaments operate at lower temperatures and can withstand extended exposure to air while operating before failure. The lower temperature contributes to less outgassing when used in a UHV gauge. Performance over time of these gauges is not as stable as tungsten, and the thoria coating is a potential source of particles.
- The cold cathode gauges are available in magnetron and inverted magnetron versions. These gauges operate by the application of a high voltage (2-3KV) to the cathode. Field emission causes an electron to leave the cathode surface and is captured in a magnetic field. It collides with a gas molecule and starts a current flow to the anode. The magnitude of this current is proportional to gas density and pressure. Advantages of these gauges over hot filament types are that there is no filament, and hence they are very rugged, that they generate little gas, and that there is no x-ray current since there are no excess electrons to cause x-rays.

The magnetron gauge is a very low cost gauge characterized by high sensitivity but limited to operation above 1 x 10^{-8} Torr (mbar). Varian's 525 is a gauge of this type. Varian offers two inverted magnetron gauges, the IMG-100 for high vacuum, and the UHV-IMG for UHV. Both of these gauges offer excellent starting times at low pressures, in contrast to the cold cathode types, and fast response times, which are ideal for interlock systems.

Please refer to the Table of Vacuum Transducers on the next page when selecting your high or ultra high vacuum gauge.

Other Considerations
All of Varian's gauges (except for the 531 TC and the Glass B-A Gauges) are constructed of 304L or 304ESR SST and employ either glass compression or ceramic to metal seals. Each gauge is individually tested and leak checked to assure reliable operation. No o-rings are used in the construction of the gauge.

When operating below the 10^{-8}T (mbar) range, ConFlat flanges are recommended. Below 1 x 10^{-9} Torr, they are required.

Controllers
Varian offers both traditional rack mount controllers as well as "active" type gauges. Your choice depends upon your system needs.

In general, superior measurement performance is obtained with rack mount systems. If there is a need for many gauges in a system, a Multi-Gauge controller can be the most cost effective solution as it can operate up to three high vacuum gauges and eight thermocouples simultaneously. Sentorr is ideal for laboratory use or for small experimental or general-purpose systems.

The EyeSys family of "active" gauges is ideal for embedding in systems where a control computer or PLC handles display and control and there is no need to access the gauge controls at the gauge itself.

Varian controllers are either listed or recognized by UL and are CE marked, with the exception of the 801.

Select Your Gauging System

Do you need a traditional rack mount controller or active-type system?

Choose a traditional **Rack Mount Controller** and passive gauges when:

- You want easy plug and play installation
- You need a localized display of gauge data
- You need radiation-resistance
- Your gauge cables are less than XXX feet
- You need to read pressure and gauge status from a distance
- You need UHV measurement capability
- You want to use the system on a lab bench

If you have selected a traditional rack mount system, next select your transducers.

The Transducer depends on the pressure range you are measuring:

Rough Vacuum
~1mT to up to atmosphere

Is good measurement performance up to atmosphere important?
➡ Choose a Convectorr product

Is speed important (response time of 200msec.)?
➡ Choose a Convectorr product

Is measurement only needed up to 2 Torr?
➡ Choose a 536 thermocouple

Is a locking type connector instead of the older style octal preferable?
➡ Choose a Convectorr product

Are there pump oils, condensable gases, or corrosives in the vacuum?
➡ Choose a 536 thermocouple or Convectorr

Is lowest cost the overriding concern and can you use a $^1/_8$" NPT fitting?
➡ Choose the 531 thermocouple

High Vacuum
1mT down to 10^{-8} Torr

Is measurement stability and repeatability over time important?
➡ Then you should choose a hot filament gauge

Are you replacing a traditional glass gauge?
➡ Select one of Varian's glass ion gauges

Do you need the smallest size?
➡ Then you should choose an MBA product

Do you need an all-metal system without glass?
➡ Then you should choose an IMG-100, MBA product

Is mechanical ruggedness more important than measurement performance?
➡ Then you should choose an IMG-100 product

Ultra High Vacuum
Below 10^{-8} Torr

Is measurement stability and repeatability over time important?
➡ Then you should choose a UHV24 or UHV24p

Is mechanical ruggedness more important than measurement performance?
➡ Then you should choose a IMG-UHV

Is very low out gassing more important than measurement performance?
➡ Then you should choose a IMG-UHV

Choose an **Active-Type System** when:

- You have very long cables and do not need UHV capability
- All your data will be displayed or used by a central computer
- You want to distribute 24V power and signals only
- A rack or mounting panel is not available

If you have chosen an Active Type system, next select the specific gauge.

What pressure range do you need to measure?

Rough Vacuum
~1mT to up to atmosphere

Do you need the lowest possible cost. (This would mean fewer advanced features.)
➡ Choose the CT-100

Do you need a display on the unit, EM relays, and serial communications capability?
➡ Choose Convectorr

High Vacuum
1mT down to 10^{-8} Torr

Do you need a display on the unit, EM relays, and serial comm capability?
➡ Then you should choose Mini-BA

Is ultimate ruggedness more important than measurement stability and advanced features?
➡ Then you should choose Mini-IMG

Now select your controller

Have you selected an IMG gauge?
➡ You must choose Multi-Gauge

Do you need to display each transducer's reading simultaneously?
➡ You should choose a Sentorr

Do you have more than one ion gauge or more than two roughing gauges?
➡ You should choose Multi-Gauge

Do you only have one ion gauge and up to two roughing gauges?
➡ You should choose a senTorr

Transducers

Varian Vacuum Technologies offers many transducer technologies for a wide variety of vacuum applications. The selection of an appropriate vacuum gauge for a particular application depends upon many factors. Some of the factors that should be considered are:

- the operating pressure ranges
- repeatability of measurement
- mounting orientation
- accuracy of measurement
- transducer ruggedness
- the presence of chemically-reactive gas species
- and any sensitivity to stray magnetic or electromagnetic fields.

While all of these factors can help influence the selection of an appropriate vacuum transducer from a theoretical perspective, experience in similar applications is by far the most meaningful and reliable method. Varian's extensive experience with many gauging technologies can help recommend the best transducer for your application. The technical staff at Varian is always ready to discuss your applications. Varian offers custom-engineered transducer products and a wide selection of flanges and fittings.

A vacuum transducer to meet every need

- Thermocouple
- Convection
- Cold cathode
- Hot filament

Table of Vacuum Transducers

Roughing Gauges

Transducer Model	Measurement Range	Response Time	Applications	Special Features	Page No.
531	1mT to 2T	Slow	Low cost, moderate tolerance to condensibles, NPT fitting.	Not for use in corrosive applications. Can be mounted in any position.	272
536	1mT to 2T	Slow	Low cost, very tolerant of condensibles and corrosives, NPT fitting.	Fully welded stainless steel tube with interiorbaffle for corrosives tolerance and better performance at high pressures. Can perform to Atmosphere when used with ConvecTorr controller.	272 273
ConvecTorr	0.1mT to Atm	Fast	Suited for rapid, repetitive pumpdowns.	Like the 536 but features a locking bayonet connector.	274

Hot Filament Types, Bayard-Alpert

Tube Type (Torr, N_2)	Measurement Range $(Torr)^{-1}$	Sensitivity Emission Current	X-ray Limit @ 10 mA	Application	Special Features	
563	4×10^{-10} to 1×10^{-3}	10	2×10^{-10}	General purpose gauge with better performance than 571 and 572 types. Tolerates accidental venting.	Platinum coating on glass surface improves accuracy in the 10^{-4} to 10^{-3} Torr range as compared to 571 and 572.	275
564	8×10^{-10} to 50×10^{-3}	8	4×10^{-10}	Special purpose tube for pressures as high as 50 mT. Smaller size. Tolerates accidental venting. Available with dual filaments.	Optimized for pressures as high as 50 mT. Requires more filament power than the 563.	276
571	4×10^{-10} to 1×10^{-3}	10	2×10^{-10}	General purpose Hi-Vac gauge. Tolerates accidental venting	Burn-out resistant thoriated-iridium filament.	277
572	4×10^{-10} to 1×10^{-3}	10	2×10^{-10}	Lowest cost Bayard-Alpert gauge. Good for hydrogen and halogen gases.	Dual tungsten filaments.	278
MBA-100/200	1×10^{-9} to 30×10^{-3}	15	5×10^{-10}	Good alternative to the 563 when use of glass is prohibited. Small size, low outgassing.	Available with single or dual low power thoriated-iridium filaments.	279
MBA-200T	1×10^{-9} to 1×10^{-3}	15	5×10^{-10}	Alternative to the 572 when use of glass is prohibited. Small size.	Dual low power tungsten filaments.	
UHV-24	4×10^{-11} to 1×10^{-3}	25	2×10^{-11}	General purpose UHV gauge. Can be baked to 250 °C. Bakeable cable available.	Available with either dual tungsten or thoriated-iridium filaments.	280
UHV-24p	1×10^{-11} to 1×10^{-3}	20	5×10^{-12}	Special purpose version of the UHV-24 with higher accuracy in the 10^{-11} range.	Available with either dual tungsten or thoriated-iridium filaments.	280

Cold Cathode Types

Tube Type (Torr, N_2)	Measurement Range $(Torr)^{-1}$	Sensitivity Emission Current	Applications	Special Features	
IMG-100	1×10^{-9} to 1×10^{-2}	2.7	General purpose Hi-Vac measurement when a filament is not desired. Low out gassing rate.	Inverted magnetron type design with high tolerance to contaminants and excellent startup time.	281
UHV-IMG	1×10^{-11} to 1×10^{-3}	2	UHV compatible gauge bakeable to 250 °C.	Inverted magnetron type design with high tolerance to contaminants and excellent startup time.	282
525	1×10^{-8} to 1×10^{-2}	3.3	Lowest cost general purpose Hi-Vac cold cathode gauge.	Very rugged, easy to clean.	283

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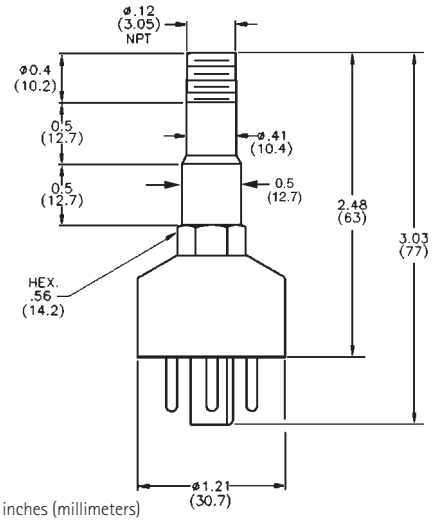
531 Thermocouple and 536 Baffled Thermocouple

The 531 Thermocouple Gauge Tube provides continuous and accurate indication of total pressure from 1 x 10^{-3} torr to 2.0 torr (1 x 10^{-3} mbar to 2.7 mbar) absolute. Developed to combine rugged dependability and outstanding performance, the 531 offers high resistance to vibration and excellent tolerance to contamination. The gauge is nickel-plated mild steel. The thermocouple and heater are noble metal to minimize the effects of contaminants on tube performance. The small thermal mass of the junction results in rapid response to pressure change. Operation is unaffected by mounting orientation.

The 536 Thermocouple Gauge Tube is fully welded stainless steel version of the 531 with the addition of a baffle. The baffle extends the life of the sensor when exposed to condensable gases and improves performance at higher pressures. It provides a continuous and repeatable indication of pressures from 1 x 10^{-3} torr to 2 torr (1 x 10^{-3} mbar to 2.7 mbar) absolute. Developed to combine rugged dependability and outstanding performance, the 536 offers fast responses and low power drain. The thermocouple and heater are noble metal so that the effect of contaminants on performance is minimized. The small thermal mass of the junction results in rapid response to pressure change.

Outline Drawing



Dimensions: inches (millimeters)

Technical Specifications

Response Time
Approximately 3 seconds, 1 x 10^{-3} torr to 2 torr
(1 x 10^{-3} mbar to 2.7 mbar)

Range
1 x 10^{-3} torr to 2 torr
(1 x 10^{-3} mbar to 2.7 mbar)

Bakeability
150 °C (with metal-to-metal fitting)

Materials
Nickel-plated mild steel, glass, platinel (531), 304L stainless steel. glass, platinel (536)

Output
0-11 mv, with 165 ma heater current and 15 Ω load

Heater Resistance
Approximately 1.4 ohms

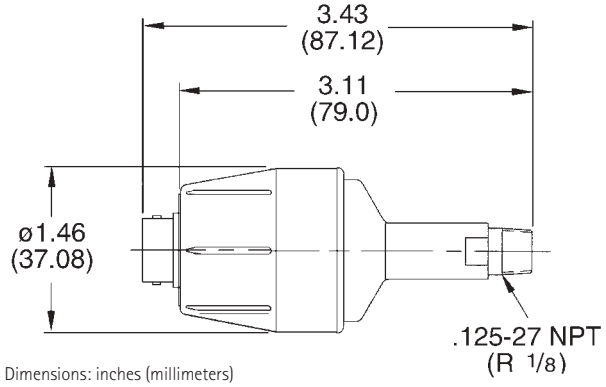
Recommended Controllers
801 (page 291), Multi-Gauge (page 285), senTorr™ Gauge Controllers (page 290)

Ordering Information

Description	Part Number	Fitting	Weight lbs. (kg)
531 Thermocouple Gauge Tube			
	F0472301	1/8 in. NPT	1.0 (0.5)
536 Thermocouple Gauge Tube			
Baffled TC tube type 304 stainless steel Platinel filament			
	L6141303	1/8 in. NPT	1.0 (0.5)
	L6141304	Mini-ConFlat	1.0 (0.5)
	L6141305	Cajon 4 VCR (female)	1.0 (0.5)
	L6141307	NW10 KF	1.0 (0.5)
	L6141308	NW16 KF	1.0 (0.5)
	L6141309	NW25 KF	1.0 (0.5)

ConvecTorr™ Gauge Tube

Outline Drawing



Dimensions: inches (millimeters)

The fast response ConvecTorr Gauge Tube is ideally suited for a wide range of vacuum system applications where accurate pressure monitoring and rapid, repetitive pumpdowns from atmosphere to 1 x 10^{-3} torr (1 x 10^{-3} mbar) are required. Gauge tube, unlike other popular convection-type gauge tubes, is not affected by system vibration. Its dependable design offers
continuous and repeatable pressure indications between 0 °C and 50 °C. The tube has been optimized for convection cooling resulting in superior readings at higher pressures and features a locking bayonet connector.

Technical Specifications

Response Time
Less than 0.60 second for a step change, vacuum to atmosphere

Range
1 x 10^{-3} torr to atmosphere
(1 x 10^{-3} mbar to atm)

Bakeability
80 °C

Materials
304L Stainless steel, with an ABS housing

Recommended Controllers
senTorr™ Controller (page 290)
Multi-Gauge Controller (page 285)

Ordering Information

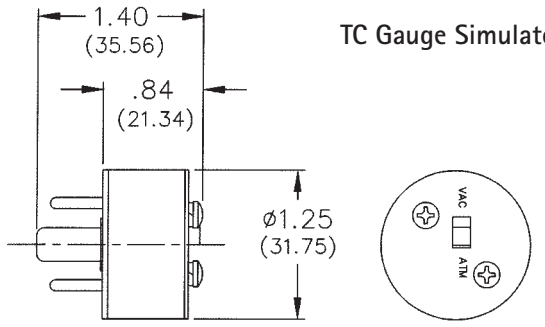
Description	Part Number	Fitting	Shipping Weight lbs. (kg)
ConvecTorr™ Gauge Tube, Platinel filament	L9090301	1/8 in. NPT	1.0 (0.5)
	L9090302	Mini-ConFlat®	1.0 (0.5)
	L9090303	Cajon 4 VCR (female)	1.0 (0.5)
	L9090305	NW16 KF	1.0 (0.5)
	L9090306	NW25 KF	1.0 (0.5)

Thermocouple and ConvecTorr™ Gauge Simulators

Designed as a vacuum atmosphere simulator for multigauge and sentorr tube to be used with any of the controllers that can accept a 531 thermocouple gauge tube. For those applications where the TC tube will never see 1 x 10^{-3} torr, it serves as an ideal reference when adjusting the vacuum (zero) calibration potentiometer on the controller. Troubleshooting is facilitated by the selectable Vac or Atm setting.

Outline Drawing

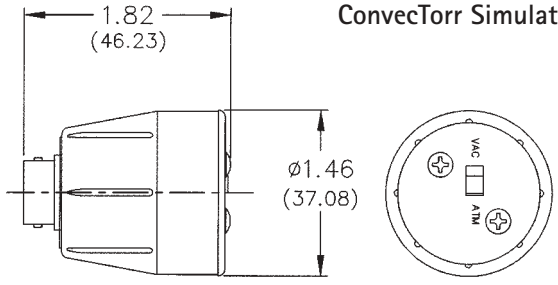
TC Gauge Simulator



Dimensions: inches (millimeters)

Outline Drawing

ConvecTorr Simulator



Dimensions: inches (millimeters)

Technical Specifications

Reference Pressure

Simulates high vacuum <10^{-4} torr and atmosphere 760 torr

Recommended Controller

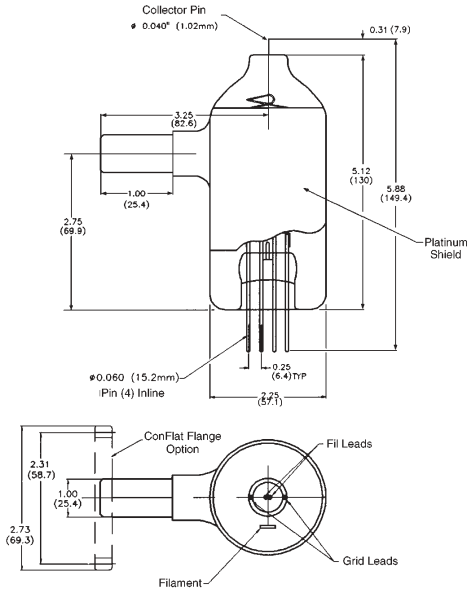
Multi-Gauge™ (page 285), and senTorr™ (page 290)

Ordering Information

Description	Part Number	Shipping Weight lbs. (kg)
ConvecTorr Simulator	L7382301	1.0 (0.5)
TC Simulator	L7383301	1.0 (0.5)

563 Series Bayard-Alpert Type Standard Range Ionization Gauge Tube

Outline Drawing



Dimensions: inches (millimeters)

The 563 is a rugged gauge with wide range of linear response: 2 x 10^{-10} to 1 x 10^{-3} torr. The platinum coating inside the bulb shields the gauge elements from electrostatic charges at low pressures and drains off the static charges which can build up at high pressures. The 563 is available in a variety of tubulations.

Technical Specifications

Sensitivity

10 $(torr)^{-1}$ $(mbar)^{-1}$ (Typical)
Exact measurement available through Varian STARRS program. Contact Varian for details

Operating Ratings

- 0 VDC (collector)
- + 180 VDC to ground (grid)
- + 30 VDC to ground
- 5 VAC nominal (filament)

X-Ray Limit

2 x 10^{-10} torr, (2.6 x 10^{-10} mbar)

Operating Pressure

2 x 10^{-10} torr to 1 x 10^{-3} torr
(2.7 x 10^{-10} mbar to 1 x 10^{-3} mbar)

Recommended Controllers

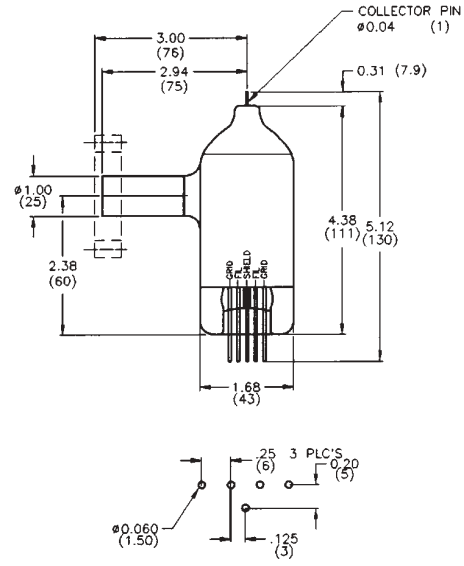
Multi-Gauge™ (page 285) and senTorr™ Gauge Controllers (page 290)

Ordering Information

Description	Part Number	Fitting	Shipping Weight lbs. (kg)
563 Ionization tube with thoria-coated iridium filament	K2466301	1 in. Glass tubulation	1.0 (0.5)
	K2466302	1 in. Kovar tubulation	1.0 (0.5)
	K2466304	3/4 in. Glass tubulation	1.0 (0.5)
	K2466305	3/4 in. Kovar tubulation	1.0 (0.5)
	K2466306	NW25 KF	1.0 (0.5)
	K2466311	NW40 KF	2.0 (1.0)
	K2466303	2.75 CFF	2.0 (1.0)
563 reference ionization tube with thoria-coated iridium filament (sealed-off at ≤5.0 x 10^{-6} torr)	K2466307	–	1.0 (0.5)

564 Broad-Range Bayard-Alpert Type Ionization Gauge Tube

Outline Drawing



Pin Alignment

Dimensions: inches (millimeters)

The 564 operates up to 1 x 10^{-1} torr for argon (5 x 10^{-2} torr for air). The tube has a burnout-resistant thoria-coated iridium filament and platinum coating for high accuracy and reliability.

Technical Specifications

Sensitivity

6 $(torr)^{-1}$ $(mbar)^{-1}$ (typical)

Operating Ratings

- 0 VDC to ground (collector)
- 0 VDC (shield)
- + 180 VDC to ground (grid)
- + 30 VDC to ground
- 4.0 VAC nominal (filament)

X-Ray Limit

4 x 10^{-10} torr, (5.2 x 10^{-10} mbar)

Operating Pressure

- 4 x 10^{-10} torr to 5 x 10^{-2} torr
  (5 x 10^{-10} mbar to 6.7 x 10^{-2} mbar)(Air)
- 4 x 10^{-10} torr to 1 x 10^{-1} torr
  (5 x 10^{-10} mbar to 1 x 10^{-1} mbar)(Argon)

Recommended Controllers

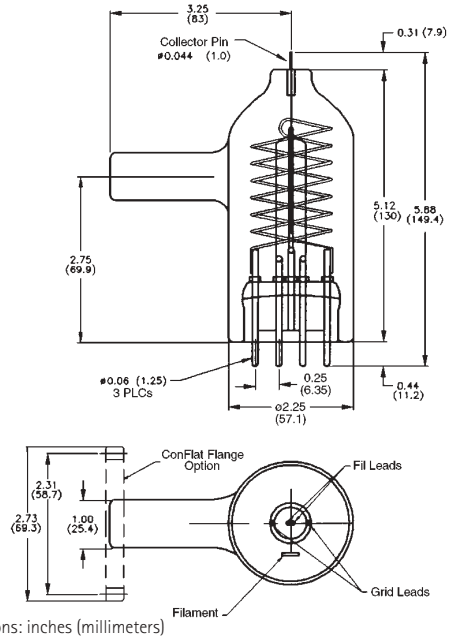
Multi-Gauge™ (page 285) and senTorr™ Gauge Controllers (page 290)

Ordering Information

Description	Part Number	Fitting	Shipping Weight lbs. (kg)
564 Ionization tube with thoria-coated iridium filament	K2500301	1 in. Glass tubulation	1.0 (0.5)
	K2500302	1 in. Kovar tubulation	1.0 (0.5)
	K2500310	NW25 KF	1.0 (0.5)
	K2500311	NW40 KF	2.0 (1.0)
	K2500303	2.75 CFF	2.0 (1.0)
564 Ionization tube with dual thoria-coated iridium filament	K2500304	2.75 CFF	2.0 (1.0)

571 Series Bayard-Alpert Type Standard Range Ionization Gauge Tube

Outline Drawing



Dimensions: inches (millimeters)

The 571 offers high performance and wide range (2 x 10^{-10} to 1 x 10^{-3} torr). The gauge is rugged; it can withstand long periods of degassing or accidental exposure to atmosphere at operating temperature and still recover its original characteristics.

Technical Specifications

Sensitivity

10 $(torr)^{-1}$ $(mbar)^{-1}$ (typical)

Operating Ratings

- 0 VDC (collector)
- + 180 VDC to ground (grid)
- + 30 VDC to ground
- 5 VAC nominal (filament)

X-Ray Limit

2 x 10^{-10} torr, (2.6 x 10^{-10} mbar)

Operating Pressure

2 x 10^{-10} torr to 1 x 10^{-3} torr
(2.7 x 10^{-10} mbar to 1 x 10^{-3} mbar)

Recommended Controllers

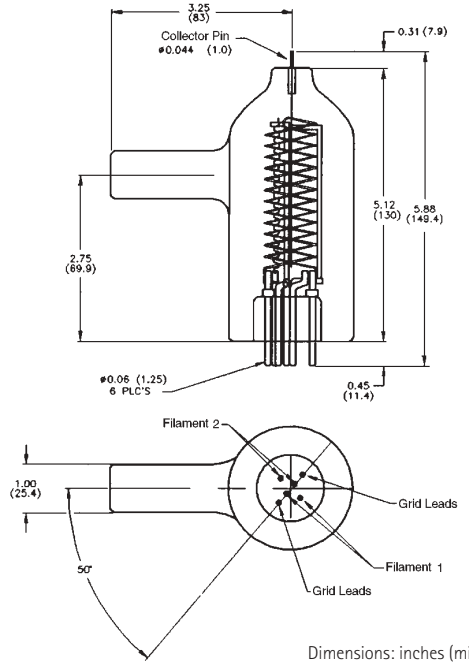
Multi-Gauge™ (page 285) and senTorr™ Gauge Controllers (page 290)

Ordering Information

Description	Part Number	Fitting	Shipping Weight lbs. (kg)
571 Ionization tube with thoria-coated iridium filament	K2471301	1 in. Glass tubulation	1.0 (0.5)
	K2471302	1 in. Kovar tubulation	1.0 (0.5)
	K2471304	3/4 in. Glass tubulation	1.0 (0.5)
	K2471305	3/4 in. Kovar tubulation	1.0 (0.5)
	K2471306	NW25 KF	1.0 (0.5)
	K2471311	NW40 KF	1.0 (1.0)
	K2471303	2.75 in. CFF	2.0 (1.0)
571 reference ionization tube with thoria-coated iridium filament (sealed off at ≤5 x 10^{-6} torr)	K2471307	–	1.0 (0.5)

572 Dual Tungsten Filament Bayard-Alpert Type Standard Range Ionization Gauge Tube

Outline Drawing



Dimensions: inches (millimeters)

The 572 is a high-performance gauge with a wide range of linear response: from 2 x 10^{-10} to 10^{-3} torr. It is designed to withstand long periods of outgassing, and to facilitate simple external switching of filaments without disturbing the vacuum system. The 572 is compatible with virtually all modern hot filament ionization gauge controllers.

Technical Specifications

Sensitivity

10 $(torr)^{-1}$ $(mbar)^{-1}$ (typical)

Operating Ratings

- 0 VDC to ground (collector)
- + 180 VDC to ground (grid)
- + 30 VDC to ground (filament)

X-Ray Limit

2 x 10^{-10} torr, (2.6 x 10^{-10} mbar)

Operating Pressure

2 x 10^{-10} torr to 1 x 10^{-3} torr
(2.7 x 10^{-10} mbar to 1 x 10^{-3} mbar)

Recommended Controllers

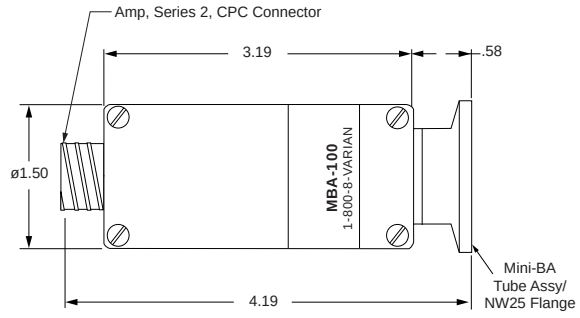
Multi-Gauge™ (page 285) and senTorr™ Gauge Controllers (page 290)

Ordering Information

Description	Part Number	Fitting	Shipping Weight lbs. (kg)
572 Dual-tungsten-filament ionization gauge tube	K7360301	1 in. Glass tubulation	1.0 (0.5)
	K7360302	1 in. Kovar tubulation	1.0 (0.5)
	K7360303	3/4 in. Glass tubulation	1.0 (0.5)
	K7360304	3/4 in. Kovar tubulation	1.0 (0.5)
	K7360305	NW25 KF	1.0 (0.5)
	K7360306	NW40 KF	5.0 (0.5)
	K7360307	2.75 in. CFF	6.0 (0.5)

MBA-100 Metal Bayard-Alpert Ion Gauge

Outline Drawing



Varian introduces the MBA-100, an all-welded, all-metal ion gauge for use across a wide range of vacuum applications. In addition to a wide measurement range of 30 mtorr to 5×10^{-10} torr, The MBA-100 features compact size, low cost, and rugged construction. Glass ion gauges are prone to breakage, leaks, and measurement instability due to electromagnetic interference. The MBA-100 solves all of these problems while occupying less space than a traditional glass gauge. It is available with either tungsten or iridium filaments.

The MBA-100 features Varian's unique etched-grid technology, providing superior gauge-to-gauge repeatability and accuracy. Instead of the traditional hand-wound wire grid, etched grids are geometrically identical, which reduces measurement variation. The plastic cover protects the user from high temperatures and the locking electrical connector ensure positive contact. The MBA-100 is compatible with Varian's Multi-Gauge (with UHV Card), and senTorr UHV.

Technical Specifications

Pressure Range
30 mtorr to 5×10^{-10} torr, 5 Pa to 5×10^{-8} Pa

Sensitivity
15/torr typical

Grid Voltage
180 to 200 vdc

Filament Bias
27 VDC

Collector Bias
0 VDC

Emission Current
1 ma max

Filament Power
~3 watts,varies with pressure

Degas
E-Beam, 600 VDC @ 10 ma maximum

Bake Out Temperature
100 °C maximum, cable disconnected, 80 °C with cable

Materials
Grid – 304 SST
Fil – Thoriated Iridium or tungsten
Coll – Tungsten

Shell
304 SST

Feedthrough
304 SST, glass, nickel alloy pins

Flanges
304 SST

Shroud
Glass-filled Minlon

Connector
Series 2 Circular Plastic Connector, size 11-9 (glass filled nylon)

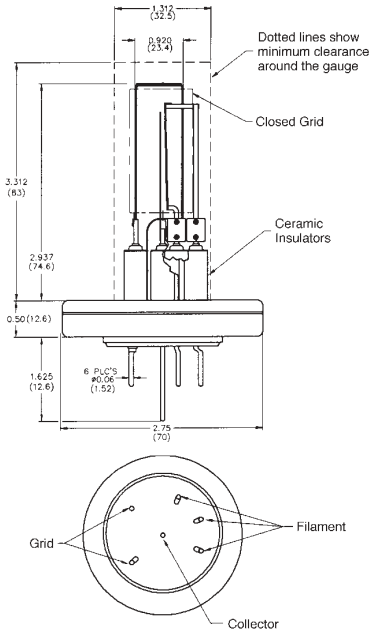
Ordering Information

Description	Part Number	Fitting	Shipping Weight lbs. (kg)
MBA-100 metal Bayard-Alpert ion gauge	R1170301	NW25 KF	2.0 (1.0)
MBA-100 metal Bayard-Alpert ion gauge	R1170302	NW40 KF	2.0 (1.0)
MBA-100 metal Bayard-Alpert ion gauge	R1170303	2.75 CFF	2.0 (1.0)
MBA-200 Dual Tungsten	R1170121	NW25 KF	2.0 (1.0)
MBA-200 Dual Iridium	R1170321	NW25 KF	2.0 (1.0)
MBA-200 Dual Tungsten	R1170122	NW40 KF	2.0 (1.0)
MBA-200 Dual Iridium	R1170322	NW40 KF	2.0 (1.0)
MBA-200 Dual Tungsten	R1170123	2.75 CFF	2.0 (1.0)
MBA-200 Dual Iridium	R1170323	2.75 CFF	2.0 (1.0)

NOTE *For information on compatible gauge controllers and cables, please refer to Multi-Gauge and senTorr and sections.*

UHV-24 and UHV-24p Nude Bayard-Alpert Type Ionization Gauge Tubes

Outline Drawing



Dimensions: inches (millimeters)

The UHV-24 is a rugged, open gauge with broad range operating pressure capabilities. The UHV-24 is available with a long-life thoria-coated iridium filament or tungsten filament that is easily replaceable in the field.
The UHV-24p measures pressure from 5 x 10^{-12} torr to 1 x 10^{-3} torr (6.7 x 10^{-12} mbar to 1 x 10^{-3} mbar) is an extended range version of the UHV-24.

Because of its small diameter and closed structure, its ionization is at least 2 times that of other ionization gauges. The small collector diameter limit the X-ray current to a pressure equivalent of approximately 5 x 10^{-12} torr (6.7 x 10^{-12} mbar).

Technical Specifications

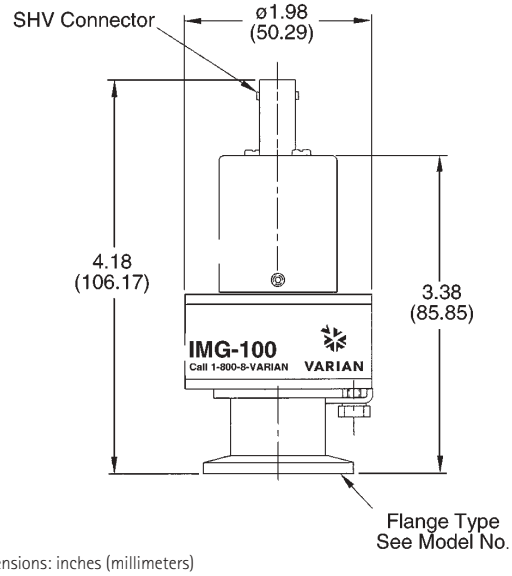
	UHV-24	UHV-24p
Sensitivity	25 $(torr)^{-1}$	20 $(torr)^{-1}$
X-Ray Limit	2 x 10^{-11} torr	5 x 10^{-12} torr (6.7 x 10^{-12})
Operating Pressure	2 x 10^{-11} torr to 10^{-3} torr (2.7 x 10^{-11} mbar to 1 x 10^{-3} mbar)	5 x 10^{-12} torr to 1 x 10^{-3} torr (6.7 x 10^{-12} mbar to 1 x 10^{-3} mbar)
Bakeability	450 °C (with ConFlat® flange) 2 x 10^{-11} torr to 10^{-3} torr	450 °C (with ConFlat® flange) 5 x 10^{-12} torr to 1 x 10^{-3} torr
Recommended Controllers	senTorr Controller (page 290) Multi-Gauge™ Controller (page 285)	senTorr Controller (page 290) Multi-Gauge™ Controller (page 285)

Ordering Information

Description	Part Number	Fitting	Shipping Weight lbs. (kg)
UHV-24 nude gauge with dual tungsten filaments	9715008	2.75 in. CFF	4.0 (2.0)
UHV-24 nude gauge with dual thoria-coated iridium filaments	9715007	2.75 in. CFF	4.0 (2.0)
UHV-24p Extended Range Nude Bayard-Alpert Type Ionization Gauge Tube with a dual tungsten filament	9715014	2.75 in. CFF	4.0 (2.0)
UHV-24p Extended Range Nude Bayard-Alpert Type Ionization Gauge Tube with a dual thoria-coated iridium filament	9715015	2.75 in. CFF	4.0 (2.0)
Filament replacement kit (thoria-coated iridium)	9710028		1.0 (0.5)
Filament replacement kit (tungsten filament)	9710018		1.0 (0.5)

IMG-100 Inverted Magnetron High Vacuum Gauge

Outline Drawing



Dimensions: inches (millimeters)

Varian introduces the IMG-100, an accurate, repeatable high vacuum gauge intended for use in dirty or corrosive applications. The IMG-100 features accuracy, repeatability, and starting times similar to Bayard-Alpert gauges. However, like cold cathode gauges, the IMG-100 is easily cleaned and repaired, making it perfect for vacuum furnace and other industrial uses. Vacuum users no longer need to deal with the limitations of traditional cold cathode gauge in order to have a rugged high-vacuum measurement solution.
The IMG-100 is an inverted magnetron design, featuring broader measurement range, faster starting time, better accuracy and superior repeatability compared to older Penning-type gauges. The compact size allows flexible installation, while the locking SHV high-voltage connector ensures safety and positive electrical contact.
The IMG-100 is compatible with Varian's Multi-Gauge for easy integration into a variety of system electronics.

Technical Specifications

Measurement Range
1 x 10^{-3} torr to 5 x 10^{-9} torr

Operating Temperature/with Cable Disconnected
15 °C to 80 °C/150 °C maximum

Ignition Response (Starting time)
<5 seconds at pressures > 1 x 10^{-6} torr

Materials Exposed to Vacuum
Stainless Steel
Nickel
Glass
Nickel Alloy 52

Sensitivity
2 A/torr

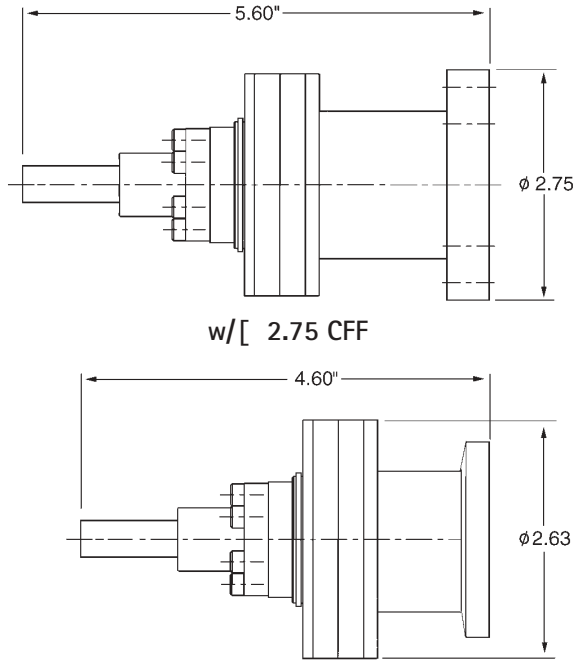
Ordering Information

Description	Part Number	Shipping Weight lbs. (kg)
IMG-100 NW25 KF	R0310301	2.0 (1.0)
IMG-100 NW40 KF	R0310302	2.0 (1.0)
IMG-100 2.75 in. CFF	R0310303	2.0 (1.0)

Inverted Magnetron Gauge for UHV

Varian Vacuum Technologies is introducing the Inverted Magnetron Cold Cathode transducer (IMG), a cold cathode gauge with controlled magnetic field in the ion chamber. This transducer is capable of reading from 10^{-3} torr (10^{-3} mbar) down to 10^{-11} torr (10^{-11} mbar) range. Its linear response and repeated quick ignition characteristic of typically <50 seconds in the 10^{-11} range are well appreciated features of this transducer.

Outline Drawing



Dimensions: inches

Features	Benefits
• No hot filament	• No burnout of filament or contamination
• 250° bakeable during operation	• Do not have to remove cable during bakeout
• Coaxial cable	• Low cost
• Starts at 10^{-11} torr	• UHV repeated fast starts

Ordering Information

Pressure Range
10^{-3} torr to 10^{-11} torr (10^{-3} mbar to 10^{-11} mbar) with CFF

Sensitivity
2 A/torr

Operating Temperature
15 °C to 250 °C with CFF only

Operating Voltage
+3 kV

Bakeout Temperature
250 °C with magnet and cable (CFF version only)

Ignition response
Typically <50 seconds at UHV

Materials Exposed to Vacuum
Stainless Steel
Nickel-Plated Steel
Copper
Aluminum
2% Thoriated Tungsten
Small Amount of Silver

Tubulation
2.75 in. CFF
NW40 KF

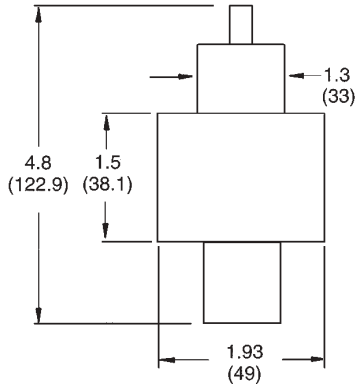
Ordering Information

Description	Part Number	Fitting	Shipping Weight lbs. (kg)
Inverted Magnetron Gauge	R0343301	2.75 CFF	2.0 (1.0)
Inverted Magnetron Gauge	R0343302	NW40	2.0 (1.0)

NOTE *For information on compatible gauge controllers and cabling, please refer to Multi-Gauge sections of catalog.*

525 Cold Cathode Ionization Gauge Tube (non-bakeable)

Outline Drawing



1. KF adds 0.15" to length
2. CFF adds 0.25" to length

Dimensions: inches (millimeters)

The 525 Cold Cathode Ionization Gauge Tube measures pressures from 1 x 10^{-8} to 1 x 10^{-2} Torr (1 x 10^{-8} to 1 x 10^{-2} mbar) and has excellent repeatability, accuracy, and reliability. Sudden exposures to atmospheric pressure will not cause any damage.
Similar in configuration to the magnetron tube, the 525 starts at very low pressures where ordinary cold cathode gauges are difficult to start.

Technical Specifications

Response Time
Full scale to half scale pressure change: less than one second

Range
1 x 10^{-8} torr to 1 x 10^{-2} torr
(1 x 10^{-8} mbar to 10^{-2} mbar)

Bakeability
100 °C

Materials
Aluminum cathode, stainless steel shell, glass

Recommended Controllers
860 and 860-2, Multi-gauge, and senTorr Gauge Controllers

Ordering Information

Description	Part Number	Fitting	Shipping Weight lbs. (kg)
525 Cold Cathode Gauge Tube	K9234301	1 in. tubulation	2.0 (1.0)
	K9234311	NW25 KF flange	2.0 (1.0)
	K9234302	NW40 KF flange	2.0 (1.0)
	K9234303	2.75 CF	2.0 (1.0)
525 Gauge tube maintenance kit	K9440301		2.0 (1.0)

Gauge Controllers

Multi-Gauge™

Vacuum Gauge Controller

5 x 10^{-12} torr to atm
(6.7 x 10^{-12} mbar to atm)

- Modular controller
- Operates Bayard-Alpert type ionization tubes, ConvecTorrs, Thermocouples, Inverted Magnetron Gauges and Capacitance Diaphragm Gauge heads
- Eight process control set points
- RS232 or RS485/RS422 interfaces available
- Resistive or electron bombardment degas available
- CE certified
- UL/cUL listed

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senTorr™

Vacuum Gauge Controller

High Vacuum models 10^{-10} torr to atm
(10^{-10} mbar to atm)

Ultra-High Vacuum models 10^{-12} torr
to atm (10^{-12} mbar to atm)

- High Vacuum Configuration
  - Bayard-Alpert Gauge
- Ultra-High Vacuum Configuration
  - UHV-24 Nude Gauge
  - Inverted Magnetron Gauge
- Operates one of three transducer combinations
  - One Ion Gauge
  - One Ion Gauge and two Thermocouples
  - One Ion Gauge and two ConvecTorrs
- Options include degas, set points, and digital communications (RS232, RS422, RS485)
- CE certified
- UL/cUL listed

page 290

801

Vacuum Gauge Controller

1 x 10^{-3} torr to 2 torr
(1 x 10^{-3} mbar to 2 mbar)

- Operates a single thermocouple gauge tube
- Temperature-compensated for temperature drift
- Line voltage regulated
- Analog meter face
- 0-11 mV recorder output

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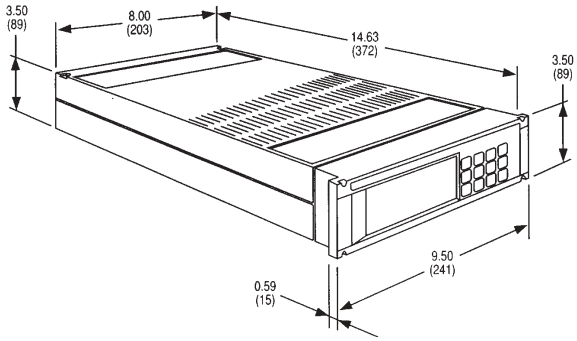
Multi-Gauge™

Outline Drawing



Dimensions: inches (millimeters)

The Varian Multi-Gauge is the leader in modular vacuum gauge controllers. Contained within its compact, half-rack, $3^1/_2$ inch height is the capability to operate simultaneously up to thirteen vacuum transducers, conserving expensive and scarce electronic rack space. Multi-Gauge can operate standard or UHV Bayard-Alpert gauges, cold cathode gauges, thermocouples, and ConvecTorr™ gauge tubes, as well as capacitance manometers. With the widest selection of transducer technology available in any vacuum gauge controller, a Multi-Gauge can be configured for your exact system requirement.

Features	Benefits
• Continuously powers up to 13 pressure transducers	• Prevents temperature instability when switched from one transducer to another
• Multiple transducer operation	• Operates: Hot Filament Ionization Gauges, UHV Ionization Gauges, Cold Cathode Gauges, Thermocouple Gauges, ConvecTorr Gauges, and Capacitance Diaphragm Gauges
• Individual transducer analog outputs	• Ideal for analytical and industrial applications
• Custom configurations	• Field- or factory-configured for your exact system requirements
• CE marked and UL, cUL listed	• Assures safety and reliable operation

Multi-Gauge™ Transducer Circuit Boards

UHV Circuit Board (High profile) L8321301
(Requires software revision P1.7 or higher)
For use with UHV-24 and UHV-24p gauge tubes
The UHV circuit board provides a complete power supply for operating a single Varian UHV-24 or UHV-24p nude ion gauge tube. Electron beam degas is included. A complete electrometer circuit is included on this board for pressure readout over 10^{-3} to 5 x 10^{-12} torr. Each board is capable of controlling one transducer; and up to three UHV boards may be installed in the Multi-Gauge for a total of up to three UHV transducers. The recorder output is a 1V/decade log-linear output.

Bayard-Alpert Circuit Board (High profile) L6427301
(Requires software revision P1.7 or higher)
For use with 563, 564, 571, 572, 580, and all standard gauge tubes
Bayard-Alpert (B/A) board operates a single Bayard-Alpert gauge tube. It provides a complete power supply for operating and resistance heater degassing of Varian 563, 564, 571, 572, or nude 580 gauge tubes. A complete electrometer circuit is included on this board for pressure readout from 10^{-1} torr (564, 580) or 10^{-3} torr (563, 571, 572) to 10^{-10} torr. Each board is capable of controlling one transducer; and up to three Bayard-Alpert boards may be installed in the Multi-Gauge for a total of up to three UHV transducers. The recorder output is a V/decade log-linear output.

Inverted Magnetron Gauge Circuit Board
(High Profile) L9066301
(Requires software revision P3.1 or higher)
For use with Varian's Inverted Magnetron Gauge (IMG) and IMG-100 gauge
The IMG board operates a single Inverted Magnetron gauge. It provides a complete power supply and electrometer circuit allowing measurements from 10^{-3} torr to 10^{-11} torr. Up to three of these boards may be installed in a single Multi-gauge for a total of three IMG transducers. The recorder output is a 1 V/Decade log-linear output.

CDG (capacitance diaphragm gauge)
Circuit Board L6491301
(Requires software revision P2.1 or higher)
For use with Multi-Gauge
The Capacitance Diaphragm Gauge Controller (CDG) board is designed to operate standard and temperature-compensated transducers which require ±15 volts up to 700ma power and have an output signal of 0 to 10 VDC. Each board is capable of controlling two transducers; and up to two CDG boards may be installed in the Multi-Gauge for a total of four CDG transducers.

ConvecTorr Circuit Board L9887301
(Requires software revision P3.1 or higher)
For use with the Varian ConvecTorr Thermocouple Gauge Tube
The ConvecTorr board operates up to two ConvecTorr tubes. It can be installed in any one of the five card slots in the Multi-Gauge Basic Unit. Up to two cards may be installed for a total of four ConvecTorrs. The analog output is a 0 to 10 VDC non-linear output. Using a ConvecTorr tube in conjunction with an ion gauge card allows the user the ability to program a set point to automatically turn on the emission of an ion gauge.

Thermocouple Circuit Board L6430301
(Requires software revision P1.7 or higher)
For use with Varian 531 and 536 Thermocouple gauge tubes
The thermocouple board operates up to four Varian series 531 and 536 Thermocouple gauge tubes. It can be installed into any one of the five card slots in the Multi-Gauge basic unit. Up to two cards may be installed for a total of eight available thermocouples. The analog output is a 0 to 10 VDC non-linear output. Using a thermocouple in conjunction with an ion gauge card allows the user the ability to program a thermocouple to automatically turn on the emission for an ion gauge.

Set Point Circuit Board L8327301
(Requires software revision P1.7 or higher)
The set point circuit board provides eight set points which can be assigned to any installed gauge tube. Each set point controls a 3 amp SPDT relay for operation at 30 VDC or 120 VAC. The card fits into one slot location out of five. Up to one card can be loaded.

Multi-Gauge™ Control Options

Remote Input-Output Circuit Board L8324301
(Requires software revision P1.7 or higher)
Remote input-output circuit board provides the capability to remotely control emission and degas for up to three ion gauges. The card fits into one out of five slot locations. Up to one card can be installed.

RS232 Interface Circuit Board L6439301
(Requires software revision P1.7 or higher)
The RS232 serial computer interface board will be installed in its own dedicated card slot location in the L8350301 Multi-Gauge controller. This is a bi-directional plug-in board which allows complete data logging and complete computer control. Only one communication board can be loaded per Multi-Gauge.

RS485/422 Serial Interface L8940301
(Requires software revision A1.0 or higher, not compatible with PX.X revisions)
This Multi-Gauge option provides serial communication capability as specified in EIA (Electronic Industry Association) standard 422 and 485; controls up to 32 units, Multi-Gauge or other operational line drop. This option installs into the slot location dedicated to communications. Only one communication board can be loaded per Multi-Gauge: RS232, or RS232 Fiber Optics, or RS485.

Software Upgrade Kit EPROM L6771302
This includes the latest version of software and instruction manual for upgrading an existing Multi-Gauge to the latest revision.

Multi-Gauge Configurations

To configure a Multi-Gauge, you will need a basic unit, at least one transducer board, a cable, and a gauge tube. Multi-Gauge can be configured with up to five circuit boards plus an RS232 or RS485/422 interface.

Up to three of the high-profile boards can be installed in any combination:

Type	# of Boards	# of Transducers Per Board	Analog Output
Bayard-Alpert Hot Filament	3	1	1 volt/Decade
UHV-24 Bayard-Alpert	3	1	1 volt/Decade
CDG (Capacitance Manometer)	2	2	0-10 volts Linear
Inverted Magnetron	3	1	1 volt/Decade

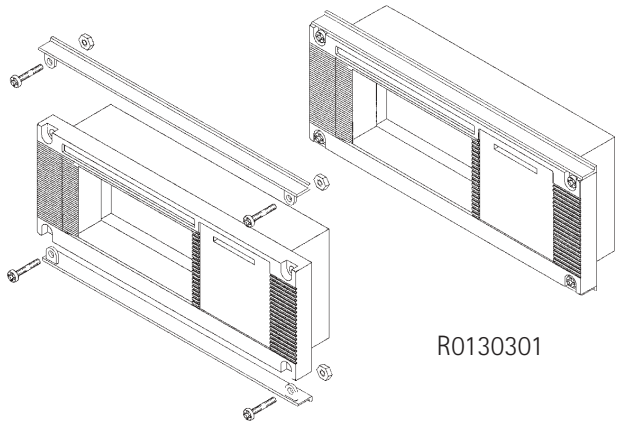
Up to two of the low-profile boards can be installed in any combination.

Type	# of Boards	# of Transducers Per Board	Analog Output
Thermocouple	2	4	0-10 volts Non Linear
ConvecTorr	2	2	1 volt/Decade

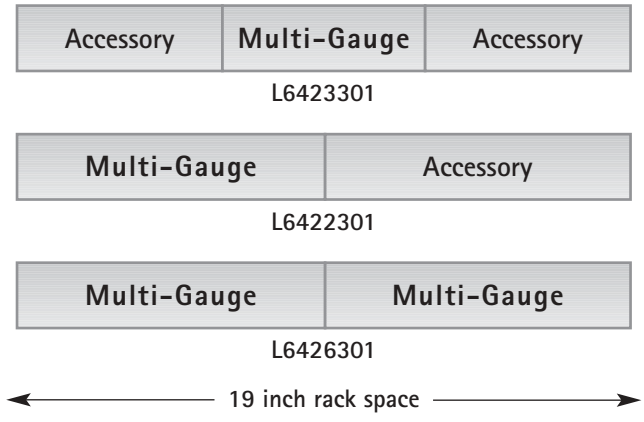
One of each of the following process control boards can be installed:

Type		# of Boards	# of Channels	Control Functions
Set point Board	1	8 SPDT Relays	Assignable to any transducer and/or software-controlled over RS232 line	
Remote I/O Board	1	8 Opto-Isolated Inputs 8 SPST Outputs	Software-controlled over RS232 line, or used for Bayard-Alpert tube remote on/off Degas	

Multi-Gauge Panel Mounting Cut-Out Accessory



Multi-Gauge Mounting Accessories (For full rack)



Multi-Gauge Technical Specifications

Power Requirements

90 to 250 VAC, 50/60 Hz, 1 phase, switchable, 120 watts (typical)

Operating Range

- TC: 2 torr to 10^{-3} torr
- ConvecTorr: 760 torr to 10^{-4} torr
- CDG: 760 torr to 10^{-6} torr (depends on CDG selected)
- B/A: 10^{-2} torr to 10^{-10} torr
- UHV: 10^{-3} torr to 10^{-12} torr
- IMG: 10^{-3} torr to 10^{-11} torr depending on IMG model selected

Operating Temperature Range

0° to 50 °C

Analog Outputs

UHV, Sequential B/A, B/A, Cold Cathode: 1 V/decade

TC, ConvecTorr, CDG: 0 –10 VDC

Degas

E-beam (UHV only)

Resistance heating

Process Set Points/Remote I/O

Set point Board: (8) SPDT Relays, rating 120 VAC 3 amps

Remote I/O Board: (8) SPST output relays, rating 24 VDC/ 120 VAC, @ 0.5 amps
(8) Opto-isolated remote logic channels

Dimensions in inches (mm)

Case: 8 (203) W x 14.63 (372) D x 3.5 (89) H

Computer Interface Options

Bi-directional RS232C or RS485/422

Data Rates: 1,200, 2,400, 4,800, 9,600, 19,200 Baud

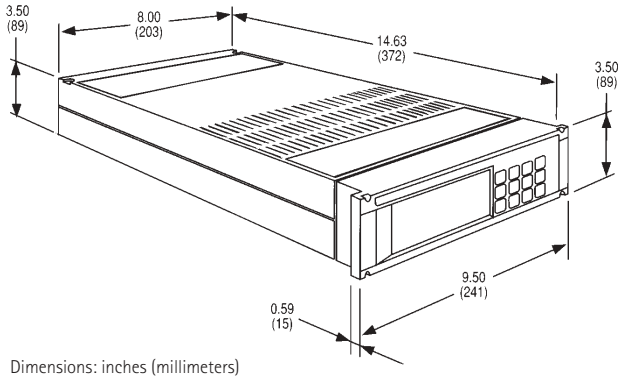
Parity: Selectable (even, odd, none)

Ordering Information

Description	Part Number	Shipping Weight lbs. (kg)
Basic Unit	L8350301	4.0 (2.0)
Transducer Circuit Boards		
UHV for use with UHV-24, UHV-24p, and MBA-100 gauge tube	L8321301	1.0 (0.5)
Bayard-Alpert (B/A) for use with 563, 564, 571, 572, 580	L6427301	1.0 (0.5)
Inverted Magnetron for use with Inverted Magnetron Gauge, IMG-100 (requires software P3.1 or higher)	L9066301	1.0 (0.5)
CDG (capacitance manometer) for use with Varian Ceramicel capacitance diaphragm gauges or equivalent commercial gauges	L6491301	1.0 (0.5)
ConvecTorr Board for use with ConvecTorr tubes (requires software P3.1 or higher)	L9887301	1.0 (0.5)
Thermocouple Board for use with 531 or 536 gauge tubes	L6430301	1.0 (0.5)
Cold Cathode Board	L6433301	1.0 (0.5)
Process Control Circuit Boards		
Set point (female D-connector)	L8327301	1.0 (0.5)
Set point (male D-connector)	L8727302	1.0 (0.5)
Remote input-output	L8324301	1.0 (0.5)
Communications Options (seriel interfaces do not occupy a board slot)		
Standard RS232 interface (includes EPROM for BCD Protocol)	L6439301	1.0 (0.5)
Standard RS485/422 interface	L8940301	1.0 (0.5)
Accessories		
Software kit upgrade to latest revision (ASCII/RS232, EPROM)	L6771302	1.0 (0.5)
Software kit upgrade to latest revision (RS-232 BCD module, EPROM)	L6771301	1.0 (0.5)
Center-rack mount kit	L6423301	1.0 (0.5)
Off-center rack mount kit	L6422301	1.0 (0.5)
Dual Multi-Gauge rack mount kit	L6426301	1.0 (0.5)
Panel cutout bezel	R0130301	1.0 (0.5)

NOTE *See pages 304 and 305 for transducer cables*

Outline Drawing



Dimensions: inches (millimeters)

Varian's senTorr is a complete half-rack vacuum gauge controller designed to increase system productivity with reliable, fast response pressure measurements, from rough to high vacuum. The analog output and programming capabilities make the senTorr ideally suited for a wide range of industrial and analytical vacuum applications where pressure measurement is a requirement. The controller is shipped ready-to-operate in one of three basic configurations.

- One high-vacuum or ultra-high vacuum transducer
  - senTorr model BA (Bayard-Alpert)
  - senTorr model UHV (Ultra-High Vacuum Nude Tube)
  - senTorr model CC (525 CCG)
- One high-vacuum or ultra-high vacuum transducer and two thermocouples
  - senTorr model BA2
  - senTorr model CC2
- One high-vacuum or ultra-high vacuum transducer and two ConvecTorrs
  - senTorr model BA2c
  - senTorr model UHV2c
  - senTorr model CC2c

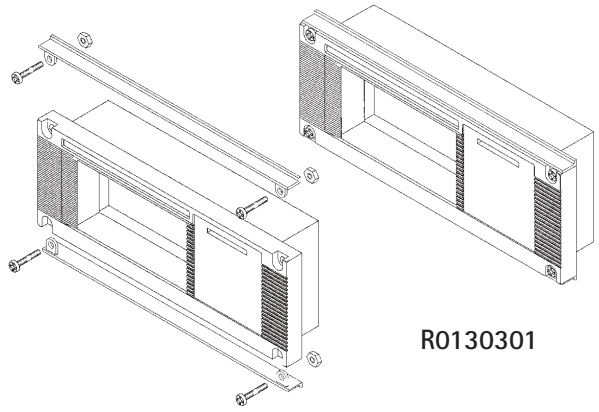
The senTorr's programming capability is easily managed from the front panel keypad. The command structure provides the user with the capability to operate other manufacturer's glass gauge tubes, measure desired gas load partial pressures, and automatically turn ion gauges on and off. Additionally, users can select torr or mbar pressure units, baud rate, sensitivity, and emission current. The senTorr has a standby mode which eliminates power to all components except the main processor. This feature conserves energy while allowing faster warm-up times than cold starts. Other system settings, such as calibration, display update rate, and fault protection are adjusted via front panel access codes.

To improve pressure measurement accuracy, the sensitivity can be adjusted to match gauge tube specifications. Emission current adjustments allow the user to extend the measurement range and/or prolong tube life. The keypad can be locked out to prevent inadvertent setting changes. The senTorr's ion gauge can be remotely operated with an applied DC voltage. Analog pressure signals for all transducers are located on the back panel.

Options include RS-232 or RS-485 interfaces, degas, and set points. RS-232 allows the senTorr to be operates remotely using a standard serial interface, while RS-485 permits the controller to be operated in a network with up to 32 senTorrs. Resistive degas is used with Bayard-Alpert gauges and electron bombardment is used with ultra-high vacuum nude gauges. The set point option provides one set point per transducer and one additional set point which can be assigned to any transducer. Set point hysteresis can be adjusted to prevent relay deactivation until pressure increases above the hysteresis setting.

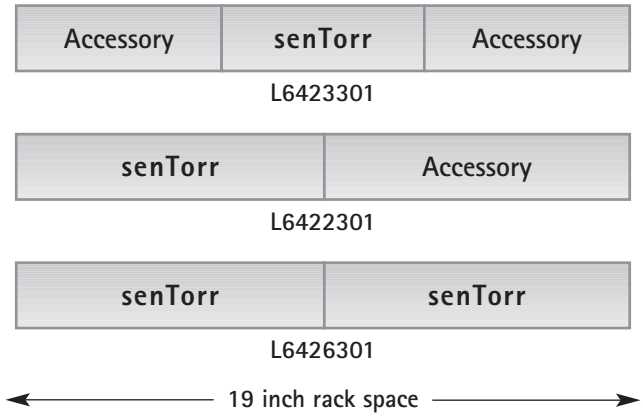
Features	Benefits
• Overpressure protection	• Automatically shuts off the ion gauge, protecting it from damage due to a sudden rise in pressure
• Auto-On	• Automatically turns the ion gauge on and off
• Low component operating temperature	• Dramatically decreases the probability of component failure
• Optional process control set points	• Control of heaters, pumps, timers, and more
• Log/linear analog outputs	• Ideal for remote monitoring of gauge pressure
• Troubleshooting error codes	• Used as a vacuum system diagnostic tool
• CE and UL, cUL listed	• Assures safety and reliable operation

senTorr Panel Mounting Cut-Out Accessory



R0130301

senTorr Full Rack (19 in.) Mounting Accessories



senTorr Technical Specifications

Power Requirements
50/60 Hz, 90 to 250 VAC, switchable
120 watts (typical)

Serial Communication
Optional: RS485, RS232
Format: Bi-directional ASCII
Data Rates: 1200, 2400, 4800, 9600, 19200
Parity: Selectable (even, odd, none)

Analog Outputs (standard on all tubes)
1 V/decade

Process Set Points
(1) SPDT/transducer; 1 additional SPDT assignable
3 amps/120 VAC

Remote Input (to turn ion gauge on/off)
Input: 5 to 24 VDC

Degas
Resistance heating

Operating Temperature Range
0 °C to 50 °C

Operating Ranges
- Thermocouple minimum pressure capability: 1 x 10^{-3} torr
- Thermocouple maximum pressure capability: 2 torr
- Sensitivity (selectable in 1/torr increments): 1/torr to 25/torr
- Emission Current (selectable in 0.1 mA increments): 1 mA to 10 mA
- Auto-on (standard): Refer to TC1
- Analog output per gauge standard: 1V/decade
- ConvecTorr™ minimum pressure capability: 1 x 10^{-3} torr
- ConvecTorr maximum pressure capability: Atmosphere

Ordering Information

To determine the ordering number, select the desired configuration as follows

Basic Configurations

One Ion Gauge	
BA - Bayard-Alpert (563, 564, 571, 572, 580, MBA-100, MBA-200)	L91203 01 X X 0 X
UHV – Ultra-High-Vacuum Nude Gauge (UHV-24)	L91103 01 X X 0 X
CC – cold cathode (525)	L91213 01 X X 0 X
One Ion Gauge, Two Thermocouple Gauges	
BA2	L91203 02 X X 0 X
CC2	L91213 02 X X 0 X
One Ion Gauge, Two ConvecTorr Gauges	
BA2c	L91203 03 X X 0 X
UHV2c	L91103 03 X X 0 X
CC2C	L91213 03 X X 0 X

Set Point Options

No set points.	0
Set points	1

Degas Options (not available with CC versions)

No degas	0
Degas	1

Communications Options

No communications	0
RS-232	1
RS-485	4

Ordering Information

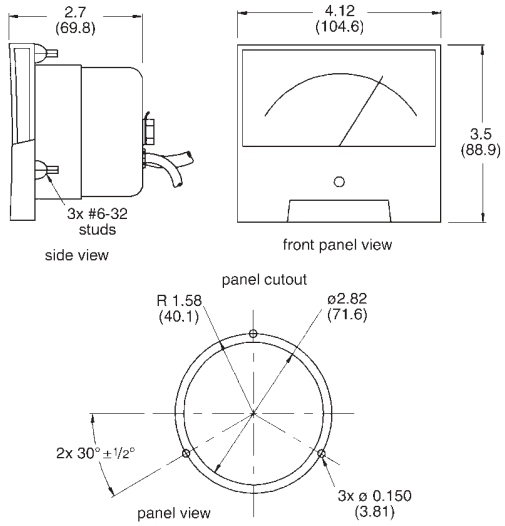
Description	Part Number	Shipping Weight lbs. (kg)
Accessories Kits		
Center rack mount kit	L6423301	1.0 (0.5)
Off-center rack mount kit	L6422301	1.0 (0.5)
Dual senTorr™ rack mount kit	L6426301	1.0 (0.5)
Panel cutout bezel (trim kit)	R0130301	1.0 (0.5)
Cables* (Gauge tubes sold separately)		
10 ft. Ion Gauge (non-bakeable) cable for use with the **563**, **564**, **571**, or **572** gauge tubes	L64553010	1.0 (0.5)
10 ft. UHV (non-bakeable) cable, for use with the **UHV24** gauge tubes	L64413010	1.0 (0.5)
10 ft. TC cable, for use with one **531** or **536** gauge tubes	L91313010	1.0 (0.5)
10 ft. ConvecTorr cable	L91223010	1.0 (0.5)
10 ft. Cold cathode cable (525 only)	L55723010	1.0 (0.5)
10 ft. cable, MBA-100, MBA-200	R11723010	1.0 (0.5)

**Other lengths and configurations for cables on page 304*

801 Thermocouple Gauge Controller

The 801 Thermocouple Gauge Controller provides repeatable and stable pressure measurements in the 1 x 10^{-3} torr to 2 torr range. The compact, light weight controller comes with ten-foot gauge cable, six-foot power cable and three mounting studs for easy panel mounting.
The 531 thermocouple gauge is sold separately. The recorder output renders it ideal for industrial and analytical data gathering applications. The front panel display is analog; its markings provide optimal resolution over the entire active pressure range.
The controller is fully temperature-compensated by the use of a thermistor placed in the gauge cable socket.

Outline Drawing



Dimensions: inches (millimeters)

The thermal response of the thermistor is equal to but opposite in direction from the thermocouple characteristics, thereby compensating for ambient temperature changes.
A VAC (zero) adjustment is available to re-calibrate the gauge readout at low pressure should the gauge tube be exposed to excessive contamination.

Features	Benefits
• Patented ambient temperature compensation	• Reliable pressure measurement
• A zero to eleven millivolt recorder output	• Ideal for analytical and industrial applications
• Rugged dependable tube design	• Continuous pressure indications
• Optimized resolution	• Easy-to-read analog front panel
• Line-voltage regulated	• Change in-line voltage produces < 1% change in reading
• Temperature compensation	• Changes in ambient temperature between 0 °C and 40 °C change the readings less than 1% of reading

NOTE • *Not CE marked or UL, CUL listed*

Technical Specifications

Range	1 x 10^{-3} torr to 2 torr	**Operating Temperature Range**	10 °C to 40 °C
Power	120 VAC, 60 Hz, 230 VAC, 50 Hz	**Transducer Cable**	10 foot (3.04 m) attached
Recorder Output	0 to 11 mV (non-linear, monotonic)	**Power Cable**	6 foot (1.83 m) supplied
Lowest Indication	1 x 10^{-3} torr	**Net Weight**	14 oz. (0.40 kg)

Ordering Information

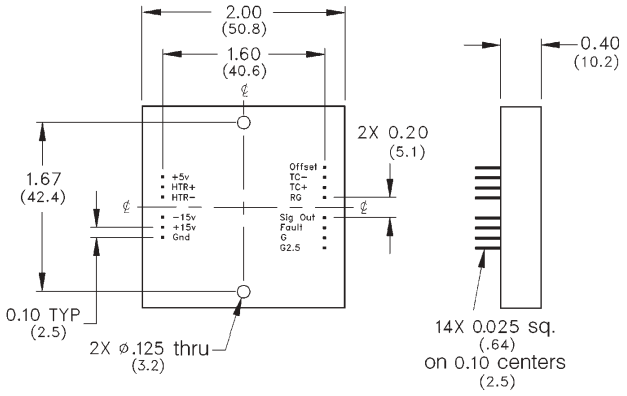
Description	Part Number	Model	Voltage	Weight lbs. (kg)
Thermocouple gauge controller (transducer sold separately)				
801	F2739301	torr	120 VAC/60 Hz	2.0 (1.0)
801	F2739302	torr	230 VAC/50 Hz	2.0 (1.0)

NOTE • *Order 531 or 536 thermocouple gauge from page 272*
• *Special-length cable quotations are available upon request*

ConvecTorr PCB Module

Varian's fast response, highly accurate ConvecTorr circuitry is available in a compact PCB-compatible transducer module ideal for OEM applications in which high performance and low cost are essential in system performance. The module is designed to be mounted on your printed circuit board; PCB cable connections are designed by your engineering group and easily integrated into your system circuitry.
The PCB Module operates with Varian's ConvecTorr gauge tube, and unlike other popular convection-type gauge tubes, is not effected by system vibration.

Outline Drawing



Dimensions: inches (millimeters)

Its dependable design offers continuous and repeatable pressure indications between 0 °C and 50 °C. The tube design has been optimized for convection cooling resulting in superior readings at higher pressures.

Features	Benefits
• Modular low profile PCB-compatible design	• Easy, low-cost custom OEM integration
• Compact electronics and transducer design	• Small footprint, limited space requirements
• Monotonic voltage output proportional to pressure	• Accurate, stable pressure readings throughout range
• Choice of 2.5 or 10 volts full scale	• Easy, alternative electronics integration
• Fault output available	• System control and reliability enhanced

Technical Specifications

Pressure Range	1000 torr to 1 x 10^{-3} torr (1000 mbar to 1 x 10^{-4} mbar)
Input Power Supply Required	+5, –15, +15 VDC at 2 watts max.
Output Signal	Non-linear 0–2.5 VDC, 0-10V, pin selectable
Fault Output	Open Collector: Low on Fault
PCB Connector	.025 in. pins, solderable

Output Impedance	100 ohms
Minimum Load Impedance	3.3 Kohms
Digital Communication	None
Calibration Adjustments	Vacuum and atmosphere, potentiometer-adjustable
Temperature Range	Operating Range: 0 to 50 °C Storage Range: –15 to 70 °C

Ordering Information

Description	Part Number	Shipping Weight lbs. (kg)
ConvecTorr PCB module	L9863301	0.5 (0.25)
1/8 in. NPT ConvecTorr tube	L9090301	1.0 (0.50)
Mini-ConFlat (1.33 inch CFF) ConvecTorr tube	L9090302	1.0 (0.50)
Cajon 4 VCR female ConvecTorr tube	L9090303	1.0 (0.50)
NW 16 KF ConvecTorr tube	L9090305	1.0 (0.50)
NW 25 KF ConvecTorr tube	L9090306	1.0 (0.50)

Active Gauges

CT-100

Active Rough Vacuum Transducer

1×10^{-3} torr to 1,000 torr
(1×10^{-3} mbar to 1,000 mbar)

- Compact, stand-alone transducer
- Available with LED display
- Available with digital communications
- Set points with digital adjustment
- 1 volt per decade analog output
- Rugged tube design
- CE certified
- UL/cUL recognized

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Eyesys ConvecTorr™

Active Rough Vacuum Transducer

1×10^{-4} torr to 1,000 torr
(1×10^{-3} mbar to 1,000 mbar)

- Compact, stand-alone transducer
- Available with LED display
- Available with digital communications
- Set points with digital adjustment
- 1 volt per decade analog output
- Rugged tube design
- CE – certified
- UL/cUL recognized

Page 298

Eyesys Mini-B/A

Active Bayard-Alpert Transducer

2×10^{-9} torr to 5×10^{-2} torr
(2×10^{-9} mbar to 6×10^{-2} mbar)

- Compact, stand-alone transducer
- Available with LED display
- Available with digital communications
- Available with two SPST set points
- 1 volt per decade analog output
- Remote degas, on/off control and status indications
- CE – certified
- UL/cUL recognized

Page 300

Eyesys Mini-IMG

Active Inverted Magnetron Transducer

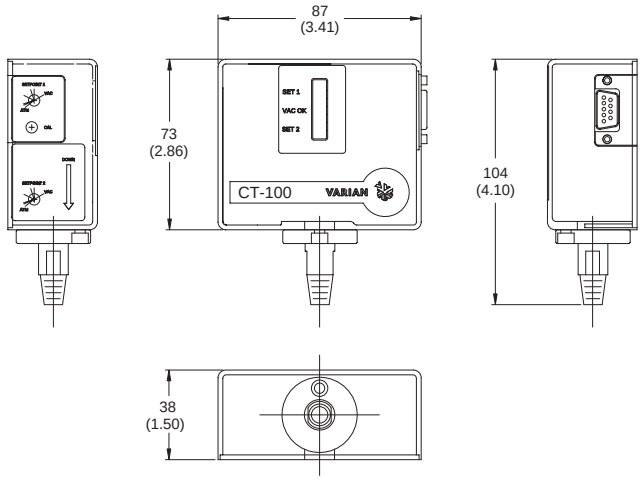
2×10^{-9} torr to 1×10^{-2} torr
(2×10^{-9} mbar to 6×10^{-2} mbar)

- Compact, stand-alone transducer
- Simple, rugged electronics with metal enclosure
- LED status indicators
- 1 volt per decade analog output
- CE certified
- UL/cUL recognized

Page 302

CT-100 Active Gauge

Outline Drawing



Dimensions: inches (millimeters)

Features	Benefits
• Selectable pressure range	• Provides accurate and repeatable readings
• 0.2 second response time	• Improves productivity and performance
• Two setpoints per gauge	• Enables cost and space savings
• Thick sensing element	• Durable and reliable design
• Single point calibration offset	• Maintains gauge accuracy over time
• Status LEDs	• Quick visual indicator of vacuum status

Technical Specifications

Pressure range N_2/Air	Factory setting (1.000 V @ ≤ 1 x 10^{-5} Torr): 1 x 10^{-4} to 100 Torr, sensitive to ATM (1.33 x 10^{-4} to 133 mbar, sensitive to ATM) (1.33 x 10^{-2} to 1.33 x 10^{-4} Pa, sensitive to ATM) Optional User Setting (8.255 V @ ATM): 20 mTorr to ATM (2.6 x 10^{-2} to 1000 mbar) (2.6 to 10^{-5} Pa)
Response time	0.2 second
Relay response time	<1 msec
Setpoint adjustment range	Greater than gauge pressure range
Operating temperature	15°C to 50°C, 90% relative humidity non-condensing
Storage temperature	–15°C to 85°C
Mounting orientation	Vacuum port pointing down for best results above 1 Torr (1.33 mbar, 133 Pa)
Weight with NPT Fitting	113 grams (1/4 lb)

Interface	
Two setpoints	Two user defined pressure setpoints for process steps, alarms, high vacuum gauge trigger, or other pressure-induced events
Setpoint	Dual, non-isolated, open collector output
"Contact" Rating	0.3 VDC @100mA (on), 30 VDC Max (off)
Adjustment	Trim pot, panel calibration, fixed hysteresis Analog voltage proportional to threshold available at connector (0 VDC – 12 VDC referred to analog output), output impedance 100 kohms

Input voltage/power	13 to 30 VDC @ 0.125 AMP, protected against reversals
Output signal (analog)	Non-linear, 1 to 9 VDC, nominal
Fault	<0.5 VDC or >9 VDC (for N_2)
Output impedance	100 ohms

Displays	
Setpoint indicators	Red LEDs – Verify an operation is underway and the appropriate vacuum has been achieved
Vacuum indicator	Green LED – Indicates <100 mTorr vacuum is achieved

Materials of construction	
Materials exposed to vacuum	Nickel-plated mild steel, glass, nickel alloy (1/8" NPT) 304 SSt, glass, nickel alloy (NW16)
Casing	Flame retardant ABS (Acrylonitrile-butadiene-styrene)
Sensor element	Platinel
Sensor internal volume	5.4 mL

Connections	
Electrical	9-pin D-Sub
Hardware	1/8" NPT or NW16 KF
Certification	UL Recognized, cUL Recognized
CE	EMC: EU 89/336, EN55011, EN61326 Safety: 73/23/EEC, Low Voltage Directive EN61010

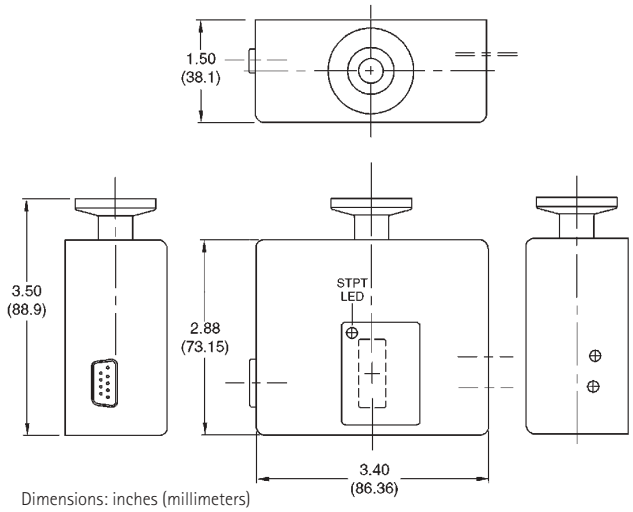
Ordering Information

Description			Part Number	Shipping Weight lbs. (kg)
CT-100 Active Rough Gauge*				
CT-100, 1/8" NPT			L7426301	2.0 (0.9)
CT-100, NW16 KF			L7426302	2.0 (0.9)
Replacement Tube, CT-100, 1/8" NPT			L7426601	1.0 (0.5)
Replacement Tube, CT-100, NW16 KF			L7426602	1.0 (0.5)
Accessories				
Vacuum Connections				
CT-100 to KF	Stainless Steel	KF16	KAFP160125S	
		KF25	KAFP250125S	
	Aluminum	KF16	KAFP160125A	
		KF25	KAFP250125A	
Interface Cable				
9-Pin D-sub to flying leads, shielded	R0907XXX. XXX = length in feet up to 100 ft.			
Mating Connector				
9-Pin D-sub connector kit with metal backshell			L7440301	
Adapter Kit				
RJ45 Adapter for Edwards ATC/APG			L7439301	
Power Supply/Breakout Box* (provides 24 VDC power and test points for signal access)			R2180302	
Calibration Service				
Factory calibration			CALEYECT-1	

**Not UL, cUL, CE certified*

Eyesys ConvecTorr™

Outline Drawing



Dimensions: inches (millimeters)

Varian's Eyesys ConvecTorr vacuum gauge is a compact pressure measurement solution with economical, reliable, and fast response from 760 torr to 1 mtorr. By maintaining the filament at a constant temperature, convection currents become measurable at higher pressures, extending the range from 1 torr to atmosphere, and the response time is greatly improved as compared to traditional thermocouple gauges. The Eyesys controller is a compact, electronics package integrated into Varian's ConvecTorr pressure transducer technology eliminating the need for more expensive rack-mounted instrumentation.
The Eyesys ConvecTorr offers an inexpensive means of vacuum process control. The user may employ the two SPST set point relays directly into standard logic inputs or to directly switch loads.

The set point relay trip level is easily set by turning a digital switch (the advantage of using a digital switch is that it will not drift) to one of the sixteen settings from 5mT to 500T. Another advantage of the Eyesys ConvecTorr is a calibration switch (smart cal.) conveniently located on the box for manual calibration at atmosphere or vacuum. By pressing on the switch when at atmosphere or when in a vacuum lower than 1 mtorr, the gauge will automatically calibrate. Automatic calibration may also be accomplished by remotely sending a low voltage pulsed signal from a PLC or computer. The Eyesys ConvecTorr offers as a standard package a pressure range from 1000 torr to 0.1 mtorr, 1v/decade log linear output, both manual and remote set point setting and calibration whether at atmosphere or vacuum. It has a standard NW16KF fitting and is CE and UL marked. A digital numeric display, NW25KF, and RS232 and RS485 seriel communications is available.

Features	Benefits
• Compact, self-contained sensor	• Cost and space savings
• Readout display available (digital numeric)	• Eliminates the need for costly panel-mounted gauges
• Remote calibration for both atmosphere and vacuum	• Fast, operator independent calibration
• Digital set point pressure adjustment	• Easy to set up, eliminates the need for voltage adjustment, high accuracy

Technical Specifications

Pressure Range
1000 torr to 1 x 10^{-3} torr (1000 mbar to 1 x 10^{-3} mbar)

Input Power Supply Required
20 VDC to 27 VDC/150 mA maximum

Output Signal
1V/Decade Log Linear

Fault Output
10 V

Output Impedance
100 ohms

Minimum Load Impedance
3.3 Kohms

Digital Communication
RS485 or RS232 ASCII

Calibration Adjustments
Vacuum and atmosphere, manual or remote via a 24 VDC pulsed input (250 msec minimum) 650 µA open collector, open drain to gnd-sink

Set Point
Digital pot setting
Two SPST relays, 100mA at 40VDC
Standard Ranges: 5mT, 10mT; 20mT, 50mT, 100mT, 200mT, 500mT, 1000mT, 2T, 5T, 10T, 20T, 50T, 100T; 200T, 500T

Temperature Range
Operating Range: 0 to 50 °C
Storage Range: –15 to 70 °C

Overpressure Capability
1500 torr

Electrical, Safety Certifications
UL, cUL recognized
CE certified

Ordering Information

To determine the ordering number, select the desired configuration as follows:

L 9 7 3 6 X X 0 X X 2 X

Pressure Units
Pa 1
mbar 2
torr 3

Display Options
No display 0
Digital display 2

Communications Options
(Note: Analog output not avaliable with communications options)
No communications 0
RS232 1
RS485 3

Fittings
NW16 2
NW25 3

Calibration
None 0
CALEYECT-1 C

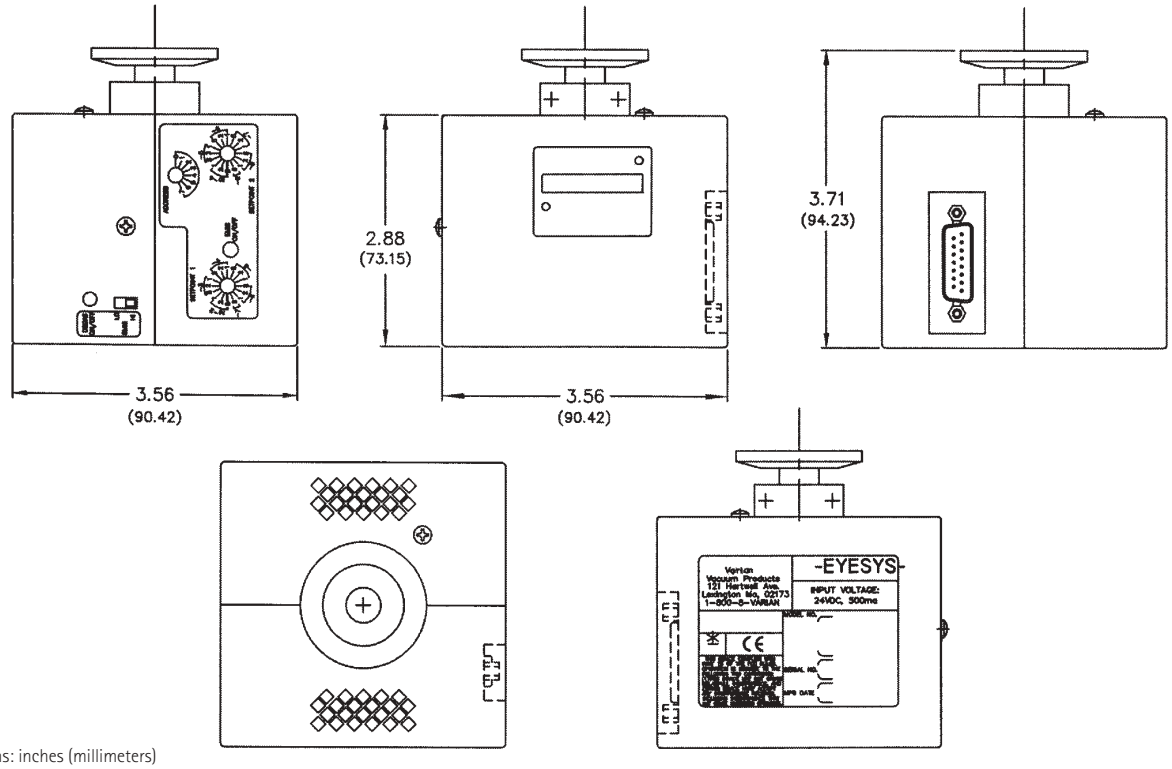
Ordering Information

Description	Part Number	Shipping Weight lbs. (kg)
Replacement Transducers (Field Replaceable)		
NW16 KF, stainless steel	L7426602	1.0 (0.5)
NW25 KF, stainless steel	L7426603	1.0 (0.5)
Accessories		
Plug-in power supply/signal breakout box (not CE marked or UL/cUL recognized)	R2180302	1.0 (0.5)

Eyesys Mini-BA Gauge

The Eyesys Mini-B/A is Varian's newest high-vacuum transducer. Like the Eyesys ConvecTorr, the Mini-B/A is a self contained transducer which does not require a separate controller. This stand-alone package is ideal for applications requiring minimum use of space or direct integration with PLCs and digital communications.
The measurement range of the Eyesys Mini-B/A is 10 mtorr to 2×10^{-9} torr, and the transducer can be operated remotely via analog logic or digital communications. The pressure reading is available from the optional LED-display,
1 volt/decade analog pressure signal, or digitally through the optional RS-232/485 interface. In addition, the two SPST set points can be used for process control. E-Beam degas is a standard feature.

Outline Drawing



Dimensions: inches (millimeters)

Features	Benefits
• Small footprint	• Cost and space savings
• LED display (digital numeric available)	• Eliminates need for panel-mount electronics
• 1 volt/decade log output	• Direct input to user's system
• Two SPST set points	• Easy PLC integration
• Remote calibration via digital interface	• Fast, operator independent calibration
• Remotely operated degas	• Maintains sensor performance

Technical Specifications

Pressure Range	10 mtorr to 2 x 10^{-9} torr
Input Power Supply Required	24 VDC ±10% @ 0.500 A
Output Signal	1V/Decade Logarithmic
Fault Output	10 VDC
Output Impedance	100 Ω
Minimum Load Impedance	1 K Ω
Emission Current	100 mA /1 mA
Filament	Thoria-Coated Iridium
Degas Method	E-Beam with auto time out
Sensitivity	15/torr
Digital Communication Options	RS-485/232

Set Points	2 SPST relays, operating range 5% to 95%, 10% hysteresis, rating 40 VDC @ 100 mA, adjustable with digital potentiometer
Temperature Range	0-50 °C operating, -15 to 70 °C storage
Size	4 in.H (flange face to end) x 3 3/8 in. W x 3 in. D
I/O Connection	15-pin D-subminiature
Overpressure Limit	1000 torr
Electrical, Safety Certifications	UL, cUL recognized CE certified

Ordering Information

To determine the ordering number, select the desired configuration as follows:

R 0 1 5 0 X X 1 X X XX

Pressure Units
- Pa 1
- mbar 2
- torr 3

Basic Configuration
Magnetic shielded metal case$675

Display Options
- No display 0
- Digital display 2

Communications Options
- No communications 0
- RS232 1
- RS485 3

Fittings
- NW16 1
- NW25 2

Calibration
- None ..... (BLANK)
- STD ..... SC
- Premium ..... PC

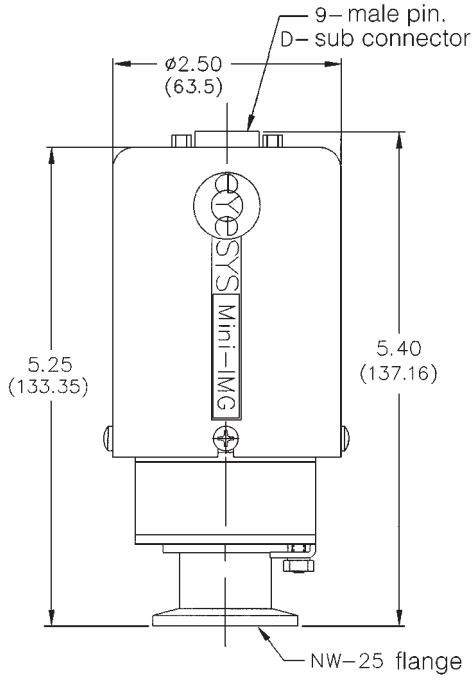
Ordering Information

Description	Part Number	Shipping Weight lbs. (kg)
Replacement Transducers (Field Replaceable)		
NW16 (SST)	R0156301	1.0 (0.5)
NW25 (SST)	R0156302	1.0 (0.5)
Replacement tube, NW16 (version 2)	R0156601	1.0 (0.5)
Replacement tube, NW25 (version 2)	R0156602	1.0 (0.5)
Replacement tube, 1.33 CFF (version 2)	R0156603	1.0 (0.5)
Accessories		
Plug-in power supply/signal breakout box	R2180301	1.0 (0.5)

Eyesys Mini-IMG

Varian Vacuum Technologies introduces the Eyesys Mini-IMG active high-vacuum gauge. The Eyesys Mini-IMG is based on the proven inverted magnetron gauge, providing reliable measurement of pressures 10^{-3} T down to 10^{-9} torr, even in corrosive and dirty applications. The gauge tube may be easily cleaned or replaced. Rack mounted control electronics are not necessary, simply supply +24 VDC power and input the 1 volt/decade analog output to your PC or PLC.
Unlike traditional cold cathode designs, Varian's inverted magnetron features fast starting even under high vacuum conditions. The gauge can also be turned on/off remotely via DC voltage signal. On-board LEDs indicate the status of the gauge.

Outline Drawing



Dimensions: inches (millimeters)

Features	Benefits
• On-board control electronics	• External control equipment not needed
• Rugged, all stainless steel gauge tube	• Reliable measurement in corrosive or dirty applications, no elastomers or o-rings
• Proven inverted magnetron design	• Rapid starting, even in high-vacuum conditions
• Compact size	• Flexible installation
• Standard D-subminiature connector	• Excellent shielding, secure locking connection

Technical Specifications

Gauge Type

Inverted magnetron ion gauge

Maximum voltage when gauge on is approximately 3 kVolts

Measurement Range

1 x 10^{-3} torr to 2 x 10^{-9} torr

Power Requirement

24 VDC ±10% @ 250 mA, typical

Output Signal

0.5 to +8.5 VDC

Scaled 1 volt per decade

Signal below +0.5 VDC indicates error

When +24 VDC is applied, but the gauge tube is not turned on, output will be above +9.0 VDC

Electrical Connection

9-pin D-subminiature

On-Board Indications

Green LED to indicate 24 VDC power applied

Red LED for gauge on (LEDs located on top of case next to 9-pin D-connector)

On-Board Control

Gauge normally turns on when +24 VDC power is applied, however, the gauge may be remotely turned on/off via dedicated pins on the D-sub connector

Gauge ON < 0.5 VDC

Gauge OFF > 0.65 VDC

Overpressure Limit

1500 torr (2 Bar)

Temperature Limitations

Operating: 0 to 50 °C

Storage: –15 to 70 °C

Materials Exposed to Vacuum

300 series stainless steel

Small amount of Nickel, glass (feedthrough)

Electrical, Safety Certifications

UL, cUL recognized

CE certified

Ordering Information

Description	Part Number	Shipping Weight lbs. (kg)
Eyesys Mini-IMG NW25	R1400301	1.0 (0.5)

Multi-Gauge™/senTorr/Eyesys Cables

NOTE • *All cables available in 5 foot increments.*

Ordering Information

Description	Length	Part Number	Shipping Weight lbs. (kg)
UHV Cables Bakeable (UHV-24, UHV-24p) (Multi-Gauge and senTorr)			
Standard bakeable (Teflon – bakeable to 250 °C)	10 feet	L64403010	2.0 (1.0)
Standard bakeable (Teflon – bakeable to 250 °C)	25 feet	L64403025	2.0 (1.0)
Radiation-resistant bakeable (Kapton – bakeable to 250 °C)	10 feet	L64404010	2.0 (1.0)
Radiation-resistant bakeable (Kapton – bakeable to 250 °C)	25 feet	L64404025	2.0 (1.0)

L 6 4 4 0 X 0 X X

Other lengths
Teflon 3
Kapton (radiation-resistant) 4
Length in feet (100 ft. maximum, 10 foot maximum when using extensions) .....

UHV Cables Non-bakeable (UHV-24, UHV-24p) (Multi-Gauge and senTorr)			
Standard non-bakeable	10 feet	L64413010	2.0 (1.0)
Standard non-bakeable	25 feet	L64413025	2.0 (1.0)

L 6 4 4 1 3 X X X

Other lengths
Length in feet (100 ft. maximum, 10 ft. maximum when using extensions) .....

Bayard-Alpert Ion Gauge Cables (571, 572, 563, 564) (Multi-Gauge and senTorr)			
Standard Non-bakeable	10 feet	L64553010	2.0 (1.0)
Standard Non-bakeable	25 feet	L64553025	2.0 (1.0)

L 6 4 5 5 3 X X X

Other lengths
Length in feet (100 ft. maximum, 10 ft. maximum when using extensions) .....

Ion Gauge Extension Cables (Multi-Gauge and senTorr)

L 6 4 5 6 3 X X X

Other lengths
Length in feet (maximum 350 feet) .....

MBA-100 Metal Ion Gauge Cables			
MBA-100	10 feet	R11723010	2.0 (1.0)
MBA-100	25 feet	R11723025	2.0 (1.0)

R 1 1 7 2 3 X X X

Other lengths
Length in feet (maximum 100 feet) .....

Use for cable lengths greater than 100 feet Order extension with a 10 foot primary cable (L6455, L6440, L6441)

IMG-100 Cables (Multi-Gauge and senTorr IMG models)			
IMG-100	10 feet	R03113010	2.0 (1.0)
IMG-100	25 feet	R03113025	2.0 (1.0)

R 0 3 1 1 3 X X X

Other lengths
Length in feet (maximum 100 feet) .....

525 Cold Cathode Cable			
525	10 feet	L55723010	2.0 (1.0)
	25 feet	L55723025	2.0 (1.0)

L 5 5 7 2 3 X X X

Other lengths
Length in feet .....

Ordering Information

Description	Length	Part Number	Shipping Weight lbs. (kg)
Inverted Magnetron Gauge for UHV Inverted Magnetron (Multi-Gauge and senTorr)			
Bakeable to 250 °C	10 feet	R03413010	2.0 (1.0)
Bakeable to 250 °C	25 feet	R03413025	2.0 (1.0)

R 0 3 4 1 3 X X X

Other lengths
Length in feet .....

Thermocouple Cables (Multi-Gauge only)			
Dual (for use with two gauges)	10 feet	L64752010	2.0 (1.0)
Dual (for use with two gauges)	25 feet	L64752025	2.0 (1.0)
Quad (for use with four gauges)	10 feet	L64754010	2.0 (1.0)
Quad (for use with four gauges)	25 feet	L64754025	2.0 (1.0)

L 6 4 7 5 X X X X

Other lengths
Single (1 gauge) .....
Dual (2 gauges) .....
Triple (3 gauges) .....
Quad (4 gauges) .....
Length in feet (maximum 100 ft.) .....

Thermocouple Cables (senTorr only)			
For use with one 531 or 536 gauge tubes	10 feet	L91313010	2.0 (1.0)
For use with one 531 or 536 gauge tubes	25 feet	L91313025	2.0 (1.0)

L 9 1 3 1 3 X X X

Other lengths
Length in feet (maximum 100 ft.) .....

ConvecTorr Cables (Multi-Gauge, senTorr and PanelVac Convectorr)			
Standard non-bakeable	10 feet	L91223010	2.0 (1.0)
Standard non-bakeable	25 feet	L91223025	2.0 (1.0)

L 9 1 2 2 3 X X X

Other lengths
Length in feet (maximum 100 ft.) .....

Capacitance Manometer Cables (Multi-Gauge)			
Standard, 15 pin connector, fits all VCMx series heads	10 feet	L91533010	2.0 (1.0)
Standard, 15 pin connector, fits all VCMx series heads	25 feet	L91533025	2.0 (1.0)

L 9 1 5 3 3 X X X

Other lengths
Length in feet (maximum 150 feet) .....

Eyesys Interface Cables (for integration with your vacuum system)			
Eyesys ConvecTorr (9-pin D, flying leads), CT-100, Mini-IMG	10 feet	R0907010	2.0 (1.0)
Eyesys Mini-BA (15-pin D, flying leads)	10 feet	R0908010	2.0 (1.0)

R 0 9 0 X X X X

Other lengths
Eyesys ConvecTorr, CT-100, Mini-IMG 7
Eyesys Mini-BA 8
Length in feet (maximum 100 feet) .....

Controller Repair/Exchange Program

Ordering Information		
Description	**Part Number**	**Shipping Weight lbs. (kg)**
815 fast response TC gauge controller	FFL5700301	4.0 (2.0)
860A-2 cold cathode gauge controller without set point	FFL5797301	5.0 (2.5)
senTorr™ BA2 controller	EXL9120302	4.0 (2.0)
ConvecTorr™ controller with dual set point	EXL9104301	4.0 (2.0)
Multi-Gauge™ basic unit	FFL8350301	10.0 (5.0)
B/A board	FFL6427301	2.0 (1.0)
UHV board	FFL8321301	2.0 (1.0)
CCG board	FFL6433301	2.0 (1.0)
CDG board	FFL6491301	2.0 (1.0)

Contact Varian's Service Department for more information on repairs and calibration services.

STARRS Calibration and Service Program

Varian introduces the STARRS Calibration and Service Program. STARRS is a total calibration, service and warranty program to ensure the optimum performance of your Varian vacuum measurement equipment. Vacuum gauges are often overlooked in many systems, however, their accurate and reliable operation is critical to any process. Proper calibration on Varian's state-of-the-art equipment will ensure that your gauges are accurate and repeatable. Our extended warranty and advanced exchange programs will eliminate downtime due to equipment problems. All of our calibration service is NIST-traceable and fully documented to meet exacting ISO standards.

The STARRS program encompasses a large number of options for calibration. We will calibrate new gauging on order from Varian or your existing Varian equipment. You may choose to have the gauges calibrated with the controllers or separately. In addition, you may choose a simple, inexpensive calibration or a more in-depth service.

In many cases, a multi-million dollar process depends on a vacuum gauge and controller. For this reason, Varian offers an advanced exchange program. This ensures that replacement equipment will be available to you right away should the need arise. Our extended warranty program offers peace of mind for all of your vacuum gauge instrumentation.

Sensitivity

Sensitivity is the most important parameter for an ion gauge. Also referred to as gauge factor, sensitivity is a measure of the ionization efficiency of a gauge. In order to understand the accuracy of an ion gauge, the sensitivity must be known. For a Bayard-Alpert gauge, the sensitivity may be calculated as follows:

$$S = \left(\frac{I^+}{I^-}\right)\left(\frac{1}{P}\right)$$

Where:

S = Sensitivity
I+ = Ion Current in Amperes (from collector)
I– = Emission Current in Amperes (from filament)
P = Pressure in torr

Using the above equation, sensitivity is expressed in "per torr" units. Simply put, the higher the sensitivity, the better the resolution of the ion gauge. In order to accurately translate the ion current signal from a gauge into a pressure value, the sensitivity must be known. Typically, sensitivity values for gauges shown in manuals or marketing literature are average or "typical" values. In particular, older controllers used to operate these ion gauges are designed for this typical value. The actual sensitivity for a particular gauge tube may be significantly different from the published value, which will mean that your achieved accuracy will be much worse than expected. However, if the sensitivity of a gauge is known, then control electronics or the output signal may be adjusted accordingly.

Traceability

The status quo for most manufacturing operations is ISO 9000 compliance, meaning all procedures and products must be completely and accurately documented. Therefore, vacuum gauge calibrations must be properly documented in order to satisfy this requirement. It is important to use equipment which has been checked and adjusted against a standard reference. Varian can supply ion gauges, Capacitance Diaphragm Gauges, and thermal rough vacuum gauges calibrated against NIST standards. In addition, Varian maintains calibration records both electronically and on paper.

Accuracy

Accuracy is an issue often misunderstood in the vacuum environment. Accuracy is defined as measurement compared to a reference standard. Depending on the type of vacuum gauge, this value is quantified as a percentage of reading or full scale. For many vacuum applications such as high-energy physics research, accuracy must be known in order to ensure publishable results. By providing gauges calibrated against NIST-traceable standards, accuracy is quantified providing consistent data to the vacuum user.

Repeatability

In the production environment, repeatability is often more important than accuracy. In this context, repeatability is the ability of a vacuum measurement system to obtain the same reading after several process cycles. Excellent repeatability means consistent, high-quality end product from your process. Poor repeatability means downtime and extra cost.

Reliability

All applications demand a reliable vacuum measurement equipment. In many cases, a multi-million dollar process is dependent on a several hundred dollar vacuum gauge. Unnecessary downtime leads to unnecessary costs.
All Varian vacuum gauge controllers and electronics have at least a one-year guarantee – and we will exchange or replace the component at your request. In order to provide extra peace of mind, Varian will also arrange an advanced exchange program with your facility. Your local Varian Vacuum Technologies sales engineer can provide details on this program.

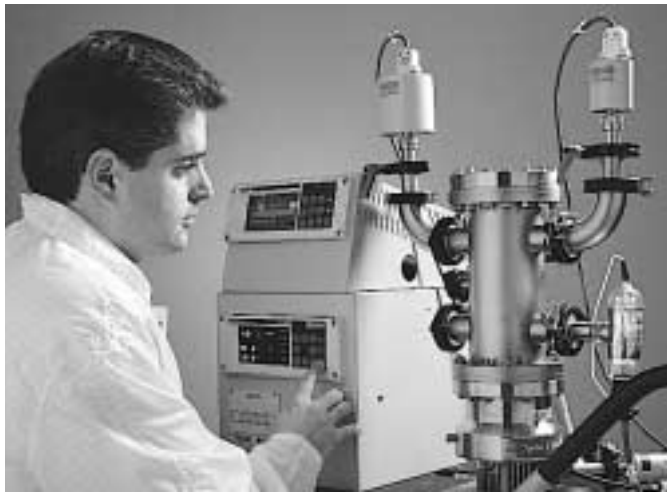
Statistical Process Control

Varian Vacuum Technologies is constantly seeking to maintain our quality and improve performance. For our broad line of vacuum gauging products, we have implemented a rigorous statistical process control (SPC) program to ensure consistent, reliable gauges. We track key performance characteristics and manufacturing parameters to maintain a high quality product.

Calibration Services Available

NIST-Traceable Gauge Only Calibration Rough Gauges (1mTorr to Atmosphere)

The Unit-Under-Test (UUT) Gauge will be operated with a NIST-calibrated Varian controller and referenced against a suitable NIST-calibrated transfer-standard capacitance manometer. The customer will be given a four-point calibration sheet indicating the performance of the gauge relative to the standard, type number and serial number for transfer standard, and conditions at the time of test. Varian CeramiCel Capacitance Diaphragm Gauges will be internally adjusted for optimum calibration. A "four-point" calibration provides UUT readings referenced against an NIST-standard at 25%, 50%, 75%, and 100% of full scale.
A "ten-point" calibration means reference data at 10%, 20%,... 100% of full scale.



NIST-Traceable System Calibration Includes Controller, Cables(s), Gauge(s)

All calibrations include documentation indicating equipment performance, environmental conditions, and NIST reference information.

NIST-Traceable Gauge Only Calibration High Vacuum and Ultra-High Vacuum Gauges

Gauge will be operated with a NIST-calibrated Varian Controller. Two types of calibration will be available: standard, using a NIST-calibrated tube to determine a mid-range gauge factor (10^{-6}), and premium, which includes an SRG calibration down to the 10^{-6} torr range and a NIST-tube calibration below this pressure. Premium service will include three gauge factor measurements – 10^{-4} torr, 10^{-5} T and 10^{-6} torr. Cost is per filament for hot-cathode gauges.
All calibrations include documentation indicating equipment performance, environmental conditions, and NIST reference information.

Calibration Services Available *(Cont'd)*

Ordering Information

Description	Part Number*
Unheated capacitance diaphragm gauge, 4 points	CALCDG-1
Unheated capacitance diaphragm gauge, 10 points	CALCDG-2
Heated capacitance diaphragm gauge, 4 points	CALCDG-3
Heated capacitance diaphragm gauge, 10 points	CALCDG-4
Standard cold cathode gauge	SCCG-1
Standard Inverted magnetron gauge	SIMG-1
Standard Bayard-Alpert gauge	SBAG-1
Standard UHV nude gauge	SUHV-1
Premium cold cathode gauge	PCCG-1
Premium inverted magnetron gauge	PIMG-1
Premium Bayard-Alpert gauge	PBAG-1
Premium UHV nude gauge	PUHV-1

Description	Part Number*	Service Performed
Multi-Gauge Controller System Calibration	CALMG-1	Calibration of electronics using NIST-traceable equipment
For each thermocouple or ConvecTorr	CALCNTC-1	Calibration of gauges using electronics and cables provided. Includes sensitivity adjustment on Multi-Gauge to match ion gauge performance
Refer to ordering information above for Capacitance Diaphragm Gauge calibration part numbers. *Refer to ordering information above for Ion Gauge calibration part numbers.*		
senTorr Controller System Calibration	CALST-1	Calibration of electronics using NIST-traceable equipment
For each thermocouple or ConvecTorr	CALCNTC-1	Calibration of gauges using electronics and cables provided Includes sensitivity adjustment on senTorr to match ion gauge performance
Refer to ordering information above for Ion Gauge calibration part numbers.		
CT-100 and Eyesys ConvecTorr Electronics and Gauge Calibration	CALEYECT-1	Calibration of transducer using NIST-traceable capacitance diaphragm gauge
Eyesys Mini-BA Electronics and Gauge Calibration (Standard Calibration)	CALYBAS-1	Calibration of transducer using NIST-traceable ion gauge. Includes sensitivity adjustment for optimum performance.
(Premium Calibration)	CALYBAP-1	Includes spinning rotor gauge reference
860 Cold Cathode Controller and Gauge Calibration	CAL860-1	Calibration of cold cathode gauge and controller using NIST-traceable ion gauge Documentation indicating results of testing and NIST reference data
ConvecTorr Analog Controller and Gauge Calibration	CALCVT-1	Calibration of ConvecTorr gauge and controller using NIST-traceable capacitance diaphragm gauge

*** Note regarding part numbers**

- *Part numbers listed above have been created specifically for new gauges purchased for calibration through this program.*
- *When returning gauges for calibration to Varian, add a "SER" prefix. Example: SER-CALCDG-1.*

Vacuum Gauge Technical Notes

Historical Notes

Early interest in pressure measurement was stimulated in the 17th century by engineers who were concerned about the inability of suction pumps to remove water from mines. The pumps were limited to about 30 feet. For example, the Duke of Tuscany (Italy) commissioned Galileo to investigate the problem.

Galileo, among others, devised a number of experiments to investigate the properties of air. Among these experiments were pistons for measuring the "force of vacuum" and a water barometer that stood about 34 feet tall.

After Galileo's death in 1642, the work was carried on by his associate, Evangelista Torricelli. Torricelli invented the mercury barometer (Figure 1) and he concluded that atmospheric air forced water up to a height of 33.6 feet.

Figure 1 Mercury Barometer

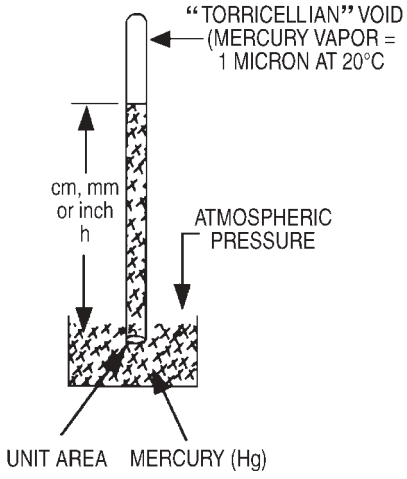


Figure 1 Notes

1. Air has weight...mass
   a) 2 lbs. per cubic yard, or
   b) 1.293 grams per liter
2. Pressure = force per unit area
3. The Barometer – At "standard conditions", the height of the Hg column above the surface of the Hg In the dish will be 760 mm or 29.9 in. The density of mercury is 0.49 lbs. per cubic inch and, if the column is 29.9 in. high, it would then exert a force per unit area of 0.49 x 29.9 = 14.7 pounds/In^2.

The weight of the atmosphere exerts a force of 14.7 pounds per square inch on the surface of the Hg in the dish. The height of the mercury column is therefore a direct measure of the pressure and the unit of pressure is 1/760 of an atmosphere, which is called a torr. The international pressure unit is Pascal, equal to one Newton per meter square.

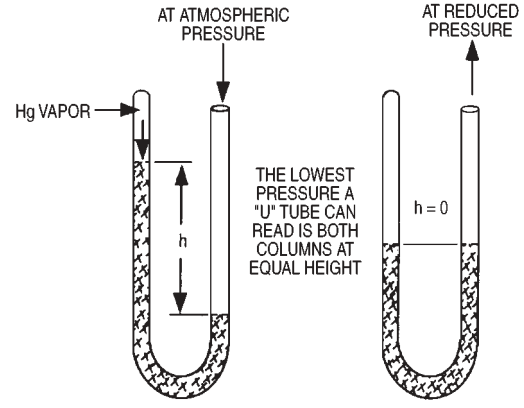
In 1644, the French mathematician, Blaise Pascal, sent a group of mountaineers up into the Alps with a barometer and proved that air pressure decreased with altitude. The average height of the mercury column at sea level is 760mm, and this is defined as a standard atmosphere.

This also is 1.01 x 10^5 Pascals or 1.01 x 10^5 dynes cm^2. The 1/760 of this value is called a Torr in honor of Torricelli.

An extension of the mercury barometer was the mercury U-tube manometer (Figure 2). Varying atmospheric pressures causes the mercury level to rise and fall in the "Torricellian Void." Likewise, if the pressure at the other end of the tube is artificially reduced by a vacuum pump, the mercury in the tube falls drastically.

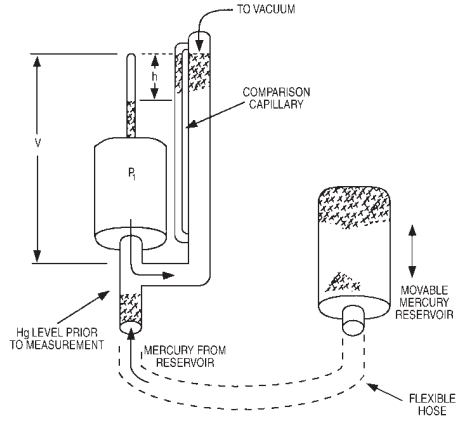
With both the barometer and the manometer, it is the difference in heights of the mercury levels that indicates the pressure, that is, the force (weight of Hg) per unit area that the air pressure will support. As the pressure on the system side is reduced, the height of the columns on either side of the U-tube approaches the same, and any difference becomes very difficult to measure (Figure 2).

Figure 2 U-Tube Manometer



Many schemes were tried to magnify the very small differences that occurred at very low pressures, but the only one that really extended the range of the manometer was invented by H. McLeod in 1872. This gauge is an application of Boyle's Law and is still in use today as a standard for calibrating secondary gauges (Figure 3).

Figure 3 McLeod Gauge



Application of Boyle's Law

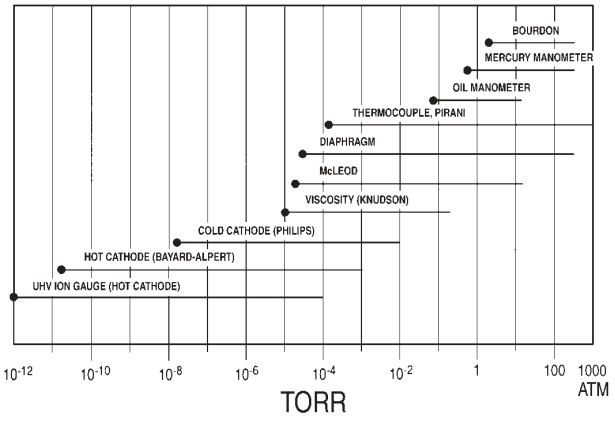
$$\begin{aligned} P_2 \qquad & V_2 \\ (P_1 + h)\, bh &= P_1V_1 \\ P_1\, bh + bh^2 &= P_1V_1 \\ bh^2 &= P_1V_1 - P_1\, bh) \\ bh^2 &= P_1\,(V_1 - bh) \\ P_1 &= \frac{bh^2}{V_1\, bh} \end{aligned}$$

V_1 = Total volume, capillary plus bulb (cm^3)
P_1 = Pressure in system
b = Volume of capillary (in cubic cm)
mm length
h = Difference in height of mercury columns
V_2 = bh (cm^3) volume in capillary
P_2 = Pressure in capillary = $P_1 + h$

Applications

The vacuum gauges in use today mainly fall into three categories: mechanical, manometric, and electronic. Which gauge is used in a particular application generally depends on the pressure range it is intended to measure. Figure 4 shows useful pressure ranges of some typical gauges.

Figure 4 Pressure Ranges of Various Vacuum Gauges



High pressures, such as those found in the rough pumping of a vacuum system, are generally measured with a thermocouple gauge. This instrument measures heat transfer rate from a heated wire. As gas is removed from the system, less heat is removed. The changes in temperature are measured by a thermocouple junction and its output is displayed as changes in pressure. The most useful pressure range for this gauge is from 5 torr to 5 microns.
At lower pressures – from 1×10^{-2} torr to 1×10^{-7} torr – found in many industrial applications, the cold cathode gauge is very useful. This instrument is basically a gaseous electric discharge cell which operates on the same principle as a diode-type ion pump. It is a rugged gauge that does not use a hot filament.

The most commonly used measurement device for high vacuum is the hot filament ionization gauge. This type of gauge can be designed to measure pressures as high as 5×10^{-1} torr, and as low as 5×10^{-12} torr. Since it is found in many industrial and scientific applications, it will be treated here in more detail.

Basic Performance Factors of Ionization Gauges

1. **Reproducibility**. A gauge must be able to give reproducible readings for identical physical situations. Drift due to electric or geometric instabilities can have adverse effects on the measurement process.
2. **Accuracy**. Gauges can be calibrated but, in general, their accuracy is limited to about ± 20%.
3. **Sensitivity**. In the ion gauge, the positive ions that impact the collector (and pick up electrons from ground) account for the positive ion current (I^+).

The electrons emitted from the filament (I^-) produce the required ionization. The fundamental relationship is:

$$I^+ = (I^-)^{PK} \qquad (1)$$

Where: (P) is the number of molecules present (Pressure)
And: (K) is the gauge constant which depends on the geometry of the device and the electrical parameters employed (K) is also referred to as the sensitivity (S), and:

$$S = \frac{I^+}{P \cdot I^-}$$

Where: Both (1^+) and (1^-) are measured in amperes and (P) is in torr.
Hence:

$$S = \frac{(I^+)\ \text{Amps}}{(I^-)\ \text{Amps Torr}} = (\text{a number})\ \text{torr}$$

For instance, the sensitivity of the Varian UHV-24 nude gauge is 25 per torr.

Operation of Ionization Gauges

When an ionization gauge is used to measure pressure, two physically observable parameters are of interest; namely, emission current and ion current. These two currents must be observed simultaneously, and the pressure can be calculated by the following rule:

$$P = \frac{(I^+)}{(I^-)}\ \frac{1}{S}$$

I^+ = Observed ion current
I^- = Observed emission current
S = Gauge sensitivity (constant for any particular gauge)

Although the McLeod gauge uses mercury in a way different from the manometer, it still expresses pressure in terms of the height of a mercury column. At the pressures attained by modern vacuum systems, gauges that depend on the mechanical effects of pressure are ineffective. So, other means had to be found that could take advantage of other properties of atoms and molecules, such as heat conductivity or the ability to be ionized.

There are many ways to express pressure and some of the more common units are listed in Table 1.

Table 1 Conversion Table

		Pascal (N/m^2) (Pa)	Torr	Standard Atmosphere (atm)	Millibar (mbar)	Dyne per Square Centimeter ($dyne/cm^2$)
1 Newton per square meter (N/m^2) = Pascal	=	1	7.5×10^{-3}	9.87×10^{-6}	10^{-2}	10
1 Torr = 1mm Hg	=	133	1	1.32×10^{-3}	1.33	1,330
1 standard atmosphere (atm)	=	101,000	760	1	1,010	1,010,000
1 millibar (mbar)	=	100	0.75	9.87×10^{-6}	1	1,000
1 dyne/square centimeter ($dyne/cm^2$)	=	10^{-1}	7.5×10^{-4}	9.87×10^{-7}	$\times 10^{-3}$	1

The gauge sensitivity, S, is a function of the design and construction of the gauge. For the Varian 563 Bayard-Alpert gauge, S has a nominal value of 10 torr. For the Varian 507 Triode gauge, S has a nominal value of 17 torr.

One could use an instrument that measured both the I^+ and I^- currents with a high degree of accuracy. However, the absolute values of I^+ and I^- are unimportant in determining P; only their ratio must be measured. Therefore, entirely equivalent results can be obtained with an instrument which measures I^+ as a fraction of I^- (a ratiometric instrument).

It is convenient to maintain a constant emission current at a preselected value rather than to observe it for each measurement of pressure. Thus, in some gauge controls, the emission current is regulated at a nominal value of 9 ma (Bayard-Alpert) or 6 ma (triode). This value of emission leads to ion currents equal to 0.1 amp/torr. During the calibration procedure, emission current is sensed by the electrometer amplifier and displayed on the panel meter. When the ion current is measured, the same amplifier and meter are used. Hence, the meter deflection observed during ion current measurement is automatically interpreted as a fraction of emission current, providing a true ratiometric measurement, even though the absolute value of emission current may be 20% different from nominal.

In conventional gauge controls, emission current is measured by the panel meter with suitable precision resistor shunts. The ion current is then amplified by an electrometer and displayed on the meter. Overall accuracy of this kind of system depends on the individual accuracies of the shunt resistors, the meter movement, and the electrometer gain. Since these items all function independently, the errors can add up.

However, in the Varian ionization gauge controls, the electrometer and meter are always used together, whether measuring emission or ion currents. Thus, some of the errors are cancelled in the calibration process. As a result, the accuracy of the Varian controls is not critically dependent on the tolerances of a large number of components, and long-term accuracy and repeatability are assured.

Some additional conversion factors for pressure and flow units are shown in Table 2.

Table 2 Pressure and Flow Unit

Pressures		
Standard atm	=	1.01325×106 Dynes cm^{-2}
	=	760 mm Hg (at 0 °C)
	=	29.9213 in. of Hg (at 32° F)
Bar	=	1×10^6 Dynes cm^{-2}
		75.0062 cm Hg (at 0 °C)
		0.986 atm
Torr	=	1333 Dynes cm^{-2}
	=	1 mm Hg (at 0 °C)
	=	$(760)^{-1}$ Standard atm
Micron	=	(length) 1000 Angstroms ($1A = 10^{-10}$ meter)
	=	(pressure) 1.33 Dyne cm^{-2}
	=	(pressure) 1×10^{-3} torr
Barye	=	1 Dyne cm^{-2}
	=	9.869×10^{-7} atm
	=	1×10^{-6} Bar
Dyne	=	Force necessary to give a one-gram mass an acceleration of one cm/sec/sec
Flows		
Cubic Foot	=	28.3 liters
	=	2.83×10^4 cm^3
CFM	=	28.3 liters min^{-1}
	=	0.47 liter sec^{-1}
Liter sec^{-1}	=	2.12 cfm
	=	3.53×10^{-2} cubic feet sec^{-1}