



# AGILENT VACUUM MEASUREMENT

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Agilent Technologies

# FEATURES AND BENEFITS

## Vacuum Measurement for Science and Industry

Agilent vacuum gauges and controllers are reliable, accurate, and cost-effective tools for measuring and controlling vacuum pressure in a wide range of applications.

- Agilent features pressure measurement technology designed for challenging industrial environments: simplicity, rugged design, plus ease of service to insure maximum productivity and uptime in your vacuum system or vacuum process.
- With over 50 years experience in science research, our superior accuracy and stability meets the most demanding scientific requirements.



### Rough Gauge Controllers

Reliable, cost-effective solutions for pressure measurement from  $1 \times 10^{-3}$  Torr to 760 Torr, these controllers come with the Agilent TC tube and cable and are pre-calibrated.

- Ready to install and operate
- Two easily configured set points to facilitate critical operations
- Large, bright LED display is easily read across a room or in dimly lit locations



### Active Gauge Controllers

These single channel controllers operate the FRG-, PVG-, PCG-, and CDG-series of Active Gauges. Both provide user selectable measurement units and adjustable set point control.

- Easy to set up
- Automatically identify the gauge type when connected
- Adjustable set point control enable critical process steps or operations

### User Friendly Interface

|                       |       |
|-----------------------|-------|
| UNITS                 | TORR  |
| SETUP LOCKOUT         | ON    |
| AUTO FILAMENT ADVANCE | OFF   |
| ATMOSPHERE VALUE      | 760   |
| SERIAL MODE           | RS232 |
| SERIAL BAUD RATE      | 19200 |
| RS485 ADDRESS         | 00    |

System Setup

| # | SETPT | ON&DELAY  | OFF&DELAY | EXIT |
|---|-------|-----------|-----------|------|
| 1 | HFIG1 | 3E-09 0.0 | 9E-08 0.0 | OFF  |
| 2 | HFIG2 | 8E-08 0.1 | 3E-06 2.0 | AUTO |
| 3 | IMG1  | 7E-08 0.0 | 5E-07 0.0 | AUTO |
| 4 | IMG2  | 2E-09 0.5 | 1E-08 0.1 | AUTO |
| 5 | CNV1  | 6E+02 0.0 | 7E+02 0.0 | AUTO |
| 6 | CNV2  | 1E        |           |      |
| 7 | CNV3  | 8E        |           |      |
| 8 | CNV4  | 1E        |           |      |

Set Points

|       |        |
|-------|--------|
| TORR  |        |
| HFIG1 | 1.8E-5 |
| IMG2  | 7.1E-7 |

Large Font

| SENSOR SETUP     |       |
|------------------|-------|
| SENSOR ID        | HFIG1 |
| USER LABEL       | HFIG1 |
| SENSOR MODEL     | UHV24 |
| AUTO ON IF GAUGE | CNV1  |
| IS LESS THAN     | 5E-3  |
| SENSITIVITY      | 01.0  |
| EMIS CURRENT(MA) | 04.0  |
| GAS CORRECTION   | 1.00  |

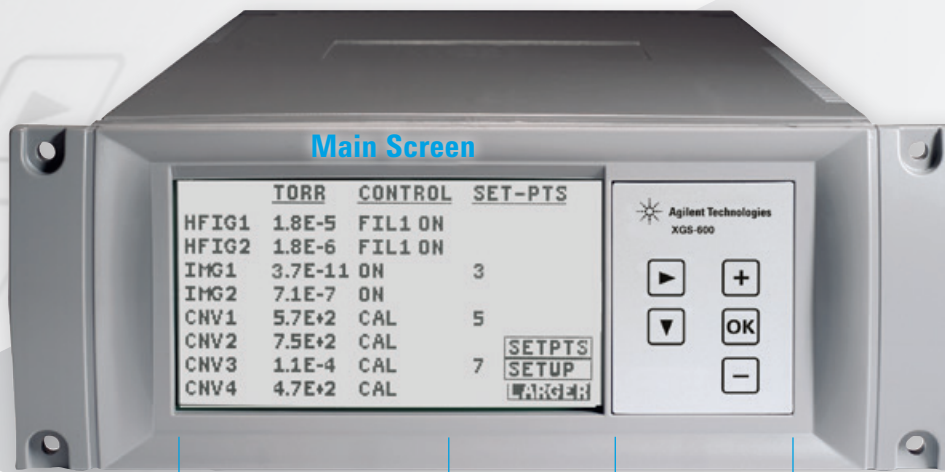
Sensor Setup

# VACUUM MEASUREMENT

## XGS-600 Gauge Controller

### Intelligent Design & Functionality

- Simultaneous operation of all gauges
    - up to 12
  - < 20 millisecond signal-to-set- point response time
  - Displays up to 8 gauges at one time
- Standard features include:
    - 16 gauge set points
    - fully programmable RS-232/485 serial communications
    - E-beam degas for hot filament gauges
    - pressure unit selection: Torr, mbar, Pascal
    - universal voltage compatibility
    - analog output



### Intuitive screen functions

- Displays up to 8 gauges on one screen
- Customizable gauge labels

### Easy key pad navigation

### Capacity, Flexibility & Expandability

Only 3 gauge cards operate all Agilent gauges:

- Add a gauge card when needed, simply and quickly
- Save the cost of additional controllers

Simultaneous operation of:

- Up to 4 hot filament gauges plus 4 convection gauges
- Up to 5 inverted magnetron gauges
- Up to 12 convection gauges



# AGILENT GAUGE SELECTION CHART

## ROUGH VACUUM

atm to  $10^{-3}$

### Transducers

Controller Required

**536** ConvecTorr quality accuracy and repeatability  
page 13

**ConvecTorr**  
Best overall accuracy and repeatability. Secure bayonet connector.  
page 12

**531** Most economical rough gauge  
page 13

*convection board*

## HIGH VACUUM

$10^{-3}$  to  $10^{-9}$

**572** Glass; most popular general purpose HV gauge (hot filament). Dual filament.  
page 15

**571** Glass; same as 563 without platinum coating  
page 16

**563** Best general purpose HV gauge (hot filament) for overall performance and reliability.  
page 17

**MBA2-200**  
Small, rugged, wide range  
page 18

**IMG-100** Most durable HV gauge (cold cathode); fastest response  
page 19

*hot filament board*

*cold cathode board*

## ULTRA HIGH VACUUM

$10^{-9}$  to  $10^{-12}$

**UHV-24** Most popular UHV gauge (hot filament)  
**UHV-24p** UHV gauge –highest vacuum reading  
page 21

**IMG-300** Most durable, UHV gauge (cold cathode); fastest response  
page 20



# VACUUM MEASUREMENT

## Rough Gauge Packages

RGC-100/RGC-150:  
Pre-calibrated rough gauges and controller packages



XGS-600 analog board



## XGS-600

Multi-gauge Controller



## Active Gauge Controller/Display

AGC-100/AGD-100: Low cost active gauge controllers automatically identify the connected gauge



## Active Gauges

No Controller Required

**PVG-500** Robust, reliable;  
general rough vacuum use  
page 22



**CDG-500** Full scale range  
options; push-button zeroing  
and setpoints  
page 24



**PCG-750** Combo Pirani  
and CDG for accuracy and  
gas-type independence  
page 26



**FRG-700** Combo Pirani  
and IMG – accuracy from  
ATM through HV

**FRG-720/730** Combo  
Pirani and B/A - widest  
vacuum measurement range  
page 28



## APPLICATIONS

### Physics R&D, Accelerators

- **Synchrotron Light Sources and Beam Lines**
- **Particle Accelerator Rings**

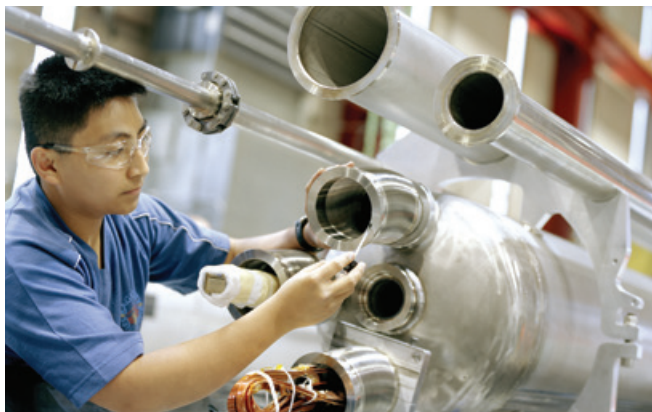
Vacuum gauges are widely used in High Energy Physics, Fusion Technology and general UHV research. Synchrotron Light Sources, Particle Accelerator Rings, UHV Laboratory research, and Fusion reactors need extremely accurate, reliable and cost effective HV and UHV gauges. Agilent offers a full range of vacuum transducers that can be equipped with high function controllers to monitor and control HV and UVH environments. If desired, Agilent also offers “Active Gauges” equipped with on-board controllers that combine highly accurate and compact vacuum measurement and control in the smallest footprint.

### Industrial Processes

- **Thin Film Deposition**
  - glass coating equipment (architectural glass, automotive glass, flat panel display substrates)
  - thin film solar cells production (photo-voltaic)
  - optical data media (Compact Discs, Digital Versatile Discs, Magneto Optical Discs)
- **Magnetic storage media (hard discs, read heads)**
- **Surface treatments (functional, decorative)**
- **Optical coating (ophthalmic, precision opto-electronics)**
- **Roll/web coating on films or foils**

In order to assure that a thin film process (PVD/sputtering) is reproducible it is necessary to measure parameters that relate to total gas pressure, which is a function of gas density and temperature, and the partial pressure of the individual gas species. These vacuum parameters should be measured precisely both during pump down to base pressure and during processing as processing often releases gas into the deposition environment.

In crowded chambers at higher pressures (>1mTorr), significant pressure differential can exist in the processing chamber. These pressure differentials can affect film



*Plasma vapour deposition (PVD). Worker adjusting the controls of a PVD machine which is being used to coat components (trays at lower centre and lower left) with a thin film metal alloy to provide a wear-resistant coating.*

properties such as residual stress, composition, electrical resistivity, etc. In sputter deposition systems, when establishing a plasma, such pressure differences can change the plasma density and thus the sputtering rate, thereby affecting the film composition deposition. In such circumstances several gauges may be used at different locations in the processing chamber to monitor the pressure differences.

- **Device Processing**
  - TV and monitor picture tube manufacture
  - Evacuation and coating of lamps (motorway lighting, beamers)
  - X-Ray tubes & electron devices (CPI, etc)
  - Medical accelerator tubes (medical devices)
  - Lasers, night vision systems
  - Cryogenic processes and instrumentation
  - Infrared detectors (DRS)
- **General Industrial Processes**
  - Vacuum furnaces – Metallurgy

#### **Vacuum Furnaces for Metal Treatment**

Brazing, sintering or annealing metals requires an atmosphere free of oxygen. Therefore, such processes are carried out under partial vacuum using inert gas. The vacuum level must be monitored and kept constantly low during the process in order to avoid oxidation of the products. As a result, it is necessary to measure the pressure in the high vacuum furnace near the gas inlet as well as at the vacuum port with high accuracy. Agilent active convection gauges with wide measuring range can detect the pressure at the furnace gas inlet and vacuum port with excellent precision. They are then linked to the system PLC by their serial port with either RS-232 or 485 communication. Based on this, all system pressure levels can be monitored at the main control system. This allows easy monitoring of the system gradient inside the furnace.

# VACUUM MEASUREMENT



Scanning electron microscopes, like the one shown here, can “see” details as small as one nanometre – one millionth of a metre!



An NRC researcher uses a liquid chromatography-mass spectrometry system to quantify toxins in shellfish samples.

## Nanotechnologies & Semiconductor Manufacturing

- **Electron Microscopy (SEM, TEM)**
- **Focused Ion-beam Systems (FIB) and Surface Analysis**
- **Semiconductor manufacturing**

Modern focused-beam systems such as SEMs, TEMs and FIB's utilize columns that project electrons or ions onto microscopic samples for detailed analysis. End users analyze all types of substances from organic compounds to semiconductor wafers. A key requirement is high sample throughput in order to lower the cost of ownership of these instruments. Agilent offers a full range of high and ultra-high vacuum gauges designed especially for the demanding requirements of SEMs, TEMs and surface analysis systems. Vacuum gauges are also a key component in modern focused-beam systems because the process gas flow can cause significant fluctuations in chamber pressures demanding a wide range of control. Agilent offers a full range of application specific SEM vacuum gauges for easy system integration and flexibility, or gauge controllers for systems that do not have integrated control systems or require dedicated remote read-out.

For the majority of semiconductor manufacturing processes, vacuum system operation usually can be enhanced through good vacuum control to improve reliability, throughput, uptime, contamination control, and process control. For example, a vacuum pump-down or purge cycle often can be shortened without degrading the product, and the time saved can significantly increase throughput. Agilent's complete line of on-board, direct measurement gauges can be easily integrated into existing OEM system controllers through digital or analog control, assuring the ability to meet demanding rapid cycle applications, such as vacuum load locks, in which high gas-load cycling and high tolerable foreline pressures are critical to the success of the process.

## Analytical Instrumentation

### • Mass Spectrometry

Mass Spectrometry has become an important analytical tool in many industries including pharmaceuticals and life sciences. Thanks to advances in electronics, instrument designers can implement cost-effective, high-performance analytical power in a cost-effective, easy-to-use system. These developments require advanced vacuum systems that are characterized by multi-chamber, high throughput designs on the high quality instruments.

Mass Spectrometers must operate with high accuracy and reliability. Periodic offset adjustment under fine vacuum conditions guarantees that even slightest hints of contamination can be detected. The precise Pirani vacuum transducer controls whether the required vacuum level for zero adjustment is achieved. With its elastic helix filament and the rugged metal housing the transducer is especially durable.



# AGILENT GAUGE CONTROLLER

## ▶ Agilent XGS-600



The XGS-600 Vacuum Gauge Controller provides unprecedented capacity, performance and flexibility in a cost effective, standard half-rack package. A single controller can simultaneously operate up to four hot filament (or four cold cathode) gauges and four convection gauges, up to five cold cathode gauges, or up to twelve convection gauges. Expansion or re-configuration in the field is easy to do. Serial communications (RS-232 or RS-485), sixteen set points,

and universal voltage compatibility are standard in all units. A programmable dot matrix LCD provides display flexibility, and simple screen organization and navigation makes the unit extremely easy to use. Drop down gauge selection automatically sets the emission current, sensitivity and overpressure. The screen displays up to eight gauges and pressures simultaneously, and permits the user to label each gauge. A large-font feature provides visibility from up to 20 feet.

### Features

### Benefits

|               |  |
|---------------|--|
| • Powerful    | <ul style="list-style-type: none"> <li>• A single unit can simultaneously operate up to:                             <ul style="list-style-type: none"> <li>– 4 BA and 4 convection gauges (or 4 IMG and 4 convection gauges)</li> <li>– 5 ion gauges (5 IMG gauges or 4 hot filament and 1 IMG)</li> <li>– 12 Convection gauges</li> <li>– 12 Agilent Active gauges</li> </ul> </li> <li>• 8 Open collector set points</li> <li>• 8 Contact relays</li> <li>• Standard Features in every unit:                             <ul style="list-style-type: none"> <li>– Serial communication (RS-232 and RS-485), universal voltage, Degas</li> </ul> </li> </ul> |
| • Flexible    | <ul style="list-style-type: none"> <li>• Operates hot filament, inverted magnetron (cold cathode), convection gauges and all Agilent Active gauges</li> <li>• Can mix and match any gauges in a single unit</li> <li>• Can expand or reconfigure easily in the field</li> <li>• Optional card supports Profibus DP communications protocol</li> </ul>  |
| • Easy to Use | <ul style="list-style-type: none"> <li>• Simple screen organization and navigation</li> <li>• Drop down gauge selection automatically sets the emission current, sensitivity and overpressure.</li> <li>• Displays up to 8 gauges simultaneously on one screen</li> <li>• Large font feature allows display of 2 gauges visible from 15-20 feet</li> <li>• Capability of programming your own 5 character gauge label</li> <li>• Set Point Screen: displays and adjusts set points for up to 8 gauges</li> </ul>   |
| • Fast        | <ul style="list-style-type: none"> <li>• &lt; 20 milliseconds from signal to set point response (Open collector only)</li> </ul>   |
| • Compact     | <ul style="list-style-type: none"> <li>• All in the impressively small half-rack package</li> </ul>  |



# VACUUM MEASUREMENT

XGS-600 Controller operates all Agilent gauges with only 3 gauge cards...  
convection, hot filament and cold cathode (inverted magnetron)

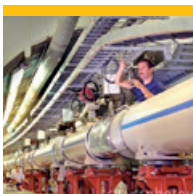


## Laboratory

- Easy to use – can be operated without a manual; screens and menus are easy to follow
- Easy to order – only 3 different controller gauge cards/modules to choose from, everything else is standard
- Easy to adapt – only one gauge card is needed to operate any Agilent gauge of a given type
- Practical – the XGS-600 can be easily reconfigured – it just takes a few minutes to add or remove a gauge card – any Agilent gauge can be operated in one unit
- Convenient – view up to 8 gauges at one time or change the font to view 2 from 15 feet away – all programming is stored in flash memory so no battery backups are needed

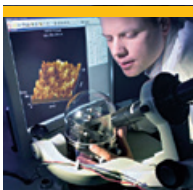
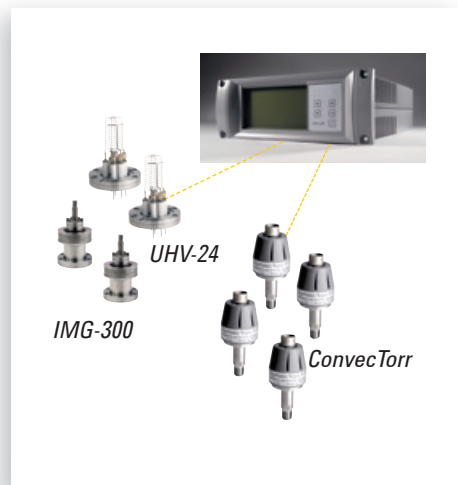
## Possible Configurations

Below are examples of ways to configure the XGS-600, but remember, you are not limited to these configurations. The flexibility of this unit allows you to setup the controller with the gauges that suit your needs.



## Accelerators, Synchrotrons and Other Large Facilities

- Signal response – <20 milliseconds from signal to set point response – ideal for fast acting valves
- Capacity – operates up to 5 IMG gauges in one controller
- Compact – half-rack size saves up to 50-75% of rack space from other controller options
- Operability – fully programmable serial communications with individual gauge labeling; choice of RS-232/485
- Flexibility – combine UHV/HV metrology and IMG interlocking in one unit – ideal in beamline applications



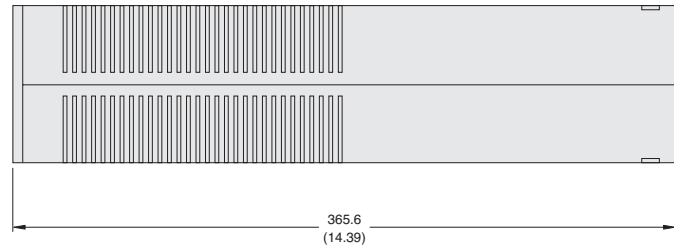
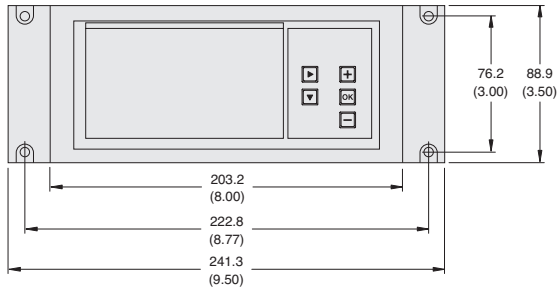
## OEM Equipment

- Reliable – The XGS-600 controller has been qualified under demanding test standards; thermal management reduces component stress and provides consistency and durability in performance
- Compact – half-rack size for up to 4 ion gauges and 4 convection gauges in one unit
- Flexibility – operates any Agilent gauge in one controller
- Performance – fully programmable serial communication is standard. Serial response time <2 milliseconds. Displays up to 8 gauges in one screen, gauge labeling. All programming stored in flash memory – no batteries needed
- Contact relay set points for maximum control flexibility and backwards compatibility with legacy controllers



# AGILENT GAUGE CONTROLLER

## ▶ Agilent XGS-600 (Cont'd)



Dimensions: millimeters (inches)

### Technical Specifications

|                                    |  |
|------------------------------------|--|
| <b>User interface</b>              | LCD monochrome dot matrix, 240 x 128, white LED backlight; 5 button keypad   |
| <b>Display capability</b>          | Up to eight simultaneous channels of pressure measurement, up to a 5 character user label for each; up to two channels in a large font; readable from 15 feet; display updates every 200 msec  |
| <b>Gauge capability</b>            | Up to 4 Hot Filament BA gauges including metal, glass, and nude UHV types using the HFIG** cards; up to 5 IMGs* using the IMG* cards; up to 12 rough gauges using the Dual Convection Gauge Cards; up to 12 Active Gauges using Dual Analog Input Cards  |
| <b>Measurement range</b>           | 1 x 10 <sup>-11</sup> Torr to Atm dependent upon card and gauge type selected  |
| <b>Set points - Open collector</b> | Eight normally open setpoints with independently programmable ON and OFF delays, manual override; fast response: 20 msec max (with delay set to 0.0 sec)   |
| <b>Contact relays</b>              | Eight normally open or normally closed mechanical relays with 24V @ 2 amp rating, using 25 pin D-sub with same pinout as MultiGauge/SenTorr; 2 set points per relay/channel  |
| <b>Serial communications</b>       | RS232 and RS485 (fully programmable)   |
| <b>Analog outputs</b>              | 1v/dec LOG, 0 – 10 V FS, on each card with 200 msec update rate  |
| <b>I/O control</b>                 | HFIG** card: Remote gauge ON/OFF, Fil select, DeGAS ON/OFF Inputs, Status Output<br>IMG* card: Remote gauge ON/OFF Input, Status Output<br>Dual Convection Card: Remote CAL inputs, Status Outputs<br>Dual Analog Input Card: Remote CAL Inputs, Status Output   |
| <b>Other</b>                       | Auto-ON capability for installed ion gauges when at least one convection card is installed<br>Sensitivity, gas correction, emission current (BA gauges only) inputs for ion gauges<br>E-BEAM degas, with auto turn off for BA gauges<br>Selectable air or argon calibration for rough gauges<br>Adjustable atmosphere value for rough gauges<br>Text error messages<br>All data stored in FLASH non-volatile memory requiring no batteries |
| <b>Power input / Temperature</b>   | Worldwide universal power input, 100-240 VAC, 2 A, 50/60 Hz, IEC inlet; 5-40 °C ambient  |
| <b>Regulatory approvals</b>        | CE certified and RoHS compliant, BV certified for USA and Canada   |

\*IMG – Inverted Magnetron Gauge

\*\*HFIG – Hot Filament Ion Gauge

# VACUUM MEASUREMENT

## Ordering Information

| Description  | Part Number   |
|--|---------------|
| XGS-600 Vacuum Controller, without cards   | XGS600H0M0C0  |
| Configure your XGS-600 Controller with cards – constructing your part number:  | XGS600HXMCC   |
| 1 Refer to the Gauge Selection Chart to help determine the gauge you need  |               |
| 2 Choose the number of HFIG** cards you want; place after the "H"; will be 0 to 4  |               |
| 3 Choose the number of IMG* (cold cathode) cards you want; place after the "M"; will be 0 to 5   |               |
| 4 Choose the number of Dual Convection Gauge Cards; place after the "C"; each card runs two convection type gauges, will be 0 to 6   |               |
| 5. If ordering Active Gauge (Analog Input) Cards, add "Ax" to the end of the part number, with the number of cards desired (1 to 6). Each card operates two Active Gauges. | XGS600HXMCCAX |

### NOTE:

- The XGS-600 has 6 gauge card slots permitting a total of 6 cards.
- Up to four slots can be used for HFIG\*\* cards. If four of these are chosen, one IMG\* card or up to two Dual Convection Gauge Cards may be selected also.
- Up to five slots can be used for IMG\* cards. If five of these are chosen, no additional gauge cards may be selected.
- All six slots may be used for Dual Convection Gauge Cards or Analog Input Cards.
- HFIG, IMG, and Dual Convection Cards can be used with Dual Analog Input Cards.

| Cables   | Part Number       |           |             |             |             |             |             |  |       |           |
|--|-------------------|-----------|-------------|-------------|-------------|-------------|-------------|--|-------|-----------|
|  | Cable Description | Length    | 3 ft        | 10 ft       | 25 ft       | 50 ft       | 65 ft       | 75 ft  | 90 ft | 100 ft    |
| XGS-600 I/O, with flying leads                         |                   |           | R32493010   | R32493025   | R32493050   |             |             | Special Order (SO)   |       |           |
| ConvecTorr Gauge, non-bakeable                         |                   |           | L91223010   | L91223025   | L91223050   |             |             | Special Order (SO)   |       | L91223100 |
| Thermocouple Gauge (531, 536)                          |                   |           | L91313010   | L91313025   | L91313050   |             | SO          | L91313075  | SO    | L91313100 |
| MBA2-200 Gauge   |                   |           | X3203-60006 | X3203-60007 | X3203-60008 | X3203-60009 | X3203-60010 |  | N/A   | N/A       |
| Glass BA Gauge standard, non-bakeable                  |                   |           | R32443010   | R32443025   | R32443050   |             |             | Not available over 50 feet – with 10 ft. standard cable, it is possible to order extension up to 250 ft. |       |           |
| UHV-24/UHV-24p standard, non-bakeable                  |                   |           | R32453010   | R32453025   | R32453050   |             |             |  |       |           |
| UHV-24/UHV-24p Teflon UHV, bakeable to 250 °C          |                   |           | R32463010   | R32463025   | R32463050   |             |             |  |       |           |
| Ion Gauge extension – all hot filament                 |                   |           | N/A         | N/A         | N/A         | R32473065   | SO          | R32473090  |       | SO        |
| IMG-100 Gauge, non-bakeable – may be used with IMG-300 |                   |           | R03113010   | R03113025   | R03113050   |             | SO          | R03113075  | SO    | R03113100 |
| IMG-300 Gauge, bakeable                                |                   |           | R03413010   | R03413025   |             | SO          | R03413065   | SO   | SO    | R03413100 |
| CT-100 Analog Input Board                              |                   | R35883003 | R35883010   | R35883025   | R35883050   |             |             |  |       |           |
| FRG-700/PVG/PCG Analog Input Board                     |                   | R35893003 | R35893010   | R35893025   | R35893050   |             |             |  |       |           |
| CDG Analog Input Board                                 |                   | R35903003 | R35903010   | R35903025   | R35903050   |             |             |  |       |           |
| FRG720/730 Analog Input Board                          |                   | R35913003 | R35913010   | R35913025   | R35913050   |             |             |  |       |           |

### Accessories

| Description  | Part Number |
|--|-------------|
| Hot Filament Ion Gauge (HFIG) card, field install      | R3075301    |
| Inverted Magnetron Ion Gauge (IMG) Card, field install | R3080301    |
| Dual Convection Gauge Card, field install              | R3084301    |
| Dual Analog Input Card, field install                  | R3487301    |
| Tilt stand accessory                                   | R3124301    |
| Center rack mount kit                                  | L6423301    |
| Off-Center rack mount kit                              | L6422301    |
| Dual Mount rack mount kit                              | L6426301    |

\*IMG – Inverted Magnetron Gauge

\*\*HFIG – Hot Filament Ion Gauge

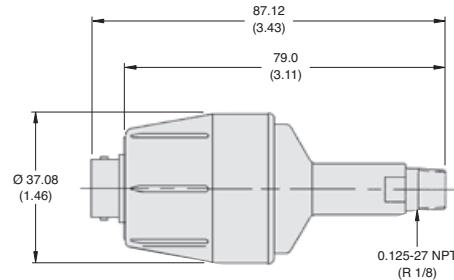
### Power Cord Selection

One power cord included with each unit

| Description                              | Part Number |
|--|-------------|
| Europe, 10 A / 220-230 VAC, 2.5 meter    | 656494220   |
| Denmark, 10 A / 220-230 VAC, 2.5 meter   | 656494225   |
| Switzerland, 10 A / 230 VAC, 2.5 meter   | 656494235   |
| UK/Ireland, 13 A / 230 VAC, 2.5 meter    | 656494250   |
| India, 10 A / 220-250 VAC, 2.5 meter     | 656494245   |
| Israel, 10 A / 230 VAC, 2.5 meter        | 656494230   |
| Japan, 12 A / 100 VAC, 2.3 meter         | 656494240   |
| North America, 13 A / 125 VAC, 2.0 meter | 656458203   |

## AGILENT GAUGES – ROUGH VACUUM

### ► Agilent ConvecTorr Gauge



Dimensions: millimeters (inches)

Agilent's unique ConvecTorr gauge is a stainless steel, convection-enhanced thermal gauge, which maintains the sensing element at a constant temperature for superior performance from  $10^{-4}$  Torr to atmospheric pressure. The ConvecTorr features accurate pressure indication over the entire rough vacuum range with extremely fast response time (0.2 seconds) and superior readings at higher vacuum pressures due to enhanced thermal stability. ConvecTorr is ideally suited for a wide range of demanding vacuum applications where accurate pressure monitoring and rapid, repetitive pump downs from atmosphere are required, such as load lock applications or control of a two-stage pump down. And, with excellent sensitivity near atmospheric pressure, ConvecTorr can often save many hours of pumping time when monitoring initial pumping of large vacuum systems.

The ConvecTorr, unlike other convection-type gauges, is not affected by system vibration and features a locking bayonet connector. The ConvecTorr offers continuous and repeatable pressure indications between 0 °C and 50 °C. The ConvecTorr is offered with a variety of mounting options and is easily interfaced with Agilent's XGS-600 gauge controller for integration in a complex vacuum system, or for use as a stand-alone pressure measurement tool.

### Technical Specifications

#### Measurement range

$1 \times 10^{-4}$  Torr to atmosphere,  $1 \times 10^{-1}$  to 133 Pascal

#### Measurement precision

+ 30 % within a pressure decade

#### Temperature limits

Operating: 0 °C to 50 °C; storage: -15 to 80 °C; bake out: 80 °C with cable disconnected

#### Pressure response time

Less than 0.2 seconds

#### Materials

304 stainless steel with platinel filament and ABS housing

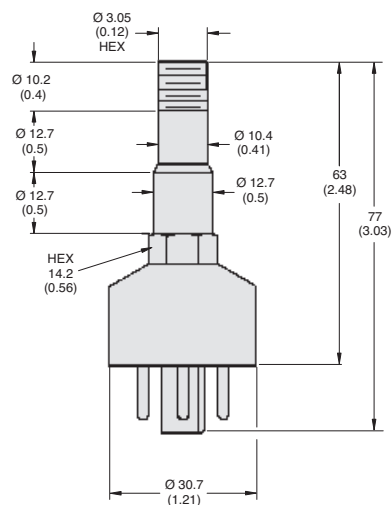
### Ordering Information

| Description                              | Part Number | Fitting              | Shipping Weight kg (lbs) |
|--|-------------|----------------------|--------------------------|
| ConvecTorr Gauge Tube, platinel filament | L9090301    | ½ in. NPT            | 0.5 (1.0)                |
|  | L9090302    | Mini-ConFlat         | 0.5 (1.0)                |
|  | L9090303    | Cajon 4 VCR (female) | 0.5 (1.0)                |
|  | L9090305    | NW16 KF              | 0.5 (1.0)                |
|  | L9090306    | NW25 KF              | 0.5 (1.0)                |



# VACUUM MEASUREMENT

## ► Agilent 531 Thermocouple and 536 Baffled Thermocouple



Dimensions: millimeters (inches)

The 531 Thermocouple Gauge Tube is the time-proven, low-cost solution (nickel-plated, soldered construction) for continuous and accurate indication of rough vacuum pressure from  $1 \times 10^{-3}$  to 2.0 Torr ( $1 \times 10^{-3}$  mbar to 2.7 mbar). Featuring rugged dependability and consistent operation unaffected by mounting orientation.

The 536 Thermocouple Gauge Tube is a welded 304 stainless steel version of the 531 with an additional baffle that greatly extends the sensor life when exposed to condensable gases in demanding applications. It provides a continuous and repeatable indication of pressures from  $1 \times 10^{-3}$  Torr to 2 Torr ( $1 \times 10^{-3}$  mbar to 2.7 mbar). The thermocouple and heater are noble metal to minimize any possible affect of contaminants on gauge performance.

Both gauges are offered in a variety of mounting options and are easily interfaced with Agilent's XGS-600 gauge controller.

### Technical Specifications

#### Measurement range

$1 \times 10^{-3}$  Torr to atmosphere,  $1 \times 10^{-1}$  to 133 Pascal

#### Temperature limits

Operating: 0 °C to 50 °C; Storage: -15 to 80 °C; bake out: 150 °C with cable disconnected

#### Pressure response time

Less than 3 seconds

### Ordering Information

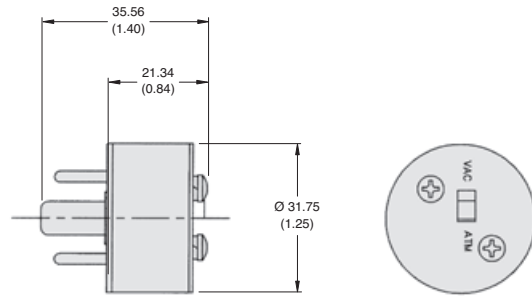
| Description                              | Part Number | Fitting              | Weight kg (lbs) |
|--|-------------|----------------------|-----------------|
| <b>531 Thermocouple Gauge Tube</b>       | F0472301    | 1/8 in. NPT          | 0.5 (1.0)       |
| <b>536 Thermocouple Gauge Tube</b>    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

# AGILENT GAUGES – HIGH VACUUM

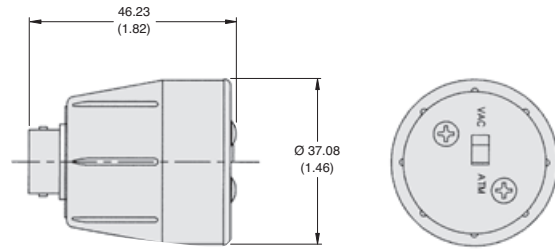
## ▶ Agilent Thermocouple and ConvecTorr Gauge Simulators – Rough Vacuum



**TC Gauge Simulator**



**ConvecTorr Simulator**



*Dimensions: millimeters (inches)*

ConvecTorr and TC Gauge Simulators are designed to be convenient tools for verifying proper operation of the control unit. For those cases when the target gauge tube cannot be brought to proper pressure levels for true in-situ calibration, the simulator is used to ensure the control unit is calibrated to the average tube. The selectable “Vac” or “Atm” setting facilitates troubleshooting.

### Technical Specifications

**Reference pressure**

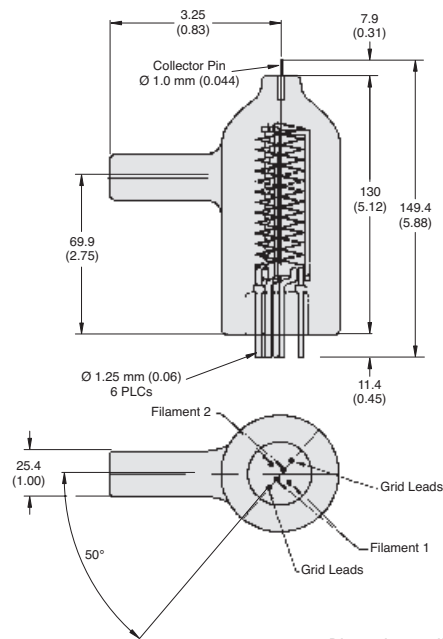
Simulates high vacuum  $<10^{-4}$  Torr and atmosphere 760 Torr

### Ordering Information

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

# VACUUM MEASUREMENT

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



Dimensions: millimeters (inches)

The 572 is a high-performance gauge with a wide range of linear response: from  $2 \times 10^{-10}$  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

$10 \text{ (Torr)}^{-1} \text{ (mbar)}^{-1}$  (typical)

#### Operating ratings

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

#### X-Ray limit

$2 \times 10^{-10}$  Torr, ( $2.6 \times 10^{-10}$  mbar)

#### Operating pressure

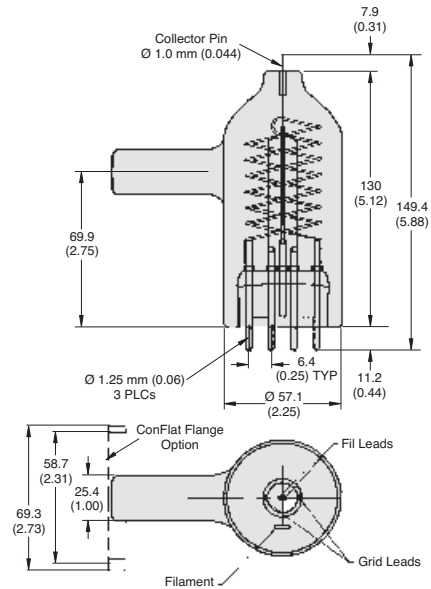
$2 \times 10^{-10}$  Torr to  $1 \times 10^{-3}$  Torr  
( $2.7 \times 10^{-10}$  mbar to  $1 \times 10^{-3}$  mbar)

### Ordering Information

| Description                                      | Part Number | Fitting                | Shipping Weight kg (lbs) |
|--|-------------|------------------------|--------------------------|
| 572 Dual-tungsten-filament ionization gauge tube | K7360301    | 1 in. Glass tubulation | 0.5 (1.0)                |
|  | K7360302    | 1 in. Kovar tubulation | 0.5 (1.0)                |
|  | K7360303    | ¾ in. Glass tubulation | 0.5 (1.0)                |
|  | K7360304    | ¾ in. Kovar tubulation | 0.5 (1.0)                |
|  | K7360305    | NW25 KF                | 0.5 (1.0)                |
|  | K7360306    | NW40 KF                | 0.5 (1.0)                |
|  | K7360307    | 2.75 in. CFF           | 0.5 (1.0)                |

## AGILENT GAUGES – HIGH VACUUM

### ► Agilent 571 Series Bayard-Alpert Type Standard Range Ionization Gauge Tube



Dimensions: millimeters (inches)

The 571 offers high performance and wide range ( $2 \times 10^{-10}$  to  $1 \times 10^{-3}$  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

$6 \text{ (Torr)}^{-1} \text{ (mbar)}^{-1}$  (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

$4 \times 10^{-10}$  Torr, ( $5.2 \times 10^{-10}$  mbar)

#### Operating pressure

- $4 \times 10^{-10}$  Torr to  $5 \times 10^{-2}$  Torr  
( $5 \times 10^{-10}$  mbar to  $6.7 \times 10^{-2}$  mbar) (Air)
- $4 \times 10^{-10}$  Torr to  $1 \times 10^{-1}$  Torr  
( $5 \times 10^{-10}$  mbar to  $1 \times 10^{-1}$  mbar) (Argon)

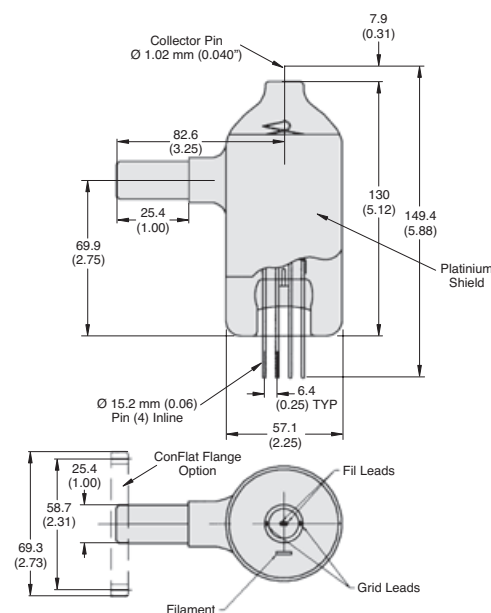
### Ordering Information

| Description  | Part Number | Fitting                | Shipping Weight kg (lbs) |
|--|-------------|------------------------|--------------------------|
| 571 Ionization tube with thoria-coated iridium filament  | K2471301    | 1 in. Glass tubulation | 0.5 (1.0)                |
|  | K2471302    | 1 in. Kovar tubulation | 0.5 (1.0)                |
|  | K2471304    | ¾ in. Glass tubulation | 0.5 (1.0)                |
|  | K2471305    | ¾ in. Kovar tubulation | 0.5 (1.0)                |
|  | K2471306    | NW25 KF                | 0.5 (1.0)                |
|  | K2471311    | NW40 KF                | 1.0 (2.0)                |
|  | K2471303    | 2.75 in. CFF           | 1.0 (2.0)                |
| 571 reference ionization tube with thoria-coated iridium filament (sealed off at $\leq 5 \times 10^{-6}$ Torr) | K2471307    | —                      | 0.5 (1.0)                |



# VACUUM MEASUREMENT

## ► Agilent 563 Series Bayard-Alpert Type Standard Range Ionization Gauge Tube



Dimensions: millimeters (inches)

The 563 is a rugged gauge with wide range of linear response:  $2 \times 10^{-10}$  to  $1 \times 10^{-3}$  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

$10 \text{ (Torr)}^{-1} \text{ (mbar)}^{-1}$  (typical)  
Exact measurement available through Agilent STARRS program.  
Contact Agilent for details

#### Operating ratings

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

#### X-Ray limit

$2 \times 10^{-10}$  Torr, ( $2.6 \times 10^{-10}$  mbar)

#### Operating pressure

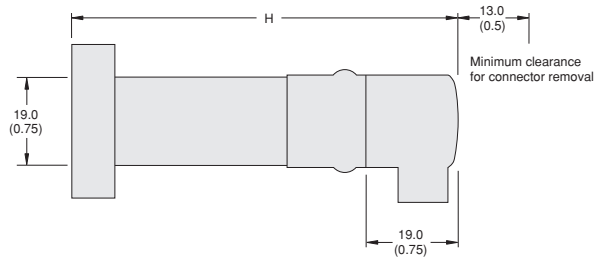
$2 \times 10^{-10}$  Torr to  $1 \times 10^{-3}$  Torr  
( $2.7 \times 10^{-10}$  mbar to  $1 \times 10^{-3}$  mbar)

### Ordering Information

| Description  | Part Number | Fitting                | Shipping Weight kg (lbs) |
|--|-------------|------------------------|--------------------------|
| 563 Ionization tube with thoria-coated iridium filament  | K2466301    | 1 in. Glass tubulation | 0.5 (1.0)                |
|  | K2466302    | 1 in. Kovar tubulation | 0.5 (1.0)                |
|  | K2466304    | ¾ in. Glass tubulation | 0.5 (1.0)                |
|  | K2466305    | ¾ in. Kovar tubulation | 0.5 (1.0)                |
|  | K2466306    | NW25 KF                | 0.5 (1.0)                |
|  | K2466311    | NW40 KF                | 1.0 (2.0)                |
|  | K2466303    | 2.75 in. CFF           | 1.0 (2.0)                |
| 563 reference ionization tube with thoria-coated iridium filament (sealed off at $\leq 5 \times 10^{-6}$ Torr) | K2466307    | —                      | 0.5 (1.0)                |

## AGILENT GAUGES – HIGH VACUUM

### ► Agilent MBA2-200 Hot Filament Gauges



| Fitting        | H        |
|----------------|----------|
| KF flange      | 73 (2.9) |
| ConFlat flange | 73 (2.9) |

*ID Shown - ID of CF & KF Flanges as per international standards*

*Dimensions: millimeters (inches)*

Agilent MBA2-200 Hot Filament Gauges are the smallest Bayard-Alpert style gauges. They are rugged with wide range, they generate low heat and provide good burnout resistance. The MBA2-200 Gauge is small (less than 5% of the volume of a glass gauge) and mounts in almost any location on your system. Its all-metal design eliminates the possibility of breakage. The MBA2-200's unique dual ion collectors and metal envelope provide measurement up to  $5 \times 10^{-2}$  Torr and it has an x ray limit equivalent to that of a glass gauge ( $3 \times 10^{-10}$  Torr).

Dual, burn-out resistant, yttria-coated iridium filaments provide long life. As a result, you can avoid unscheduled downtime by using the second filament as a backup until the gauge can be replaced during regular maintenance procedures. In addition, an MBA2-200 gauge requires only 8% of the power of a glass gauge, which means less heat to potentially disturb a process or experiment, cause accidental burns, or melt wiring that may come in contact with the gauge.

### Technical Specifications

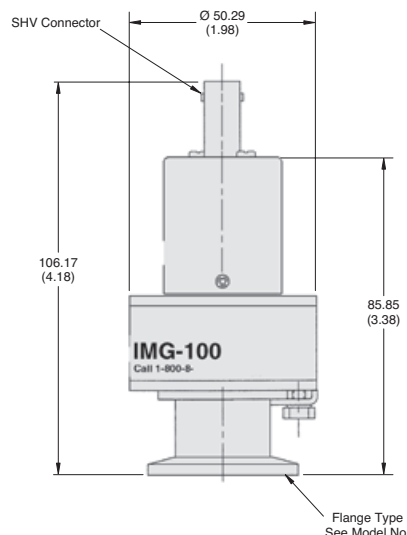
|  |   |
|--|---|
| <b>Mounting orientation</b>              | Any   |
| <b>Materials</b>                         | Vacuum fired, UHV compatible  |
| <b>Envelope</b>                          | 304L stainless steel  |
| <b>Collector</b>                         | Tungsten  |
| <b>Grid</b>                              | Tantalum  |
| <b>Filaments</b>                         | Tungsten or yttria-coated iridium   |
| <b>Weight</b>                            | 0.1 kg (4 oz.) with 1.33 in ConFlat flange (NW 16CF)  |
| <b>Internal volume</b>                   | 10.8 cm <sup>3</sup> (0.66 in. <sup>3</sup> )   |
| <b>X ray limit</b>                       | $3 \times 10^{-10}$ Torr ( $3.99 \times 10^{-10}$ mbar, $3.99 \times 10^{-8}$ Pa) maximum       |
| <b>Sensitivity for N<sub>2</sub></b>     | 20/Torr (15/mbar, 0.15/Pa)  |
| <b>Electron bombardment degas</b>        | 3 W at 250 to 330 V   |
| <b>Bakeout temperature, nonoperating</b> | 200 °C (392 °F) maximum with cable disconnected<br>150 °C (302 °F) maximum with cable connected |
| <b>Operating temperature</b>             | 0 to 50 °C (32 to 122 °F) ambient, noncondensing  |
| <b>Filament emission current</b>         | 4 mA maximum<br>15 mA for electron bombardment degas  |
| <b>Filament bias potential</b>           | +30 V   |
| <b>Filament heating voltage</b>          | 1.2 V (2.3 V maximum)   |
| <b>Filament heating current</b>          | 2.0 A (3.0 A maximum)   |
| <b>Collector potential</b>               | 0 V   |
| <b>Grid potential</b>                    | +180 V  |

### Ordering Information

| Description                                 | Part Number |
|---|-------------|
| MBA2-200T, Dual Tungsten Fils, NW25         | X3203-60000 |
| MBA2-200T, Dual Tungsten Fils, NW40         | X3203-60001 |
| MBA2-200T, Dual Tungsten Fils, CFF2.75      | X3203-60002 |
| MBA2-200, Dual Yttria-Iridium Fils, NW25    | X3203-60003 |
| MBA2-200, Dual Yttria-Iridium Fils, NW40    | X3203-60004 |
| MBA2-200, Dual Yttria-Iridium Fils, 2.75Cff | X3203-60005 |
| Cable, 10', MBA2 HFIG, XGS-600              | X3203-60006 |
| Cable, 25', MBA2 HFIG, XGS-600              | X3203-60007 |
| Cable, 50', MBA2 HFIG, XGS-600              | X3203-60008 |
| Cable, 65', MBA2 HFIG, XGS-600              | X3203-60009 |
| Cable, 75', MBA2 HFIG, XGS-600              | X3203-60010 |

# VACUUM MEASUREMENT

## ► Agilent IMG-100 Inverted Magnetron Gauge



Dimensions: millimeters (inches)

The IMG-100 is a rugged and accurate high vacuum gauge featuring a wide measurement range, fast starting time, good accuracy and superior repeatability in challenging environments. The IMG-100 is ideal for use in industrial applications such as metal deposition, glass coaters, vacuum furnaces, degassing ovens, and electron-beam welders. The simple design requires no heated filament, so the IMG-100 has an excellent lifetime, is easily serviced, and is tolerant of sudden or frequent exposure to atmosphere. Further, there is less risk of heat from the gauge interfering with a critical experiment or process. The compact size allows flexible installation in any orientation, while the locking SHV high-voltage connector ensures safety and positive electrical contact. A precisely designed magnetic field constrains ionized gas molecules for accurate pressure measurement, so emission of stray electrons and photons is minimized. The IMG-100 is easily interfaced with Agilent's XGS-600 gauge controller for integration into a variety of vacuum systems, or for use as a stand-alone pressure measurement tool.

### Technical Specifications

#### Measurement range

$1 \times 10^{-3}$  Torr to  $5 \times 10^{-9}$  Torr,  $1 \times 10^{-1}$  Torr to  $7 \times 10^{-7}$  Pascal

#### Measurement precision

+ xx % within a pressure decade standard, + xx % with STARRS Calibration

#### Temperature limits

Operating: 0 °C to 80 °C; storage: -15 to 80 °C

#### Bake out temperature with Conflat flange

150 °C maximum with Cable Disconnected

#### Ignition response (starting time)

$T < 5$  seconds at pressures  $< 1 \times 10^{-6}$  Torr

#### Materials exposed to vacuum

300 series stainless steel, nickel, glass (feedthrough)

#### Operating voltage

3 kilovolts

#### Sensitivity

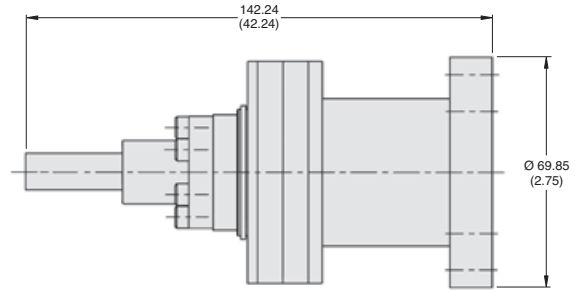
2.7 A / Torr + 20% at  $5 \times 10^{-6}$  Torr

### Ordering Information

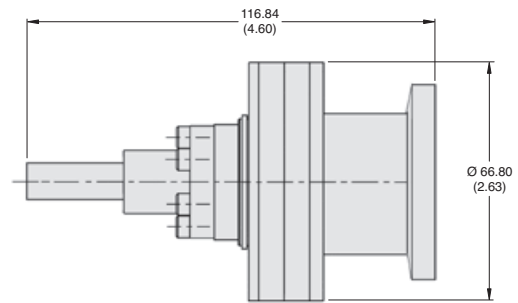
| Description          | Part Number | Shipping Weight kg (lbs) |
|----------------------|-------------|--------------------------|
| IMG-100 NW25 KF      | R0310301    | 1.0 (2.0)                |
| IMG-100 NW40 KF      | R0310302    | 1.0 (2.0)                |
| IMG-100 2.75 in. CFF | R0310303   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

# AGILENT GAUGES – ULTRA-HIGH VACUUM

## ▶ Agilent IMG-300 UHV Inverted Magnetron Gauge



w/2.75 CFF



w/NW40 Flange

Dimensions: millimeters (inches)

The IMG-300 inverted magnetron gauge combines excellent ultra-high vacuum measurement capability with fast pressure response. This sensor is optimized for UHV applications such as particle accelerators, synchrotron light beam lines and energy research applications, where stable UHV pressure measurement and fast pressure response are equally critical. Inverted magnetron gauges have no x-ray limit, so the ability to read extremely low pressure is limited only by the number of gas molecules present.

The magnetic design provides superior sensitivity at UHV pressures and ensures starting within 30 seconds at  $1 \times 10^{-10}$  Torr (millibar). With no hot filament, there is minimal outgassing from within the gauge that would degrade absolute accuracy of pressure response, and there is no electron or photon emission to disrupt an experimental process.

The all-metal gauge design is radiation-resistant and bakeable to 250 °C during operation, while the locking SHV high-voltage connector ensures safety and positive electrical contact. Radiation-resistant, bakeable cables are also available. The IMG-300 is easily interfaced with Agilent’s XGS-600 gauge controller for integration into a variety of vacuum systems, or for use as a stand-alone pressure measurement tool.

### Technical Specifications

#### Measurement range

$1 \times 10^{-3}$  Torr to  $1 \times 10^{-11}$  Torr,  $1 \times 10^{-1}$  Torr to  $1 \times 10^{-9}$  Pascal

#### Measurement precision

+ 50 % within a pressure decade standard,  
+ 20 % with STARRS Calibration

#### Temperature limits

Operating: 0 °C to 250 °C; storage: -15 to 80 °C

#### Bake out temperature

250 °C maximum with cable and magnet attached

#### Pressure response time

< 50 milliseconds @ UHV pressures

#### Ignition response (starting time)

< 30 seconds @  $1 \times 10^{-10}$  Torr

#### Operating voltage

3 kilovolts

#### Materials exposed to vacuum

Stainless steel, nickel, glass, nickel alloy 52

#### Sensitivity

2 A / Torr + 20% at  $5 \times 10^{-6}$  Torr

### Ordering Information

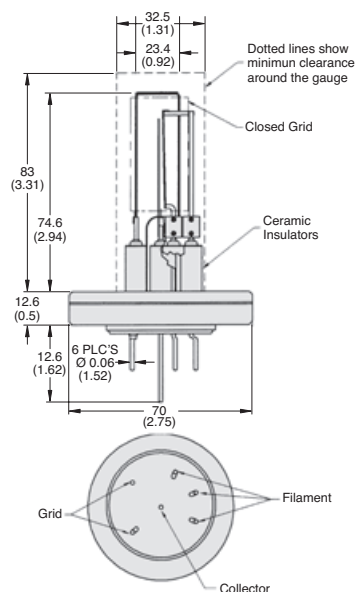
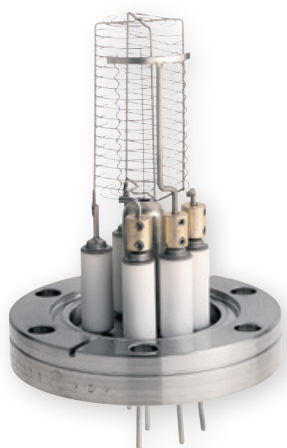
**NOTE** For information on compatible gauge controllers and cabling, please refer to Multi-Gauge sections of catalog.

| Description | Part Number | Fitting       | Shipping Weight kg (lbs) |
|-------------|-------------|---------------|--------------------------|
| IMG-300     | R0343301    | 2.75 inch CFF | 1.0 (2.0)                |



# VACUUM MEASUREMENT

## ► Agilent UHV-24 and UHV-24p Bayard-Alpert Ion Gauge



The UHV-24 is a Bayard-Alpert ion gauge using Agilent's etched-grid structure to provide a broad operating pressure range with ionization effectiveness (sensitivity) at least 2 times that of other ionization gauges. The UHV-24 gauges excel in applications where superior measurement accuracy and repeatability of measurement are equally critical. The heated filament provides a constant source of electrons for ionization of gas molecules resulting in accurate and stable results. The precision collector limits X-ray current to a pressure equivalent of approximately  $5 \times 10^{-12}$  Torr ( $6.7 \times 10^{-12}$  mbar).

The UHV-24P, an extended range version of the UHV-24, measures pressure from  $5 \times 10^{-12}$  Torr to  $1 \times 10^{-3}$  Torr

( $6.7 \times 10^{-12}$  mbar to  $1 \times 10^{-3}$  mbar). The UHV-24 and 24P feature a 2-3/4-inch ConFlat flange with long-life thoria-coated iridium or tungsten filaments that are easily replaceable in the field.

The UHV-24 and 24P are easily interfaced with Agilent's XGS-600 gauge controller for integration into a variety of vacuum systems, or for use as a stand-alone pressure measurement tool.

### Technical Specifications

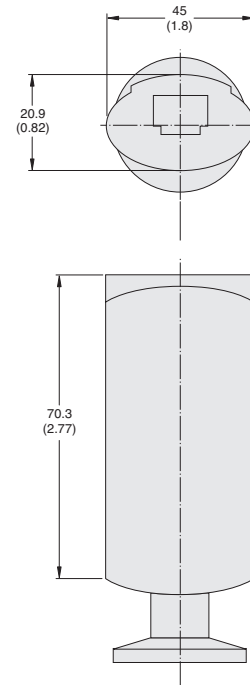
|                              | UHV-24   | UHV-24p  |
|------------------------------|--|--|
| <b>Pressure range</b>        | $2 \times 10^{-11}$ to $1 \times 10^{-3}$ Torr<br>$2 \times 10^{-11}$ to $1 \times 10^{-3}$ mbar | $5 \times 10^{-12}$ to $1 \times 10^{-3}$ Torr<br>$6.7 \times 10^{-12}$ to $1 \times 10^{-3}$ mbar |
| <b>Sensitivity</b>           | 25 Torr <sup>-1</sup>  | 20 Torr <sup>-1</sup>  |
| <b>X-Ray limit</b>           | $2 \times 10^{-11}$ Torr   | $5 \times 10^{-12}$ Torr ( $6.7 \times 10^{-12}$ )   |
| <b>Measurement precision</b> | + 20% of full scale within a pressure decade   |  |
| <b>Emission current</b>      | 4 milliamps default (10 A to 9.99 mA)  |  |
| <b>Bake temperature</b>      | 450 °C with cable connected  |  |
| <b>Temperature limits</b>    | Operation 0 °C to 250 °C; storage -15 to 80 °C   |  |
| <b>Degas</b>                 | Electron bombardment 400 volts @ 65 mA   |  |
| <b>Materials</b>             | 304 ST, ceramic, Kovar, iridium or tungsten  |  |

### Ordering Information

| Description   | Part Number | Fitting      | Shipping Weight kg (lbs) |
|---|-------------|--------------|--------------------------|
| UHV-24, dual tungsten filaments                       | 9715008     | 2.75 in. CFF | 2.0 (4.0)                |
| UHV-24, dual thoria-iridium filaments                 | 9715007     | 2.75 in. CFF | 2.0 (4.0)                |
| UHV-24P Extended Range, dual tungsten filaments       | 9715014     | 2.75 in. CFF | 2.0 (4.0)                |
| UHV-24P Extended Range, dual thoria-iridium filaments | 9715015     | 2.75 in. CFF | 2.0 (4.0)                |
| Filament replacement kit (thoria-iridium)             | 9710028     |              | 0.5 (1.0)                |
| Filament replacement kit (tungsten filament)          | 9710018     |              | 0.5 (1.0)                |

## ACTIVE GAUGES

### ▶ Agilent PVG-500/PVG-500S/PVG-502S Pirani Gauges



Dimensions: millimeters (inches)

The Agilent PVG-500 series of Pirani gauges provides the ultimate combination of state-of-art technology and ruggedness within a compact design. The PVG-500 series utilizes the most advanced digital Pirani technology combined with a stainless steel sensor design to meet the various needs of the market today.

#### Applications

- Fore pressure vacuum pressure monitoring
- Controlling high vacuum ionization gauges
- Safety monitoring in vacuum systems
- General vacuum measurement and control in the medium and rough vacuum range

#### Features

- Compact, rugged aluminum housing that mounts in any orientation with a logarithmic signal output
- Stainless steel sensor cell with metal-sealed feedthrough
- Easy push button ATM and High Vacuum (HV) adjustment
- Nickel filament option
- Optional set points

#### Benefits

- Ease of integration
- Rugged design for a wide range of applications
- Ease of set-up
- Solution for corrosive applications
- Utilize pressure readings to perform critical operations

# VACUUM MEASUREMENT

## Technical Specifications

|  |   |  |                                      |
|--|---|--|--------------------------------------|
| <b>Measurement range</b> (Air, O <sub>2</sub> , CO, N <sub>2</sub> ) | 5 x 10 <sup>-4</sup> to 1000 mbar (3.75 x 10 <sup>-4</sup> to 750 Torr)               |  |                                      |
| <b>Accuracy</b> (N <sub>2</sub> )                                    | <b>% of reading</b>   | <b>Units</b>   |                                      |
|  |   | 1 x 10 <sup>-3</sup> to 100 mbar (1 x 10 <sup>-3</sup> to 75 Torr)                                       |                                      |
|  |   | 5 x 10 <sup>-4</sup> to 1 x 10 <sup>-3</sup> mbar (3.75 x 10 <sup>-4</sup> to 1 x 10 <sup>-3</sup> Torr) |                                      |
|  | ±15%  | 100 to 1000 mbar (75 to 750 Torr)  |                                      |
|  | ±50%  |  |                                      |
|  | ±50%  |  |                                      |
| <b>Repeatability</b> (Air)   | 1 x 10 <sup>-3</sup> to 100 mbar (1 x 10 <sup>-3</sup> to 75 Torr) – % of reading 62% |  |                                      |
| <b>Output signal</b><br>(measurement signal)                         | <b>Voltage range</b>  | <b>Measurement range</b>   |                                      |
|  | 0 to 10.3 V   | 1.9 to 10.0 V  |                                      |
| <b>Voltage vs. pressure</b>  | 1.286 V/decade, logarithmic   |  |                                      |
| <b>Error signal</b>  | 0 to 0.5 V (filament rupture)   |  |                                      |
| <b>Minimum loaded impedance</b>                                      | 10 kΩ, short-circuit proof  |  |                                      |
| <b>Response time</b>   | 80 ms   |  |                                      |
| <b>Adjustment</b>  | One tactile switch for both ATM and HV adjustment                                     |  |                                      |
| <b>Identification gauge</b>  | 27 kΩ, referenced to supply common  |  |                                      |
|  | <b>PVG-500</b>  | <b>PVG-500S, PVG-502S</b>  |                                      |
| <b>Setpoint</b>  | None  | 2  |                                      |
| <b>Setting range</b>   | None  | 2 x 10 <sup>-3</sup> to 500 mbar (1.5 x 10 <sup>-3</sup> to 375 Torr)                                    |                                      |
| <b>Hysteresis</b>  | None  | 10% above lower threshold % of reading   |                                      |
| <b>Relay contact</b>   | None  | 30 VDC / 0.5 ADC floating  |                                      |
| <b>Switching time</b>  | None  | <20 ms   |                                      |
| <b>Supply voltage</b>  | <b>At gauge</b>   | <b>Ripple</b>  | <b>Power consumption</b>             |
|  | 14 to 30 VDC  | ≤1 V <sub>pp</sub>   | ≤1 W                                 |
| <b>Electrical connection</b>   | FCC 68/RJ45 appliance connector, 8 poles, male  |  |                                      |
| <b>Sensor cable</b>  | 8 poles plus shielding  |  |                                      |
| <b>Cable length</b>  | ≤100 meter (330 ft)   |  |                                      |
| <b>Materials exposed to vacuum</b>                                   | Glass, Ni, NiFe, tungsten (tungsten version)  |  |                                      |
| <b>Admissible temperature</b>  | <b>Operation</b>  | <b>Storage</b>   | <b>Vacuum Connection<sup>1</sup></b> |
|  | 5 to 60 °C  | -20 to +65 °C  | 80 °C                                |
| <b>Mounting orientation</b>  | Any   |  |                                      |
| <b>Weight</b>  | 80 g  |  |                                      |

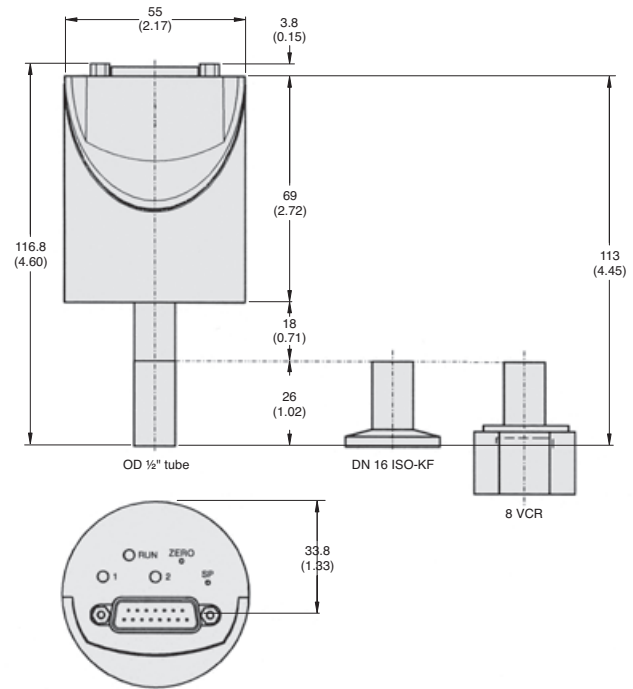
<sup>1</sup> In horizontal mounting position

## Ordering Information

| Description  | Part Number  |
|--|--------------|
| PVG-500 Pirani, KF16   | PVG500KF16   |
| PVG-500 Pirani tungsten filament with setpoints, KF16                            | PVG500KF16S  |
| PVG-502 Pirani nickel filament with setpoints, KF16 – for corrosive applications | PVG502KF16S  |
| <b>Accessories</b>   |              |
| PVG-500 Replacement sensor (tungsten) – recommended for most applications        | PVG500KF16RS |
| PVG-502 Replacement sensor (nickel) – recommended for corrosive applications     | PVG502KF16RS |

## ACTIVE GAUGES

### ▶ Agilent CDG-500 Capacitance Diaphragm Gauge



Dimensions: millimeters (inches)

The Agilent CDG-500 series of temperature compensated Capacitance Diaphragm gauges provides a high level of accuracy in the high pressure region. Full scale measurement ranges are available from 1000 Torr to 1 Torr. The CDG-500 series uses a corrosion resistant ultra pure alumina ceramic diaphragm providing exceptional signal stability, fast recovery from atmosphere, short warm-up times and unparalleled robustness.

#### Features

- Full scale ranges from 1 to 1000 Torr with push button zeroing and optional set point control
- Excellent long term signal stability and repeatability
- Fast recovery from atmospheric pressures and rapid stabilization after start-up
- Corrosion resistant ceramic sensor with sensor shielding protection

#### Applications

- General thin film and vacuum processes
- Industrial vacuum processes
- Data storage and display manufacturing
- Etch, CVD, PVD and other semiconductor production processes
- Reference sensor for monitoring of test instruments
- Transfer standard for traceability measurements

#### Benefits

- Ease of integration
- Long term performance – comparable to competitor's heated versions
- Reduces process cycle times
- Application robustness

# VACUUM MEASUREMENT

## Technical Specifications

|  |  |   |                                 |                                |       |
|--|--|---|---------------------------------|--------------------------------|-------|
| <b>Measurement range</b> (full scale)                            | Torr   | 1000  | 100                             | 10                             | 1     |
|  | Pa   | 133,322   | 13,332                          | 1,333                          | 133   |
|  | mbar   | 1333  | 133                             | 13.3                           | 1.3   |
| <b>Accuracy</b> <sup>1</sup>                                     | % of reading   | 0.2   | 0.2                             | 0.2                            | 0.2   |
| <b>Temperature effect</b>  |  |   |                                 |                                |       |
| on zero  | % F.S./°C  | 0.005   | 0.005                           | 0.005                          | 0.015 |
| on span  | % of reading/°C  | 0.01  | 0.01                            | 0.01                           | 0.01  |
| <b>Resolution</b>  | % F.S.   | 0.003   | 0.003                           | 0.003                          | 0.003 |
| <b>Pressure, maximum</b>   | kPa (absolute)   | 400   | 260                             | 260                            | 260   |
| <b>Lowest reading</b>  | % F.S.   | 0.01  |                                 |                                |       |
| <b>Lowest suggested reading</b>                                  | % F.S.   | 0.05  |                                 |                                |       |
| <b>Lowest suggested control pressure</b>                         | % F.S.   | 0.05  |                                 |                                |       |
| <b>Temperature</b>   | <b>Operation</b> (ambient)<br>5 to 50 °C   | <b>Bakeout</b> (at flange) <sup>2</sup><br>≤ 110 °C |                                 | <b>Storage</b><br>-40 to 65 °C |       |
| <b>Supply voltage</b>  | 14 to 30 VDC   |   |                                 |                                |       |
| <b>Power consumption</b>   | ≤ 1 W  |   |                                 |                                |       |
| <b>Output signal</b> (analog)                                    | 0 to 10 VDC  |   |                                 |                                |       |
| <b>Response time</b>   | 30 ms  |   |                                 |                                |       |
| <b>Degree of protection</b>                                      | IP30   |   |                                 |                                |       |
| <b>Electrical connection</b>                                     | D-sub, 15 pole, male   |   |                                 |                                |       |
| <b>Setpoints</b> <sup>3</sup> – Two (2) setpoints, SP 1 and SP 2 | <b>Relay Contact</b><br>30 VDC; ≤ 0.5 ADC  |   | <b>Hysteresis</b><br>1% of F.S. |                                |       |
| <b>Materials exposed to vacuum</b>                               | Aluminum oxide ceramic (Al <sub>2</sub> O <sub>3</sub> ), Vacon 70 <sup>4</sup> , stainless steel (AISI 316L <sup>5</sup> )<br>AgCuTi hard solder, sealing glass |   |                                 |                                |       |

<sup>1</sup> Non-linearity, hysteresis, repeatability at 25 °C ambient operating temperature without temperature effects after 2 hours operation

<sup>2</sup> Non operating

<sup>3</sup> CDG-500 setpoint versions only

<sup>4</sup> 28% Ni, 23% Co, 49% Fe

<sup>5</sup> 18% Cr, 10% Ni, 3% Mo, 69% Fe

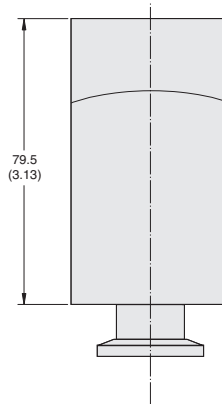
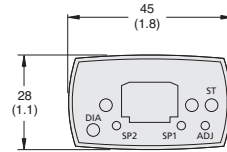
## Ordering Information

| Description  | Part Number      |                  |
|--|------------------|------------------|
|  | KF16             | VCR8             |
| CDG-500 Capacitance Diaphragm Gauge (1000 Torr)                | CDG500T1000KF16  | CDG500T1000VCR8  |
| CDG-500 Capacitance Diaphragm Gauge (100 Torr)                 | CDG500T0100KF16  | CDG500T0100VCR8  |
| CDG-500 Capacitance Diaphragm Gauge (10 Torr)                  | CDG500T0010KF16  | CDG500T0010VCR8  |
| CDG-500 Capacitance Diaphragm Gauge (1 Torr)                   | CDG500T0001KF16  | CDG500T0001VCR8  |
| CDG-500 Capacitance Diaphragm Gauge (1000 Torr) with setpoints | CDG500T1000KF16S | CDG500T1000VCR8S |
| CDG-500 Capacitance Diaphragm Gauge (100 Torr) with setpoints  | CDG500T0100KF16S | CDG500T0100VCR8S |
| CDG-500 Capacitance Diaphragm Gauge (10 Torr) with setpoints   | CDG500T0010KF16S | CDG500T0010VCR8S |
| CDG-500 Capacitance Diaphragm Gauge (1 Torr) with setpoints    | CDG500T0001KF16S | CDG500T0001VCR8S |



## ACTIVE GAUGES

### ▶ Agilent PCG-750/PCG-752 Pirani/Capacitance Diaphragm Gauges



Dimensions: millimeters (inches)

The Agilent PCG-750 series of Pirani Capacitance Diaphragm gauges combines Agilent's Pirani and ceramic capacitance diaphragm sensors into a single design that provides gas-type independence with increased accuracy from Atm to  $5 \times 10^{-5}$  mbar ( $3.8 \times 10^{-5}$  Torr).

### Applications

- Fore pressure vacuum monitoring
- Safety monitoring in vacuum systems
- General vacuum measurement and control in the medium and rough vacuum range
- Load lock control

### Features

- High accuracy and reproducibility at atmosphere
- Fast atmospheric detection
- Gas-type independent above 10 mbar
- Compact, rugged housing that mounts in any orientation with a logarithmic signal output
- Set point control
- Exchangeable plug and play sensor
- Nickel filament option
- Bright color LCD display option

### Benefits

- Reliable atmospheric pressure monitoring
- Shortens process cycle times
- Allows safe venting with any gas mixture
- Ease of integration
- Utilize pressure readings to perform critical operations
- Easy to repair with low cost of ownership
- Solution for corrosive applications
- Monitor pressure readings easily

# VACUUM MEASUREMENT

## Technical Specifications

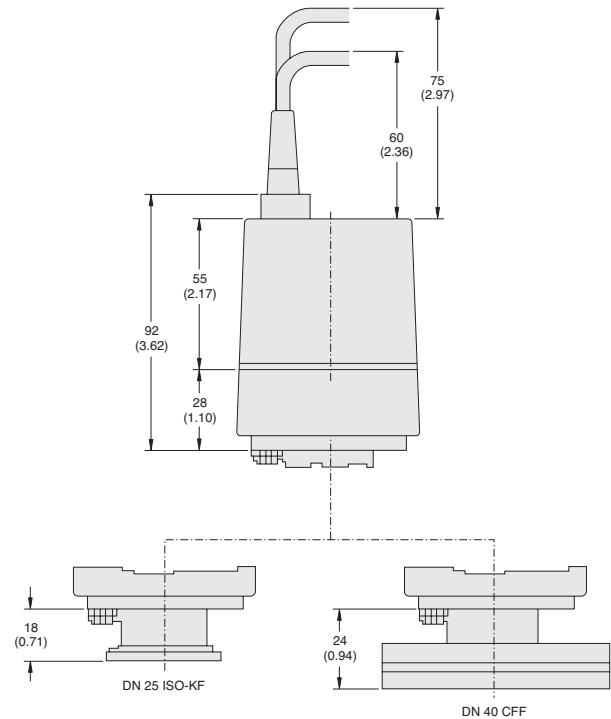
|  |                                   |   |                   |   |  |                       |
|--|-----------------------------------|---|-------------------|---|--|-----------------------|
| <b>Measurement range</b> (Air, O <sub>2</sub> , CO, N <sub>2</sub> ) |                                   | 5 x 10 <sup>-5</sup> to 1500 mbar (3.8 x 10 <sup>-5</sup> to 1125 Torr)   |                   |   |  |                       |
| <b>Accuracy</b>  | <b>% of reading</b>               | <b>Units</b>  |                   |   |  |                       |
|  | ±50%                              | 5 x 10 <sup>-5</sup> to 1 x 10 <sup>-3</sup> mbar (3.75 Torr to 1 x 10 <sup>-3</sup> Torr)  |                   |   |  |                       |
|  | ±15%                              | 1 x 10 <sup>-3</sup> to 100 mbar (1 x 10 <sup>-3</sup> to 75 Torr)  |                   |   |  |                       |
|  | ±5%                               | 100 to 950 mbar (75 to 712.5 Torr)  |                   |   |  |                       |
|  | ±2.5%                             | 950 to 1050 mbar (712.5 to 787.5 Torr)  |                   |   |  |                       |
| <b>Repeatability</b> (N <sub>2</sub> )                               | <b>% of reading</b>               | <b>Units</b>  |                   |   |  |                       |
|  | ±2.5%                             | 1 x 10 <sup>-3</sup> to 1100 mbar (1 x 10 <sup>-3</sup> to 825 Torr)  |                   |   |  |                       |
| <b>Admissible pressure</b>   |                                   | ≤ 5 bar absolute  |                   |   |  |                       |
| <b>Burst pressure</b>  |                                   | ≤ 10 bar absolute   |                   |   |  |                       |
| <b>Admissible temperature</b>  | <b>Operation</b> (ambient)        | <b>Storage</b>  |                   | <b>Bakeout flange</b>                       |  |                       |
|  | 10 to 50 °C                       | -20 to +65 °C   |                   | ≤ 80 °C                                     |  |                       |
| <b>Supply voltage</b>  |                                   | 15 to 30 VDC @ < 0.8 A  |                   |   |  |                       |
| <b>Output signal</b>   |                                   | 0 to 10.23 V  |                   |   |  |                       |
| <b>Measurement range</b>   |                                   | 0.61 to 10.23 V   |                   |   |  |                       |
| <b>Voltage vs. pressure</b>  |                                   | 1.286 V/decade  |                   |   |  |                       |
| <b>Load impedance</b>  |                                   | > 10 kΩ   |                   |   |  |                       |
| <b>Setpoint relay</b> (2)  | <b>Range</b> (N <sub>2</sub> )    | <b>Relay Contact</b>  | <b>Hysteresis</b> | <b>Contact Rating</b><br>Solid state relays | <b>Contact Rating</b><br>Mechanical relays | <b>Switching time</b> |
|  | 5 x 10 <sup>-5</sup> to 1500 mbar | n.o., potential free  | 10 % of threshold | ≤30VDC/<br>≤0.3ADC                          | ≤30VDC/<br>≤1ADC                           | ≤30 ms                |
| <b>Interface</b> (digital)   |                                   | RS232C  |                   |   |  |                       |
| <b>Power connection</b>  |                                   | FCC, 8 pin  |                   |   |  |                       |
| <b>Materials exposed to vacuum</b>                                   |                                   | PCG-750: W, Ni, NiFe, Al <sub>2</sub> O <sub>3</sub> , SnAg, SS, glass PCG752: Ni, NiFe, Al <sub>2</sub> O <sub>3</sub> , SnAg, SS, glass |                   |   |  |                       |

## Ordering Information

| Description   | Part Number   |
|---|---------------|
| PCG-750 Pirani/CDG combination gauge (tungsten), KF16                                     | PCG750KF16    |
| PCG-750 Pirani/CDG combination gauge (tungsten) with setpoints and display, KF16 (mbar)   | PCG750KF16SD1 |
| PCG-750 Pirani/CDG combination gauge (tungsten) with setpoints and display, KF16 (Torr)   | PCG750KF16SD2 |
| PCG-750 Pirani/CDG combination gauge (tungsten) with setpoints and display, KF16 (pascal) | PCG750KF16SD3 |
| PCG-750 Pirani/CDG combination gauge (tungsten) with setpoints and Profibus, KF16 (mbar)  | PCG750KF16SP  |
| PCG-752 Pirani/CDG combination gauge (nickel), KF16                                       | PCG752KF16    |
| PCG-752 Pirani/CDG combination gauge (nickel) with setpoints and display, KF16 (mbar)     | PCG752KF16SD1 |
| PCG-752 Pirani/CDG combination gauge (nickel) with setpoints and display, KF16 (Torr)     | PCG752KF16SD2 |
| PCG-752 Pirani/CDG combination gauge (nickel) with setpoints and display, KF16 (pascal)   | PCG752KF16SD3 |
| PCG-752 Pirani/CDG combination gauge (nickel) with setpoints and Profibus, KF16 (mbar)    | PCG752KF16SP  |
| <b>Accessories</b>  |               |
| PCG-750 (tungsten) Replacement sensor –recommended for most applications                  | PCG750KF16RS  |
| PCG-752 (nickel) Replacement sensor –recommended for corrosive applications               | PCG752KF16RS  |

## ACTIVE GAUGES

### ▶ Agilent FRG-700/FRG-702 Full Range Pirani/Inverted Magnetron Gauges



Dimensions: millimeters (inches)

The Agilent FRG-700 and FRG-702 (all metal version) are full range gauges that provide two measuring technologies in a single, compact and economical package to measure process and base pressure from  $5 \times 10^{-9}$  mbar to atmosphere ( $3.8 \times 10^{-9}$  Torr to atmosphere). The single, compact unit with one logarithmic analog output signal significantly reduces the complexity of installation, setup and integration. The benefit is reduced cost and reduction in valuable space requirements

### Applications

- High vacuum pressure monitoring
- Base pressure for evaporation and sputtering systems
- General vacuum measurement and control in the medium and high vacuum range

### Features

- Combination gauge – inverted magnetron and Pirani, with wide measurement range from  $5 \times 10^{-9}$  mbar to atmosphere
- No filament to burn out; easy to clean
- Excellent ignition properties
- Can be operated by a Agilent V-81 or V-301 rack controller and used with the TPS Compact and MiniTask
- LED indicator for high voltage on

### Benefits

- Measures 9 decades using 1 compact gauge, 1 connection, 1 sensor cable and 1 A/D converter; reduces complexity and cost
- Low maintenance and reduced cost
- Rapid start-up
- Greatly reduces cost and space requirements
- Provides quick visual indication of status

# VACUUM MEASUREMENT

## Technical Specifications

|  |   |   |  |   |
|--|---|---|--|---|
| <b>Measurement range</b>                     | 5 x 10 <sup>-9</sup> to 1000 mbar (3.8 x 10 <sup>-9</sup> to 760 Torr)  |   |  |   |
| <b>Accuracy</b>                              | ±30% of reading, typical  |   |  |   |
| <b>Repeatability</b>                         | ±5% of reading, typical   |   |  |   |
| <b>Mounting orientation</b>                  | Any   |   |  |   |
| <b>Admissible temperature</b>                | <b>Operation</b><br>(ambient)<br>5 to 55 °C   | <b>Storage</b><br>-40 to +65 °C                               | <b>Bake-out*</b><br>(w/o electronics)<br>150 °C                            | <b>Filament temperature</b><br>(Pirani)<br>120 °C |
| <b>Supply voltage</b>                        | <b>At gauge</b><br>15 to 30 VDC   |   | <b>Ripple</b><br>≤1 Vpp  | <b>Power consumption</b><br>≤2 W                  |
| <b>Output signal</b><br>(measurement signal) | <b>Voltage range</b><br>0 to 10.5 V   |   | <b>Measurement range</b><br>1.82 to 8.6 V                                  |   |
| <b>Voltage vs. pressure</b>                  | 0.6 V/decade, logarithmic   |   |  |   |
| <b>Error signal</b>                          | <0.5 V (no supply), >9.5 V (Pirani sensor, filament rupture)  |   |  |   |
| <b>Minimum loaded impedance</b>              | 10 kΩ, short-circuit proof  |   |  |   |
| <b>Response time</b>                         | <10 ms (@ p> 10 <sup>-6</sup> mbar), ≈1000 ms (@ p= 10 <sup>-8</sup> mbar)                                    |   |  |   |
| <b>Identification gauge</b>                  | 85 kΩ, referenced to supply common  |   |  |   |
| <b>Status</b>                                | <b>Pirani-only mode</b><br>0 V (low)  | <b>Combined Pirani/cold cathode mode</b><br>15 V to 30 (high) |  | <b>LED</b><br>LED green high voltage on           |
| <b>Electrical connection</b>                 | FCC 68 appliance connector, 8 poles, female   |   |  |   |
| <b>Sensor cable</b>                          | 8 poles plus shielding  |   |  |   |
| <b>Maximum cable length</b>                  | ≤50 m   |   |  |   |
| <b>Operating voltage/current</b>             | ≤3.3 kV/≤500 A  |   |  |   |
| <b>Materials exposed to vacuum</b>           | <b>FRG-700</b> - SS, Al <sub>2</sub> O <sub>3</sub> , FPM75, Mo, Ni, Au, W                                    |   | <b>FRG-702</b> - SS, Al <sub>2</sub> O <sub>3</sub> , FPM75, Mo, Ni, Au, W |   |
| <b>Internal volume</b>                       | ≈ 20 cm <sup>3</sup>  |   |  |   |
| <b>Weight</b>                                | <b>FRG-700</b> - DN 25 ISO-KF ≈700g, DN 40 CF ≈980 g<br><b>FRG-702</b> - DN 25 ISO-KF ≈730g, DN 40 CF ≈1010 g |   |  |   |
| <b>Standards</b>                             | EN 61000-6-2, EN 61000-6-3, EN 61010-1  |   |  |   |

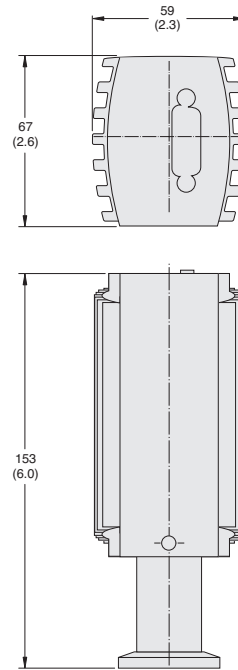
\* Without electronics and magnetic shielding.

## Ordering Information

| Description   | Part Number |
|---|-------------|
| FRG-700 Pirani/IMG Combination Gauge, KF 25                         | FRG700KF25  |
| FRG-700 Pirani/IMG Combination Gauge, DN40 CF                       | FRG700CF35  |
| FRG-702 Pirani/IMG Combination Gauge, KF25, All Metal – bakeable    | FRG702KF25  |
| FRG-702 Pirani/IMG Combination Gauge, DN40 CF, All Metal – bakeable | FRG702CF35  |
| <b>Accessories</b>  |             |
| FRG-700 Gauge Maintenance Kit                                       | FRG700MAINT |
| FRG-700 Gauge Repair Kit  | FRG700REPR  |
| FRG-702 Gauge Maintenance Kit                                       | FRG702MAINT |
| FRG-702 Gauge Repair Kit  | FRG702REPR  |
| FRG-700/702 Magnetic Shielding                                      | FRG700MSHD  |
| FRG-700 Cable, Gauge to AG Turbo Controller, 3M                     | 9699960     |
| FRG-700 Cable, Gauge to AG Turbo Controller, 5M                     | 9699961     |

## ACTIVE GAUGES

### ▶ Agilent FRG-720/FRG-730 Full Range Pirani/Bayard-Alpert Gauges



Dimensions: millimeters (inches)

The Agilent FRG-720 and FRG-730 combine Agilent's Pirani and Bayard-Alpert sensor into a single compact design that provides measuring capability from  $5 \times 10^{-10}$  mbar to atmosphere ( $3.8 \times 10^{-10}$  Torr to atmosphere). Combining these two technologies into a single unit reduces complexity and integration challenges while protecting the Bayard-Alpert sensor from premature burnout.

#### Applications

- Wide range from industrial coating and semiconductor processing to research and laboratory environments
- General vacuum measurement and control in the low to ultra-high vacuum range

#### Features

- Combination gauge – Bayard-Alpert and Pirani
- Pirani interlock
- Long-life yttrium oxide coated iridium filament
- Set point control
- LCD display option
- Profibus communication option

#### Benefits

- Wide measurement range from  $5 \times 10^{-10}$  mbar to atmosphere
- Protects Bayard-Alpert sensor from premature burnout and contamination effects from high pressure operation
- Rugged design for a wide range of applications
- Utilize pressure readings to perform critical operations
- Monitor pressure readings easily
- Ease of network integration



# VACUUM MEASUREMENT

## Technical Specifications

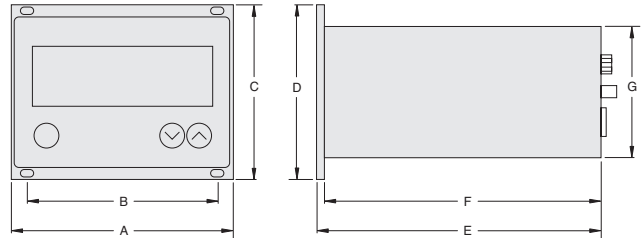
|  |   |  |                                      |                                       |                                      |
|--|---|--|--------------------------------------|---------------------------------------|--------------------------------------|
| <b>Measurement range</b> (Air, O <sub>2</sub> , CO, N <sub>2</sub> ) | 5 x 10 <sup>-10</sup> to 1000 mbar (3.8 x 10 <sup>-10</sup> to 760 Torr)  |  |                                      |                                       |                                      |
| <b>Accuracy</b>  | 10 <sup>-8</sup> to 10 <sup>-2</sup> mbar/Torr – ±15% of reading  |  |                                      |                                       |                                      |
| <b>Repeatability</b>   | 10 <sup>-8</sup> to 10 <sup>-2</sup> mbar/Torr – ±5% of reading   |  |                                      |                                       |                                      |
| <b>Degas</b>   | p < 7.2 x 10 <sup>-6</sup> mbar – electron bombardment, max. 3 min  |  |                                      |                                       |                                      |
| <b>Pressure, maximum</b>   | 2 bar absolute  |  |                                      |                                       |                                      |
| <b>Temperature</b>   | <b>Operation (ambient)</b>  | <b>Storage</b>   | <b>Bakeout at flange w/extension</b> | <b>Bakeout at flange wo/extension</b> | <b>Bakeout w/electronics removed</b> |
|  | 0 to 50 °C  | -20 to +70 °C  | 150 °C                               | 80 °C                                 | 150 °C                               |
| <b>Supply voltage</b>  | 20 to 28 VDC, 1.4 A on startup for 200 msec, 0.8 A operating  |  |                                      |                                       |                                      |
| <b>Output signal analog</b>  | 0 to 10 V   |  |                                      |                                       |                                      |
| <b>Measurement range</b>   | 0.774 to 10.0 V   |  |                                      |                                       |                                      |
| <b>Voltage vs. pressure</b>  | 0.75 V/decade   |  |                                      |                                       |                                      |
| <b>Error signal</b>  | 0.3/0.5 V   |  |                                      |                                       |                                      |
| <b>Minimum loaded impedance</b>                                      | 10 kΩ   |  |                                      |                                       |                                      |
| <b>Communications interface</b>                                      | RS-232C   |  |                                      |                                       |                                      |
| <b>Electrical connection</b>   | D-sub, 15 pin, male   |  |                                      |                                       |                                      |
| <b>Maximum cable length</b>  | 100 m (330 ft)  |  |                                      |                                       |                                      |
| <b>Materials exposed to vacuum</b>                                   | Yt <sub>2</sub> O <sub>3</sub> , Ir, Pt, Mo, Cu, W, NiFe, NiCr, stainless steel, glass  |  |                                      |                                       |                                      |
| <b>Internal volume</b>   | KF/CF   | 24 cm <sup>3</sup> (1.46 in <sup>3</sup> )/34 cm <sup>3</sup> (2.1 in <sup>3</sup> ) |                                      |                                       |                                      |
| <b>Weight</b>  | KF/CF   | 285 g/550 g  |                                      |                                       |                                      |
| <b>Protection type</b>   | IP30  |  |                                      |                                       |                                      |
| <b>Setpoint relays (1) for FRG-730</b>                               | <b>Range</b>  | <b>Relay Contact</b>   | <b>Hysteresis</b>                    | <b>Contact rating</b>                 |                                      |
|  | 1 x 10 <sup>-9</sup> to 100 mbar  | n.o., potential free   | 10 % of reading                      | 30 V/0.5 A DC                         |                                      |
| <b>Profibus option</b>   |   |  |                                      |                                       |                                      |
| <b>Baud rates</b>  | 9.6/19.2/93.75/187.5/500 kBaud; 1.5/12 mBaud  |  |                                      |                                       |                                      |
| <b>Address</b>   | 2 switches (address 00 – 127) or network programmable   |  |                                      |                                       |                                      |
| <b>Digital functions</b>   | Read pressure, select units (Torr, mbar, Pa); degas function, Pirani full scale adjust; monitor gauge status; safe state allows definition of behavior in case of error; detailed alarm and warning information |  |                                      |                                       |                                      |
| <b>Analog functions</b>  | 0 to 10 V analog output pressure indication; two setpoint relays A + B  |  |                                      |                                       |                                      |
| <b>Setpoint relays (2)</b>   | <b>Range</b>  | <b>Relay Contact</b>   | <b>Hysteresis</b>                    | <b>Contact rating</b>                 |                                      |
|  | 1 x 10 <sup>-9</sup> to 100 mbar  | n.o., potential free   | 10 % of reading                      | 60 V/0.5 A DC                         |                                      |
| <b>Connector for Profibus DP</b>                                     | D-sub, 9 pin, female  |  |                                      |                                       |                                      |

## Ordering Information

| Description  | Part Number  |              |
|--|--------------|--------------|
|  | KF25         | CF35         |
| FRG-720 Pirani/Bayard Alpert combination gauge – single filament                       | FRG720KF25   | FRG720CF35   |
| with display   | FRG720KF25D  | FRG720CF35D  |
| with setpoints and Profibus  | FRG720KF25SP | FRG720CF35SP |
| FRG-730 Pirani/Bayard Alpert combination gauge – dual filaments w/set pts              | FRG730KF25S  | FRG730CF35S  |
| FRG-730 Pirani/Bayard Alpert combination gauge – dual filaments w/set pts. and display | FRG730KF25SD | FRG730CF35SD |
| FRG-730 Pirani/Bayard Alpert combination gauge – dual filaments w/set pts and Profibus | FRG730KF25SP | FRG730CF35SP |
| <b>Accessories</b>   |              |              |
| FRG-720 Replacement sensor–KF25  | FRG720KF25RS |              |
| FRG-720 Replacement sensor–CF35  | FRG720CF35RS |              |
| FRG-730 (dual filaments)–KF25 Replacement sensor                                       | FRG730KF25RS |              |
| FRG-730 (dual filaments)–CF35 Replacement sensor                                       | FRG730CF35RS |              |
| FRG-720/730 Baffle   | FRG720BFL    |              |
| FRG-720/730 Power Supply 24 V DC/RS232C  | FRG720PWR    |              |
| FRG-720/730 Bakeout extension, 100mm   | FRG720BKE    |              |

## ACTIVE GAUGES

### ▶ Agilent AGC-100 Active Gauge Controller/ AGD-100 Active Gauge Display



|                | A            | B           | C           | D           | E            | F            | G           |
|----------------|--------------|-------------|-------------|-------------|--------------|--------------|-------------|
| <b>AGC-100</b> | 106<br>(4.2) | 91<br>(3.6) | 78<br>(3.1) | 84<br>(3.3) | 210<br>(8.3) | 207<br>(8.2) | 67<br>(2.6) |
| <b>AGD-100</b> | 106<br>(4.2) | 91<br>(3.6) | 78<br>(3.1) | 84<br>(3.3) | 136<br>(5.3) | 132<br>(5.2) | 62<br>(2.4) |

*Dimensions: millimeters (inches)*

AGC-100 is single channel controller compatible with the FRG 7xx, PVG-5xx, PCG-75x and CDG-500 series of active gauges and automatically identifies the active gauge connected.

AGD-100 is a low cost single channel display option for the FRG-700/702, PVG-5xx and PCG-75x series of active gauges. Both units have user selectable measurement unit (mbar, Torr, Pascal), and adjustable setpoint control.

#### Features

- Automatic identification of Agilent active gauges
- User selectable pressure units (mbar, Torr, Pascal)
- Adjustable setpoint control

#### Benefits

- Ease of setup
- Global compatibility
- Utilize pressure readings to perform critical operations

# VACUUM MEASUREMENT

## Technical Specifications

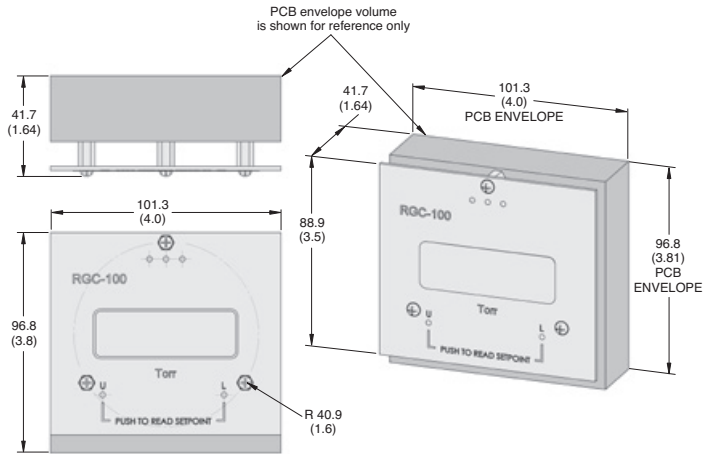
|   |  |
|---|--|
| <b>Measurement channels</b>             | One (1)  |
| <b>Measurement range</b>                | $2 \times 10^{-10}$ to 1500 mbar ( $1.5 \times 10^{-10}$ to 1125 Torr) |
| <b>Measurement unit</b> (selectable)    | mbar, Torr, Pascal   |
| <b>Rate</b>                             | 10/sec   |
| <b>A/D converter</b>                    | 16 bit   |
| <b>Setpoints</b>                        |  |
| <b>Setpoint relays</b>                  | One (1)  |
| <b>Channel assignment</b>               | One (1)  |
| <b>Relay contact</b>                    | Potential free change over contact                                     |
| <b>Hysteresis</b>                       | Adjustable   |
| <b>Contact rating</b>                   | 30 VAC/1A; 60 VDC/0.5A   |
| <b>Connector</b>                        | D-Sub, 9 pin, male   |
| <b>Display</b>                          | LED  |
| <b>Analog output</b>                    |  |
| <b>Range</b>                            | 0-10.3 V, sensor analog output signal                                  |
| <b>Connector</b>                        | D-Sub, 9 pin, male   |
| <b>Supply</b>                           | 90-250 V, 50/60 Hz   |
| <b>Consumption</b>                      | #30W   |
| <b>Operation temperature</b> (ambient)  | 5 to 50 °C   |
| <b>Digital interface</b> (AGC-100 only) | RS-232C ; D-Sub, 9 pin, female   |

## Ordering Information

| Description  | Part Number |
|--|-------------|
| Active Gauge Controller for FRG 7xx, PVG-5xx, PCG-75x and CDG-500 Series | AGC100      |
| Gauge display for FRG-700/702 and PVG-5xx and PCG-75x Series             | AGD100      |
| <b>Accessories</b>   |             |
| Front adapter for controller, rack adaptor, 3u                           | AGC100ADPT  |
| Cable (FRG700/702, PVG, PCG) – 3 m (9.9 ft)                              | AGCCBL103   |
| Cable (FRG700/702, PVG, PCG) – 5 m (16.4 ft)                             | AGCCBL105   |
| Cable (FRG700/702, PVG, PCG) – 10 m (33 ft)                              | AGCCBL110   |
| Cable (FRG720/730) – 3 m (9.9 ft)  | AGCCBL203   |
| Cable (FRG720/730) – 5 m (16.4 ft)                                       | AGCCBL205   |
| Cable (FRG720/730) – 10 m (33 ft)  | AGCCBL210   |
| Cable (CDG500) – 3 m (9.9 ft)  | AGCCBL303   |
| Cable (CDG500) – 5 m (16.4 ft)   | AGCCBL305   |
| Cable (CDG500) – 10 m (33 ft)  | AGCCBL310   |
| <b>Power Cord Selection</b> One power cord included with each unit       |             |
| Europe, 10 A/220-230 VAC, 2.5 meter                                      | 656494220   |
| Denmark, 10 A/220-230 VAC, 2.5 meter                                     | 656494225   |
| Switzerland, 10 A/230 VAC, 2.5 meter                                     | 656494235   |
| UK/Ireland, 13 A/230 VAC, 2.5 meter                                      | 656494250   |
| India, 10 A/220-250 VAC, 2.5 meter                                       | 656494245   |
| Israel, 10 A/230 VAC, 2.5 meter  | 656494230   |
| Japan, 12 A/100 VAC, 2.3 meter   | 656494240   |
| North America, 13 A/125 VAC, 2.0 meter                                   | 656458203   |

## ACTIVE GAUGES

### ► Agilent RGC-100 Rough Gauge Controller



Dimensions: millimeters (inches)

The Agilent RGC-100 Rough Gauge Controller is a cost effective solution for pressure measurements in the  $1 \times 10^{-3}$  Torr to 760 Torr region.

The RGC-100 package includes the TC tube, sensor cable and power supply to provide a pre-calibrated turnkey rough vacuum solution.

### Applications

- General vacuum measurement and control in the rough vacuum range
- Monitor forelines, chamber evacuation and crossover to high vacuum pumps

### Features

- Thermocouple gauge – Agilent 531 – and controller are pre-calibrated as a set at the factory
- Runs on 100-230 VAC, 50/60 Hz and displays in Torr or mbar
- Large bright LED display
- No moving parts
- Optional set point control, analog output, RS232 communications
- Economical vacuum gauge

### Benefits

- No calibration required at initial setup
- Globally compatible
- Easily read from across a room, or in dimly lit locations
- Shock resistant and requires infrequent calibration
- Easily integrated
- Ideal choice for integrators

**NOTE** Factory calibration is performed using equipment under NIST Standards. Calibration certificates are not available with these products.

# VACUUM MEASUREMENT

## Technical Specifications

|   |  |   |
|---|--|---|
| <b>Measurement range</b>                | 1.3 x 10 <sup>-3</sup> to 1000 mbar (1.0 x 10 <sup>-3</sup> to 760 Torr) |   |
| <b>Accuracy</b>                         | <b>% of reading</b>  | <b>Units</b>  |
|   | ±10%   | 1.3 x 10 <sup>-3</sup> to 1.3 mbar (1 milli Torr to 1 Torr) |
|   | ±15%   | 1.3 to 13.3 mbar (1 to 10 Torr)                             |
|   | ±50%   | 13.3 to 213 mbar (10 to 160 Torr)                           |
|   | ±25%   | 213 to 1000 mbar (160 Torr to 760 Torr)                     |
| <b>Vacuum fitting</b>                   | ½ inch NPT-M   |   |
| <b>Interface cable length</b>           | 10 ft.   |   |
| <b>Sensor</b>                           | Agilent 531 TC gauge tube  |   |
| <b>Display</b>                          | See below  |   |
| <b>Dimensions</b>                       | Mounts in 2.66 inch panel hole with 3 screws on 1.60 inch radius         |   |
| <b>Supply voltage</b>                   | 100-240 VAC, 50/60 Hz  |   |
| <b>Standards</b>                        | CE, ROHS compliant   |   |
| <b>Optional setpoint controls</b>       | 7 A, 250 V   |   |
| <b>Optional communication interface</b> | RS-232   |   |
| <b>Optional analog output</b>           | 0-5 VDC  |   |

## Ordering Information

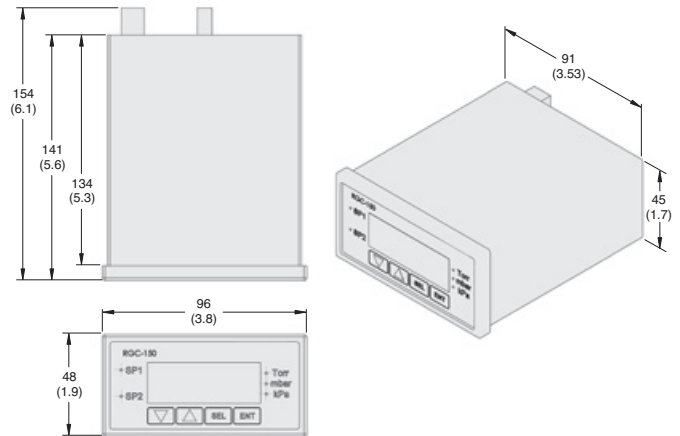
| Description  | Part Number  |
|--|--------------|
| RGC-100 Rough Gauge Controller (mbar)                          | RGC100M      |
| RGC-100 Rough Gauge Controller (Torr)                          | RGC100T      |
| RGC-100 Rough Gauge Controller with setpoints and RS232 (mbar) | RGC100MS     |
| RGC-100 Rough Gauge Controller with setpoints and RS232 (Torr) | RGC100TS     |
| RGC-100, 1.33" CFF TC, mbar, Controller                        | RGC100MCF    |
| RGC-100, KF16 536 TC, mbar, Controller                         | RGC100MKF16  |
| RGC-100, KF25 536 TC, mbar, Controller                         | RGC100MKF25  |
| RGC-100, 1.33" CFF TC, mbar, SPs, Controller                   | RGC100MSCF   |
| RGC-100, KF16 536 TC, mbar, SPs, Controller                    | RGC100MSKF16 |
| RGC-100, KF25 536 TC, mbar, SPs, Controller                    | RGC100MSKF25 |
| RGC-100, 1.33" CFF TC, Torr, Controller                        | RGC100TCF    |
| RGC-100, KF16 536 TC, Torr, Controller                         | RGC100TKF16  |
| RGC-100, KF25 536 TC, Torr, Controller                         | RGC100TKF25  |
| RGC-100, 1.33" CFF TC, Torr, SPs, Controller                   | RGC100TSCF   |
| RGC-100, KF16 536 TC, Torr, SPs, Controller                    | RGC100TSKF16 |
| RGC-100, KF25 536 TC, Torr, SPs, Controller                    | RGC100TSKF25 |
| <b>Accessories</b>   |              |
| Replacement sensors  |              |
| ½ inch NPT-M   | F0472303     |
| KF16   | L6141308     |
| KF25   | L6141309     |
| 1.33 in CFF  | L6141304     |

**NOTE** All part number with "S" include the optional set points, RS232, and analog output.



## ACTIVE GAUGES

### ► Agilent RGC-150 Rough Gauge Controller



Dimensions: millimeters (inches)

The Agilent RGC-150 Rough Gauge Controller is a cost effective solution for pressure measurements in the  $1 \times 10^{-3}$  Torr to 760 Torr region.

The RGC-150 package includes the TC tube, sensor cable and power supply to provide a pre-calibrated turnkey rough vacuum solution.

### Applications

- General vacuum measurement and control in the rough vacuum range
- Monitor forelines, chamber evacuation and crossover to high vacuum pumps

### Features

- Thermocouple gauge – Agilent 531 – and controller are pre-calibrated as a set at the factory
- Two easily configured set points
- Runs on 100-230 VAC, 50/60 Hz and displays in Torr, mbar and kPa
- Large bright LED display
- Optional Ethernet connection and software that allows for remote monitoring through a web browser

### Benefits

- No calibration required at initial setup
- Utilize pressure readings to perform critical operations
- Globally compatible
- Easily read from across a room or in dimly lit locations
- Monitor vacuum performance from a remote location

**NOTE** Factory calibration is performed using equipment under NIST Standards. Calibration certificates are not available with these products.

# VACUUM MEASUREMENT

## Technical Specifications

|                                |  |  |
|--------------------------------|--|--|
| <b>Measurement range</b>       | 1.3 x 10 <sup>-3</sup> to 1000 mbar (1.0 x 10 <sup>-3</sup> to 760 Torr) |  |
| <b>Accuracy</b>                | <b>% of reading</b>  | <b>Units</b>   |
|                                | ±10%   | 1.3 x 10 <sup>-3</sup> to 1.3 mbar (1 milliTorr to 1 Torr) |
|                                | ±15%   | 1.3 to 13.3 mbar (1 to 10 Torr)                            |
|                                | ±50%   | 13.3 to 213 mbar (10 to 160 Torr)                          |
|                                | ±25%   | 213 to 1000 mbar (160 Torr to 760 Torr)                    |
| <b>Vacuum fitting</b>          | ½ inch NPT-M   |  |
| <b>Interface cable length</b>  | 10 ft.   |  |
| <b>Sensor</b>                  | See below  |  |
| <b>Display</b>                 | 0.38 inch high 6 digit red LED   |  |
| <b>Dimensions</b>              | 1.7 inch high, 3.52 inch wide, 5.35 inch deep                            |  |
| <b>Analog output</b>           | 0-5 VDC  |  |
| <b>Supply voltage</b>          | 100-240 VAC, 50/60 Hz  |  |
| <b>Standards</b>               | CE, ROHS compliant   |  |
| <b>Set point controls</b>      | 7 A, 250 V   |  |
| <b>Communication interface</b> | RS-232   |  |
| <b>Mounting</b>                | ½ DIN rack mount   |  |

## Ordering Information

| Description   | Part Number |
|---|-------------|
| RGC-150 Rough Gauge Controller                            | RGC150      |
| RGC-150 Rough Gauge Controller with Ethernet and Software | RGC150E     |
| RGC-150, 1.33" CFF TC, Rough Vac Controller               | RGC150CF    |
| RGC-150, KF16 536TC, Rough Vac Controller                 | RGC150KF16  |
| RGC-150, KF25 536TC, Rough Vac Controller                 | RGC150KF25  |
| RGC-150, 1.33" CFF TC, Rough Vac Controller, Ethernet     | RGC150ECF   |
| RGC-150, KF16 536TC, Rough Vac Controller, Ethernet       | RGC150EKF16 |
| RGC-150, KF25 536TC, Rough Vac Controller, Ethernet       | RGC150EKF25 |

### Accessories

|                     |          |
|---------------------|----------|
| Replacement sensors |          |
| ½ inch NPT-M        | F0472303 |
| KF16                | L6141308 |
| KF25                | L6141309 |
| 1.33 in CFF         | L6141305 |

**NOTE** All units include set points, RS232 and analog output.

## GAUGE CABLES

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

### Ordering Information

| Description  | Length (in feet) | Part Number | Shipping Weight kg (lbs) |
|--|------------------|-------------|--------------------------|
| <b>XGS-600</b> I/O, with flying leads  | 10               | R32493010   | 2.0 (1.0)                |
|  | 25               | R32493025   | 2.0 (1.0)                |
|  | 50               | R32493050   | 3.0 (1.5)                |
| <b>Thermocouple Cables</b> ( <i>XGS-600 and senTorr only</i> )<br>For use with one 531 or 536 gauge tubes  | 10               | L91313010   | 2.0 (1.0)                |
|  | 25               | L91313025   | 2.0 (1.0)                |
|  | 50               | L91313050   | 3.0 (1.5)                |
|  | 75               | L91313075   |                          |
|  | 100              | L91313100   |                          |
| <b>ConvecTorr Cables</b> ( <i>XGS-600, Multi-Gauge, senTorr and PanelVac ConvecTorr</i> )<br>Standard non-bakeable   | 10               | L91223010   | 2.0 (1.0)                |
|  | 25               | L91223025   | 2.0 (1.0)                |
|  | 50               | L91223050   | 3.0 (1.5)                |
|  | 100              | L91223100   |                          |
| <b>Thermocouple Cables</b> ( <i>Multi-Gauge only</i> )<br>Dual (for use with two gauges)<br>Dual (for use with two gauges)<br>Quad (for use with four gauges)<br>Quad (for use with four gauges) | 10               | L64752010   | 2.0 (1.0)                |
|  | 25               | L64752025   | 2.0 (1.0)                |
|  | 10               | L64754010   | 2.0 (1.0)                |
|  | 25               | L64754025   | 2.0 (1.0)                |
| <b>Glass BA Gauge Cables</b><br>Standard non-bakeable  | 10               | R32443010   | 2.0 (1.0)                |
|  | 25               | R32443025   | 2.0 (1.0)                |
|  | 100              | R32443050   | 2.0 (1.0)                |
| <b>MBA2-200 Gauge Cables</b>   | 10               | X320360006  | 2.0 (1.0)                |
|  | 25               | X320360007  | 2.0 (1.0)                |
|  | 50               | X320360008  | 3.0 (1.5)                |
|  | 65               | X320360009  | 3.0 (1.5)                |
|  | 75               | X320360010  | 3.0 (1.5)                |
| <b>UHV-24/UHV-24p Standard</b><br>Standard non-bakeable  | 10               | R32453010   | 2.0 (1.0)                |
|  | 25               | R32453025   | 2.0 (1.0)                |
|  | 50               | R32453050   | 3.0 (1.5)                |
| <b>UHV-24/UHV-24p PTFE (for UHV)</b><br>bakeable to 250 °C   | 10               | R32463010   | 2.0 (1.0)                |
|  | 25               | R32463025   | 2.0 (1.0)                |
|  | 50               | R32463050   | 3.0 (1.5)                |
| <b>Ion Gauge Extension Cables</b> ( <i>XGS-600</i> )   | 65               | R3247065    |                          |
|  | 90               | R3247090    |                          |

# VACUUM MEASUREMENT

## Ordering Information

| Description   | Length (in feet)             | Part Number        | Shipping Weight kg (lbs) |              |
|---|------------------------------|--------------------|--------------------------|--------------|
| <b>IMG-100 Cables</b> ( <i>XGS-600</i> )<br>Standard non-bakeable<br>may be used with IMG-300 | 10                           | R03113010          | 2.0 (1.0)                |              |
|   | 25                           | R03113025          | 2.0 (1.0)                |              |
|   | 50                           | R03113080          | 3.0 (1.5)                |              |
|   | 75                           | R03113075          |                          |              |
|   | 100                          | R03113100          |                          |              |
| <b>IMG-300 Cables</b> Inverted Magnetron Gauge ( <i>UHV</i> )<br>Bakeable to 250 °C           | 10                           | R03413010          | 2.0 (1.0)                |              |
|   | 25                           | R03413025          | 2.0 (1.0)                |              |
|   | 65                           | R03413065          |                          |              |
|   | 100                          | R03413100          |                          |              |
| <b>FRG-700 Cables</b>   | Gauge to FRG Controller      | 3 m                | AGCCBL103                |              |
|   | Gauge to FRG Controller      | 5 m                | AGCCBL105                |              |
|   | Gauge to AG Turbo Controller | 3 m                | 9699960                  |              |
|   | Gauge to AG Turbo Controller | 5 m                | 9699961                  |              |
| <b>XGS-600 Analog Board Cables</b>  |                              | <b>Part Number</b> |                          |              |
| <b>Cable Length</b>   | <b>3 ft</b>                  | <b>10 ft</b>       | <b>25 ft</b>             | <b>50 ft</b> |
| FRG-700/PVG/PCG Analog Input Board  | R35893003                    | R35893010          | R35893025                | R35893050    |
| CDG Analog Input Board  | R35903003                    | R35903010          | R35903025                | R35903050    |
| FRG720/730 Analog Input Board   | R35913003                    | R35913010          | R35913025                | R35913050    |

## Vacuum Gauge Technical Notes

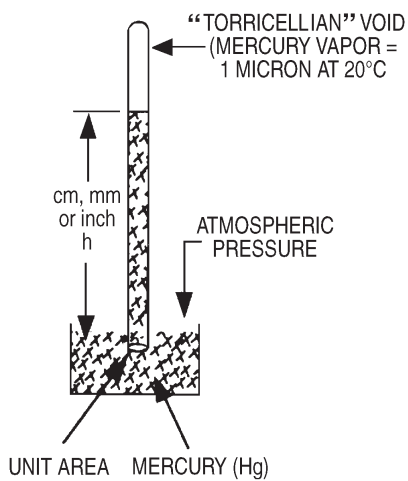
### Historical Notes

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

- Air has weight...mass
  - 2 lbs per cubic yard, or
  - 1.293 grams per liter
- Pressure = force per unit area
- 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  $0.49 \times 29.9 = 14.7$  pounds/in<sup>2</sup>.

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 760 mm, and this

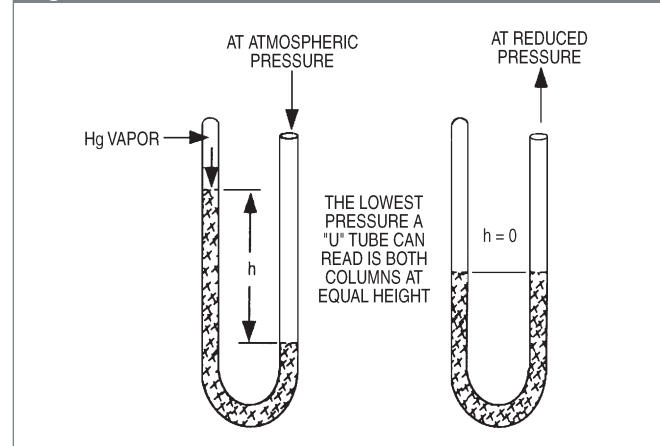
is defined as a standard atmosphere.

This also is  $1.01 \times 10^5$  Pascals or  $1.01 \times 10^5$  dynes cm<sup>2</sup>. 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.

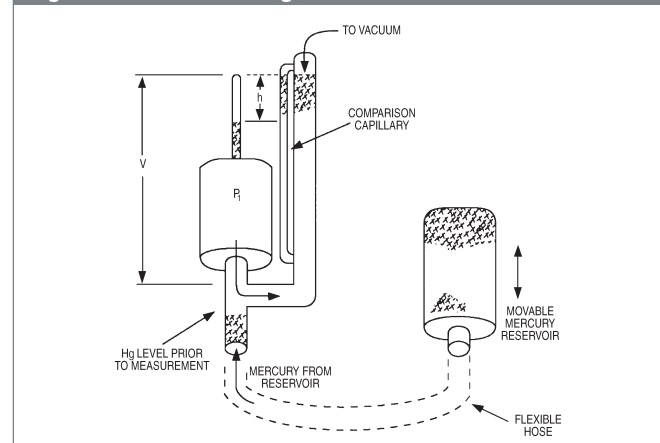
With both the barometer and the manometer, it is the difference in heights of the mercury levels that indicates the pressure, that is, the force (weight of Hg) per unit area that the air pressure will support. As the pressure on the system side is reduced, the height of the columns on either side of 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





# VACUUM MEASUREMENT

## Application of Boyle's Law

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

$V_1$  = Total volume, capillary plus bulb (cm<sup>3</sup>)

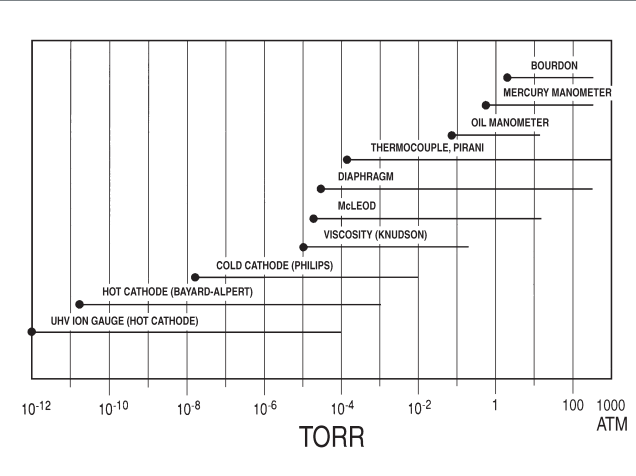
$P_1$  = Pressure in system

$b$  = Volum of capillary (in cubic cm) mm length

$h$  = Difference in height of mercury columns

$V_2$  =  $bh$  (cm<sup>3</sup>) volume in capillary

Figure 4 - Pressure Ranges of Various Vacuum Gauges



## 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.

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  $1 \times 10^{-2}$  Torr to  $1 \times 10^{-7}$  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  $5 \times 10^{-1}$  Torr, and as low as  $5 \times 10^{-12}$  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  $\pm 20\%$ .
- 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:

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

**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 ( $I^+$ ) and ( $I^-$ ) are measured in amperes and ( $P$ ) is in Torr.

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

For instance, the sensitivity of the Agilent UHV-24 nude gauge is 25 per Torr.

# AGILENT TECHNICAL NOTES

## Operation of Ionization Gauges

| Table 1 - Conversion Table                                       |                                    |                        |                              |                    |   |
|--|------------------------------------|------------------------|------------------------------|--------------------|---|
|  | Pascal<br>(N/m <sup>2</sup> ) (Pa) | Torr                   | Standard<br>Atmosphere (atm) | Millibar<br>(mbar) | Dyne per Square<br>Centimeter (dyne/cm <sup>2</sup> ) |
| <b>1 Newton per square meter</b><br>(N/m <sup>2</sup> ) = Pascal | = 1                                | 7.5 x 10 <sup>-3</sup> | 9.87 x 10 <sup>-6</sup>      | 10 <sup>-2</sup>   | 10  |
| <b>1 Torr = 1 mm Hg</b>  | = 133                              | 1                      | 1.32 x 10 <sup>-3</sup>      | 1.33               | 1,330   |
| <b>1 standard atmosphere (atm)</b>                               | = 101,000                          | 760                    | 1                            | 1,010              | 1,010,000   |
| <b>1 millibar (mbar)</b>   | = 100                              | 0.75                   | 9.87 x 10 <sup>-6</sup>      | 1                  | 1,000   |
| <b>1 dyne/square centimeter</b><br>(dyne/cm <sup>2</sup> )       | = 10 <sup>-1</sup>                 | 7.5 x 10 <sup>-4</sup> | 9.87 x 10 <sup>-7</sup>      | x 10 <sup>-3</sup> | 1   |

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:

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

- I<sup>+</sup> = Observed ion current
- I<sup>-</sup> = 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.

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

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

| Table 2 - Pressure and Flow Unit |  |
|----------------------------------|--|
| <b>Pressures</b>                 |  |
| Standard atm                     | = 1.01325 x 10 <sup>6</sup> Dynes cm <sup>-2</sup><br>= 760 mm Hg (at 0 °C)<br>= 29.9213 in. of Hg (at 32 °F)                                    |
| Bar                              | = 1 x 10 <sup>6</sup> Dynes cm <sup>-2</sup><br>75.0062 cm Hg (at 0 °C)<br>0.986 atm   |
| Torr                             | = 1333 Dynes cm <sup>-2</sup><br>= 1 mm Hg (at 0 °C)<br>= (760) <sup>-1</sup> Standard atm   |
| Micron                           | = (length) 1000 Angstroms<br>(1A = 10 <sup>-10</sup> meter)<br>= (pressure) 1.33 Dyne cm <sup>-2</sup><br>= (pressure) 1 x 10 <sup>-3</sup> Torr |
| Barye                            | = 1 Dyne cm <sup>-2</sup><br>= 9.869 x 10 <sup>-7</sup> atm<br>= 1 x 10 <sup>-6</sup> bar  |
| Dyne                             | = Force necessary to give a one-gram mass<br>an acceleration of one cm/sec/sec   |
| <b>Flows</b>                     |  |
| Cubic Foot                       | = 28.3 liters<br>= 2.83 x 10 <sup>4</sup> cm <sup>3</sup>  |
| CFM                              | = 28.3 liters min <sup>-1</sup><br>= 0.47 liter sec <sup>-1</sup>  |
| Liter sec-1                      | = 2.12 cfm<br>= 3.53 x 10 <sup>-2</sup> cubic feet sec <sup>-1</sup>   |

# VACUUM MEASUREMENT

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 Agilent 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 Agilent 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.

## Cold Cathode Gauges

The cold cathode gauge is an often overlooked, cost-effective gauge for ion implanters and other high-vacuum applications. A cold cathode gauge has no filament, is not subject to burnout and has a significantly longer life and lower annual replacement cost than a hot cathode Bayard-Alpert gauge. A cold-cathode gauge can be replaced at predictable intervals, whereas a hot cathode gauge must be replaced whenever a burnout occurs. In addition, the annual cost of replacement is less. A modern inverted magnetron cold cathode gauge is stable and can operate over a wide pressure range from 10 mTorr down to ultra-high vacuum. Repeatability is better than 98%. Cold cathode gauges have a reputation as 'slow starters,' since they must rely on an ionization source such as a cosmic ray to initiate a discharge. The lower the pressure, the less likely an ionizing collision and the longer the start delay. At 1 mTorr or higher, there is no delay; but at  $10^{-8}$  Torr, starting can take up to 3 hours. The traditional solution is to start the gauge in the mTorr range, but often this is not practical. A relatively new technique uses ultraviolet induced photoemission to generate an ionizing electron to start the gauge.<sup>8</sup> At  $10^{-6}$  Torr the start time is 4-5 seconds.