BROOKS AUTOMATION

CRITICAL COMPONENTS GROUP

Granville-Phillips® Series 274 Bayard-Alpert Type Ionization Gauge Tube

VACUUM PRODUCTS

Benefits

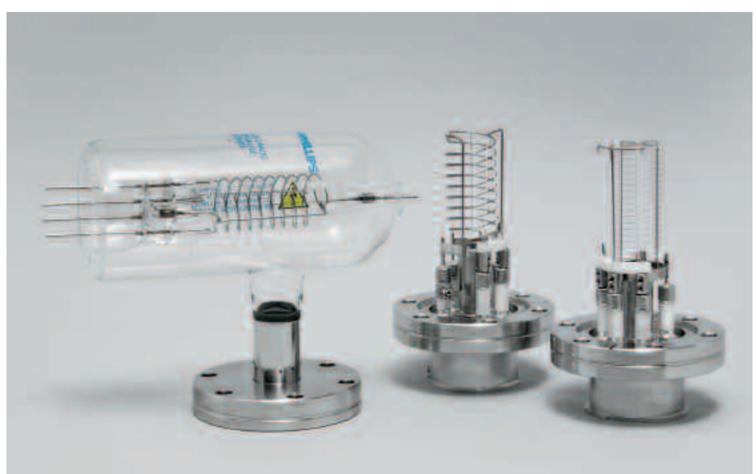
- Good vacuum pressure measurement for economical cost
- Operates on industry standard electrode voltages and wide range of electron emission currents (10 µA to 10 mA)
- Well-known performance characteristics in vacuum industry
- Ion collector electrode well-shielded from leakage currents
- Available with burn-out resistant filaments and standard vacuum connections
- All units can be degassed by electron bombardment; some can be resistance degassed

Operating Principle

The pressure indication of a Bayard-Alpert (a hot cathode) gauge is based on the ionization of gas molecules by a constant flow of electrons. The negative electrons are emitted at a well-controlled, selectable rate from a heated cathode and are accelerated toward a positively charged wire grid (anode). Electrons pass into the space between the grid and a collector wire at ground. In this space the electrons collide with gas molecules from the vacuum system, producing positive ions. The positive ions are then collected by the grounded collector wire that is located along the axis of the cylindrical grid. At a constant filament to grid voltage and electron emission current, the rate that positive ions are formed is directly proportional to the density of molecules (pressure) in the space for pressures below 1×10^{-3} Torr. The strength of the ion current is then indicated on a microammeter that is calibrated in units of pressure. Inasmuch as the pressure indication is linear, the hot cathode Bayard-Alpert gauge is generally considered the most accurate continuous indicator for pressures below 1×10^{-3} Torr.

The low end of the operating range of a Bayard-Alpert gauge is determined by the X-ray limit of this type of gauge. The X-ray limit varies with different gauge designs. X-rays are produced when the electrons emitted by the cathode impact the grid and support wires. Because of the geometry of the Bayard-Alpert gauge, only a small fraction of the emitted X-rays are intercepted by the ion collector. When the X-rays strike the collector wire they cause electrons to be photoelectrically ejected from the collector. This X-ray current limits the pressures that can be measured, and is equivalent to a pressure reading in the 10^{-10} or 10^{-11} Torr ranges, depending upon the gauge model. Earlier gauges that had a cylindrical collector outside the grid experienced an X-ray limit of about 10^{-8} Torr. The X-ray limit refers to the lowest pressure indication that may be obtained in a gauge when all the output current is due to X-ray induced photoemission and there is an absence of gas.

The X-ray limit will be increased as a result of hydrocarbon contamination of the electrodes, since contaminated surfaces release more secondary electrons under X-ray bombardment. Such contamination can generally be removed by thorough degassing of the electrodes.



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Gas Species Effects

Bayard-Alpert ionization gauges have different relative sensitivities for different gas species. As a result, pressure readout provides a direct reading only for the gas for which the gauge is specified (nitrogen). This is called a readout of nitrogen equivalent pressure. A simple mathematical conversion of the direct pressure readout to the pressure of the non standard gas can be made. This conversion is made using the relative gauge sensitivity for the specific gas. These sensitivities are tabulated in reference material and are contained in the Granville-Phillips instruction manual for Series 274.

Hot cathode type ionization vacuum gauges work best in given pressure ranges for individual gauge designs. The following is a brief outline of the considerations relevant to selection of the proper gauge.

A glance at the chart (Figure 1) will quickly indicate the gauge or gauges suitable for a given application. The useful range of most of these gauges starts at 1 x 10^{-3} Torr. Variations in design permit operation to various orders of vacuum. The nude type 274022, 274023, 274041 and 274042 are suitable to 2 x 10^{-11} Torr.

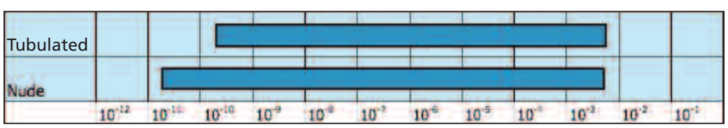


Figure 1. Operating Range for Bayard-Alpert Ionization Gauge Tube

Cathodes

All gauges listed in this brochure have either tungsten or thoria coated iridium cathodes. The relative advantages and disadvantages of each are tabulated in Figure 2.

Phenomenon	Tungsten Filament	Thoria-Iridium Filament
Accidental exposure to atmosphere	No tolerance	High tolerance
High Oxygen Partial pressure	Easily oxidized	Relatively immune to Oxidation
Chemical reaction with gas to be measured	Higher filament temperature, higher reaction rate	Lower filament temperature, lower reaction rate

Figure 2. Cathode Characteristics

Sensitivity

The sensitivity is defined as follows:

$$S\ (\text{Sensitivity}) = \frac{(\text{Ionization Current})}{(\text{Electron Current})\ (\text{Pressure})}$$

(Current measured in amperes. Pressure in Torr.)

This definition makes the sensitivity relatively independent of the electron current and dependent only on gauge construction. In practice, it is often necessary to determine the lowest pressure that can be read with a given gauge tube and controller. To determine this, the lowest readable current sensitivity of the electrometer portion of the controller must be known.

Knowing the sensitivity of the gauge tube from the manufacturer's data, the relationship for ionization current vs. pressure can be determined.

Degassing

To reduce the outgassing in a gauge to a negligible level, the process of degassing is employed. For attainment of the lowest pressure levels the glass envelope gauges should be baked at 400°C for 1 hour.

The electrodes are degassed by heating to a temperature of 900°C nominally for approximately 15 minutes after baking.

The electrode heating is accomplished by either electron bombardment (EB) or by passing a heavy current (I^2R) at low voltage through the grid. In general, gauges equipped with built up grids; i.e., squirrel cage or grids welded at multiple intersecting components, are degassed only by electron bombardment. The collector may be degassed only by the electron bombardment method. Grids consisting of a helix or double helix, in which both ends of the helix have external connections, are degassed by the heavy current method. All gauges with helical grids may also be degassed by means of electron bombardment.

The 274022, 274023, 274041 and 274042 gauges utilize a squirrel cage grid and must use electron bombardment for degassing. To provide a nude gauge suitable for I^2R degassing, the 274028 and 274043 gauges were developed.

Electrical Leakage

The accuracy of pressure measurement, which depends on the measurement of currents as low as nanoamperes and below, is affected by leakage. These paths may be classified as either internal or external.

Internal and external leakage is held to the lowest possible value in designs such as the tubulated Bayard-Alpert. The collector terminal of the gauge is at the opposite end of the envelope from the grid and cathode terminals.

Designs which bring the collector out as one of a series of pins in a base or header are more susceptible to leakage problems than the tubulated design.

Internal leakage usually results from the evaporation of tungsten or thoria vapor from the cathode. This is controlled by means of a shield where the collector lead passes through the stem or header insulator. Great care must be exercised in insulating and shielding the lead to the collector terminal on the gauge from the controller.

Pumping

The ionization gauge exhibits a certain pumping capacity. This is due to both chemical and electrical effects. Chemical pumping is due, in general, to the affinity of gases for very clean surfaces. As the surface becomes saturated, the pumping action is diminished and reaches a steady state value. Readings for a typical glass tabulated gauge will be 20 to 50 percent lower during the period of chemical pumping. The duration of the pumping may be of the order of four hours at 1×10^{-9} Torr. Electronic or ionic pumping saturates after pumping approximately three months at 1×10^{-9} Torr. The most common remedy for pumping effects is to provide a passage of large conductance between the gauge and the vacuum system.

A third mechanism of pumping in gauges involves chemical reactions with the hot cathode. A number of gases such as oxygen, nitrogen, water vapor, and hydrogen have been shown to react with the carbon present in tungsten. The ratio of these reactions are dependent on the cathode temperature, and are low enough that serious errors in measurement can be avoided when high-conductance connections are used. In small systems, however, the change in gas composition may be significant.

Several gauge configurations are available to cope with the pumping phenomenon.

The glass envelope gauge equipped with 3/4-inch tubulation, such as the 274002, has adequate conductance for use down to the 10^{-8} Torr range. A gauge for use down to the 10^{-10} Torr range is available with 1-inch tubulation (274015). To compensate for the high electronic pumping speed, all internally shielded gauges should be specified with 1-inch tubulations.

Nude gauges are the best solution to severe ionization gauge pumping problems. With the nude geometry, the gauge elements can be positioned directly into the vacuum chamber, thereby eliminating the pressure differential normally associated with a tubulated gauge. The time response of this gauge system is greatly reduced as compared to the tubulated gauge.

Comparing the requirements of a given application to the items above will permit the selection of the most appropriate gauge for the purpose.

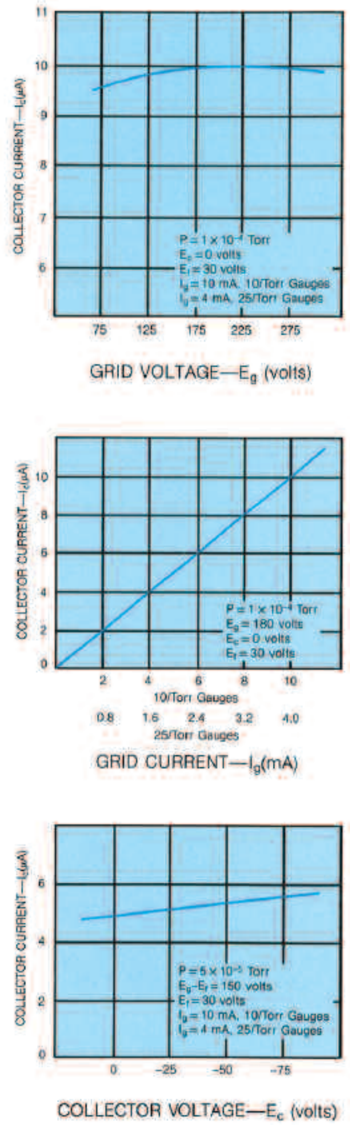


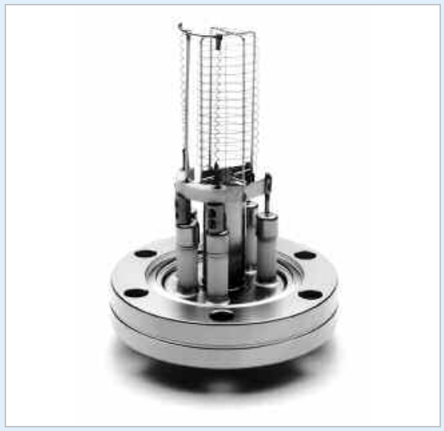
Figure 3. Operating Characteristics for Series 274 Ionization Gauge Tubes

Specifications

Tubulated Ionization Gauge

Features:

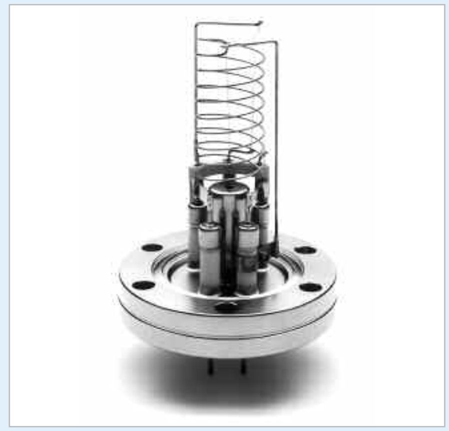
- Non-sag bifilar grid
- Burn-out resistant cathode or dual tungsten cathodes
- Tubulation— 3/4-inch or 1-inch diameters in Kovar, Pyrex or flanged
- I^2R or electron bombardment degas
- Mates with standard electric connector



Electron Bombardment Degas Nude Ionization Gauge

Features:

- Cage grid
- Burn-out resistant cathode or dual tungsten cathodes
- Electron bombardment degas
- Mates with standard flanged connector
- Uses replacement cathode assemblies



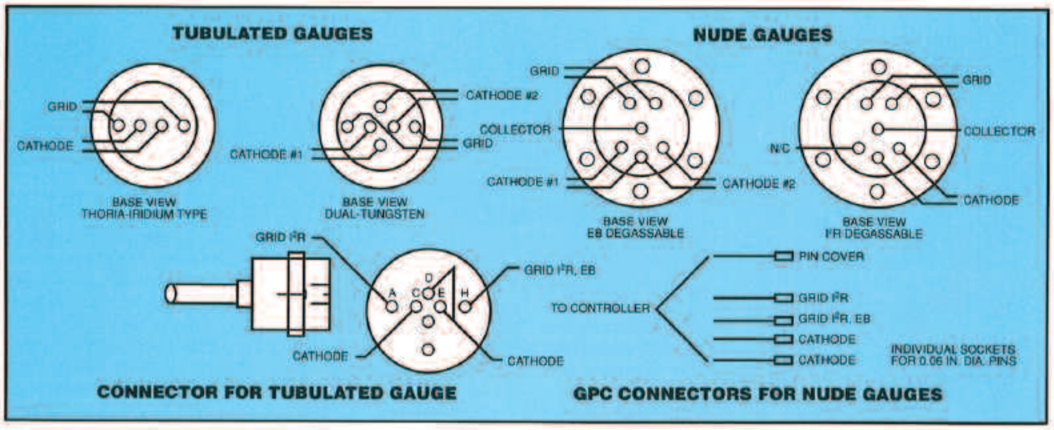
I^2R or EB Degas Nude Ionization Gauge

Features:

- Non-sag bifilar grid
- Burn-out resistant cathode
- I^2R or electron bombardment degas
- Mates with standard electric connector
- Uses replacement cathode assemblies

SPECIFICATIONS			
Physical Data	**Tubulated Gauge**	**Electron Bombardment Degassable Nude Gauge**	**Resistance Heated (I^2R) Degassable Nude Gauge**
Tubulation	3/4 in. (19mm) or 1 in. (25 mm) dia. x 2 1/4 in. (57 mm) long, Kovar, Pyrex, or flanged	N.A.	N.A.
Envelope	Nonex 7720 glass, 2 1/4 in. (57 mm) dia. x 5in. (127 mm) long	Nude with 2 3/4 in. o.d. ConFlat® flange	Nude with 2 3/4 in. o.d. ConFlat flange
Mounting Position	Any, Vertical preferred	Any	Any
Collector	Tungsten, .010 in. dia.	Tungsten, .005 in. dia.	Tungsten, .010 in. dia.
Cathode	Dual tungsten or one thoria coated iridium	Dual tungsten or dual thoria coated iridium on replaceable assembly	Thoria coated iridium on replaceable assembly
Grid	Refractory Metals	Refractory Metals	Refractory Metals
Overall Length	6 in. (152 mm)	4 1/8 in. (105 mm)	4 1/8 in. (105 mm)
Insertion Length	N.A.	3 in. (76mm)	3 in. (76mm)
OPERATING DATA			
Sensitivity for N^2	10/Torr	25/Torr	10/Torr
Typical Accuracy	±20%	±20%	±20%
X-ray Limit	About 3×10^{-10} Torr	About 2×10^{-11} Torr	About 4×10^{-10} Torr
Electron Bombardment Degas	100 watts max.	40 watts max.	100 watts max. 70 watts nominal
Resistance Heated Degas (I^2R)	6.3 to 7.5 Vac at 10 A	N.A.	6.3 to 7.5 Vac at 10 A
Bakeout	450°C	450°C	450°C
Cathode - Heating Current	4 to 6 A	2.5 to 3.5 A	4 to 6 A
Cathode - Heating Voltage	3 to 5 V	3 to 5 V	3 to 5 V
Cathode - Voltage Potential	+30 Vdc	+30 Vdc	+30 Vdc
Collector Potential	0 V	0 V	0 V
Grid Potential	+180 Vdc	+180 Vdc	+180 Vdc

Gauge Tube and Cable Connector Data



EQUIVALENT LIST
Bayard-Alpert Ion Gauge Tube Model Numbers

CATHODE	TUBULATION DIAMETER	Description	Granville-Phillips	ETI Number	Huntington Mechanical Labs	CHA Ind.	Veeco	Varian (-K2471-) (-K7360-)
IRIDIUM–Thoria Coated	3/4"	Pyrex Kovar 1 5/16" Flange 2 3/4" Flange	274002 274003 274020 274007	4336-P 4336-K 4336-F	IP-100 IK-100 IK-100-F	IG-100-P IG-100-K	RG-75-P RG-75-K	571-305
IRIDIUM–Thoria Coated	1"	Pyrex Kovar 2 3/4" Flange NW25KF	274005 274006 274008 274032	4336-P/1 4336-K/1 4336-F/1	IP-150 IK-150 IK-150-F	IG-101-P IG-101-K		571-302 571-303
TUNGSTEN	3/4"	Pyrex Kovar 1 5/16" Flange 2 3/4" Flange	274012 274013 274021 274017	4336-TP 4336-TK	TP-100 TK-100 TK-100-F	IGT-100-P IGT-100-K	TG-75-P TG-75-K	
TUNGSTEN	1"	Pyrex Kovar 2 3/4" Flange	274015 274016 274018	4336-TP/1 4336-TK/1	TP-150 TK-150			
NUDE*		Dual Tungsten EB Degas Only	274022 274041	8130T	IGT-T			971-5008
NUDE*		Dual Iridium Thoria Coated EB Degas Only	274023 274042	8130	IGT-TI			971-5007
NUDE*		Iridium Thoria Coated I^2R or EB Degas	274028 274043	8140				

Figure 4. Bayard-Alpert Ion Gauge Tube Equivalent List
* Electrically Equivalent, Pin Geometry May Vary

Granville-Phillips® Series 274 Bayard-Alpert Type Ionization Gauge Tube

Ordering Information

GLASS TUBULATED GAUGES

Single thoria-coated iridium filament

3/4 inch Pyrex glass inlet port	274002
3/4 inch Kovar metal inlet port	274003
1 inch Pyrex glass inlet port	274005
1 inch Kovar metal inlet port	274006
15 mm Pyrex glass inlet port	274036
NW25KF flange with 1 inch port	274032
1.33 inch (NW16CF) non-rotatable, 3/4 inch port	274020
2.75 inch (NW35CF) non-rotatable, 3/4 inch port	274007
2.75 inch (NW35CF) non-rotatable, 1 inch port	274008

Dual tungsten filaments

3/4 inch Pyrex glass inlet port	274012
3/4 inch Kovar metal inlet port	274013
1 inch Pyrex glass inlet port	274015
1 inch Kovar metal inlet port	274016
15 mm Pyrex glass inlet port	274037
1.33 inch (NW16CF) non-rotatable, 3/4 inch port	274021
2.75 inch (NW35CF) non-rotatable, 3/4 inch port	274017
2.75 inch (NW35CF) non-rotatable, 1 inch port	274018

NUDE GAUGES

Single thoria-coated iridium filament (resistive or electron bombardment degas)

NW40KF flange with pin guard/locking strain relief	274053
2.75 inch (NW35CF) non-rotatable	274028
2.75 inch (NW35CF) non-rotatable, pin guard/locking strain relief	274043
Replacement filament	274029

UHV NUDE GAUGES

Dual thoria-coated iridium filament (electron bombardment degas only)

NW40KF flange with pin guard/locking strain relief	274058
2.75 inch (NW35CF) non-rotatable	274023
2.75 inch (NW35CF) non-rotatable, pin guard/locking strain relief	274042
Replacement filaments	274025

Dual tungsten filaments (electron bombardment degas only)

NW40KF flange	274050
NW40KF flange, pin guard/locking strain relief	274057
2.75 inch (NW35CF) non-rotatable	274022
2.75 inch (NW35CF) non-rotatable, pin guard/locking strain relief	274041
Replacement filaments	274024

ACCESSORIES

Glass tubulated test gauge with thoria-coated iridium filament, pumped down to approximately 10^{-5} Torr and sealed off. NOT to be used as a pressure reference.	274031

Backed by GUTS®

All Granville-Phillips products are backed by the GUTS (Guaranteed Uptime Support) rapid response network, our comprehensive customer support program. When you call the GUTS service center, you are guaranteed immediate, competent response and action by a vacuum expert from our world-wide technical support staff. We're at work for you 24 hours a day, 365 days a year. 1-800-FOR-GUTS (800-367-4887).

For more information, please contact your local Brooks Automation sales representative or visit www.brooks.com.

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