THE FREDERICKS COMPANY

Industry Leading Hot Ion

Vacuum Gauges

Quality Hot Ionization Vacuum Sensors, Filaments, and Components

Principles of Operation

Welcome to the ETI® brand of The Fredericks Company! ETI® manufactures hot cathode ionization gauges (also called hot ionization gauges, hot ion gauges, or hot filament gauges) such as glass and nude Bayard-Alpert gauges. Other hot ion gauge types include triode, Schulz-Phelps, and the extractor gauge, all of which have the same basic operating principle.

Electrons are emitted from a hot filament at constant rate and accelerated towards a positively charged electron collector. In the space between the electron emitter (filament) and the ion collector, these electrons collide with gas molecules, ionizing them. Positive ions are formed, which are collected on the ion collector. The number of gas molecules ionized at a fixed electron flux is proportional to the gas density and, therefore, to the gas pressure. We can define a proportionality constant S such that:

S (Sensitivity) =
Ion collector current/(Electron collector current)(Pressure)

Where the current is in amperes and the pressure is in Torr.

The sensitivity defined in this manner is independent of the electron current over a wide range and dependent only to the gauge geometry and the gas type. This means that if you know the sensitivity (from the manufacturer's data) and the ion current at a known electron current, the pressure can be calculated.

Gas	Sensitivity
He	0.13
Ar	1.47
H_2	0.42
N_2	1.00

Table 1

Gas	Sensitivity
0_2	0.77
Dry Air	0.90
CO	1.01
CO_2	1.09

Table 2

Hot ionization gauges have different relative sensitivities for different gases and will only give true pressure measurement if the gas composition is known. Table 1 and Table 2 gives the relative sensitivity of certain common gases. Gauges which are usually calibrated for nitrogen can then be used for other gases. Essentially, the different types of hot ion gauges are determined by the shapes, sizes, and distribution of the three basic elements (electron emitter, electron collector, and ion collector).

Triode Gauges

The earliest configuration of a hot ion gauge was a simple triode vacuum tube. It was soon learned that if the functions of the grid and anode of the tube were interchanged so that the grid became the electron collector and the anode the ion collector, a higher sensitivity could be achieved. In this case electrons leaving the filament are attracted to the positively charged electron collector (grid). Due to the open nature of the grid, most of the electrons miss the grid and are repelled by the negatively charged ion collector, and then return to the grid. A significant fraction misses again, so that the electrons transit the grid-to-ion-collector space several times before finally striking the grid. This greatly increases the probability that an electron will ionize a gas molecule and that the resulting ion will strike the ion collector.

Triode gauges of small dimensions or of unusual configurations are well-suited to measurements of relatively high pressure approaching 10^{-1} Torr. However, they are limited at low pressures to 10^{-6} Torr, or in some configurations, 10^{-8} Torr.

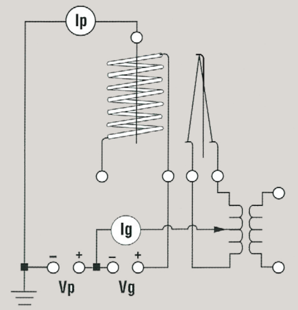
Triode Gauges and the X-Ray Limit

It was learned that the low-pressure (high vacuum) limit of the triode gauge was caused by energetic electrons striking the electron collector and producing soft X-rays. A fraction of these X-rays strike the ion collector releasing photoelectrons. An electron current leaving the ion collector is indistinguishable from an ion current arriving at the ion collector, thus setting a limit to the lowest pressure that can be measured.

Bayard-Alpert (BA) Gauges

The Bayard-Alpert gauge is essentially a triode gauge reconfigured so that only a small fraction of the X-rays discussed above are able to strike the collector.

To achieve this reconfiguration, the electron emitter filament was moved outside the grid and the massive ion collector was replaced by a fine wire in the center of the grid. The improved performance at lower pressures requires some sacrifice of high-pressure performance. The range of measurement for glass Bayard-Alpert Gauges is nominally from the 10^{-3} to 10^{-10} Torr scale. Nude Bayard-Alpert Gauges operate from 10^{-3} to 10^{-11} Torr.



Typical Bayard-Alpert Configuration

Vg = Grid Potential
Vp = Filament Bias Potential
Ip = Ion (collector) Current
Ig = Electron (Emission) Current

Electron-Simulated Ion Desorption

The Electron-Stimulated Ion Desorption (ESID) effect in Bayard-Alpert gauges is caused by ionization of adsorbed gas molecules on the electron collector by the arriving electrons. These ions are then driven by the internal electric fields in the gauge to the collector, along with the ions formed from the gas phase. The result is a falsely high apparent pressure measurement which gets proportionally worse as the pressure falls. ESID errors exhibit themselves as false high pressures or prolonged or inconsistent pump-down times and are noticeable at pressures as high as 10^{-7} Torr.

General Vacuum Practice

To ensure that the measured pressure accurately mirrors the system pressure, several factors should be considered. The gauge should be well de-gassed, especially when measuring very low pressures. The gauge should be baked under high vacuum for one hour at a temperature of at least 250°C or as high as is practical up to the maximum set by the particular gauge specification. The internal electrodes are de-gassed by heating them to a temperature of about 900°C for approximately 15 minutes. The electrode heating is accomplished by either electron bombardment (EB) or by passing a high current and voltage (I^2R) through the grid.

Gauges equipped with squirrel-cage grids or those where the grid wire is welded, brazed, or swaged to the support wire at multiple locations are usually only de-gassed by electron bombardment. The collector in present designs can only be de-gassed by electron bombardment. Grids consisting of a helix or double helix with both ends having external connections can be de-gassed by either the EB or high current I^2R method. Care must be taken to have a heavily-grounded gauge circuit and to avoid touching exposed electrodes especially during EB de-gas when higher voltages are present.

The ionization gauge has a certain pumping capacity due to both chemical and electrical effects. Chemical pumping is due, in general, to reactions on the hot filament and the adsorption of gases on very clean surfaces. As the surface becomes saturated, the pumping decreases. Pumping due to electronic phenomena continue as long as voltages are applied.

The vacuum connection between the ionization gauge and the rest of the system can have a great effect on the measuring ability and life of the gauge. If the tabulation has too small a diameter or is connected by long plumbing to the vacuum system, the gauge reading may differ from the system pressure by as much as a factor of ten. This difference is most pronounced when system pressures change rapidly and the system is at low pressures. It is wise to select the largest diameter tubulation possible or even use a nude gauge in the vacuum system. A glass gauge with 3/4-inch tubulation has adequate conductance for use down to the 10^{-8} Torr scale. A gauge with 1-inch tubulation can be used down to the 10^{-10} Torr scale.

When considering gauge placement and tubulation size, a number of factors can come into play. If the application is one where material is evaporated or sputtered, care must be taken to keep the material out of the gauge. Contamination of the gauge can severely limit life and lead to grossly inaccurate measurements. Also, operations taking place in the 10^{-2} to 10^{-4} Torr range, with relatively high voltage and current, can lead to long path arc discharge. A simple right-angle connector has been shown to lessen both the long path arc and evaporation problems, but with some sacrifice of conductance.

Manufacturer's Cross Reference

Each manufacturer's gauge is made to custom requirements and, therefore, generic gauges purchased from unknown "second sources" should be approached with caution. In some cases, generic material or approximate tolerances are used. These generic gauges may not perform as intended by the original manufacturer or are of inferior quality. It is, therefore, recommended that you contact the original manufacturer of the gauge to ensure that complete operational specifications are met. In the case where the original manufacturer no longer provides this gauge, they can best guide you to a reliable source of gauges. Several companies, no longer in operation, have made arrangements with ETI® to provide gauges that meet the exact, original specifications. If you are uncertain about the source of your replacement gauges, please contact ETI®.

Special ETI® Gauges

Selected ETI® gauges can be ordered with high stability "S" option. These gauges are manufactured with a spring-tensioned, burn-out resistant, iridium filaments, improved supports, and gold-plated connector pins. This improved design significantly reduces any variation in the filament due to grid spacing, which affects gauge sensitivity. Filament sag is eliminated and allows the user to mount the gauge in any orientation. Special materials are also used to minimize or eliminate ESID. The resultant benefit is a gauge that has double the useful life over the traditional gauges. Erroneous pressure readings due to physical/sensitivity changes are eliminated. Gold-plated pins assure that the gauge tube can be easily removed from the connector after extended use.

The improved "S" gauges can be used with all manufacturers' gauge controller electronics, and will improve system measurement stability and accuracy without having to invest in a new gauge controller.

Specialty Manufacturing Services That Promise Precision and Partnership

For more than 85 years, Fredericks has specialized in tilt and vacuum measurement products. Today, our precise manufacturing processes produce the most accurate and advanced products on the market, ensuring perfection every time. A true specialty service provider, we are willing and eager to put our experience and capabilities to good use, helping OEMs achieve even the most complex designs.

Even though timely customer service and expert product support should be a standard for doing business, in recent times we've found it to be the exception instead of the rule. Getting the quick, ongoing support you need is critical when you have time sensitive engineering challenges to work through. At that point, you don't just need a part – you need a partner, and expert product support is something you can rely on from Fredericks with anytime access to our product specialists and leadership team.

High Performance Products Designed and Manufactured with Pride in the USA

Fredericks is a global provider and U.S. manufacturer and designer of high-performance tilt and vacuum measurement products. Built to last, our products are made with state-of-the-art sensing technology, proven processes and an intrinsic passion for the trade. Offering simple integration and quality and safety benchmarks, our customers benefit not just from standard-setting reliability, but from our commitment to competitive pricing and performance.

A Partnership That Prioritizes Uptime, Lead Time, and Service

Fredericks guarantees customer satisfaction and our ‘not too big, not too small’ operation is what enables us to offer a true partnership experience. Our dedicated representatives and engineers offer exceptionally responsive service and some of the fastest lead times in the industry, knowing that uptime is the key to your success. With anytime-access to our leadership team and solutions that enhance your products, you will feel the Fredericks difference.

Vacuum Measurement Tools Built for the Toughest Jobs

Fredericks’ world-class vacuum sensors, gauges, and control instrumentation are engineered for the most demanding applications and environments. Our patented Televac® and ETI® vacuum brands feature cold-cathode technology, thermocouple and convection gauges, and precision-manufactured hot ionization gauges. Dedicated solely to vacuum gauging and calibration services, we provide industrial heating, national laboratories, cryogenics, industrial gas, and LNG applications, among many others, with fast lead times and industry-leading performance. Covering the entire practical vacuum range, our products deliver rapid response vacuum readings and superior sensitivity.

Women-Owned Small Business

Fredericks is proud to be a Women-Owned Small Business (WOSB). We are ISO 9001:2015 certified and registered with the U.S. State Department as ITAR compliant. All of our products are designed and manufactured at our facility in Huntingdon Valley, PA.

Visit our website to view all of our ETI® products, purchase online, download datasheets, and more.

www.frederickscompany.com

Contact our sales and application support teams to request a quote or answer questions about our products.

sales@frederickscompany.com

Chat with our sales and application support teams online today.

Chat with us online today!

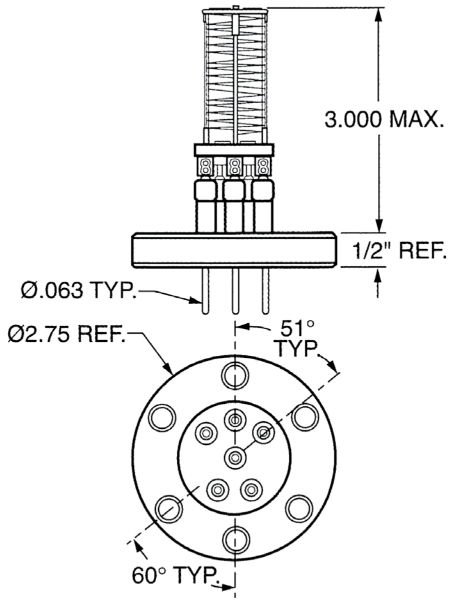
ETI® Nude Ionization Gauge Type 8130

The ETI® type 8130 nude hot ion gauge is a high-sensitivity gauge covering the vacuum range of $1*10^{-3}$ to $2*10^{-11}$ Torr.

This gauge features replaceable filaments, dual tungsten or single iridium, and a small diameter cage, with a tantalum grid on platinum-clad, molybdenum support rods. A 0.005” diameter collector is used. This results in a low X-ray limit, sensitive gauge, capable of being baked out to 450°C for those applications requiring high-temperature processing.

Physical Data

Connection	CF40 or KF40
Envelope	None
Mounting Position	Vertical
Collector	0.005” Tungsten
Filament Option 1	Replaceable Coated Iridium
Filament Option 2	Replaceable Dual Tungsten
High Stability Geometry	Available in Single Iridium Only
Grid	Tantalum and Pt/Moly Support Suirrel Cage

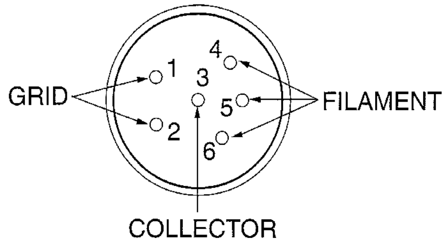


Operating Data

Sensitivity for N_2	25/Torr
X-ray limit	$2*10^{-11}$ Torr
Operating Pressure	$2*10^{-11}$ Torr to $1*10^{-3}$ Torr
Electron Bombardment De-gas	40 W @ 500 V DC
Resistance Heated De-gas	NA
Bakeout temperature	450°C

Recommended Electrical Operating Parameters

Collector Potential	0 volts
Shield Potential	NA
Grid Potential	150 to 180 V DC
Filament Current	4 to 6 A
Filament Voltage	3 to 5 V DC
Filament Potential to Ground	30 V DC



8130 Pin Configuration

Pin #1	Grid
Pin #2	Grid
Pin #3	Collector
Pin #4	Filament #1
Pin #5	Common
Pin #6	Filament #2

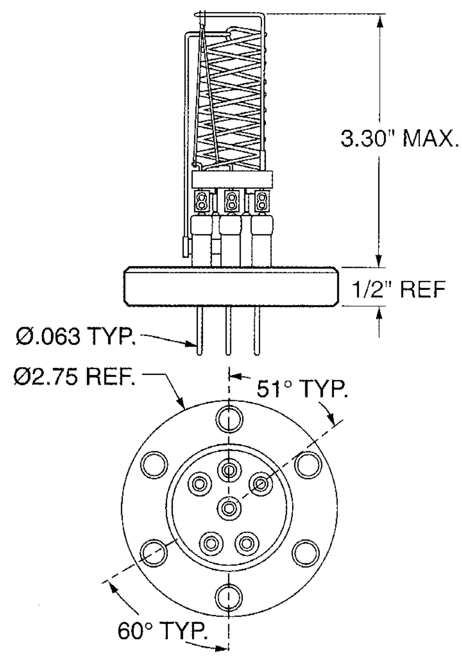
ETI® Nude Ionization Gauge Type 8140

The ETI® type 8140 nude hot ion gauge is a flange-mounted, Bayard-Alpert type for the range of $1*10^{-3}$ to $4*10^{-10}$ Torr. It is equipped with a single iridium, replaceable filament. The grid is of bi-filar construction. A 0.005” diameter tungsten collector is provided for a low X-ray limit.

The ETI® 8140 is suited to either the I^2R or the electron bombardment (EB) method of electrode de-gassing, making it compatible with either type of controller. This gauge may be baked to 450°C.

Physical Data

Connection	CF40 or KF40
Envelope	None
Mounting Position	Vertical
Collector	0.005” Tungsten
Filament Option 1	Replaceable Single Coated Iridium
Filament Option 2	Replaceable Dual Tungsten
High Stability Geometry	Available in Single Iridium Only
Grid	Tungsten Helix Configuration



Operating Data

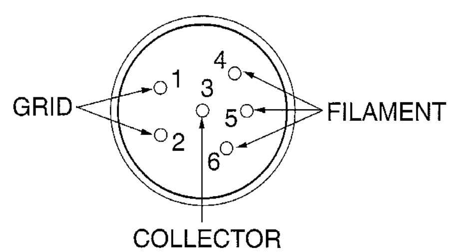
Sensitivity for N_2	10/Torr
X-ray limit	$4*10^{-10}$ Torr
Operating Pressure	$4*10^{-10}$ Torr to $1*10^{-3}$ Torr
Electron Bombardment De-gas	70 W
Resistance Heated De-gas	6.3 to 7.5 V DC @ 10A
Bakeout temperature	450°C

Recommended Electrical Operating Parameters

Collector Potential	0 V DC
Shield Potential	NA
Grid Potential	150 to 180 V DC
Filament Current	4 to 6 A
Filament Voltage	3 to 5 V DC
Filament Potential to Ground	30 V DC

8140 Pin Configuration

Pin #1	Grid
Pin #2	Grid
Pin #3	Collector
Pin #4	Filament
Pin #5	Filament
Pin #6	Not Used

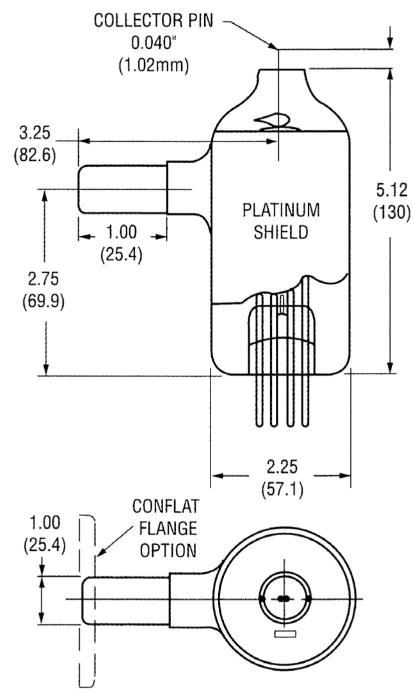


ETI® Glass Ionization Gauge
Type 8142

The ETI® 8142 ionization gauge is constructed with a rugged bi-filar grid and a single iridium filament. The interior of the tube is platinum-coated, shielding the gauge components from electrostatic and static charges which can occur in various operating conditions. This gauge contains a burn-out resistant, iridium filament.

Physical Data

Tubulation Option 1	3/4”, 1” Pyrex or Nonex Glass
Tubulation Option 2	3/4”, 1” Kovar, flanges available on request
Envelope	Nonex, platinum-coated interior
Mounting Position	Vertical
Collector	0.005” Tungsten
Filament	Single Coated Iridium
High Stability Geometry	Available
Grid	Tungsten Helix Configuration



Operating Data

Sensitivity for N_2	10/Torr
X-ray limit	$2*10^{-10}$ Torr
Operating Pressure	$2*10^{-10}$ Torr to $1*10^{-3}$ Torr
Electron Bombardment De-gas	70 W
Resistance Heated De-gas	6.3 to 7.5 V DC @ 10 A
Bakeout temperature	250°C

Recommended Electrical Operating Parameters

Collector Potential	0 V DC
Shield Potential	Connection to filament return
Grid Potential	150 to 180 V DC
Filament Current	4 to 6 A
Filament Voltage	3 to 5 V DC
Filament Potential to Ground	30 V DC

8142 Pin Configuration

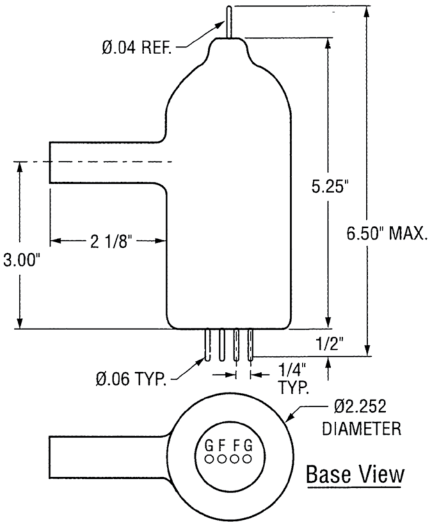
Pin #1	Grid
Pin #2	Filament
Pin #3	Filament (platinum coating connected to this pin)
Pin #4	Grid

ETI® Glass Ionization Gauge Type 4336 and 8135

The ETI® type 4336 hot ion gauge is a Bayard-Alpert type gauge available with either a burn-out resistant, single iridium-coated filament, or two tungsten filaments. ETI® was the first to incorporate a bi-filar grid design in its Bayard-Alpert gauges. Through this design, only half of the grid weight is suspended on each support, thereby making it more sag resistant during frequent outgassing conditions.

Physical Data

Tubulation Option 1	3/4”, 1” Pyrex or Nonex Glass
Tubulation Option 2	3/4”, 1” Kovar, flanges available on request
Envelope	Nonex 7720 Glass
Mounting Position	Vertical
Collector	0.005” Tungsten
Filament	Single Coated Iridium
High Stability Geometry	Available
Grid	Tungsten Helix Configuration



Operating Data

Sensitivity for N_2	10/Torr
X-ray limit	$2*10^{-10}$ Torr
Operating Pressure	$2*10^{-10}$ Torr to $1*10^{-3}$ Torr
Electron Bombardment De-gas	70 W
Resistance Heated De-gas	6.3 to 7.5 V DC @ 10 A
Bakeout temperature	250°C

Recommended Electrical Operating Parameters

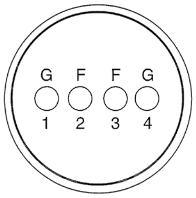
Collector Potential	0 V DC
Shield Potential	Connection to filament return
Grid Potential	150 to 180 V DC
Filament Current	4 to 6 A
Filament Voltage	3 to 5 V DC
Filament Potential to Ground	30 V DC

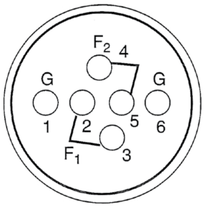
Pin Configurations

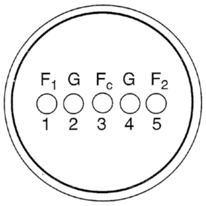
4336 Single Coated Iridium	
Pin #1	Grid
Pin #2	Filament
Pin #3	Filament
Pin #4	Grid

4336T Dual Tungsten	
Pin #1	Grid
Pin #2	Filament #1
Pin #3	Filament #1
Pin #4	Filament #2
Pin #5	Filament #2
Pin #6	Grid

8135 Dual Tungsten	
Pin #1	Filament #1
Pin #2	Grid
Pin #3	Filament Common
Pin #4	Grid
Pin #5	Filament #2







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