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

**Selecting a Vacuum Measurement System**

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

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

Within the high vacuum range:

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

Varian supplies products for all but the XHV range.

**Roughing Gauges**

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

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

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

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

A convection-enhanced thermal gauge maintains the sensing element at a constant temperature. This provides two benefits:

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

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

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

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

**High and Ultra-High Vacuum Gauges**

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

- **Hot cathode gauges** of the Bayard-Alpert (B-A) design, the only ones Varian supplies, are preferred over cold cathode gauges for their better accuracy and repeatability over time. They are offered in glass, metal, and nude versions. Because of low initial cost, a glass B-A gauge can be the most cost effective
gauge for measuring high vacuum. However, the danger of glass breakage may make a totally metal encased version, such as the MBA series, a better choice. The filament provides a ready source of electrons and therefore operation is assured over the entire high vacuum range. However, the filament is hot, and though more rugged than that of a light bulb, it is subject to degradation over time and can be damaged by shock and vibration. The filament is also a source of gas and excess electrons. These electrons generate x-rays when they hit the chamber walls and other surfaces causing an offset current, called the x-ray limit, that effectively limits the lower range of the gauge.

Hot filament gauges are available with either tungsten or thoriated-iridium filaments. Tungsten is the material of choice for low cost and stable operation or when operating with hydrogen or halogen gases. However, it runs very hot and oxidizes readily if accidentally exposed to air. Thoriated-iridium filaments operate at lower temperatures and can withstand extended exposure to air while operating before failure. The lower temperature contributes to less outgassing when used in a UHV gauge. Performance over time of these gauges is not as stable as tungsten, and the thoria coating is a potential source of particles.

The cold cathode gauges are available in magnetron and inverted magnetron versions. These gauges operate by the application of a high voltage (2-3KV) to the cathode. Field emission causes an electron to leave the cathode surface and is captured in a magnetic field. It collides with a gas molecule and starts a current flow to the anode. The magnitude of this current is proportional to gas density and pressure. Advantages of these gauges over hot filament types are that there is no filament, and hence they are very rugged, that they generate little gas, and that there is no x-ray current since there are no excess electrons to cause x-rays.

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

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

Other Considerations

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

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

Controllers

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

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

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

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

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

Choose a traditional **Rack Mount Controller** and passive gauges when:
- You want easy plug and play installation
- You need a localized display of gauge data
- You need radiation-resistance
- Your gauge cables are less than XXX feet
- You need to read pressure and gauge status from a distance
- You need UHV measurement capability
- You want to use the system on a lab bench

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

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

The Transducer depends on the pressure range you are measuring:

**Rough Vacuum**
- ~1mT to up to atmosphere

Is good measurement performance up to atmosphere important?
- Choose a Convector product

Is speed important (response time of 200msec.)?
- Choose a Convector product

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

Is a locking type connector instead of the older style octal preferable?
- Choose a Convector product

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

Is lowest cost the overriding concern and can you use a 1/8" NPT fitting?
- Choose the 531 thermocouple

**High Vacuum**
- 1mT down to 10⁻⁸ Torr

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

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

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

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

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

**Ultra High Vacuum**
- Below 10⁻⁸ Torr

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

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

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

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

Now select your controller

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

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

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

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

What pressure range do you need to measure?

**Rough Vacuum**
- ~1mT to up to atmosphere

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

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

**High Vacuum**
- 1mT down to 10⁻⁸ Torr

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

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

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

Are you replacing a traditional glass gauge?
- Select one of Varian’s glass ion gauges

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

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

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

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

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

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

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

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

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

What pressure range do you need to measure?

**Rough Vacuum**
- ~1mT to up to atmosphere

If you have chosen an IMG gauge, next select your transducers.
Varian Vacuum Technologies offers many transducer technologies for a wide variety of vacuum applications. The selection of an appropriate vacuum gauge for a particular application depends upon many factors. Some of the factors that should be considered are:

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

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

**A vacuum transducer to meet every need**

- Thermocouple
- Convection
- Cold cathode
- Hot filament
### Table of Vacuum Transducers

#### Roughing Gauges

<table>
<thead>
<tr>
<th>Transducer Model</th>
<th>Measurement Range</th>
<th>Response Time</th>
<th>Applications</th>
<th>Special Features</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>531</td>
<td>1mT to 2T</td>
<td>Slow</td>
<td>Low cost, moderate tolerance to condensibles, NPT fitting.</td>
<td>Not for use in corrosive applications. Can be mounted in any position.</td>
<td>6</td>
</tr>
<tr>
<td>536</td>
<td>1mT to 2T</td>
<td>Slow</td>
<td>Low cost, very tolerant of condensibles and corrosives, NPT fitting.</td>
<td>Fully welded stainless steel tube with interior baffle for corrosives tolerance and better performance at high pressures. Can perform to Atmosphere when used with ConvecTorr controller.</td>
<td>6</td>
</tr>
<tr>
<td>ConvecTorr</td>
<td>0.1mT to Atm</td>
<td>Fast</td>
<td>Suited for rapid, repetitive pumpdowns.</td>
<td>Like the 536 but features a locking bayonet connector.</td>
<td>7</td>
</tr>
</tbody>
</table>

#### Hot Filament Types, Bayard-Alpert

<table>
<thead>
<tr>
<th>Tube Type (Torr, N₂)</th>
<th>Measurement Range (Torr)⁻¹</th>
<th>Sensitivity (Torr⁻¹)</th>
<th>X-ray Limit @ 10 mA</th>
<th>Application</th>
<th>Special Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>563</td>
<td>4 x 10⁻¹⁰ to 1 x 10⁻³</td>
<td>10</td>
<td>2 x 10⁻¹⁰</td>
<td>General purpose gauge with better performance than 571 and 572 types. Tolerates accidental venting.</td>
<td>9</td>
</tr>
<tr>
<td>564</td>
<td>8 x 10⁻¹⁰ to 50 x 10⁻³</td>
<td>8</td>
<td>4 x 10⁻¹⁰</td>
<td>Special purpose tube for pressures as high as 50 mT. Smaller size. Tolerates accidental venting.</td>
<td>10</td>
</tr>
<tr>
<td>571</td>
<td>4 x 10⁻¹⁰ to 1 x 10⁻³</td>
<td>10</td>
<td>2 x 10⁻¹⁰</td>
<td>General purpose Hi-Vac gauge. Tolerates accidental venting</td>
<td>11</td>
</tr>
<tr>
<td>572</td>
<td>4 x 10⁻¹⁰ to 1 x 10⁻³</td>
<td>10</td>
<td>2 x 10⁻¹⁰</td>
<td>Lowest cost Bayard-Alpert gauge. Good for hydrogen and halogen gases.</td>
<td>12</td>
</tr>
<tr>
<td>MBA-100/200</td>
<td>1 x 10⁻⁹ to 30 x 10⁻³</td>
<td>15</td>
<td>5 x 10⁻¹⁰</td>
<td>Good alternative to the 563 when use of glass is prohibited. Small size, low outgassing.</td>
<td>13</td>
</tr>
<tr>
<td>MBA-200T</td>
<td>1 x 10⁻⁹ to 1 x 10⁻³</td>
<td>15</td>
<td>5 x 10⁻¹⁰</td>
<td>Alternative to the 572 when use of glass is prohibited. Small size.</td>
<td>14</td>
</tr>
<tr>
<td>UHV-24</td>
<td>4 x 10⁻¹¹ to 1 x 10⁻³</td>
<td>25</td>
<td>2 x 10⁻¹¹</td>
<td>General purpose UHV gauge. Can be baked to 250 °C. Bakeable cable available.</td>
<td>14</td>
</tr>
<tr>
<td>UHV-24p</td>
<td>1 x 10⁻¹¹ to 1 x 10⁻³</td>
<td>20</td>
<td>5 x 10⁻¹²</td>
<td>Special purpose version of the UHV-24 with higher accuracy in the 10⁻¹¹ range.</td>
<td>14</td>
</tr>
</tbody>
</table>

#### Cold Cathode Types

<table>
<thead>
<tr>
<th>Tube Type (Torr, N₂)</th>
<th>Measurement Range (Torr)⁻¹</th>
<th>Sensitivity (Torr⁻¹)</th>
<th>Emission Current</th>
<th>Applications</th>
<th>Special Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMG-100</td>
<td>1 x 10⁻⁹ to 1 x 10⁻²</td>
<td>2.7</td>
<td></td>
<td>General purpose Hi-Vac measurement when a filament is not desired. Low out gassing rate.</td>
<td>15</td>
</tr>
<tr>
<td>UHV-IMG</td>
<td>1 x 10⁻¹¹ to 1 x 10⁻³</td>
<td>2</td>
<td></td>
<td>UHV compatible gauge bakeable to 250 °C.</td>
<td>16</td>
</tr>
<tr>
<td>525</td>
<td>1 x 10⁻⁸ to 1 x 10⁻²</td>
<td>3.3</td>
<td></td>
<td>Lowest cost general purpose Hi-Vac cold cathode gauge.</td>
<td>17</td>
</tr>
</tbody>
</table>