Operation and Use of the

PVS-6

Portable Vacuum Calibration System

Outline

Gauge Tutorial

General Calibration System Operating Principles
PVS-6B Components and Subassemblies

PVS-6B Operation:

- Initial Set-Up & Start-Up Procedures
- Zeroing the System
- Manual Calibration Procedure
- Semi-Auto Calibration Procedure
- Shutdown Procedure

Calibration Procedures for MKS Baratrons

Addendum: Operation of the PVS-60

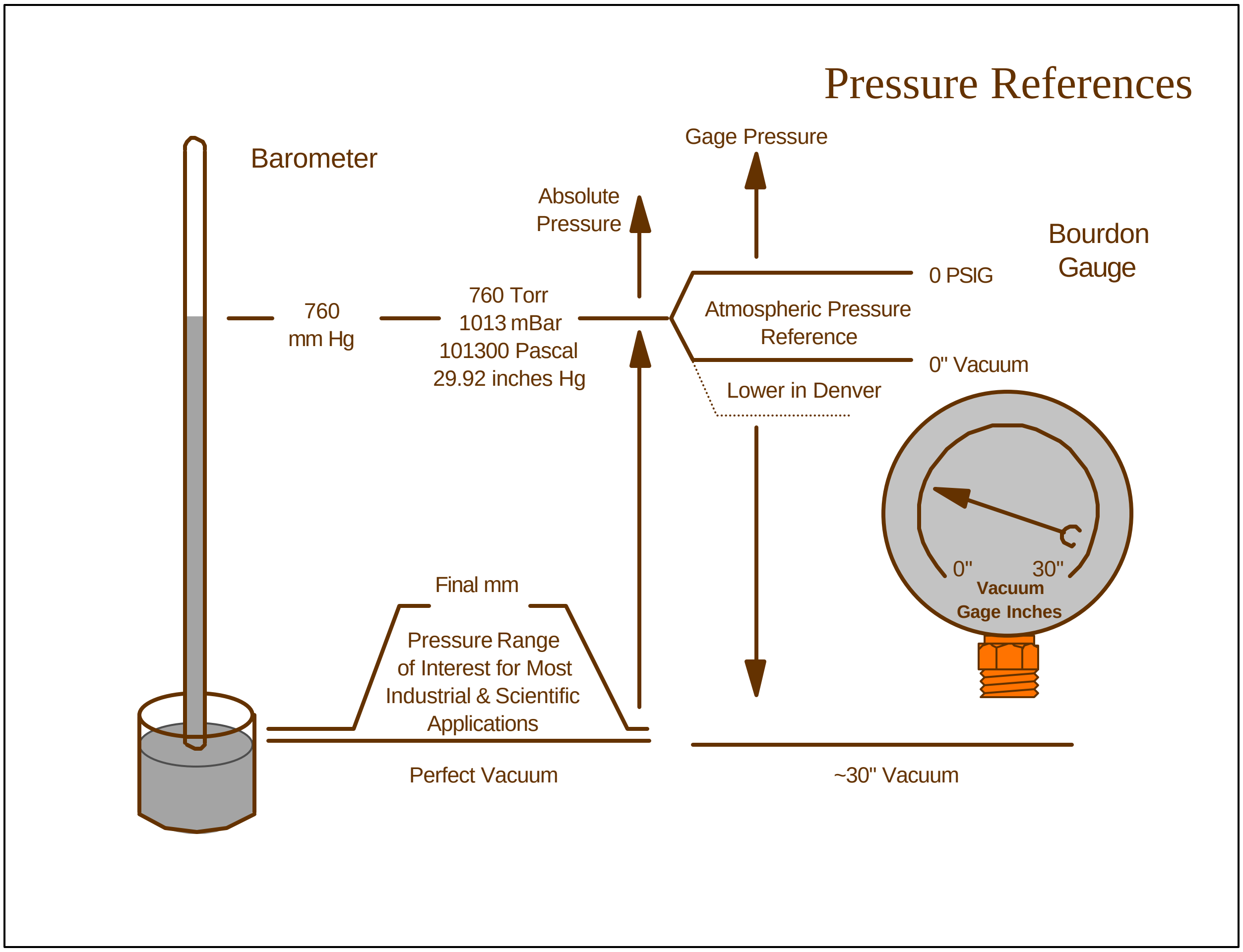
- The PVS-6B is a portable vacuum gauge calibration system using high accuracy Transfer Standard Baratrons® to provide NIST-traceable calibrations within the range of 10^-5 (0.00001) to 1000 Torr when using the applicable Transfer Standards.
- Gauges that may be calibrated against the Transfer Standards using the PVS-6B include:
  - Capacitance Manometers
  - Pressure Transducers & Transmitters
  - Thermal Conductivity Gauges (Thermocouple, Pirani & Convection Pirani)
  - Dial (Bourdon and Diaphragm) Gauges
  - Ion Gauges over the upper end of their range

Gauge Tutorial Outline

Units and Conventions

Indirect Total Pressure Gauges
- Medium Vacuum: Thermal Conductivity Gauges
- Medium to High Vacuum: Spinning Rotor Gauge
- High to Ultra High Vacuum: Ion Gauges

Direct Total Pressure Gauges
- Capacitance Manometer: Principles and Accuracy Considerations



- Gage pressure and absolute pressure are the two common ways of expressing the degree of vacuum. For our purposes, unless otherwise noted, pressure will be expressed in terms of absolute units where "0" is the total absence of pressure.
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- Gage pressure is referenced to normal atmospheric pressure, a variable quantity at best. Commonly used in rough vacuum applications with dial gauges and simple pumps, a higher reading translates to "better vacuum." In process systems, gage pressure is useful in applications such as loadlock monitoring and control where it is important or necessary to open the door either precisely at or slightly above the prevailing atmospheric pressure.
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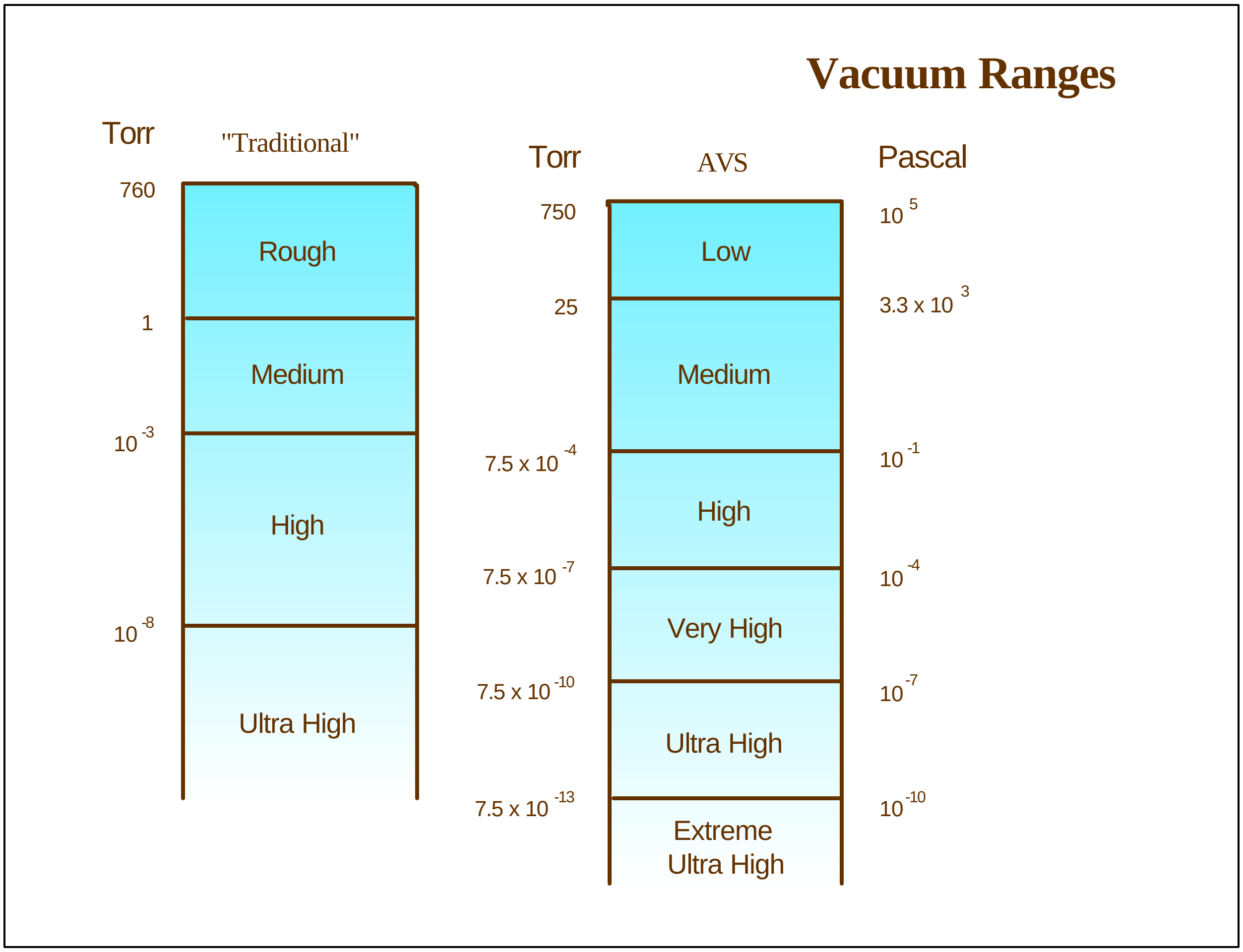
- Differential pressure is another term that is often encountered. This is simply the pressure difference that exists between any two points in a system. For example, a glove box might have a slightly higher pressure inside than exists in the surrounding ambient. This keeps room contaminants from entering the box. a differential gauge would then be of use to ensure that the proper pressure difference exists between the glovebox and the room.
-
- The oldest vacuum measuring instrument is the mercury barometer. A "standard" atmosphere of pressure will support a column of mercury 760 mm high. The Torr is the most commonly used unit and it is equivalent to a 1 mm high column of mercury in the barometer. The Pascal (Pa) is the scientifically correct unit as it is based on force per unit area (Newtons per square meter). One Bar (equivalent to 750 Torr) is equal to 100,000 Pa..



- For convenience, the various degrees of vacuum have been divided into a number of ranges, with most of the division in that "final mm" at the bottom of the barometer. These divisions are not at all arbitrary but instead are related to varying physical properties that may be found in each of the ranges.
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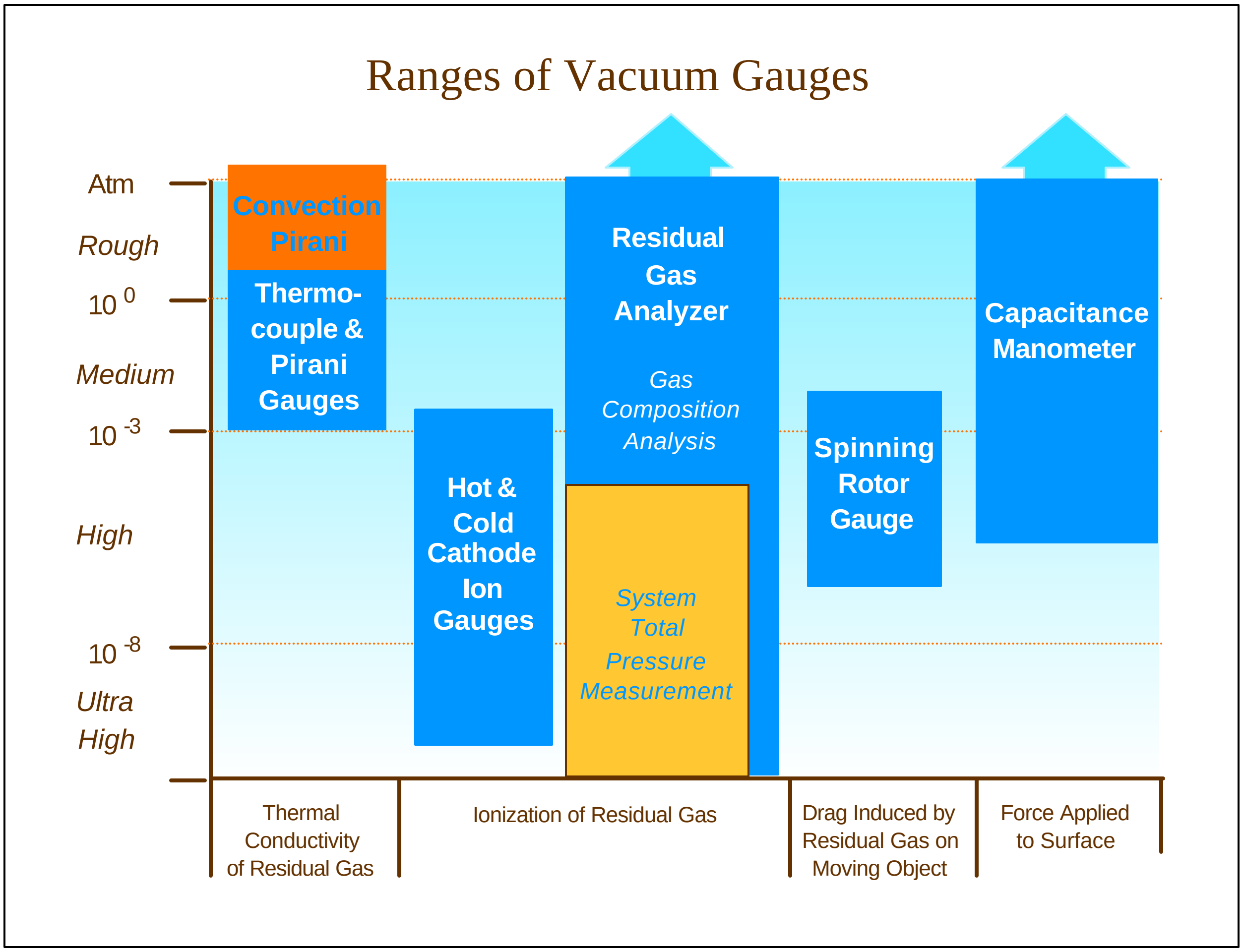

- By definition, pressure is the amount of force that is applied to a given area. Therefore, the most straightforward method of measuring pressure is by sensing how much force is applied to a surface. Common gauges that work on this principle include the Bourdon dial gauge and liquid manometers. This type of gauge is called a direct gauge since it measures true pressure.
-
- In vacuum applications, the amount of force becomes very small and these simple direct gauges lose accuracy and resolution. However, a number of physical properties of gases change in predictable ways at low pressures and it is possible to exploit these changes. All that is required of the property is that it be repeatable and able, in some way, to be related to pressure as defined as force per unit area. Such properties include thermal conductivity, the extent that the gas can be ionized, and the drag (friction) that the gas exerts on a moving surface. Gauges that measure some property are called indirect gauges.
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- Over the past several decades, direct vacuum gauges have been developed that offer high performance and accuracy into the high vacuum range. Referred to as capacitance diaphragm gauges or capacitance manometers, these instruments sense the displacement of a metal diaphragm by electronic means.
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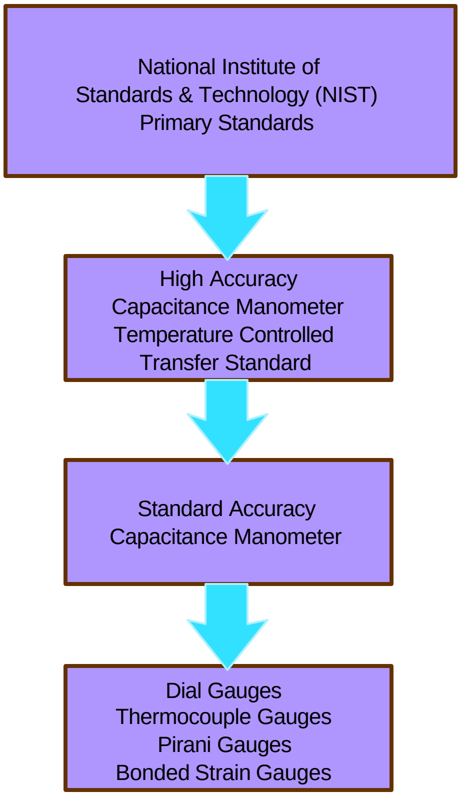
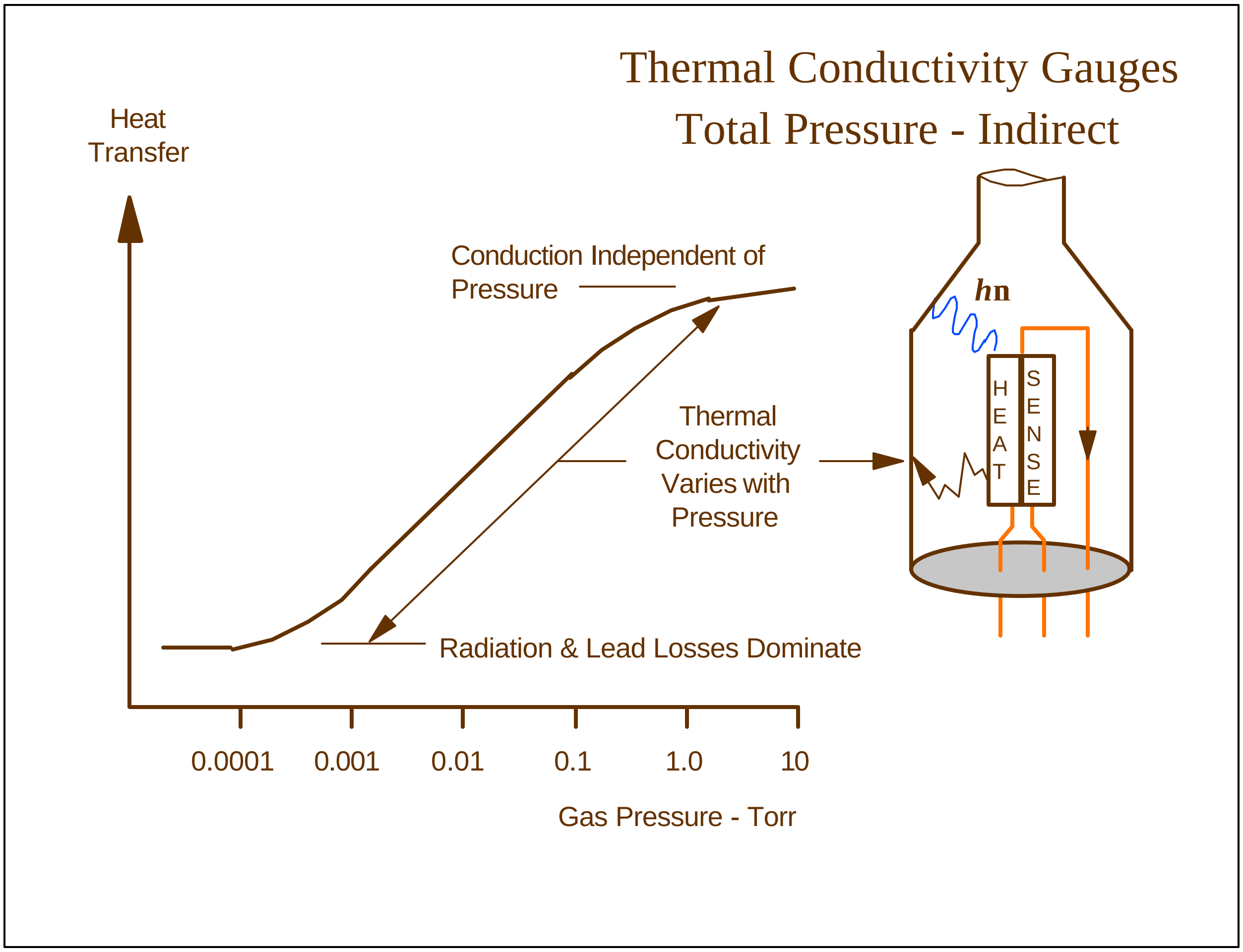
- This section will discuss the operating principles of the more important indirect gauges. Then we will look at capacitance manometers in more detail.

Hierarchy of Pressure Measurement Standards



- Direct gauges that measure on the basis of prime physical quantities (i.e. directly measurable force over an area) are called Primary Standards. Deadweight testers and liquid manometers fall into this category. Transfer Standards are high stability gauges that are traceable to NIST Primary Standards. Transfer Standards act as a convenient bridge between the Primary Standards and the various gauges used in process applications. The PVS6-B uses the MKS 690A high accuracy Baratron® as its Transfer Standard.



- A large class of indirect gauge are those that depend upon the variation of thermal conductivity of a gas through the medium vacuum range and, in some cases, up to atmospheric pressure. The two common thermal conductivity gauges, the thermocouple gauge and the Pirani gauge, both date from the early 20th century.
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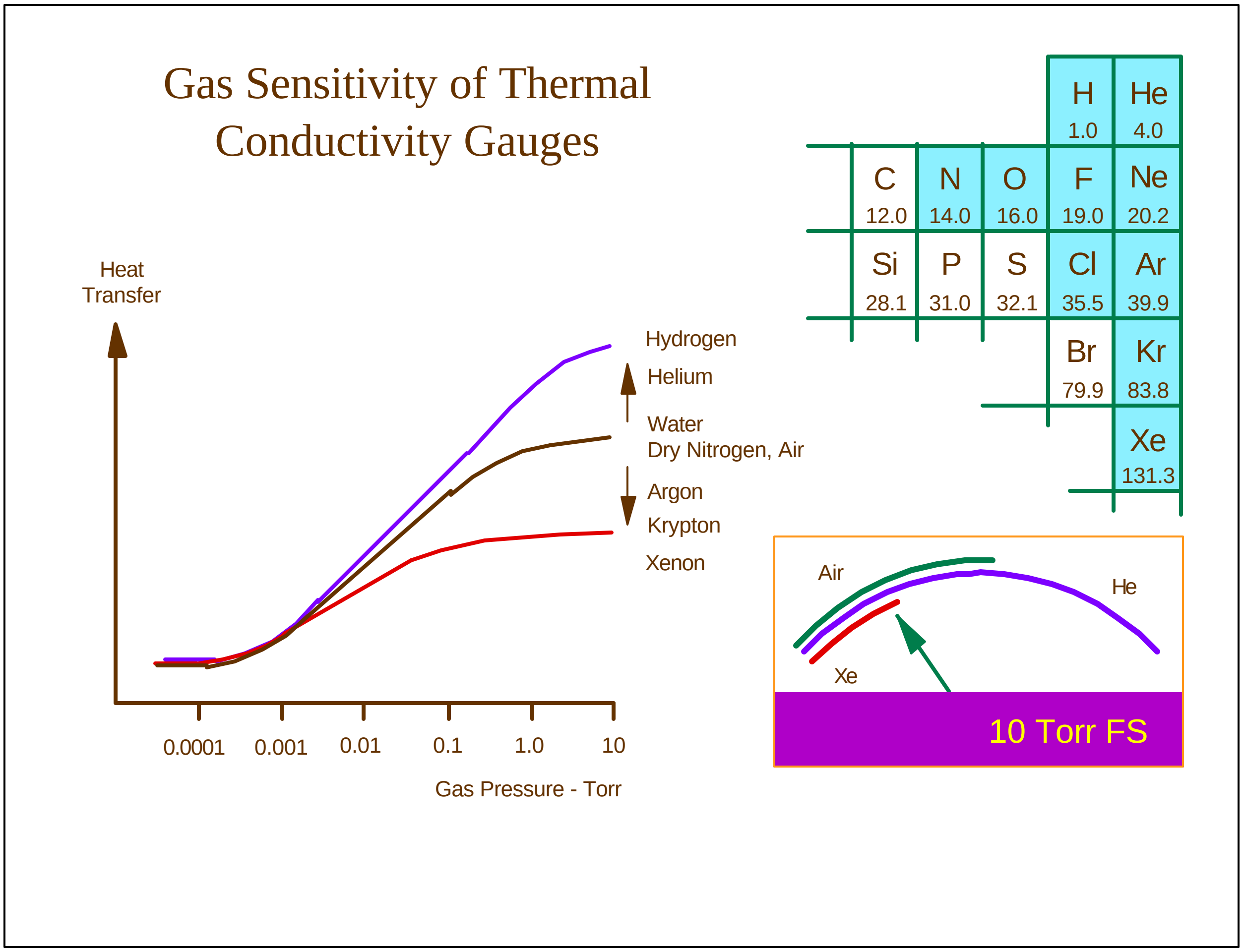
- The lower limit of usefulness is determined by the very low thermal conductance of a gas at the lower end of the medium vacuum range and the increasing background thermal losses caused by radiation from the heater and conduction through the supporting wires and leads.



- Different gases have varying thermal conductivities. Gases that are lighter than air, such as helium, are better thermal conductors because the molecules travel faster. Gases that are heavier than air, such as argon and xenon, are relatively poor thermal conductors. Since thermocouple and Pirani gauges work on the principle of thermal conductivity, their readings will change with gas type.
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- The errors are particularly large at higher pressures. Some gauges, usually Piranis, will have calibration curves for various pure gases and corrections for a few common gases (helium, argon) may be incorporated in the electronics of the controller. When calibrating a thermal conductivity gauge (or any other kind of indirect gauge) the gauge must be calibrated with the gas that the gauge will be used with.
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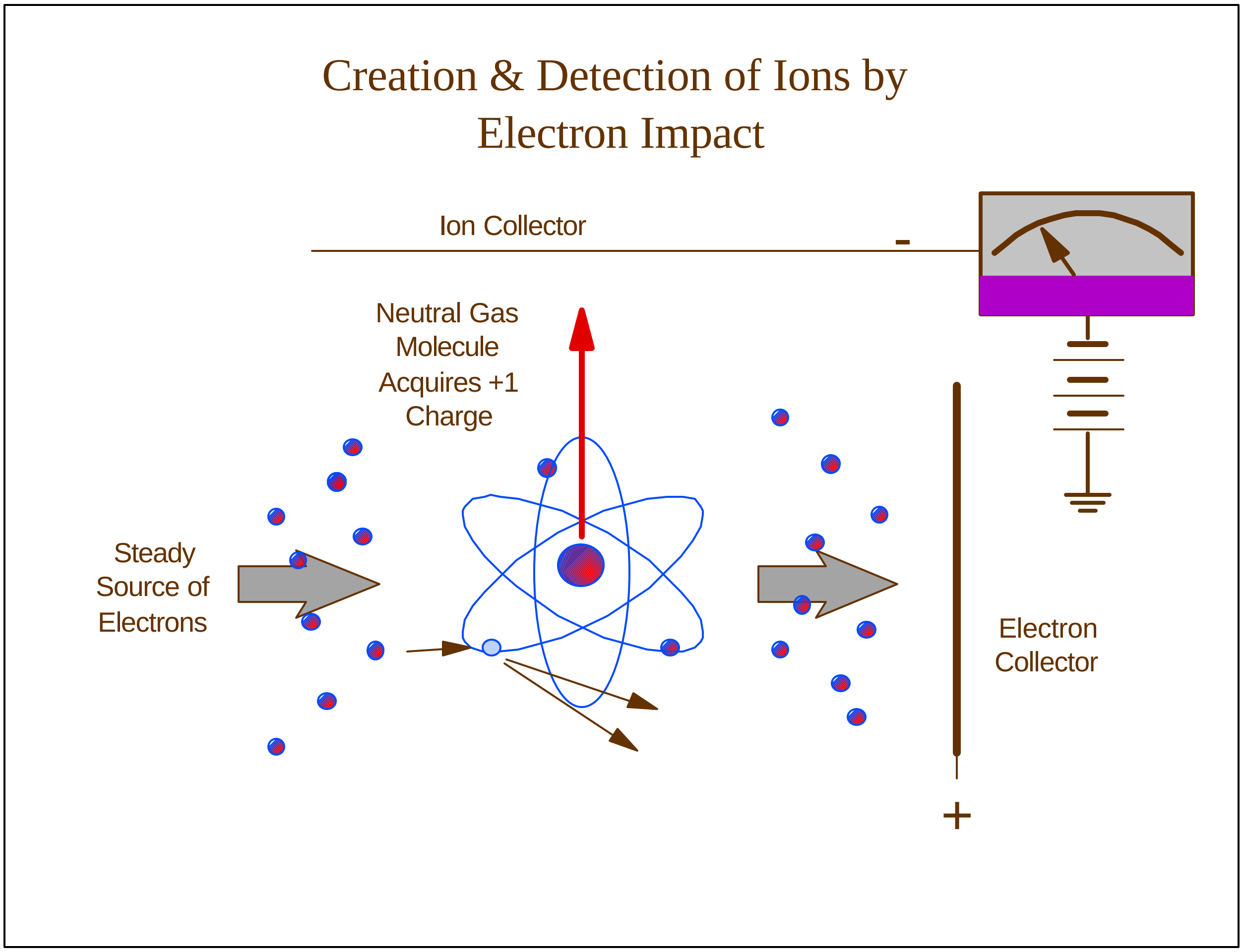
- Recommended test gases for the PVS calibration instruments are dry nitrogen, helium and argon. The gas purity should be 99.9% and water vapor content should be under 15 ppm. Gases that are hazardous, oxidizing (e.g. oxygen) or that may attack the components of the instrument must be avoided.



- The ion gauge is another type of indirect gauge. The property it measures is the number of molecules of gas that are ionized (i.e. which acquire positive charges by having one or more electrons knocked away from them) by a current of electrons passing through the gas. The number of molecules which become ionized is dependent upon the pressure (number of molecules available to be ionized), the strength of the electron current and the type of gas. Because of this last characteristic, the calibration of an ion gauge will change according to the composition of the residual gas in the vacuum system.
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- Electrons may be generated by thermionic emission from a filament or from a high voltage discharge that is sustained between two electrodes. The former type is called a hot cathode gauge, the latter a cold cathode gauge.
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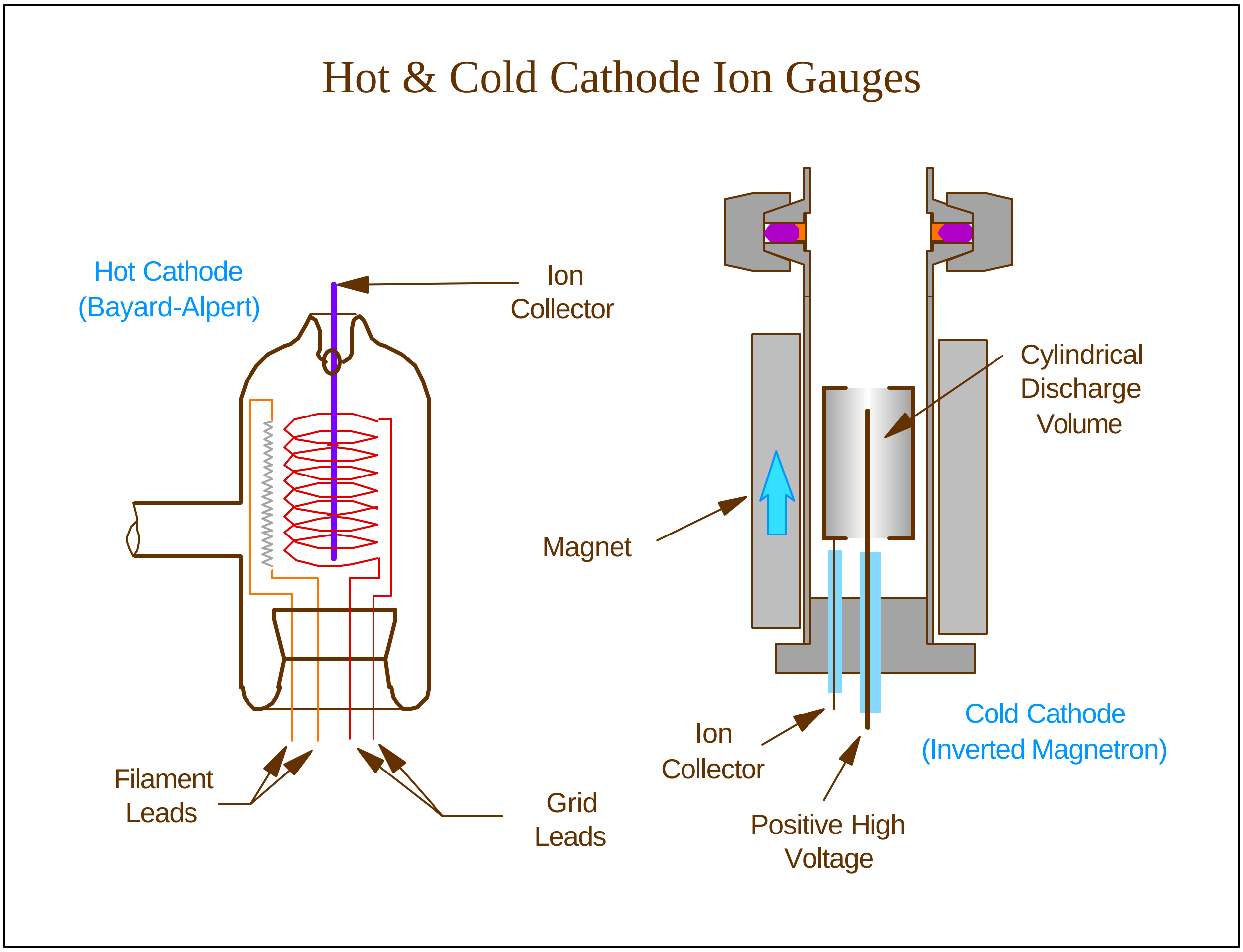

- In a hot cathode gauge, electrons are produced by thermionic emission - they are "boiled" off of a hot filament. The electrons are accelerated by means of a wire grid which is held at a positive potential. Ions that are produced by electron impact are collected by a thin collector electrode. This electrode is held at a negative potential. The current at the collector is related to the pressure.
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- The cold cathode gauge is a two electrode discharge tube. Normal discharge tubes (such as a neon sign tube) will cease to conduct at low pressures as the probability of electrons colliding with ions is too small to maintain a discharge. However, by immersing the discharge volume in a magnetic field, the electrons will move in spiral paths. This long path increases the probability of collisions sufficiently for a discharge to be maintained, even at very low pressures. The discharge current provides the measure of pressure.
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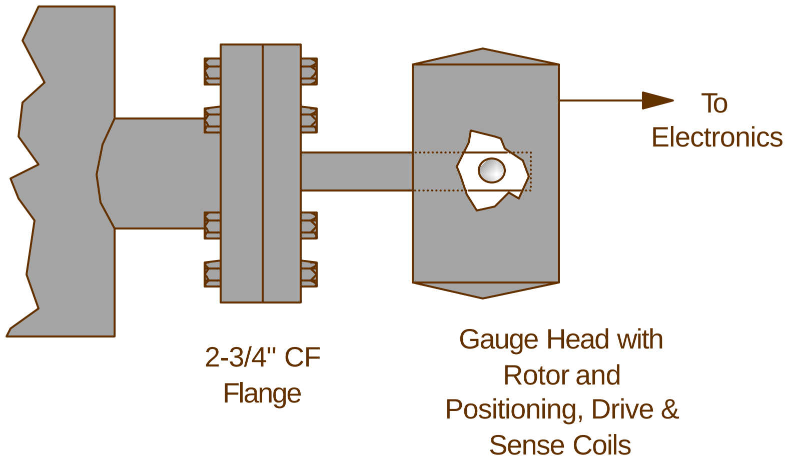
The Spinning Rotor Gauge



- The drag induced on a moving object has been employed with various levels of success for the indirect measurement of vacuum. Such drag gauges have made use of pendulums, oscillating quartz crystals, vibrating wires and levitated spinning spheres. The latter approach, first introduced in 1981 and termed the spinning rotor gauge (SRG), has been successfully developed into a highly accurate and repeatable gauge that covers the range of 5 x 10e-7 Torr to 10e-2 Torr. This gauge may be used as a transfer standard for the calibration of other gauges, especially ion gauges where there is a substantial overlap between the upper end of the ion gauge range and the range of the SRG.
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- The head of the SRG contains a tube within which is a small (4.5 mm diameter) stainless steel ball. The ball is levitated and stabilized within the tube by a combination of permanent and electromagnets. Another set of coils drives the ball to a rotational speed of about 400 revolutions per second. Finally there are sense coils that detect the speed of the ball. In operation the ball is run up to speed whereupon the drive is turned off and the decay in rotational speed is detected and translated into a pressure measurement.
-
- The controller calculates the pressure given: The molecular weight of the gas, the ambient temperature, the diameter and density of the ball, other coefficients including low pressure residual drag (mainly induced by eddy currents in the ball) and the "accomodation coefficient" which deals with how energy is transferred from the ball to the gas.
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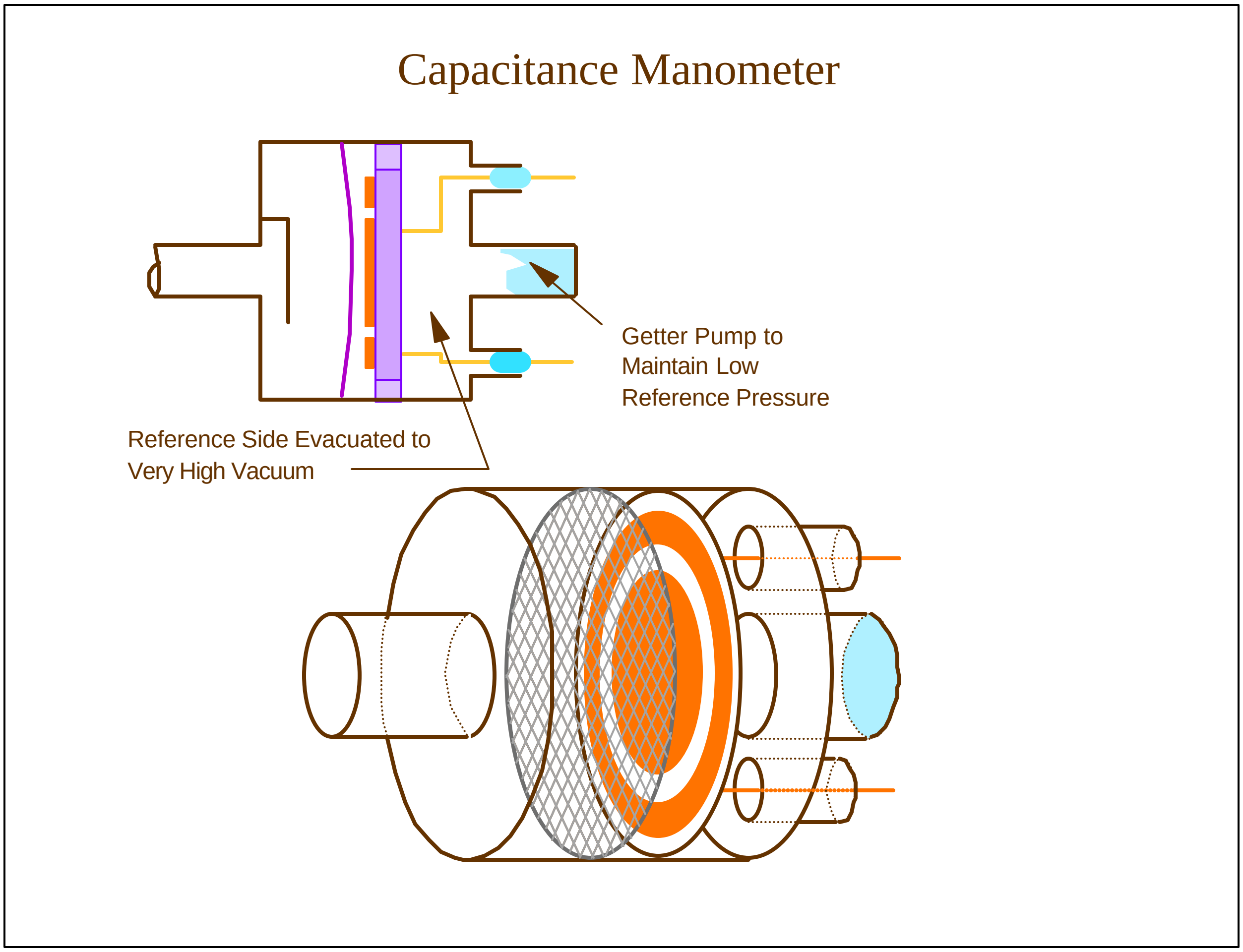
- Because of the intermittant nature of the readings, SRGs are not appropriate for applications where continuous reading are required. They also cannot be used in applications where the ball could be contaminated or etched.



- A capacitance manometer uses the capacitance between a metal diaphragm and an electrode structure to measure pressure. With a highly evacuated reference side, a reduction in pressure on the measurement side will cause the diaphragm to move away from the adjacent dual-electrode structure, toward a state of lower tension. A precision bridge circuit translates the capacitance measurement into a pressure reading.
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- A capacitance manometer measures true total pressure independent of gas species.
- The thin tensioned Inconel diaphragm provides:
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- Very low hysteresis
- Excellent repeatability
- Excellent cycling capability
- Excellent corrosion resistance
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- The gauge also has a high level voltage or current output.
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- Accuracy is usually stated as % of reading and performance is maximized by minimizing temperature effects.
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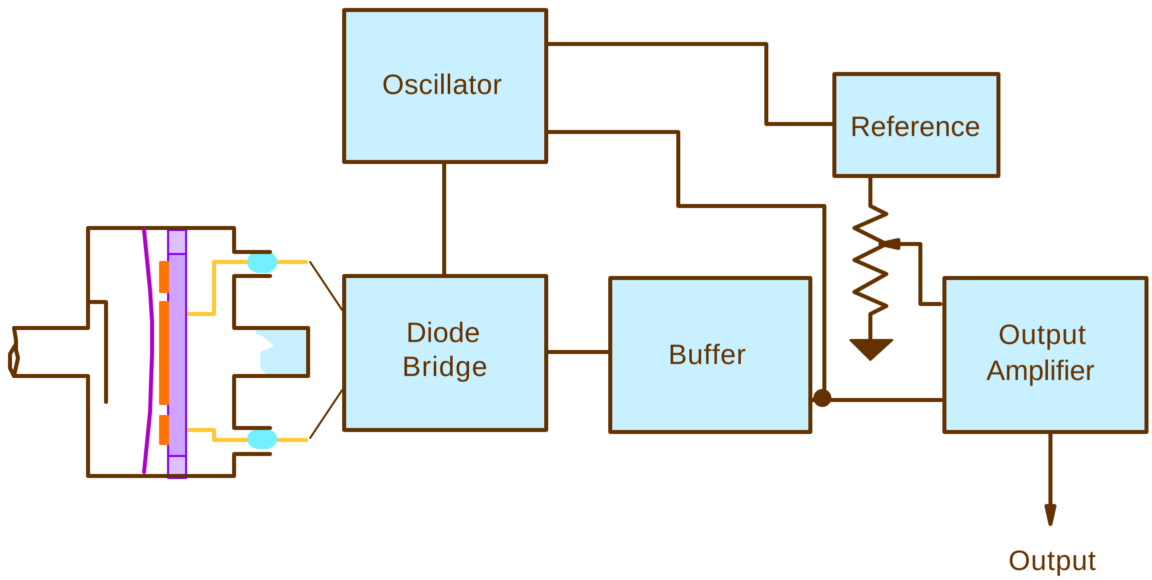
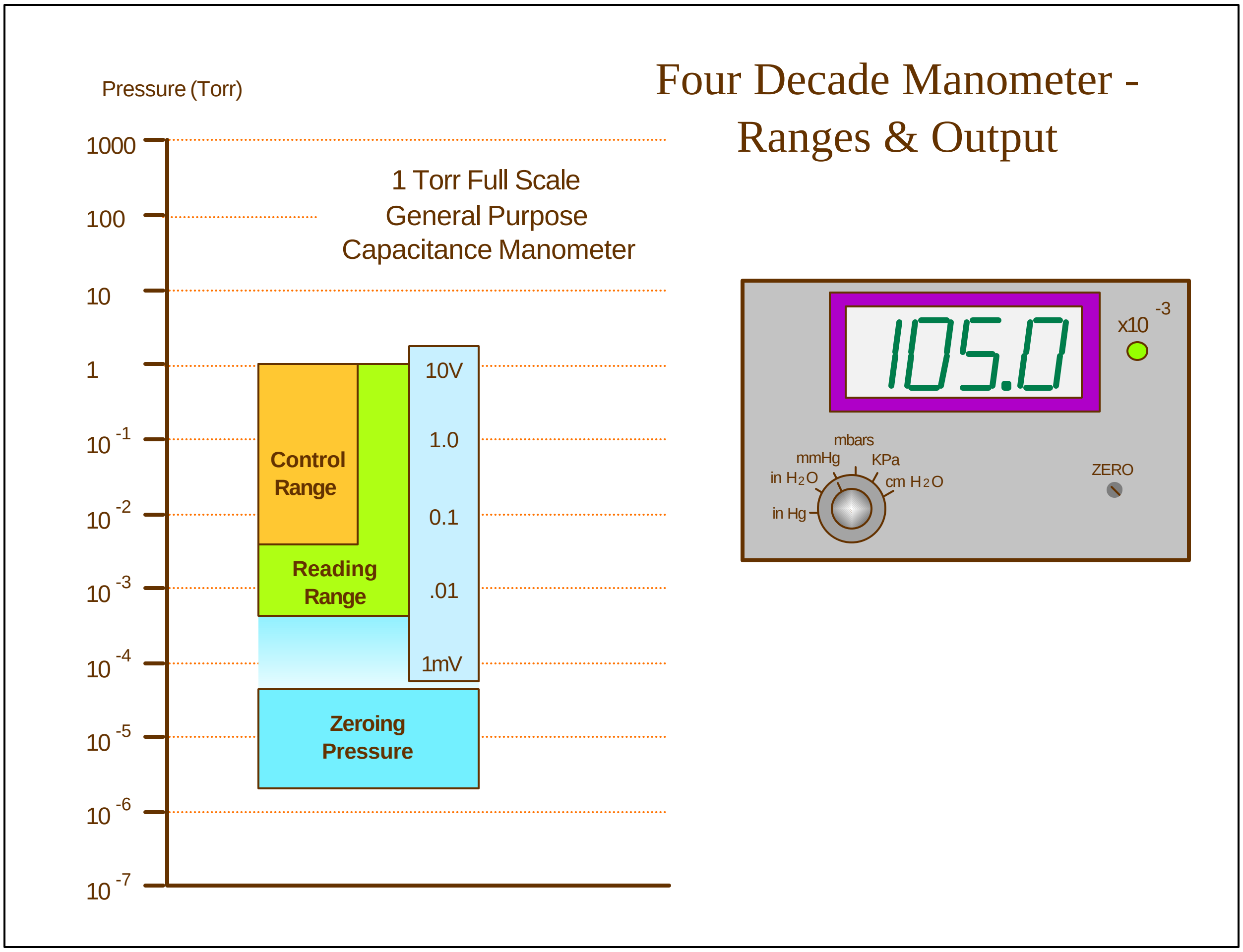
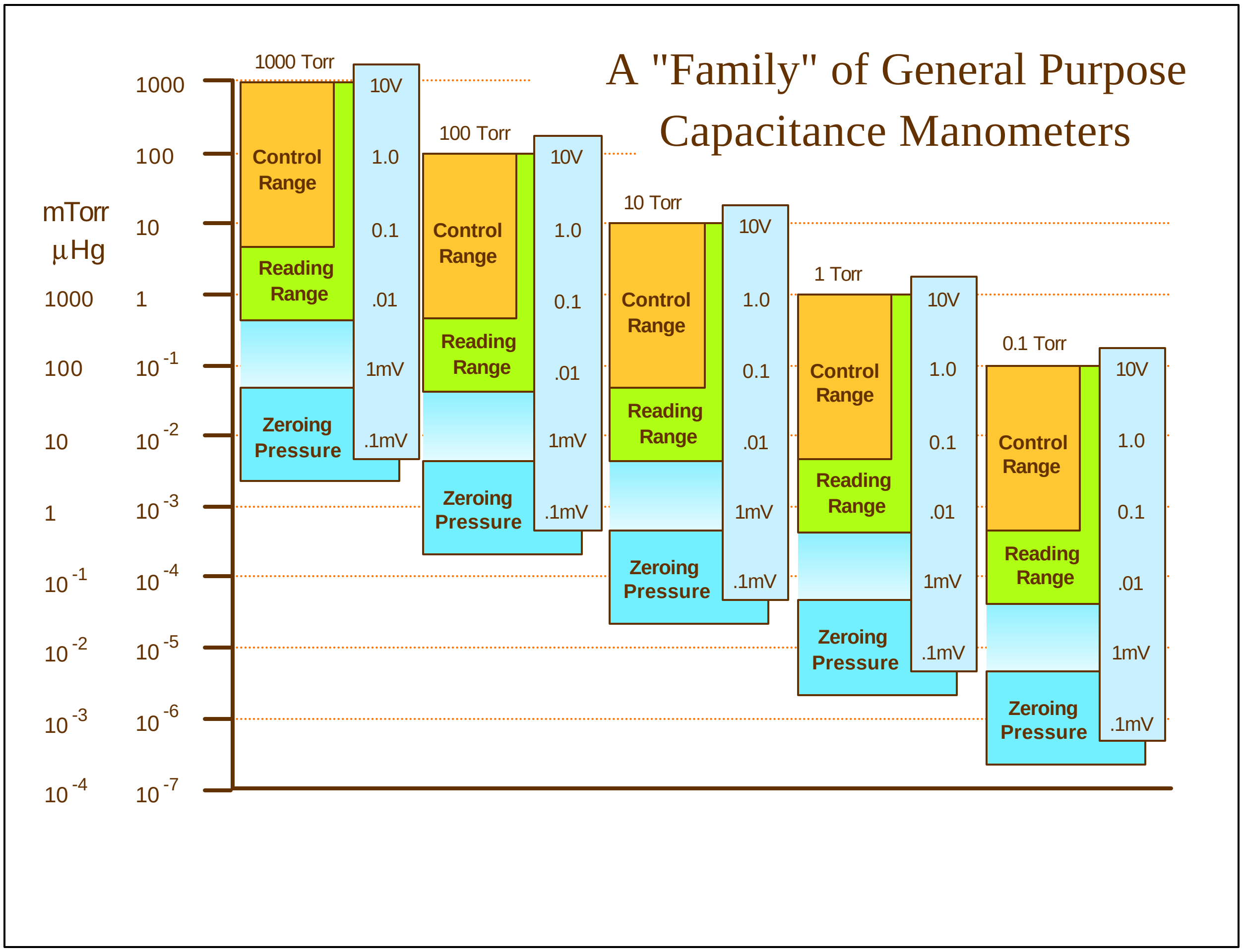
Sensor and Signal Conditioner Electronics



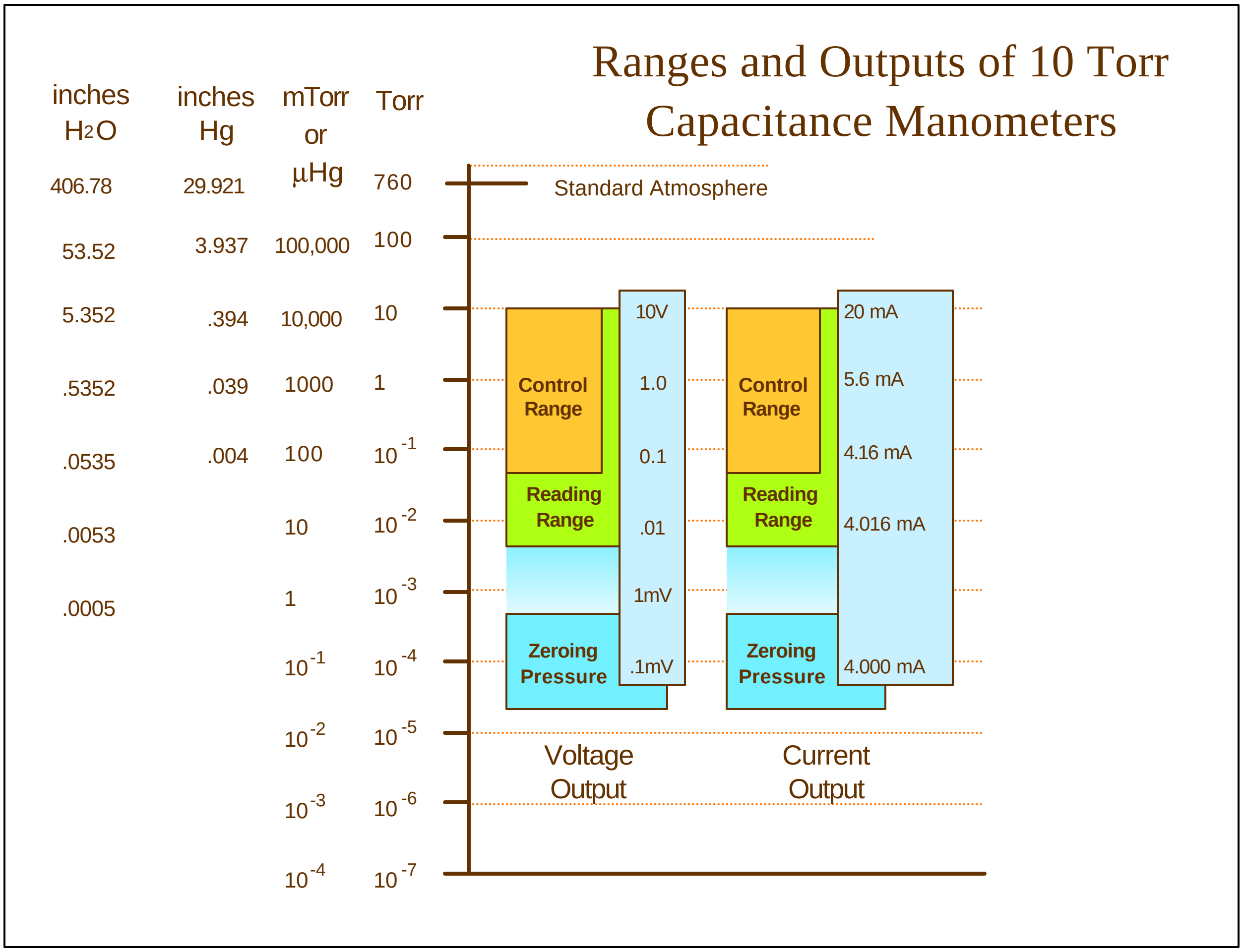
- The electronics consists of a precision sine-wave oscillator that drives the bridge circuit. An imbalance in the sensor electrode capacitances produces a difference output that is amplified by the buffer. The gain of the output amplifier is adjusted by a potentiometer that sets the span, or range, of the instrument.
- While span is factory set, a user-adjustable zeroing pot (not shown) is necessary and is provided.
- The electronics is of very high stability and produces a high level output. The circuitry is usually located within the same enclosure as the sensing element.



- Typically, a capacitance manometer's signal conditioner will provide an output varying from 0 to 10 volts with a linear relationship between voltage and pressure. Capacitance manometers are described by their full scale pressure (i.e. the pressure corresponding to 10 volts) and the number of pressure decades covered.
- The lower end is limited by the resolution of the electronics. When a capacitance manometer is used for pressure control, it is recommended that a narrower range of pressures be used (the control range) to assure that the control device is operating sufficiently above the instrument's noise floor.
- In the case of an absolute instrument, zeroing should be performed at least a full decade below the minimum of the reading range.
- The electronics readout, which takes the signal conditioner output, translates the voltage signal to a useful pressure reading.

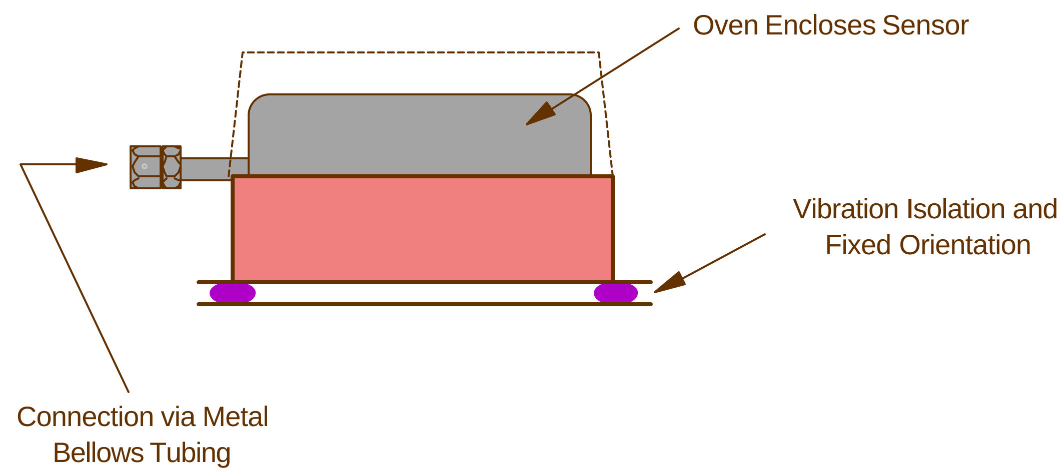


• Families of capacitance manometers are manufactured with overlapping ranges. Some applications and processes may require multiple manometers.

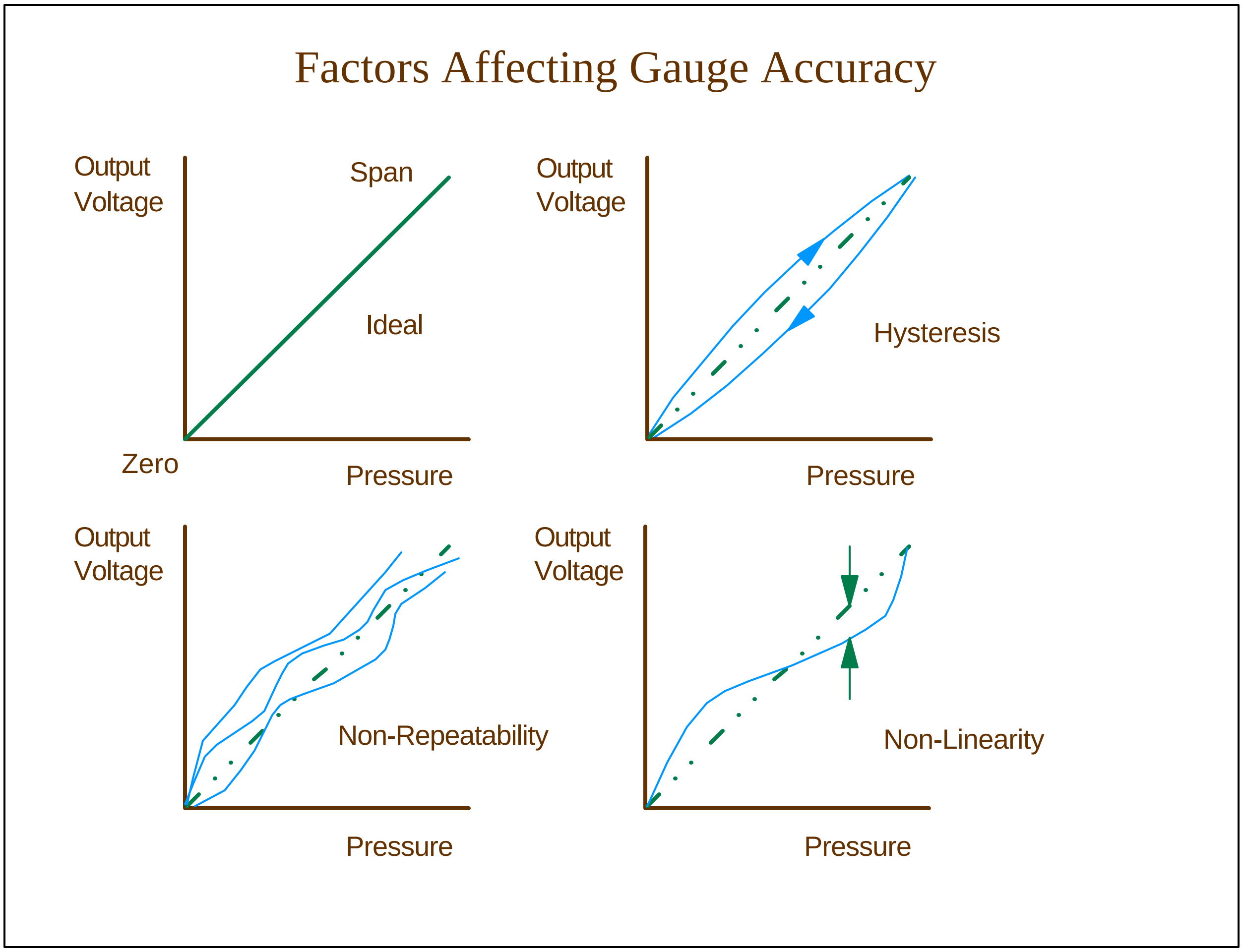


Ranges and Outputs of 10 Torr Capacitance Manometers
inches H2O
inches Hg
mTorr or µHg
Torr
406.78
29.921
760
Standard Atmosphere
53.52
3.937
100,000
100
5.352
.394
10,000
10
.5352
.039
1000
1
.0535
.004
100
10 -1
.0053
10
10 -2
.0005
1
10 -3
10 -1
10 -4
10 -2
10 -5
10 -3
10 -6
10 -4
10 -7
Control Range
Reading Range
Zeroing Pressure
10V
1.0
0.1
.01
1mV
.1mV
20 mA
5.6 mA
4.16 mA
4.016 mA
4.000 mA
Voltage Output
Current Output

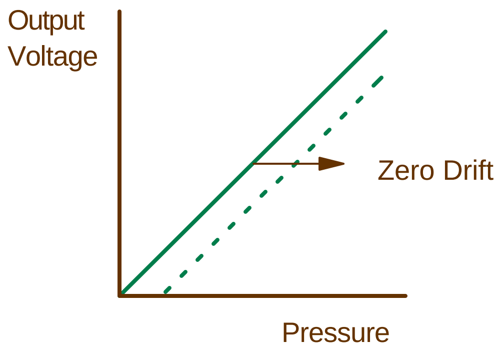
High Accuracy Capacitance Manometers



- This is the configuration for the 690A Transfer Standard that is supplied with the PVS-6B.

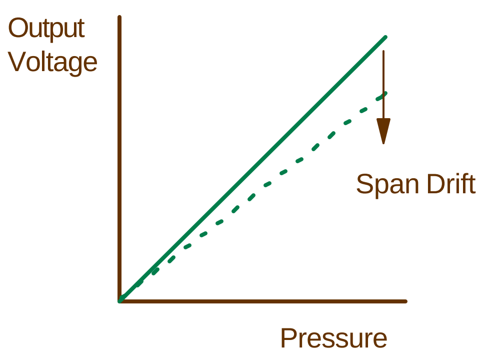

Factors Affecting Gauge Accuracy
Output
Voltage
Span
Ideal
Zero
Pressure
Output
Voltage
Hysteresis
Pressure
Output
Voltage
Non-Repeatability
Pressure
Output
Voltage
Non-Linearity
Pressure

Other Factors Affecting Gauge Accuracy: Temperature Coefficients



Zero Temperature Coefficient (Thermal Zero Drift)

The Zero Drift Due to Changes of the Ambient Room Temperature. Usual units are ppm of Full Scale per Degree C

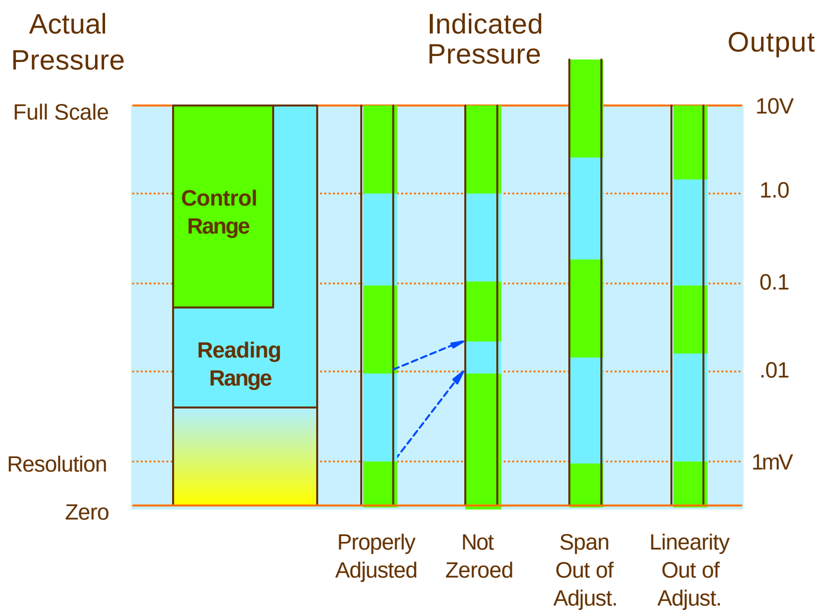


Span Temperature Coefficient (Thermal Span Drift)

The Error Induced Across the Entire Range of the Instrument from Changes in the Room Ambient Temperature. Usual Units are ppm of Reading per Degree C

- Drifting of the zero is minimized by ensuring that the ambient temperature around the gauge remains relatively stable. Avoid positioning the manometer near air ducts or heaters. If temperature fluctuations are unavoidable, check and adjust the zero as frequently as necessary. A heated manometer may be required in some situations.

Zero, Span, Linearity



- When a capacitance manometer's electronics are properly adjusted, there will be a direct correspondence between pressure input and voltage output.
-
- If the zero is misadjusted, an offet will be induced across the entire range of the instrument.
- If the span is out of adjustment, the overall range will be greater or smaller than it should be.
- If the linearity is out of adjustment, the endpoints (zero and full scale) may be correct, but the intermediate readings may be in error.
-
- The most common source of reading inaccuracy occurs when the manometer is either not zeroed or is improperly zeroed. This has the effect of moving the entire range of the instrument. For example, if a 1 Torr full scale manometer has a zero offset of 2 milliTorr (i.e. 20 millivolts), every reading will have that offset as part of the instrument's error. Thus, a pressure reading at 10 milliTorr would produce a reading of 12 milliTorr, other sources of error aside. A reading at 800 milliTorr would produce a reading of 802 milliTorr. Thus, expressed as a percent of reading error, the degree of error is more significant at the low end of the instrument's range.
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- Zeroing should be done upon installation and should be checked on a regular basis. The frequency will primarily depend upon environmental conditions such as changes in ambient temperature or physical orientation of the instrument.
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- To put this in an everyday perspective, it's much like using dial calipers. Zeroing is done frequently. The span and linearity are inherent in the original engraving and mechanical construction of the instrument.
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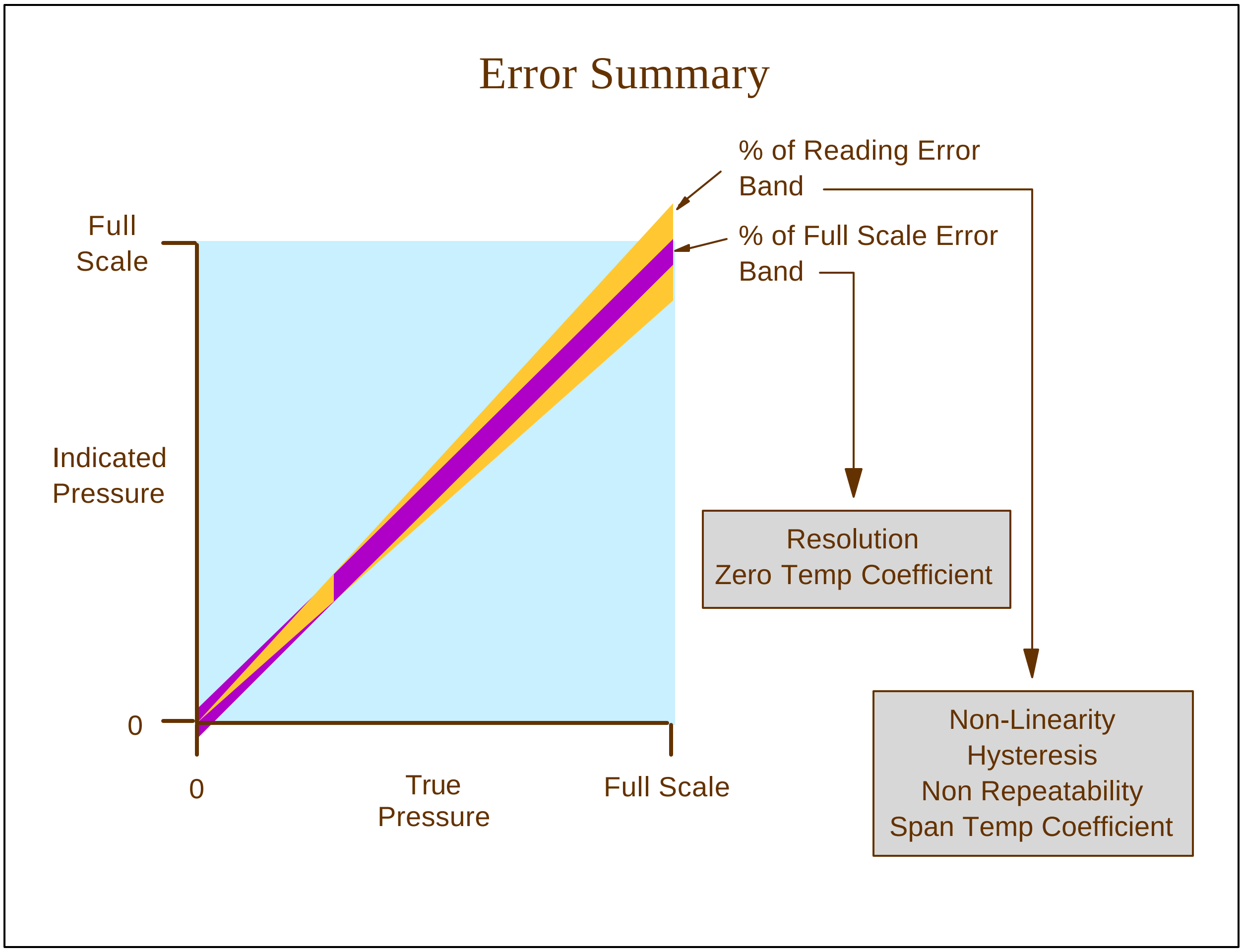

- Capacitance manometers are specified with an accuracy in terms of percent of reading. This accuracy figure includes non-linearity, hysteresis and non-repeatability.
-
- For example, a manometer that is used for high accuracy process control might have a specified accuracy of 0.25% of reading. For a 100 Torr FS transducer, that means that the error could be up to 0.25 Torr at 100 Torr, up to 0.025 Torr at 10 Torr, etc. In other words, the absolute value of the error declines through the measuring range. The span temperature coefficient is also a percent of reading type of error.
-
- There are also percent of full scale errors that can add to the percent of reading errors. These are primarily due to environmental effects such as temperature changes. The zero temperature coefficient is one such error. Improper zeroing will also result in this form of error.
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- Since drifts in the zero can cause errors that are larger than the inherent percent of reading errors, especially at the lower end of the instrument's range, it is especially important to maintain a relatively constant thermal environment around the transducer and check the zero setting on a regular basis.
- Finally, the resolution of the instrument shows up as a percent of full scale error since the resolution is specified in terms of the full scale range.
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- As can be seen from the chart, the inherent percent of reading errors tend to dominate in the upper part of the instrument's range. The percent of full scale errors tend to dominate the lower end.
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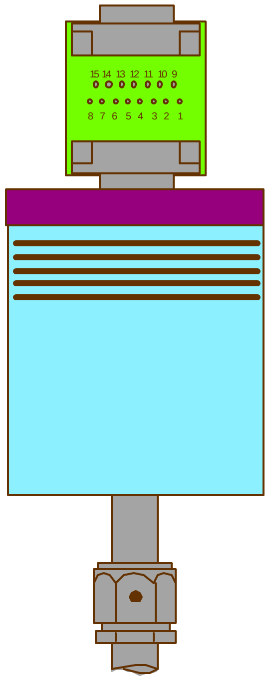
Troubleshooting



Vacuum Applied During Warm Up (1 Torr FS and Under) & Testing

Breakout Connector for Electrical Troubleshooting

Check Power Supply Voltage & Stability, Zero Adjustment, Signal Voltage/Pressure Correspondence

Adequate Warm Up Time?

Non-Temperature Regulated, All Ranges:	15 min.
Temperature Regulated, 1 Torr & Above:	4 hrs.
Temperature Regulated, Below 1 Torr	8 hrs.

Proper Zeroing Pressure?

Full Scale Range (Torr)	Highest Pressure for Zeroing (Torr) - General Purpose
0.1	$<5x10^{-6}$
1.0	$<5x10^{-5}$
10.0	$<5x10^{-4}$
100.0	$<5x10^{-3}$
1000.0	$<5x10^{-2}$

- Improper operation of capacitance manometer may often be traced to factors such as:
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- Inadequate warm-up time as indicated by drifting of the output pressure signal
- or zero adjustment.
-
- Improper zeroing as indicated by non-repeatability of a pressure measurement.
-
- Power supply voltages either not present or noisy as indicated by no output pressure signal or an erratic output.
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- Zeroing pressures for temperature controlled and high accuracy instruments should be performed at or below the manufacturer's specified resolution.
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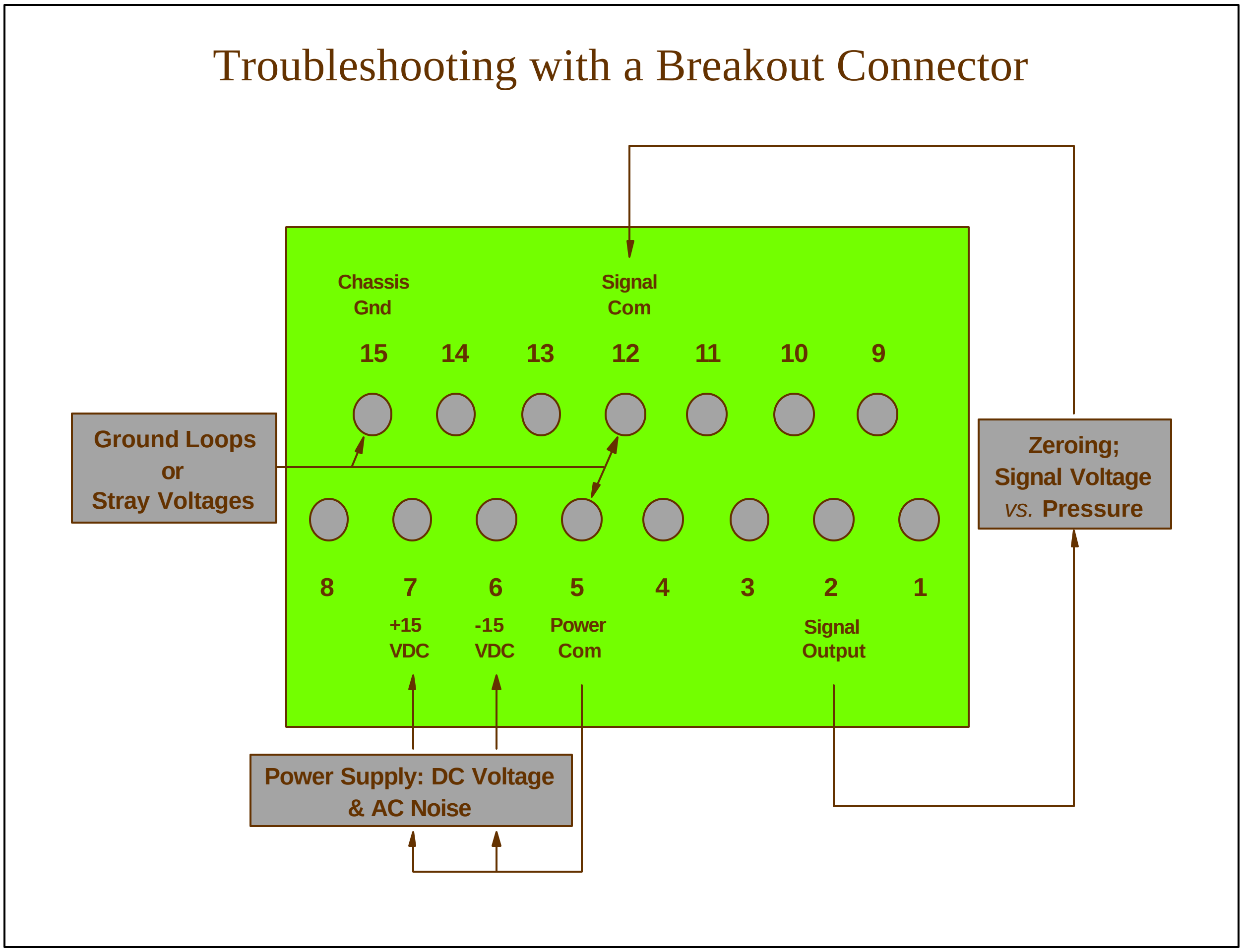

- Install a breakout connector as shown in the illustration. Using a DVM:
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- With the DVM set to measure DC voltage, check the plus and minus 15 volt power connections..
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- With the DVM set to measure AC voltage, ensure that the AC noise is less than 50 mV RMS on the plus and minus power connections.
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- With the DVM set to measure DC voltage, check for ground loops or stray voltages between the common and ground pins. No voltage should be present between any pair.
-
- With the DVM set to measure DC voltage, the output pin should measure between 0 and 10 VDC, proportional to pressure and depending upon the full scale pressure rating of the transducer. For example, a 1 Torr full scale transducer will create a 1 volt change for every 100 milliTorr change in pressure.
-
- Check to ensure that the pressure as measured at the transducer pin corresponds to the pressure that is displayed on the screen of the controller. If not, there is a problem with the A/D conversion. Check the A/D calibration.
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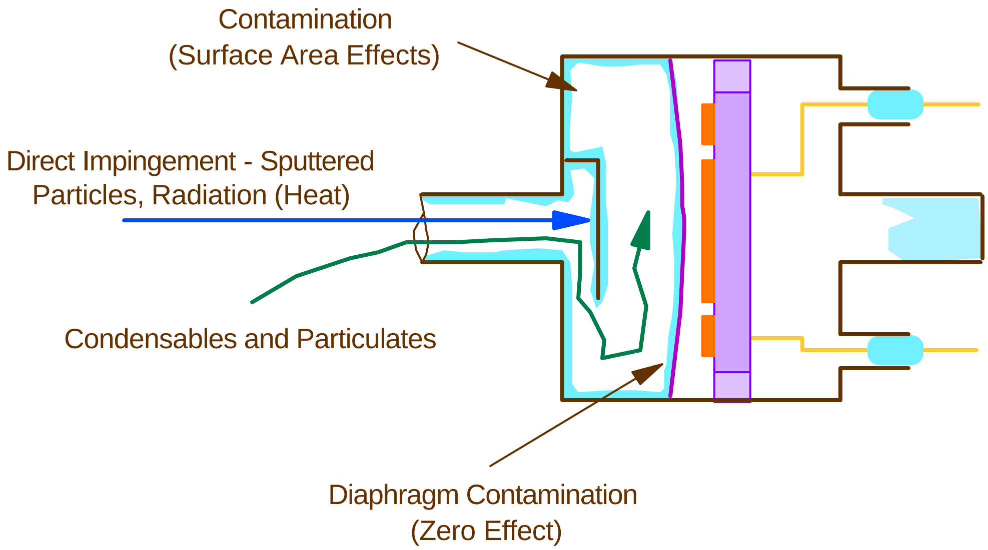
- At or below the maximum zero adjustment pressure, the output signal pin should read 0.000 volts. If not, adjust the zero pot.

Zero Shift

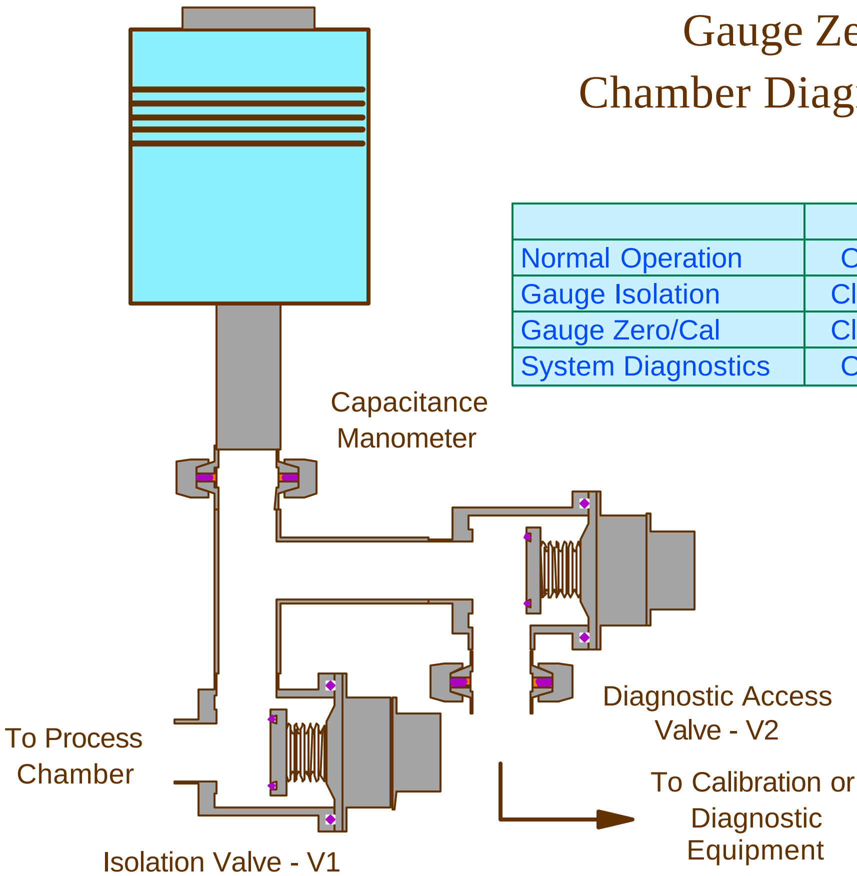


Observed as an offset in the output, increasing over a period of time. Almost always due to a build-up of particulates on the diaphragm.

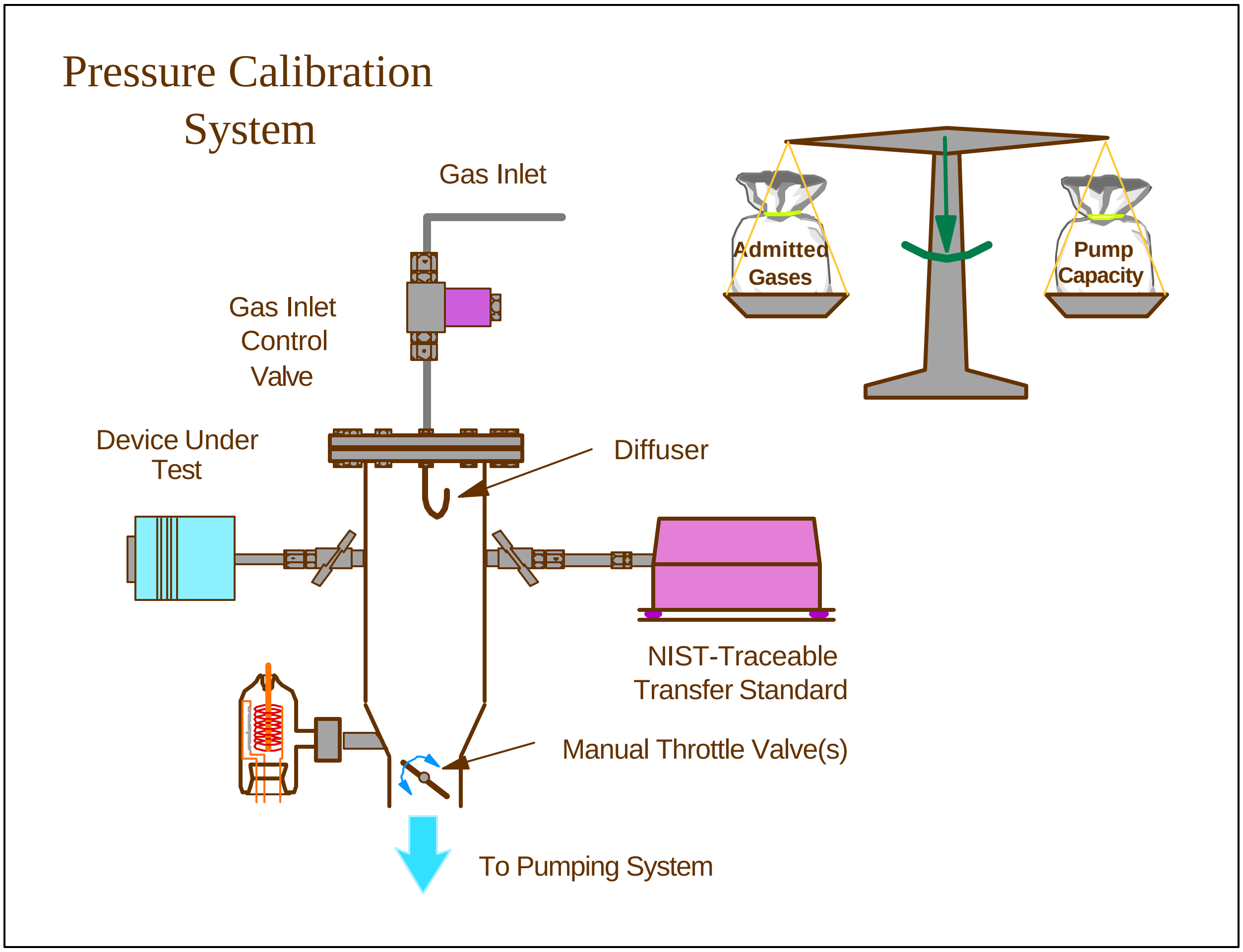
- In some process situations, particulates or condensable matter may build up on the internal surfaces of the sensor. This matter is a potential source of outgassing and can result in the reintroduction of particulates into the process system. Particulate contamination can generally be minimized by mounting the manometer in a port-down (always preferred) or port-horizontal position. General particulate contamination can be discouraged in many cases by isolating the sensor during the vent cycle. Heating the manometer may also be required under some circumstances, particularly if condensables are the problem.
- Since the diaphragm will also become covered with contamination, a shift of the zero over time will result as the mass of the diaphragm is changed. The first "correction" is usually to rezero the manometer. Eventually, however, the zero pot will be unable to correct for the shift.
- Checking for a zero shift condition can be done by "weighing" the diaphragm. This involves nothing more than observing the shift while changing the manometer's attitude from port-down to port-horizontal while the manometer is within its full-scale range. For MKS manometers (122, 127, 128, 622, 627, 628) the observed shift for uncontaminated manometers is approximately:
- 390 milliTorr for Full Scale range of 1000 Torr
- 45 to 65 milliTorr for Full Scale range of 100 Torr
- 12 to 15 milliTorr for Full Scale range of 10 Torr
- 12 milliTorr for Full Scale range 1 Torr or less
- Performing this test on new manometers provides a useful baseline..

Gauge Zeroing & Chamber Diagnostic Access

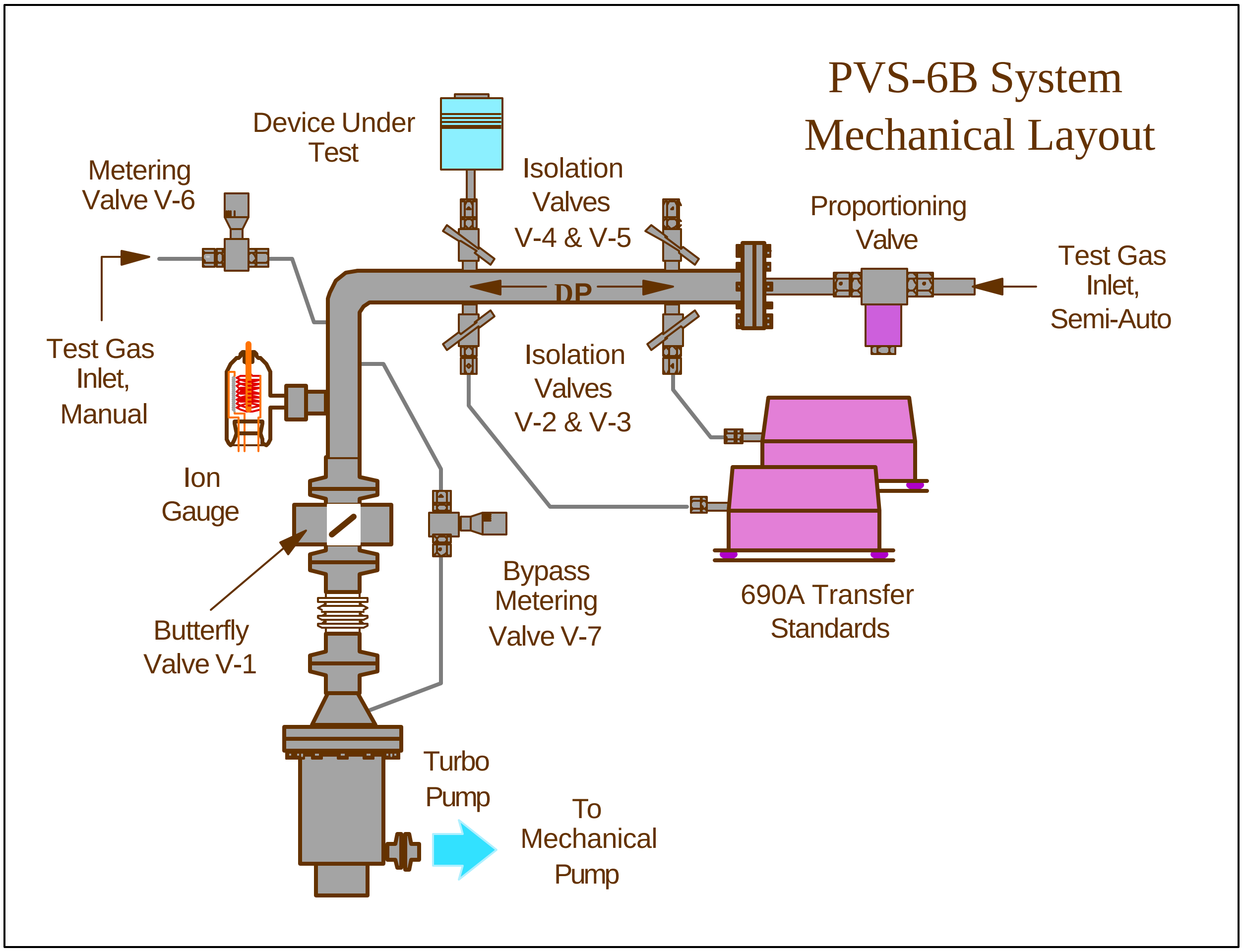
	V1	V2
Normal Operation	Open	Closed
Gauge Isolation	Closed	Closed
Gauge Zero/Cal	Closed	Open
System Diagnostics	Open	Open



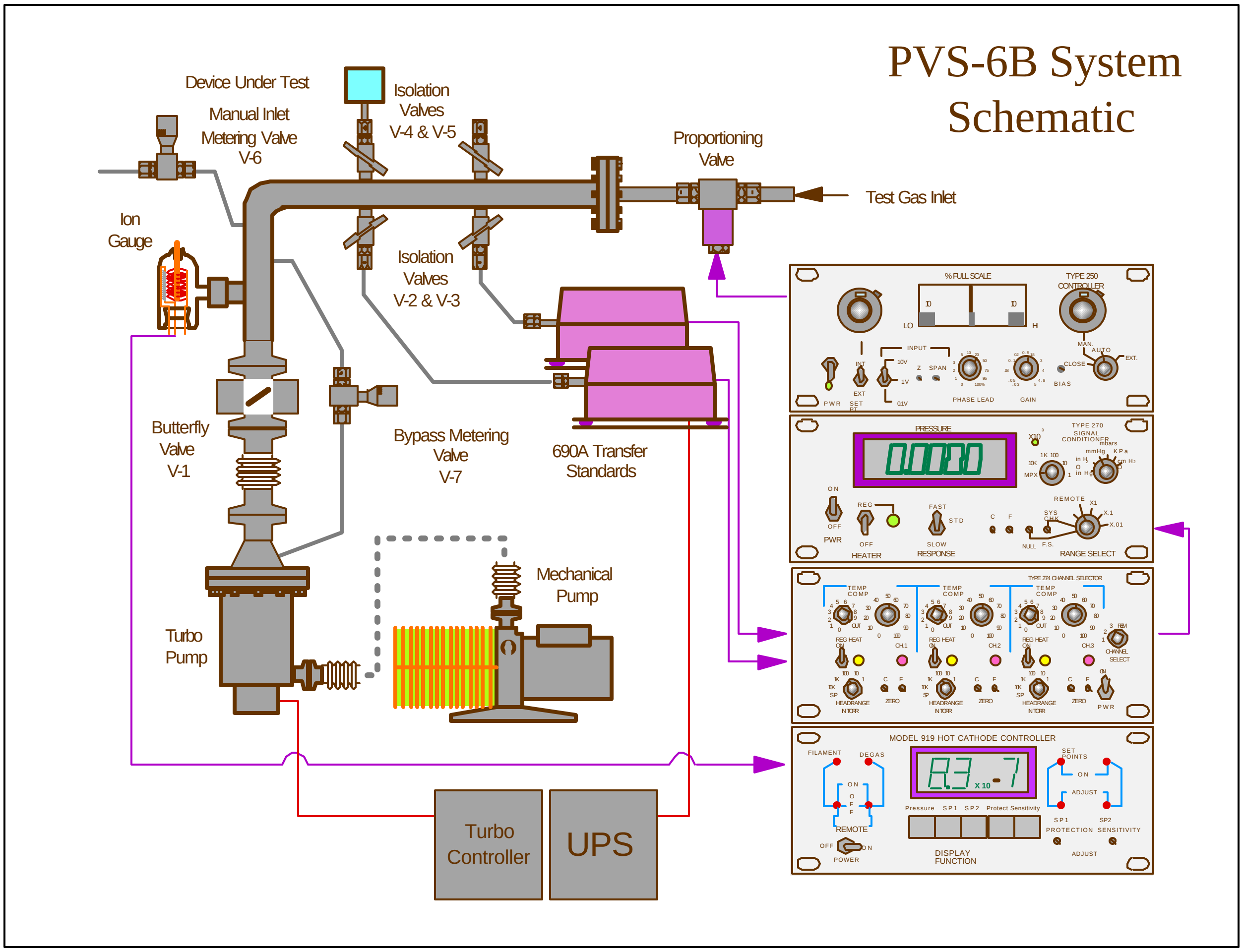
- Zeroing must be accomplished at a much lower pressure than the lowest reading pressure and many process systems are unable to achieve these pressures. Alternatives include removing the gauge and attaching it to the high vacuum port of a leak detector, RGA or high vacuum gauge calibration system. In these cases, care needs to be taken to ensure the same orientation of the manometer in order to avoid errors.
- An alternative is to leave the manometer in place and use a double valve system to allow access to just the gauge by a high vacuum system such as the PVS6 or 60.. This type of valve system can also be used for calibration and other forms of system and process diagnostics, as is indicated in the table.
- MKS provides a combination valve, the In-Situ Diagnostic Access (or IDA) valve for this purpose.
- In-situ calibration also minimizes zero temperature drift, avoids warm-up delays in the case of heated gauges and permits the use of the system's power supplies and displays.



- The calibration system works by comparing the indicated pressure of the test device (DUT) to the indicated pressure from the Transfer Standard.
-
- The first function of a calibration system is to achieve a low enough pressure to zero the Transfer Standards and the Device Under Test. This is done by running the system with the highest effective pumping speed (throttle valve open) and with no gas admitted to the system. A low equilibrium pressure in the 10e-7 Torr range will be reached if the system is clean and operating properly. This pressure is indicated by the high vacuum ion gauge.
-
- The second function of the calibration system is to run a comparison of the DUT's indicated pressures against the pressures as indicated by the Transfer Standard. As the calibration must be carried out across the pressure range of the DUT gauge, the calibration system must have the capability to provide a wide range of pressures within the manifold. In the PVS-6B this is done by controlling both the effective pumping speed (by means of the throttle valve) and by metering a quantity of a known, nonreactive test gas into the system. The desired pressure, a indicated by the gauge readout, is reached when a balance is achieved between gas inflow and pumping speed. This can be done either manually or with an automatic pressure regulating system. Capabilities for both are included on the PVS-6B.
-
- As most calibrations are performed at pressures well above the comfortable operating region of the turbo (a few milliTorr maximum), a throttle valve is positioned at the pump inlet. This produces a pressure drop and also helps to conserve gas.
-



- Manual admission of the test gas is done with the needle valve, V-6. Automatic control is accomplished with a solenoid proportioning valve. The proportioning valve is driven by a closed-loop pressure control system that will be described later.
-
- Pumping rate is controlled by two manual valves: the coarse 1/4-turn butterfly valve, V-1, and a needle (metering) valve V-7. These valves are connected in parallel. At higher manifold pressures, where the turbo requires the most throttling, the butterfly is operated in the closed (or nearly closed) position and the needle valve is used for fine adjustment. At lower manifold pressures, only the butterfly is used and it is most likely in an open to nearly open position.
-
- Because there is gas flowing through the manifold, a slight pressure drop may occur along the length of the manifold. The pressure drop may be reduced by minimizing the gas flow through the system by throttling the pump first and then admitting gas. This also helps to conserve gas. Calibration errors due to this effect are best eliminated by using opposing ports for the Transfer Standard and the DUT.
-
- The Transfer Standards are maintained at a constant temperature of 45 °C to achieve high accuracy and stability.

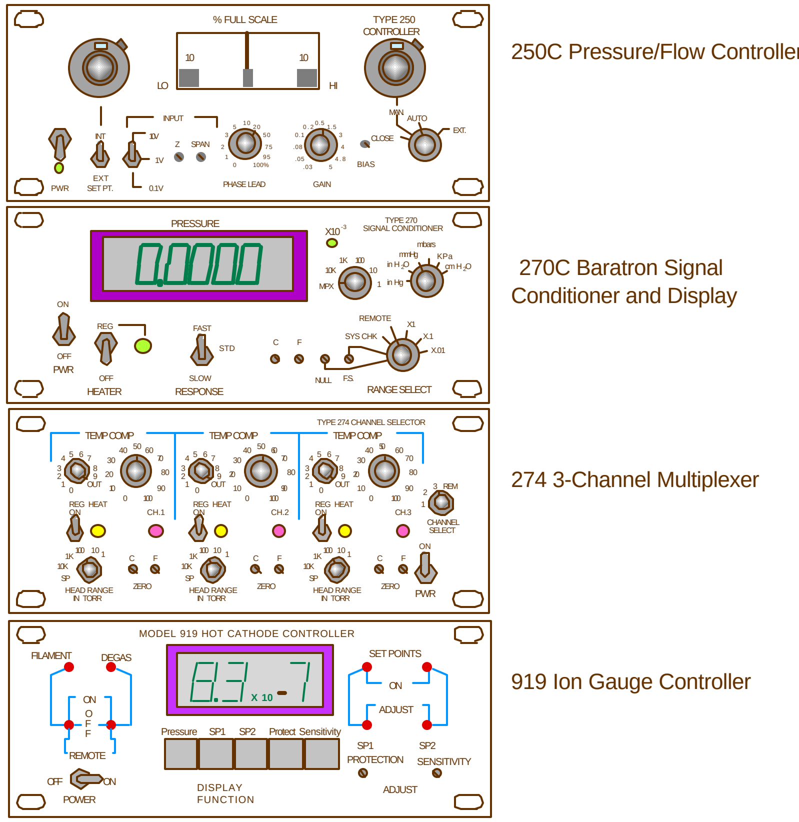


This diagram shows the complete system with associated power supplies and instrumentation.

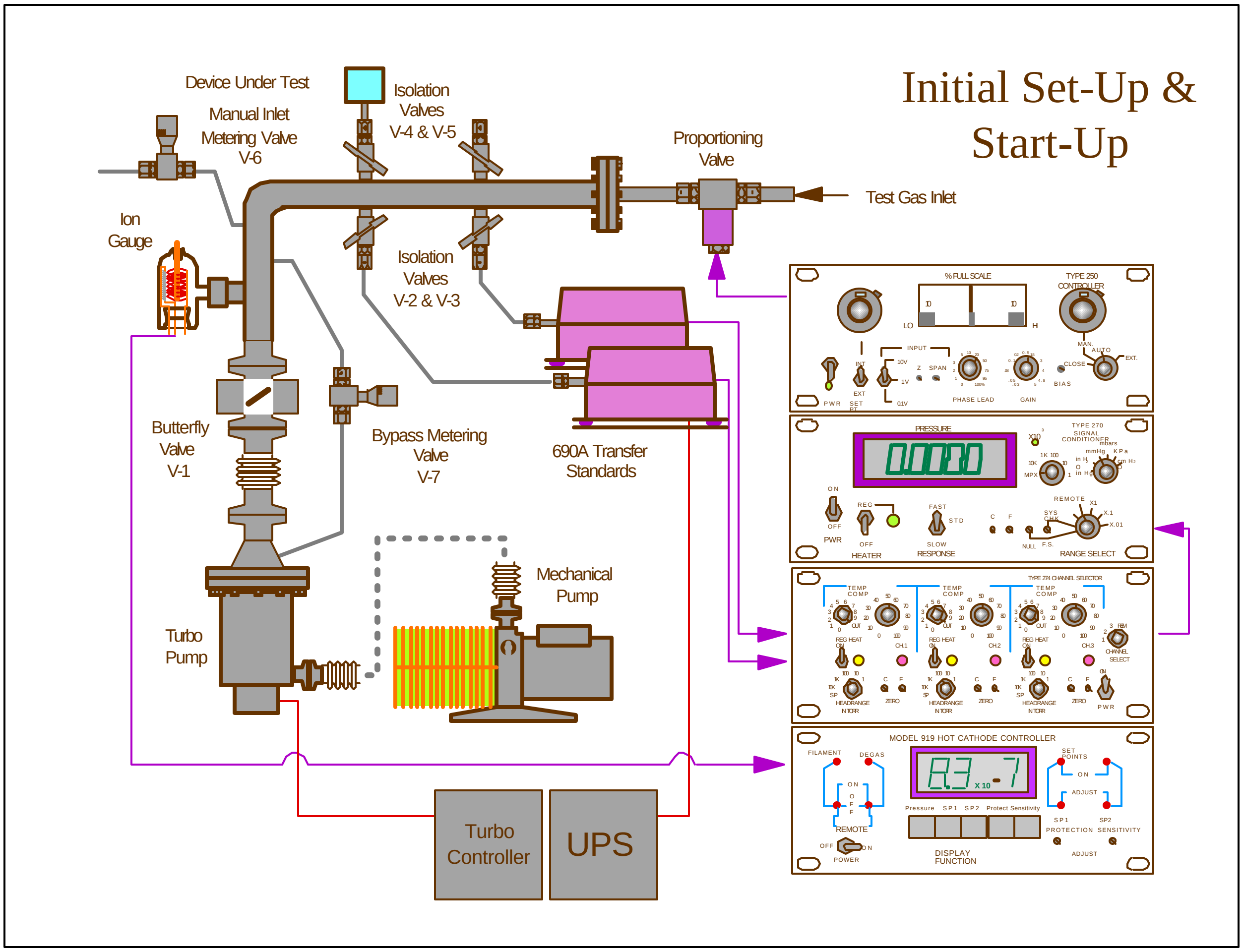
The Uninterruptible Power Supply (UPS) maintains heater power to the Transfer Standards (approximately four hours for two Transfer Standards) when the system is being moved or when there is a power outage.

The instrumentation will be discussed next.

PVS-6B Instrumentation



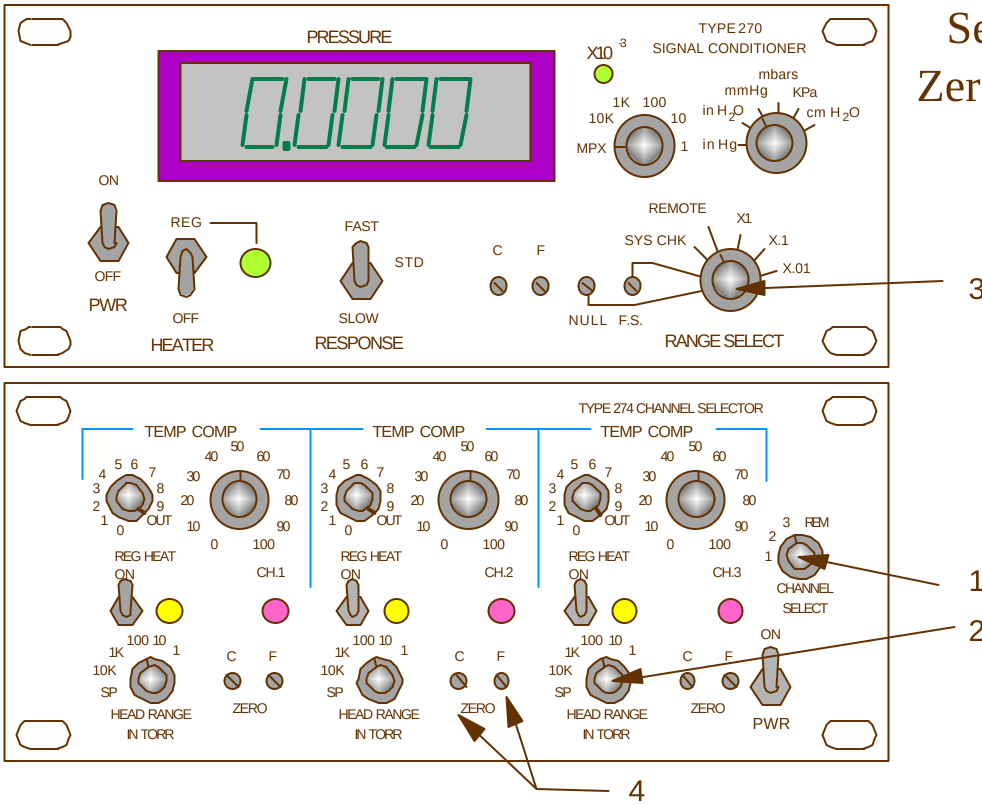
- The 250C controls the flow of gas to the manifold when the system is operated in the semi-auto mode (automatic pressure regulation). It does this by comparing the pressure indication from the selected 690A Transfer Standard to the setpoint pressure. It then modulates the inlet proportioning valve to achieve and maintain the setpoint pressure. The setpoint is dialed on the 250C's vernier.
- The 270C displays the pressure measured by the selected 690A Transfer Standard. It also provides power to the 690As. While the 270C can supply heater power, in the PVS-6B, heater power is provided by the 274. In the MPX mode, the 270C provides automatic sensor ranging
- The 274 operates up to three 690A Transfer Standards. It will display the indication from the selected 690A on the 270C. The 274 also provides heater power. A temperature compensation feature is provided but is not used with the heated 690As.
- If it is compatible with the 274C, a DUT may be operated from an unused channel of the 274C. However, we recommend that the DUT be calibrated with its own associated electronics. This also permits the simultaneous reading of the pressure indications from the DUT and Transfer Standard as well as allowing pressure control with the 250C.
- The 919 is a general purpose hot cathode ion gauge controller with a range of 10e-3 to 10e-9 Torr. It is used to indicate when a satisfactory base pressure has been attained. Above 10e-3 Torr the gauge will shut down to protect the tube. The degas feature should not be used for times in excess of 2 minutes.



Do not operate, adjust or service this instrument alone. Ensure that the equipment is properly grounded. Do not permit hazardous or reactive gases to enter the system.

Make sure all electronics are "off".
Close all manual valves (V-1, V-2, V-3, V-4, V-5, V-6 and V-7). Do not overtighten the metering and isolation valves.
Plug in the AC power cord.
Turn master power switch "on." (This switch is on the power strip at the rear of the instrument.)
Start the mechanical pump by plugging it in.
Turn the UPS "on". This maintains heater power to the 690As in the event of a temporary power outage.
Turn the 270C and 274 "on". Turn 274 Reg. Heat "on". Observe that the associated heater regulator light is illuminated. Ensure that the Temperature Compensation switch is set to "out".
The 250C should be left "off". However, do make sure that the Close/Manual/Auto/Ext control is set to "close" This prevents the possibility of the proportioning valve venting at full flow when the 250C is energized..
Turn V-1 to its open position to evacuate the upper manifold.
Open V-2 or V-3 to check for a low pressure reading on the 270C.
Turn turbo pump "on". Yellow light will indicate start. Green light will come on in about 5 minutes. If the yellow light does not go out, there is a significant leak in the system.
919 ion gauge controller may now be switched "on".
The pressure sensors require a 4 hour warm-up period before use or zero checking.

270C and 274 Settings - Zeroing Stds



Ensure that the Transfer Standards have had at least 4 hours to warm-up at base pressure - at least an order of magnitude lower than the minimum resolution of the gauges. Also, recheck to ensure that the Temp Comp switches on the 274 are in the "out" position.

Set the 274 Channel Select [1] to the Transfer Standard to be zeroed.
Set the 274 Head Range [2] to the range of the selected Transfer Standard.
Use the 270C Range Select [3] to confirm that the Transfer Standard is working.
On the 270C:

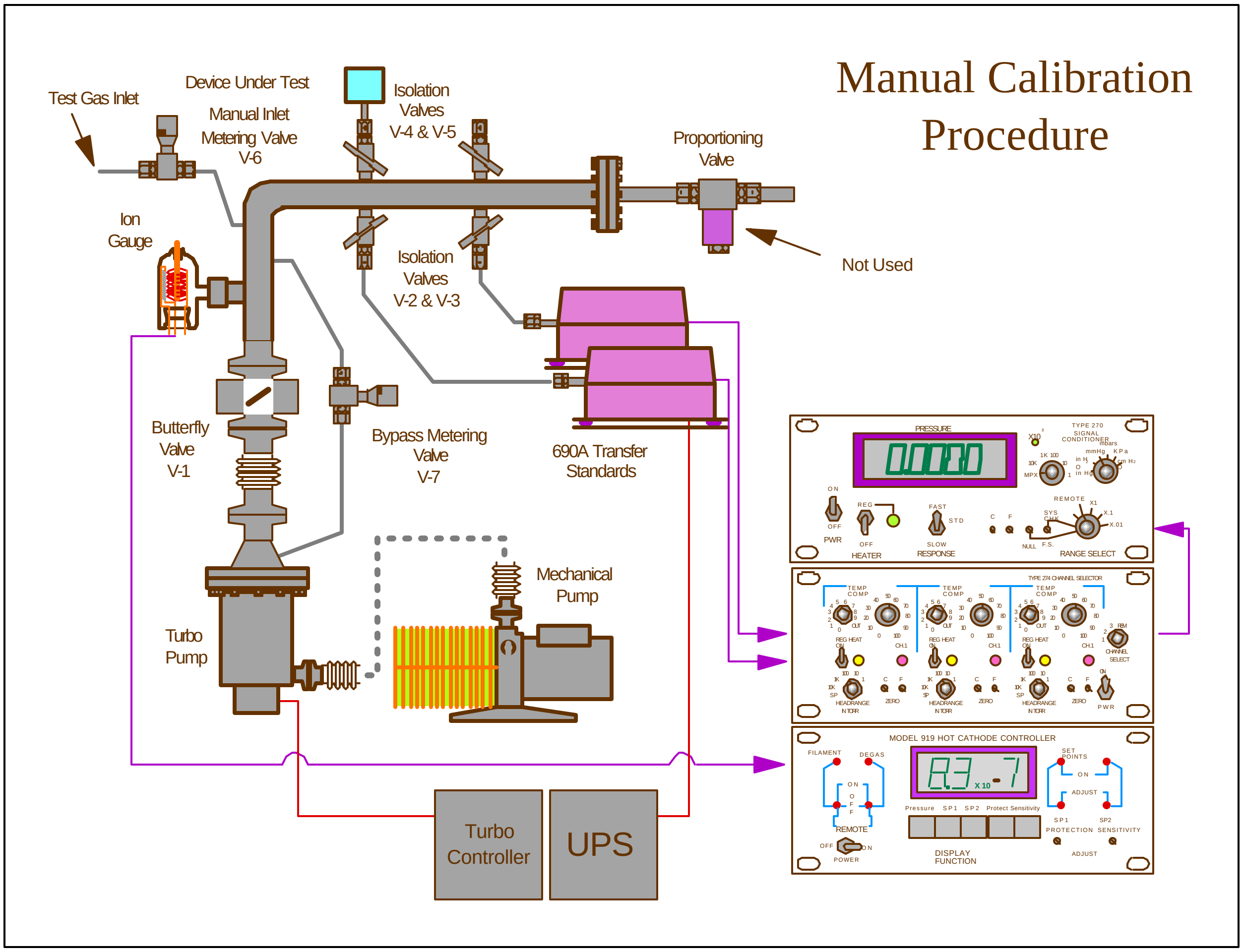
> Switch Range Select [3] to "Null". The display should show {00000}.
> Switch Range Select to "Full Scale". The display should show {10000}
> Switch Range Select to "Sys Chk". The display should show ~ {10000}
> Turn Range Select to "X1" and record the value on the display.

On the 274:

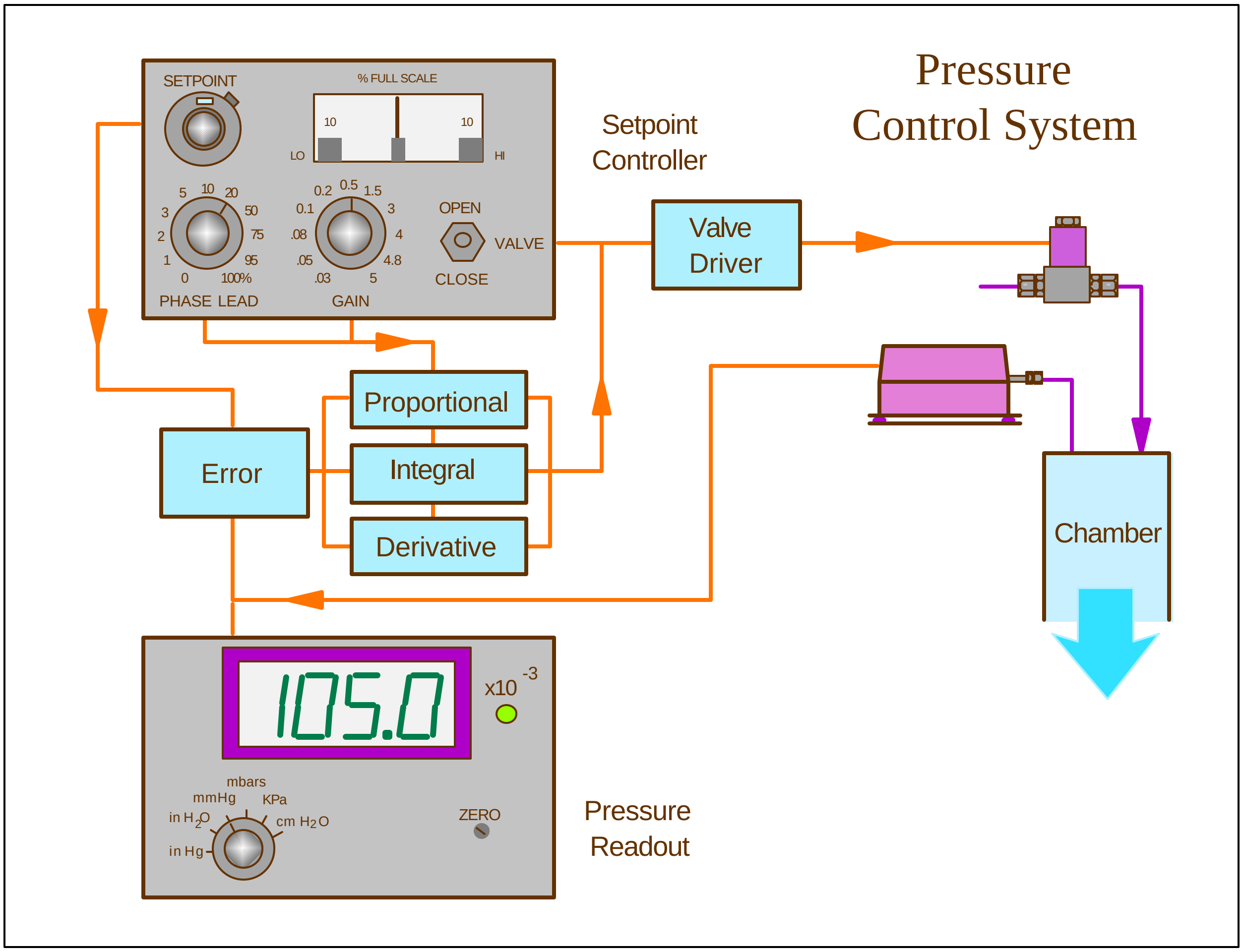
> Adjust "F" (Fine) pot [4] CW until the display stops increasing. Note value.
> Adjust "F" CCW until the display stops decreasing. Note value.
> Add the two values and divide by 2. This will give the pot center value.
>> Turn "F" until this value is displayed.
>
> Adjust the "C" (Coarse) pot to read {0.0}. Adjust "F" to read {0.00}

DO NOT ADJUST THE POTS LOCATED ON THE TRANSFER STANDARDS

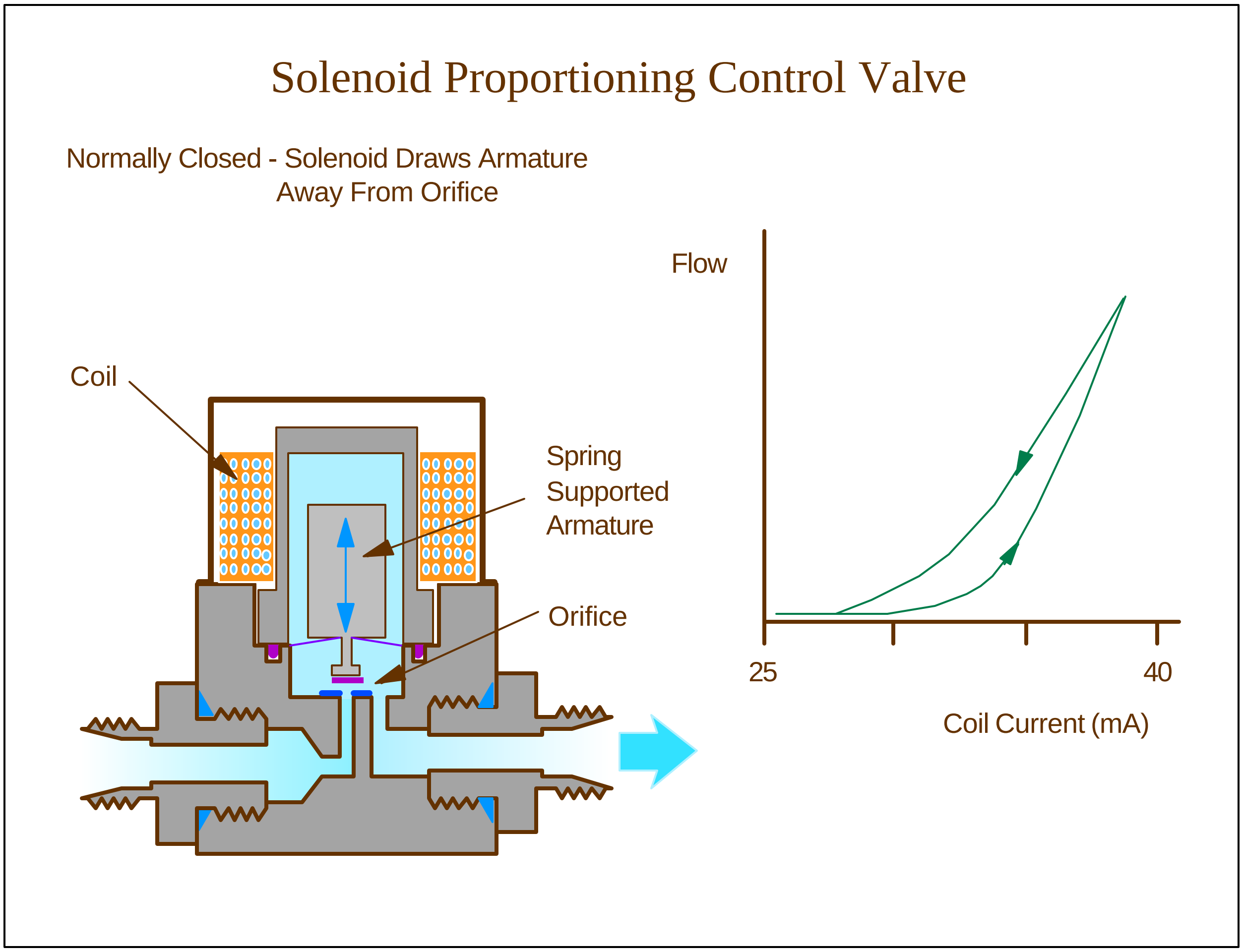
Zero the DUT following the manufacturer's instructions.



- Select the Transfer Standard to be used for the calibration. (The Transfer Standard selected should have the same range as the DUT.) Check or adjust the Transfer Standards as necessary.
- Attach the DUT.
- Attach a source of clean, dry nitrogen to the gas inlet. Pressure should not exceed 15
- PSIG at the regulator.
- If the calibration range is above 10 Torr, close the butterfly valve, V-1, and use metering
- valve V-7 for the system bleed.
- Close the valves associated with any Transfer Standard or DUT that might be damaged
- by pressures over the full-scale of those sensors.
- Turn off the 919 ion gauge controller. Open gauge isolation valves as required. Zero the DUT.
- Slowly open gas metering valve V-6 while monitoring manifold pressure on the 270C.
- Adjust V-6 and V-7 as necessary to stabilize the pressure. Be sure the 270C reading
- stabilizes before taking a reading.
- Note pressure readings and repeat the process for each higher pressure of interest.
- Low pressures may require the opening of the butterfly valve V-1.
- When completing the calibration sequence, close V-6, open V-1, and allow the system to
- reach a low base pressure.
- Before removing the DUT from the manifold, close its test port isolation valve to
- avoid contaminating the system.
-
-

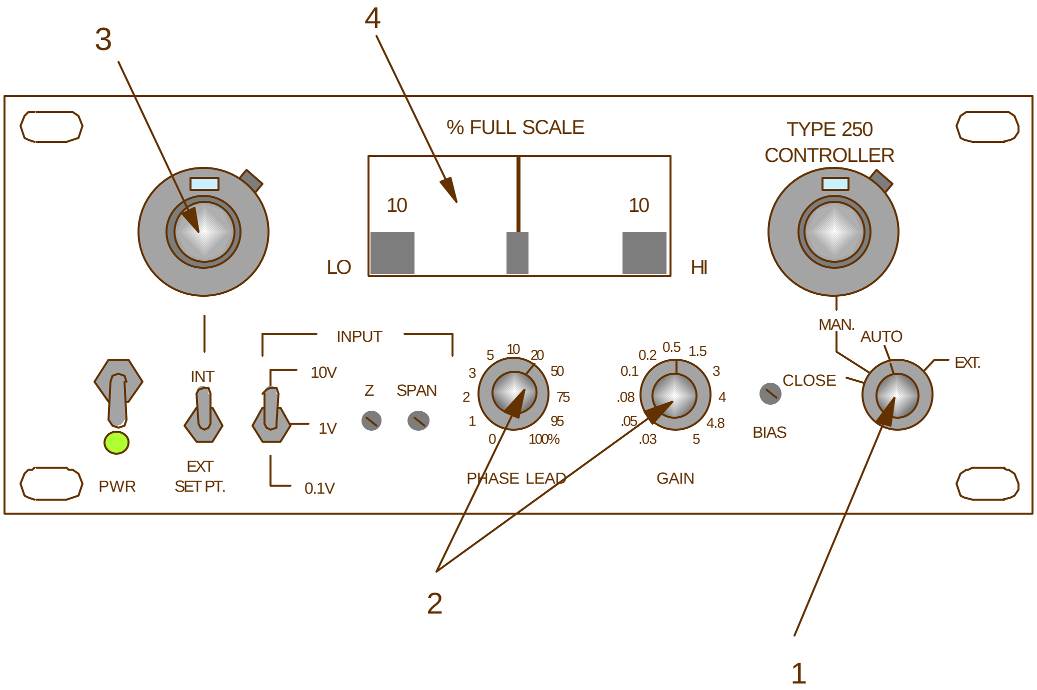


- The pressure transducer feeds a signal to the pressure display which shows the pressure in Torr (or other selected unit). The signal also goes to the pressure controller which compares the measured pressure to a dialed-in setpoint. The controller then sends a signal to the valve which admits more or less gas in order to drive the actual pressure to the setpoint value. A deviation meter indicates the difference between setpoint and actual pressure It is of the most use when showing overshoot and oscillation
-
- The standard control system is a PID (proportional, integral, derivative) system. The proportional element provides a valve action that is instantaneous and is a linear function of the error signal. The integral element provides an additional signal that is proportional to the length of time that the error signal has existed. The derivative element provides a signal that is proportional to the rate of change of the error signal.
-
- The operator may adjust the characteristics of the control system with the phase lead and gain controls. Phase lead compensates for lags in the control system. Too low a setting will result in overshoot; too high will give a slow response. The gain control sets the overall gain of the control system. Increasing gain will reduce the deadband but too high a setting will lead to oscillation.
-

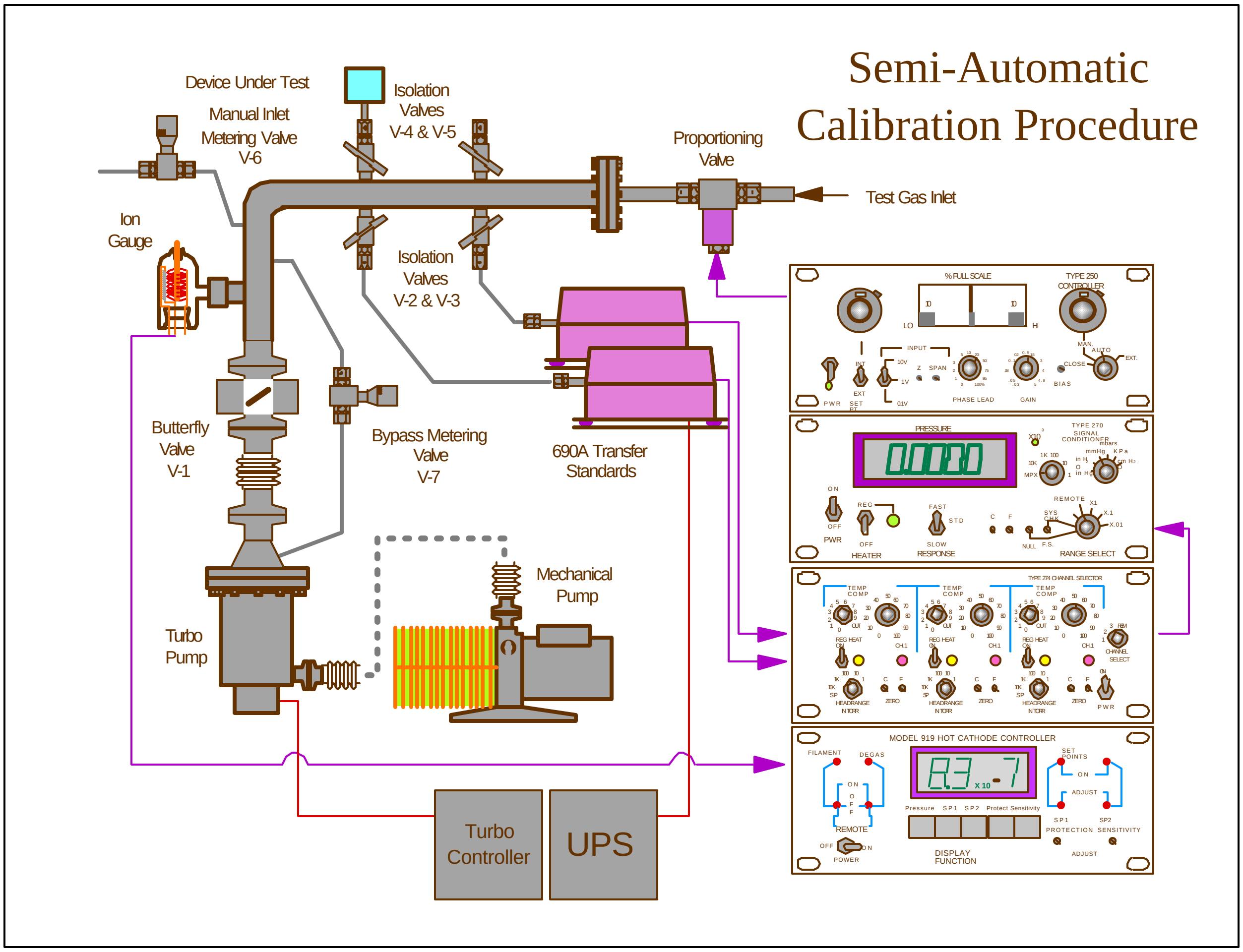


- The most widely used and most cost effective control valve is the solenoid (electromagnetic) proportioning valve. Their performance is well understood, the overall design is straightforward, and their reliability is typically quite high.
-
- The major elements of construction are a coil, a spring-supported armature, plug, orifice and body. These valves can be configured with elastomer seals or they can be of all metal design.
-
- While there is some hysteresis due to the magnetic materials, the control electronics compensates for this.
-
- Common features include field adjustability for control response and/or shut-off capability.

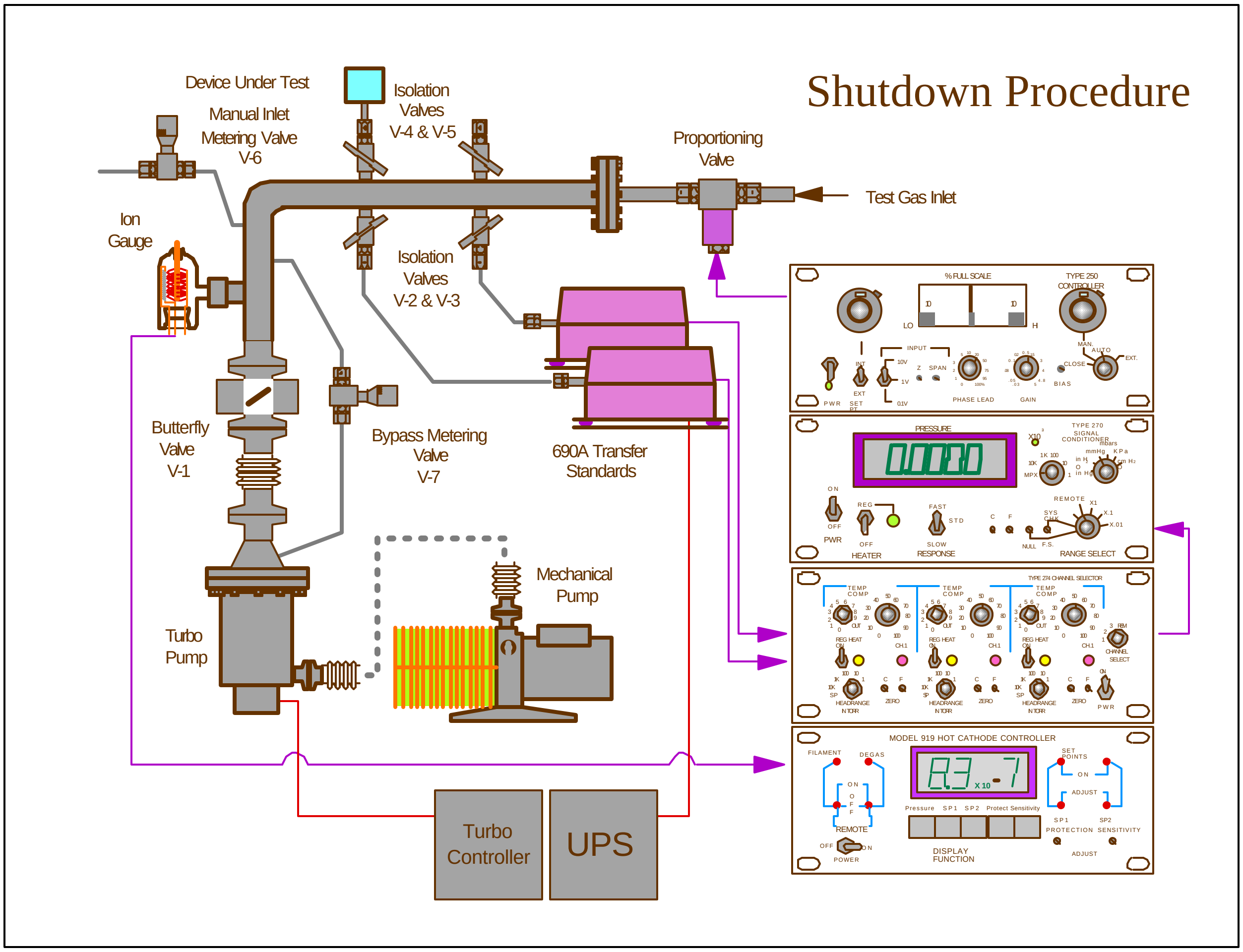
250C Control Settings



- Set the Close/Manual/Auto/Ext control [1] to "close".
  - This controls the proportioning valve and should always be set in the closed position when the 250C is not in use. Failure to do this could result in the valve venting at full flow.
- The Phase Lead and Gain controls [2] are adjusted as needed to stabilize at the desired pressure.
  - Phase Lead compensates for lags in the control system. Too low a setting will result in overshoot; too high will give a slow response.
  - The Gain control sets the overall gain of the control system. Increasing gain will reduce the deadband but too high a setting will lead to oscillation.
- The Setpoint vernier [3] is adjusted to the fraction of full scale pressure.
- The Deviation meter [4] indicates the difference between setpoint and actual pressure It is of the most use when showing overshoot and oscillation.



- Initial set-up is the same as for the manual procedure except that the test gas is
- connected to the proportioning valve.
- 250C Adjustments:
- Turn the setpoint vernier of the 250C fully CCW to read "0.0".
- Set the Setpoint Int/Ext switch to "Int". Set the Input switch to "10V".
- For calibrations >10 Torr: Phase Lead at "3"; Gain at "50". Then tweak as needed.
- For calibrations <10 Torr, Phase Lead at "0.5"; gain at "10". Then tweak as needed.
- Turn Close/Man/Auto/Ext control to "Auto".
- Since the Setpoint dial is at "0.0", no signal is sent to the proportioning valve
- and no gas will flow into the system. The Setpoint dial is turned CCW to
- increase pressures to points of interest.
- Open the DUT valve and begin the calibration process.
-
-



- This will prevent wet atmospheric air from entering the system during an extended shutdown period.
-
- Turn off the ion gauge.
- Connect the calibration test gas line to either inlet.
- Select the 1000 Torr Transfer Standard by using the 274 Channel Select. Ensure that the other Transfer Standards are isolated under vacuum conditions by closing their respective isolation valves.
- Turn off the turbo and mechanical pumps in that order. Unplug the mechanical pump
-     from the outlet strip.
- If using the manual inlet metering valve, open the valve slightly and bleed in gas until
-     the pressure has reached 800 Torr.
- If using the 250C controller:
-     Adjust Phase Lead to "5.0", Gain to 70%.
-     Turn Close/Man/Auto/Ext control to "Auto".
-     Dial "8.0" on the Setpoint Vernier with the switch set to "Int".
-     The pressure will now rise to 800 Torr.
-     Turn Close/Man/Auto/Ext control to "Close".
-     Turn off the electronics.
- Turn off the UPS and main power.
-
- The system should not be left under vacuum with the mechanical pump off as oil can be sucked back into the turbo pump. If a full shutdown is not desired, the system may be placed in standby by following the above procedure with the exception of leaving the main power, UPS and 274 on. This will keep the Transfer Standards warm.

Field Calibration Procedures for MKS Baratrons

General Information

Procedures:

- 100 Series (122/127)
- 200 Series
- 600 Series
- 621 Series
- 390/398 and 690/698

General Information

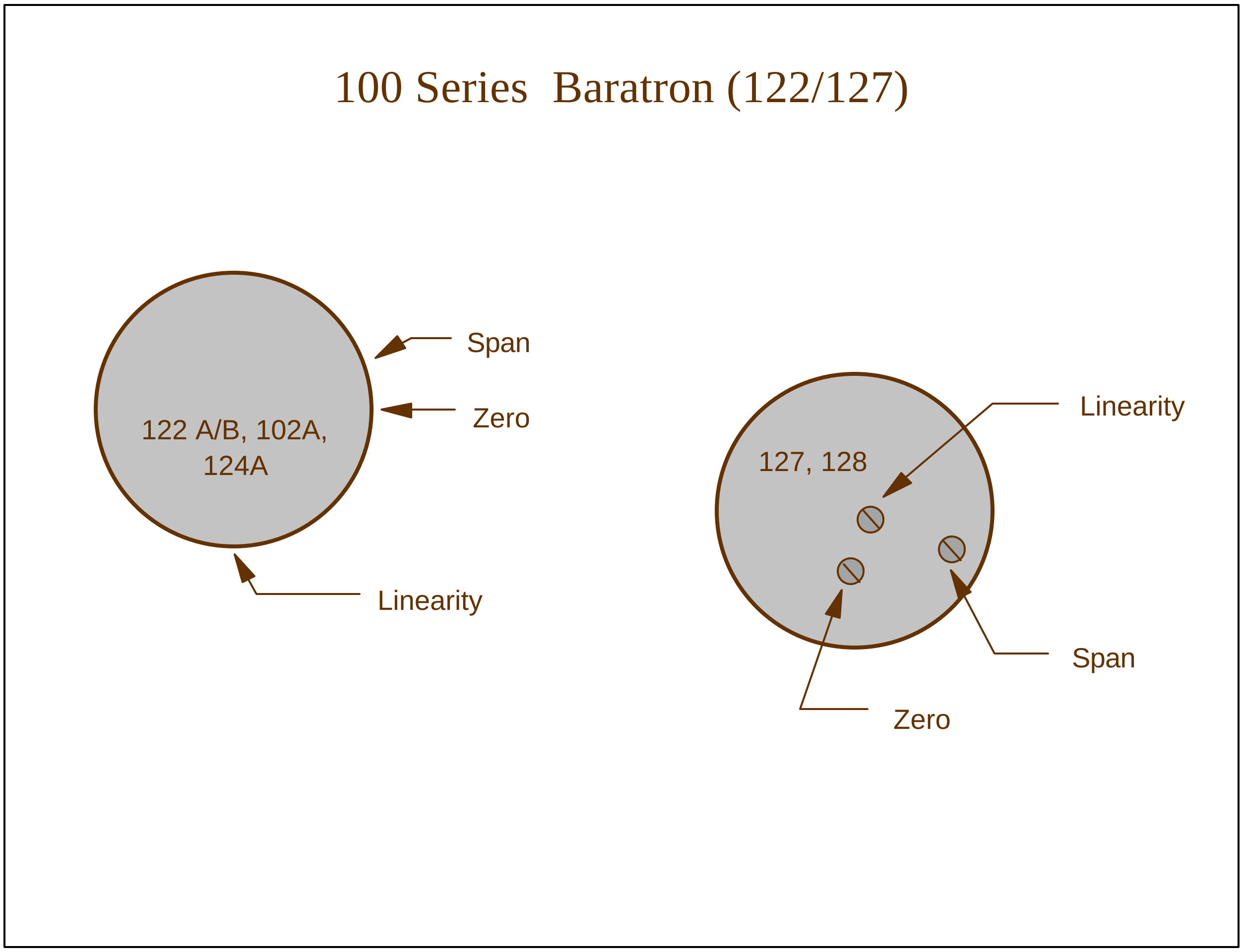
Equipment Requirements: Baratron with Associated Power Supply/Readout, 5 Digit DVM, or Equivalent

Interconnect Cabling for Above

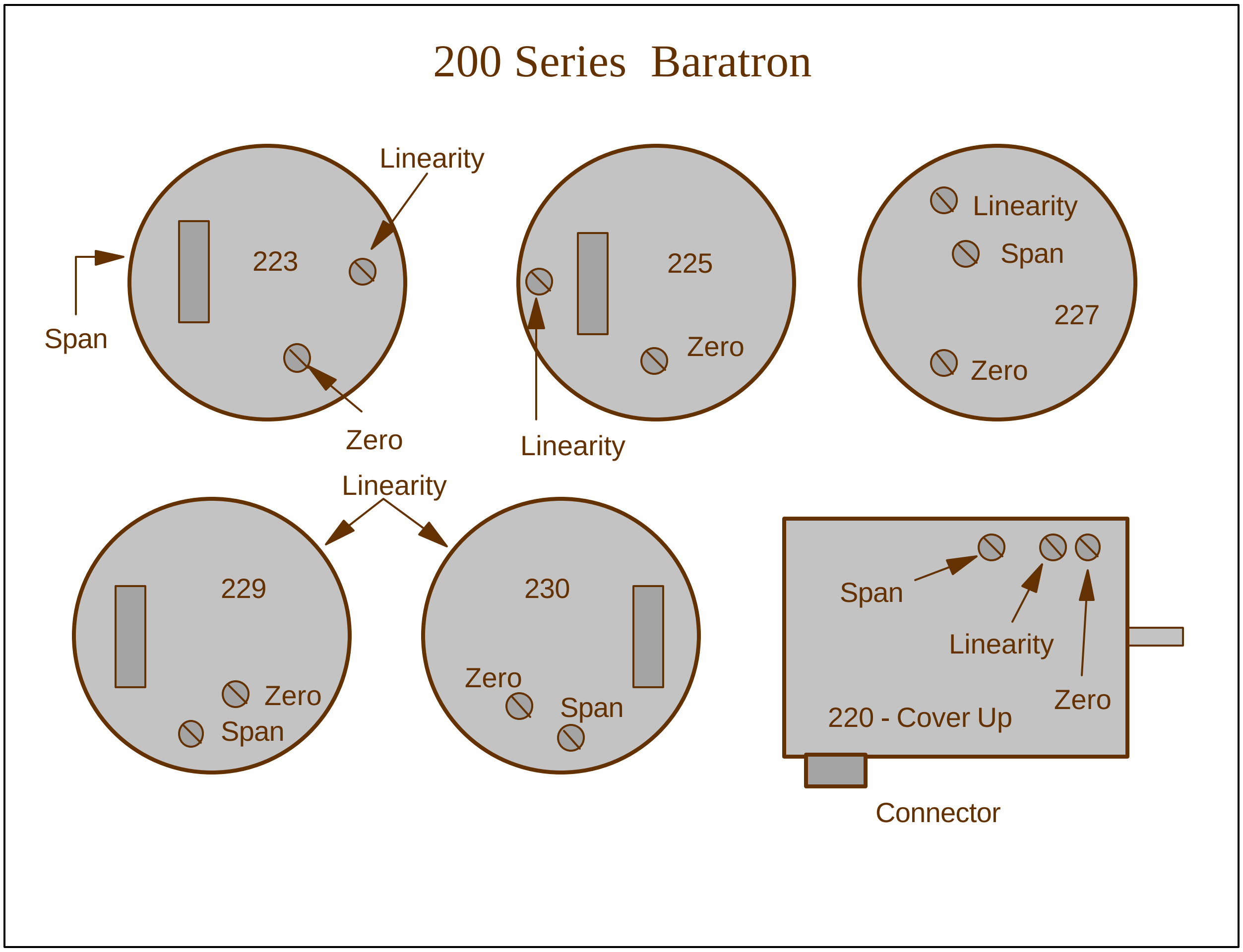
MKS Vacuum Calibration System with Applicable Transfer Standard

Zeroing Requirements: Maximum Base Pressures Required to Zero both the DUT and Transfer Standard:

100 mTorr FS	$<1 \times 10^{-7}$ Torr
1 Torr FS	$<1 \times 10^{-6}$ Torr
10 Torr FS	$<1 \times 10^{-5}$ Torr
100 Torr FS	$<1 \times 10^{-4}$ Torr
1000 Torr FS	$<1 \times 10^{-3}$ Torr



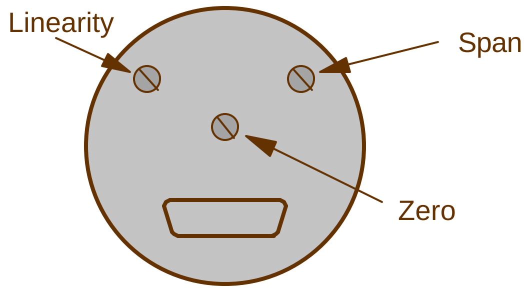
- The Transfer Standard will have already been zeroed. Units used through the procedure may be Torr, milliTorr, volts, etc. However, the units used must be consistent between DUT and Transfer Standard and through the procedure.
-
- 1. With the manifold below the maximum zeroing pressure, adjust the DUT's zero pot for a
- reading of {0.000}.
- 2. With the DUT properly zeroed, increase the manifold pressure until the Transfer
- Standard reads approximately Full Scale. This is done following the Manual or Semi-Auto
- operating procedures as outlined previously.
- 3. Adjust the span pot on the DUT so that its reading matches that of the Transfer Standard.
- 4. Repump the manifold back to below the maximum zeroing pressure. Recheck DUT and
- Transfer Standard zeroes and reset if necessary.
- 5. Increase the pressure until the Transfer Standard reads 10% of Full Scale.
- 6. Note the reading of the DUT and the Transfer Standard and compute the error:
- ERROR = [Transfer Standard Reading - DUT Reading]. Compute an adjusted error:
- ADJUSTED ERROR = ERROR X 4.
- 7. Increase the manifold pressure to Full Scale as indicated by the Transfer Standard. Adjust the
- DUT's linearity pot by the amount of the Adjusted Error (positive or negative).
- 8. While at Full Scale pressure, adjust the DUT's span pot until the DUT's reading matches that
- of the Transfer Standard.
- 9. Repeat Steps 1 through 8 until the DUT's output is linearized to within its specifications.
- 10. If zero, span or linearization is not possible, the unit should be returned to an MKS
- Service/Calibration Center.



- The Transfer Standard will have already been zeroed. Units used through the procedure may be Torr, milliTorr, volts, etc. However, the units used must be consistent between DUT and Transfer Standard and through the procedure.
-
- 1. With the manifold below the maximum zeroing pressure, adjust the DUT's zero pot for a
- reading of {0.000}.
- 2. With the DUT properly zeroed, increase the manifold pressure until the Transfer
- Standard reads approximately Full Scale. This is done following the Manual or Semi-Auto
- operating procedures as outlined previously.
- 3. Adjust the span pot on the DUT so that its reading matches that of the Transfer Standard.
- 4. Repump the manifold back to below the maximum zeroing pressure. Recheck DUT and
- Transfer Standard zeroes and reset if necessary.
- 5. Increase the pressure until the Transfer Standard reads 10% of Full Scale.
- 6. Note the reading of the DUT and the Transfer Standard and compute the error:
- ERROR = [Transfer Standard Reading - DUT Reading].
- 7. Adjust the DUT's linearity pot by an amount equal to the NEGATIVE of the Error. For
- example, if the Error is -50 mV, adjust the linearity pot by +50 mV.
- 8. Increase the manifold pressure to Full Scale as indicated by the Transfer Standard and adjust
- the DUT's span pot until the DUT's reading matches that
- of the Transfer Standard.
- 9. Repeat Steps 1 through 8 until the DUT's output is linearized to within its specifications.
- 10. If zero, span or linearization is not possible, the unit should be returned to an MKS
- Service/Calibration Center.

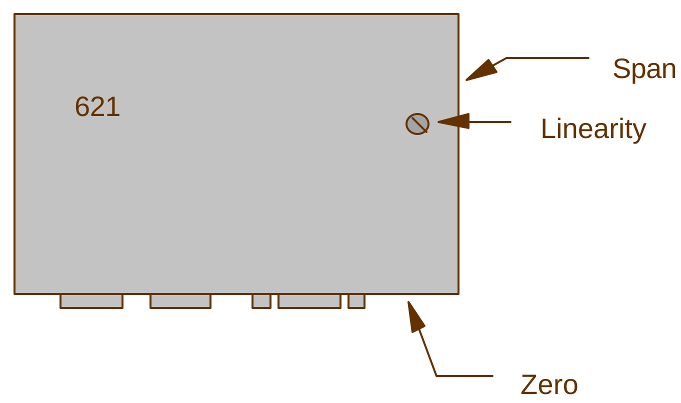
600 Series Baratron

622, 626, 627, 628

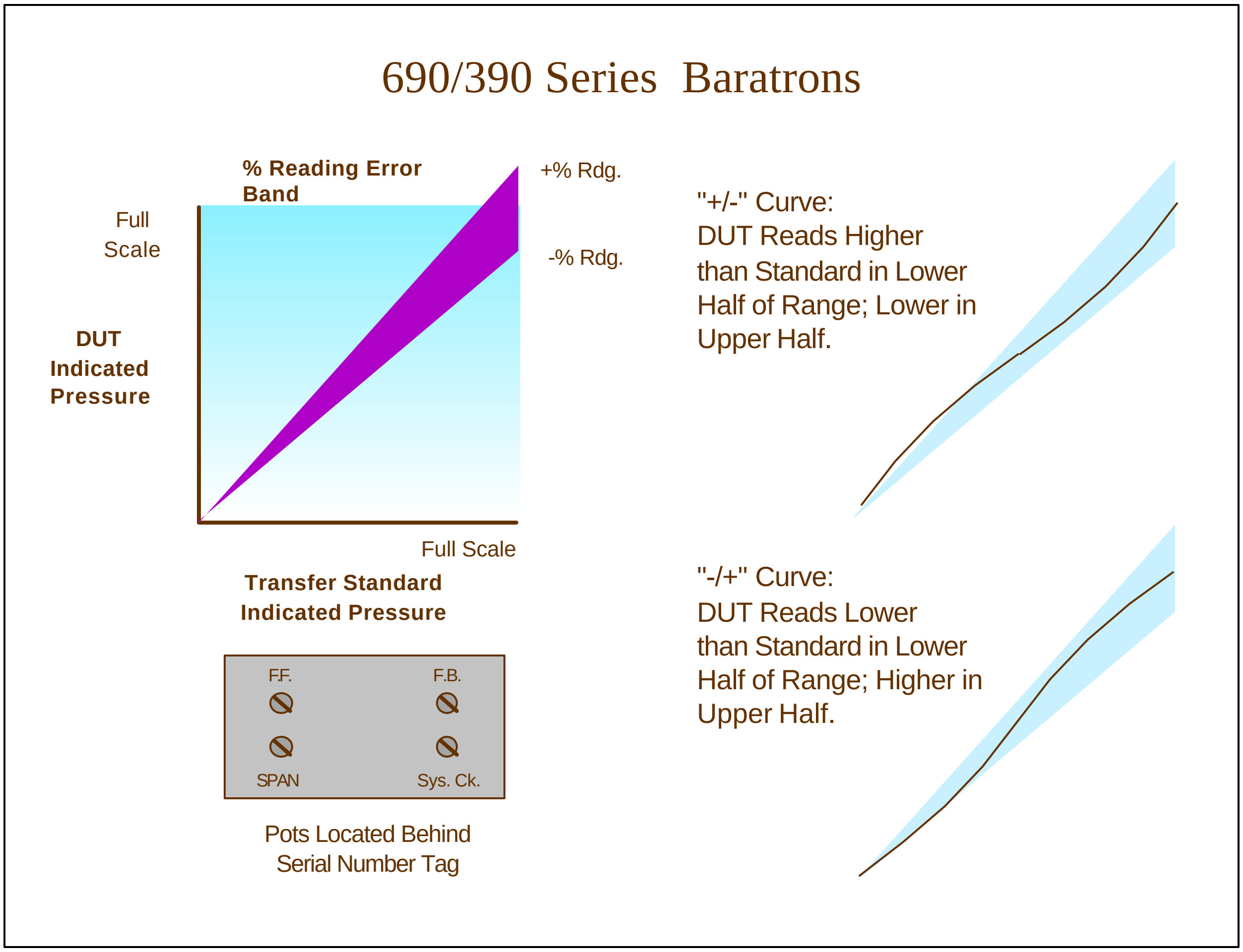


- The Transfer Standard will have already been zeroed. Units used through the procedure may be Torr, milliTorr, volts, etc. However, the units used must be consistent between DUT and Transfer Standard and through the procedure.
-
- 1. With the manifold below the maximum zeroing pressure, adjust the DUT's zero pot for a
- reading of {0.000}.
- 2. With the DUT properly zeroed, increase the manifold pressure until the Transfer
- Standard reads approximately Full Scale. This is done following the Manual or Semi-Auto
- operating procedures as outlined previously.
- 3. Adjust the span pot on the DUT so that its reading matches that of the Transfer Standard.
- 4. Repump the manifold back to below the maximum zeroing pressure. Recheck DUT and
- Transfer Standard zeroes and reset if necessary.
- 5. Increase the pressure until the Transfer Standard reads 10% of Full Scale.
- 6. Note the reading of the DUT and the Transfer Standard and compute the error:
- ERROR = [Transfer Standard Reading - DUT Reading]. Compute an adjusted error:
- ADJUSTED ERROR = ERROR X 4.
- 7. Increase the manifold pressure to Full Scale as indicated by the Transfer Standard. Adjust the
- DUT's linearity pot by the amount of the Adjusted Error (positive or negative).
- 8. While at Full Scale pressure, adjust the DUT's span pot until the DUT's reading matches that
- of the Transfer Standard.
- 9. Repeat Steps 1 through 8 until the DUT's output is linearized to within its specifications.
- 10. If zero, span or linearization is not possible, the unit should be returned to an MKS
- Service/Calibration Center.

621 Series Baratron



- The Transfer Standard will have already been zeroed. Units used through the procedure may be Torr, milliTorr, volts, etc. However, the units used must be consistent between DUT and Transfer Standard and through the procedure.
-
- 1. With the manifold below the maximum zeroing pressure, adjust the DUT's zero pot for a
- reading of {0.000}.
- 2. With the DUT properly zeroed, increase the manifold pressure until the Transfer
- Standard reads approximately Full Scale. This is done following the Manual or Semi-Auto
- operating procedures as outlined previously.
- 3. Adjust the span pot on the DUT so that its reading matches that of the Transfer Standard.
- 4. Repump the manifold back to below the maximum zeroing pressure. Recheck DUT and
- Transfer Standard zeroes and reset if necessary.
- 5. Increase the pressure until the Transfer Standard reads 10% of Full Scale.
- 6. Note the reading of the DUT and the Transfer Standard and compute the error:
- ERROR = [Transfer Standard Reading - DUT Reading].
- 7. Adjust the DUT's linearity pot by an amount equal to the NEGATIVE of the Error. For
- example, if the Error is -50 mV, adjust the linearity pot by +50 mV.
- 8. Increase the manifold pressure to Full Scale as indicated by the Transfer Standard and adjust
- the DUT's span pot until the DUT's reading matches that
- of the Transfer Standard.
- 9. Repeat Steps 1 through 8 until the DUT's output is linearized to within its specifications.
- 10. If zero, span or linearization is not possible, the unit should be returned to an MKS
- Service/Calibration Center.



- The Transfer Standard will have already been zeroed. Units used through the procedure may be Torr, milliTorr, volts, etc. However, the units used must be consistent between DUT and Transfer Standard and through the procedure.
-
- 1. With the manifold below the maximum zeroing pressure, adjust the DUT's zero pot for a
- reading of {0.0000} on a 5-1/2-digit DVM.
- 2. With the DUT properly zeroed, increase the manifold pressure until the Transfer
- Standard reads approximately Full Scale. This is done following the Manual or Semi-Auto
- operating procedures as outlined previously.
- 3. Adjust the span pot on the DUT so that its reading matches that of the Transfer Standard.
- 4. Repump the manifold back to below the maximum zeroing pressure. Recheck DUT and
- Transfer Standard zeroes and reset if necessary.
- 5. Increase the pressure until the Transfer Standard reads 50% of Full Scale.
- 6. Adjust the F.B. pot so that the DUT's reading matches that of the Transfer Standard.
- 7. Repump the manifold back to below the maximum zeroing pressure and reset zero with the
- zero pot.
- 8. Increase the manifold pressure in 10% increments comparing the output of the DUT to the
- Transfer Standard. This will determine whether the basic shape of the output curve
- is a +/- or -/+ "S".
- 9. If the "S" curve is +/- then increase the F.F. pot and decrease the F.B. pot. If the "S" curve
- is -/+ then decrease the F.F. pot and increase the F.B. pot.
- 9. Repeat Steps 1 through 8 until the DUT's output is linearized to within its specifications.
- 10. If zero, span or linearization is not possible, the unit should be returned to an MKS
- Service/Calibration Center.