

Selection Guide for Mechanical Differential Pressure Gauges

A common specialized pressure gauge that uses the input from two pressure sources is the differential pressure gauge. A differential pressure (ΔP) gauge has two pressure sources acting on and displacing one or two sensors to display the difference between the two pressure sources on one gauge with one pointer.

In some applications the two sides of a ΔP gauge are attached to either side of a system feature or component where the user needs an indication of pressure drop, before and after the component. In some cases the pressure difference between two systems must be known.

ΔP gauges were designed to replace two pressure gauges and eliminate the need for the user to subtract one reading from another. At times users don't immediately understand the relationship between two gauges. One ΔP gauge makes this self-evident.

In addition, one ΔP gauge can sometimes eliminate the accumulated errors two pressure gauges can present. One gauge also facilitates special scales that will allow the reader to view application specific values such as flow rate or level; something two gauges cannot do well.

Typically ΔP gauges use one or two of the same sensor elements as standard pressure gauges making them exhibit similar characteristics as the standard pressure gauge. This makes it possible to consider the same selection criteria for this category of specialty gauge as those mentioned in "Selection Guidelines for Mechanical Pressure Gauges".

Different manufacturers incorporate different features or varying levels of components that make each ΔP gauge type difficult to characterize as a group. Accordingly, within each ΔP gauge type is a wide variety of accuracies, pressure ratings and other specifications to choose from. This requires the prospective user to closely examine the specifications from the manufacturers and weigh the costs for each.

Types of ΔP Gauges

Note: Illustrations of the ΔP gauges described below can be found at the end of this section.

Dual Bourdon Tube:

The movement of two C-type bourdon tubes, connected to two pressure sources, act on a single mechanical linkage to rotate the pointer.

Note: Moderate accuracy, high ΔP , moderate working pressure, moderate price

Single Bourdon Tube:

A single bourdon tube is mounted inside a pressure capsule. One pressure source is applied inside the tube; the other pressure source is applied into the capsule and acts on the outside of the tube. The pressure differential causes the tube to move, which transmits motion to a rotary pointer via mechanical linkage and a magnetic coupling.

Note: High accuracy, high ΔP , high working pressure, higher price

Dual Bellows:

Two liquid filled, metal bellows, one connected to a high pressure chamber and the other to a low pressure chamber, exchange fluid between each other as the differential pressure changes. This causes linear movement of the bellows. The linear movement of the bellows, connected to a mechanical linkage, rotates the pointer. Typically they have overpressure protection valves that allow them to protect the bellows from high line pressures. Most models offered exhibit high accuracy.

Note: High accuracy, moderate ΔP , high working pressure, higher price

Single Bellow:

Single bellow ΔP gauges have the two pressure sources acting against both sides of one bellow. Linear movement of the bellow, connected to a mechanical linkage, rotates the pointer.

Note: High accuracy, low to moderate ΔP , high working pressure, moderate price

Single Diaphragm:

Single diaphragm ΔP gauges have the two pressure sources acting against each side of a metal or elastomeric diaphragm. Linear movement of the diaphragm, connected to a mechanical linkage, rotates the pointer.

Note: Moderate accuracy, moderate ΔP , moderate working pressures, moderate price

Dual Diaphragm:

Two diaphragms, one connected to a high-pressure chamber and the other to a low-pressure chamber, move linearly, in proportion to ΔP . This linear movement, connected to a mechanical linkage, rotates the pointer. Typically they have valves to protect the diaphragms from high line pressures.

Note: Moderate accuracy, moderate ΔP , moderate working pressures, moderate price

Magnetically Coupled Piston:

Two pressure sources act against both sides of a spring-loaded piston/magnet sensor. As differential pressure changes the sensor moves linearly in proportion to ΔP . The movement of the magnet in the sensor induces a rotation of a second magnet, attached to the pointer. The piston sensor allows for high line pressures but slight piston bypass makes them inappropriate for gas or diaphragm seal applications.

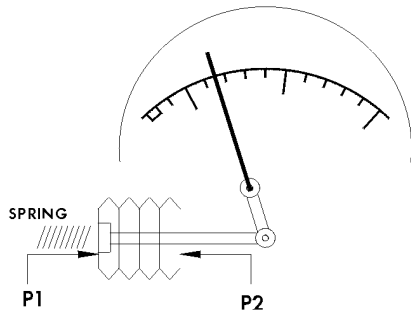
Note: Moderate accuracy, moderate to high ΔP high working pressures, low price

Magnetically Coupled Diaphragm:

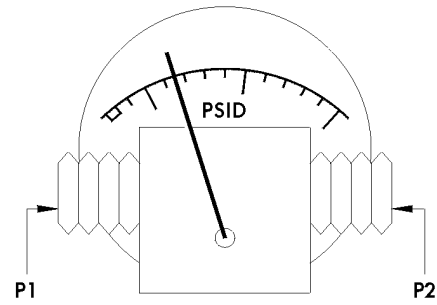
Similar to the piston model, two pressure sources act against a single spring-loaded elastomeric diaphragm/magnet sensor. The movement of the sensor magnet induces a rotation of a second magnet attached to the pointer.

Note: Moderate accuracy, low to moderate ΔP , low to moderate working pressures, low price

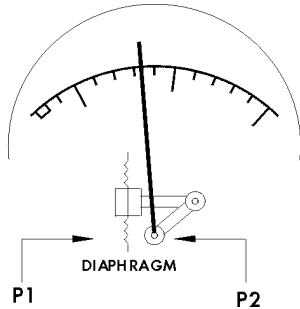
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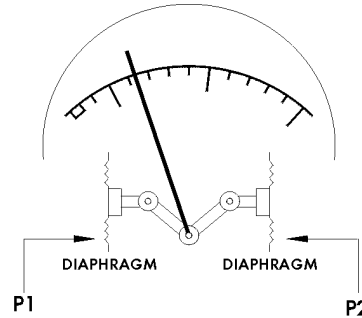
SINGLE BELLOW



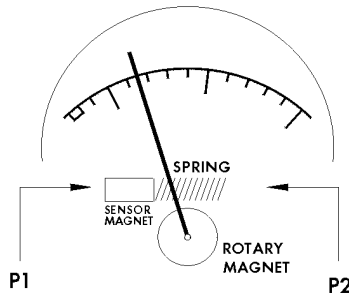
DUAL BELLOWS



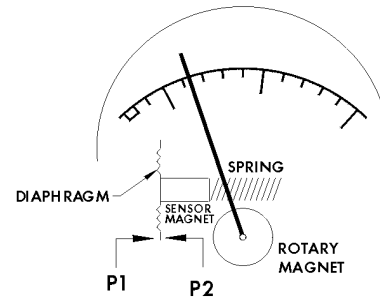
SINGLE DIAPHRAGM



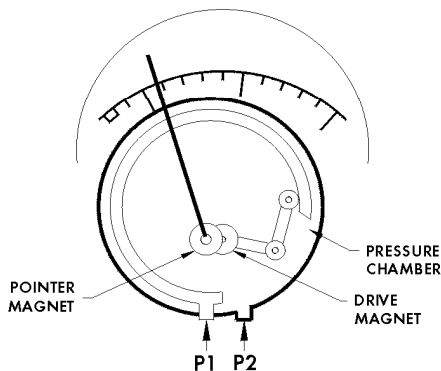
DUAL DIAPHRAGM



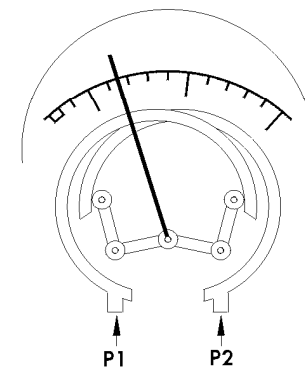
PISTON MAGNET



DIAPHRAGM MAGNET



SINGLE BOURDON TUBE



DUAL BOURDON TUBE

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Applications

Note: Illustrations of the applications described below can be found at the end of this section.

Filtration:

Connecting a ΔP gauge high-pressure port to the inlet of a filter or strainer and the low-pressure port to the outlet can help the user identify its health. As the filter become clogged the differential pressure reading increases and the efficiency of the system it supports can degrade. Eventually it will increase to a point where the user needs to take action such as changing the filter element or backwashing the system.

The scale can read in units of differential pressure or other values such as clean and dirty. The alarm condition (dirty) would be at the high end of the scale.

Flow:

The two sides of a ΔP gauge can be connected before and after a primary flow element such as an orifice plate or venturi. Following Bernoulli's Law, the flow rate is proportional to the square root of the differential pressure.

In this case the scale can read in ΔP values or in flow rate values using a square root dial.

Level:

Level of a liquid in a pressurized tank, such as those used in cryogenics, can be determined using a ΔP gauge. The high-pressure port would be connected to the liquid, bottom portion of the tank while the low-pressure port would be connected to the gas fill portion of the tank at the top. The pressure differential between the top and bottom of the tank allow for the level of the tank to be measured.

Scales can read in ΔP values, in level values, such as empty or full or 1/4, 1/2, 3/4 full, volumes such as gallons or liters of product or mass such as lbs, tons or kg of product. In level applications the alarm condition is often at the low end of the scale.

Heat exchangers:

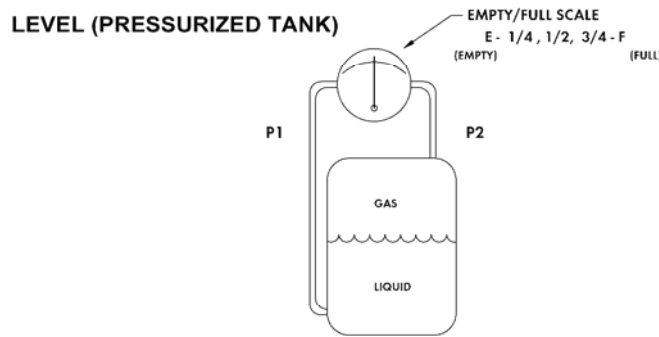
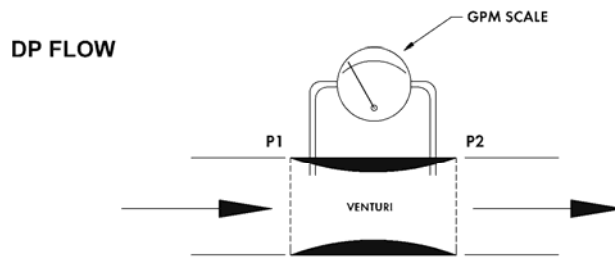
The health of a heat exchanger can be determined using a ΔP gauge. As heat exchangers age residue or scale can build up within the elements of the unit resulting in a pressure drop. This can inhibit the flow of fluid and reduce the efficiency of the system it supports. Measuring the pressure drop from the input to the output of the heat exchanger allows the user to determine the best time to clean or flush the system or even replace it.

Controlled environments:

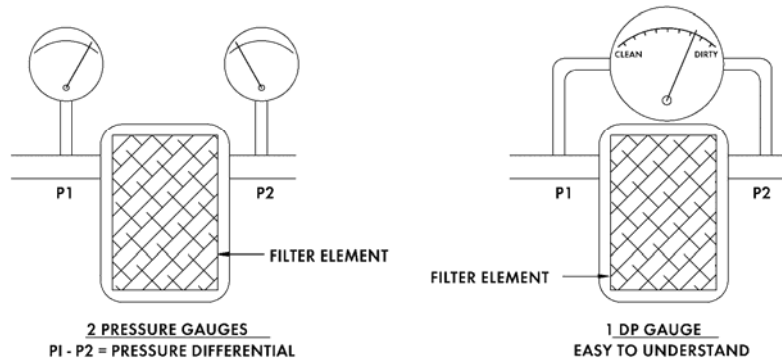
Clean rooms, hospital rooms and other controlled environments often require a specific balance between one room or compartment and the area around it to maintain the proper pressure

differential. A positive pressure must be maintained in clean rooms to eliminate the ingress of contaminants. A hospital room may require the same positive pressure or one may want to keep contaminants from leaving a contaminated area. Measuring the differential pressure, sometimes very low ΔP , between two rooms or areas can help reduce the unwanted movement of contaminants. Simple heating and ventilation systems can also be made more efficient by balancing the relative pressures within the system.

DIFFERENTIAL PRESSURE APPLICATIONS



FILTRATION



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Special Considerations

Static Working Pressure vs. Full Scale Range

Most differential pressure gauges have static working pressures that are independent of the full-scale range. The static working pressure is based on the pressure housing and the full-scale range is based on the sensing element. This results in most differential pressure gauges having high static working pressures with low full-scale ranges. (i.e. 3000 PSIG working pressure with 0-1 PSID range)

Over-Range Protection

A ΔP gauge is over-ranged when a pressure differential greater than the full-scale range is applied to one side of the ΔP gauge. Different types of over-range protection are employed depending on the differential pressure gauge design. The user should learn about the over-range protection of a ΔP gauge to insure it will perform properly in their application.

- Some ΔP gauges limit the working pressure of the gauge to the range of the gauge.
- Some ΔP gauges limit the over range pressure on either side of the sensing element to a multiple of the range of the gauge, which may be less than the rated working pressure. (i.e. 200 PSIG working pressure, 0-15 PSID full scale range, over-range protected to 4 times range or 60 PSID)
- Some ΔP gauges should not be exposed to reverse pressure (pressure on the low side of the gauge exceeding the pressure on the high side of the gauge).
- Some ΔP gauges use liquid fill and valves to protect the sensing element from over range. Care should be taken to insure the fill fluid is compatible with the process fluid in the event of a leak. Care should be taken at temperature extremes as the fill fluid will expand or contract at elevated or reduced process or environmental temperatures causing calibration shifts.
- Some ΔP gauges use bi-directional relief valves to protect the sensing element from over range. While the relief valve operates process fluid from the high side and low side mix. Care should be taken to insure that the mixing of the process fluid(s) from the high side and low side is acceptable in the application.

Regardless of the ΔP gauge design it is wise practice to utilize a 3-valve manifold or assembly when installing ΔP gauges. The 3-valve manifold or assembly consists of a bypass valve, a high side isolation valve and a low side isolation valve. When bringing a ΔP gauge on line the bypass valve is opened to equalize the pressure on both sides of the sensing element when opening the high and low side isolation valves. Open the isolation valves slowly. After the ΔP gauge is pressurized the bypass valve is closed to obtain the pressure differential. See the last page for a 3-valve manifold illustration.

Δ P Gauge Mounting

Most Δ P gauges are remote mounted with instrument lines running to the high and low side of the instrument as compared to a pressure gauge, which has a single connection. A variety of connection options are available including end connections, back connections, bottom connections and dual top and bottom connections. Select the connections that will make tubing and mounting the instrument as simple as possible.

The Δ P gauge should be mounted above the process connections for gas applications to promote self-draining of any condensate that may form in the instrument lines or gauge. The Δ P should be mounted below the process connections for liquid applications to promote self-bleeding of the instrument lines and gauge. Instrument lines should slope a minimum of 1 inch per foot to avoid liquid or gas entrapment.

For instrument lines less than 50 ft $\frac{1}{4}$ " pipe or tubing is adequate. For instrument lines between 50 and 100 ft $\frac{1}{2}$ " pipe or tubing is recommended. Instrument lines in excess of 100 ft should be avoided. Small diameter instrument lines and long lengths of instrument lines can cause slow gauge response. Joints in instrument lines should be minimized to eliminate leak points.

The Δ P gauge should not be operated above its maximum working temperature. Uninsulated instrument lines generally drop the process temperature 50° F (10° C) per foot. Adequate length instrument lines must be employed to provide sufficient temperature drop to protect the instrument in high temperature applications. Conversely instrument lines may need to be insulated or heated to protect the instrument lines from freezing when installed in cold environments.

Δ P gauges are generally heavier than pressure gauges so they should be carefully mounted especially when vibration is present. Mounting options such as 2" pipe mounting brackets, panel mounting or wall mounting brackets should be employed to adequately support the Δ P gauge.

Materials of Construction

Δ P gauges have more wetted components than pressure gauges, which include gauge bodies, sensing elements, springs and elastomers. Care should be taken to insure that all of the wetted components are compatible with the process fluid.

Switch and Transmitter Options

Many Δ P gauges are available with electrical options such as switches and transmitters. They come in many forms and can add to the complexity and cost of the instrument.

Combining electrical options with a Δ P gauge offers the user the advantage of having both a local and remote indication of the process conditions. This can also lower instrumentation and

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installation costs. The gauge can sometimes act as a backup. It is common to add a gauge to a process just in case a transmitter or switch malfunctions or if there is a loss of power. Be careful though; having a common sensor for both the gauge and electronics can be a drawback. If this sensor fails, both the gauge and electrical output can fail. If this is a real concern, a separate gauge and transmitter or switch may be preferred.

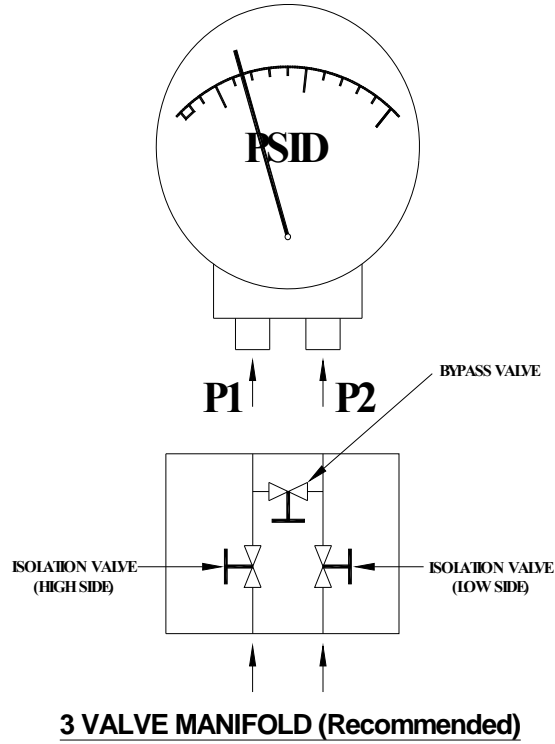
A switch added to a ΔP gauge, set at a preset value, adds the ability to signal an alarm or trigger a control device such as a pump or valve. A second switch can be used on some instruments for high-low set-points or to act as a backup switch. Some switches have fixed set-points while many switches can be adjusted in the field by the user. Relays are often used in lieu of switches when used in high-inductive circuits such as those incorporating solenoids or motors.

Adding a transmitter feature to a ΔP gauge allows the user to have an electrical signal sent to a PLC or a computer so that the process conditions are known at all times, just like the gauge. This allows for a number of actions to be taken throughout the range of the instrument.

Transmitters have a number of outputs such as voltage, current, RS232 or frequency. Each has their advantages and disadvantages. Please refer to FCI TS #I 303, *s Selection Guide for Pressure Transducers* for more details on transmitters and transducers.

The user should take great care in learning the current, voltage and power limits of the electrical option to insure proper operation in the field. For hazardous locations or explosion proof environments ΔP instruments with the proper listings and ratings must be selected to insure safe operation.

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