

PRESSURE CONTROL

DESIGN AND CONSTRUCTION OF PRESSURE SWITCHES

Pressure controls can either (1) control or maintain the pressure of a gas, liquid, or solid at some specified value, or they can (2) sense when pressure is moving out of an established safe range and set off an alarm or shut down the malfunctioning equipment responsible for any deviation.

PRESSURE

Pressure is defined as “force per unit area.” Such forces always produce a deflection, a distortion, or some change in the volume or dimensions of the material under pressure, no matter how small or large the force. It is this change in a sensing element that provides the basic measurement and controlling movement of pressure instruments. The proportional deflection of a sensing element can be used in a pressure controller to trip an electrical switch at a given pressure. The switch in the controller may be used, for example, to actuate and deactivate a compressor as needed to maintain process pressure at a predetermined value.

The most common units of pressure are pounds per square inch (psi), inches of water column in a manometer (WC), or inches of mercury in a manometer (Hg). The most popular metric unit of measurement is the kilopascal (kPa). Pressure must be measured with respect to a given reference pressure, which is most commonly atmospheric pressure at sea level or absolute zero pressure.

Pressure is one of the most important industrial process variables, stretching from ultra-high vacuum to positive pressures of 10,000 psi and above.

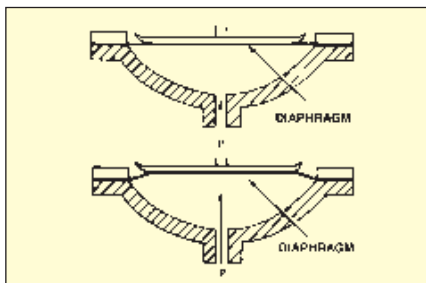
1. PRESSURE SENSING

The most important component of any instrument used to measure or control pressures is the sensing/measuring element. It is this sensing element in combination with an opposing spring that determines the range of pressures measured and the sensitivity and accuracy of the measurement. The particular sensing element being used also determines the overall ruggedness, life expectancy, size, and cost of the instrument. OMEGA® employs several styles of pressure sensing devices—the diaphragm, piston, bellows, and hi-proof/low-set diaphragm.

DIAPHRAGMS

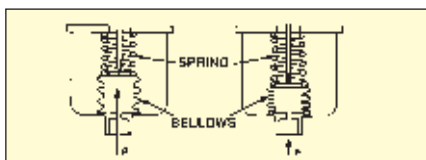
OMEGA uses both flat and convoluted elastomer diaphragms (such as Buna-N and PTFE). The diaphragm is a deflecting mechanism that is installed with a backup plate. When pressure is applied at the lower part, the diaphragm and plate deflect, acting against a load spring, which determines the range and basic sensitivity.

Diaphragms used on controls may sense pressures within 30 inHg vacuum to 6000 psi. They feature a large effective area, hence, large forces, which makes possible the sensing of low pressures with a relatively low-cost mechanism. PTFE diaphragms combine corrosion resistance to many media with sensitivity to deflect under small pressure changes. As with a bellows, the load spring is interchanged for altering ranges and sensitivities. The spring remains unchanged, except for vacuum service, where it is reversed.



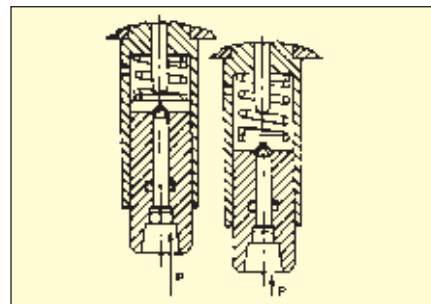
BELLOWS

A metallic bellows is a cylindrical element, generally closed at one end, with several deep folds or convolutions that expand or contract when subjected to pressure. It is commonly used for measuring vacuum (30 inHg) and positive pressures up to 500 psig. The bellows material may be brass, phosphor bronze, or stainless steel, depending on the pressure range, sensitivity, corrosion resistance, and cost desired. Most controls are furnished with bellows elements. Since bellows life is increased when axial travel is kept to a minimum, a load spring is employed to oppose this movement. A change in the load spring will change the range and sensitivity of the control.



PISTON

A piston is designed for high pressure operation, for example, on hydraulic pressures up to 10,000 psi. Pistons are usually manufactured with a stainless steel, smooth piston rod that moves against a load spring to produce measurable movement. An O-ring is employed to seal the piston housing from the medium. The higher the pressure applied to the piston, the more forcefully the O-ring squeezes the piston rod, and the less sensitive the pressure measurement/control device will be as pressure increases. The overall range of the piston sensor is determined by the selection of load spring opposing the piston's movement. As with bellows and diaphragm elements, the load spring, acting against the piston, determines the range.

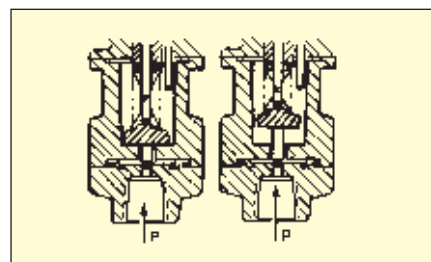


HI PROOF/LO SET

The hi-proof/lo-set sensor assembly combines the sensitivity of a diaphragm with the ruggedness and high-proof pressures of a piston. It is designed for applications in which low setpoints and high overpressures up to 2500 psi are anticipated.

2. FROM SENSOR TO SWITCH

Once the pressure has been sensed and turned to measurable movement, this movement must be transferred to an actuating device, such as an on-off switch. For this function, a rod connects the bellows, diaphragm, or piston with the switch plunger. The plunger then moves to actuate or deactivate the switch.



NEMA ENCLOSURE RATINGS AND EXPLOSION-PROOF ENCLOSURES

A setpoint can be obtained by threading the plunger tip in (higher setting) or out (lower setting), or by positioning the switch(es) in relation to the plunger. The further away the switch is from the sensor plunger, the more the plunger must travel, and hence the higher the setting.

For “Force Balance” products, the setpoint adjustment positions an opposing spring that restricts the sensor movement until the pressure approaches the setpoint.

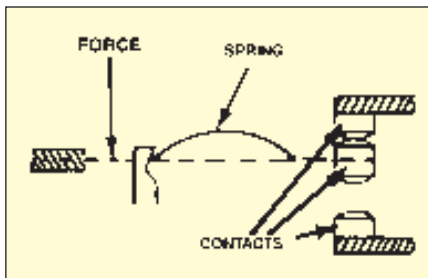
For models with knob/dial calibrations, the switch can be positioned in relationship to the sensor. Also, because a load spring usually opposes the movement of a bellows, diaphragm, or piston sensor, the moving of an adjustment thread or knob changes the amount of spring tension against the sensor. If we increase the setting, we have increased the spring tension and, hence, the sensor requires a greater pressure to actuate the switch at the new setpoint.

3. THE SWITCH

The movement from the sensor actuates an electrical signal by changing the position of electrical contacts in a switch. The final component required for a simple pressure control device is the electric snap switch (providing on-off action). Most OMEGA® controls have a single pole double throw (SPDT) switch. Such switches can be wired either to make or break an electrical circuit. They have 2 modes—normally open and normally closed. When wired normally open, the circuit is open when the switch is not actuated. When wired normally closed, the circuit is closed when the switch is not actuated.

Electric snap switches consist of a snap-acting mechanism built into a molded case. A lever is spring-formed to provide positive snap action when the actuating plunger drives the lever to the transfer point. A high-quality switch has a beryllium copper lever with a silver contact tip that transfers from one stationary contact to the other. When the actuating force is relieved, the lever snaps back to its normal position.

Electric switches transfer signals in response to movement of mechanical sensors, as covered in the preceding pages. Switches allow us to actuate a warning light (if lube oil pressure is falling), a vacuum pump (if pressure is falling), and many other similar functions. In short, we can “make something happen” in response to our sensors.



AN EXPLANATION OF NATIONAL ELECTRIC MANUFACTURING ASSOCIATION (NEMA) ENCLOSURES*

TYPE NO. 4 (Watertight and Dust-Tight):

An enclosure intended for indoor use to protect the enclosed control against splashing water, seepage of water, falling or hose-directed water, and severe external condensation. These enclosures have provisions for watertight connectors and for mounting external to the enclosure cavity.

TYPE NO. 4X (Watertight, Dust-Tight and Corrosion-Resistant): Same as Type 4 with corrosion-resistant construction as well.

EXPLOSION-PROOF ENCLOSURES

MEANING OF EXPLOSION-PROOF:

Explosion-proof means that the enclosure must be strong enough to withstand any internal pressures caused by an explosion and tight enough to prevent the issuance of flames. Explosion-proof does not mean that the equipment has to be gas-tight. This is not feasible, because any time the enclosure has to be opened, the explosive atmosphere could enter the apparatus. It is in Class I locations only that explosion-proof electrical equipment is required.

HAZARDOUS LOCATIONS: These are defined by the National Electrical Code (ART. 500) as follows:

CLASS I: A location in which flammable gases or vapors exist in quantities sufficient to render the resultant atmosphere explosive or ignitable.

DIVISION 1: Locations where hazardous concentrations of flammable gases or vapors exist:

1. Continuously, intermittently, or periodically under normal conditions
2. Frequently because of repair or maintenance operations or because of leakage

3. Owing to breakdown or faulty operation of equipment or processes, which might also cause simultaneous failure of electrical equipment.

DIVISION 2: Locations in which flammable volatile liquids or flammable gases are handled, processed, or used, but in which the hazardous liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment.

GROUP A: Atmospheres containing acetylene

GROUP B: Atmospheres containing hydrogen or gases or vapors of equivalent hazard such as manufactured gas

GROUP C: Atmospheres containing ethyl-ether vapors, ethylene, or cyclopropane

GROUP D: Atmospheres containing gasoline, petroleum, naphtha, alcohols, acetone lacquer solvent, and natural gas

CLASS II: Any location that is hazardous because of a quantity of combustible dust sufficient to explode if in suspension in the air, or where an accumulated quantity of dust on electrical apparatus may overheat the apparatus and cause a fire or explosion

GROUP E: Atmospheres containing metal dust

GROUP F: Atmospheres containing carbon black, coal, or coke dust

GROUP G: Atmospheres containing flour, starch, or grain dusts

CLASS III: Locations that are hazardous because of the presence of easily ignitable fibers or flyings, but where they are not likely to be in suspension in air in quantities sufficient to produce ignitable mixtures

DIVISION 1: Locations in which easily ignitable fibers or materials producing combustible flyings are handled, manufactured, or used

DIVISION 2: Locations in which easily ignitable fibers are stored or handled (except in process of manufacture)

* For international “IP” ratings of enclosures, see IEC Publication 529.



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