Pressure

Content

Measurement Principles and Sensors for Pressure Measurement

Concepts

Absolute pressure

A pressure related to Reference "0" (vacuum), identified as absolute pressure. To differentiate from other types of pressure it is identified by the index abs (p_{abs}).

Atmospheric air pressure

The most important pressure for the measurement of environmental conditions on earth is the atmospheric air pressure p_{amb}. This arises from the weight of the layer of air that envelops the earth up to an altitude of approximately 500km. Up to this altitude where absolute pressure p_{abs} = 0 rules, the atmospheric air pressure constantly decreases. At sea level air pressure p_{amb} is on average 1013,25hPa. Air pressure referenced to sea level is the effective air pressure at the measurement location, converted to sea level. Conversion takes place by the addition of a pressure difference that arises from the weight of the air column between the measurement location and sea level. By this means air pressures may be compared independently of sea level. The air pressure in our weather system varies by approximately ± 5% between so-called high and low-pressure positions.

Given an identical temperature over the various distances from the earth's surface, with increasing altitude the air pressure decreases exponentially. The so-called international altitude formula applies here:

$$p_{amb} = p_0 (1 - \frac{6,5 \times h}{288km})^{5,255}$$

whereby the effective air pressure at a specific altitude *h* can be determined.

Differential pressure

The difference between two pressures p_1 and p_2 is called the differential pressure $\Delta p = p_1 - p_2$. In cases where the difference between two pressures represents the measurement value itself, one refers to differential pressure p_{12}.

Atmospheric differential pressure, Overpressure

In the area of technology, atmospheric differential pressure p_e is most commonly measured. This is the pressure difference between p_{abs} and p_{amb}. This pressure differential is known as overpressure. Positive overpressure is when absolute pressure is higher than atmospheric air pressure, negative overpressure when it is lower.

Piezoelectric effect

An electrical charge collects on the surface of certain materials dependent on the influencing weight. This charge that is proportional to weight can be used for pressure measurement.

Measurement Principles and Sensors for Pressure Measurement

In pressure measurement one differentiates between those instruments that derive the measurement value directly from one of two basic formulae:

$p = \frac{F}{A}$ or $\Delta p = \Delta h \times \rho_m \times g$

and those instruments that convert changes in length, or the electrical, optical or chemical effects of a change in pressure, into a corresponding signal.

Direct pressure measuring instruments

Liquid pressure measuring instruments

The pressure to be measured *p* is compared with the height *h* of a column of liquid. Pressure is determined in accordance with the above formula (ρ_m: density of measurement medium, *g*: acceleration).

Pressure balances/piston pressure measuring instruments

Pressure balances and piston pressure measuring instruments work according to the basic definition of pressure. Pressure acts on a defined surface *A* and produces a force *F*. This force is compared with, for example, a spring or counterweight. The spring displacement or the mass of the weight is then a measure of pressure.

Indirect pressure measuring instruments

Mechanical pressure measuring instruments

The most commonly used mechanical pressure measuring instruments are those with spring elastic receiving elements (Bourdon gauge). In this case the pressure enters into a defined space within the measuring device, one or more of whose walls bend elastically in proportion to the pressure.

Electronic pressure sensors

There is a multiplicity of electrical pressure sensors using different measurement principles. The following highlights just some important processes:

Strain gauges, semiconductor strain gauges (piezoresistive effect) etc.

Through the application of pressure the length and thereby the value of an electrical resistance changes in accordance with the following formula:

$$\Delta R = \rho \times \Delta\left(\frac{l}{Q}\right) + \Delta\rho \times \left(\frac{l}{Q}\right)$$

where ρ represents the specific resistance, *l* and *Q* the length and profile of the resistance.

This change of resistance is calculated using a special procedure, the so-called Wheatstone measuring bridge, and is converted into a pressure-dependent output signal.

Other strain gauges, in addition to the already mentioned semiconductor technology, are thick and thin film strain gauges and foil strain gauges.

Hall-effect sensors

A Hall-effect sensor determines the change of a magnetic field dependent on the deflection of a membrane or similar material.

Capacitive sensors

In pressure measurement with capacitive sensors one makes use of the pressure-dependent change in gap between the two condenser plates.

Conversion of important pressure units

	SI-Units			Technical Units		
	bar	**mbar**	**Pa**	**mmHg**	**kp/cm²**	**atm**
1 bar	1	10^3	10^5	750,064	1,01972	0,986923
1 mbar	10^{-3}	1	100	750,064E-03	1,01972E-03	0,986923E-03
1 Pa	10^{-5}	0,01	1	7,50064E-03	10,1972E-06	9,86923E-06
1 mmHg	1,33322E-03	1,33322	133,322	1	1,35951E-03	1,31579E-03
1 kp/cm²	0,980665	0,980665E03	98,0665E-03	735,561	1	0,967841
1 atm	1,01325	1,01325E03	101,325E-03	760	1,03323	1

Additional conversions:

1 hPa = 1 mbar

1 Pa = 1 N/m^2

1 mmHg = 1 Torr

1 kp/cm^2 = 1 atü