Understanding pressure instrumentation

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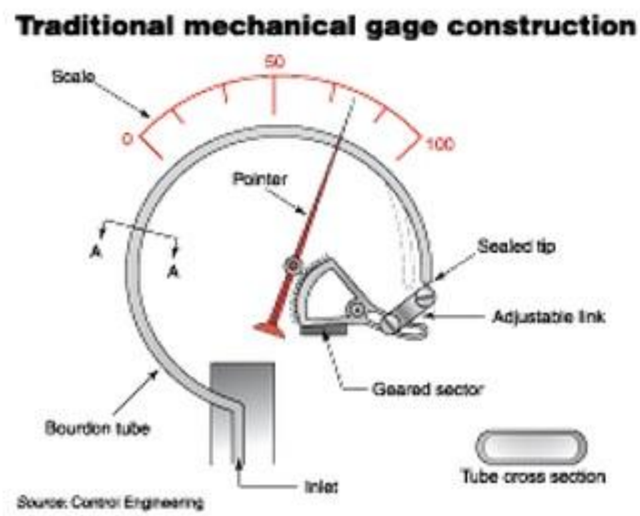

Measuring pressure is one of the most basic instrumentation functions in any industry. From an oil refinery to a bulldozer, measuring the pressure of compressed air, hydraulic fluid, process liquids, steam, or countless other media is a daily occurrence and critical to all manner of control. As a result, pressure measurement devices are everywhere, and there are countless varieties of options. Reviewing technologies in general terms can yield better applications, although there likely will be exceptions to any specific point.

Pressure, also called compressive stress in mechanical terms, has peculiar characteristics that affect approaches to measure it:

• It is usually quantified in units of force per unit of area;
• It exists in both static and moving fluids; and,
• Fluid pressure is always measured as a differential to something else.

Two types of pressure measurements can be divided into three categories:

Absolute pressure is measured against an absolute vacuum, discounting entirely the effects of atmospheric pressure. This measure is used primarily for research or design, but there are some applications where an absolute reading is useful in a process context. Since it isn't practical to pull a full vacuum inside a sensor housing, sensors typically adjust a gage reading using either a fixed correction factor or more sophisticated units use a measured barometric pressure.

Differential pressure is the pressure in one area or vessel measured against another. The reading is the difference between the two and does not account for the pressure of either side relative to atmosphere or a vacuum.

Gage pressure, which is a type of differential pressure, is the pressure in one area or vessel measured against atmosphere. This is the most common practice.

The two most common units of pressure measurement are psi and bar. While the former is primarily still used in the U.S., the latter metric unit is becoming more common. Bar has largely replaced pascals and kilopascals since the numbers are more convenient. Many other units of measure exist, but their uses generally are relegated to specialized applications. Both psi and bar use a suffix "a" or "g" to indicate absolute or gage. When there is no suffix, gage is assumed.

Instrumentation

Traditional mechanical gages (see diagram) use a curved, closed 'bourdon tube' that tends to straighten as internal pressure increases.

Differential pressure measurements do not specify absolute or gage, since both sides of the measurement are compared directly. The reading is the difference and has no indication of the magnitude of the two sides. If the differential pressure between two tanks is 50 psi, the tanks could be 10 psi and 60 psi, or 5,000 psi and 5,050 psi. There is no way to determine pressure relative to atmosphere without another sensor. Differential pressures often use a suffix “d.”

Traditionally, mechanical gages with curved bourdon tubes were standard, and these are still available in many configurations. As with other forms of instrumentation, however, electronic versions have gained popularity.

Accuracy, range, and safety

Electronic pressure instruments and mechanical gages express accuracy in the same way, specifying an error factor as a percentage of range. For example, a good quality 0-500 psi gage could offer accuracy of its operating level while allowing for potential pressure surges or spikes. In other words, if your process runs at 75 psi, it is better to use a 0-100 psi gage rather than a 0-500 psi gage, even if they have the same accuracy rating. Poor ranging is frequently cited as the most common mistake when selecting and applying pressure devices. Cost-minded purchasers choose one pressure instrument for the sake of minimizing inventory and then try to make it work in a wide range of applications. Accuracy suffers as a result.

Some electronic sensors can have their range adjusted. For example, a unit designed to measure 0-500 psi can be electronically adjusted to read 0-300.

This helps spread out the relevant reading area on the 4-20 mA signal, but does not actually increase accuracy. The turn-down ratio will be the same as the full 0-500 scale in most cases.

Users need to consider what is going on inside the system when trying to determine an appropriate level of ruggedness. Water hammer, caused when a fluid is moving and a valve opens or closes suddenly, sends a pressure spike traveling at the speed of sound through the system that can damage a sensor or at least knock it out of calibration. Static applications and compressible fluids do not need as much protection from spikes as a more dynamic environment.

Selection considerations

Housing: The safety needs of a wastewater plant differ from an oil refinery. Many options can comply with environments that demand explosion proof or intrinsically safe instrumentation. Moreover, many companies have established clear policies on what gets used and where. On the other hand, if an explosive environment isn’t a concern, the device variety available is much larger. Also, the bulkiness of the unit will depend mostly on the ancillary electronic equipment needed to communicate. A simple transducer with only a 4-20 mA output pigtail can be very compact, whereas a smart transmitter with a fieldbus connection will be larger to accommodate additional circuitry.

Mounting connection: Instruments usually have a pipe thread inlet ranging from 1/8 to 1/2 in. NPT or BSPT. However, there are additional choices for more specialized applications, including sanitary tri-clamps and other flange options. Differential pressure devices often use manifolds to simplify connections.

Communication: Most transducers create some type of voltage, capacitance, or resistance analog signal natively. For transmission, this is converted to a more standardized format such as a 4-20 mA analog signal. This may involve some additional signal conditioning to ensure reliable transmission. Transmitters also communicate via fieldbus, wireless, and may add HART communication.

Sensing technology: There are at least 10 technologies and variations for converting a pressure into a scalable electronic signal, but none is universal. Device manufacturers tend to employ one or two technologies following a combination of performance attributes and commercial applicability, doing their best to optimize performance and minimize drawbacks. Product literature often doesn't even mention the technologies used. Some suppliers use multiple sensor technologies because they're optimized for a specific range. The capabilities of microprocessors in smart transmitters compensate for sensor weaknesses.

Accessories can simplify mounting, or protect the device. Examples include:

Block and bleed valve —A valve mounted on the impulse line that allows pressure to be released from the sensor once the process connection is closed.

Snubber —A device to retard flow from process to sensor, primarily to suppress pulsations in an effort to extend sensor life. When properly applied, the reading is correct without harming the sensor diaphragm.

Diaphragm seal —A diaphragm mounted below the sensor to transmit pressure without allowing process fluid to infiltrate the sensor. When used, the sensor has to be filled with an inert fluid, usually a silicone oil, to transmit the system pressure.

Overpressure protector —A spring loaded valve that closes in an overpressure situation before the sensor is harmed, used where major spikes are a possibility.

Manifold —A device to simplify complex piping to a differential pressure gage, usually incorporating internal valves to facilitate cutoff, pressure relief, and equalization functions.

Long-term operation

Maintenance and calibration requirements vary tremendously, based on the individual instrument and process needs. A quality device in an application that is of secondary importance could operate for years without attention. On the other hand, in a critical application where precision is paramount, transmitters will need periodic calibration. However, high quality transducers and transmitters receive very precise calibration at the factory, which is well beyond the capabilities of most in-plant maintenance departments. Often, attempts to improve performance only manages to make it worse. Devices from reputable manufacturers that drift or need constant attention have most likely been damaged, or are mounted in a way that hinders the ability to transmit reliable data.

Ultimately the best advice for selecting a pressure measuring device or any type of instrumentation, is to know the application. Knowledge of precision, communication, and diagnostics translates readily into specifications. Otherwise, pressure sensor selection could miss the mark and you'll lose a critical element of process control.

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