HOW TO SELECT THE BEST PRESSURE TRANSDUCER FOR INDUSTRIAL APPLICATIONS

WHITEPAPER

Today's technologically advanced pressure transducers are more accurate, reliable and rugged than ever before. They're ideal for long-term use even in harsh environments of extreme temperature, humidity and vibration. Industrial pressure transducers are used in a wide variety of industrial applications ranging from HVAC/R compressors, refrigeration and variable speed pumps to hydraulic pressure, oil and water.

They might measure the:

- Pressure of fluorocarbon refrigerants to optimize refrigerant flow in industrial refrigeration applications
- Pressure of hot & chilled water in refrigeration systems
- Hydraulic pressure on heavy-duty off road loaders and forklifts
- Shop air pressure through a large automotive plant for use by air tools
- Braking system pressure on a locomotive
- Discharge & suction pressure for compressors or pumps
- Water pressure on a fire truck

A transducer can be used anywhere a pipeline or chamber is located. Its function is to sense and convert pressures into a proportional electrical output signal that is transmitted to a monitoring or control system. These sensors monitor the performance and efficiency of systems and help optimize their operations. Selecting and installing the correct transducer for a new application is a very important decision; the wrong transducer can result in system problems.

1. The Top 5 Product Considerations For Selecting a Pressure Transducer

Pressure

The most important consideration when selecting a transducer is pressure. A number of questions must be answered to ensure the correct transducer is selected. Knowing the pressure specifications of the application will narrow down the type of pressure transducer required.

What's Inside

Next, refer to the pressure transducer's data sheet or and locate the specifications to help with the following questions:

- What is the pressure range that the transducer will measure?
- What is the maximum pressure the transducer will encounter?
- What is the potential for over pressure in the system?
- What is the proof pressure (the maximum pressure that may be applied without changing performance beyond specifications)?
- What is the burst pressure (the pressure that will rupture the diaphragm or transducer case and cause leakage)?

If the sensor specifications can't be found on the data sheet, contact the manufacturer's applications engineers for help.

Media

Any wetted surfaces of the transducer must be compatible with the media, which can include motor oil, brake fluid, refrigerants, hydraulic fluids, seawater, wastewater, tap water, oxygen, compressed air, and nitrogen, to mention just a few. Special consideration must be made for harsh media such as ammonia, ionized water, salt water, hydrogen, acids and jet fuel. Also, be sure that the diaphragm, fittings and welds are compatible with the media. A lot of this information is provided on the product data sheet, but a reputable manufacturer will have technical support available to answer additional questions you may encounter.

Temperature

The consideration of temperature refers to the temperature of both environment and process media. It is important to note that transducers can operate in most environments and process media temperatures. When an application involves high temperatures, the purchaser should open a dialog with the transducer manufacturer to find solutions for seemingly difficult or impossible installations. For example, say you have an application of 300°F steam, but the transducer you're considering only has a compensated temperature range of up to 150°F. In this case the problem can be solved by taking the line that runs from the steam line to the transducer, put a link to the tubing (even as short as 12 inches, depending on the environment) and that high temperature is dissipated into the atmosphere.

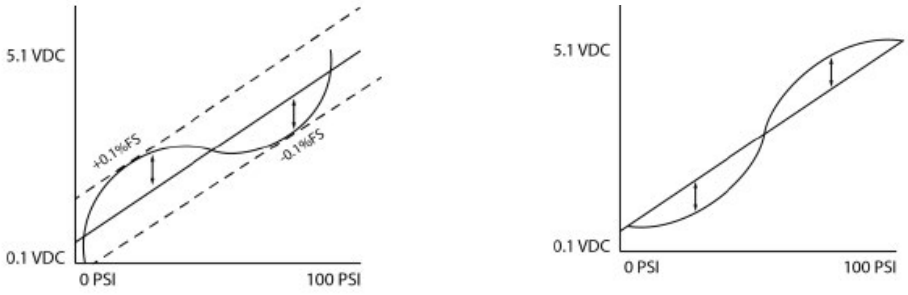
Environment

The environment where the transducer will operate also needs to be considered. This includes not only temperature and humidity, but also ingress protection. Sometimes the true ingress protection needed for the application is not documented in the design specification, and customers create specialized tests for critical components like the industrial pressure transducer. The transducer manufacturer should be contacted to discuss ingress protection requirements.

Other considerations include shock and vibration that the transducer may encounter, especially in more rugged applications such as locomotives or fire trucks. The amount of available space within the installation, location of the application and orientation of the transducer should also be taken into account. The transducer manufacturer may have similar requirements and can provide recommendations for your application.

Accuracy

A transducer's accuracy is the combined effects of its linearity (the closeness to which a curve approximates a straight line), hysteresis (the ability of the sensor to give the same output when the same increasing and then decreasing pressures are applied consecutively[1], and repeatability (the sensor's ability to produce the same output with consecutive applications of the same pressure[2]) (See Figures 1- 3). The accuracy of a pressure transducer can be found on the data sheet. A very common accuracy is ±0.25% FS output, but if the application requires higher accuracy, models with ±0.10% FS are also available.



Best Fit Straight Line Method (BFSL) Endpoint Method

Figure 1: Linearity Graphs

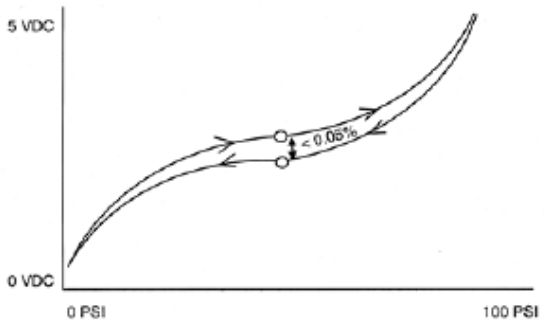


Figure 2: Hysteresis Graph

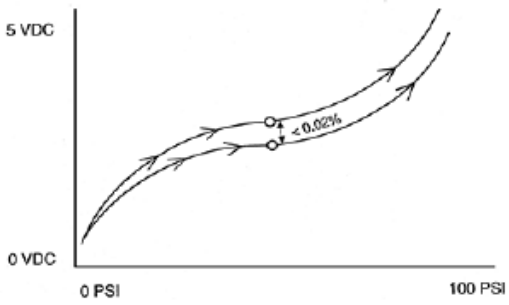


Figure 3: Repeatability Graph

2. The Top 3 Design Considerations For Selecting a Pressure Transducer

Construction/Robust Mechanical Design

After considering the pressure, media, temperature and environment in which the new transducer will be installed, it's time to look at transducer construction. When selecting a transducer, select one with an all-welded construction for a robust design. Also consider the robustness of the connectors welded on the housing. Be sure the manufacturer offers a wide selection of pressure fittings, including standards like 1/4" and1/8" NPT as well as custom process fittings.

A wide variety of industry standard electrical connectors are available for transducers. Since the mating electrical connectors aren't typically shipped with the transducer, be sure to specify electrical connectors that properly mate with connectors in the field. Depending on the noise produced by other equipment near the transducer, select an electrical connector that protects the signal's integrity.

Some transducers need protection from humidity to prevent corrosion around the pins in the connector, while more robust transducer designs can be exposed to humid environments. To isolate a gauge pressure transducer (a transducer referencing ambient air), remove the unit from the humid environment and relocate it in a nearby sealed junction box, allowing it to breath through a cable to the atmosphere. A desiccate can be placed in the junction box to further protect the transducer from humidity.

Transducers are available in a wide variety of ratings depending on the application requirements. If protecting the transducer from a harsh environment is a concern, find one with an ingress protection (IP) rating that satisfies the needs of the installation. . A transducer with a rating of IP65 provides complete protection from infiltration of dust and is protected from water projected from a nozzle. A transducer with an IP67 rating is protected against dust and the effects of temporary immersion of water. An IP69K rating is for high pressure, high temperature applications. If liquid ingress is a risk, protect the transducer with sealed cables.

If the transducer is located outside for use in an industrial refrigeration application, requirements defined by the OEM must be met to provide accurate measurements on a consistent basis. It must have the capability to return to its normal function and provide accurate results after a freeze/thaw cycle.

The unit should have electromagnetically capability (EMC) approval to withstand electromagnetic interference originating from a source that can induce voltage into the transducer and produce an erroneous output. Also check for construction that has high vibration and shock tolerances. When possible, avoid transducers sealed with epoxy, internal elastomers and O-rings, since they do not react well with some process media like refrigerants. Avoid crimped or thread-sealed housings to prevent water ingress problems. Finally, look for a unit with minimal solder joints, which are at risk for disconnecting in certain environments when experiencing extreme vibrations. Hand solder joints should also be avoided since their consistency is difficult it maintain. It can be hard to catch a bad solder joint before it enters into an application.

Ideally, find a sensor that is available in multiple configurations. Sometimes the sensor can be ordered with a variety of output options beyond pressure, such as temperature, PSI or bar pressure ranges and compound, gauge or sealed gauge pressure types.

There is additional information on the transducer's specification sheet that may be important to the application. For example, it will specify if the transducer is CE and RoHS compliant, or UL approved. It will also list the fatigue life, which should be around 100,000,000 cycles. Also look for the unit's long-term stability, which is the ability to retain performance characteristics for a relatively long time period (Ex: better than ±0.1% FS/Yr).

When possible, avoid oil-filled sensors since it adds additional material with a different thermal coefficient, increasing sensor instability. As the oil temperature warms up or cools down, its characteristics change in relation to the diaphragm. As warmed oil expands, it exerts pressure against the sensing diaphragm, resulting in an inaccurate pressure reading. Further, if the diaphragm touching the process media ruptures, then the media is contaminated with oil. Ceramic technology shouldn't be used in high pressure transducers. They're extremely linear, but the ceramic is brittle and has lower burst pressure than other sensor types.

Robust Circuit Design

Today, sputtered thin film strain gauge technology is considered state of the art for industrial applications. This type of transducer employs the well-proven Wheatstone bridge principle (See Figure 4). In this design molecular layers are sputtered onto a 17-4 pH stainless steel (SS) diaphragm and the circuit is etched to provide excellent resistor definition and uniformity. Sputtered thin film technology allows the for design of simple, highly accurate and compact strain gauges deposited onto the back of the sensing diaphragm, which is in direct contact with the media.

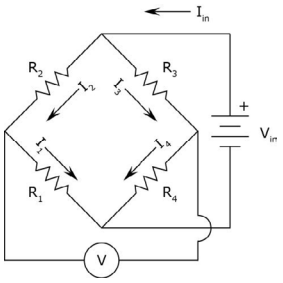


Figure 4

This method virtually eliminates drift, while offering enhanced sensitivity. Thin Film Strain Gauge technology incorporates a compact design with good temperature stability. Since the circuit is etched on, there isn't glue or epoxy to break down or separate, which can result in inaccurate measurements.

In operation, the strain gauge is embedded in the flexible, circular diaphragm, which is wired to a Wheatstone bridge circuit to measure pressure variations. When system pressure is applied to the diaphragm, it is displaced, putting surface strains on the gauge proportional to the pressure. This generates a linear and proportional analog electrical output signal, typically 4-20 mA through two-wires.

This circuit design also offers linear temperature compensation, an important consideration since extreme temperature fluctuations can adversely alter a transducer's output signal. To avoid this, a unit with temperature compensation capabilities counteracts temperature errors in the media by electronically adjusting the transducer's output signal. The unit's specification sheet has detailed information on the compensated temperature range.

The design provides short connections in the circuitry from the diaphragm to the intermediate circuit board and from the circuit board up to the connectors. Shorter connections minimize vibrations that may result in a fault.

One additional benefit of modular transducer design is fast turnaround time to meet each customer's unique needs. Since transducers are modular, their various components, housing, circuit boards, diaphragm, terminals, pressure ports, connections and fittings, can be easily taken from inventory, assembled and shipped in short time frame.

Finally, select a supplier that calibrates and tests each transducer over its entire operating range for stability and linearity, before specifying the OEM pressure sensor.

Supplier's Supply Chain and Design Control

There is a wide range of OEM pressure sensor suppliers that design and manufacture pressure transducers for industrial process environments. Choose a supplier that makes most of its own components, has direct control over its printed circuit board assemblies and has control over its supply chain. In addition, it's recommended to purchase from a company that owns and controls the intellectual property of the transducers' critical design components. Suppliers that own their own intellectual property have the flexibility to customize a product to meet a unique situation.

In most instances, a transducer can be selected from a supplier's catalog or website. If it's not a straightforward selection, when extreme temperatures, pressures or environments are involved, contact the supplier to review the system. Although the customer may consider the application to be challenging, the transducer manufacturer has likely encountered it before, enabling them to provide a solution. A supplier can discuss previous customer problems, field issues, past failures, technical support and provide recommendations for a successful installation.

3. Resources

- "Field Guide to Pressure Transducers"
- "How to Compare Price/Performance of Different Pressure Transducers."
- Pressure Sensor Accuracy: Why it is important
- Two-Part Whitepaper on Selecting a Low Differential Pressure Transducer
- Definitions and Terminology: http://blog.setra.com/commonly-used-pressure-terminology-acronyms/2012/10/17
- White Paper: How to Prevent Pressure Transducer Failures [http://content.setra.com/how-to-prevent-pressure-transducer-failures-whitepaper]
- Application Note: Corrosion Resistance Table
- Article: How do Shock & Vibration Effect a Pressure Transducer? [http://blog.setra.com/shock-vibration-pressure-transducer-effects/2013/07/24]
- Article: Differential Pressure Transducers in Critical Pressure Applications [http://blog.setra.com/differential-pressure-transducers-critical-pressure-applications/2013/06/12]
- Article: How to Select Multi-Range Pressure Sensors [http://blog.setra.com/select-right-multi-range-pressure-sensor/2013/03/06]

[1,2] Sensor Magazine (November 1, 1998). Fundamentals of Pressure Sensor Technology.