

How to Select a Pressure Transducer for industrial applications

OVERVIEW

Today's technologically advanced pressure transducers are more accurate, reliable and rugged than ever before. They are 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, for example, 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 there is a pipeline or chamber. 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. Consequently, selecting and installing the correct transducer for a new application is a very important decision. Selecting the wrong transducer can result in system problems.



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Section I

The top 5 product considerations for selecting a pressure transducer



Pressure

The first and most important consideration is pressure. A number of questions must be answered to ensure the correct transducer is selected. 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?

When you have answered the questions above that relate to your application, it is recommended to refer to the pressure transducer's data sheet and locate the values for the following questions: What is the proof pressure (the maximum pressure that may be applied without changing performance beyond specifications)? Finally what is the burst pressure (the pressure that will rupture the diaphragm or transducer case and cause leakage)? The answers to these questions are readily available online via the manufacturer's technical data sheets, but a well-established manufacturer will have application engineers available to discuss your application requirements further.

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. Much 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 in which the transducer will operate needs to be closely examined. 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. Customers are encouraged to contact their transducer manufacturer to discuss ingress protection requirements.

Other considerations include shock and vibration that the transducer may encounter, especially in more severe applications such as locomotives or fire trucks. If space is at a premium, find a unit with a small footprint. Location and orientation are further installation considerations. The transducer manufacturer may have encountered similar requirements and may have recommendations for your application.

Accuracy

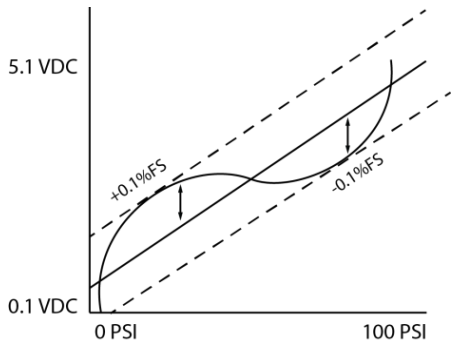
A transducer's accuracy is the combined effects of its linearity (the closeness to which a curve approximates a straight line, see Figure 1 on page 4), hysteresis (the ability of the sensor to give the same output when the same increasing and then decreasing pressures are applied consecutively¹, see Figure 2 on page 4), and repeatability (the sensor's ability to produce the same output with consecutive applications of the same pressure², see Figure 3 on page 4). Accuracy can be found on each model's specification sheet. A very common accuracy rating is ± 0.25 percent of full-scale output. If higher accuracy is needed, models with ± 0.10 percent are available.

^{1,2} Sensor Magazine (November 1, 1998). Fundamentals of Pressure Sensor Technology.

Accuracy (continued)

Figure 1: Linearity Graphs

(best-fit straight-line method)



(end-point method)

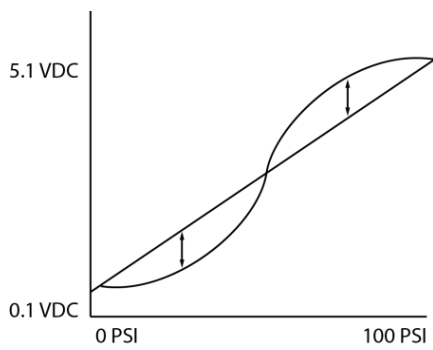


Figure 2: Hysteresis Graph

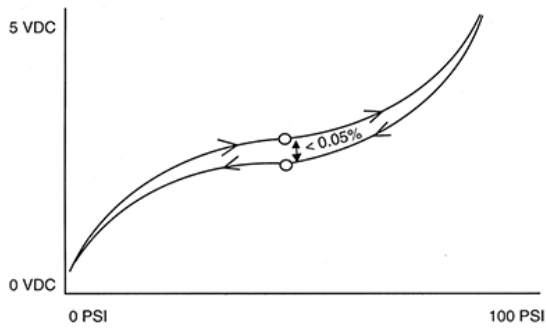
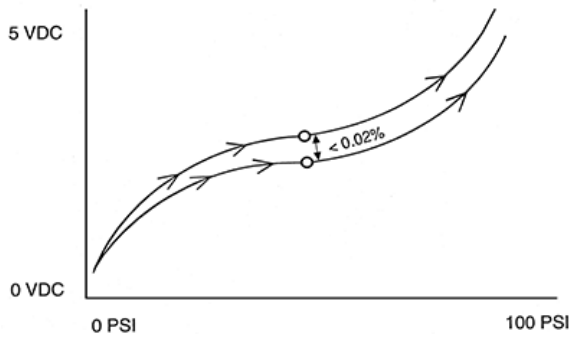


Figure 3: Repeatability Graph



Section II

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" and 1/8" NPT as well as custom process fittings.

A wide variety of industry standard electrical connectors are available as well. Because the mating electrical connectors are not 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 to be protected from humidity to prevent corrosion around the pins in the connector while more robust transducer designs can be subjected to humid environments. To isolate a gauge pressure transducer (a transducer referencing ambient air), the unit can be removed from the humid environment and located in a nearby sealed junction box where they can breathe through a cable to the atmosphere. A desiccant can be placed in the junction box to further protect the transducer from humidity.

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. Transducers are available in a wide variety of ratings. 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, sealed cables are a must.

If the transducer is to be located outside for use in an industrial refrigeration application, for example, then it must meet additional

requirements defined by the OEM to provide accurate measurements on a consistent basis. It must be able to return to its normal function and provide accurate results after a freeze/thaw cycle.

In addition, the unit should be EMC approved to withstand electromagnetic interference originating from, say, a large motor generator that can induce voltage into the transducer and produce an erroneous output. Furthermore, the construction should have high vibration and shock tolerances. When possible, avoid transducers sealed with epoxy, internal elastomers and O-rings because they do not react well with some process media like refrigerants. Also, avoid crimped or thread-sealed housings to avoid water ingress problems. Finally, look for a unit with minimal solder joints. They are at risk for disconnecting in certain environments (such as ones experiencing extreme vibrations). Hand solder joints are to be avoided since hand soldering consistency is difficult to maintain, it is often hard to catch a bad solder joint before it enters into an application.

Ideally, find a model that is available in multiple configurations and, if necessary, can be ordered with a variety of output options beyond pressure, such as temperature, psi or bar pressure ranges, 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, and if it is 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—its ability to retain performance characteristics for a relatively long time period, i.e., better than $\pm 0.1\%$ FS/Yr.

When possible, avoid oil-filled sensors because it adds an additional material with a different thermal coefficient that could add to the sensor instability. As the oil temperature warms up or cools down, its characteristics change compared to the diaphragm. As warmed oil expands, it exerts pressure against the sensing diaphragm, resulting in an inaccurate pressure reading. Further, if the diaphragm that is touching the process media ruptures, then the media is contaminated with oil. Ceramic technology should not be used in high pressure transducers, they are extremely linear but the ceramic is brittle and the burst pressure is lower 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 diaphragm and the circuit is etched to provide excellent resistor definition and uniformity. Sputtered thin film technology allows the 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.

This method virtually eliminates drift, while offering enhanced sensitivity. This technology incorporates a compact design with good temperature stability. Because the circuit is etched on, there is no glue or epoxy to break down or separate, which would result in measurement inaccuracy.

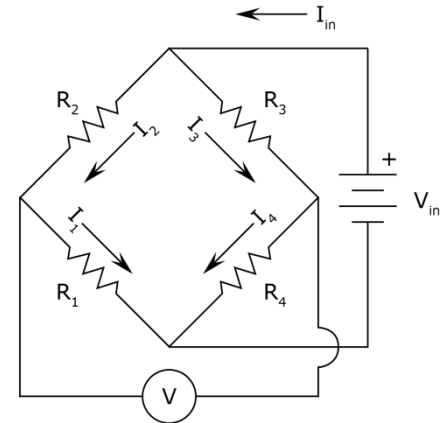
In operation, the strain gauge is embedded in the flexible, circular diaphragm, which is wired to a Wheatstone bridge circuit to measure pressure variations. When system pressure is applied to the diaphragm, it is displaced, putting surface strains on the gauge proportional to the pressure. This generates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

This circuit design offers other features such as linear temperature compensation. This is an important consideration because extreme temperature fluctuations can adversely alter a transducer's output signal. To avoid this, a unit with temperature compensation capabilities counteracts known temperature errors in the media by electronically adjusting the transducer's output signal. The unit's specification sheet will detail its compensated temperature range.

This design also 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. Because transducers are modular, their various components—housing, circuit boards, diaphragm, terminals, pressure ports, connections, fittings, etc.—can be quickly gathered from inventory, assembled and shipped in a timely fashion.

Figure 4
Wheatstone bridge diagram



Finally, select a supplier that calibrates and then 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 an industrial process environment. Go with 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. But if it's not a clear-cut selection—when extreme temperatures, pressures or environments are involved—it's wise to contact the supplier to review the system. Although the customer may consider the application to be unique, challenging or even impossible, the pressure transducer manufacturer has undoubtedly encountered it many times before, and can advise you on a workable solution. Such a supplier can discuss the customer's previous problems, field issues, and past failures, as well as provide phone support, technical documentation, answers to questions, and recommendations to help ensure it is a long-term successful installation.

About the Author:

Melanie Cavalieri is the Product Planner for Industrial Products at Setra Systems, Inc., She is responsible for new product development and marketing for Industrial, Refrigeration and Medical markets.

Prior to entering the marketing role at Setra, Melanie worked in Quality and Manufacturing for Setra in Boxborough, MA and Kollmorgen Motors in Radford, VA. Melanie also has R&D experience at Kodak Versamark in Dayton, OH and Ethicon Endo-Surgery in Blue Ash, OH.

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Setra Systems is a leading global designer and manufacturer of pressure sensors, and transducers, humidity transmitters, current switches, current transducers, and calibration equipment for the HVAC and Industrial markets