

How to Select the Best 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.

PURPOSE OF THIS GUIDE

The purpose of this guide is to help you understand the selection process so that you can speak intelligently to any supplier and quickly find the best solution for your particular application. We have learned that it is nearly impossible to accurately narrow the choice down to a single product based solely on specifications, as multiple products may fit within those specifications.



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Using the wrong type of pressure transducer is the most common reason for pressure transducer failure.

If you're relatively new to the pressure transducers, we also have a **"Field Guide to Pressure Transducers"** that clearly explains the theory, key differences between the types of pressure transducers, and the general applications of each. And, when you're ready to narrow your selection to a specific manufacturer, you should review our guide on **"How to Compare Price/Performance of Different Pressure Transducers."** This guide outlines the most important criteria you should use to do an apples-to-apples comparison of comparable products from different manufacturers.

Section I

Primary considerations in determining the type of pressure transducer

If it seems that selecting the right pressure transducer for an application is complicated, that may be due to the evolution of the industry. The ongoing advancements in technology have created an ever-increasing overlap in the capabilities and specifications of the various transducer technologies. The result is a very wide choice of transducers that might be used in a single application.

"Digital configurators" may help you to narrow your selection, but they require an inordinate amount of detailed information about your requirements and how those requirements match up to the capabilities of different products.

A much more reasonable approach is to first understand HOW an application engineer thinks through the selection process, and then come to the conversation armed with the information he or she will need to provide you with the best possible solution, based on your specific application, requirements, and environment.

1: What is your application?

This question is rather broad, but it is typically the first question we ask. Pressure transducers have thousands of possible uses, so your exact

application may not fit into a tidy box or a simple drop-down menu on a website. Here is a short list of possible applications:

- HVAC:
 - Low pressure monitoring in refrigeration and chiller applications
 - Single or multi-range for low air pressure
 - Applications that require high accuracy
 - Humidity and temperature sensing
 - Current sensors
- Semiconductors:
 - In situ process pressure measurement
 - Pressure measurement of purge gas delivery systems
 - Load-lock pressure measurement and control
 - Clean room air control
 - Leak detection
 - Fume hood controls
 - Laser interferometers
 - Solar & Energy
- Vacuum sensing to support the fabrication of solar cells
- Test and measurement:
 - Engine testing
 - Engine control
 - Gas turbines
 - Performance analysis of diesel engines
 - Environmental pollution control
- Barometric pressure in aircraft altimeter verification, lab and process monitoring, altitude chambers, and weather stations.
- Calibration of equipment to maintain the accuracy in pharmaceutical manufacturing applications
- Room pressure monitoring for hospitals, labs, and animal research facilities used to protect patients, personnel and animals from the spread of airborne infectious diseases.
- “General Industrial” applications, such as: pressure transducers that can accurately measure pressure in a variety of media.

2: What media are you measuring?

With such a broad range of possible applications for pressure transducers, it is often valuable to understand the specific media that you are measuring.

Any wetted surfaces of the transducer must be compatible with the media, which can include motor oil, brake fluid, refrigerants, hydraulic



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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.

3: What kind of pressure range are you measure?

Questions you'll be asked to include:

- What pressure range will you measure?
- What is the maximum pressure that the transducer might encounter? (Exceeding the range of your transducer will lead to product failure)
- What is the potential for over pressure in the system? Again, exceeding the range can lead to product failure.

By knowing the media and the maximum pressure, you can identify the pressure reference required by your application:

- Absolute
- Gauge
- Sealed Gauge
- Differential
- Compound

4: Temperature Considerations

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, you 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.

You'll want to consider both the operating temperature range and any compensation temperature range.

5: Environment & Configuration

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.

Other considerations include:

- Shock and vibration that the transducer may encounter, especially in more severe applications such as locomotives or fire trucks.
- Space limitations and size requirements (does it need to fit in a small space?).
- Electrical output from the sensor:
 - Analog
 - Digital
 - Combination
- Electrical Termination:
 - Connector or integral cable
 - Customer specified
 - Mating connectors and cable assemblies
 - Connector/cable orientation
 - Wiring codes and pin-outs
 - DIN rail mount or in-line
- Environment:
 - EMI/RFI conditions
 - IP or NEMA rating required?
 - Hazardous environment?
 - Indoor or outdoor use? – Exposure to elements, dirt, temperature extremes, etc.
 - Submersible? – Salt or fresh water? Depth?
- Special requirements:
 - Calibration requirements
 - Special approvals/testing/Certifications/Cleaning
 - Special labeling requirements
 - Frequency response
- Serviceability:
 - How often is it serviced?
 - How accessible must it be?

6: Accuracy & Performance Considerations

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, and
- Repeatability: The sensor's ability to produce the same output with consecutive applications of the same pressure.

See ["Pressure Sensor Accuracy: Why it is important"](#)

[Also, this Two-Part Whitepaper on Selecting a Low Differential Pressure Transducer](#) has an extensive selection on accuracy and performance considerations.

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

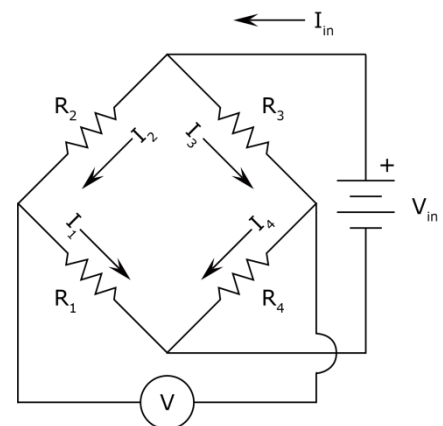
Today, sputtered thin film strain gauge technology is considered state of the art for industrial applications. This type of transducer employs the well-proven Wheatstone bridge principle. (See Figure 1) In this design molecular layers are sputtered onto a 17-4 PH stainless steel diaphragm and the circuit 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

Figure 1
Wheatstone bridge diagram



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.

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.

Section III

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>]
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