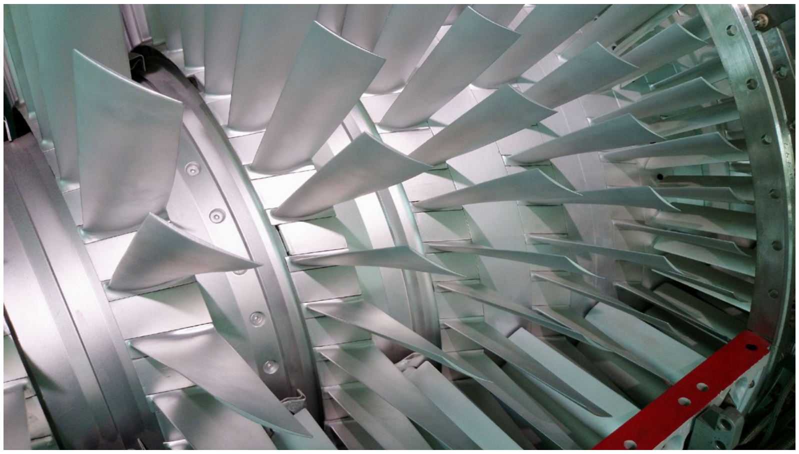
HOW TO SELECT DIFFERENTIAL PRESSURE TRANSDUCERS
For Low Differential, Critical Pressure Applications Part 2

WHITEPAPER



System manufacturers are providing the highest quality, most reliable and most energy efficient automobiles, airplanes, turbine and gas engines and associated components ever produced. This is due in large part to the manufacturers' ever increasing demand for rigorous test and measurement of these products. Differential pressure transducers (DPTs) are an integral part of that process for applications that demand reliability, repeatability and high accuracy.

Differential pressure transducers are commonly used in test stands, wind tunnels and leak detection systems. Engineers for each application look for transducer improvements critical to their industry.

The performance of today's differential pressure transducers has improvements to provide solutions to demanding applications. This paper discusses six characteristics and considerations to note when selecting a sensor for low differential, critical pressure applications.

1. Orientation Effect

Improper installation, vibration or even system maintenance can cause a transducer to change orientation. This is known as the orientation effect, which has traditionally been a problem for other types of sensing technologies. Even a properly installed unit will have marginal gravity effect. For example, a unit rotated 180º has gone from positive to negative gravity, causing a change in force of 2 G's. In this case, the sensor can't distinguish between the weight put on it through gravity from the force that is applied through the pressure ports. Consequently, it will combine the gravitational weight effect with the port pressure, sending a false signal.

The orientation effect can be considerably worse in rotated units that have their sensors filled with silicone oil or other isolation fluid. Those units have the weight of both the diaphragm and the fluid fill, both acting on the sensor. The unit can't establish the true pressure and will emit an erroneous value with changes in position.

Fortunately, some transducers have capacitance diaphragms that are, thin, of very little mass, and have no fluid fill, causing them to be minimally affected by gravity. Therefore,

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these units can be mounted in any orientation, knowing they will deliver reliable measurements, especially in installations where space is at a premium. For optimal installation, the unit should be mounted in the same orientation as it was calibrated. For example, if it was factory calibrated in the vertical position with the pressure port downward, its recommended to orient it this way in the field to minimize the orientation effect. When this is not possible, the minimal zero offset shift can be compensated for, by manually adjusting the zero offset on the sensor or through a secure calibration key.

2. Vibration

Similarly, low-frequency vibrations transmitted from a nearby motor or fan can influence an otherwise properly oriented sensor. For example, the fluid in an oil-filled sensor may pick-up low frequency vibration and transmit an inertial load the diaphragm, which is incorrectly interpreted as changing process pressure.

To avoid this vibration effect, end-users may need to mount transducers in remote, quiet areas. If the reference port is vented, it needs to be channeled to an area without acoustic vibration noise or wind. In the case of a wind tunnel, a pitot-static tube is mounted so that both pressure ports are connected to a remotely mounted transducer. The pitot-static tube is connected to flexible or semi-flexible tubing to prevent turbulent air noise, or mechanical vibration from being transferred to the sensor.

Engineers may consider using a capacitor transducer design to minimize orientation and vibration issues by using a stretched stainless steel diaphragm that isn't fluid filled. The only gravity effect it has is the weight of the diaphragm, which is very small and easily compensated for in the field.

3. Overpressure Protection

Overpressure and reverse pressure protection are continuously becoming issues for leak detection system manufacturers. These systems look for small leak rates in applications in which differential pressure is low and static pressure is very high. Leak detection manufacturers increasingly want to measure lower and lower leak rates. Since the leak rate is directly proportional to differential pressure, there's a need for measuring increasingly smaller differential pressures. This can be accomplished by increasing the static test pressure even higher.

Under these conditions of low differential pressure and very high static pressure, a unit that is accidentally overpressured could require major recalibration or stop operating. The same result occurs if the system being measured has a gross leak.

Today's sensors are much more robust, enabling them to overcome these concerns. They're considerably more tolerant of overpressure events in both positive (process) and negative (reference) directions, a critical feature to the system. Previously, sensors were protected only in the positive direction, where a leak in the reverse direction could cause overpressure in the unit's reverse direction. Transducers with adequate protection in both directions are suitable for applications where unintentional overpressure or a gross leak could occur. If it does, the transducer will continue to function.

Transducers can withstand occasional pressures up to their proof pressure rating, 150 PSI for example, and will return to their natural state. Beyond the proof pressure the diaphragm may become permanently deformed, causing the zero to shift. Pressures beyond the burst pressures of 300 PSI applied to either port will breach the containment chamber, possibly resulting in a weld failing, seal leak or the diaphragm or case might rupture.

Original equipment manufacturers (OEMs) and applications engineers must be aware of the transducer's proof and burst pressure limitations. They must understand that their own system can be accidentally vented, or a component of the tested device may not be leak tight, either could potentially damage the transducer. Only use a small, rugged, stainless steel transducer with appropriate pressure protection in both directions that can withstand unintended events.

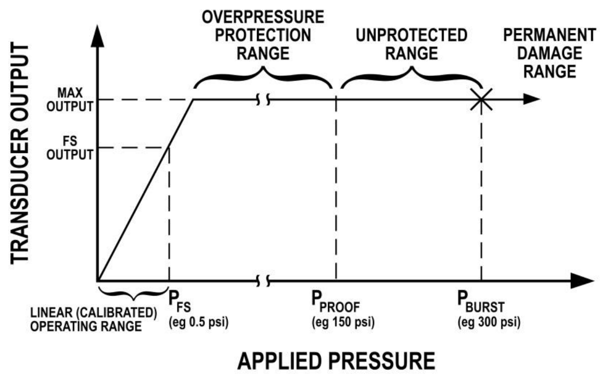

Figure 1: Pressure Transducer Performance Limits

4. Line Pressure Effect

In addition to overpressure, changes in line pressure can be a concern, especially in leak detection applications where static line pressure is elevated. Line pressure is the absolute pressure applied to the transducer's ports. However, changes in static line pressure can produce minor stress-induced variations to the sensor's structure. These stresses modify the unit's calibration response, affecting the zero and span of the transducer. The latest generation of sensors incorporates designs that significantly minimize the amount of stress that static pressure can apply to the sensing element. Look for a transducer with a low-pressure effect rating, such as ±2% FS/100 PSIG.

Fortunately, errors due to line pressure can be easily corrected by recalibrating or re-zeroing the unit. This can be accomplished manually, through the use of a potentiometer, or by using advanced models that have a small calibration key accessory with a digital display that mounts on the transducer for easy and secure calibration adjustments. Calibration key functions include reset trimming for zero, span or recovering factory settings.

5. Response Time

Response time is another important factor, especially for pressure control and in wind tunnel applications. A transducer's response time, the time interval for the transducer to product the output signal in response to an applied pressure, is primarily determined by the technology in the unit's sensing element and its electronics. Diaphragms that use capacitive sensing typically respond very quickly. They detect and measure pressure through the change in charge across a sensing capacitor, one plate of which is a diaphragm that deflects slightly with changes in applied pressure. The resulting change in capacitance is detected by the transducer's electronics, which linearizes, thermally compensates, conditions and outputs a proportional, high-level signal.

The need for fast response time is determined by the application requirements. For example, in wind tunnel events where dynamic air velocity changes are measured, the signal output from the transducer must change with the velocity, thus requiring a fast response time. A response time of 10-80 milliseconds (ms) is typically acceptable for most test stand, leak detection and wind tunnel applications. Response time is less critical for routine process and monitoring applications that usually respond in seconds versus milliseconds. When designing a system it's important to understand the response time required of a pressure transducer. Sometimes a fast transducer can respond to short, unfiltered and undesirable system noise or turbulent pressure oscillations if the transducer response is too fast. In these cases, filtering the output signal will damp out these unwanted disturbances.

6. Other Considerations

It is also advisable to select a transducer with excellent long-term stability, its ability to retain performance characteristics for a relatively long time period, especially span stability. Usually, it will be less than ±0.15% FS/Yr, but can be found on the unit's specification sheet.

Also check the specification sheet to see if the transducer is CE and RoHS compliant. Having the CE mark means that the transducer meets the EU's consumer safety, health and environmental requirements. RoHS compliance designates that the unit is limited to the maximum allowable concentrations of six hazardous substances: lead, mercury, cadmium, hexavalent chromium, PBB and PBDE.

Finally, find a supplier that offers transducers in multiple configurations. This allows end-users the ability to work with one manufacturer that can provide different units with specific accuracies, resolutions and ranges that are ideal for their various applications.

System designers, manufacturers, sales engineers and distributors of test stand and leak detection systems are constantly searching for transducers with state-of-the-art features to meet their challenging requirements. They can be confident that today's differential pressure transducers have high accuracy, overpressure capability, low thermal error, excellent stability, high-line pressure capability and rugged stainless steel construction. These features are constantly being improved by transducer suppliers through their ongoing research & development programs. Continuously improving sensors enable system manufacturers to produce high quality products.

Author Bio:
Gino Pinto is the Manager of R&D Engineering at Setra Systems Inc. where he has worked for over 17 years with primary responsibilities in research, design and new Product Development. With over 28 years of industry experience, Gino had also worked at successful start-up companies having since been acquired by Motorola, Goodrich Corp., and Gefran Inc. Gino received his Masters of Science in Mechanical Engineering and BSME from UMass Lowell and holds 9 US patents related to sensing devices.

About Setra:
Founded by former professors of Engineering at Massachusetts Institute of Technology (M.I.T.), Setra has been designing and manufacturing sensor products since 1967. Our specialty is in the pressure and sensing in a wide range of markets including HVAC/R building automation, pharmaceutical, energy, medical sterilization, industrial OEM, test & measurement, meteorology and semiconductor.

Setra Creates Solutions:
- Over 40 years of expertise in sensing and sensing applications
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- Sensors cover a wide range of pressure rages with unique expertise in low pressures
- Sales and manufacturing in the U.S., Europe, and Asia for fast solutions and products