

Why Bonded Foil?

Why bonded foil pressure transducers are the logical starting point for engineers looking for an optimal custom pressure, torque or load sensing solution.



There are a variety of sensor technologies that may be used to engineer custom pressure, torque and load sensing solutions. Some of the most commonly used, along with their unique characteristics, advantages and disadvantages are detailed in the table on the opposite page. If you have decided that your device or product requires a custom sensor, then you will need to find a sensing solution partner with expertise in manufacturing sensors based on one or more of these technologies. But which one?

By reviewing the table you may learn that there are obvious trade-offs that would favor one or another of the technologies shown. If this is not the case, then the logical starting point for your review of applicable sensor technologies is the bonded foil strain gage pressure transducer.

What is a bonded foil strain gage?

Pressure, torque and load sensors use a variety of sensing devices to provide an electrical output proportional to applied pressure. Many sensors use bonded foil strain gages as a base technology. Bonded foil strain gages are manufactured using photo-etching technology, which is similar to that used in producing printed circuit boards. This fabrication technique allows the strain gage manufacturer to produce almost any size and shape of strain gage needed to accommodate the requirements of the particular sensing application. The use of foil in the strain gage design results in improved heat dissipation, simplified bonding techniques, reduced creep effects, lowered gage cost and allows greater freedom in providing gages adaptable to complex transducer geometries.

Predominantly Advantageous

For more than five decades, the bonded foil strain gage pressure transducer has been the predominant choice for the widest range of pressure, torque and load sensing applications. The advantages include:

- Low and predictable thermal effects allow accurate operation over a wide temperature range. Compensation and correction techniques are straightforward.

- Strain gages can be creep corrected by the manufacturer to match the requirements of the transducer designer.
- Small size and low mass allows operation over a wide frequency range and minimum sensitivity to shock effect.
- Because the strain gage is fully bonded to the transducer's sensing element, there are no mechanical connections to compromise ruggedness and dynamic performance.
- The strain gage changes resistance with strain; increasing under tensile strains and decreasing when in compression. Since it is essentially insensitive to supply voltage frequency, it can be used with AC or DC systems.
- The cost of the strain gage is relatively low and can be custom manufactured in a variety of shapes, sizes and materials.
- Bonded foil strain gages are very stable and transducers retain their calibration and performance over extended periods of time.
- They have excellent repeatability and linearity over a wide range of strains.
- They are broadly adaptable to the widest range of custom sensor applications.

¹For guidance in deciding whether or not your application requires a custom sensor ask for our white paper *Going Custom Sensor*.



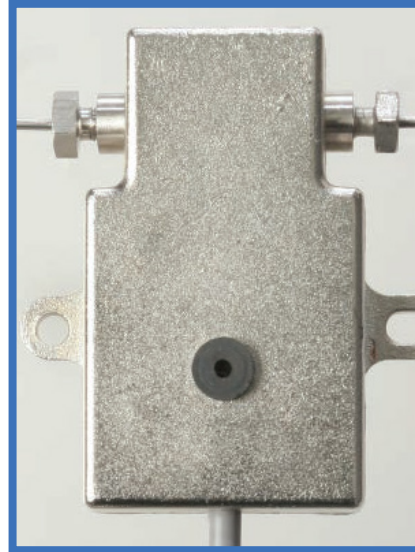
Custom 30 lb. load cell used in the medical equipment industry.

Beyond The Base Technology

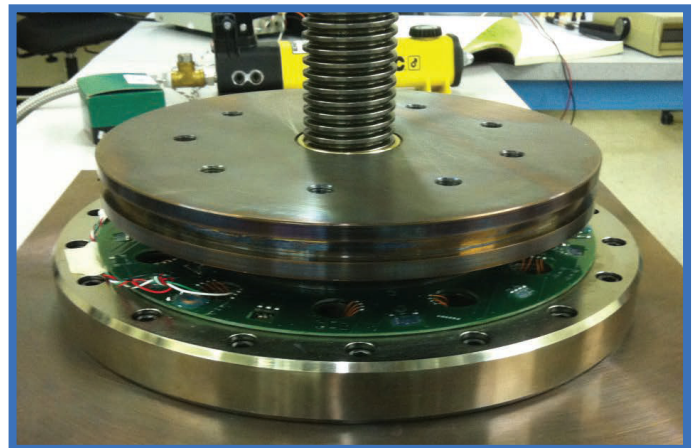
Once you have decided that the bonded foil strain gage is the logical starting point in your search for an ideal custom sensing solution for your application, you will want to identify a design, engineering and manufacturing resource who will be your partner throughout the sensor development process. Some important criteria for evaluating a potential custom sensor partner include:

- Depth of experience in creating a broad range of custom sensing solutions.
- Specific experience in developing solutions for applications like yours.
- Facilities manned and equipped for custom manufacturing vs. an approach that produces customized sensors as a side-stream to production manufacturing.
- Rigorous simulation and testing capabilities.
- Ability to accommodate your specific requirements as long as they are feasible.
- Ability to get in sync with your accelerated delivery cycles.
- A custom sensor development methodology that takes into account product performance, cost, testing, timely manufacturing and delivery along with making unique value-added contributions to your device or product.

Working closely with a carefully selected custom sensor manufacturer, you can meet almost any reasonable cost, performance and delivery objective. You will also benefit from a partnership that can bring into focus issues that would compromise your design as well as technology advantages that could provide your device or product with a competitive advantage in your marketplace.



Custom pressure transducer for in-line liquid pressure measurement.



Custom 100,000 lb. load cell used in the transportation industry.

Table I: Common Sensor Technologies and their relative advantages and disadvantages

Sensor Technology	Characteristics	Advantages	Disadvantages
Silicon Piezoresistive	<ul style="list-style-type: none"> • Similar To Strain Gage • Based on Wheatstone Bridge • Used for Lower Pressure Applications • Excellent Overpressure Protection 	<ul style="list-style-type: none"> • Higher Sensitivity means higher output for a given deflection • Low pressure capability (2 psi) 	<ul style="list-style-type: none"> • Not good in cyclic applications • Not designed for high pressures • High temperature effects • Thin diaphragm • Oil-filled
Ceramic Piezoresistive		<ul style="list-style-type: none"> • Less expensive (than silicon piezoresistive) • More rugged (than silicon piezoresistive) • Ceramic wetted face 	<ul style="list-style-type: none"> • Low upper pressure limit – burst • Not suitable for fast pressure cycles, shocks, or vibrations • High temperature effects
Variable Capacitance	<ul style="list-style-type: none"> • Measures capacitance based on position of a deflected membrane 	<ul style="list-style-type: none"> • Extremely sensitive to small changes in pressure, down to 1 inch of water column • High overpressure capability • Differential, gage or absolute measurement capability 	<ul style="list-style-type: none"> • Expensive • Difficult to Manufacture. • More Noise • Low pressure only
Monolithic Semiconductor	<ul style="list-style-type: none"> • Small slivers of silicon or germanium crystals doped to achieve specific properties, then cut and etched to a specified resistance 	<ul style="list-style-type: none"> • Small in size • Inexpensive • Higher response to strain compared to foil gages 	<ul style="list-style-type: none"> • Highly non-linear temperature effects. • Poor media compatibility • Low overpressure capability • High capital investment to manufacture
Thick Film on Ceramic	<ul style="list-style-type: none"> • A conductive paste which is applied to the ceramic in grid patterns similar to foil gages, then cured in ovens to adhere to the ceramic 	<ul style="list-style-type: none"> • Small in size • Good accuracy • Withstands aggressive media • Gage and absolute pressure • Economical in mass produced quantities 	<ul style="list-style-type: none"> • Not designed for high pressure applications • Not suitable for fast pressure cycles, shocks, or vibrations
Bonded Foil Strain Gage	<ul style="list-style-type: none"> • Solid machined metal sensor. • Photo etching technology 	<ul style="list-style-type: none"> • Durable sensor design • High shock and vibration resistance • Excellent for high pressure applications • Very stable 	<ul style="list-style-type: none"> • Not suitable for wet-wet differential applications • Low sensitivity - low output per unit deflection
Thin Film	<ul style="list-style-type: none"> • Vacuum-deposited, conductive film 	<ul style="list-style-type: none"> • Same as bonded foil • More stable than bonded foil 	<ul style="list-style-type: none"> • Requires specialized equipment • Economical only in large volume • Diaphragm area has design-constraints due to deposit equipment needs



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