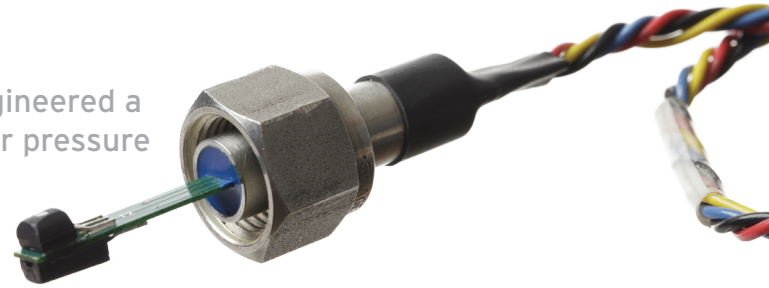
Douglas Electrical Components

Sealed Sensor Assembly Gets A Reliability Boost

Learn how Lumasense and Douglas Electrical re-engineered a humidity sensor assembly to eliminate failures under pressure



What's the best way to incorporate sensors and sensing electronics into a pressure or vacuum chamber? Traditionally, the answer would have involved a hermetically sealed wire feedthrough. And in applications with complex or numerous electrical connections, well-designed hermetic feedthroughs are still the way to go.

However, there is another lesser-known way to bring sensors and similar electronics into a pressure chamber. Rather than pass sealed wires through the pressure wall as with a feedthrough, you can instead hermetically seal circuit board assemblies that interface with a sensor. These sealed circuit board assemblies can then protrude directly into the pressure or vacuum chamber.

In the right applications, sealed circuit board assemblies have some persuasive performance and cost benefits. One company that recently reaped those benefits is Lumasense, a leading provider of condition monitoring systems for power generation and distribution equipment.

SEALED SENSING ASSEMBLY

Lumasense engineers recently worked with our engineering team to create a custom hermetically sealed sensing assembly for the company's SmartDGA Guide™, a predictive maintenance system for transformers.

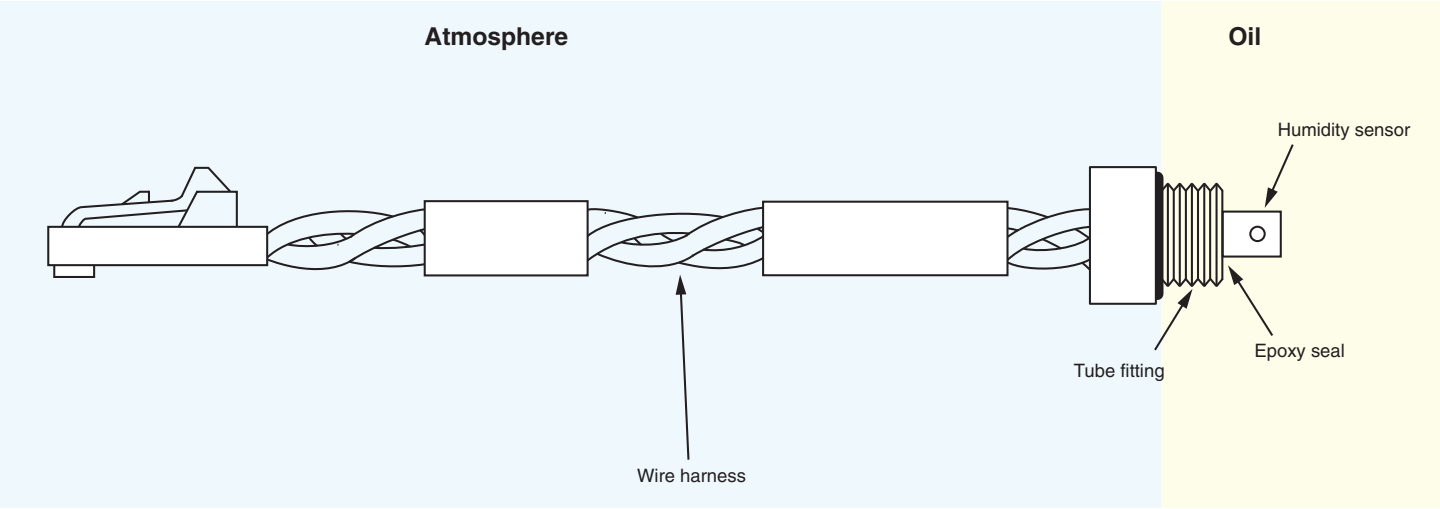
The system works by diverting transformer oil into a pressurized manifold that contains an array of sensors. The sensors look for the presence and saturation of dissolved gasses and moisture in the oil and use that information to diagnose any impending transformer problems (see sidebar).

One of the key sensing elements in the SmartDGA is a humidity sensor assembly. On the pressure side of the manifold wall, it includes the humidity sensor itself along with its printed circuit board (PCB). These extend about a half inch into the pressurized manifold.

On the atmosphere side, the assembly includes a wire harness. The entire assembly is packaged in a threaded fitting that mounts to the manifold wall. To prevent the 50-psia oil from leaking through manifold wall, the assembly required a hermetic seal. "It was extremely important to us that the seal be robust because we can't tolerate any failures in the field," says Terry Stapleton, a sensor development engineer with Lumasense.

CLEVER DESIGN, CHALLENGING EXECUTION

Early on in the development of the Smart DGA, Lumasense's engineering team came up with an innovative design for the sensor assembly. "Our initial idea was to package a long skinny PCB and sensor in a threaded fitting. We would then use epoxy to create a seal between circuit board and the fitting housing," Stapleton recalls. "That's pretty much what we ended up with."



Yet the sealed circuit board proved far easier to design than to manufacture. Stapleton says that early prototypes of the assembly didn't perform well due to a CTE mismatch between the different assembly components. "The CTE mismatch opened up leak paths between the circuit board and epoxy," he explains.

Lumasense tried to fix the problem by experimenting with many different epoxy formulations and assembly processes. But the sensor assemblies kept leaking. "It quickly became clear to us that we could not achieve in-house the sealing confidence we needed. It's really not a do-it-yourself job," says Stapleton.

So Stapleton and his team decided to give our hermetic circuit board sealing technology a try. Called CircuitSeal™, this proprietary technology uses epoxy compounds to hermetically seal a variety of circuit boards styles (see sidebar).

By directly sealing the circuit boards, CircuitSeal eliminates a potential failure point at the electrical connection. And Stapleton reports that Lumasense saw an immediate elimination of failures. The prototype version that Lumasense started with failed at rates above 30%. "The production version from Douglas has had zero failures," he reports.

DESIGNED FOR ASSEMBLY, FULLY TESTED

For Lumasense, failure-proofing its sensor assemblies is more than enough justification for CircuitSeal. But there were additional benefits beyond sealing reliability.

According to Stapleton, the move to CircuitSeal provided a good opportunity to fine-tune Lumasense's initial design to make assembly process foolproof and repeatable.

The production version of the assembly, for example, has mechanical features that ensure the correct orientation of the flat circuit board in the

CircuitSeal Basics

CircuitSeal hermetically seals to flex, rigid, hybrid and flat flex cable (FFC). Directly sealing the circuit board eliminates potential failure points at the electrical connection and allows for increased conductor density while providing a smaller, lighter and less expensive solution. Circuit seals also make it easy to incorporate passive electrical components—such as filters, fuses and resistors.

Intended for mid-to-high volume production settings, CircuitSeal applications include:

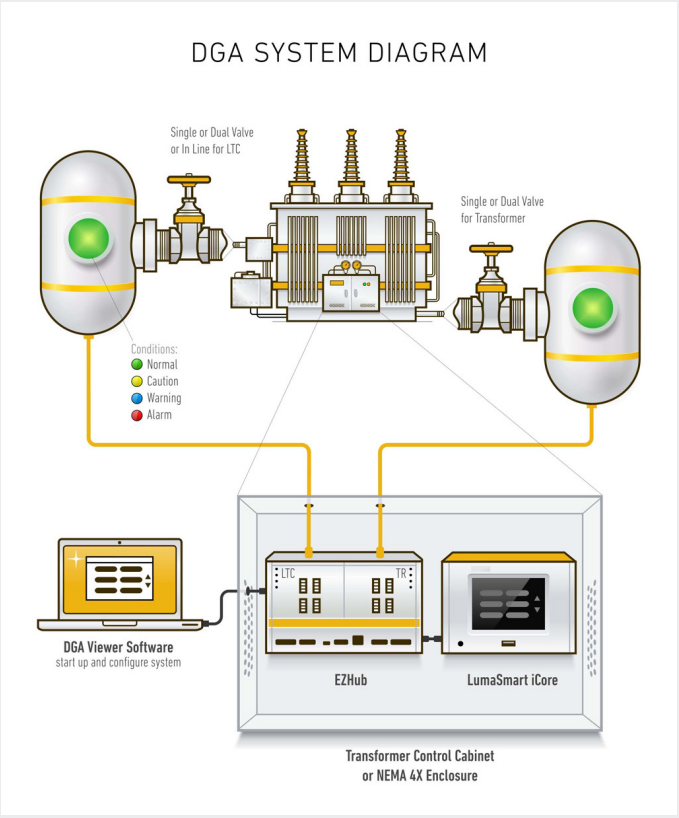
- Semiconductor manufacturing
- Instrumentation and Control Systems
- Automotive
- Magnetic Bearings
- Space Simulation
- Military Equipment
- Missiles or Bomb Fuses
- Laser Equipment

SmartDGA

The SmartDGA Guide™ prevents transformer failures by collecting and analyzing dissolved gasses in the transformer oil. This dissolved gas analysis (DGA) system measures and reports nine different gases and moisture at half the cost of comparable products. Features include:

- 24–7 online monitoring critical transformers
- Ability to identify all types of faults in transformer oil using popular IEEE / IEC diagnostic methods—including Duval's triangle, key gas ratio and Rogers ratio.
- Quick installation
- No routine maintenance or calibration, no requirement for carrier gas
- Supports smart grid ready communication protocols like IEC 61850, Modbus and DNP3.

For more information, visit **www.lumasense.com**.



round fitting "to make sure its not leaning or off-axis in any way," says Stapleton. Another mechanical feature—opposing shoulders in the fitting and on the PCB—establishes the correct depth of the sensor in the fitting. This critical dimension ultimately determines how far the sensor will protrude in the oil.

Taken together, the design-for-assembly improvements in the sensor assembly ensure that all Lumasense's critical dimensions are on the money in the finished assemblies. "Douglas also verifies all those critical dimensions as part of their testing process," Stapleton says.

That testing goes well-beyond dimensional checks to include environmental, electrical, pressure and vibration testing. Stapleton points to the extensive quality control regimen as one of the major benefits of buying a pre-tested assembly rather than a collection of individual components. "The sensor units arrive ready for us to install," he says.

RELIABILITY IN, COST OUT

Reliability engineering is one of the core design principles at Lumasense. So the ability to eliminate a potential leak path made CircuitSeal a natural for this application. Factor in the ease-of-assembly and testing advantages, and CircuitSeal also emerged as the low-cost alternative to in-house assembly.

Stapleton says piece-part costs for in-house assemblies may have come in a bit lower than CircuitSeal. But the lower yields, potential failures and extra assembly time associated with the in-house version gave CircuitSeal a compelling edge in total installed cost.

After the development of the humidity sensor assembly, Lumasense took a similar approach with another sensor in the Smart DGA. "Sourcing these sensors as assemblies makes a lot of sense for us," says Stapleton.