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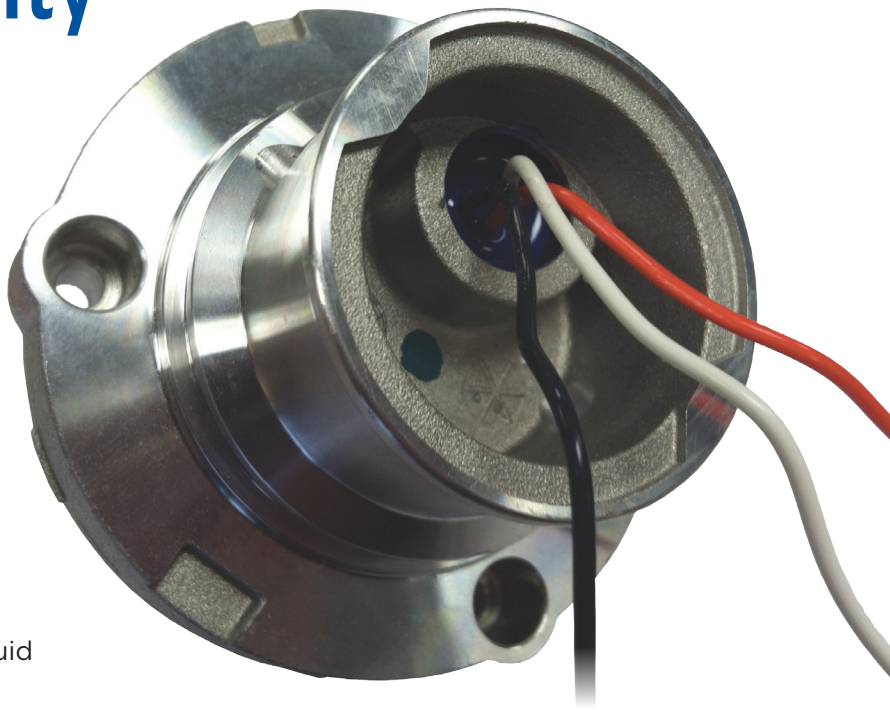
# Integrated Epoxy Feedthroughs Improve Fuel Pump Reliability



Of all the design decisions that affect the operation of an in-tank fuel pump, the way you seal the pump housing may top the list. A bad seal will allow liquid fuel to work its way into the housing, which will eventually corrode the electronics and potentially cause a risk of fire. Given the importance of these seals, it's surprising that many self-contained fuel delivery systems still use o-ring assemblies to seal the power and signal leads that pass though fuel pump housing.

Not all elastomers resist degradation with long-term exposure to gasoline, diesel, jet fuel and liquid propane. And the o-ring materials that do resist these fuels tend to be costly. O-rings must also be properly greased to ensure they don't crack and leak prematurely, but many of the greases used today are not compatible with common fuels.

Making matters worse, o-ring seals have some drawbacks from a manufacturability standpoint. For one, o-ring seals typically require supplementary components, such as snap rings or jam nuts, for retention on the fuel pump cap. For another, o-rings need to be high-quality and very clean prior to the initial install or else they will create a leak at the first sign of pressure contamination, surface imperfections on feedthrough or fuelpump cap. Dual o-ring housings are a common way to alleviate issues with dirty or poor quality o-rings, but this approach adds cost and lengthens the seal area. Lastly, o-rings need a significant amount of high-touch installation labor and additional quality checks, which drives even more cost and lengthens delivery times.

A more effective way to seal fuel pump wiring involves the use of epoxy-based feedthrough technology. Epoxies have a number of advantages in these applications—not least of which is best-of-class resistance to all common fuels and other chemicals. The use of epoxy wire feedthroughs for fuel pumps isn't exactly new. We've shipped more than a million fuel pump feedthroughs for all kinds of automotive, commercial aviation, aerospace, heavy equipment, recreational vehicle and small engine applications.

What is new, however, is how the epoxy is being applied. In the past, many of these epoxy wire feedthroughs were delivered as separate assemblies that would then require assembly into the fuel pump cap or housing. Today, epoxy feedthroughs can often be integrated into fuel pump itself through a direct casting process.

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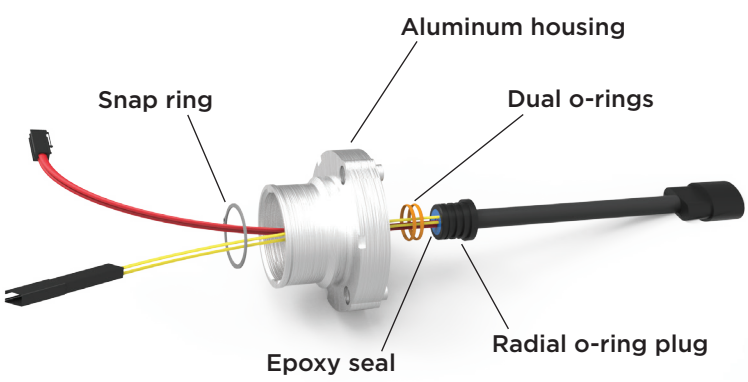
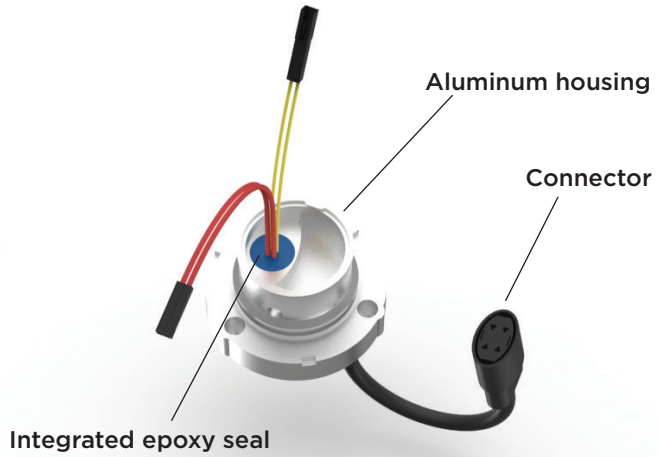
## FUEL CAP FEEDTHROUGH EVOLUTION




### Before–With Radial O-Rings

- **10** components
- **4-step** assembly
- **No** weight savings
- **No** space savings
- **No** cost savings

### After–Integrated Wire Seals

- **6** components
- **1-step** assembly
- **25%** lower weight
- **25%** less space
- **20%** lower cost

## Integrated Wire Feedthroughs

Direct casting does just what its name suggests: We cast the epoxy feedthrough into an opening in fuel pump housing—typically the cap. The process sounds simple enough, but it involves a number of difficult engineering challenges. The epoxy formulation, for example, has to have just the right balance of flow and mechanical properties to satisfy both the manufacturability and end-use requirements. And the design of the feedthrough and its opening needs to be optimized to create a strong mechanical bond between the epoxy and the pump housing material—typically aluminum or other metal in high-performance pumps. In particular, the design has to accommodate differences in the coefficient of thermal expansion (CTE) of the epoxy and the metal.

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Once these engineering challenges have been met, the resulting feedthrough creates a true hermetic seal around any wires that pass through the pump housing. We've designed and manufactured integrated wire feedthroughs that withstand fuel pressures to 2,250 psi for liquid propane (LP) systems while offering true hermetic sealing with leak rates better than $1 \times 10^{-8}$ ccHe/sec. In extensive testing and in the field, these integrated feedthroughs have also withstood long term exposure without cracking or shrinking to gasoline, ethanol, diesel, jet fuels and LP. And they pass a battery of rigorous tests, including:

- Vibration to IAW MIL-STD-810G
- Thermal cycling from -40 to 130°C
- Thermal shock from -40 to 80°C
- Salt fog exposure.
- Burst testing to and above 2,000psi

## Integration Has Economic Advantages

The advantages to the integrated feedthrough approach go beyond superior sealing. Integrating the feedthrough into the fuel pump saves space, weight and money.

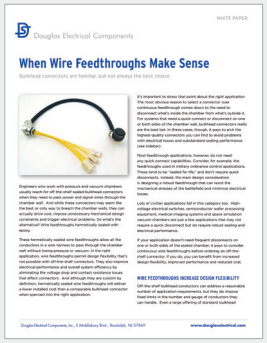
A typical o-ring assembly used in fuel pump applications consists not just of the o-ring itself but also a snap ring or other retaining component. Not only do these components add extra materials cost, they also add labor cost for the assembly. They also add long-term costs in the form of recalls and rework due to failed o-rings. In our experience, integrated epoxy feedthrough have an 20% lower installed cost based on the component and labor savings.

By eliminating extraneous components, the integrated wire feedthroughs also save space and weight compared to traditional o-ring wire seals. In most fuel pump designs, the weight and space savings can be as much as 25%.

Integrated wire feedthroughs have so far mostly been applied to applications requiring extreme performance and reliability—for example motorsport, aerospace and military vehicles. But the performance and cost advantages are increasingly making integrated feedthroughs a good fit for other applications as well.

**To learn more about incorporating feedthroughs into fuel pumps, visit www.douglaselectrical.com.**

## Read our other technical papers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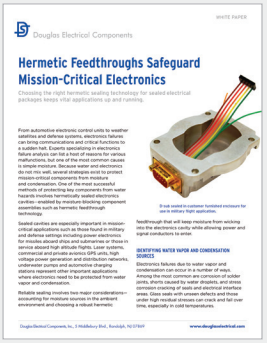
When Wire Feedthroughs Make Sense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Hermetic Feedthroughs Safeguard Mission-Critical Electronics


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New Cryogenic Feedthrough Improves Ease-of-Use

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