

# Leak-Tight Cable Pass-Through into Hostile Environment (Oil, Temperature, Vibration) Such as Inside Engine or Gear Box

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## ABSTRACT

In recent years, more and more electric components like sensors or actuators are being positioned in hostile environments like those of commercial trucks. Next to the underbody area there are additional application zones such as the braking, the interior of the engine, or the gear box. Often the connection of the electric components to the wiring harness is created by an expensive header connector; usually it is placed at the interface point between the adverse area and the standard environment, or within the adverse area itself. An alternative solution is to guide the leads through by using an overmolded and leak-tight pass-through. This has many advantages, but requires a high level of knowledge of the behavior and interaction of all involved materials. New developments often indicate increasing operation temperatures in combination with advanced aggressive media such as engine or gear box oil, Adblue®, or break fluid. At the design state many influences and material property changes in usage have to be taken into account to generate a feasible solution. The advantages and limitations of this technology will be discussed, as well as proven existing solutions and the latest developments.

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## E/E ARCHITECTURE AND FUTURE DEVELOPMENT

Due to different effects, the E/E architecture in the truck is always changing and becoming more complex. Thus, the amount of connection points at the ECU, sensors, and actuators will rise and the requirements for the harness and some of its components will increase. At all of these parts, leak-tight electrical pass-through solutions are necessary.

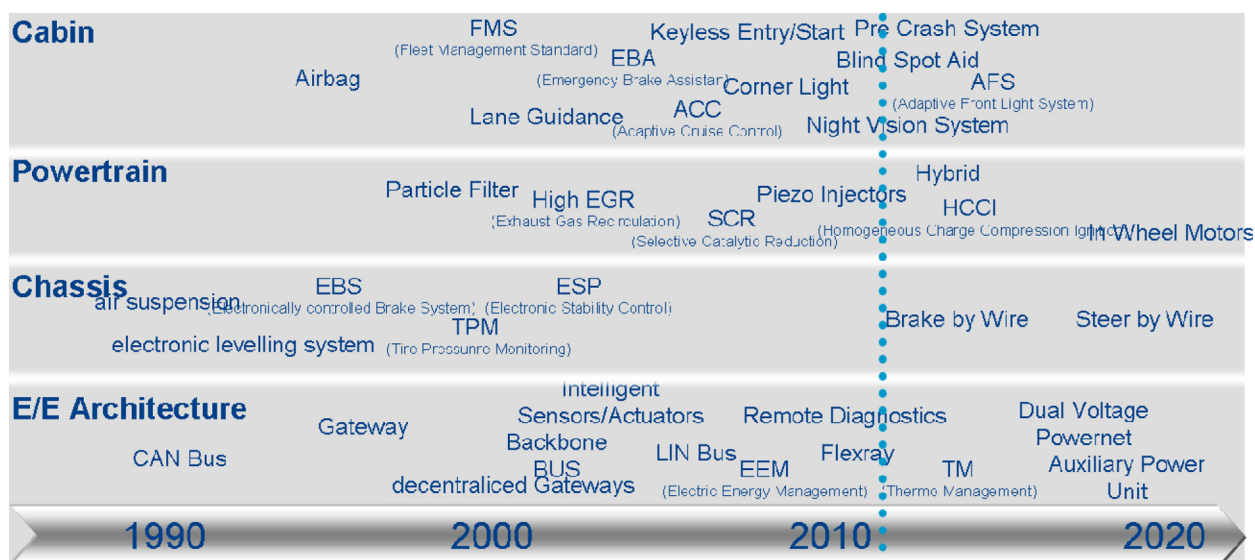
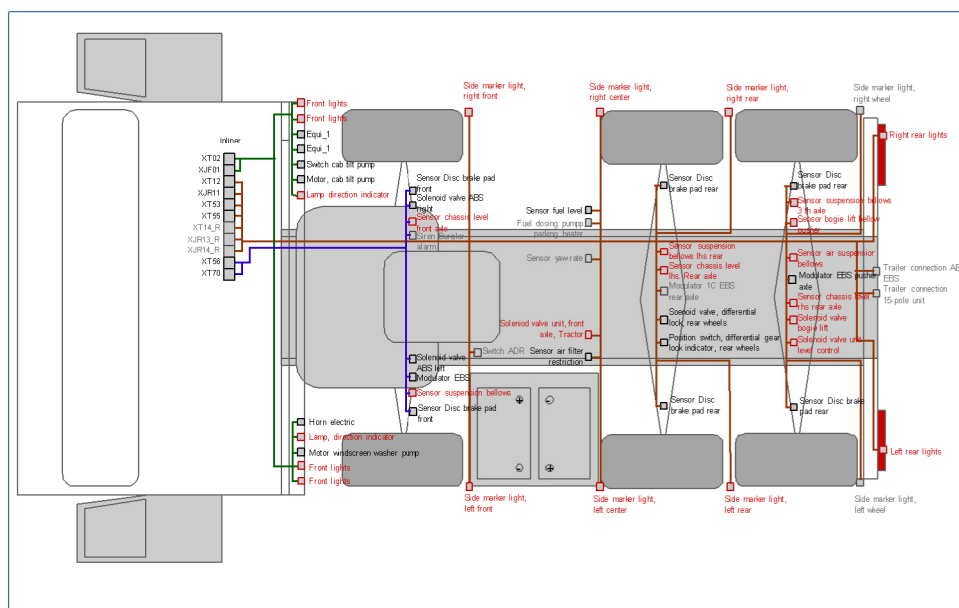
It is difficult to say which change has the biggest effect: the E/E architecture or the requirements. For a more detailed, cross-sectional view, the truck is split into a chassis section and a powertrain section. (see [fig. 1](#))

At the chassis we often have most of the ECUs in the cabin, as this is a protected area. The increasing number of sensors and actuators makes the main harness bundle bigger and requires more space for the ECUs. Eventually, the main harness is too big to handle and must be guided through the fire wall and into the cabin while remaining leak-tight. The remaining space in the cabin is not sufficient for all ECUs, hence the trend is to move the ECUs into the chassis area with an increase of requirements for temperature, chemical resistance, and leak-tightness for the ECUs and their connections.

But what is the reason for bigger harnesses? Besides the basic electrical functions such as the lights or the horn, there are now established functions like the ABS/EBS (electronic brake system), air suspension, or assistant systems such as electronic stability control or ACC (adaptive cruise control) (see [fig. 2](#)). Also, brake- or steer-by-wire is another emerging technology that could become a factor.

New electrical connections are necessary for all the functions listed above. As these new functions are safety related, a very high reliability is a must. We see that the change of the E/E architecture at the chassis will require more and improved solutions for passing the current into the E/E components free from outside influence.

At the powertrain, the biggest driver for change can be easily identified: the legislation for emission reduction. Despite different standards in Europe and USA, both are heading the same direction towards intensive reduction of air pollution. EPA'07 reduced NOx emissions by 50 percent, and reduced particulate matter by 90 percent. EPA'10 requires NOx reduction of 99 percent, and the next level EPA'13 will go a step further. Technologies such as electronic fuel system, EGR (Exhaust Gas Recirculation), VGT (Variable Geometry Turbocharging), DPF (Diesel Particulate Filter) and SCR (Selective Catalytic Reduction with diesel exhaust



fluid [with urea]) are used to reach the target. This increases the amount of electrical connections dramatically and also generates many on the hot side of the engine. For example, an EPA'05 engine had 27 connections, EPA'10 has 29 connections (see [fig. 3](#)) and an engine for the EPA'13 level will have up to 54 connections. The new engine developments “electrify” the engine.

All engines have an electrical fuel system with an electric injector system which needs an injector harness. Most of the engines have an internal injector harness that has to work in extreme temperatures, high loads of oil, and other harmful media for its entire lifetime.

Based on this analysis we can say that the amount of leak-tight electrical pass-throughs in hostile environment will increase substantially in the next few years.

## INCREASING REQUIREMENTS VS. SIMPLIFYING STANDARDS

Due to the redesign of the E/E architecture, the amount of requirements in the chassis area is increasing. Connections which have been moved from the cabin into the chassis have to be re-rated for a higher class of stress.

As a result of field experiences, the specifications of many connections on the body harness increase as well. The

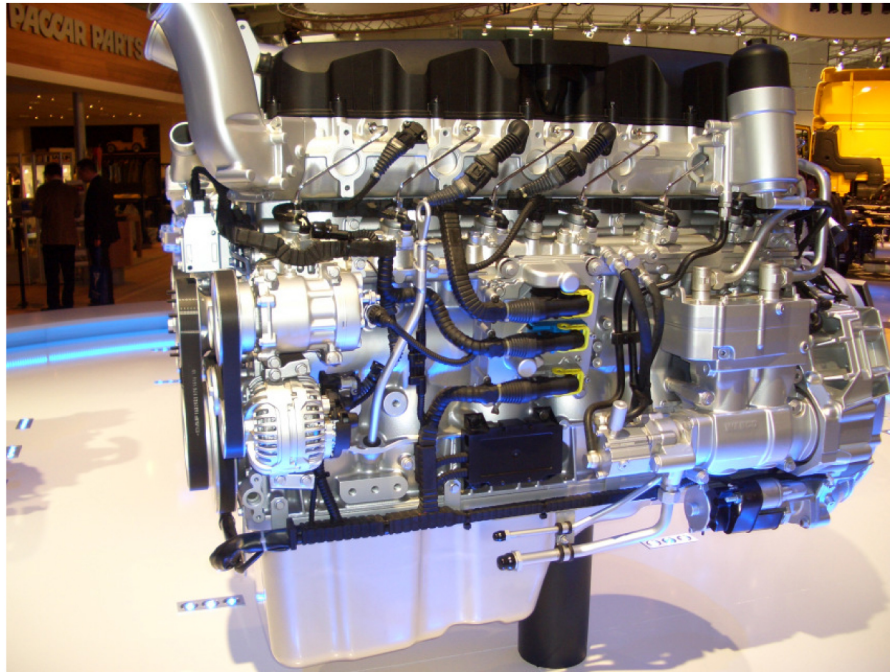


**Fig. 3. Example of an EPA'10 engine (source: LEONI)**

specification for leak-tightness acc. IEC 60529 moved to IP69k, which means a high pressure washer test, and IP67: submersion under a water column, is also required. As for chemicals, resistance fluids like AdBlue® (32.5% Urea solution in demineralized water) were added to the list.

At the powertrain section, the main change for the next generation of engines will be the increased operating temperature. The main causes being: the legislation for exhaust emissions; the need for connections on the hot side of the engine and near the exhaust system; and the tighter package for the rising amount of components. Exact temperature measurements of the running engine will reveal in the future the peak and permanent temperatures in the different areas. The target is to stay at a temperature rating of 300 °F (150°C) on the cold side of the engine and to not go much higher than that.

In addition, an interesting development is taking place as far as the engine lubricants. The engine oil has to fulfill plenty of different and partially contradicting expectations. Recently biofuel and more blow-by gases from the EGR system made an alteration of engine oil necessary. Foremost, the blow-by gases leads to a pH-value change into acidic and an increase of humidity in the oil usage cycle.

The transmission fluids for the gear box are often especially aggressive against several plastics and also to some of the conductor metals. GM created one of the main technical specifications for automatic transmission fluids called DEXRON®. One can see the difficulty in selecting materials based on the current use of the DEXRON specification: At the end of 2006 the DEXRON 3 spec expired and was substituted by the DEXRON 6 by GM, but

the standard for cable validation - the ISO 6722 - still lists the DEXRON 3 as an optional test. For 2011 an update of the standard is planned that will consider a test with the DEXRON 6 fluid. Furthermore, the test will still be done at 122°F (50°C) for 20 hours and an outside diameter change of 25% is allowed.

These points reveal that the standards are useful for material selection with short time chemical contact, they are not sufficient for recurring exposure, or long-term usage of the cables with the defined chemicals at higher temperatures. So it is necessary to define a representative test in order to standardize a realistic performance with a lifetime acceleration method.

## REAL LIFE VS. TEST SPECIFICATIONS

Wear is everywhere - especially plastic materials that are aging or changing their material properties under load. No doubt that all parts have to function properly their entire lifetime. But when will the product die of old age and how sure can we be that it will be after the life time? It is a question of failure prediction and the method behind it. In former times the prediction methods were simple: Take the best material and use a lot of it, and then it will work. But in times of cost and material optimization a new and complex prediction method has to be developed. During use, plenty of mechanical, thermal, and chemical stress combinations will harm the material and the entire system over a varying period of time. To analyze the influence of all loads and their combinations the amount of tests shall be calculated with the